Appendix 6A

Supplemental Water Budget Results Tables

DRAFT

TABLE 6A-A

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE(1)

Scenario: 2030 Climate, no projects, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS(2)	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)(3)	0	0	-2,752	-954	-5,060	-8,767
Net Cross-Boundary Flows (AFY)	-1,167	-472	649	3,160	-94	2,078
Seaside Subbasin	*-19*	*-2*	*-3*	*1,764*	*-380*	*1,361*
180/400 Subbasin	*-396*	*-598*	*245*	*-200*	*-979*	*-1,927*
Corral de Tierra WBZ	*0*	*0*	*0*	*-206*	*1,232*	*1,026*
Ocean	*-752*	*128*	*407*	*1,802*	*32*	*1,617*
Presumed Freshwater	*-752*	*0*	*0*	*0*	*0*	*-752*
Presumed Seawater	*0*	*128*	*407*	*1,802*	*32*	*2,369*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,017	2,183	102	3,927	8,228
Underlying Unit Exchange (AFY)	-1,996	-2,138	-71	-3,927	0	-8,132

CHANGE IN GROUNDWATER STORAGE	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
ANNUAL AVERAGE (AFY)	**63**	**56**	**8**	**145**	**-43**	**230**
50-YEAR CUMULATIVE (AF)	*952*	*841*	*122*	*2,174*	*-638*	*3,451*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.
(2) All values in acre-feet per year (AFY) unless otherwise noted.
(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

TABLE 6A-B

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: 2030 Climate, no projects, MT boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)[3]	0	0	-2,752	-954	-5,060	-8,767
Net Cross-Boundary Flows (AFY)	-1,121	-624	493	2,959	95	1,801
Seaside Subbasin	*-16*	*-1*	*-2*	*2,632*	*-101*	*2,513*
180/400 Subbasin	*-380*	*-900*	*-17*	*-1,547*	*-1,004*	*-3,849*
Corral de Tierra WBZ	*0*	*0*	*0*	*-238*	*1,161*	*923*
Ocean	*-725*	*276*	*512*	*2,112*	*38*	*2,214*
Presumed Freshwater	*-725*	*0*	*0*	*0*	*0*	*-725*
Presumed Seawater	*0*	*276*	*512*	*2,112*	*38*	*2,939*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,094	2,140	-92	3,653	7,795
Underlying Unit Exchange (AFY)	-2,052	-2,109	118	-3,653	0	-7,697

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**52**	**9**	**-1**	**23**	**-128**	**-44**
50-YEAR CUMULATIVE (AF)	*787*	*128*	*-10*	*347*	*-1,919*	*-667*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MT = Minimum Thresholds
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-C

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE(1)

Scenario: 2030 Climate, no projects, seawater intrusion protective boundary conditions

NET ANNUAL GROUNDWATER FLOWS(2)	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)(3)	0	0	-2,752	-954	-5,060	-8,767
Net Cross-Boundary Flows (AFY)	-1,227	-492	1,247	3,546	-752	2,323
Seaside Subbasin	*-24*	*-3*	*-4*	*454*	*-770*	*-347*
180/400 Subbasin	*-409*	*-350*	*1,042*	*2,084*	*-1,196*	*1,171*
Corral de Tierra WBZ	*0*	*0*	*0*	*-208*	*1,193*	*985*
Ocean	*-794*	*-138*	*209*	*1,216*	*21*	*514*
Presumed Freshwater	*-794*	*0*	*0*	*0*	*0*	*-794*
Presumed Seawater	*0*	*-138*	*209*	*1,216*	*21*	*1,308*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,922	2,090	609	4,676	9,298
Underlying Unit Exchange (AFY)	-1,920	-1,987	-565	-4,676	0	-9,148

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**79**	**92**	**20**	**290**	**48**	**529**
50-YEAR CUMULATIVE (AF)	*1,186*	*1,382*	*294*	*4,347*	*722*	*7,931*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

TABLE 6A-D

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE(1)

Scenario: 2030 Climate, with projects, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS(2)	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)(3)	0	0	-1,364	-476	-2,648	-4,488
Net Cross-Boundary Flows (AFY)	-1,183	-609	-261	623	-574	-2,005
Seaside Subbasin	*-21*	*-2*	*-3*	*1,173*	*-535*	*612*
180/400 Subbasin	*-398*	*-698*	*-590*	*-1,928*	*-1,287*	*-4,901*
Corral de Tierra WBZ	*0*	*0*	*0*	*-219*	*1,220*	*1,001*
Ocean	*-764*	*91*	*332*	*1,596*	*28*	*1,283*
Presumed Freshwater	*-764*	*0*	*0*	*0*	*0*	*-764*
Presumed Seawater	*0*	*91*	*332*	*1,596*	*28*	*2,047*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,994	1,932	286	2,017	6,228
Underlying Unit Exchange (AFY)	-1,976	-1,972	-293	-2,017	0	-6,257

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**67**	**61**	**14**	**180**	**-21**	**301**
50-YEAR CUMULATIVE (AF)	*1,005*	*911*	*210*	*2,696*	*-313*	*4,509*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

TABLE 6A-E

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: 2030 Climate, with projects, MT boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)[3]	0	0	-1,364	-476	-2,648	-4,488
Net Cross-Boundary Flows (AFY)	-1,138	-761	-423	426	-384	-2,279
Seaside Subbasin	*-18*	*-2*	*-2*	*2,052*	*-253*	*1,776*
180/400 Subbasin	*-382*	*-999*	*-859*	*-3,280*	*-1,314*	*-6,833*
Corral de Tierra WBZ	*0*	*0*	*0*	*-251*	*1,149*	*898*
Ocean	*-738*	*239*	*438*	*1,906*	*34*	*1,879*
Presumed Freshwater	*-738*	*0*	*0*	*0*	*0*	*-738*
Presumed Seawater	*0*	*239*	*438*	*1,906*	*34*	*2,617*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,070	1,889	86	1,742	5,788
Underlying Unit Exchange (AFY)	-2,032	-1,945	-97	-1,742	0	-5,816

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**56**	**13**	**6**	**58**	**-106**	**27**
50-YEAR CUMULATIVE (AF)	*839*	*202*	*84*	*876*	*-1,591*	*410*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MT = Minimum Thresholds
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-F

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE(1)

Scenario: 2030 Climate, with projects, seawater intrusion protective boundary conditi

NET ANNUAL GROUNDWATER FLOWS(2)	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,226	648	0	1,764	1,184	6,823
Well Pumping (AFY)(3)	0	0	-1,364	-476	-2,648	-4,488
Net Cross-Boundary Flows (AFY)	-1,244	-630	340	1,006	-1,234	-1,762
Seaside Subbasin	*-26*	*-4*	*-4*	*-152*	*-928*	*-1,115*
180/400 Subbasin	*-411*	*-451*	*209*	*368*	*-1,503*	*-1,788*
Corral de Tierra WBZ	*0*	*0*	*0*	*-222*	*1,180*	*958*
Ocean	*-806*	*-175*	*135*	*1,011*	*17*	*182*
Presumed Freshwater	*-806*	*0*	*0*	*0*	*0*	*-806*
Presumed Seawater	*0*	*-175*	*135*	*1,011*	*17*	*989*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,899	1,840	798	2,768	7,305
Underlying Unit Exchange (AFY)	-1,900	-1,821	-791	-2,768	0	-7,280

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**83**	**97**	**25**	**324**	**70**	**598**
50-YEAR CUMULATIVE (AF)	*1,238*	*1,449*	*372*	*4,860*	*1,045*	*8,964*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

TABLE 6A-G

DRAFT

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: Baseline Climate, no projecs, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,020	605	0	1,627	1,104	6,356
Well Pumping (AFY)[3]	0	0	-2,752	-954	-5,060	-8,767
Net Cross-Boundary Flows (AFY)	-1,101	-439	660	3,348	-9	2,459
Seaside Subbasin	*-16*	*-2*	*-2*	*1,873*	*-265*	*1,589*
180/400 Subbasin	*-364*	*-556*	*273*	*-84*	*-962*	*-1,694*
Corral de Tierra WBZ	*0*	*0*	*0*	*-189*	*1,187*	*998*
Ocean	*-721*	*119*	*390*	*1,748*	*31*	*1,567*
Presumed Freshwater	*-721*	*0*	*0*	*0*	*0*	*-721*
Presumed Seawater	*0*	*119*	*390*	*1,748*	*31*	*2,288*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,916	2,076	7	3,889	7,888
Underlying Unit Exchange (AFY)	-1,887	-2,029	24	-3,889	0	-7,781

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**31**	**53**	**8**	**139**	**-76**	**156**
50-YEAR CUMULATIVE (AF)	*472*	*802*	*116*	*2,087*	*-1,142*	*2,334*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-H

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: Baseline Climate, with projects, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,020	605	0	1,627	1,104	6,356
Well Pumping (AFY)[3]	0	0	-1,364	-476	-2,648	-4,488
Net Cross-Boundary Flows (AFY)	-1,118	-576	-250	810	-489	-1,623
Seaside Subbasin	*-18*	*-2*	*-3*	*1,283*	*-420*	*840*
180/400 Subbasin	*-366*	*-656*	*-563*	*-1,813*	*-1,271*	*-4,668*
Corral de Tierra WBZ	*0*	*0*	*0*	*-202*	*1,174*	*972*
Ocean	*-734*	*82*	*315*	*1,542*	*27*	*1,233*
Presumed Freshwater	*-734*	*0*	*0*	*0*	*0*	*-734*
Presumed Seawater	*0*	*82*	*315*	*1,542*	*27*	*1,966*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,893	1,825	192	1,979	5,889
Underlying Unit Exchange (AFY)	-1,867	-1,863	-198	-1,979	0	-5,908

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**35**	**58**	**14**	**174**	**-54**	**226**
50-YEAR CUMULATIVE (AF)	*523*	*873*	*204*	*2,609*	*-816*	*3,393*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.
(2) All values in acre-feet per year (AFY) unless otherwise noted.
(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

TABLE 6A-I

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: 2070 Climate, no projects, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
Recharge (AFY)	3,606	710	0	1,932	1,261	7,509
Well Pumping (AFY)[3]	0	0	-2,752	-954	-5,060	-8,767
Net Cross-Boundary Flows (AFY)	-1,293	-537	633	2,908	-191	1,521
Seaside Subbasin	*-25*	*-3*	*-3*	*1,576*	*-512*	*1,033*
180/400 Subbasin	*-464*	*-677*	*199*	*-363*	*-1,001*	*-2,306*
Corral de Tierra WBZ	*0*	*0*	*0*	*-225*	*1,289*	*1,063*
Ocean	*-804*	*143*	*437*	*1,920*	*34*	*1,730*
Presumed Freshwater	*-804*	*0*	*0*	*0*	*0*	*-804*
Presumed Seawater	*0*	*143*	*437*	*1,920*	*34*	*2,534*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,199	2,353	254	3,986	8,792
Underlying Unit Exchange (AFY)	-2,192	-2,312	-225	-3,986	0	-8,714

CHANGE IN GROUNDWATER STORAGE	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
ANNUAL AVERAGE (AFY)	**122**	**61**	**9**	**154**	**-4**	**341**
50-YEAR CUMULATIVE (AF)	*1,823*	*916*	*134*	*2,306*	*-62*	*5,117*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-J

AVERAGE ANNUAL PROJECTED GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

Scenario: 2070 Climate, with projects, MO boundary conditions

NET ANNUAL GROUNDWATER FLOWS[2]	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,606	710	0	1,932	1,261	7,509
Well Pumping (AFY)[3]	0	0	-1,364	-476	-2,648	-4,488
Net Cross-Boundary Flows (AFY)	-1,310	-675	-277	371	-671	-2,562
Seaside Subbasin	*-27*	*-3*	*-4*	*985*	*-668*	*283*
180/400 Subbasin	*-466*	*-777*	*-636*	*-2,091*	*-1,309*	*-5,279*
Corral de Tierra WBZ	*0*	*0*	*0*	*-238*	*1,276*	*1,038*
Ocean	*-817*	*106*	*363*	*1,714*	*30*	*1,396*
Presumed Freshwater	*-817*	*0*	*0*	*0*	*0*	*-817*
Presumed Seawater	*0*	*106*	*363*	*1,714*	*30*	*2,213*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,176	2,101	437	2,075	6,790
Underlying Unit Exchange (AFY)	-2,171	-2,145	-446	-2,075	0	-6,837

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**125**	**66**	**15**	**188**	**17**	**411**
50-YEAR CUMULATIVE (AF)	*1,876*	*987*	*221*	*2,827*	*262*	*6,172*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
MO = Measurable Objectives
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-K
AVERAGE ANNUAL CURRENT GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE(1)
DWR Water Years 2015 - 2018

NET ANNUAL GROUNDWATER FLOWS(2)	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
Recharge (AFY)	3,360	791	0	2,207	1,266	7,624
Well Pumping (AFY)(3)	0	0	-581	-198	-2,723	-3,503
Net Cross-Boundary Flows (AFY)	-855	-855	-935	-872	-394	-3,912
Seaside Subbasin	*-12*	*0*	*1*	*2,515*	*-788*	*1,715*
180/400 Subbasin	*-268*	*-1,344*	*-1,470*	*-5,204*	*-1,421*	*-9,707*
Corral de Tierra WBZ	*0*	*0*	*0*	*-379*	*1,776*	*1,397*
Ocean	*-574*	*489*	*534*	*2,196*	*39*	*2,684*
Presumed Freshwater	*-574*	*0*	*0*	*0*	*0*	*-574*
Presumed Seawater	*0*	*489*	*534*	*2,196*	*39*	*3,258*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	2,044	1,919	376	1,428	5,767
Underlying Unit Exchange (AFY)	-1,854	-2,029	-397	-1,428	0	-5,709

CHANGE IN GROUNDWATER STORAGE	**Dune Sand**	**Upper 180-Foot**	**Lower 180-Foot**	**400-Foot**	**Deep**	**TOTAL**
ANNUAL AVERAGE (AFY)	**651**	**-48**	**5**	**83**	**-423**	**267**
WY 2004 - 2018 CUMULATIVE (AF)	*2,604*	*-194*	*18*	*334*	*-1,694*	*1,069*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.
(2) All values in acre-feet per year (AFY) unless otherwise noted.
(3) Includes 285 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

DRAFT

TABLE 6A-L

AVERAGE ANNUAL HISTORICAL GROUNDWATER BUDGET - MARINA/ORD AREA WATER BUDGET ZONE[1]

DWR Water Years 2004 - 2018

NET ANNUAL GROUNDWATER FLOWS[2]	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
Recharge (AFY)	2,557	639	0	1,794	1,154	6,144
Well Pumping (AFY)[3]	0	0	-1,336	-467	-2,543	-4,346
Net Cross-Boundary Flows (AFY)	-886	-840	-656	-1,242	194	-3,431
Seaside Subbasin	*-13*	*0*	*0*	*2,268*	*-945*	*1,310*
180/400 Subbasin	*-349*	*-1,236*	*-1,115*	*-5,071*	*-861*	*-8,633*
Corral de Tierra WBZ	*0*	*0*	*0*	*-421*	*1,965*	*1,544*
Ocean	*-524*	*396*	*459*	*1,982*	*35*	*2,348*
Presumed Freshwater	*-524*	*0*	*0*	*0*	*0*	*-524*
Presumed Seawater	*0*	*396*	*459*	*1,982*	*35*	*2,872*
Salinas River Exchange (AFY)	0	0	0	0	0	0
Overlying Unit Exchange (AFY)	0	1,894	1,705	-273	276	3,602
Underlying Unit Exchange (AFY)	-1,595	-1,778	258	-276	0	-3,392

CHANGE IN GROUNDWATER STORAGE	Dune Sand	Upper 180-Foot	Lower 180-Foot	400-Foot	Deep	TOTAL
ANNUAL AVERAGE (AFY)	**76**	**-87**	**-29**	**-464**	**-918**	**-1,422**
WY 2004 - 2018 CUMULATIVE (AF)	*1,138*	*-1,299*	*-442*	*-6,963*	*-13,768*	*-21,334*

Notes:

(1) Marina/Ord Area WBZ includes the Reservation Road portion of the Corral de Tierra Management Area.

(2) All values in acre-feet per year (AFY) unless otherwise noted.

(3) Includes 287 AFY of pumping from the Reservation Road portion of the Corral de Tierra Management Area.

Abbreviations:

AF = acre-feet
AFY = acre-feet per year
DWR = California Department of Water Resources
WBZ = Water Budget Zone
WY = DWR Water Year (October - September)

Appendix 6B

Monterey Subbasin Groundwater Flow Model Documentation

MONTEREY SUBBASIN GROUNDWATER FLOW MODEL DOCUMENTATION

TABLE OF CONTENTS

1. MODEL DEVELOPMENT OVERVIEW 6

2. METHODOLOGY AND APPROACH 6

2.1 Model Source Code 6

2.2 Discretization 6

2.2.1 Spatial Approach 6

2.2.2 Temporal Approach 7

2.2.3 Vertical Geometry 8

2.3 Initial Conditions 11

2.3.1 Historical Simulation 11

2.3.1 Projected Simulations 11

2.4 Boundary Conditions 11

2.4.1 No-Flow Boundary 11

2.4.2 General-Head Boundary 12

2.4.3 River Boundary 19

2.5 Aquifer Properties 20

2.5.1 Hydraulic Conductivity 20

2.5.2 Storage 22

3. STRESSES 23

3.1 Recharge 23

3.1.1 Historical Simulation 24

3.1.2 Projected Simulations 25

3.2 Pumping 27

3.2.1 Historical Simulation 27

3.2.2 Projected Simulations 27

4. CALIBRATION 28

4.1 Calibration Approach 28

4.2 Calibration Data 29

4.3 Aquifer Properties 29

4.3.1 Evaluation of Calibrated Aquifer Properties 30

4.4 GHB Conductance 31

4.5 Streambed Conductance 31

4.6 Recharge 32

4.7 Calibration Results 32

5. SENSITIVITY AND UNCERTAINTY ANALYSIS 34

6. MODEL LIMITATIONS AND SUGGESTED FUTURE REFINEMENTS 35

7. REFERENCES 38

TABLES

Table 1. Generalized Geologic – Hydrogeologic Relationships

Table 2. Mapping of Seaside Model Layers to MBGWFM GHB Cells at the Seaside Boundary

Table 3. Freshwater Equivalent Sea Levels – Historical Simulation

Table 4. Freshwater Equivalent Sea Levels – Projected Simulations

Table 5. Horizontal Hydraulic Conductivity (Kh) Estimates from Pumping Tests

Table 6. Specific Storage (Ss) Measurements from Pumping Tests

Table 7. Projected MCWD Deliveries

Table 8. Projected MCWD Pumping Rates

Table 9. MBGWFM Calibrated Storage Parameters

Table 10. MBGWFM Calibration Statistics

FIGURES

Figure 1. MBGWFM Active Extent and Grid

Figure 2. Leapfrog Cross-Section and MBGWFM Layering within the Marina-Ord Management Area

Figure 3. MBGWFM Active Layer Extents and Uppermost Principal Aquifer Units

Figure 4. MBGWFM Layer Top Elevations (Layers 1 – 4)

Figure 5. MBGWFM Layer Top Elevations (Layers 5 – 8)

Figure 6. MBGWFM Layer Thickness (Layers 1 – 4)

Figure 7. MBGWFM Layer Thickness (Layers 5 – 8)

Figure 8. MBGWFM Boundary Conditions Summary

Figure 9. MBGWFM Northern Boundary Conditions – Historical Simulation

Figure 10. MBGWFM Northern Boundary Conditions – Projected Simulations

Figure 11. MBGWFM Southern Boundary Conditions

Figure 12. Annual Net Cross-Boundary Flow Estimates between the Seaside and Monterey Subbasins
Figure 13. Salinas River Stages at USGS Spreckels Gauge
Figure 14. MBGWFM Texture Map – Layer 1
Figure 15. MBGWFM Texture Map – Layer 3
Figure 16. MBGWFM Texture Map – Layer 5
Figure 17. MBGWFM Texture Map – Layer 7
Figure 18. MBGWFM Texture Map – Layer 8
Figure 19. Pumping Test Well Locations
Figure 20. SSURGO Soil Types
Figure 21. SSURGO Hydrologic Soil Groups
Figure 22. SSURGO Saturated Vertical Hydraulic Conductivity
Figure 23. PRISM Cells
Figure 24. Water Service Areas
Figure 25. Historical Land Use
Figure 26. VIC Grid Cells Used for Climate Change Scenarios
Figure 27. Future Land Use
Figure 28. MBGWFM Pumping Wells
Figure 29. MBGWFM Calibration Wells
Figure 30. Horizontal Hydraulic Conductivity (Layers 1 – 4)
Figure 31. Horizontal Hydraulic Conductivity (Layers 5 – 8)
Figure 32. Vertical Hydraulic Conductivity (Layers 1 – 4)
Figure 33. Vertical Hydraulic Conductivity (Layers 5 – 8)
Figure 34. Comparison of Modeled and Observed Horizontal Hydraulic Conductivity
Figure 35. Comparison of Annual Recharge Rates between Soil Moisture Balance Model and SVIHM
Figure 36. Calibration Statistics
Figure 37. Average Residuals by Well
Figure 38. Composite Sensitivities for the Most Sensitive Model Parameters

ATTACHMENTS

Attachment 1. Hydrographs

ABBREVIATIONS AND ACRONYMS

AF	acre-feet
AFY	acre-feet per year
BAS	MODFLOW Basic Package
CalVeg	USDA Forest Service Region 5 Classification and Assessment with Landsat of Visible Ecological Groupings
CCR	California Code of Regulations
CIMIS	California Irrigation Management Information System
CVHM	Central Valley Hydrologic Model
CWS	California Water Service
DEM	Digital Elevation Model
DWR	California Department of Water Resources
EKI	EKI Environment & Water, Inc.
ET	Evapotranspiration
ETo	Reference evapotranspiration
ft	feet
ft bgs	feet below ground surface
ft/d	feet per day
ft/yr	feet per year
GHB	MODFLOW General Head Boundary Package
GSA	Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
HCM	Hydrogeological Conceptual Model
Kh	Horizontal Hydraulic Conductivity
Kv	Vertical Hydraulic Conductivity
MBGWFM	Monterey Subbasin Groundwater Flow Model
MCWD	Marina Coast Water District
MCWRA	Monterey County Water Resources Association
NMGWM	North Marina Groundwater Model
MT	Minimum Threshold
MO	Measurable Objective
PEST	Model-Independent Parameter Estimation and Uncertainty Analysis
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RCH	MODFLOW Recharge package
RIV	MODFLOW River package
RMSE	root mean square error
SMB	Soil moisture budget accounting model
Ss	Specific Storage
SSURGO	USDA Soil Survey Geographic Database

STR	MODFLOW Stream Package
SVBGSA	Salinas Valley Basin Groundwater Sustainability Agency
SVIHM	Salinas Valley Integrated Hydrologic Model
SWI	Seawater Intrusion
Sy	Specific Yield
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VIC	Variable Infiltration Capacity
WEL	MODFLOW Well Package
WY	Water Year

1. MODEL DEVELOPMENT OVERVIEW

The Monterey Subbasin Groundwater Flow Model (MBGWFM or "model") is an approximation of the spatial extent and variability of the Monterey Subbasin (Basin) and can be used to quantitatively evaluate local hydrogeologic conditions associated with water inflows, outflows, and associated connectivity between the adjacent Seaside Subbasin, 180/400-Foot Aquifer Subbasin, and the Pacific Ocean. The purpose of the MBGWFM is to quantify the historical, current, and projected water budgets for the Basin and their uncertainties, and to evaluate the impacts of future land use, hydrologic, and water supply/demand projections as well as any proposed management decisions on groundwater conditions within the Basin. The model can also help identify gaps in available data and deficiencies in the conceptual understanding of groundwater conditions in the Basin. These results help prioritize plans for future data collection and other Groundwater Sustainability Plan (GSP) implementation activities.

2. METHODOLOGY AND APPROACH

2.1 Model Source Code

The MBGWFM utilizes the United States Geological Survey (USGS) computer code MODFLOW-NWT (Niswonger et al., 2011); MODFLOW is a widely used model code and is publicly available and supported by the USGS. MODFLOW-NWT is a Newton formulation of MODFLOW-2005 which excels at solving models whose cells have active drying and rewetting in the unconfined groundwater flow equation (Niswonger et al., 2011). As the Basin has variable degrees of confinement depending on aquifer formation and location, MODFLOW-NWT is an appropriate and effective computer code to solve the groundwater flow equation.

MODFLOW-NWT's utility is enhanced by additional software processes for model development, processing, and analysis of results. Specifically, ZONEBUDGET version 3 (Harbaugh, 1990) is a post-processor used to extract water budget results for user-defined model subareas.

As discussed in more detail below in *Section 3.1*, a soil moisture balance code was developed and used to represent the root zone processes and ultimately create the recharge datasets within the MBGWFM.

2.2 Discretization

When employing numerical models, the spatial domain is discretized into "model cells" and time is discretized into "stress periods". The discretization of the spatial domain is the spatial approach and the discretization of time is referred to as the temporal approach. Both approaches are further discussed below.

2.2.1 Spatial Approach

MODFLOW represents the groundwater system as a set of discrete, rectangular blocks (cells) forming a grid in space. MODFLOW then computes an approximate solution to the groundwater flow mathematical equations at each model cell. The model grid consists of 260 rows and 214 columns of cells that cover the entire extent of the California Department of Water Resources (DWR) Basin boundary (DWR No. 3-004.01) as well as areas on the periphery of the boundary (**Figure 1**). The rectangular cells have a variable dimension of 200 feet (ft) up to 675 ft on a side, with the most resolved (200 x 200 ft) grid cells located in the Marina-Ord area where the majority of groundwater extraction and monitoring occurs within the Basin. The coordinates of the lower left corner of the grid are 5,740,227 E., 2,169,843 N. (CA State Plane Zone 4, NAD83, Feet). The grid is rotated 240 degrees counterclockwise so that the rows align approximately with the 180/400-Foot Aquifer Subbasin boundary to the north and the Seaside Subbasin boundary to the south, consistent with the alignment of the Seaside Basin Groundwater Model (*Hydrometrics 2009 & 2019,* see *Section 2.4.2.2*).

The rectangular model grid has been further segmented into an active area (i.e., where groundwater flow is explicitly simulated) and an inactive area (where cells are assigned no-flow boundary conditions). The active area covers the entirety of the Basin as well as the small portion of the 180/400-Foot Aquifer Subbasin south of the Salinas River. The northern boundary of the active grid is the Salinas River, the western boundary is the Pacific Ocean, the southern boundary is the Seaside Subbasin boundary, and the eastern boundary is the Basin edge (i.e., where aquifer sediments come in contact with impermeable bedrock outcrops). Transient groundwater conditions along each of the active model boundaries are represented using unique boundary conditions as further described in *Section 2.4*. The number and location of active cells varies by model layer based on previously mapped aquifer extents as further described in *Section 2.2.3*.

2.2.2 Temporal Approach

2.2.2.1 Historical Simulation

The historical simulation is discretized temporally into 240 monthly stress periods, representing a 20-year simulation period from DWR Water Year (WY) 1999 (i.e., October 1998) through WY 2018 (i.e., September 2018). All 20 years of the historical simulation period were used for model calibration as further described in *Section 4*.

GSPs are required to "*provide a quantitative assessment of the historical water budget, starting with the most recently available data and extending back a minimum of 10 years, or as is sufficient to calibrate and reduce the uncertainty of the tools and methods used to estimate and future water budget information and future aquifer response to proposed sustainable groundwater management practices over the planning and implementation horizon*" (23-California Code of Regulations [CCR] §354.18(b)(2)). The historical water budget accounting period is WY 2004 – 2018, which allows for a five-year pre-conditioning period (i.e., WY 1999 – 2003) to minimize the influence of uncertainty in the specified initial conditions.

2.2.2.2 Projected Simulations

Projected water budgets are required "*to estimate future baseline conditions of supply, demand, and aquifer response to Plan implementation*" (23-CCR §354.18(b)(3)). The projected water budget "*must use 50 years of historical precipitation, evapotranspiration (ET), and streamflow information as the basis for evaluating future conditions under baseline and climate-modified scenarios"* (23-CCR §354.18(e)(2)(A)).

Several projected scenarios were developed from the historical model to evaluate aquifer response to future climate, land use, and water supply and demand conditions (See GSP *Section 6.5 Projected Water Budget* for further details). To develop the required 50 years-worth of hydrologic input information, first an "analog period" was created from 20 years-worth of historical information (WY 1999-2018) by combining the years in a specific way that, on average, maintained the long-term average hydrologic conditions. This approach allowed for the creation of a complete 50-year period to inform the projected water budget analysis, even when certain component datasets were not available for that length of time. The sequence of actual years that were combined to create the 50-year analog period is as follows:

Analog Years 1-20:	Based on actual years 1999-2018
Analog Years 21-40:	Based on actual years 1999-2018
Analog Years: 41-50:	Based on actual years 1999-2008

The above mapping of actual years to analog years within the required 50-year projected water budget period applies to precipitation and ET datasets.

The projected simulations are discretized temporally into 600 monthly stress periods, representing a simulated analog period from WY 2019 (i.e., October 2018) through WY 2068 (i.e., September 2068). This 50-year simulation was used to develop projected water budget estimates and to evaluate the benefits of proposed projects and management actions over the 50-year planning and implementation period following GSP submittal.

2.2.3 Vertical Geometry

The model is discretized vertically into eight layers as described below:

- **Layer 1** represents Dune Sand Aquifer;
- **Layer 2** represents the Fort Ord/Salinas Valley Aquitard;
- **Layer 3** represents the Upper 180-Foot Aquifer;
- **Layer 4** represents the 180-Foot Aquitard;
- **Layer 5** represents the Lower 180-Foot Aquifer;
- **Layer 6** represents the 180/400-Foot Aquitard;
- **Layer 7** represents the 400-Foot Aquifer; and
- **Layer 8** represents the Deep Aquifer / El Toro Primary Aquifer[1]

Each layer of the MBGWFM represents a unique Principal Aquifer or Aquitard unit defined in the GSP and is consistent with previous hydrogeologic conceptualizations of the Basin. A more detailed description of the hydrogeology, geometry, and current groundwater conditions of each Principal Aquifer and Aquitard unit within the Basin is provided in *Sections 4 and 5* of the GSP. A summary table of the geologic-hydrogeologic relationships of each Principal Aquifer and Aquitard unit is provided in **Table 1** below:

---

[1] The El Toro Primary Aquifer is defined as the only Principal Aquifer unit within the Corral de Tierra Management Area and is generally consistent in hydrogeology to the lower 400-Foot and Deep Aquifers within the Main Basin. See GSP *Section 4.2.2.* for further details.

Table 1. Generalized Geologic – Hydrogeologic Relationships

Period/Epoch	Geological Unit	Principal Aquifers and Aquitards
Holocene	Recent Dune Sand (Qd) Older Dune Sand (Qod)	**Dune Sand Aquifer**
Pleistocene	Old Alluvium / Valley Fill Deposits (Qo/Qvf)	Fort Ord-Salinas Valley Aquitard
		180-Foot Aquifer (1)
	Aromas Sand (Qae)	180/400-Foot Aquitard
		400-Foot Aquifer
	Paso Robles Formation (QT)	400-Foot/Deep Aquitard
Pliocene	Purisima Formation (Ppu)	**Deep Aquifers**
	Santa Margarita Formation (Msm)	
Miocene	Monterey Formation (Mmd)	N/A (Minimally Water-Bearing)

Notes:

(1) The 180-Foot Aquifer is separated into "upper" and "lower" zones, separated by a thin clay layer known as the "180-Foot Aquitard". Data collected within the former Fort Ord show that significant head differences exist between the upper and lower zones of the 180-Foot Aquifer.

As described in detail in GSP *Sections 4 and 5*, Principal Aquifer units within the Basin have varied extent, thickness, and degrees of confinement. As part of GSP development, a three-dimensional (3D) hydrostratigraphy model of the Basin was prepared using the Leapfrog Geo[2] geologic modeling software program to provide for a more accurate representation of Principal Aquifer and Aquitard geometries and to facilitate MBGWFM grid development. The Leapfrog hydrostratigraphy model of the Basin was originally developed as part of two Airborne Electromagenetic (AEM) geophysical surveys conducted by Marina Coast Water District (MCWD) in 2017 and 2019 (*Stanford/Aqua Geo Frameworks, 2017; Aqua Geo Frameworks, 2019*) to help characterize seawater intrusion within the Basin. The Leapfrog hydrostratigraphy model was revisited and modified by EKI in 2020 to incorporate additional lithologic and hydrostratigraphy data from various well and borehole logs and well as several cross-sections previously developed for the Basin (*Harding ESE, 2001; GeoSyntec, 2007; GeoSyntec, 2010*). The updated Leapfrog hydrostratigraphy model was used as the basis to inform the spatial extents, elevations, and thicknesses of each layer within the MBGWFM. **Figure 2** shows a representative cross-section of the

---

[2] https://www.seequent.com/products-solutions/leapfrog-geo/

Marina-Ord area of the Basin derived from the Leapfrog hydrostratigraphy model and corresponding MBGWFM layers.

One limitation of the Leapfrog hydrostratigraphy model is that it does not extend into the southern portion of the Corral de Tierra Management Area on the southeastern side of the Basin. Within the southern Corral de Tierra area, aquifers have historically been described by their geologic names, such as the Aromas Sand, Paso Robles Formation, and Santa Margarita Sandstone (*Geosyntec, 2007; Yates 2005*). Based on best available information, these geologic formations are grouped together to form the "El Toro Primary Aquifer System" for the Corral de Tierra Area as described in further detail in GSP *Section 4*. These geologic formations also comprise the lower portions of the 400-Foot Aquifer and the Deep Aquifers in the northern Salinas Valley including the Marina-Ord Area. As such, the El Toro Primary Aquifer was represented using model Layer 8, which is the only active model layer within the Corral de Tierra Management Area (see **Figure 3**).

Another limitation of the Leapfrog hydrostratigraphy model is that it does not effectively map the bottom of the Basin, which is defined as the top of the Monterey Formation (see GSP *Section 4*). As such, the bottom of MBGWFM Layer 8 (Deep Aquifer / El Toro Primary Aquifer) was delineated in the MBGWFM using a raster surface of Top of Monterey Formation Elevations previously developed by the Seaside Basin Watermaster (see GSP *Figure 4-3*).

Figure 3 shows the active extents of each layer within the MBGWFM and the uppermost active Principal Aquifer units encountered across the model domain. **Figure 4** and **Figure 5** show the top elevations of each model layer, while **Figure 6** and **Figure 7** show the layer thicknesses. These figures demonstrate that the MBGWFM reasonably represents the geometry and extent of each Principal Aquifer unit defined within the Basin as described in detail in *Section 4* of the GSP.

As described in *Section 5* of the GSP, each Principal Aquifer unit may experience varied degrees of confinement depending on location within the Basin, presence of overlying aquitard units, and current groundwater level conditions. As such, each layer was assigned a "convertible" layer type (LAYTYP > 0) in the Upstream Weighting Package (UPW) of the MODFLOW-NWT program to allow for continued transition between confined and unconfined conditions throughout the model simulation depending on transient groundwater head conditions. Similarly, as mentioned in *Section 2.1,* the Newton formulation version of MODFLOW-2005 (MODFLOW-NWT) was employed for the MBGWFM because it allows for rewetting of cells (as opposed to inactivating them) in the event the water table drops below the bottom elevation of a given cell at any point during the transient simulation.

Finally, there are areas of the Basin where certain aquifer or aquitard units pinch out to zero thickness and terminate, resulting in direct connectivity between non-sequential aquifer units. An example of this is the Fort Ord/Salinas Valley Aquitard (Layer 2), which only exists in a portion of the Marina-Ord Area. Where the aquitard is not present, the Dune Sand Aquifer (Layer 1) is in direct contact with the Upper 180-Foot Aquifer (Layer 3). Pinch-out geometries are challenging to accurately represent in MODFLOW-NWT because cells with zero thickness and inactivated cells will act as no-flow boundaries and prevent vertical hydraulic connection between overlying and underlying model layers. A minimum cell thickness of five feet was applied to model cells in these pinch-out areas to allow for continued hydraulic connectivity between non-sequential model layers. As described further in *Section 2.5,* these cells were assigned the same aquifer parameters as the nearest overlying active model layer such that they essentially act as "flow-through" cells allowing unhindered groundwater flow between non-sequential model layers. The location of these "flow-through" cells are shown by layer on **Figure 6** and **Figure 7.**

2.3 Initial Conditions

2.3.1 Historical Simulation

The availability and density of historical groundwater elevation data varies substantially throughout the Basin. While the Monterey County Water Resources Association (MCWRA) maintains a database of water level records throughout the entire Salinas Valley Groundwater Basin, available records before WY 1999 were generally limited to the Marina-Ord Management Area of the Basin. As such, initial heads in the MBGWFM were derived from Fall 1998 water level data wherever available and supplemented with historical water level contour maps previously created for the Corral de Tierra Management Area to provide for complete coverage of the Basin.

Fall 1998[3] water levels were compiled from MCRWA records for 362 wells within the Basin and in the surrounding Seaside and 180/400-Foot Aquifer Subbasins and used to create preliminary surfaces (i.e., rasters) of initial heads for the MBGWFM historical simulation. Initial head rasters were created in Surfer using the Kriging interpolation method, whereby a Gaussian model variogram was fitted to the water level datasets and applied to create rasters of Fall 1998 water levels for each Principal Aquifer unit.

As mentioned previously, initial heads in the Corral de Tierra Management Area were also informed by contoured water level maps previously created by Geosyntec Consultants as part of the El Toro Groundwater Study (*Geosyntec, 2007*). Specifically, a contour map of January 2001 groundwater elevations (Figure 4-5 of *Geosyntec, 2007*) was digitized and loaded into Surfer, and subsequently used to refine and extend the initial head rasters so that they covered the entirety of the Basin.

Groundwater elevations were subsequently extracted from the initial head rasters at every active grid cell for each aquifer layer of the MBGWFM (i.e., layers 1, 3, 5, 7, and 8) to populate the initial head arrays in the Basic (BAS) package of MODFLOW-NWT. Initial heads were assigned to the aquitard layers (i.e., layers 2, 4, and 6) using water level surfaces from the overlying aquifer unit where applicable.

2.3.1 Projected Simulations

Initial heads for all projected simulations in the MBGWFM were defined using the final head outputs from the historical simulation (i.e., simulated heads from September 30, 2018).

2.4 Boundary Conditions

Boundary conditions represent flow constraints in the model domain. Three types of boundary conditions are specified in the MBGWFM: 1) no-flow boundary, 2) general-head boundary, and 3) river boundary. Each of these boundary conditions are discussed in greater detail below. A schematic summarizing all boundary conditions employed in the model is presented in **Figure 8**.

2.4.1 No-Flow Boundary

A no-flow boundary is employed wherever groundwater flow is assumed to be zero within a cell, effectively removing it from the groundwater flow simulation. No-flow boundaries are commonly used to represent contacts with impermeable (non-water bearing) formations or to inactivate a portion of the

---

[3] Seasonal average water levels were calculated for each well, where Fall includes measurements from August 15th to November 15th and Spring includes measurements from January 15th to April 15th.

model grid that is outside the study area. The following areas are represented as no-flow boundaries within the MBGWFM:

- The eastern Basin boundary, where aquifer sediments of the El Toro Primary Aquifer (Layer 8) come in contact with impermeable bedrock outcrops;
- The model bottom, which coincides with the top of the Monterey Formation (i.e. bedrock); and
- The western Basin boundary within the Deep Aquifer (Layer 8), as it is assumed the Deep Aquifer is not hydraulically connected to the Pacific Ocean (see *Section 2.4.2.3*).

All other cells outside the active model area are also assigned as no-flow cells such that they are excluded from the MODFLOW simulation.

2.4.2 General-Head Boundary

The general-head boundary (GHB) is a head-dependent flow boundary, and the flow across this boundary is proportional to the difference between the model-calculated head at the boundary and a specified head located a certain distance from the boundary. The proportionality constant used to calculate the flow is the conductance, which is calculated from the hydraulic conductivity of the boundary cell, the area of the face of the boundary cell, and the distance from the boundary cell to the specified head location.

As described in more detail in GSP *Sections 4 and* 5, the northern, southern, and western boundaries of the Basin are hydraulically connected to aquifer units of the 180/400-Foot Aquifer Subbasin, Seaside Subbasin, and the Pacific Ocean, respectively. As such, the northern, southern, and western boundaries of the active model domain are represented by GHBs[4].

The general process for developing GHBs in the MBGWFM was to: (1) identify GHB cells for each active model layer, (2) gather specified head data from nearby locations to the GHB cells outside the active model domain, (3) calculate distances and associate GHB cells with their nearest specified head location, and (4) assign specified heads and conductance properties to each GHB cell[5]. The methods and datasets used to develop GHBs at each boundary are further described below.

2.4.2.1 *Northern Boundary (Salinas River / 180-400-Foot Aquifer Subbasin)*

As mentioned in *Section 2.2.1,* the active model area extends north of the Basin boundary up to the Salinas River, thus including a small portion of the 180/400-Foot Aquifer Subbasin. While the Salinas River is explicitly simulated in MBGWFM layers 1 and 2 (see *Section 2.4.3*), the northern boundary in underlying layers (i.e., layers 3-8) is represented by GHBs in the model to simulate groundwater exchanges between the Monterey Subbasin the neighboring 180/400-Foot Aquifer Subbasin.

2.4.2.1.1 Historical Simulation

Transient specified heads were assigned to northern boundary GHB cells using historical groundwater elevation monitoring data provided by MCWRA. Groundwater elevation measurements from the historical simulation period (i.e., October 1999 – September 2018) were compiled from all monitoring

---

[4] Two exceptions to this are: (1) the northern boundary of Layers 1 and 2, where the Salinas River is directly simulated using a River boundary (see *Section 2.4.3*), and (2) the western boundary of Layer 8, which is represented as a no-flow boundary because is assumed the Deep Aquifer is not hydraulically connected to the Pacific Ocean.

[5] GHB conductance parameters were adjusted during calibration as described in *Section 4.3*.

wells to the immediate north of the Salinas River and examined for quality. A subset of these wells were ultimately selected as "representative" monitoring wells to assign transient specified heads at GHB cells along the northern boundary for model layers 3–8. The selection of representative wells to use for GHB parameterization was informed by the availability, frequency, and quality of historical monitoring data as well as the location and distribution of wells along the northern boundary.

The final network of representative monitoring wells includes seven wells in the Upper 180-Foot Aquifer (Layer 3), 12 wells in the Lower 180/400-Foot Aquifer (Layers 5 and 7)[6], and three wells in the Deep Aquifer (Layer 8). Each active GHB cell in model layers 3–8 was associated to the nearest representative well[7] and the distance between the GHB cell and its associated representative well was calculated to inform the GHB conductance term. GHB cells along the northern model boundary and their associated representative monitoring wells are shown for each model layer in **Figure 9.**

Historical groundwater elevation data from each representative monitoring well was post-processed to create a continuous monthly timeseries of specified heads to assign to its associated GHB cells. Where multiple records existed for a well within a given month, an average groundwater elevation was calculated for that month. Where data was unavailable at a well for a particular month, the monthly water level was either estimated via (Pearson) correlation[8] to nearby monitoring wells with data for that month or, when no well-correlated data was available, via linear interpolation between measurements at the well. The final (post-processed) monthly water level datasets from each representative monitoring well were subsequently used to assign transient specified heads at all associated GHB cells throughout the historical model simulation period.

2.4.2.1.2 Projected Simulations

The same approach described above was used to set up the northern boundary GHB in the projected simulations, except now the specified heads were informed by groundwater elevation Sustainability Criteria defined in the 180/400-Foot Aquifer Subbasin GSP ("180/400 GSP", *SVBGSA, 2020)* as opposed to historical monitoring data. Specifically, the "representative" monitoring well network used to inform historical specified heads at nearby GHB cells was updated to include all SGMA monitoring network wells located immediately north of the Salinas River in the 180/400-Foot Aquifer Subbasin. In many cases, these SGMA monitoring wells were the same representative wells employed in the historical simulation.

The final network of SGMA monitoring wells used for projected simulations includes seven wells in the Upper 180-Foot Aquifer (Layer 3), 10 wells in the Lower 180/400-Foot Aquifer (Layers 5 and 7), and three wells in the Deep Aquifer (Layer 8). Each active GHB cell in model layers 3–8 was reassociated to the nearest SGMA monitoring well[9] and the distance between the GHB cell and its associated SGMA well was

---

[6] MCWRA water level records classify wells in a grouped "Lower 180/400-Foot Aquifer" system, and thus specified heads from these wells were assigned to both Layer 5 and Layer 7 of the MBGWFM.

[7] Specified heads were assigned to GHB cells in aquitard units (i.e., model layers 4 and 6) using water level data from representative wells in the overlying aquifer unit (i.e., model layers 3 and 5, respectively).

[8] A linear regression (Pearson) correlation matrix was developed for all representative wells within a Principal Aquifer unit to identify "well-correlated" wells for use in data-gap filling. A correlation coefficient (R) threshold of R ≥ 0.8 was used to determine if wells were well-correlated and thus suitable for use in estimating missing water level data. The final linear regression equations used to estimate missing water level records were derived from the nearby well with the highest R value (where R ≥ 0.8) to the representative well in question.

[9] *Ibid [6].*

calculated to inform the GHB conductance term. GHB cells along the northern model boundary and their associated SGMA monitoring wells are shown for each model layer in **Figure 10.**

Depending on the projected scenario, GHB cells were then assigned specified heads based on one of the following three ranges in future groundwater level conditions that could be encountered at the 180/400-Foot Aquifer Subbasin while maintaining SGMA compliance:

- **"Minimum Threshold" (MT)** water levels (as defined in the 180/400 GSP)
- **"Measurable Objective" (MO)** water levels (as defined in the 180/400 GSP)
- **"Seawater Intrusion (SWI) Protective"** water levels (see *Section 2.4.2.3* for further details).

For all projected scenarios, initial specified heads at the GHB cells were informed by final head outputs from the historical simulation (i.e., simulated heads from September 30, 2018)[10]. Specified heads were then adjusted using a 20-year "ramp up" period to reach the projected water level conditions described above. For the "MT" and "SWI Protective" water level scenarios, the ramp up period was applied linearly over 20 years. For the "MO" water level scenario, the ramp up period was informed by five-year interim milestones defined at each SGMA monitoring well in the 180/400 GSP. All projected water levels at the GHB cells were then held constant for the remaining 30 years of the projected simulations, under the assumption that these water levels would be maintained in perpetuity after the 20-year SGMA implementation deadline.

2.4.2.2 Southern Boundary (Seaside Subbasin)

As mentioned in *Section 2.2.1,* the southern boundary of the active model area is aligned with the Seaside Subbasin boundary. This boundary was represented as a GHB in the MBGWFM to simulate groundwater exchanges between the Monterey Subbasin the neighboring Seaside Subbasin.

2.4.2.2.1 Historical Simulation

Transient specified heads were assigned for southern boundary GHB cells in the MBGWFM historical simulation using head outputs from the Seaside Basin Groundwater Model ("Seaside Model") (*Hydrometrics, 2009 & 2019*). The Seaside Model simulates groundwater flow within the Seaside Subbasin from January 1987 – January 2018 and extends partially into the Monterey Subbasin. A copy of the Seaside Model was provided to EKI by the Seaside Basin Watermaster in early 2020 to facilitate direct incorporation of simulated head outputs from the Seaside Model along the Basin boundary into the MBGWFM.

EKI extracted simulated head outputs from the Seaside Model at a series of 20 regularly spaced "proxy" monitoring locations distributed along the south side of the Seaside boundary. Each active GHB cell along the Seaside boundary in the MBGWFM was subsequently associated to its nearest proxy monitoring location, and transient specified heads were assigned to the GHB cells using the monthly simulated head

---

[10] Review of historical groundwater level data indicates that September water levels represent a reasonable annual average condition (i.e., between seasonal high and low conditions) within the 180/400-Foot Aquifer subbasin and are thus appropriate to use as a starting point for developing projected heads at the northern GHB boundary.

outputs from the Seaside Model at their respective proxy monitoring locations[11]. GHB cells along the Seaside boundary and their associated proxy monitoring locations are shown in **Figure 11.**

While employing the Seaside Model to develop Seaside boundary GHBs in the MBGWFM provides for a common set of assumptions regarding historical heads along the boundary, there are notable differences in hydrogeologic conceptualization and geometry between the two models that will result in imperfect matching of head conditions and unique estimates of cross-boundary flows. Notably, the Seaside Model defines aquifer units differently than the MBGWFM and includes a different number of layers. The Seaside Model is comprised of five layers that represent the following aquifer units (*Hydrometrics, 2009*):

- Layer 1 represents the Older Dune deposits and Aromas Red Sands
- Layer 2 represents the upper Paso Robles Aquifer
- Layer 3 represents the "brown sand layer" of the lower Paso Robles Aquifer
- Layer 4 represents the "semi-continuous blue clays" encountered at the base of the Paso Robles Aquifer
- Layer 5 represents the Santa Margarita/Purisima Aquifer

As demonstrated in **Table 1** (see *Section 2.2.3*), these aquifer units are generally defined based on the geologic formations encountered in the region and are only loosely tied to the Principal Aquifer Units defined in the Monterey Subbasin. For example, Older Dune deposits and Aromas Red Sands deposits (Seaside Model layer 1) have been further stratified into the Dune Sand Aquifer (Layer 1), Upper 180-Foot Aquifer (Layer 3), Lower 180-Foot Aquifer (Layer 5), and 400-Foot Aquifer (Layer 7) in the MBGWFM. Previous hydrogeologic investigations (see *GSP Section 4*) indicate that the 400-Foot Aquifer is likely comprised of both Aromas Sands (Seaside Model layer 1) as well as upper portions of the Paso Robles formation (Seaside Model layer 2) depending on location within the Monterey Subbasin. Similarly, the Deep Aquifer (Layer 8) of MBGWFM represents the combined lower Paso Robles (Seaside Model layers 3-4) and Santa/Margarita Purisima (Seaside Model layer 5) formations.

Given the imperfect match in conceptualization and layering between the two models, a few simplifying assumptions were needed to effectively link head outputs from the Seaside model to GHB cells along with southern boundary of the MBGWFM. Ultimately, the selection of which Seaside Model layers should be associated to GHB cells in the MBGWFM was informed by: (1) a comparison of Seaside Model head outputs along the boundary with recent (i.e., Spring and Fall 2017) contour maps developed by EKI for each Principal Aquifer Unit in the Monterey Subbasin; and (2) an iterative evaluation of water budget and simulated head outputs from MBGWFM to ensure cross-boundary flow estimates generally agreed with Seaside Model outputs, both in magnitude and in spatial trends. The final mapping of MBGWFM GHB cells to their corresponding Seaside Model layers is presented in **Table 2** below:

---

[11] As the Seaside Model historical simulation period ends in January 2018, simulated head outputs were estimated in the MBGWFM for Feb. 2018 – Sept. 2018 using Seaside Model head outputs for Feb. 2017 – Sept. 2017.

Table 2. Mapping of Seaside Model Layers to MBGWFM GHB Cells at the Seaside Boundary

MBGWFM GHB Layer	MBGWFM Principal Aquifer Unit	Seaside Model Layer	Seaside Model Aquifer Unit
1	Dune Sand Aquifer	1	Older Dune deposits and Aromas Red Sands
3	Upper 180-Foot Aquifer	1	Older Dune deposits and Aromas Red Sands
5	Lower 180-Foot Aquifer	1	Older Dune deposits and Aromas Red Sands
7	400-Foot Aquifer	2	Upper Paso Robles Aquifer
8	Deep Aquifer / El Toro Primary Aquifer	3 (Proxy Points 1-9)	Lower Paso Robles Aquifer
		4 (Proxy Point 10)(1)	Paso Robles Base (Blue Clays)
		5 (Proxy Points 11-20)(2)	Santa Margarita / Purisima Aquifer

Notes:

(1) Seaside Model layer 3 becomes dry moving east of proxy point 9 along the boundary, and thus the uppermost active unit is layer 4.

(2) Seaside Model layer 4 is either dry or constrained by dry cells and shows erroneously high-water levels (i.e., >200 feet above ground surface) moving east of proxy point 10. Thus, the only reliable layer to use east of proxy point 10 becomes layer 5.

Annual net cross-boundary flow estimates from the Seaside Model and the calibrated MBGWFM over the historical water budget period[12] are compared on **Figure 12.** Over like timeframes, the Seaside Model estimates an average net inflow from the Seaside Subbasin to the Monterey Subbasin of +935 acre-feet per year (AFY) while the MBGWFM estimates an average net inflow of +918 AFY. These results indicate that the calibrated MBGWFM reasonably recreates historical groundwater level conditions simulated by Seaside Model along the boundary and that resulting water budget estimates of cross-boundary flows between the two models are in very close agreement at the Basin-level.

2.4.2.2.2 Projected Simulations

Unlike the 180/400-Foot Aquifer Subbasin, the Seaside Subbasin is an adjudicated groundwater basin and is not subject to SGMA. As such, no Sustainability Criteria have been defined for groundwater elevations within the Seaside Subbasin, as the basin is managed to a groundwater budget as opposed to groundwater conditions. For the projected simulations, a simplifying assumption was made that the Seaside Subbasin would be able to maintain Fall 2017 water levels over the long term, thus

---

[12] WY 2018 is excluded from the comparison as the Seaside Model only simulates historical groundwater conditions through January 2018

managing to a balanced water budget (i.e., no long-term depletion of groundwater storage). As such, September 2017 water level outputs from the Seaside Model were used to define specified heads along the southern GHB boundary for all MBGWFM projected simulations throughout the entire 50-year simulation period.

One exception to the assumption described above is along the southeastern edge of the Seaside-Monterey boundary (i.e., near Laguna Seca). In this area, simulated Fall 2017 water levels from the Seaside Model were already below the Minimum Thresholds (MTs) defined for wells in the Corral de Tierra Management Area on the Monterey Subbasin side of the boundary (i.e., 170 feet above mean sea level [ft msl], see GSP *Sections 7 and 8*). Per the request of the Salinas Valley Basin Groundwater Sustainability Agency (SVBGSA), projected specified heads were adjusted to 170 ft msl in the MBGWFM for all GHB cells in the Laguna Seca area whose simulated water levels were below 170 ft msl in the Seaside Model as of September 2017. This adjustment was ultimately made to all GHB cells associated with “proxy” monitoring points 14 and 15 along the Seaside boundary (see **Figure 11**).

It is recognized that there is considerable uncertainty regarding future groundwater conditions within the Seaside Subbasin (particularly within the Laguna Seca area) and that groundwater management decisions in the Monterey Subbasin are likely to impact groundwater conditions within the Seaside Subbasin, and vice-a-versa. Various studies and projects have been proposed (see *GSP Section 9*) or are already being implemented by water management entities in both subbasins to better characterize and model local groundwater conditions and cross-boundary flows in the Laguna Seca area and across the entire Monterey-Seaside boundary. As more data and information is developed in the coming years, the MBGWFM will be revised and updated accordingly as part of the next five-year update to the GSP.

2.4.2.3 Western Boundary (Pacific Ocean)

As mentioned in *Section 2.2.1,* the western boundary of the active model area is aligned with the Pacific Ocean. This boundary was represented as a GHB in the MBGWFM to simulate exchanges between the Basin and the ocean and to inform estimates of potential seawater intrusion rates into the Basin.

The current version of the MBGWFM does not directly simulate variable-density groundwater flow and transport. Instead, the Pacific Ocean boundary is represented as a GHB using freshwater equivalent sea levels calculated at the aquifer-seafloor interface for each Principal Aquifer unit assumed to be in hydraulic connection with the ocean.

Freshwater equivalent sea levels are calculated based on the *Ghyben-Herzberg Relation*, which states that for every foot of freshwater above sea level there is approximately 40 feet of freshwater below sea level (*Barlow, 2003*):

$$h_{fw} = \frac{\rho}{\rho_f} h - \frac{\rho - \rho_f}{\rho_f} Z$$

where h_{fw} = freshwater equivalent head, h = sea level, ρ = saline water density, ρ_f = freshwater density, and Z = depth of freshwater below sea level.

Previous hydrogeologic investigations along the Monterey coastline indicate that the Recent and Older Dune Deposits, Aromas Red Sands, and Paso Robles Formations are at least partially in contact with the seafloor at varying distances offshore from the Basin, while the deeper Santa Margarita and Purisima Formations may be hydraulically restricted from the sea floor by the Monterey Bay Fault Zone (*Feeney, 2003).* More recent investigations of seawater intrusion conditions within the Basin (*Aqua Geo Frameworks, 2019,* see GSP *Section 5*) also indicate that the Deep Aquifer is not currently seawater intruded along the Monterey coastline. As such, GHB cells were assigned along the Pacific Ocean boundary for all layers in the MBGWFM apart from layer 8 (i.e., the Deep Aquifer), which was modeled as a no-flow boundary at the Monterey coastline.

2.4.2.3.1 Historical Simulation

For the historical simulation, freshwater equivalent sea levels were calculated for each model layer using the *Ghyben-Herzberg Relation* described above at a sea level elevation of **0** ft msl and a saline water density of **1.025** grams per cubic centimeter (g/cm^3). Average depths below sea level at which each Principal Aquifer unit are assumed to contact the seafloor were estimated using a previously developed geologic cross-section of the Monterey Bay coastal aquifer system (see Figure 5 of *Feeney, 2003*). Corresponding offshore distances to the assumed point of contact with the seafloor were then calculated at each GHB cell using a bathymetry map of seafloor elevations and used to inform conductance term at each cell. **Table 3** below presents a summary of freshwater heads assigned to each model layer for the historical simulation.

Table 3. Freshwater Equivalent Sea Levels – Historical Simulation

MBGWFM GHB Layer	Corresponding Geologic Formation from *Feeney, 2003*	Average Offshore Distance to Seafloor Contact (ft)	Average Depth Below Sea Level (ft msl)	Calculated Freshwater Equivalent Head (ft msl)
1 – 6	Recent / Older Dune Deposits	9,000	-155	**3.8**
7	Aromas Red Sands / Paso Robles	26,800	-335	**8.4**

Calculated freshwater heads were held constant in Pacific Ocean GHB cells throughout the historical simulation under the assumption that the sea level did not change significantly between WY 1999 – 2018.

2.4.2.3.2 Projected Simulations

As further described in *Section 3.1*, three climate change scenarios were modeled in the MBGWFM projected simulations. Each of these scenarios employed unique assumptions regarding future sea level rise that were derived from the 180/400 GSP (*SVBGSA, 2020*). These included:

- **Baseline Conditions** – assumes no change in sea level (0 ft msl)
- **2030 Climate Change –** assumes a "moderate" increase in sea levels of 15 cm (+ 0.492 ft msl)
- **2070 Climate Change** – assumes a "severe" increase in sea levels of 45 cm (+ 1.475 ft msl)

Freshwater equivalent ocean heads were recalculated under each projected scenario using the same assumptions about offshore contact depths and distances employed in the historical simulation (see **Table 3** above). **Table 4** below presents a summary of freshwater heads assigned to Pacific Ocean GHB cells for each model layer under the various projected scenarios.

Table 4. Freshwater Equivalent Sea Levels – Projected Simulations

MBGWFM GHB Layer	"Baseline" Freshwater Equivalent Head (ft msl)	"2030 Climate Change" Freshwater Equivalent Head (ft msl)	"2070 Climate Change" Freshwater Equivalent Head (ft msl)
1 – 6	3.8	4.3	5.4
7	8.4	8.9	9.9

Calculated freshwater heads were held constant in Pacific Ocean GHB cells throughout each of the 50-year projected simulations.

As described in *Section 2.4.2.1.2*, projected simulations along the northern GHB boundary included a "Seawater Intrusion (SWI) Protective" water level scenario to estimate potential cross-boundary flows assuming the 180/400-Foot Aquifer Subbasin is able to maintain freshwater equivalent sea levels along the entire length of the 180/400-Monterey boundary. For this scenario, GHB cells along the northern boundary were assigned specified heads using the freshwater equivalent sea levels calculated under each climate scenario shown in **Table 4**. Consistent with the MT and MO scenarios, GHB cells along the northern boundary were allowed a 20-year "ramp up" period starting from their Fall 2018 heads to reach these SWI Protective water levels and were then held constant for the remaining 30 years of the projected simulation period.

2.4.3 River Boundary

The Salinas River was explicitly simulated in model layers 1 and 2 at the MBGWFM northern boundary using MODFLOW's River (RIV) package[13] (**Figure 9**). The RIV package is used to simulate head-dependent flux boundaries between a river and the underlying groundwater system.

RIV cells were identified in the MBGWFM using a shapefile of the Salinas River obtained from the National Hydrography Dataset (NHD). River segment lengths were calculated at each model cell from the NHD shapefile, and land surface elevations were estimated using a 30-meter USGS National Elevation Dataset (NED) raster. Streambed widths were assigned to each RIV cell using data obtained from the North Marina Groundwater Model (NMGWM) (*Hydrofocus, 2017)*. A streambed thickness of **5 feet** was assigned to each RIV cell consistent with the NMGWM and the Salinas Valley Integrated Ground and Surface Water Model

---

[13] A small number of RIV cells were also assigned to model layer 7 at the northeastern Basin boundary, where layer 7 is the uppermost active model unit (**Figure 9**).

(SVIGSM)[14] (MCWRA & *LSCE, 2006*), and river bottom elevations were calculated as the land surface elevation minus the streambed thickness. Riverbed conductance values were initially assigned to each RIV cell using parameters obtained from the NMGWM and were subsequently adjusted during model calibration (see *Section 0*).

2.4.3.1 Historical Simulation

For the historical simulation, river stages were assigned to each RIV cell using historical streamflow monitoring data obtained from the USGS Spreckels Gauge (Site No. 11152500)[15]. The Spreckels Gauge is conveniently located in the active MBGWFM domain at model cell [40,85] and thus serves as a reasonable proxy for estimating Salinas River stages along the length of the northern model boundary.

The Spreckels Gauge provides monthly discharge rates within the river and a series of field measurements that contain both stage and flow data at the monitoring station. These field measurements were used to develop a streamflow rating curve for the site, which was subsequently applied to estimate river stages at the Spreckels Gauge location from monthly discharge data for October 1998 – September 2018 (**Figure 13).** River stage elevations were subsequently assigned to each RIV cell upstream and downstream of the Spreckels Gauge location using differences in land surface elevations as an adjustment factor.

2.4.3.2 Projected Simulations

At the time of MBGWFM construction, no information was readily available to assign projected Salinas River flow conditions under future baseline or climate change conditions. As such, a simplifying assumption was made that Salinas River stages would mimic historical trends depending on water year type. Transient RIV stages were therefore estimated for all projected scenarios using historical stages calculated for the 50-year "analog" hydrologic period described in *Section 2.2.2.2*, where:

- Analog Years 1-20: Based on actual years 1999-2018
- Analog Years 21-40: Based on actual years 1999-2018
- Analog Years: 41-50: Based on actual years 1999-2008

2.5 Aquifer Properties

Aquifer properties were initialized in the MBGWFM using available pumping test data and relevant information from prior hydrogeological studies and were subsequently refined during model calibration (see *Section 4.3*). A summary of the initial model parameterization process for hydraulic conductivity and storage properties is provided below.

2.5.1 Hydraulic Conductivity

In alluvial aquifers, the spatial distribution of hydraulic conductivity is influenced by the distribution of sediment texture (i.e., the fraction of coarse-grained sand and gravel relative to the fraction of fine-grained silt and clay), the size and shape of the pores between the sediment grains, and the effectiveness of the interconnections between those pores. To better represent the spatial distribution in hydraulic

---

[14] The SVIGSM was recently updated to the Salinas Valley Integrated Hydrologic Model (SVIHM) by the USGS, with preliminary outputs released to the public in mid-2021. The SVIHM was not available for use at the time of MBGWFM construction.

[15] https://waterdata.usgs.gov/nwis/uv?site_no=11152500

conductivities within each Principal Aquifer unit, texture maps were constructed for each aquifer layer of the MBGWFM (i.e., layers 1, 3, 5, 7, and 8) based on lithologic descriptions from **332** boreholes distributed throughout the model domain[16]. The final texture maps assigned to each layer are shown on **Figure 14 through Figure 18**.

The texture maps are based on the lithologic descriptions from borehole logs. The borehore logs vary in depth and may be used to assign texture classifications to multiple layers. Layer 1 utilized 145 borehole logs, layer 3 utilized 212 borehole logs, layer 5 utilized 65 borehole logs, layer 7 utilized 178 borehole logs, and layer 8 utilized 144 borehole logs. The logs were coded on a 1-ft interval as either coarse-grained or fine-grained material, using a rubric consistent with the USGS' Central Valley Hydrologic Model (CVHM; *Faunt et al., 2009*). For each borehole, the average fraction of coarse-grained sediment was calculated over the total thickness of each model layer. Resultant values were interpolated in Surfer using the Kriging interpolation method to create rasters of coarse-grained fractions for each aquifer layer and were subsequently snapped to each active model cell by layer (**Figure 14 through Figure 18**). In general, the borehole data indicate that layer 1 has the greatest fraction of coarse-grained sediment, and the sediments generally become finer with depth.

Areas and depth intervals characterized with relatively coarse-grained sediments transmit water at a higher rate than areas and depth intervals characterized by fine-grained sediments. The resulting distributions in the fraction of coarse-grained sediment was therefore utilized to specify the spatial distribution in horizontal and vertical hydraulic conductivity. The modeled horizontal hydraulic conductivity is calculated as the product of the fraction of coarse-grained sediment and specified coarse-grained horizontal hydraulic conductivity. Vertical hydraulic conductivity is typically less than horizontal hydraulic conductivity because fine-grained beds can impede the downward movement of water. The modeled vertical hydraulic conductivity is therefore calculated as the specified vertical hydraulic conductivity divided by the fraction of fine-grained sediment, where the fine-grained fraction is calculated as one minus the coarse-grained fraction.

Aquifer test results compiled from **161** pumping tests conducted throughout the Basin were used to inform initial estimates of coarse-grained horizontal hydraulic conductivities within the model.[17] The locations of pumping test wells within the Basin are shown on **Figure 19**. A summary of horizontal hydraulic conductivities estimated from pumping tests is provided in **Table 5** below.

Initial coarse-grained hydraulic conductivities were assigned to each aquifer layer using average hydraulic conductivities calculated from pumping tests for wells whose coarse-grained fractions were in the upper 50th percentile of the texture map for that layer. The final specified coarse-grained horizontal and vertical hydraulic conductivities vary by layer and were determined by calibration, as discussed below in *Section 4.3.*

---

[16] Texture maps were not created for the aquitard layers of the model (i.e., layers 2, 4, and 6) as it is assumed they are predominantly fine-grained in nature. Final hydraulic conductivities assigned to aquitard units were determined through model calibration as further discussed in *Section 4.2*.

[17] Aquifer transmissivity (T) measurements from pumping test data were converted to effective hydraulic conductivities by dividing the T value by the entire length of well screen.

Table 5. Horizontal Hydraulic Conductivity (Kh) Estimates from Pumping Tests

Principal Aquifer Unit	Horizontal Hydraulic Conductivity (Kh), [ft/d]		
	Minimum	Average	Maximum
Dune Sand Aquifer	2.7	72	750
180/400-Foot Aquifers	0.04	168	1110
Deep Aquifer	2.2	11.6	25.4

2.5.2 Storage

As mentioned above, each Principal Aquifer unit within the Basin may experience varied degrees of confinement depending on location within the Basin, presence of overlying aquitard units, and current groundwater level conditions. As such, both the specific yield (Sy) and specific storage (Ss) parameters must be specified in order to effectively simulate transient head conditions in the Basin.

Aquifer test results compiled from 40 pumping tests conducted throughout the Basin were used to inform initial estimates of specific storage (Ss) within the model[18]. The locations of pumping test wells within the Basin are shown on **Figure 19**. A summary of Ss values estimated from pumping tests is provided in **Table 6** below. Final Ss values were determined by calibration, as discussed below in *Section 4.3.*

Table 6. Specific Storage (Ss) Measurements from Pumping Tests

Principal Aquifer Unit	Specific Storage (Ss) [1/ft]		
	Minimum	Average	Maximum
Dune Sand Aquifer	1.6E-05	9.5E-04	4.8E-03
180/400-Foot Aquifers	9.9E-07	3.4E-05	2.6E-04
Deep Aquifer (1)	N/A	N/A	N/A

Notes:

(1) No Ss data is currently available from pumping tests for the Deep Aquifer.

Very little data exists to inform estimates of specific yield within individual aquifer units of the Basin. Specific yields have been estimated to range from 0.04 to 0.4 within the Dune Sand Aquifer, and a bulk specific yield of 0.12 was used for the El Toro Primary Aquifer in prior studies (*Todd, 2016*). As such, an initial specific yield (Sy) value of 0.12 was assigned to all aquifer units in the model, consistent with values reported for silty sands in the literature. Final Sy values were determined by calibration, as discussed below in *Section 4.3.*

---

[18] Confined storativity (S) measurements from pumping test data were converted to specific storage by dividing the S value by the entire length of well screen.

3. STRESSES

3.1 Recharge

Recharge is simulated using the Recharge (RCH) Package. To quantify the spatial and temporal distribution of recharge across the MBGWFM domain, a Soil Moisture Budget accounting model (SMB) was developed using *MATLAB* programming code. The SMB simulates land surface processes (e.g., precipitation, applied water, and plant evapotranspiration [ET]) and root zone processes which ultimately determine the amount of deep percolation on a grid cell basis that is specified as groundwater recharge to the uppermost active layer of the MBGWFM grid.

The SMB uses a mass-balance approach to quantify the movement of water that arrives at the land surface from either precipitation or irrigation into the subsurface or atmosphere. The processes included in the SMB code are (1) precipitation, (2) interception, (3) canopy evaporation, (4) rainfall excess runoff, (5) applied water from District deliveries, (6) applied water from private pumping (deficit pumping), (7) ET by vegetation, (8) recharge, (9) saturation excess runoff, and (10) dynamic soil moisture storage.

The SMB calculates the above processes on a grid cell basis across the entire active MBGWFM grid. Spatially variable parameters within the SMB include:

- Soil types (**Figure 20**) and properties, including soil hydrologic group (**Figure 21**), vertical hydraulic conductivity (**Figure 22**), soil depth, field capacity, wilting point, and total porosity, from the United States Department of Agriculture (USDA) Soil Survey Geographic Database (SSURGO)[19]
- Spatial land use data from the U.S. Department of Agriculture (USDA) Forest Service Region 5 Classification and Assessment with Landsat of Visible Ecological Groupings (CalVeg) dataset for Zone 5 (Central Valley)[20] and from various historical and projected land use surveys (see *Sections 3.1.1 and 3.1.2* below)
- Gridded precipitation data from the 4-kilometer *Parameter-elevation Regressions on Independent Slopes Model* (PRISM)[21] dataset (**Figure 23**)
- Reference evapotranspiration (ETo) data measured at California Irrigation Management Information System (CIMIS) Salinas North #116 and Laguna Seca #229 stations
- Water service area boundaries for the five water service areas within the Basin, including MCWD, CalAm (Ambler, Hidden Hills and Toro Units) and California Water Service (CWS) (**Figure 24**)

Additional non-transient parameters to the SMB include:

- Curve numbers for runoff for agriculture, urban, and native vegetation classifications including conifer forest/woodland, hardwood forest/woodland, mixed conifer and hardwood forest/woodland, shrub, herbaceous, and barren (*USDA, 1986*)
- Monthly crop coefficients and canopy storage properties for native, agricultural, and urban land use types from California Polytechnic State University's Irrigation Training and Research Center (*Howes et al., 2015*)

---

[19] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

[20] https://www.fs.usda.gov/detail/r5/landmanagement/resourcemanagement/?cid=stelprdb5347192

[21] https://prism.oregonstate.edu/recent/

The combination of soil type and land use type determines the Curve Number (runoff coefficient) that controls rainfall excess runoff. ET is calculated for each land use type from the crop coefficient method using daily CIMIS ETo rates and monthly crop coefficients specific to the land use type. ET is limited when soil moisture declines to the wilting point. Irrigation with private groundwater occurs for irrigated agricultural lands when the combination of precipitation, applied delivered water, and soil moisture storage is insufficient to meet vegetative water demand (ET). Private groundwater pumping rates are further adjusted to account for irrigation inefficiency[22].

The SMB calculates a running soil moisture balance for each grid cell on a daily timestep and is driven by daily spatially variable daily precipitation data from the PRISM dataset. Recharge is simulated to occur when the water content in the soil column after infiltration of precipitation, applied water, and ET uptake is greater than the field capacity of the soil. When this occurs, recharge is released from the soil column to the point where soil water content equals field capacity. Daily calculated recharge rates are summed into monthly totals for use as input to the MBGWFM.

In addition to the recharge calculated by the SMB, the MBGWFM also includes water distribution and conveyance system leakage in the RCH Package. Leakage was estimated as 5% of delivered water and was uniformly distributed across all cells within each of the five water service areas in the Basin (**Figure 24**).

A more detailed description of the transient input datasets to the SMB for the historical and projected simulations is provided below.

3.1.1 Historical Simulation

3.1.1.1 Climate

The historical SMB simulation calculates recharge rates for the period October 1, 1998 through September 30, 2018 using daily precipitation data from PRISM and daily ETo data from CIMIS as described above.

3.1.1.2 Land Use

As limited historical land use information exists within the Basin, spatial land use classifications were derived from the CalVeg dataset (10x10 meter resolution). The CalVeg land use map was further supplemented with a map of 2014 land use classes prepared by DWR to identify irrigated agricultural parcels within the Basin and their respective crop types. A single historical land use class was subsequently assigned to each active grid cell based on the dominant land use type mapped within the cell area and was assumed to remain static throughout the duration of the 20-year historical simulation. The final historical land use map is shown in **Figure 25.**

3.1.1.3 Deliveries

Monthly historical delivery records were obtained for the three water suppliers within the Basin (MCWD, CalAm, and CWS) and used to estimate historical outdoor delivery rates within each of the five water service areas in the Basin. MCWD pumping records were obtained directly from MCWD, while monthly delivery records for the each of the CalAm and CWS service areas were provided by the Seaside Basin Watermaster. As no detailed breakdown of indoor vs. outdoor deliveries was available for any of the water

---

[22] A uniform irrigation efficiency of 85% was assumed in the calculation of private groundwater pumping on agricultural lands in line with values commonly employed for high-efficiency (e.g., micro-drip) irrigation systems.

agency delivery records, a simplifying assumption was made that 25% of total deliveries within the service area would be used for outdoor consumption (i.e., irrigation) over a 6-month growing season (i.e., April through September). This assumption generally consistent with information provided in MCWD's 2020 Urban Water Management Plan (UWMP, *Schaff & Wheeler, 2021*) and assumptions used in the Seaside Model (*Hydrometrics, 2019)*. Monthly outdoor deliveries were uniformly distributed across all cells within each of the five water service areas in the Basin (**Figure 24**). As mentioned above, an additional 5% of total monthly deliveries were added to the recharge outputs from the SMB for all cells within a water service area to simulate leakage contributions to the Basin. Leakage was assumed to occur throughout the entire calendar year.

3.1.2 Projected Simulations

3.1.2.1 Climate

As mentioned in *Section 2.4.2.3.2*, three climate change scenarios were modeled in the MBGWFM projected simulations. These climate change scenarios were informed by climate change modeling completed by DWR (*DWR, 2020*) and include the following:

- **Baseline Conditions –** no climate change impacts
- **2030 Climate Change (Central Tendency) –** "moderate" climate change impacts
- **2070 Climate Change (Central Tendency) –** accounts for "severe" climate change impacts

For the Baseline scenario, projected daily precipitation and ETo datasets were developed using historical PRISM and CIMIS data for the 50-year "analog" hydrologic period described in *Section 2.2.2.2*, where:

Analog Years 1-20:	Based on actual years 1999-2018
Analog Years 21-40:	Based on actual years 1999-2018
Analog Years: 41-50:	Based on actual years 1999-2008

For the 2030 and 2070 climate change scenarios, DWR provided monthly scaling factors to account for impacts of climate change on precipitation and ET rates. Precipitation and ET climate change factors are spatially variable and mapped to a variable infiltration capacity (VIC) grid (**Figure 26**). These monthly climate change factors were extracted for VIC grid cells that intersect the Basin and used to modify the 50-year historical "analog" precipitation and ET datasets developed for the Baseline projected scenario.

On average, applying the 2030 climate change factors resulted in a -0.5% decrease in precipitation rates and a +3.1% increase in ET rates throughout the Basin relative to Baseline projected conditions, while applying the 2070 climate change factors resulted in a -2.2% decrease in precipitation rates and a 7.7% increase in ET rates throughout the Basin relative to Baseline projected conditions. Notably, the DWR climate change factors dataset appears to indicate that precipitation events within the Basin are projected to be less frequent and of significantly higher intensity as climate change impacts become more severe, with a single-month maximum change in precipitation rates of +56% under the 2030 climate scenario and +71% under the 2070 climate scenario. This could result in comparatively higher average recharge rates within the Basin relative to Baseline conditions, even though total precipitation rates are projected to remain nearly constant. On the other hand, the DWR climate change dataset appears to indicate that ET rates are projected to be marginally yet consistently higher as climate change impacts become more severe, with a single-month maximum change in ET rates of +7% under the 2030 climate scenario and +17% under the 2070 climate scenario.

3.1.2.2 Land Use

For all projected scenarios, the historical land use map was updated to reflect future planned urban development and expansion of the MCWD service area in line with future land use conditions specified in MCWD's 2020 Water Master Plan (*AKEL, 2020*). Specifically, a map of future land use (Figure 2.3 of the MCWD Master Plan) was used to adjust the urban footprint within the Marina-Ord Management Area to include all future residential, commercial, industrial, institutional, and mixed-use parcels designated for development over the next 20 years (i.e., by 2040). Land use in the remaining areas of the Basin was assumed to remain constant with current conditions, in line with the assumption of no future increases in water demands within the Corral de Tierra Management Area (see *Section 3.1.2.3*). The final future land use map is shown in **Figure 27.**

Additionally, for all projected scenarios a stormwater catchment area was delineated around the future MCWD service area boundary to track urban runoff rates in the SMB. Here, an adjustment was made to the SMB code that allowed runoff on urban lands within the future MCWD service area to be re-routed into recharge as a means of directly simulating MCWD's ongoing stormwater recharge management program (see GSP *Section 9.4.4., project M1)*. The SMB estimates that full implementation of this stormwater recharge management program could provide as much as ~1,100 AFY of additional recharge to the future MCWD service area under Baseline projected conditions. It is important to note however that this added recharge from stormwater capture is at least partially offset by reduced recharge in newly urbanized areas. The MCWD stormwater catchment area is included on the future land use map (**Figure 27**).

3.1.2.3 Deliveries

Projected MCWD deliveries were estimated within the SMB using projected total future water demands from 2020 through 2040 specified in Table 4.10 of the 2020 UWMP (*Schaff & Wheeler, 2021)*. Projected deliveries within the future MCWD service area are detailed in **Table 7** below.

Table 7. Projected MCWD Deliveries

Year	Projected Demand (AFY)
2020	3,367
2025	6,001
2030	7,802
2035	8,879
2040	9,584

Projected MCWD deliveries were scaled linearly over five-year increments up through 2040 (i.e., projected model year 2022), and were then held constant through the remainder of the 50-year projected simulation period.

Per direction from the SVBGSA, deliveries from all other water service areas within the Basin (including CalAm and CWS service areas) were assumed to remain constant at current (i.e., WY 2018) rates throughout the entire 50-year projected simulation period.

Consistent with the historical model, it was assumed that 25% of total projected deliveries would be applied for outdoor uses between April – September, while the remainder of deliveries would be used to meet potable and non-potable indoor demands. It was also assumed that 5% of total projected deliveries would be lost to leakage and thus contribute directly to recharge within each water service area of the Basin.

3.2 Pumping

Pumping is simulated in the MBGWFM using the Well (WEL) Package. Monthly pumping rates were estimated for all known municipal/public supply, agricultural, and domestic wells within the Basin based on available data provided by MCWD (for the Marina-Ord Management Area) and SVBGSA (for the Corral de Tierra Management Area). All pumping was vertically distributed based on available well construction information (i.e., screened interval depths or total well depths). When well construction information was unavailable, pumping was distributed based on aquifer classifications previously determined by MCWD or SVBGSA. A subset of wells are presumed to screen multiple Principal Aquifer units; for these wells, pumping was assigned proportionally to model layers based on the total screen intervals within each layer.

A summary of the datasets and assumptions used to develop historical and projected pumping datasets is provided below. Locations of the pumping wells specified in the model and their relative historical average monthly pumping rates are shown on **Figure 28**.

3.2.1 Historical Simulation

Historical pumping within the Marina-Ord Management Area was estimated from records provided by MCWD. Monthly historical pumping rates from October 1998 – September 2018 were provided for all nine (9) MCWD-owned production wells within the Basin that were in operation over the historical period.

Historical pumping within the Corral de Tierra Management Area was estimated from records provided by SVBGSA. Monthly historical pumping rates from October 1998 – September 2018 were estimated for 393 known public supply, agricultural, and domestic wells based on an analysis of public water system wells and information obtained from recent water demand studies within the Corral de Tierra (*Wallace Group, 2020*).

Additional historical pumping records were obtained from MCWRA for five MCWRA-owned wells north of the Basin boundary.

3.2.2 Projected Simulations

Projected pumping within the Marina-Ord Management area was estimated using projected MCWD water demands specified in the 2020 UWMP (*Schaff & Wheeler, 2021)* and outlined in **Table 7** above. Specifically, two projected pumping scenarios were estimated for MCWD:

- **"No-Projects" Scenario –** assumes 100% of future water demands will be met by groundwater pumping from the MCWD well network
- **"Projects" Scenario –** assumes a portion of future water demands will be met by recycled water or other augmented water supplies (see GSP *Sections 6.5.2 and 9.4.6*)

Under the "Projects" scenario, it is assumed that a portion of MCWD's projected water demand will be satisfied through some form of water supply augmentation. For evaluation purposes, the current projections assume that all recycled water generated by MCWD will be used to augment water supplies within its service area. This project is consistent with the Recycled Water Reuse Through Landscape Irrigation and Indirect Potable Reuse project described in GSP *Section 9.4.6* (project M3). Practically, projected MCWD pumping is reduced from the total projected demands specified in the 2020 UWMP to account for increased availability of recycled water (or other augmented water supplies) over the 20-year planning period. These augmented water supplies are currently modeled as "in-lieu" of groundwater pumping, i.e., through direct, proportional reductions in groundwater pumping from MCWD-owned wells relative to the "no project" scenario pumping demands.

A summary of the projected pumping rates within MCWD under each scenario is provided in **Table 8** below. For both scenarios, pumping was distributed within individual MCWD wells based on historical monthly and total pumping rates at each well[23]. All pumping was scaled linearly over five-year increments up through 2040 (i.e., projected model year 2022), and was then held constant through the remainder of the 50-year projected simulation period.

Table 8. Projected MCWD Pumping Rates

Year	"No Projects" Scenario Pumping (AFY)	Recycled / Augmented Water Supply Offset (AFY)	"Projects" Scenario Pumping (AFY)
2020	3,367	(0)	3,367
2025	6,001	(600)	5,401
2030	7,802	(4,571)	3,231
2035	8,879	(5,129)	3,880
2040	9,584	(5,495)	4,089

Consistent with information and projections provided by SVBGSA, projected pumping within the Corral de Tierra Management Area was assumed to remain constant at current (WY 2018) rates.

4. CALIBRATION

4.1 Calibration Approach

A primary goal of model calibration is to minimize the residual (i.e., difference) between model-calculated and observed water levels throughout the Basin. This is primarily achieved through systematic modifications to model parameters such that simulated water levels match well with observed measurements, both spatially and temporally. Additionally, it is important to observe and account for

---

[23] One exception to this is that all historical pumping contributions from MCWD Well 12 will be redistributed to Well 34 since Well 12 was recently taken offline.

water budget outputs during model calibration to ensure that groundwater inflows and outflows are within reasonable ranges based on prior available information and studies conducted within the Basin.

In total, **65** unique parameters are specified within the MBGWFM. Model parameters primarily relate to aquifer properties (i.e., hydraulic conductivity and storage) defined within each model layer and for each boundary condition (e.g., conductance terms for the RIV and GHB packages). Given the high complexity and parameterization of the model, calibration was primarily conducted using a software package for Model-Independent Parameter Estimation and Uncertainty Analysis (PEST)[24]. PEST manages the systematic changes to the model parameters, runs the model multiple times, evaluates the effect on model-calculated water levels, and attempts to minimize model error through use of an objective function. PEST calibration is guided by user input, including specifying priors, bounds, and relationships between model parameters, and can thus be systematically applied to achieve an acceptable model error while keeping the parameter space constrained within reasonable limits.

Further details regarding the model calibration process and results are provided below.

4.2 Calibration Data

Historical groundwater elevation data collected from wells located throughout the Basin were used to calibrate the model. In total, **30,354** groundwater elevation observations collected from **603** wells between October 1998 and September 2018 were used for model calibration. Calibration well locations are shown in **Figure 29**.

4.3 Aquifer Properties

As described in *Section 2.5,* preliminary estimates of aquifer properties were used as initial conditions within the MBGWFM. Through an iterative approach, the modeled water-transmitting and storage properties were calibrated by systematically adjusting the parameter values in PEST to minimize water level residuals.

The calibrated distribution of horizontal hydraulic conductivities are mapped by model layer in **Figure 30** and **Figure 31**. The calibrated distribution of vertical hydraulic conductivities are mapped by model layer in **Figure 32** and **Figure 33**. **Table 9** presents the calibrated storage parameters (including specific yield and specific storage) by model layer.

---

[24] https://pesthomepage.org/

Table 9. MBGWFM Calibrated Storage Parameters

MBGWFM Layer	Specific Yield (Sy) [-]	Specific Storage (Ss) [1/ft]
1	0.12	1.0E-05
2	0.12	1.0E-05
3	0.12	5.0E-06
4	0.12	5.0E-06
5	0.12	4.0E-06
6	0.12	1.0E-05
7	0.12	3.0E-05
8	0.12	1.0E-05

4.3.1 Evaluation of Calibrated Aquifer Properties

Horizontal hydraulic conductivities (Kh) differ substantially by model layer. Within aquifer units, Kh values are generally highest in model layers 3, 5, and 7 (the Upper 180-Foot, Lower 180-Foot, and 400-Foot Aquifer) and lowest in model layer 8 (the Deep Aquifer). Kh values in aquitard units (i.e., layers 2, 4, and 6) are almost always lower than in overlying and underlying aquifer layers. Boxplots showing a comparison of Kh values estimated from pumping tests (see *Section 2.5*) and model calibrated Kh values are shown in **Figure 34**. In nearly all cases, calibrated Kh values are within the range of values estimated from aquifer pumping tests and other previous hydrogeologic studies as presented in *Section 2.5*.

Vertical hydraulic conductivities (Kv) also differ substantially by layer. Within aquifer units, Kv values are generally highest in layers 5 and 7 (Lower 180-Foot and 400-Foot Aquifers) and lowest in layer 3 (Upper 180-foot aquifer). Kv values in aquitard units (i.e., layers 2,4, and 6) are almost always lower than in overlying and underlying aquifer layers. Kv values are always lower than their Kh counterparts for each model layer, which is indicative of the vertical anisotropy in transmissivity observed within the Basin. No field estimates are currently available to validate Kv values in the Basin, though the calibrated values are generally within the range for alluvial aquifer systems and aquitard units presented in the literature (*Freeze & Cherry, 1979*).

Specific storage (Ss) values differ by aquifer layer. Within aquifer units, Ss values are highest in model layer 7 (400-Foot Aquifer) and lowest in model layers 3 and 5 (Upper and Lower 180-Foot Aquifers). In most cases, calibrated Ss values fall are within the range of values estimated from aquifer pumping tests and other previous hydrogeologic studies as presented in *Section 2.5*. Calibrated Ss in model layer 1 (Dune Sand Aquifer) looks to be somewhat low compared to pumping test measurements, though layer 1 is almost always unconfined and thus Ss is usually not employed in head and storage change calculations within this aquifer unit.

Specific yield (Sy) values were ultimately held constant at 0.12 after final model calibration. This is within the range of estimates provided from prior hydrogeologic studies as presented in *Section 2.5*.

4.4 GHB Conductance

GHB conductance terms along each model boundary were ultimately coupled with the Kh values by model layer to provide for a continuous distribution in horizontal hydraulic conductivity along the Basin boundaries.

As discussed in *Section 2.4.2.2.1*, calibrated GHB conductance terms along the southern model boundary result in a very close match in historical estimates of Seaside Subbasin cross-boundary flows with the Seaside Model. As discussed in GSP *Section 4,* MBGWFM estimates of historical cross-boundary flows with the 180/400-Foot Aquifer Subbasin are significantly higher than analogous estimates provided in the 180/400 GSP (*SVBGSA, 2016*). This discrepancy is not surprising and well founded. Due to time constraints, historical and current water budgets presented in the 180/400 Foot Aquifer GSP were developed by aggregating data and analyses from previous reports and other available sources. No numerical modeling was completed to develop the historical or current water budget. The limitations of the historical water budget analyses included in the 180/400 Foot Aquifer GSP are well acknowledged within the GSP and additional analyses are being conducted as part of the 5-year review process.

In fact, as noted in the 180/400 Foot Aquifer GSP, the estimated inflow from the Monterey Subbasin of 3,000 AFY/year was taken from a Montgomery Watson document produced in 1997. This document generally looks at data that pre-dates the Historical Period evaluated in the Monterey GSP (1994 through 2018). It is based on a very limited data set and does not reflect conditions within these subbasins over the last 15 years. The Salinas Valley Integrated Hydrologic Model (SVIHM), which was developed by the U.S. Geological Survey (USGS) for the entire Salinas Valley Groundwater, was used to develop projected water budgets in the 180/400 Foot Aquifer GSP and water budgets for other Salinas Valley subbasins. However, as discussed in detail in Montgomery & Associates 2 April 2021 Technical Memorandum to the SVBGSA Advisory Committee (GSP Appendix 6C) "SVIHM does not accurately reflect hydrologic conditions in the Monterey Subbasin. SVIHM calibration efforts primarily focus on other portions of the Salinas Valley Groundwater Basin where there is significant agricultural groundwater use. The SVIHM was not calibrated to any groundwater level data from the Seaside Subbasin and included only one calibration location in the Monterey Subbasin. M&A believes the SVIHM is not detailed or accurate in the Monterey Subbasin." Thus, any direct comparison between cross-boundary subbasin flow estimates developed using the MBGWFM and those presented in the 180/400 Subbasin GSP or developed using SVIHM are not useful. No prior estimates of volumetric exchanges between the Monterey Subbasin and the Pacific Ocean are available for comparison.

SVBGSA is in the process of developing a dual density groundwater model for the coastal regions of the greater Salinas Valley Basin. This model will incorporate the MBGWFM and be used to further assess volumetric exchanges between the ocean and the Salinas Valley groundwater basin. It will also aid in evaluating flows across subbasin boundaries and will be used evaluate impacts of potential regional projects that have been proposed in this GSP and other GSPs to address seawater intrusion in the Salinas Valley groundwater basin.

4.5 Streambed Conductance

Streambed conductance terms were adjusted in PEST and range from 0.1 ft/d to 10 ft/d depending on reach and uppermost active underlying model layer. Model results indicate the Salinas River is largely hydraulically disconnected from the Basin due to its presence on top of the largely impermeable Fort Ord/Salinas Valley Aquitard. An exception to this trend is in the northeastern corner of the Basin within the Corral de Tierra Management Area, where the Salinas River is directly underlain by the more permeable El Toro Primary Aquifer System. Here, the Salinas River is estimated to contribute a net inflow of ~150 AFY to the Basin during the historical model period.

4.6 Recharge

Unlike with aquifer storage properties, recharge rates are difficult to quantify with precision due to the general absence of direct monitoring data to support model calibration. Recharge inputs to the MBGWFM were not explicitly included as a parameter in the PEST calibration routine, but were rather manually adjusted through systematic modifications to parameters in the SMB to ensure recharge rates were within reasonable ranges when compared to other regional models and prior studies.

On average, the calibrated SMB calculates 10,055 AFY of recharge to the Basin, or 0.33 ft/yr. This represents a normalized recharge rate of 24% of total precipitation and applied water within the Basin, which is within the range of typical recharge rates estimated for the region. Recharge rates vary significantly by year, with most recharge occurring during wet years (e.g., 0.62 ft/yr in WY 2006) and very little occurring during dry years (e.g., 0.06 ft/yr in WY 2012). Recharge rates are typically highest in undeveloped areas of the Basin and are lowest in urbanized areas with significant impervious lands.

As part of SMB calibration, recharge outputs were compared to analogous outputs from the Salinas Valley Integrated Hydrologic Model (SVIHM)[25] (**Figure 35**). The SVIHM employs the MODFLOW Farm Package to estimate recharge rates, which functions similarly to the SMB developed for the MBGWFM. Comparison between the SMB and SVIHM indicates that average Basin-wide recharge rates calculated from the SMB are +12% higher than those calculated from the SVIHM over like timeframes. However, it is important to note that data and assumptions on land use classes, applied water, and other parameters differ between the two models, and thus a direct comparison of recharge volumes may be misleading. When looking closer at normalized recharge rates, it appears that the SMB and SVIHM track very closely in most areas of the Basin. For example, the SMB calculated ~25.3% of total precipitation and applied water as contributing to recharge in the Corral de Tierra Management Area, compared to ~25.6% calculated from the SVIHM. The most significant difference between the two models is within urban areas, where the SMB calculates ~11.6% recharge of precipitation and applied water compared to ~5.8% calculated from SVIHM. Notably, the SVIHM does not appear to account for deliveries from the various water suppliers within the basin in its Urban "farm", which may in part explain the discrepancy. The SVIHM also does not account for leakage from water conveyance systems within these areas. Therefore, it appears the discrepancy in Basin-level recharge between the two models can be primarily explained by differences in input datasets and assumptions between the two models rather than fundamental differences in recharge calculation methodologies.

4.7 Calibration Results

MBGWFM calibration was assessed using statistics calculated from the differences between observed and model-calculated water levels (residuals), a map of residuals, plots of calibration results, and hydrographs of observed and calculated water levels. Final model calibration statistics are summarized by aquifer layer and for the entire model in **Table 10**.

---

[25] *Ibid [14].*

Table 10. MBGWFM Calibration Statistics

MBGWFM Layer	Water Level Count	Range in Observations (ft)	Mean Residual (ft)	Residual Standard Deviation (ft)	RMSE (ft)	Normalized RMSE (%)
1	11,941	198.4	-0.4	11.4	11.4	5.7%
3	9,032	98.7	-2.1	5.2	5.7	5.7%
5	4,785	74.6	-6.5	3.5	7.3	9.8%
7	1,836	119.9	-5.0	5.2	7.2	6.0%
8	3,210	728.4	7.1	19.6	20.8	2.9%
ALL	**30,354**	**728.4**	**-1.3**	**10.7**	**10.8**	**1.5%**

The root-mean square error (RMSE)[26] for the entire model is **10.8 ft** and the mean residual (error) is **-1.3 ft**, indicating that model-calculated water levels are underestimated by 1.3 ft on average. The normalized RMSE, expressed as a percent of the observed range in water levels, is below 10% within individual model layers and **1.5%** for the entire model. A generalized rule of thumb in model calibration is that the model is considered well-calibrated when the normalized RMSE is less than 10%. The low normalized RMSEs are therefore an indicator that the model is well-calibrated as a whole and within individual layers given the range of observed data.

A scatter plot of calculated vs. observed water levels and a histogram of residuals are shown in **Figure 36**. In a perfect calibration, the points would plot exactly along the solid 1:1 match line. Points above the line represent simulated water levels that are overestimated relative to observed data and points below the line represent simulated water levels that are underestimated relative to observed data. The scatter plot shows a fairly equal distribution of points above and below the line. The coefficient of determination (R^2) of 0.96 indicates that there is a good match between calculated and observed water levels. Residuals are the difference between calculated and observed water levels. The histogram of residuals shown on **Figure 36** shows that the residuals exhibit a normal distribution, are centered close to zero, and that most residuals are between the values of **-10 and +10 ft**. The slight bias of residuals to the negative side of zero indicates that the model-calculated water levels tend to be slightly smaller than observed water levels.

Average residuals are shown by well on **Figure 37**. Residuals are representative of site-specific errors between the modeled and observed water levels and are calculated as simulated minus observed groundwater elevations. Therefore, a positive value indicates model-calculated water levels are greater than observed water levels and a negative value indicates model-calculated water levels are less than observed water levels. Average residuals are spatially variable with no discernable spatial pattern between positive and negative residuals. In general, the greatest residuals occur within the Corral de Tierra Management Area in model layer 8, where limited historical water level data are available to inform model calibration in this area.

Hydrographs of model-calculated and observed water levels are included in ***Attachment 1.*** The locations of wells with hydrographs are shown on **Figure 29**. Hydrographs of measured and simulated water levels

---

[26] RMSE is a quantitative measure of the closeness of fit and is calculated as the square root of the average squared residuals.

generally match well for most wells within the Basin, especially within model layers 1, 3, 5, and 7. Model errors are noticeably greater at certain wells in model layer 8, where less data is available to inform aquifer properties and their spatial and vertical distribution. A more complete discussion of model limitations and suggested future refinements is provided in *Section 6* below.

5. SENSITIVITY AND UNCERTAINTY ANALYSIS

A sensitivity analysis was conducted to evaluate the effects of changing model parameters on model calibration. The analysis was conducted by changing model parameters in a systematic way and assessing the impact on the model-calculated water levels. The sensitivity analysis was conducted using PEST. PEST manages the systematic changes to the model parameters, runs the model multiple times, evaluates the effect on model-calculated water levels, and calculates the composite sensitivities for each parameter of interest.

The composite sensitivity was calculated for **65** parameters representing horizontal hydraulic conductivity, vertical hydraulic conductivity, specific storage, specific yield, general-head boundary conductance, and streambed conductance. The composite sensitivities were calculated for each layer represented by these parameters. Composite sensitivities for the 10 most sensitive parameters are shown in **Figure 38.** These 10 parameters represent 99.8% of the total composite sensitivities in the model. The composite sensitivities for the 54 parameters not shown in the figure are each less than 0.13%.

The most sensitive parameters in the MBGWFM are, by relative order: (1) the vertical hydraulic conductivity of Layer 2 (the Fort Ord/Salinas Valley Aquitard); (2) the specific storage values for all layers; and (3) the specific yield values for layer 1.

Vertical conductivity (Kv) in layer 2 appears to govern how much recharge enters the lower layers of the model versus being withheld within layer 1 (i.e., the Dune Sand Aquifer). As such, it is to be expected that Kv of layer 2 will have a substantial influence on model-calculated water levels in all layers. The final calibrated Kv of layer 2 was set at 2.0E-4 ft/d, in line with typical vertical conductivities for a clay-rich confining unit (*Freeze & Cherry, 1979)*. Additional data collection regarding seepage rates through the Salinas Valley Aquitard and interconnectivity between the Dune Sand and underlying 180-Foot Aquifer could help further constrain this parameter and thus improve model calibration.

There are very little data characterizing specific storage or specific yield values in the Basin apart from a limited number of pumping test measurements (see *Section 2.5.2*), which are in themselves quite variable. Given the uncertainty in measured values of specific storage and specific yield and the high sensitivity of these parameters, additional data collection (e.g., more pumping tests) could help constrain the range of values specified in the model.

Sensitivity analysis was performed on inputs to the SMB to determine which inputs have the largest impacts on recharge outputs. Recharge calculations in the SMB were found to be most sensitive to precipitation and ET inputs. Precipitation input to the SMB was estimated using PRISM data and ET input was estimated using crop coefficients and CIMIS reference evapotranspiration data (see *Section 3.1)*. A 10% change in precipitation input to the SMB model resulted in a 7% change in recharge. A 10% change in ET input to the SMB resulted in a 7% change in recharge. Recharge is less sensitive to other parameters and assumptions in the SMB such as soil depth, depression storage, and the ET stress function multiplier.

6. MODEL LIMITATIONS AND SUGGESTED FUTURE REFINEMENTS

Numerical models are mathematical representations of physical systems. They have limitations in their ability to represent physical systems exactly and due to limitations in the data inputs used. There is also inherent uncertainty in groundwater flow modeling itself, since mathematical (or numerical) models can only approximate physical systems and have limitations in how they compute data. However, DWR recognizes that although models are not exact representations of physical systems because mathematical depictions are imperfect, they are powerful tools that can provide useful insights (*DWR, 2018*).

The MBGWFM was developed using established scientific practices and principals for groundwater flow simulation and calibrated using the best available data within the Basin. Inputs to the models are carefully selected using best available data, the model's calculations represent established science for groundwater flow, and the model calibration error is within acceptable bounds. Therefore, the models are the best available tools for estimating water budgets and simulating projected groundwater conditions. As demonstrated by the calibration error statistics summarized in *Section 4.7* the MBGWFM reasonably represents historical groundwater conditions within the Subbasin using a set of parameters that are within real-world observations and established scientific principles.

As is the case with any numerical groundwater flow model, the MBGWFM is subject to uncertainties and data gaps in hydrogeologic conceptualization (e.g., depth and extent of principal aquifer units), model parameterization (e.g., aquifer transmitting and storage properties) and calibration data (i.e., historical water level monitoring data), and simulated stresses (e.g., recharge, pumping, and boundary conditions). Here, "uncertainty" refers to the incomplete understanding of the physical setting, characteristics, and current conditions that significantly affect calculation of the water budgets presented above. "Data gaps" refer to limitations in the spatial coverage of measured data, or periods of time when no data are available. Each of these main categories of uncertainty and/or data gaps contribute to overall uncertainty in the water budget outputs from MBGWFM.

A summary of the main limitations of the model and corresponding water budgets identified from this analysis is provided below.

- **<u>Uncertainty in Simulated Boundary Conditions.</u>** As described in *Section 2.4.2*, inter-basin cross-boundary flows were simulated at the 180/400 Foot Aquifer Subbasin boundary based on historical groundwater elevation measurements from nearby wells, at the Seaside Subbasin boundary based on outputs from the historical Seaside Basin Groundwater Flow Model (*Hydrometrics 2009 & 2018*), and at the Monterey Coast based on freshwater equivalent sea levels. The datasets and assumptions used to model boundary conditions at each Subbasin boundary are subject to their own uncertainties, data gaps, and limitations, including:
    - *Lack of Deep Aquifer wells with historical data in the 180/400 Foot Aquifer Subbasin.* As described in *Section 2.4.2.1*, only a small number of wells exist in the Deep Aquifers within the 180/400 Foot Aquifer Subbasin with observed water level data spanning the full duration of the Historical Period. As such, simulated Deep Aquifers heads along the northern model boundary are subject to the limitations in available data to the north of the boundary, which may impact resulting calculations of 180/400 Foot Aquifer Subbasin exchanges within the water budget.
    - *Incomplete conceptualization of Principal Aquifer units in the Seaside Basin Groundwater Flow Model.* As described in *Section 2.4.2.2*, The Seaside model does not explicitly

simulate groundwater flow from each Principal Aquifer unit defined in the Monterey Subbasin GSP, but rather uses a unique conceptualization of aquifer units that is primarily based on the main geologic formations encountered in the Seaside Area Subbasin (i.e., the Aromas Sands, Paso Robles Formation, and Santa Margarita/Purisima Formations). As such, there is considerable uncertainty surrounding the assumptions employed to link outputs from the Seaside model to individual layers of the MBGWFM, which may impact resulting calculations of Seaside Area Subbasin exchanges within the water budget.

  - *Uncertainty in freshwater equivalent head calculations at the Monterey Coast.* As discussed in *Section 2.4.2.3*, freshwater equivalent sea levels at the Monterey Coastline are calculated based on the Ghyben-Herzberg Relation. The depths and distances at which principal aquifer units outcrop along the seafloor were estimated to inform corresponding freshwater equivalent heads at the aquifer-seafloor interface. There is considerable uncertainty surrounding the depths and distances at which each principal aquifer unit comes in contact with the sea floor, which may impact resulting calculations of Ocean exchanges within the water budget.

- **Uncertainty in Pumping Estimates within the Corral de Tierra (CDT) Management Area.** Very limited historical groundwater pumping data are available for the CDT Management Area. As such, CDT groundwater pumping demands were estimated for small water systems and domestic wells by SVBGSA using extraction reported to MCWRA and SWRCB where available, and approximated based on number of households to account for small water systems connections and *de minimis* pumpers. Therefore, the accuracy of CDT groundwater pumping estimates included in the water budget is limited by the lack of available pumping data and uncertainty in the CDT pumping estimates provided by SVBGSA.

- **Uncertainty in Deep Aquifers Representation.** Groundwater elevation data collected from the Deep Aquifers and the El Toro Primary Aquifer System (both represented by model layer 8) show heterogeneous conditions in the upper and lower portions of these aquifers. As discussed in GSP *Section 5*, a vertical gradient exists between the Paso Robles and Santa Margarita formations of the El Toro Primary Aquifer System. In addition, heterogeneous groundwater elevations were observed in the shallow and deep screens of Deep Aquifer well clusters as shown in GSP Figure 5-14. However, currently there is not enough spatial coverage of data to characterize the upper and lower portions of these aquifers as separate aquifers. Refining representation of the Deep Aquifers and the El Toro Primary Aquifer System will facilitate connectivity between the MBGWFM and the Seaside Subbasin Model, and therefore refine calculation of inter-basin flows. Additional data is needed within both (a) the Monterey Subbasin to characterize and calibrate upper and lower portions of these aquifers and (b) the adjacent subbasins to establish boundary conditions.

- **Lack of Water Level Calibration Data.** Though the MCWD service area, former Fort Ord Site, and CWS/Cal-Am water service areas within CDT are well monitored, very limited historical groundwater elevation data exists in other portions of the Basin including near the Reservation Road area, in the Fort Ord Hills, and within the Deep Aquifer unit. As such, MBGWFM calibration in these areas is limited by the lack of available calibration data to quantify model error and inform localized adjustments to model parameterization.

- **Climate Change Uncertainty.** As described in *Section 3.1.2.1*, climate change scenarios were developed based on DWR's 2030 and 2070 Central Tendency climate modeling scenarios (DWR, 2020). These climate scenarios provide a standard framework for defining what might be considered the most likely future climate conditions within the Basin; however, they are inherently subject to considerable uncertainty. As stated in DWR (2018):

  - *"Although it is not possible to predict future hydrology and water use with certainty, the models, data, and tools provided [by DWR] are considered current best available* science *and, when used appropriately should provide GSAs with a reasonable* point *of reference for future planning.*

  - *All models have limitations in their interpretation of the physical system and the types of data inputs used and outputs generated, as well as the interpretation of outputs. The climate models used to generate the climate and hydrologic data for use in water budget development were recommended by [the DWR Climate Change Technical Advisory Group] for their applicability to California water resources planning."*

- **Uncertainty in Aquifer Parameters.** As described in *Section 5*, a sensitivity analysis was performed to identify the most sensitive aquifer parameters that will impact model-calculated water levels and was subsequently used to direct further calibration efforts. In general, it was discovered that the model was most sensitive to specific storage parameters in each principal aquifer unit as well as the vertical hydraulic conductivity in the Fort Ord/Salinas Valley Aquitard. These aquifer parameters were further calibrated using a combination of PEST calibration procedures and professional judgement. As described in *Section 4*, all final calibrated aquifer parameters fall within their respective ranges reported in available pumping test data collected from wells within the Basin.

7. REFERENCES

AKEL Engineering Group, 2020. Marina Coast Water District Water Master Plan, dated May 2020.

Aqua Geo Frameworks, 2019. Final Report Entitled 2019 Airborne Electromagnetic Survey of Selected Areas Within the Marina Coast Water District, dated 11 December 2019.

Barlow, 2003. Ground Water in Freshwater-Saltwater Environments of the Atlantic Coast, U.S. Geological Survey Circular 1262.

DWR, 2018. Guidance Document for the Sustainable Management of Groundwater – Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development, dated July 2018.

DWR, 2020. DWR climate change datasets, available online at https://data.cnra.ca.gov/dataset/sgma-climate-change-resources.

Faunt CC, Hanson RT, Belitz K, 2009. *Groundwater Availability of the Central Valley Aquifer, California. Chapter A Introduction, Overview of Hydrogeology, and Textural Model of California's Central Valley*: U.S. Geological Survey Professional Paper 1766.

Feeney, 2003. Deep Aquifer Investigation—Hydrogeologic Data Inventory, Review, Interpretation and Implications, dated 31 March 2003.

Freeze, R.A. & Cherry, J.A., 1979. *Groundwater*. Englewood Cliffs, N.J. Prentice Hall. Print.

Geosyntec Consultants, 2007. El Toro Groundwater Study, dated July 2007.

Geosyntec, 2010. Geologic Map and Cross-Sections from El Toro to Salinas Valley, dated June 2010.

Harding ESE, 2001. Hydrogeologic Investigation of the Salinas Valley Basin in the Vicinity of Fort Ord and Marina, Salinas Valley, California, dated 12 April 2001.

Howes, D.J, Fox, P., & Hutton, P. H., 2015. Evapotranspiration from Natural Vegetation in the Central Valley of California: Monthly Grass Reference-Based Vegetation Coefficients and the Dual Crop Coefficient Approach. *J. Hydrologic Engineering,* Vol. 20 Issue 10, dated 20 January 2015. https://doi.org/10.1061/(ASCE)HE.1943-5584.0001162

Hydrofocus, 2017. Draft North Marina Groundwater Model Review, Revision, and Implementation for Future Slant Well Pumping Scenarios, dated January 2017

HydroMetrics, 2009. Seaside Groundwater Basin Modeling and Protective Groundwater Elevations, dated November 2009.

HydroMetrics, 2019. 2018 Seaside Groundwater Model Update, dated January 2019.

MCWRA; LSCE, 2006. Monterey County Groundwater Management Plan, dated May 2006.

Niswonger RG, Panday S, and Ibaraki M, 2011. MODFLOW-NWT, A Newton formulation for MODFLOW-2005: U.S. Geological Survey Techniques and Methods 6–A37, 44 p.

PRISM, 2019. Descriptions of PRISM Spatial Climate Datasets for the Conterminous United States. Last revised October 2019.

Schaaf & Wheeler, 2021. Marina Coast Water District 2020 Urban Water Management Plan, dated May 2021.

Stanford/Aqua Geo Frameworks, 2018. Interpretation of Hydrostratigraphy and Water Quality from AEM Data Collected in the Northern Salinas Valley, CA, dated 15 March 2018.

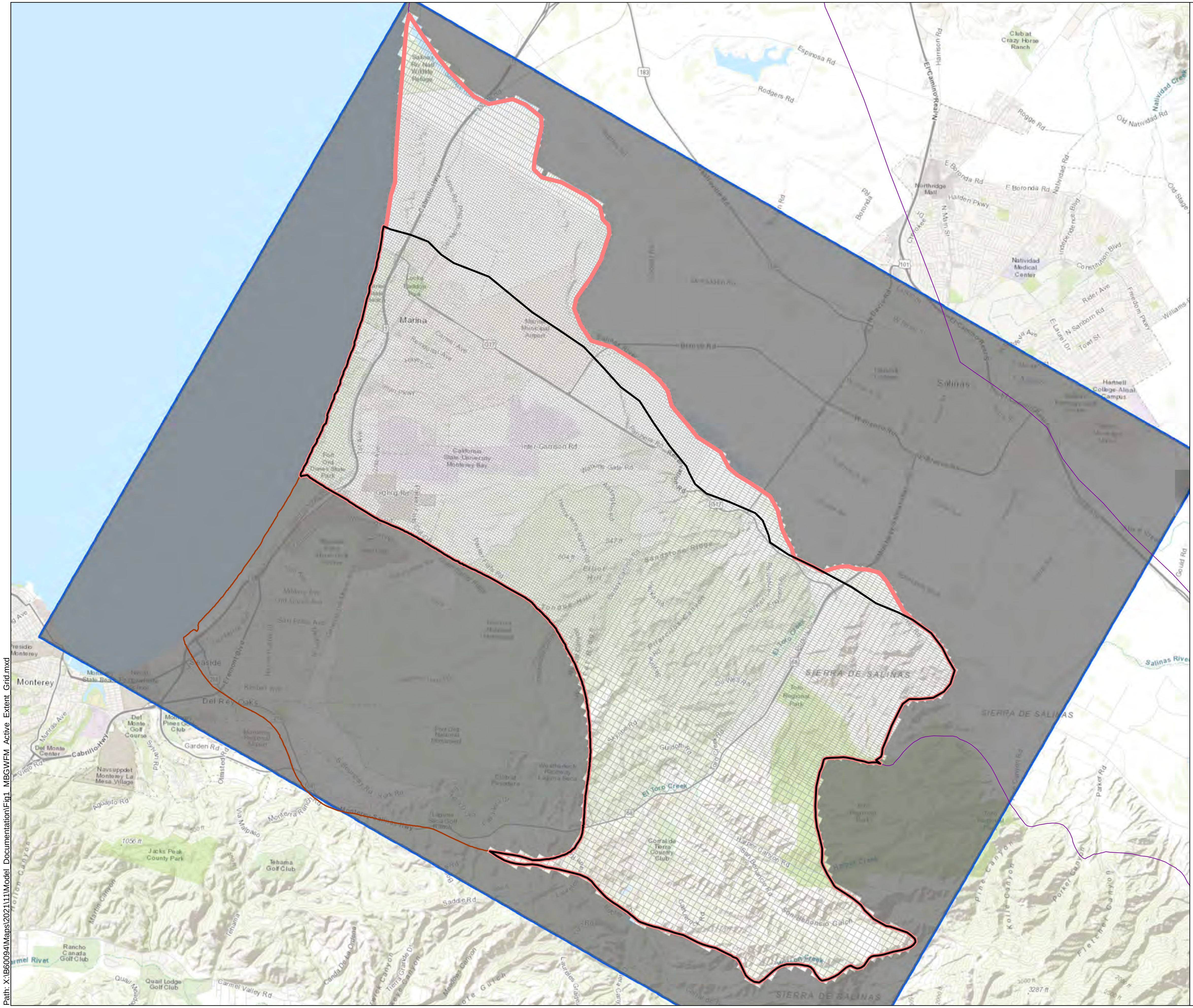
SVBGSA, 2020. Salinas Valley Groundwater Basin 180/400-Foot Aquifer Subbasin Groundwater Sustainability Plan, adopted 9 January 2020.

Todd, 2016. Final Engineering Report, Pure Water Monterey Groundwater Replenishment Project. Table 9-1.

USDA, 1986. Urban Hydrology for Small Watersheds. *TR-55*, dated June 1986.

Wallace Group, 2020. Corral de Tierra Subarea Water and Wastewater Usage Analysis, dated 30 October 2020.

Yates, 2005. Seaside Groundwater Basin: Update on Water Resource Conditions, dated 14 April 2005.



Legend

▭ Monterey Subbasin

▭ 180/400-Foot Aquifer Subbasin

▭ Seaside Subbasin

▭ Grid Extent

▭ MBGWFM Active Area

MBGWFM Grid

□ Active Cells

■ Inactive Cells

Abbreviations

DWR = California Department of Water Resources

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

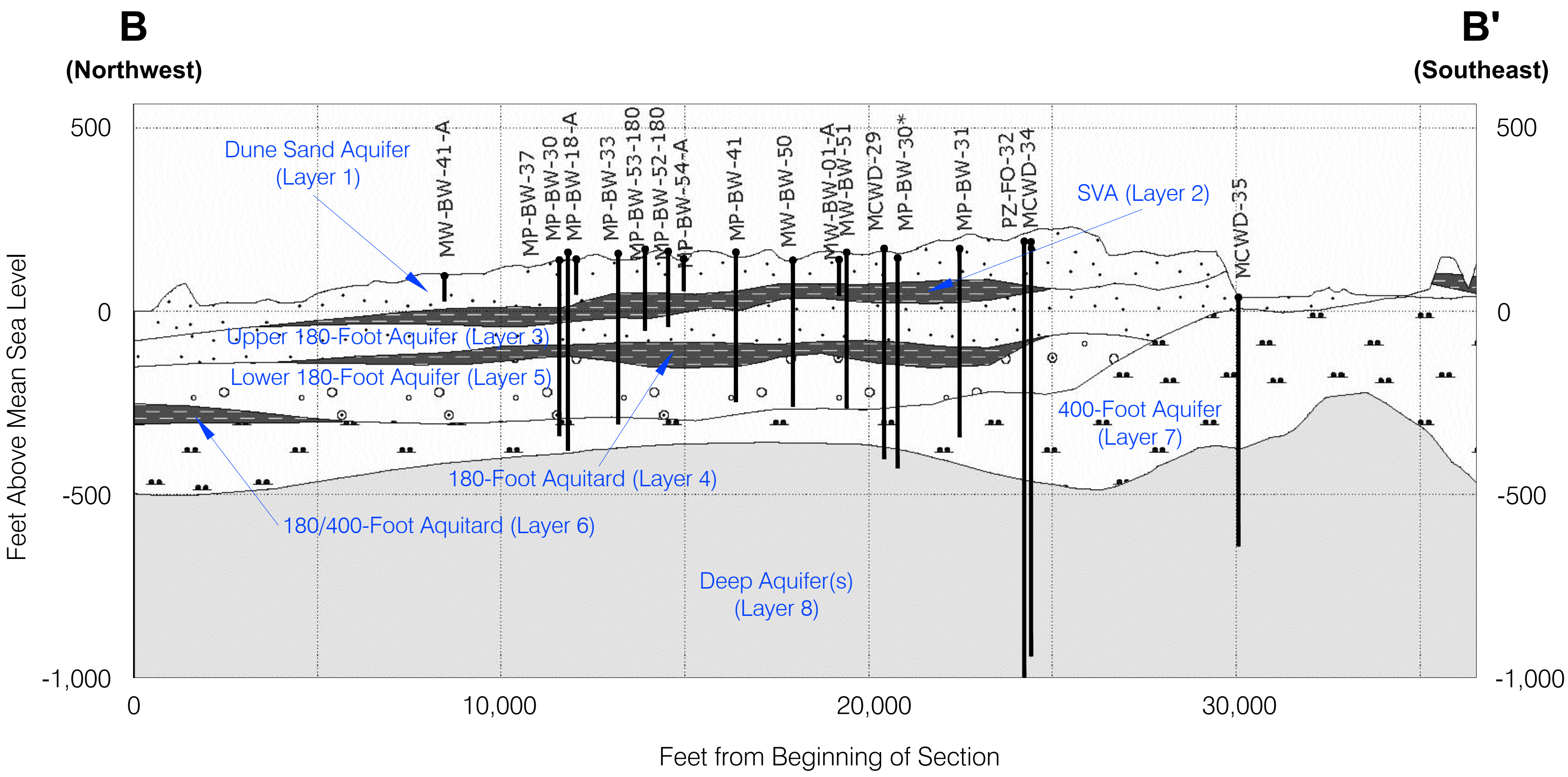
eki environment & water

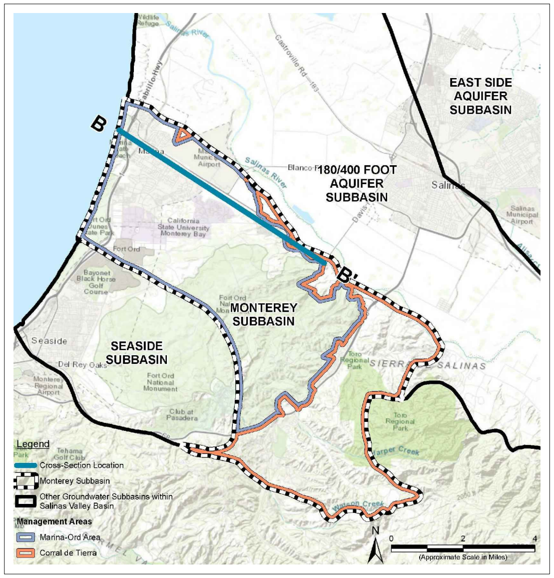
MBGWFM Active Extent and Grid

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 1

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig1_MBGWFM_Active_Extent_Grid.mxd





Key Map

Legend:

Hydrostratigraphy Model

☐ Aquifers

▨ Aquitards

☐ Deep Aquitard / Deep Aquifer(s)

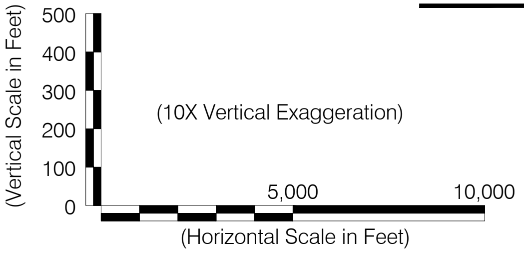
Borehole

Abbreviations:

AEM	= airborne electromagnetic
mg/L	= milligrams per liter
SVA	= Salinas Valley Aquitard

Notes:

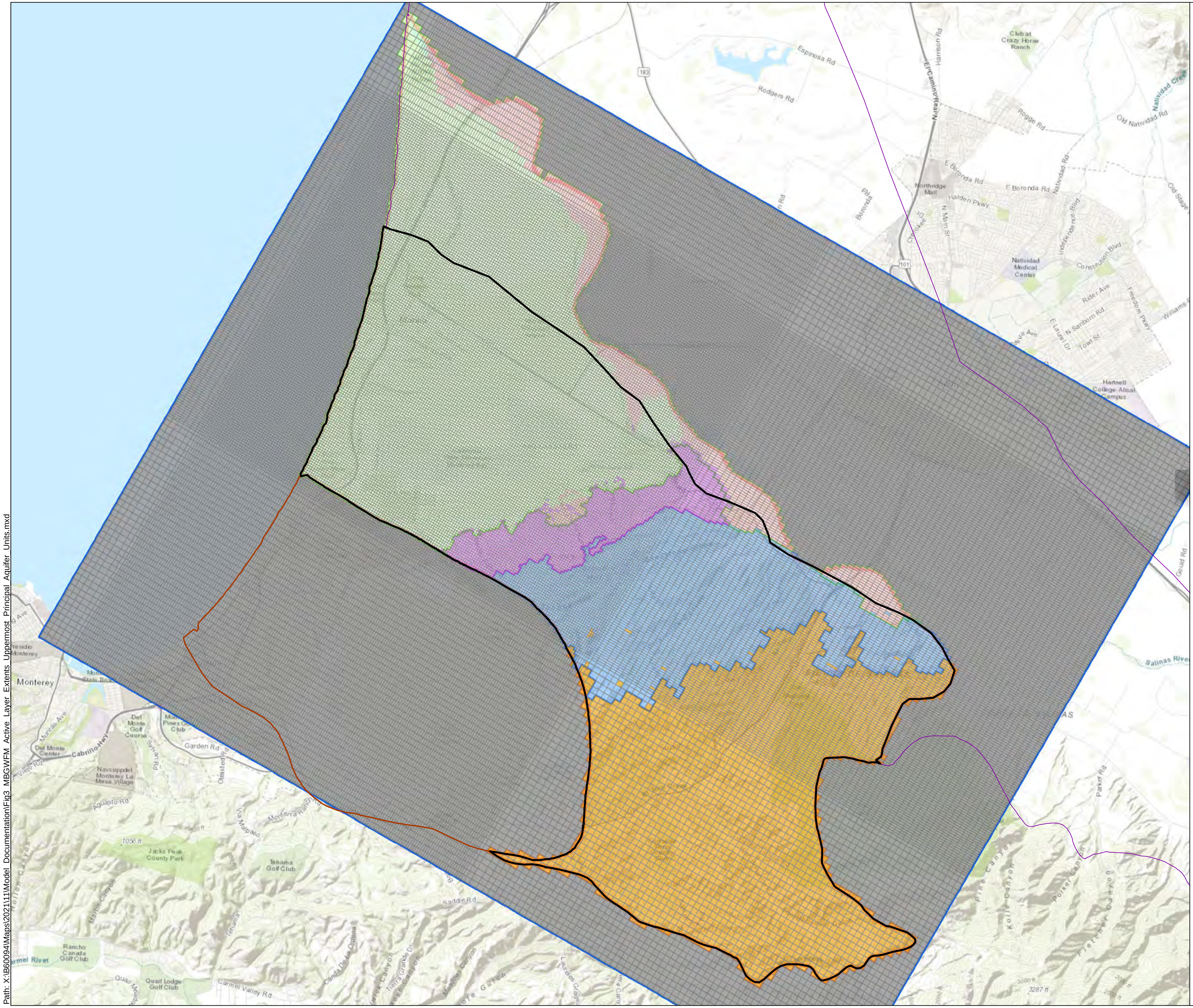
1. All locations are approximate.
2. The hydrostratigraphy model is Model A obtained from Stanford/Aqua Geo Frameworks (2018), developed based on cross-sections from previously published reports, borehole lithology logs, and 2017 AEM survey data. The hydrostratigraphy model is approximate.



Leapfrog Cross-Section and MBGWFM Layering within the Marina-Ord Management Area

Monterey Subbasin
Groundwater Sustainability Plan
November 2021

Figure 2



Legend

▭ Monterey Subbasin

▭ Seaside Subbasin

▭ 180/400-Foot Aquifer Subbasin

Uppermost Active Unit

🟩 Layer 1

🟥 Layer 2

🟪 Layer 3

🟥 Layer 6

🟦 Layer 7

🟧 Layer 8

⬜ Inactive

MBGWFM Grid

⬜ Active Cells

⬛ Inactive Cells

▭ Grid Extent

▭ Layers 1-2 Extent

▭ Layers 3-6 Extent

▭ Layer 7 Extent

▭ Layer 8 Extent

▭ MBGWFM Active Area

Abbreviations
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N
0 1 2
(Scale in Miles)

MBGWFM Active Layer Extents and Uppermost Principal Aquifer Units

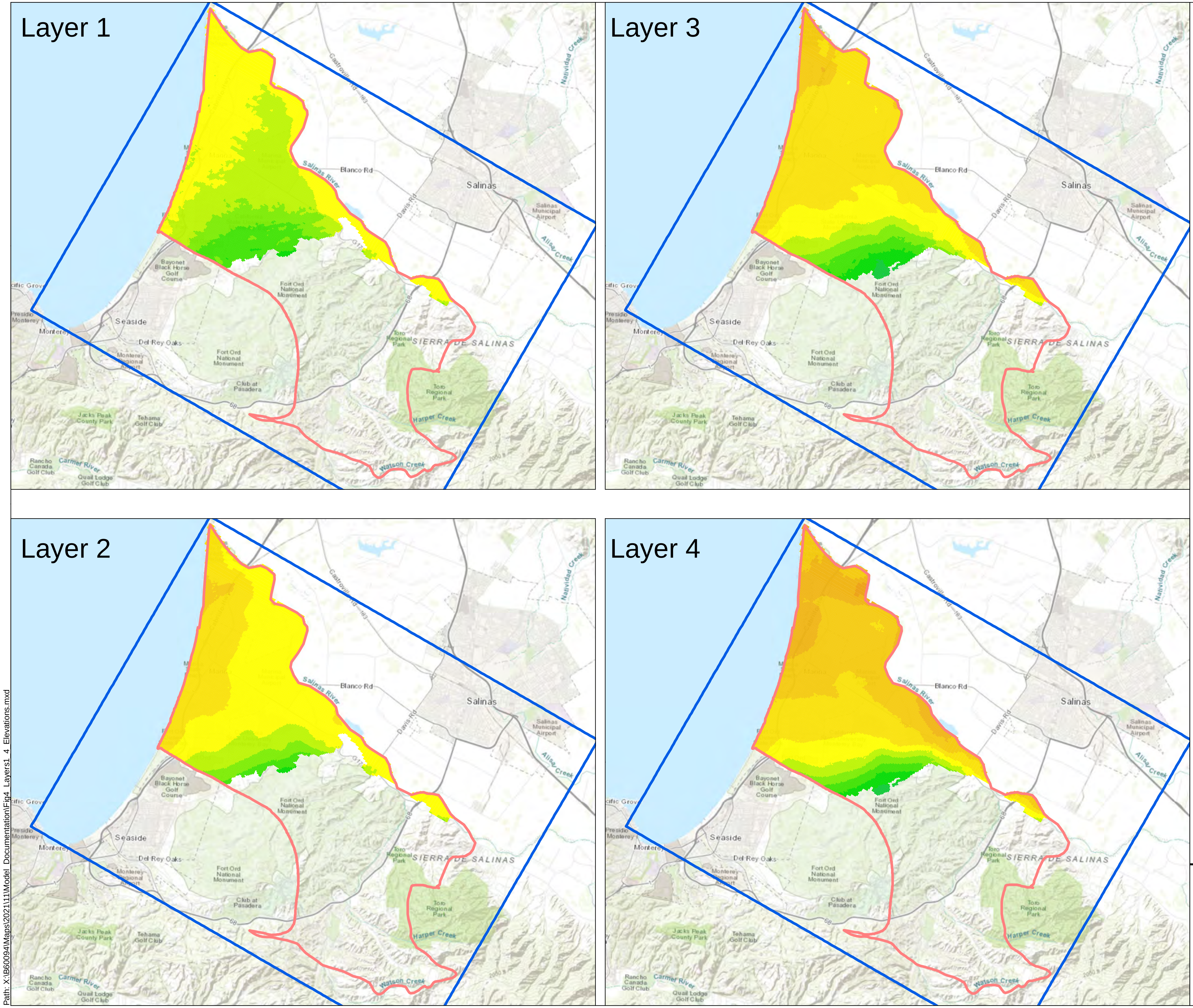
DRAFT

eki environment & water

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 3

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig3_MBGWFM_Active_Layer_Extents_Uppermost_Principal_Aquifer_Units.mxd



Legend

🟦 Grid Extent

🟥 MBGWFM Active Area

Layer Top Elevation (ft msl)

- <-700
- -699 - -600
- -599 - -500
- -499 - -400
- -399 - -300
- -299 - -200
- -199 - -100
- -99 - 0
- 1 - 100
- 101 - 200
- 201 - 300
- 301 - 400
- 401 - 500
- 501 - 600
- 601 - 700
- 701 - 800
- 801 - 900
- 901 - 1000
- 1001 - 1100
- 1101 - 1200
- >1201

Abbreviations

ft msl = feet above mean sea level
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 3 6
(Scale in Miles)

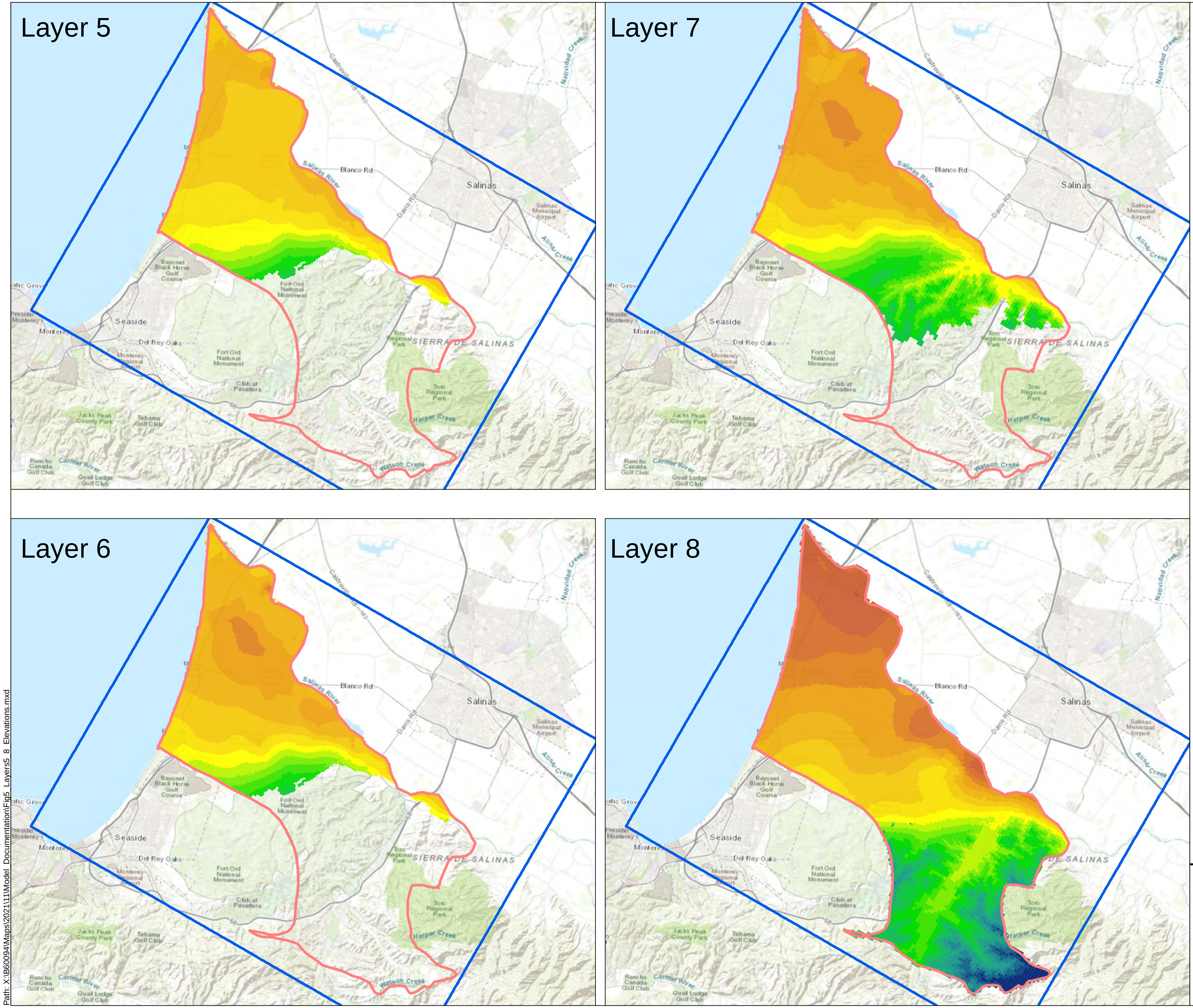
DRAFT

MBGWFM Layer Top Elevations
Layers 1 - 4

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03
Figure 4

eki environment & water

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig4 Layers1 4 Elevations.mxd



Abbreviations
ft msl = feet above mean sea level
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

DRAFT

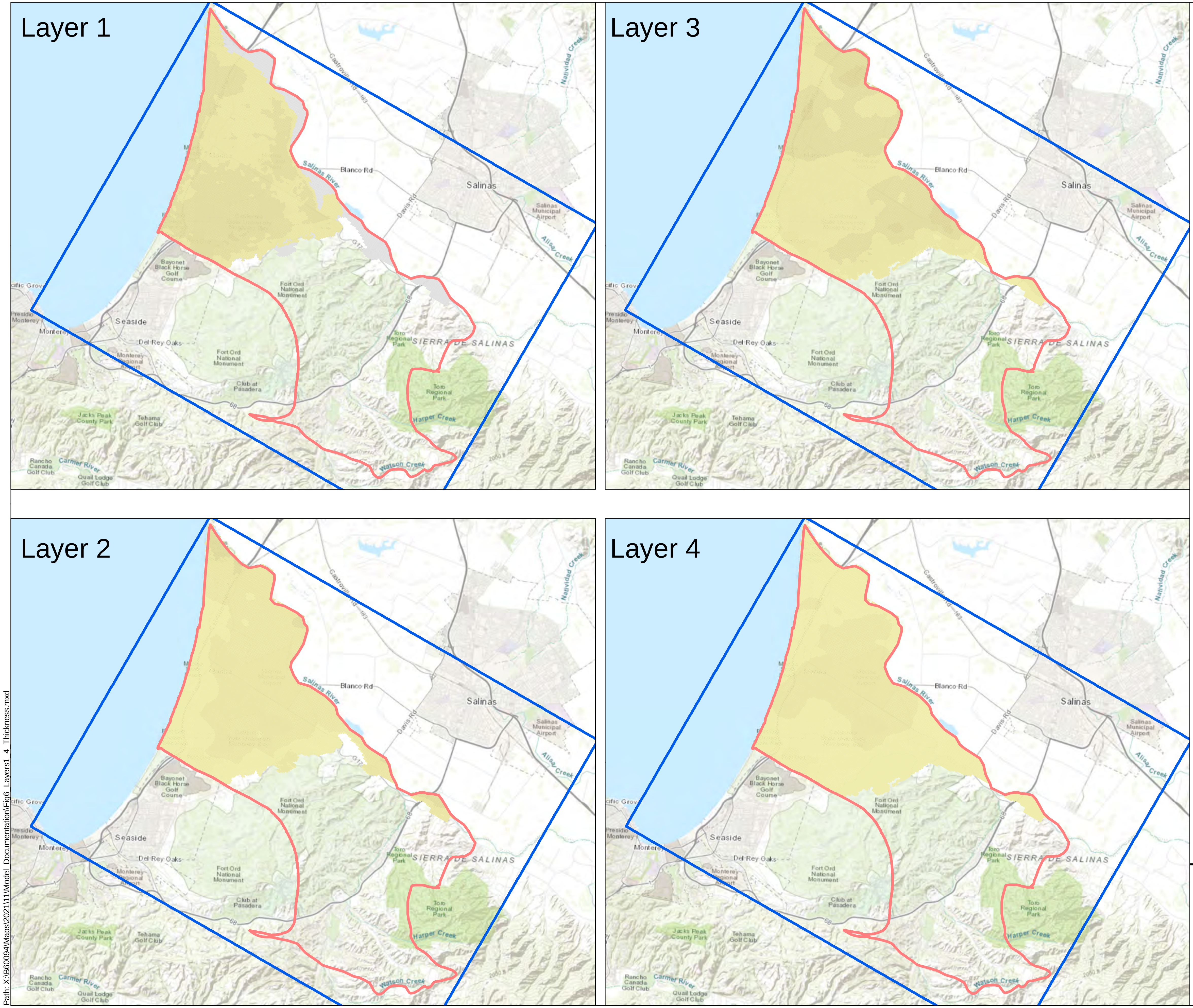
MBGWFM Layer Top Elevations
Layers 5 - 8

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03

eki environment & water

Figure 5

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig5 Layers5 8 Elevations.mxd



Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig6_Layers1_4_Thickness.mxd

Legend

- ☐ Grid Extent
- ☐ MBGWFM Active Area

Layer Thickness (ft)

- ▨ 5 ft (flow-through cells)
- ▨ 6 - 100
- ▨ 101 - 200
- ▨ 201 - 300
- ▨ 301 - 400
- ▨ 401 - 500
- ▨ 501 - 600
- ▨ 601 - 700
- ▨ 701 - 800
- ▨ 801 - 900
- ▨ 901 - 1000
- ▨ 1001 - 1100
- ▨ 1101 - 1200
- ▨ 1201 - 1300
- ▨ 1301 - 1400
- ▨ 1401 - 1500
- ▨ 1501 - 1600
- ▨ 1601 - 1700
- ▨ 1701 - 1800
- ▨ 1801 - 1900
- ▨ 1901 - 2000
- ▨ 2001 - 2015
- ▨ 2016 - 2200
- ▨ 2201 - 2300
- ▨ 2301 - 2400
- ▨ 2401 - 2500
- ▨ >2501

Abbreviations

ft = feet

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 3 6

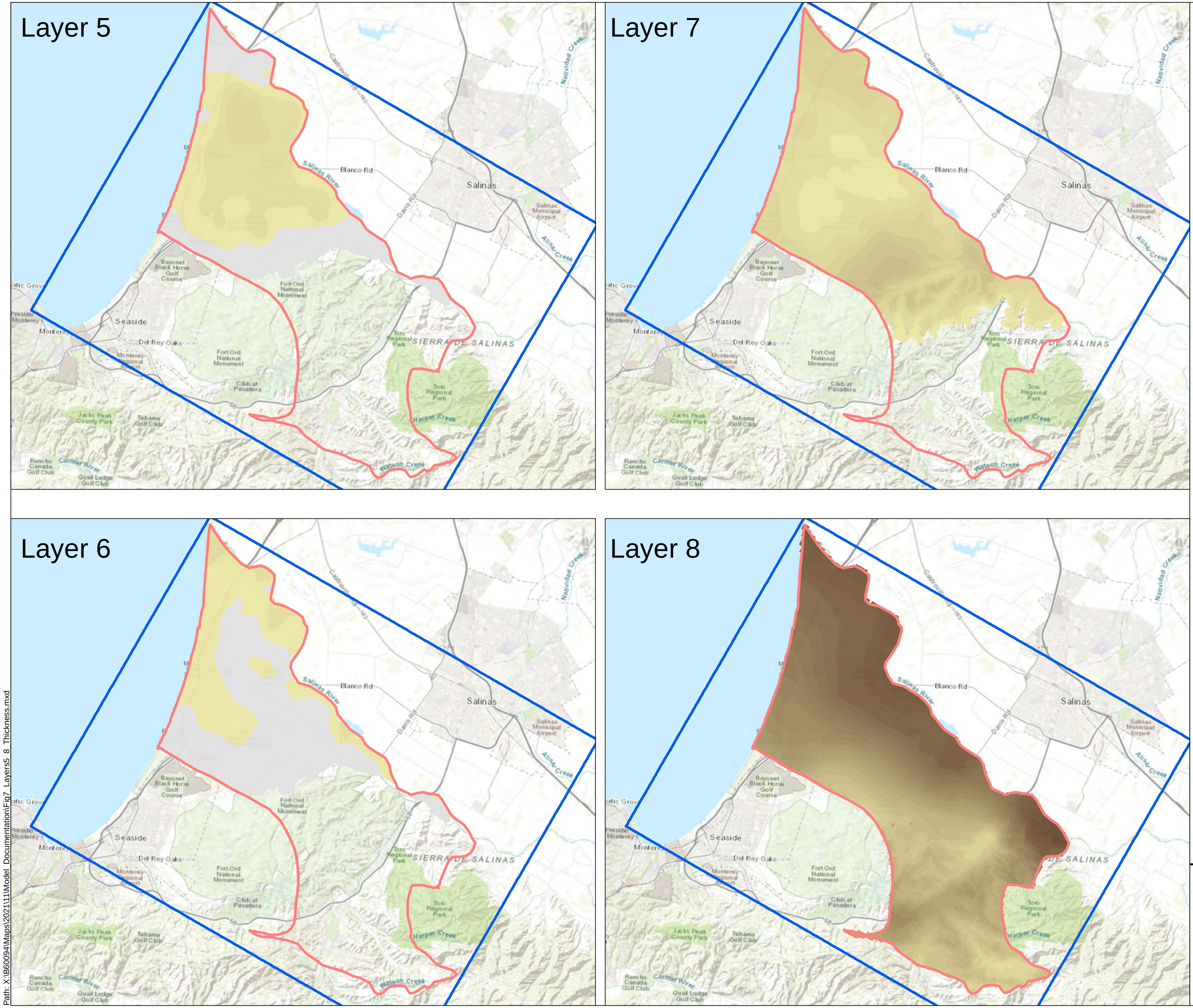
(Scale in Miles)

DRAFT

MBGWFM Layer Thickness
Layers 1 - 4

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03
Figure 6

eki environment & water



Legend

▭ Grid Extent

▭ MBGWFM Active Area

Layer Thickness (ft)

- ▭ 5 ft (flow-through cells)
- ▭ 6 - 100
- ▭ 101 - 200
- ▭ 201 - 300
- ▭ 301 - 400
- ▭ 401 - 500
- ▭ 501 - 600
- ▭ 601 - 700
- ▭ 701 - 800
- ▭ 801 - 900
- ▭ 901 - 1000
- ▭ 1001 - 1100
- ▭ 1101 - 1200
- ▭ 1201 - 1300
- ▭ 1301 - 1400
- ▭ 1401 - 1500
- ▭ 1501 - 1600
- ▭ 1601 - 1700
- ▭ 1701 - 1800
- ▭ 1801 - 1900
- ▭ 1901 - 2000
- ▭ 2001 - 2015
- ▭ 2016 - 2200
- ▭ 2201 - 2300
- ▭ 2301 - 2400
- ▭ 2401 - 2500
- ▭ >2501

Abbreviations

ft = feet

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 3 6

(Scale in Miles)

DRAFT

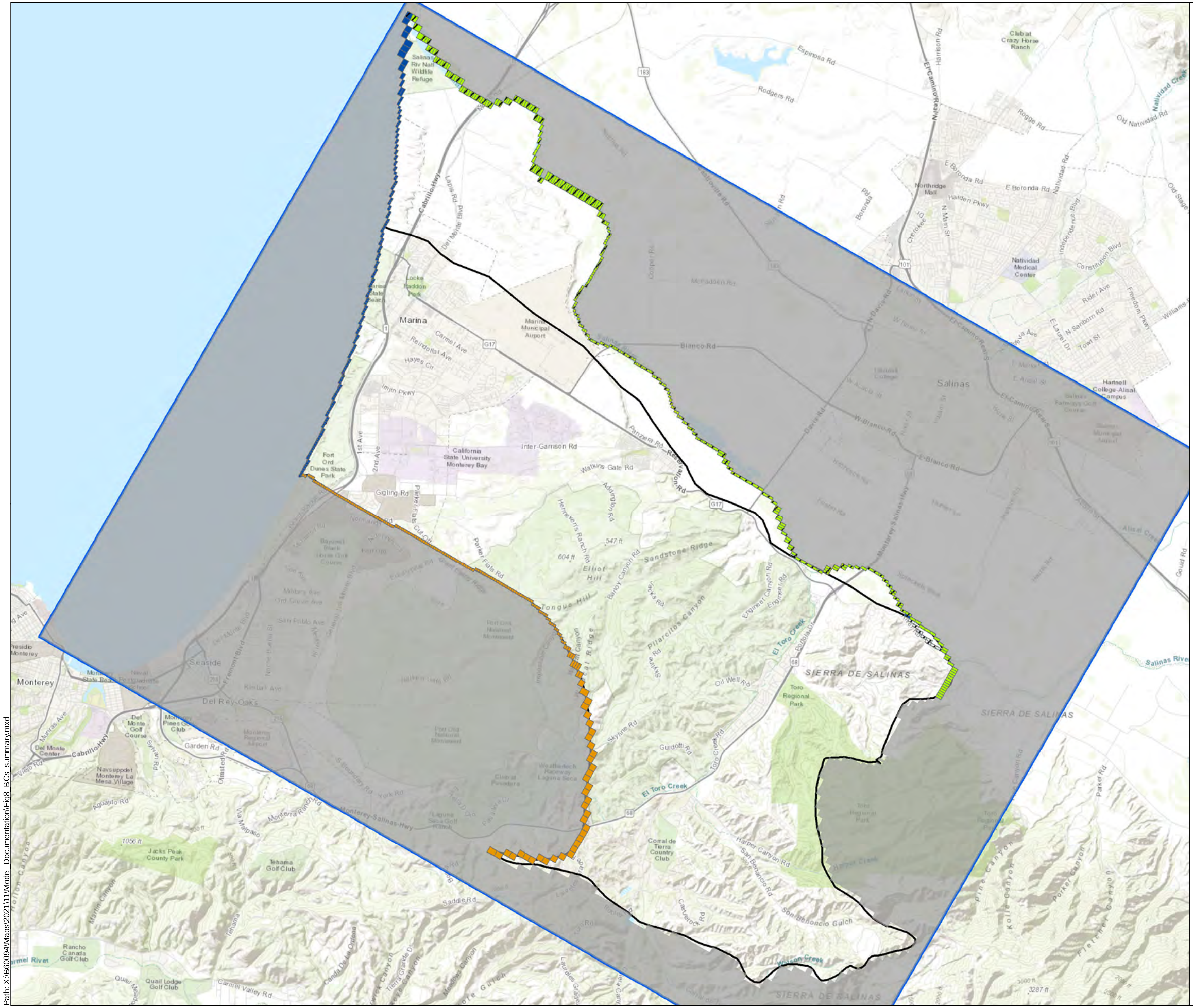
MBGWFM Layer Thickness
Layers 5 - 8

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03

Figure 7

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig7_Layers5_8_Thickness.mxd



Legend

- ▭ Monterey Subbasin
- ▭ Grid Extent
- ▨ River Cells (Layers 1-2,7)
- 🟧 GHB Cells - Seaside Boundary (Layers 1-8)
- 🟩 GHB Cells - Northern Boundary (Layers 3-8)
- 🟦 GHB Cells - Pacific Ocean (Layers 1-7)
- ⬜ No-Flow Cells

Abbreviations

DWR = California Department of Water Resources
GHB = General Head Boundary
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

MBGWFM Boundary Conditions Summary

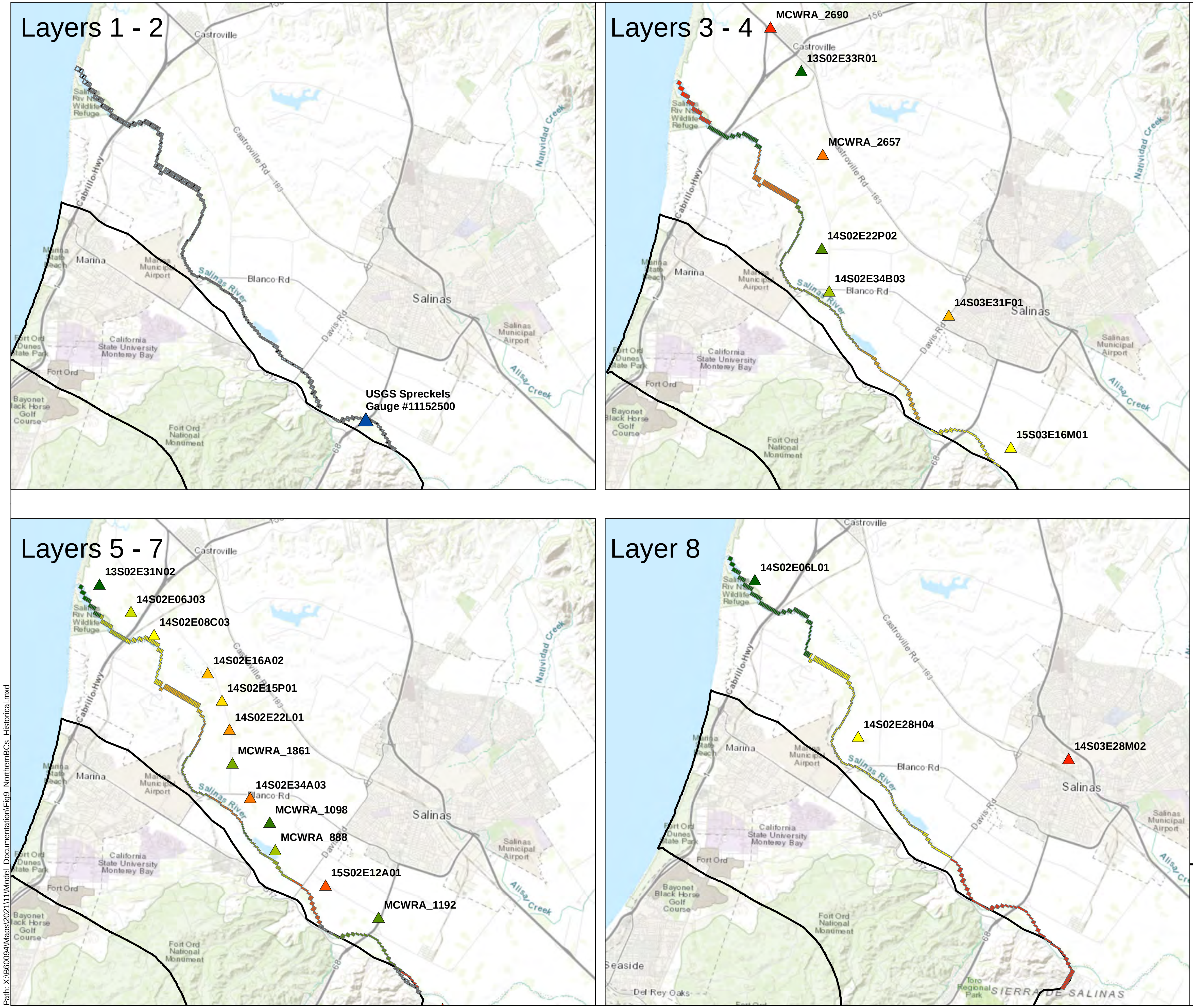
DRAFT

eki environment & water

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 8

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig8_BCs_summary.mxd



Legend

▭ Monterey Subbasin

▲ Representative Monitoring Well (see Note 1)

▨ GHB Cells (see Note 1)

▨ River Cells

Abbreviations

ft msl = feet above mean sea level

GHB = General Head Boundary

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. GHB cells are color-coded by their associated representative monitoring well that is used to inform specified heads.
2. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 2 4

(Scale in Miles)

DRAFT

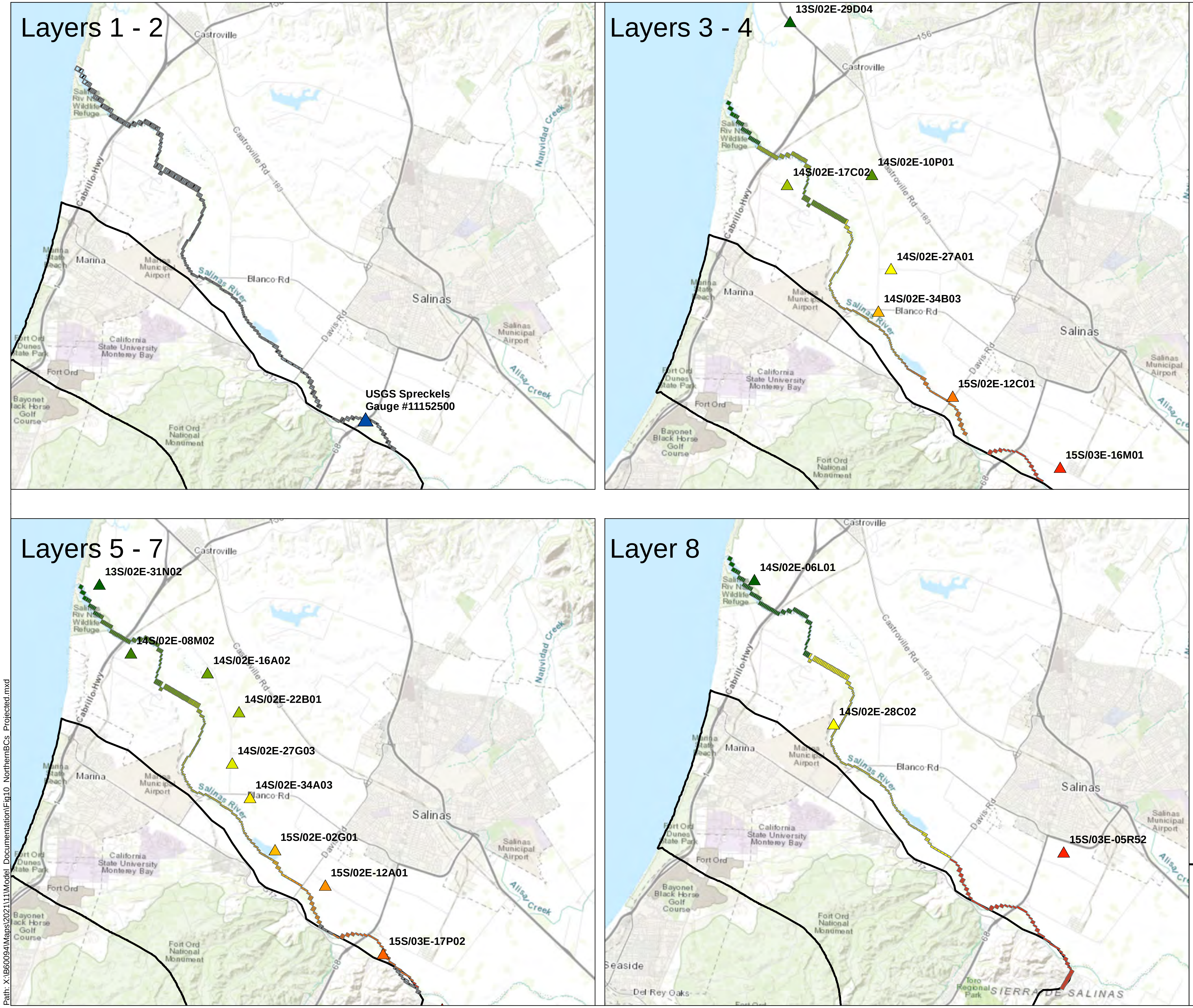
MBGWFM Northern Boundary Conditions - Historical Simulation

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03

Figure 9

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig9_NorthernBCs_Historical.mxd



Legend

☐ Monterey Subbasin

▲ SGMA Monitoring Well (see Note 1)

■ GHB Cells (see Note 1)

▨ River Cells

Abbreviations

ft msl = feet above mean sea level

GHB = General Head Boundary

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. GHB cells are color-coded by their associated representative monitoring well that is used to inform specified heads.
2. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 2 4

(Scale in Miles)

DRAFT

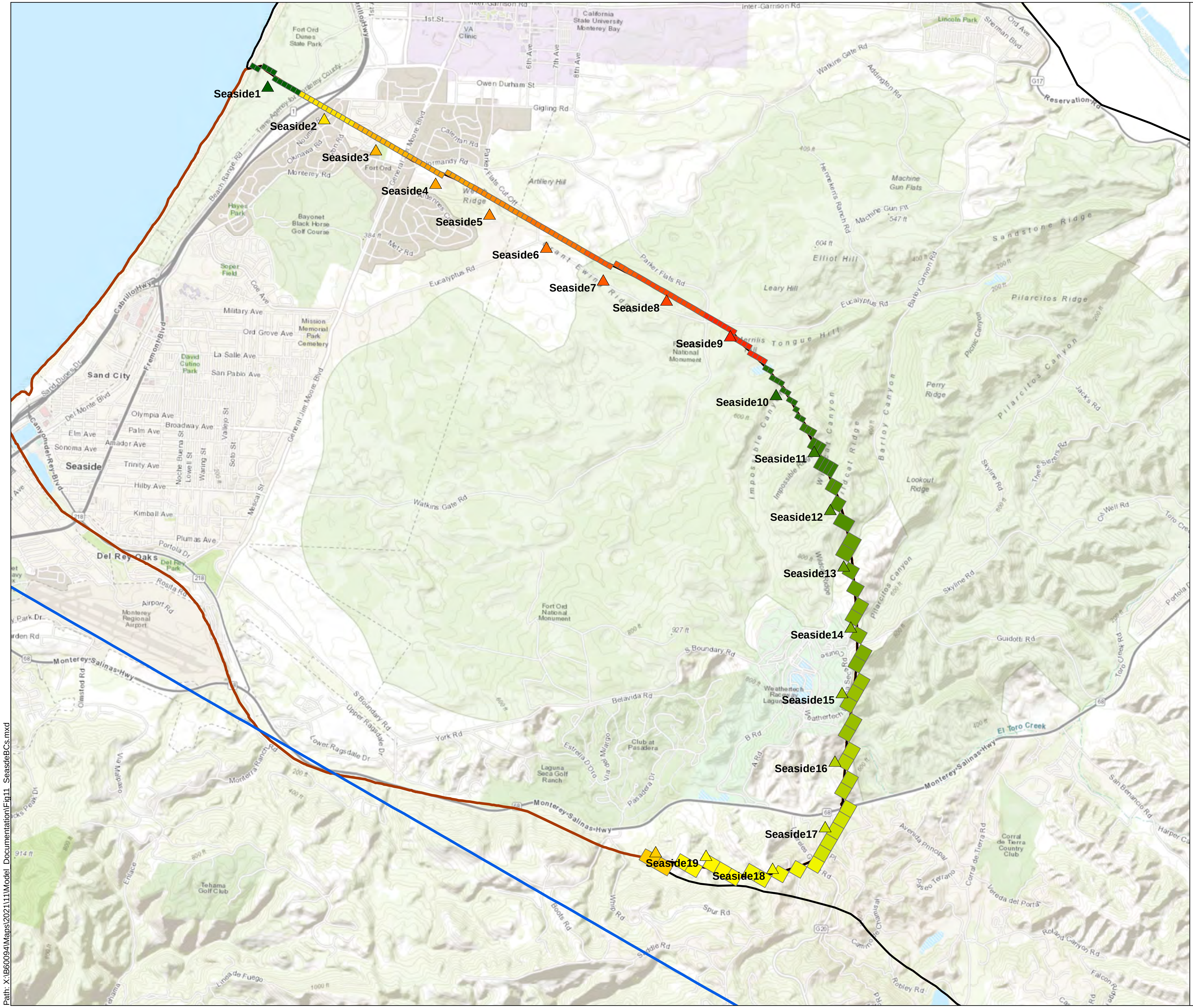
MBGWFM Northern Boundary Conditions - Projected Simulations

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.03

Figure 10

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig10_NorthernBCs_Projected.mxd



Legend

- ▭ Monterey Subbasin
- ▭ Seaside Subbasin
- △ Seaside Proxy Monitoring Location (see Note 1)
- ▨ GHB Cells (see Note 1)

Abbreviations

DWR = California Department of Water Resources
GHB = General Head Boundary
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. GHB cells are color-coded by their associated Seaside proxy monitoring well that is used to inform specified heads.
2. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 0.5 1
(Scale in Miles)

MBGWFM Southern Boundary Conditions

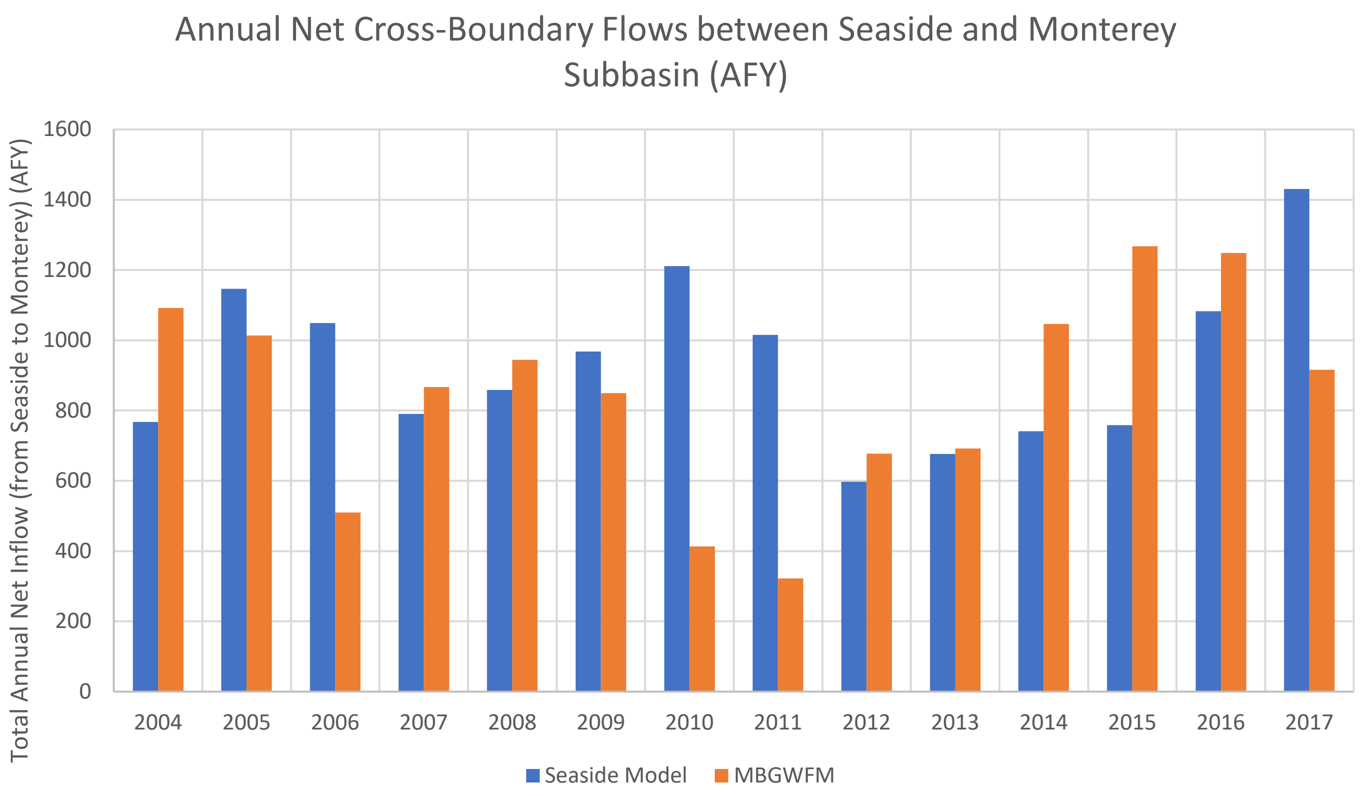
DRAFT

eki environment & water

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 11

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig11_SeasideBCs.mxd



Legend

🟦 = Seaside Model

🟧 = MBGWFM

Abbreviations

AFY = acre-feet per year

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. Positive values indicate a net inflow from Seaside to the Monterey Subbasin.

Sources

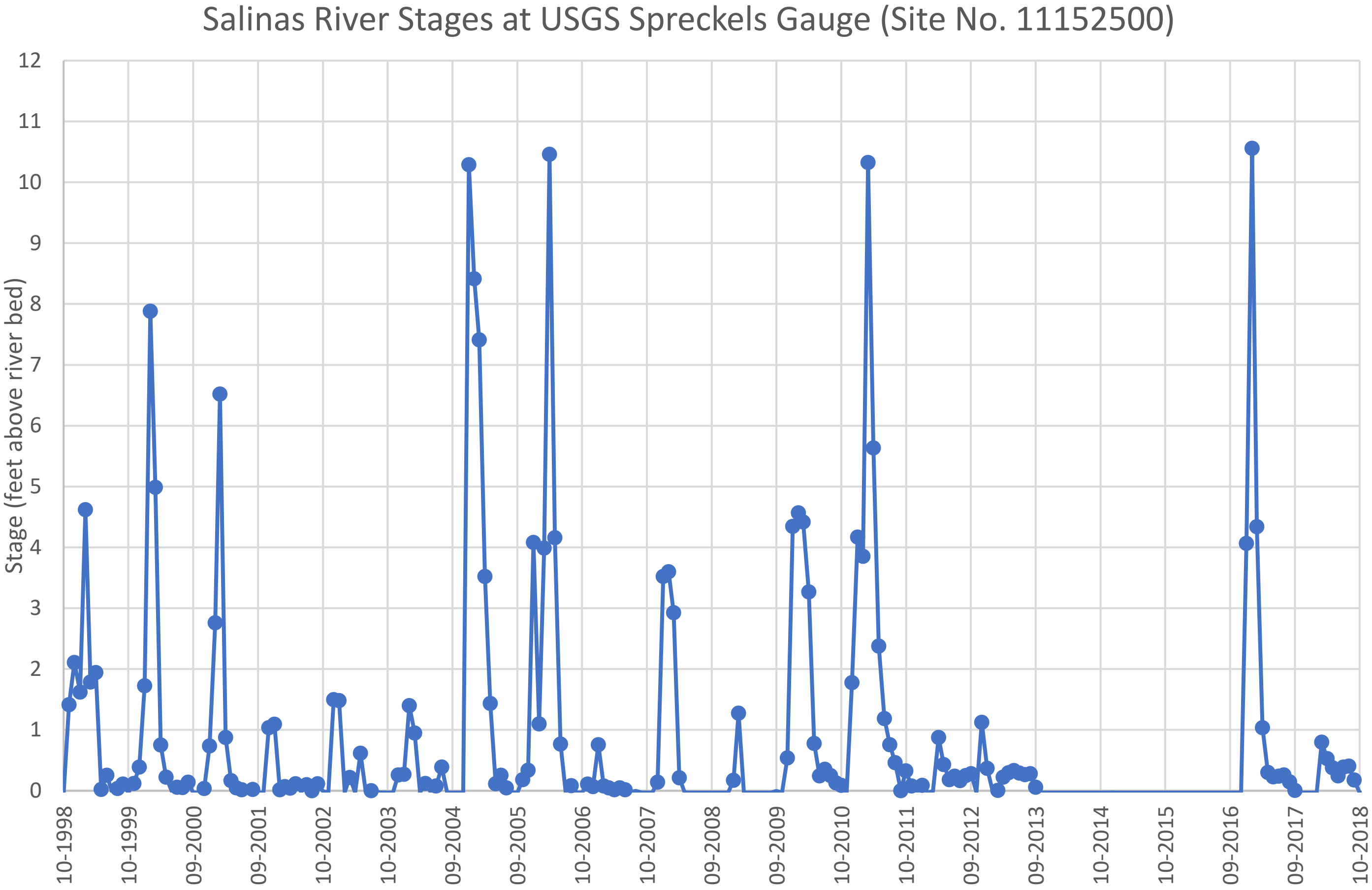
1. MBGWFM
2. Seaside Groundwater Flow Model

Annual Net Cross-Boundary Flow Estimates between the Seaside and Monterey Subbasins

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.12

DRAFT

Figure 12



Legend

— = Salinas River Stage (ft)

Abbreviations
ft = feet

Notes
1. Salinas River stages are approximated from flow data (see *Section 2.4.3*).

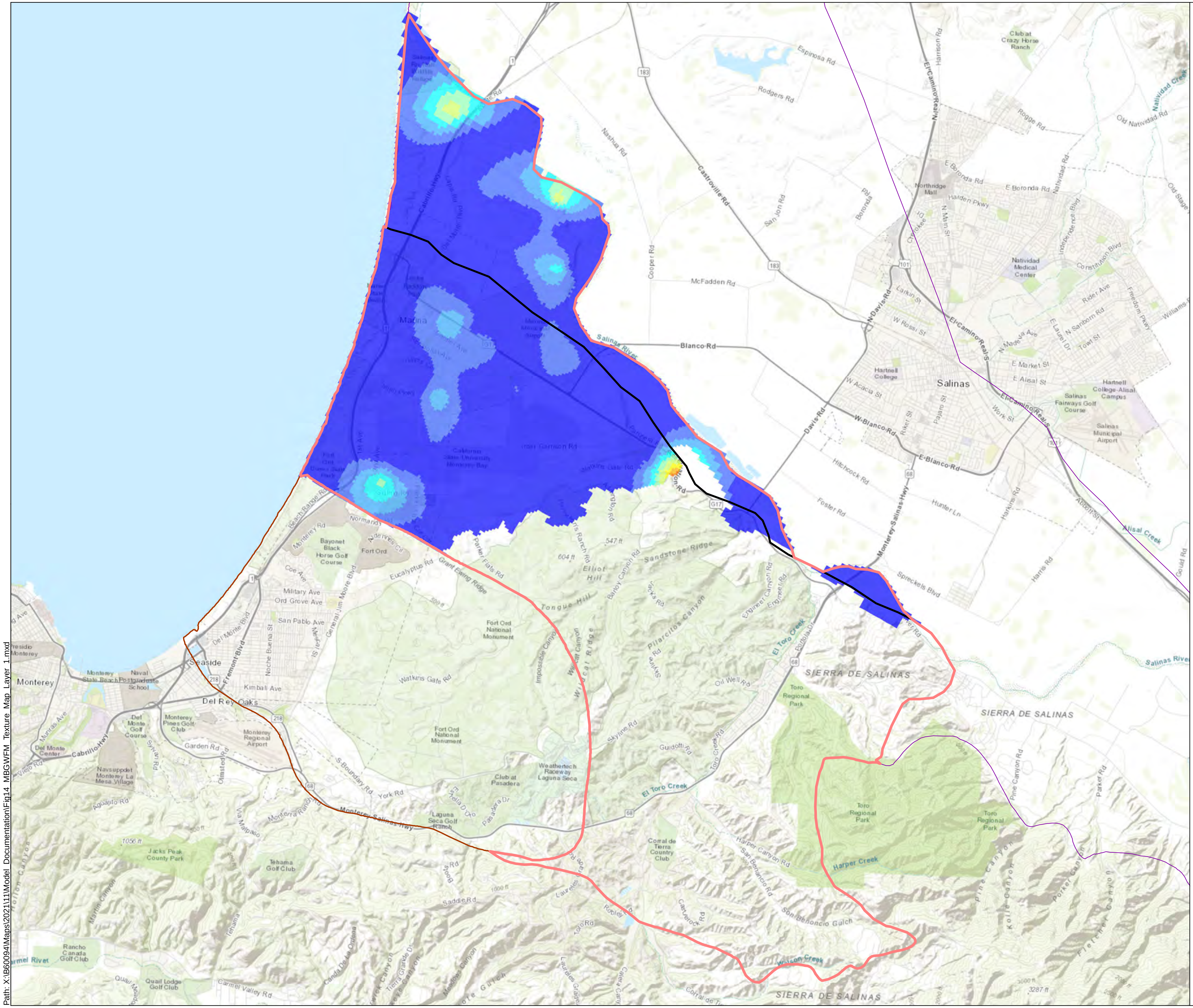
Sources
1. Monterey Subbasin Groundwater Flow Model

eki environment & water

Salinas River Stages at USGS Spreckels Gauge

DRAFT

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.12
Figure 13



Legend

- ▭ Monterey Subbasin
- ▭ Seaside Subbasin
- ▭ 180/400-Foot Aquifer Subbasin
- ▭ MBGWFM Active Area

Layer 1 % Coarse

- 🟥 0.00 - 0.10
- 🟧 0.11 - 0.20
- 🟧 0.21 - 0.30
- 🟨 0.31 - 0.40
- 🟩 0.41 - 0.50
- 🟩 0.51 - 0.60
- 🟦 0.61 - 0.70
- 🟦 0.71 - 0.80
- 🟦 0.81 - 0.90
- 🟦 0.91 - 1.00

Abbreviations

DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

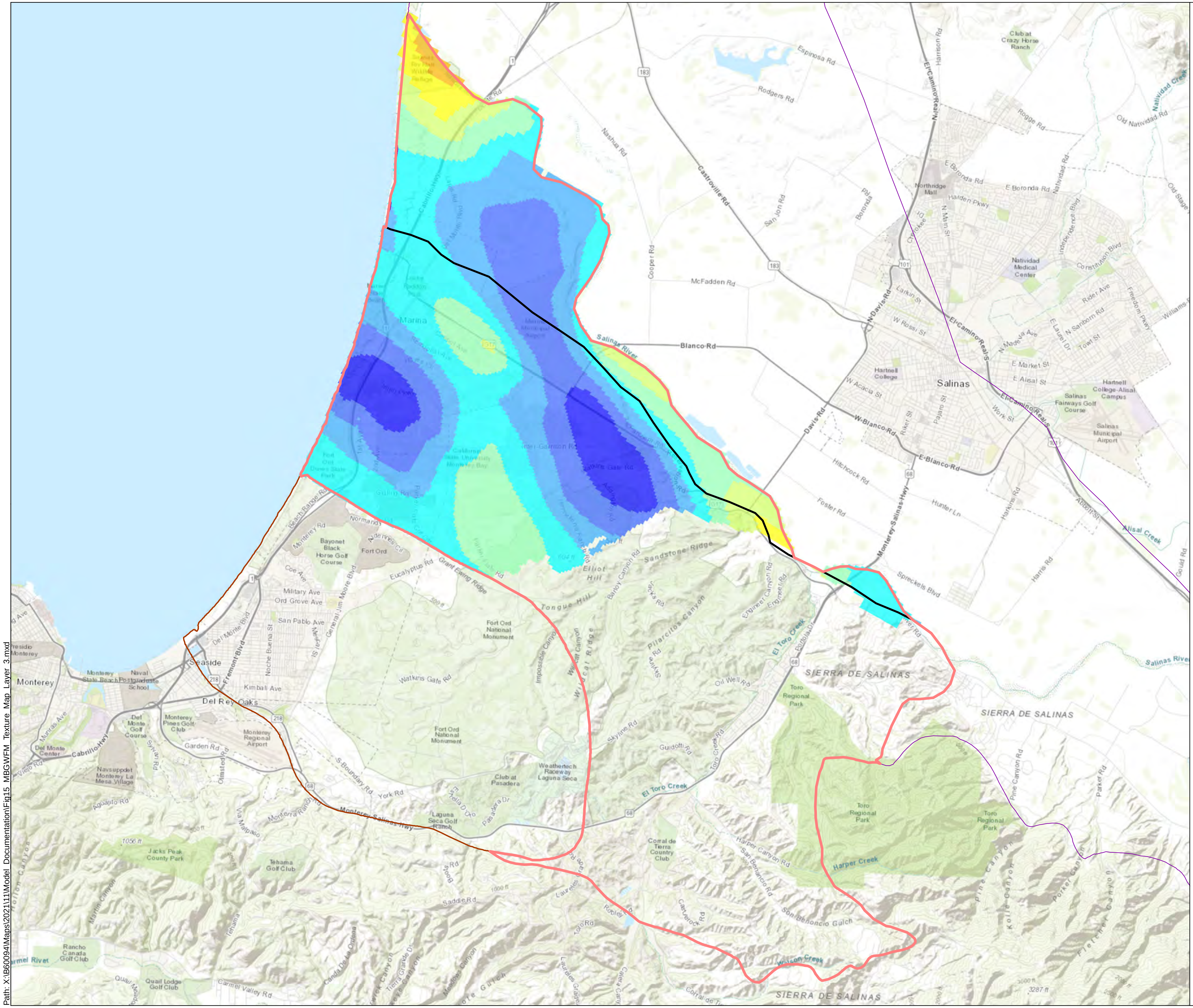
MBGWFM Texture Map - Layer 1

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 14

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig14_MBGWFM_Texture_Map_Layer_1.mxd



Legend

- ▭ Monterey Subbasin
- ▭ Seaside Subbasin
- ▭ 180/400-Foot Aquifer Subbasin
- ▭ MBGWFM Active Area

Layer 3 % Coarse

- 🟥 0.00 - 0.10
- 🟧 0.11 - 0.20
- 🟨 0.21 - 0.30
- 🟨 0.31 - 0.40
- 🟩 0.41 - 0.50
- 🟩 0.51 - 0.60
- 🟦 0.61 - 0.70
- 🟦 0.71 - 0.80
- 🟦 0.81 - 0.90
- 🟦 0.91 - 1.00

Abbreviations
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

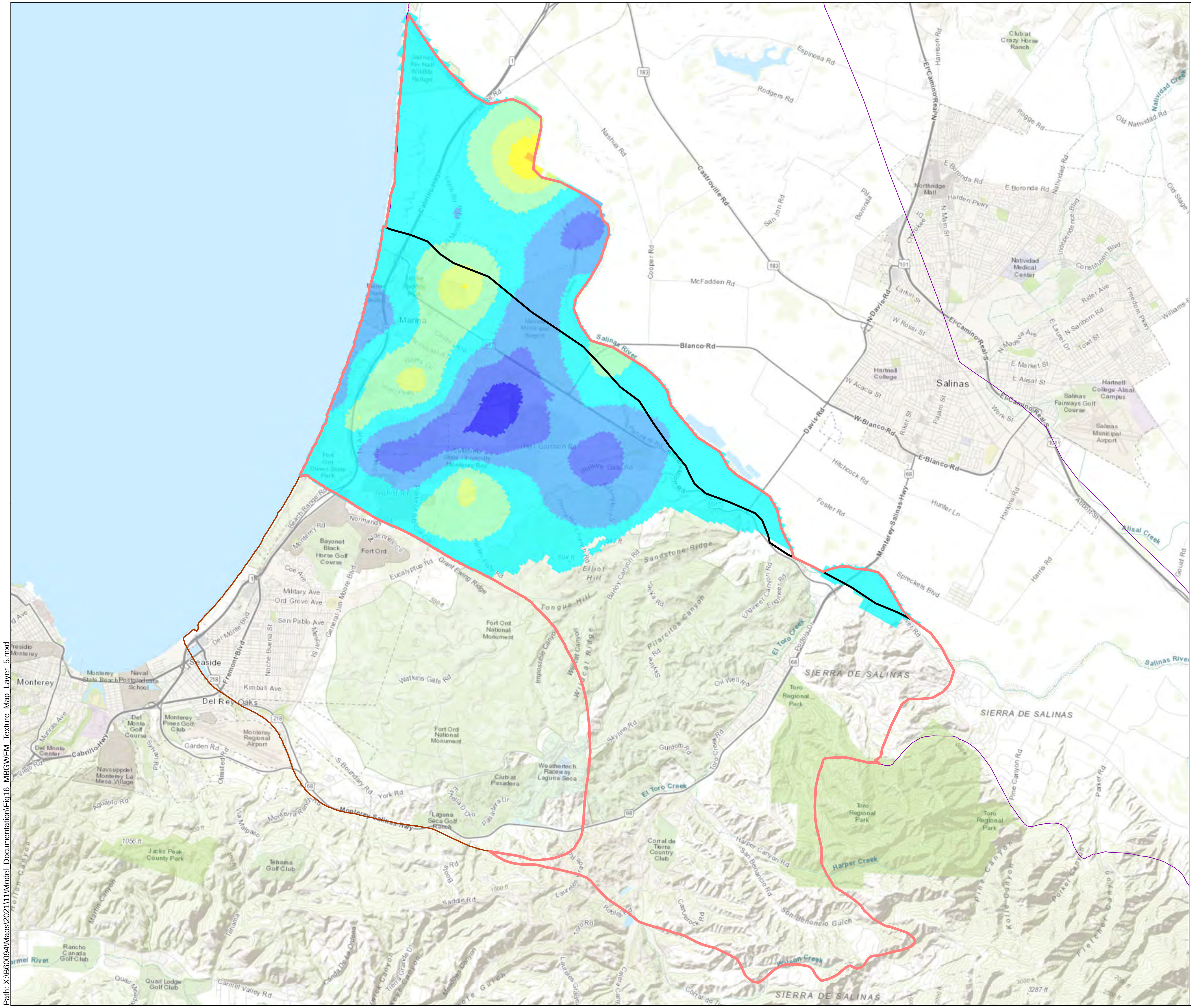
DRAFT

eki environment & water

MBGWFM Texture Map - Layer 3

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 15

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig15_MBGWFM_Texture_Map_Layer_3.mxd



Legend

▭ Monterey Subbasin

▭ Seaside Subbasin

▭ 180/400-Foot Aquifer Subbasin

▭ MBGWFM Active Area

Layer 5 % Coarse

🟥 0.00 - 0.10

🟧 0.11 - 0.20

🟧 0.21 - 0.30

🟨 0.31 - 0.40

🟩 0.41 - 0.50

🟩 0.51 - 0.60

🟦 0.61 - 0.70

🟦 0.71 - 0.80

🟦 0.81 - 0.90

🟦 0.91 - 1.00

Abbreviations

DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

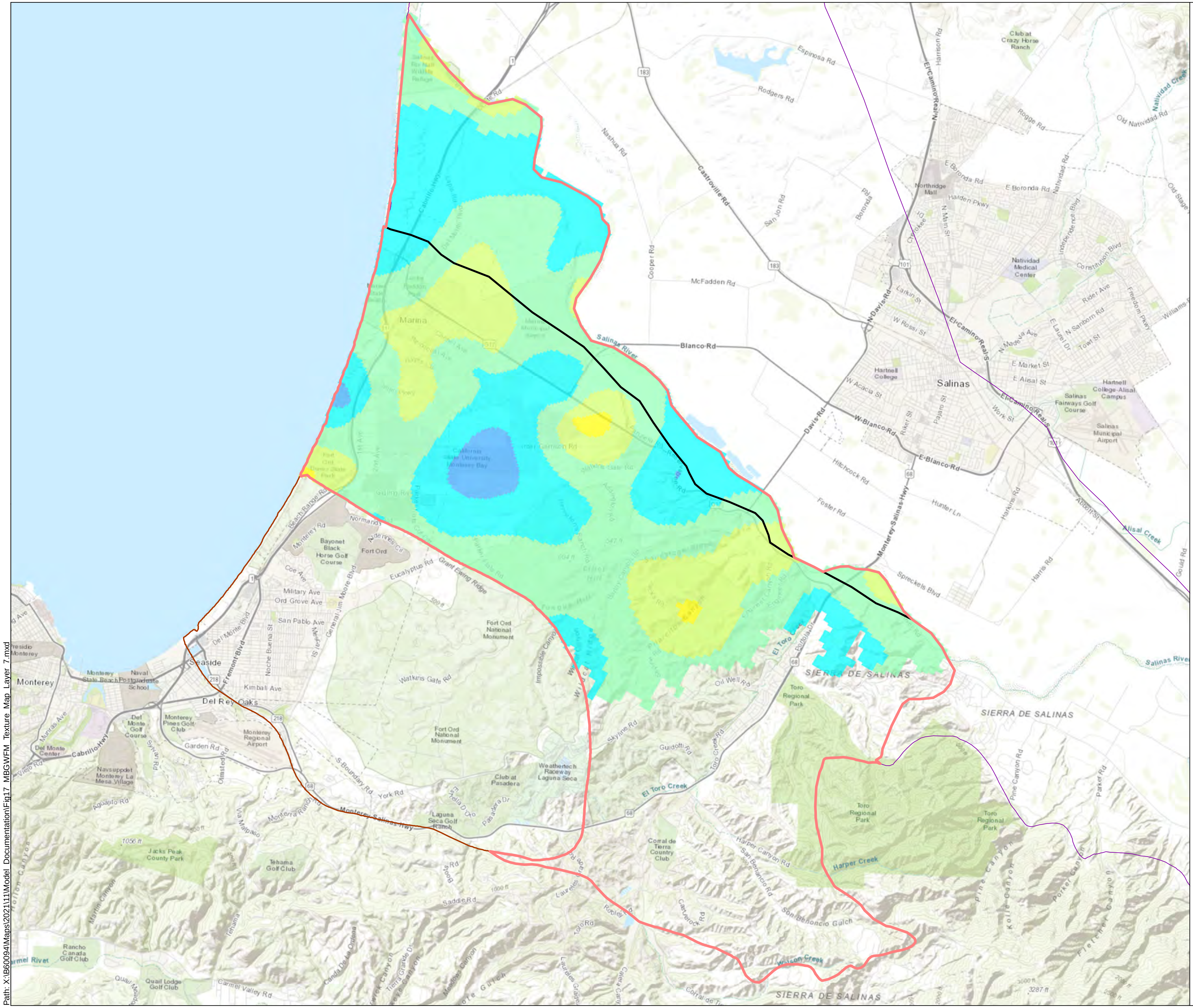
DRAFT

eki environment & water

MBGWFM Texture Map - Layer 5

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 16

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig16_MBGWFM_Texture_Map_Layer_5.mxd



Legend

☐ Monterey Subbasin
☐ Seaside Subbasin
☐ 180/400-Foot Aquifer Subbasin
☐ MBGWFM Active Area

Layer 7 % Coarse

🟥 0.00 - 0.10
🟧 0.11 - 0.20
🟧 0.21 - 0.30
🟨 0.31 - 0.40
🟩 0.41 - 0.50
🟩 0.51 - 0.60
🟦 0.61 - 0.70
🟦 0.71 - 0.80
🟦 0.81 - 0.90
🟦 0.91 - 1.00

Abbreviations
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

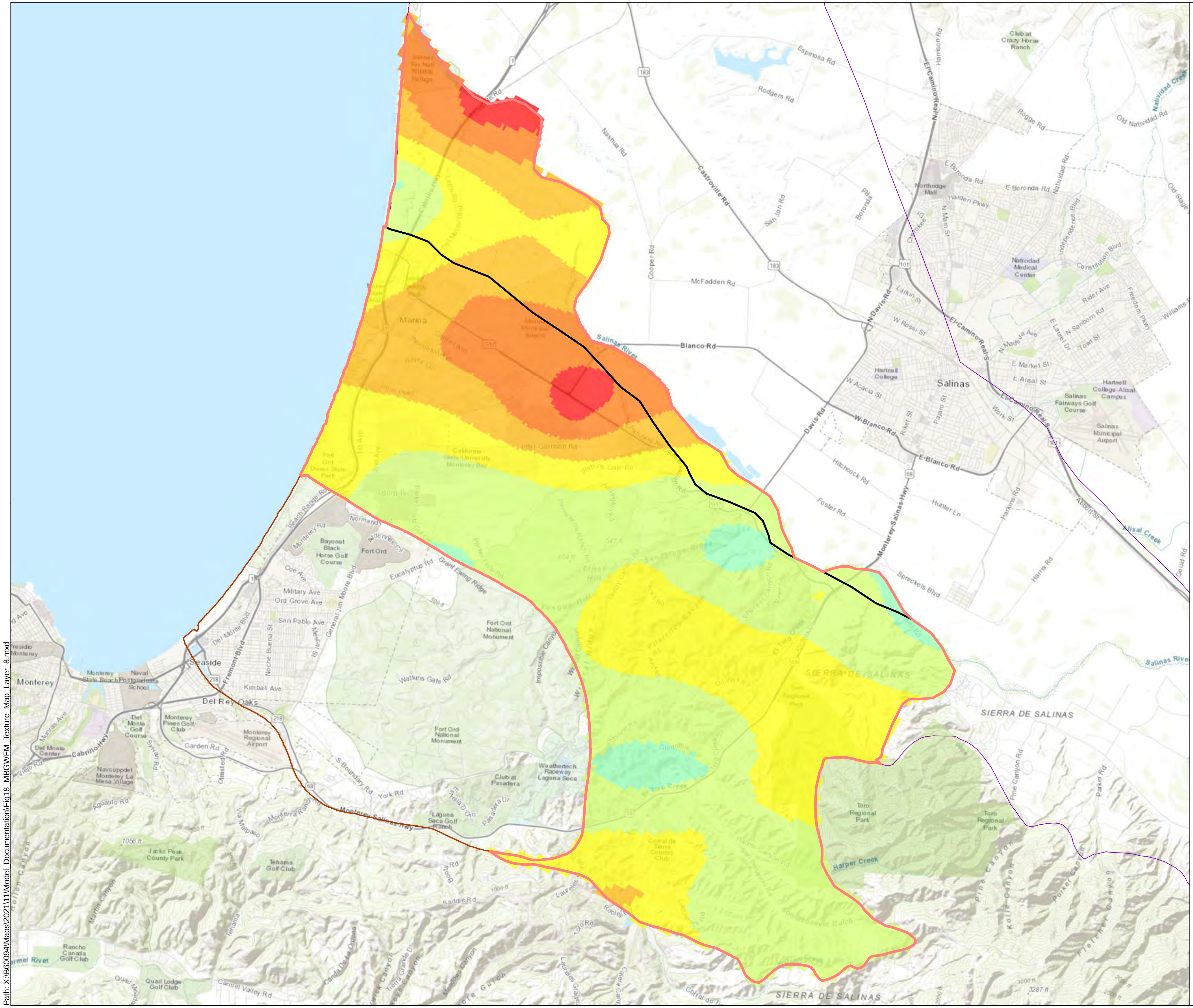
DRAFT

eki environment & water

MBGWFM Texture Map - Layer 7

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 17

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig17 MBGWFM Texture Map Layer 7.mxd



Legend

☐ Monterey Subbasin

☐ Seaside Subbasin

☐ 180/400-Foot Aquifer Subbasin

☐ MBGWFM Active Area

Layer 8 % Coarse

🟥 0.00 - 0.10

🟧 0.11 - 0.20

🟧 0.21 - 0.30

🟨 0.31 - 0.40

🟩 0.41 - 0.50

🟩 0.51 - 0.60

🟦 0.61 - 0.70

🟦 0.71 - 0.80

🟦 0.81 - 0.90

🟦 0.91 - 1.00

Abbreviations

DWR = California Department of Water Resources

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

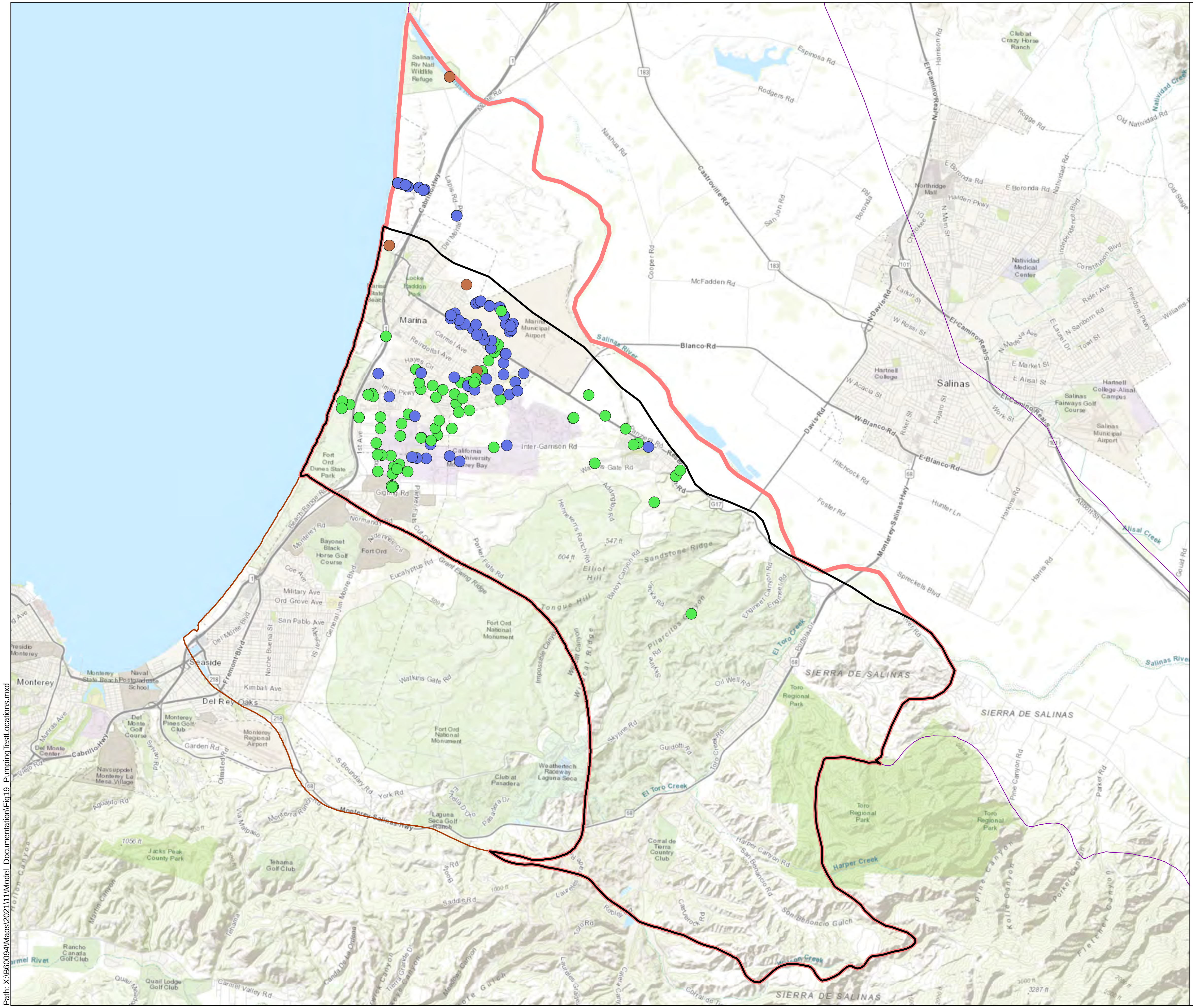
MBGWFM Texture Map - Layer 8

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

eki environment & water

Figure 18

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig18_MBGWFM_Texture_Map_Layer_8.mxd



Legend

▭ Monterey Subbasin

▭ MBGWFM Active Area

▭ Seaside Subbasin

▭ 180/400-Foot Aquifer Subbasin

Pumping Test Wells

Principal Aquifer Designation

● Dune Sand Aquifer

● 180/400-Foot Aquifer

● Deep Aquifer

Abbreviations
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

Pumping Test Well Locations

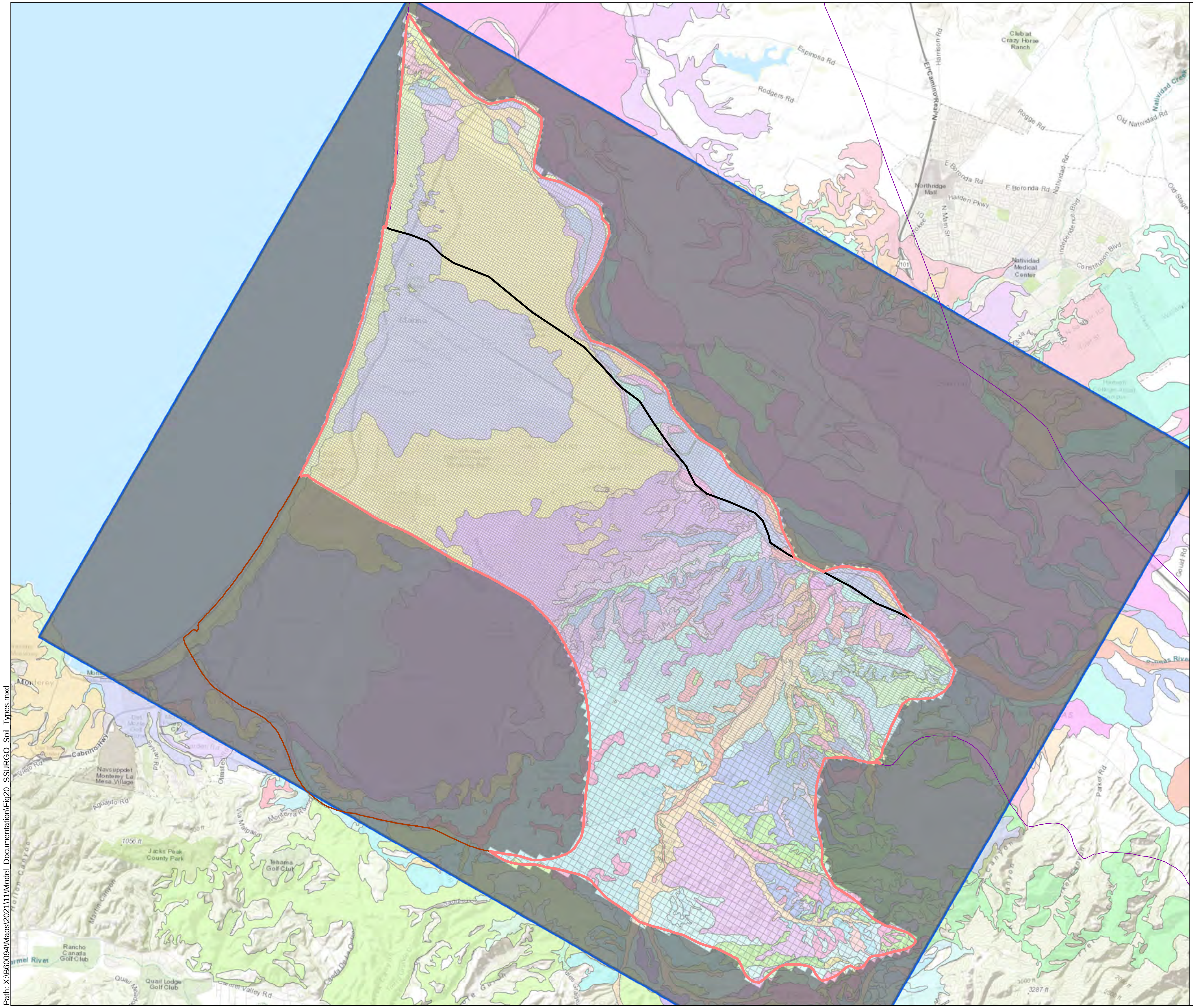
DRAFT

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

eki environment & water

Figure 19

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig19_PumpingTestLocations.mxd



Legend

- ▭ Monterey Subbasin
- ▭ Seaside Subbasin
- ▭ 180/400-Foot Aquifer Subbasin
- ▭ MBGWFM Active Area
- ▭ Grid Extent

MBGWFM Grid

- ▭ Active Cells
- ■ Inactive Cells

SSURGO Soil Map Unit

300
Ac
Ad
AeA
AeC
AeD
Af
AkD
AkF
Am
Ar
AsB
AsC
AvB
Ba
BbC
CaE
CaF
CbA
CbB
CbC
CcG
Cf
Cg
Cm
CnA
CnC
DaC
DbD
DbE
DbF
DdE
Df
EaA
EbC
GhC
GhD
GkB
HbB
LaE
LaF
LcG2
LhE
Me
Mf
Mg
MnA
MoA
NcC
OaD
Pa
PdC
PdD
Pf
Pm
PnA
PnC
PnD
PnE
Pr
RaA
RaC
RaD
Rb
Rc
SaA
SbA
SbC
ScE
ScG
SdF
SfD
SfE
SfF
Sg
ShC
ShD
ShD2
ShE
SoD
SoG
TaC
TbB
VaE
VaG
Vb
W
Xb
Xc
Xd

Abbreviations

DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model
SSURGO = Soil Survey Geographic Database

Notes

1. All locations are approximate.
2. List of SSURGO soil unit keys and corresponding names can be found at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

SSURGO Soil Types

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 20

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig20_SSURGO_Soil_Types.mxd

Legend

☐ Monterey Subbasin

☐ Seaside Subbasin

☐ 180/400-Foot Aquifer Subbasin

☐ MBGWFM Active Area

☐ Grid Extent

MBGWFM Grid

☐ Active Cells

■ Inactive Cells

Hydrologic Soil Groups

🟩 A

▨ A/D

🟩 B

🟨 C

▨ C/D

🟥 D

Abbreviations

DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model
SSURGO = Soil Survey Geographic Database

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

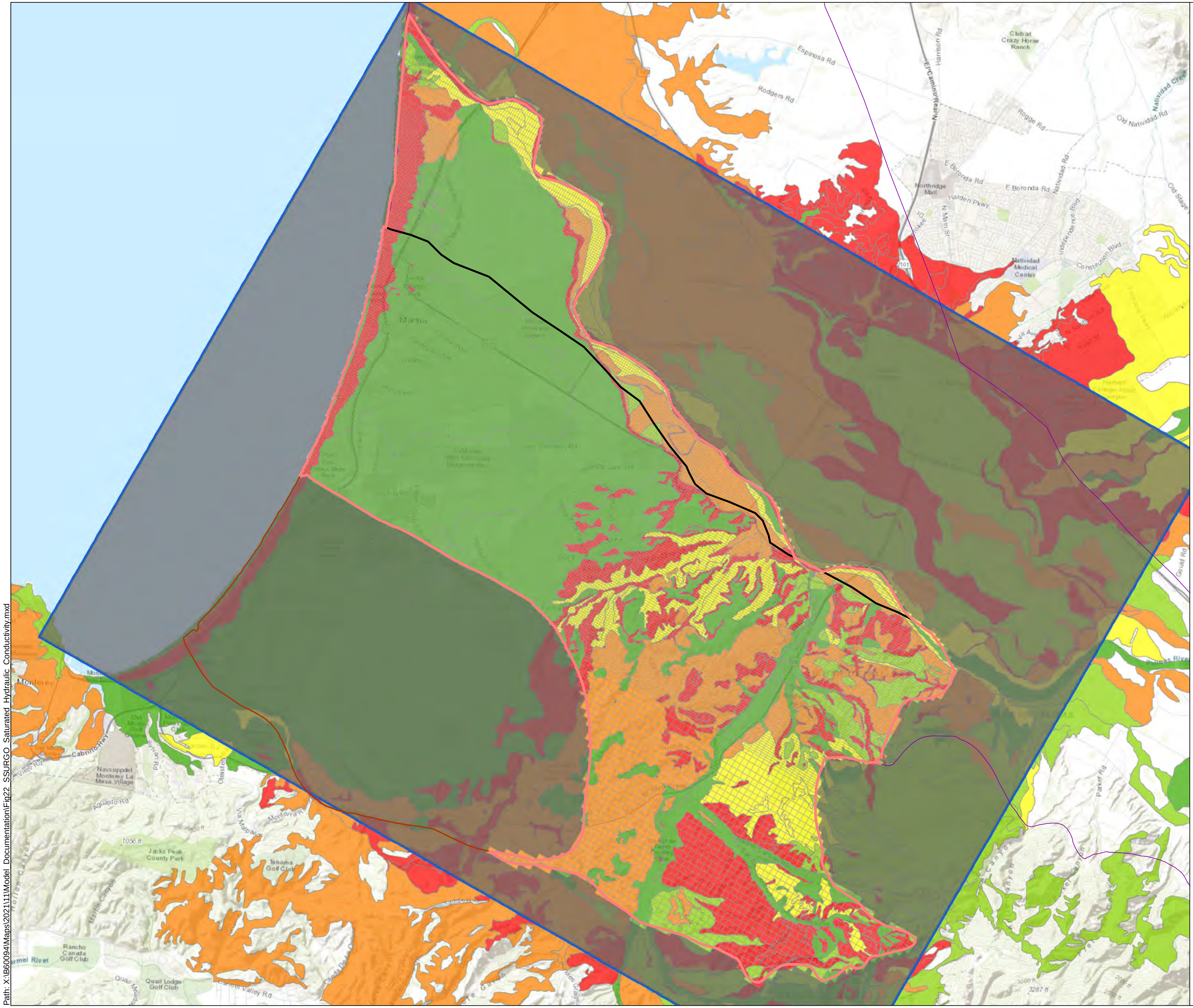
SSURGO Hydrologic Soil Groups

DRAFT

eki environment & water

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 21

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig21_SSURGO_Hydrologic_Soil_Groups.mxd



Legend

- ⬜ Monterey Subbasin
- ⬜ Seaside Subbasin
- ⬜ 180/400-Foot Aquifer Subbasin
- ⬜ MBGWFM Active Area
- ⬜ Grid Extent

MBGWFM Grid

- ⬜ Active Cells
- ⬛ Inactive Cells

Saturated Hydraulic Conductivity (ft/d)

- 🟥 0.00 - 3.23
- 🟧 3.24 - 9.00
- 🟨 9.01 - 18.92
- 🟩 18.93 - 35.32
- 🟩 35.33 - 232.00

Abbreviations
DWR = California Department of Water Resources
ft/d = feet per day
MBGWFM = Monterey Subbasin Groundwater Flow Model
SSURGO = Soil Survey Geographic Database

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

SSURGO Saturated Vertical Hydraulic Conductivity

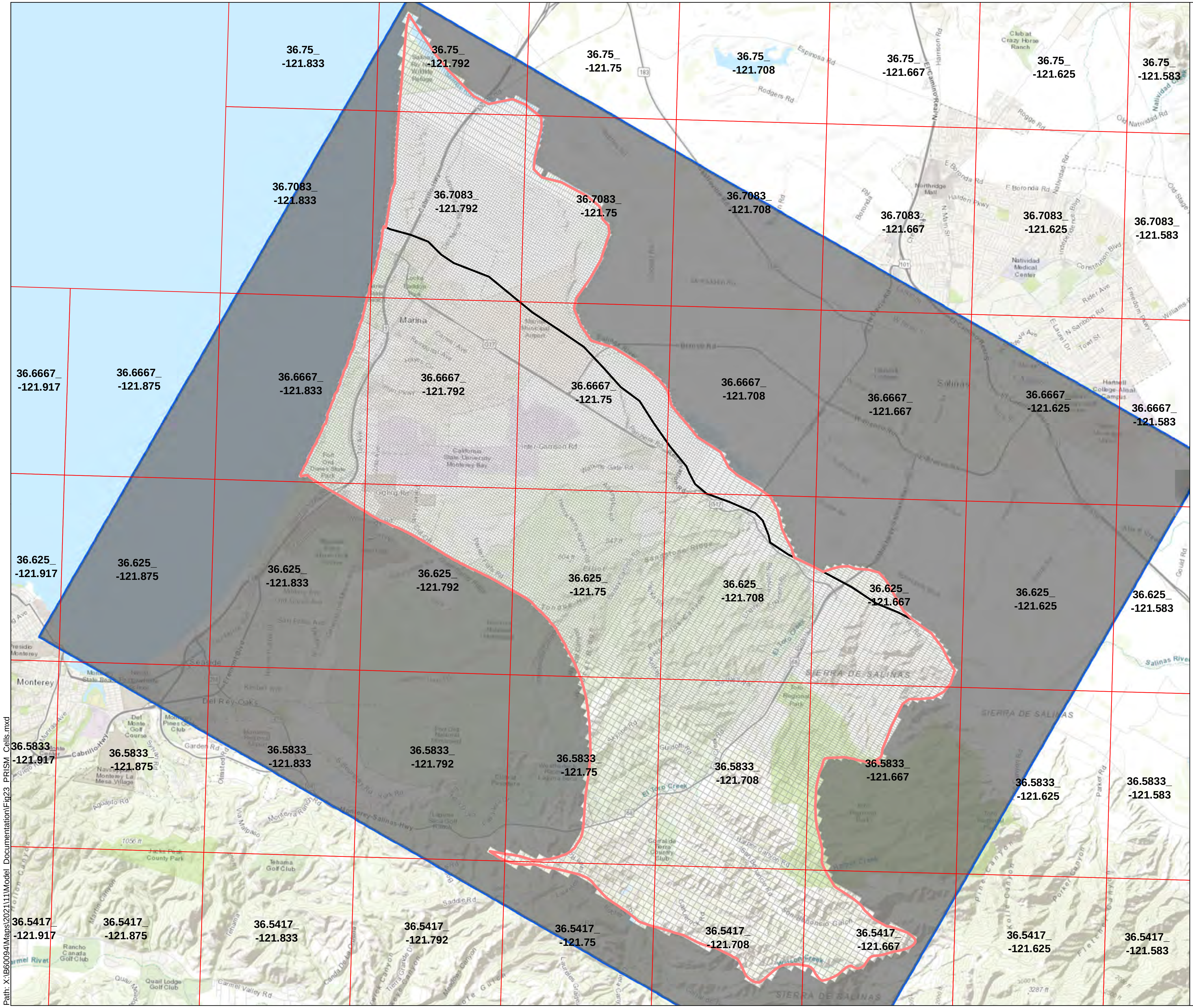
DRAFT

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

eki environment & water

Figure 22

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig22 SSURGO Saturated Hydraulic Conductivity.mxd



Legend

🟥 PRISM Cells

🟥 MBGWFM Active Area

▭ Monterey Subbasin

MBGWFM Grid

⬜ Active Cells

▩ Inactive Cells

🟦 Grid Extent

Abbreviations

DWR = California Department of Water Resources
Lat/Long = latitude and longitude
MBGWFM = Monterey Subbasin Groundwater Flow Model
PRISM = Parameter-elevation Regressions on Independent Slopes Model

Notes

1. All locations are approximate.
2. Labels show PRISM cell identifiers in Lat_Long convention.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N
0 1 2
(Scale in Miles)

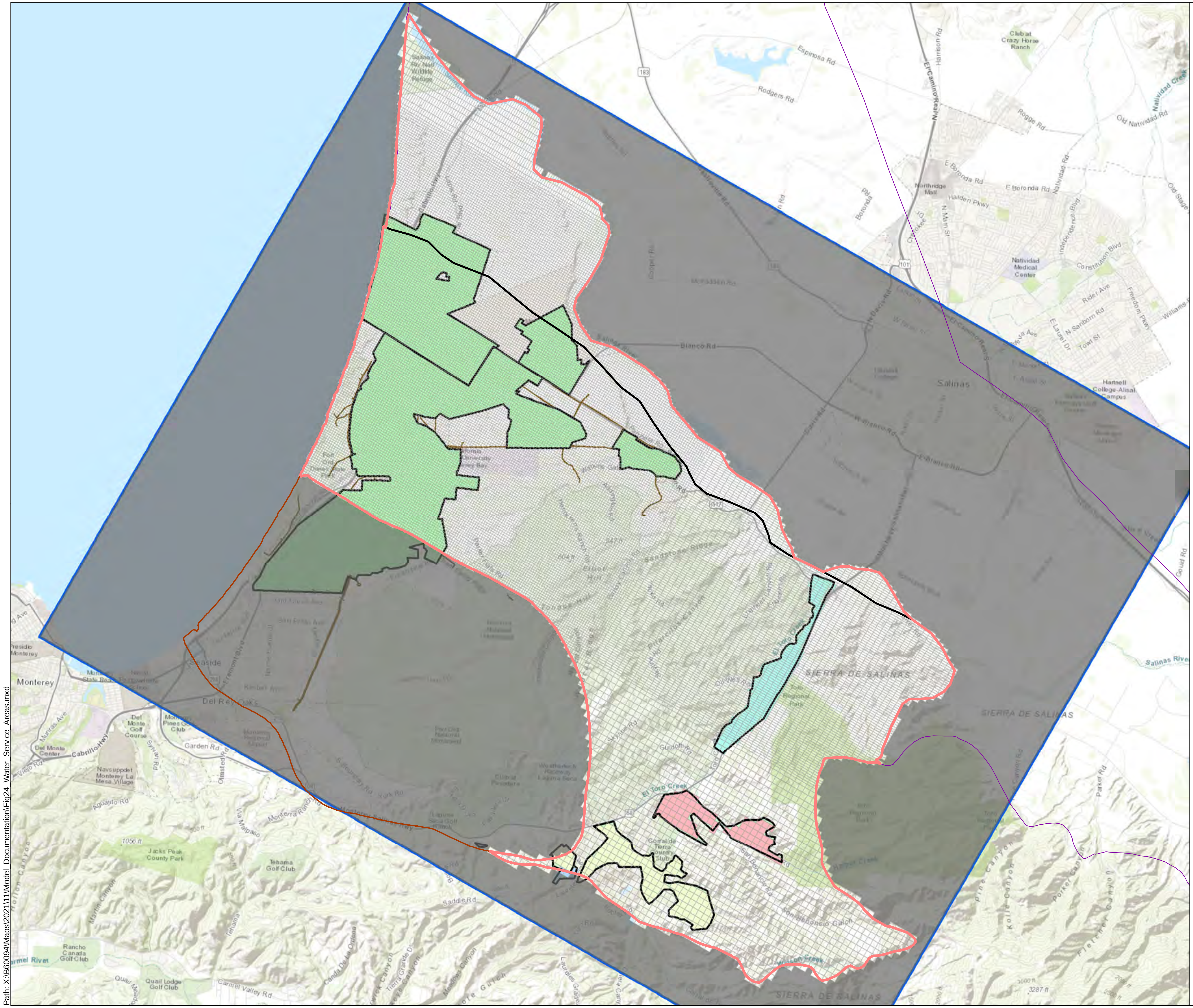
DRAFT

PRISM Cells

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 23

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig23_PRISM_Cells.mxd



Legend

- 🟥 MBGWFM Active Area
- ⬛ Monterey Subbasin
- 🟫 Seaside Subbasin
- 🟪 180/400-Foot Aquifer Subbasin

MBGWFM Grid

- ⬜ Active Cells
- ⬛ Inactive Cells
- 🟦 Grid Extent

Water Service Areas

- 🟥 CAW Ambler
- 🟦 CAW Hidden Hills
- 🟨 CAW Toro
- 🟦 CWS
- 🟩 MCWD

Abbreviations

DWR = California Department of Water Resources
CAW = CalAm Water
CWS = California Water Service
MBGWFM = Monterey Subbasin Groundwater Flow Model
MCWD = Marina Coast Water District

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

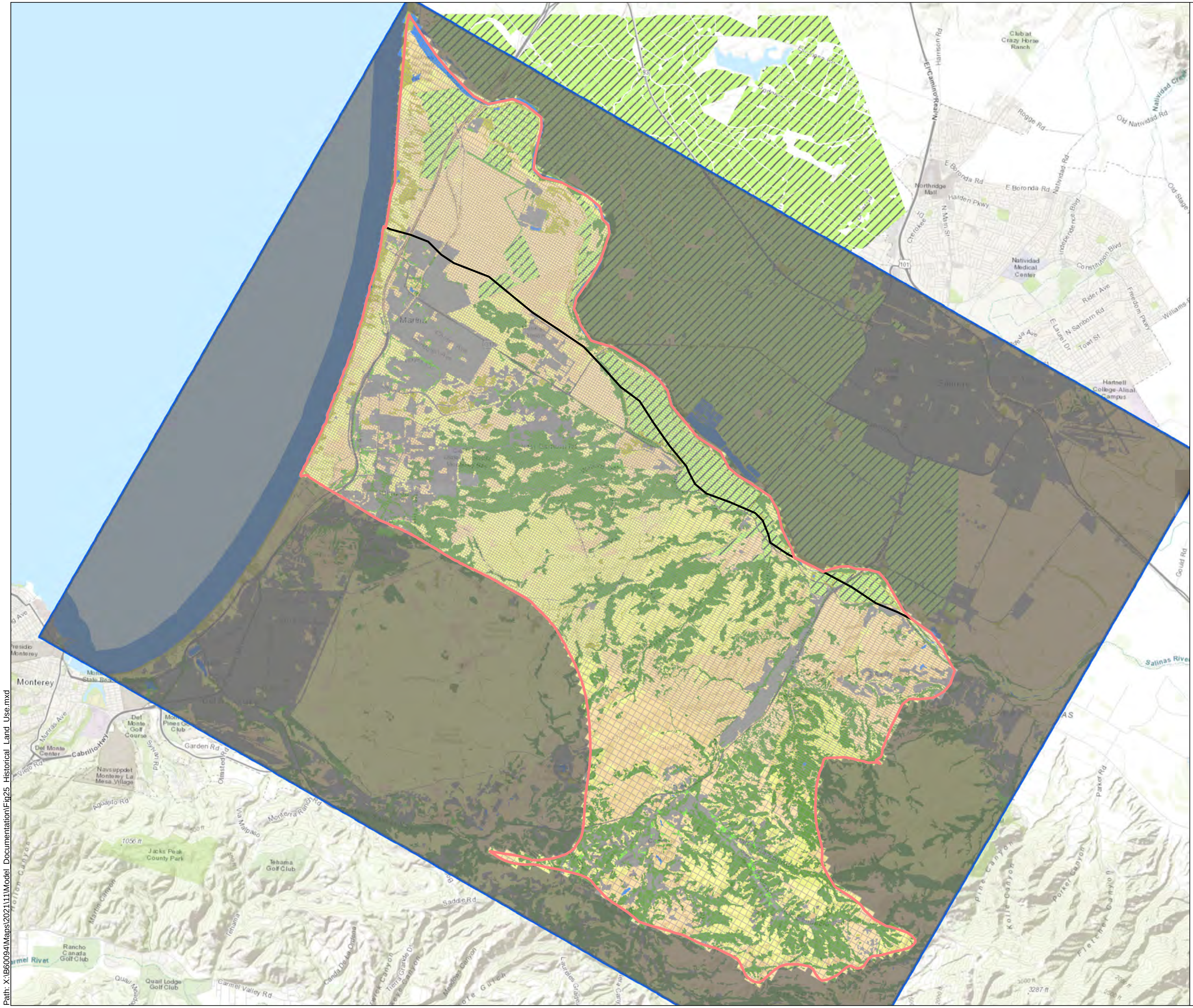
DRAFT

eki environment & water

Water Service Areas

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 24

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig24_Water_Service_Areas.mxd



Legend

- ▭ Monterey Subbasin
- ▭ MBGWFM Active Area
- ▭ Grid Extent

MBGWFM Grid

- □ Active Cells
- ■ Inactive Cells

Agricultural Areas

- ▨ Truck Nursery and Berry Crops

CalVeg Land Use Classes

- ■ Barren
- ■ Conifer / Woodland
- ■ Hardwood Forest/Woodland
- ■ Herbaceous
- ■ Mixed Conifer & Hardwood Forest
- ■ Shrub
- ■ Urban
- ■ Water

Abbreviations

CalVeg = Classification and Assessment with Landsat of Visible Ecological Groupings
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model
USDA FS = United States Department of Agriculture, Forest Service

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. CalVeg data sourced from the USDA FS website.
3. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

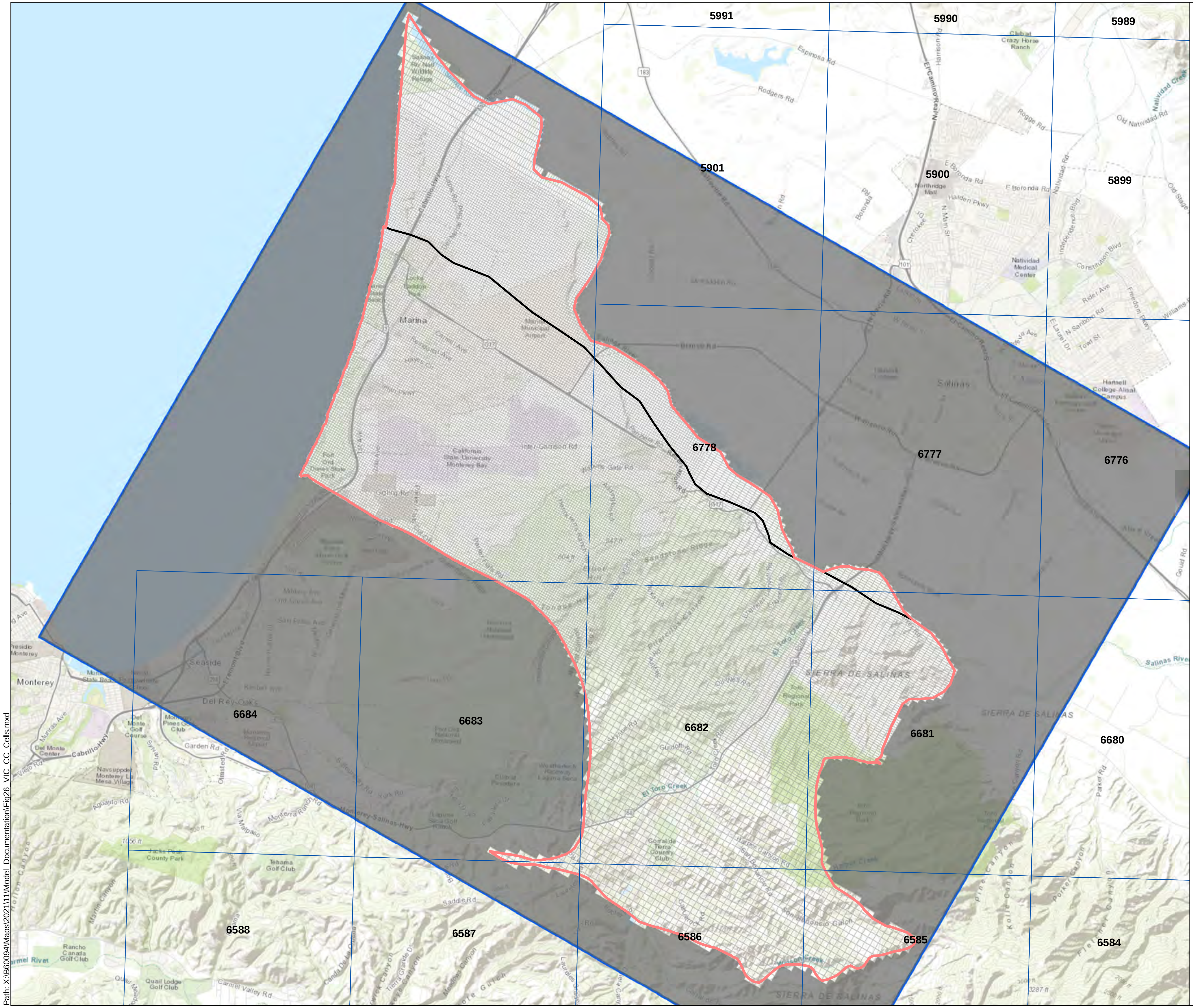
eki environment & water

Historical Land Use

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 25

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig25_Historical_Land_Use.mxd



Legend

- ☐ VIC Grid Cells
- ☐ MBGWFM Active Area
- ☐ Monterey Subbasin

MBGWFM Grid

- ☐ Active Cells
- ■ Inactive Cells
- ☐ Grid Extent

Abbreviations

DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model
VIC = Variable Infiltration Capacity

Notes

1. All locations are approximate.
2. Labels show VIC cell identifiers.
3. Climate change factors for areas within the active MBGWFM grid not covered by a VIC grid cell were estimated by taking an average from VIC cells 5901 and 6778.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

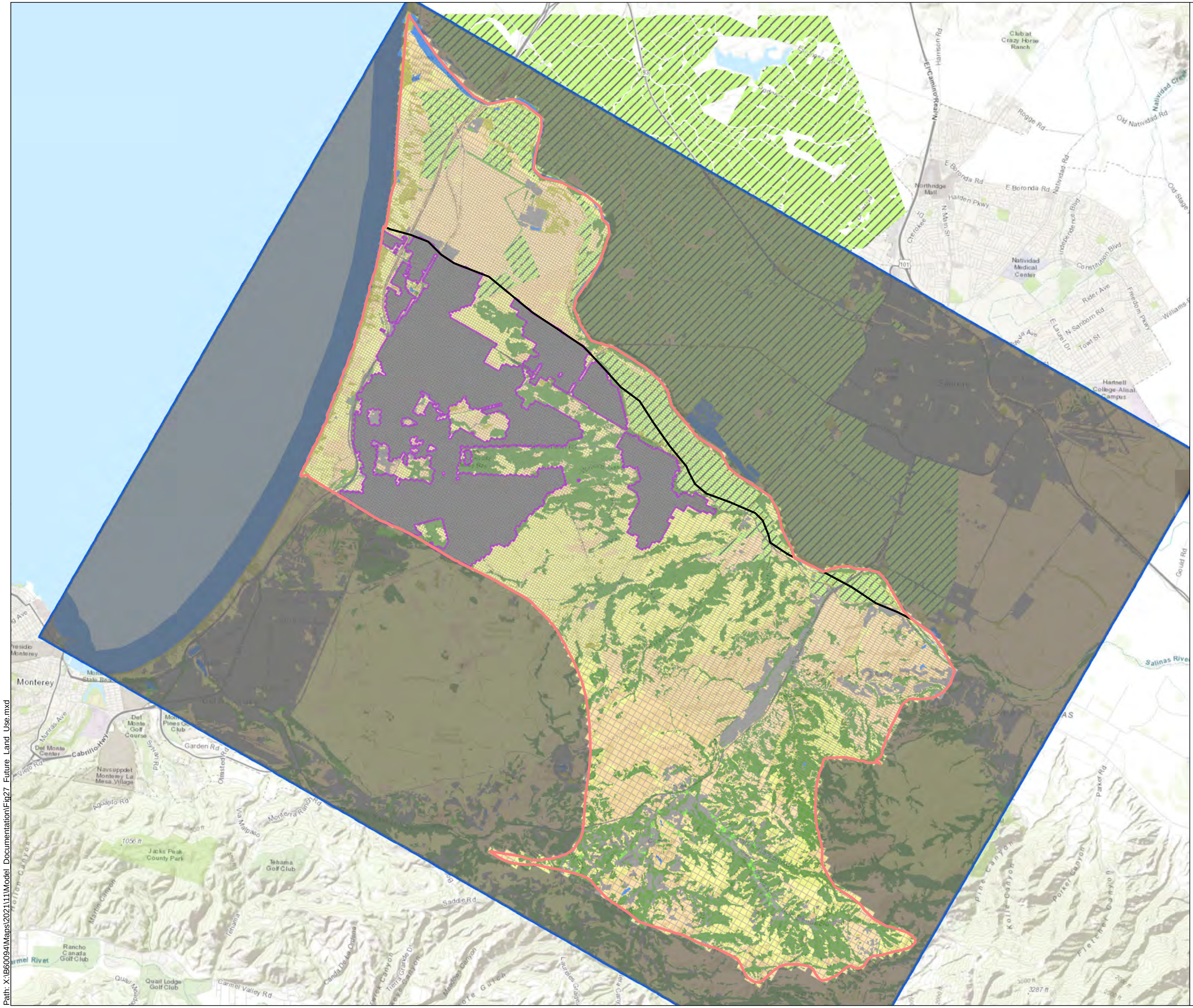
N 0 1 2
(Scale in Miles)

VIC Grid Cells Used for Climate Change Scenarios

DRAFT

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 26

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig26_VIC_CC_Cells.mxd



Legend

▭ Monterey Subbasin

▭ MBGWFM Active Area

▭ Grid Extent

▭ MCWD Future Stormwater Catchment Area

MBGWFM Grid

□ Active Cells

■ Inactive Cells

Agricultural Areas

▨ Truck Nursery and Berry Crops

CalVeg Land Use Classes

■ Barren

■ Conifer / Woodland

■ Hardwood Forest/Woodland

■ Herbaceous

■ Mixed Conifer & Hardwood Forest

■ Shrub

■ Urban

■ Water

Abbreviations

CalVeg = Classification and Assessment with Landsat of Visible Ecological Groupings
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model
MCWD = Marina Coast Water District
USDA FS = United States Department of Agriculture, Forest Service

Notes

1. All locations are approximate.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. CalVeg data sourced from the USDA FS website.
3. Future MCWD land use based on map obtained from 2019 Water Master Plan
4. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

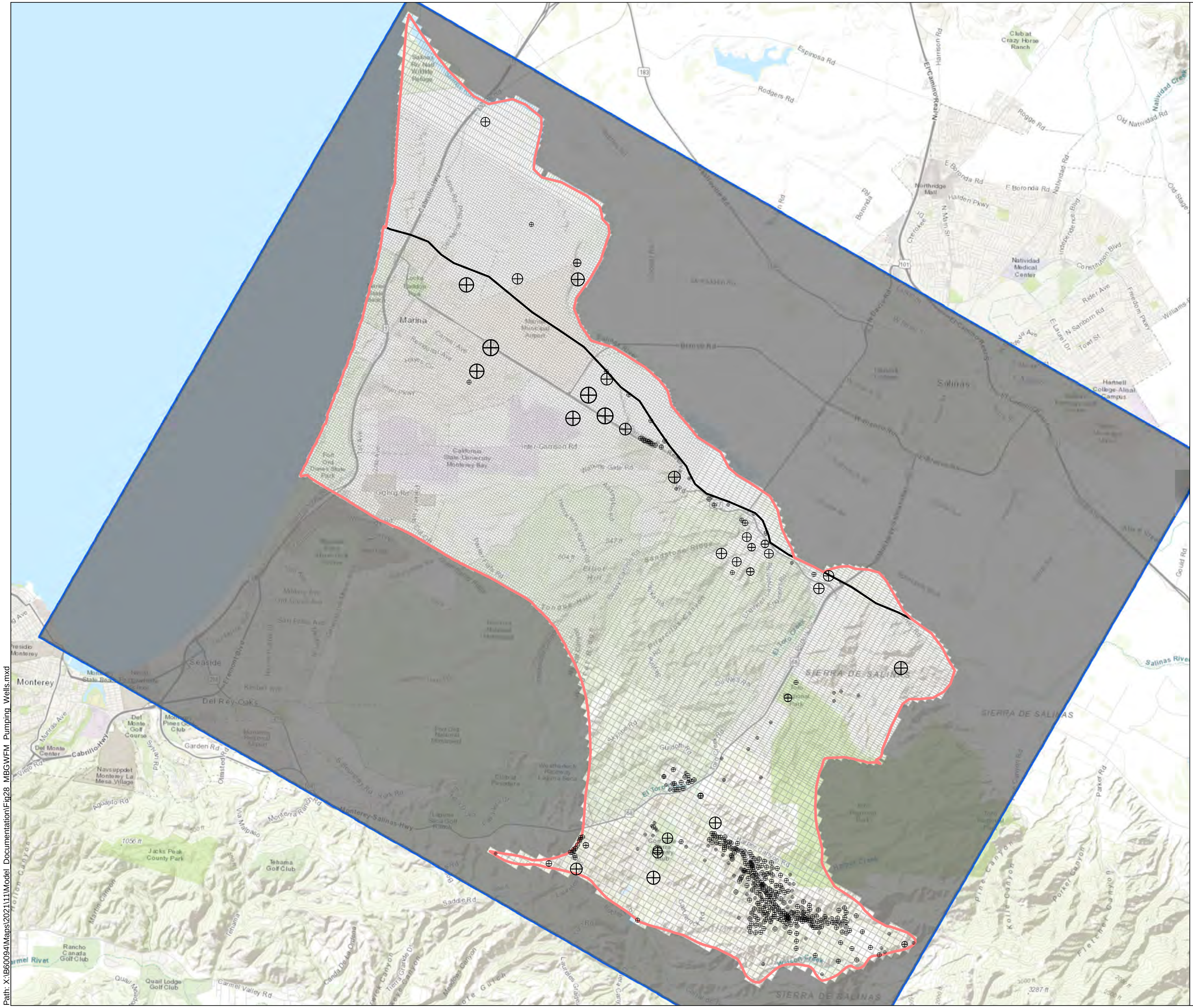
DRAFT

eki environment & water

Future Land Use

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 27

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig27_Future_Land_Use.mxd



Legend

▭ Monterey Subbasin

🟥 MBGWFM Active Area

🟦 Grid Extent

MBGWFM Grid

☐ Active Cells

▨ Inactive Cells

Pumping Wells

Average Monthly Pumping Rate (AF/month)

⊕	0.00 - 0.02
⊕	0.03 - 0.31
⊕	0.32 - 1.11
⊕	1.12 - 2.22
⊕	2.23 - 4.49
⊕	4.50 - 8.62
⊕	8.63 - 15.80
⊕	15.81 - 22.45
⊕	22.46 - 49.40
⊕	49.41 - 74.28

Abbreviations
AF = acre-feet
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.
2. Pumping well symbol size reflects average historical pumping rate in units of acre-feet per month.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

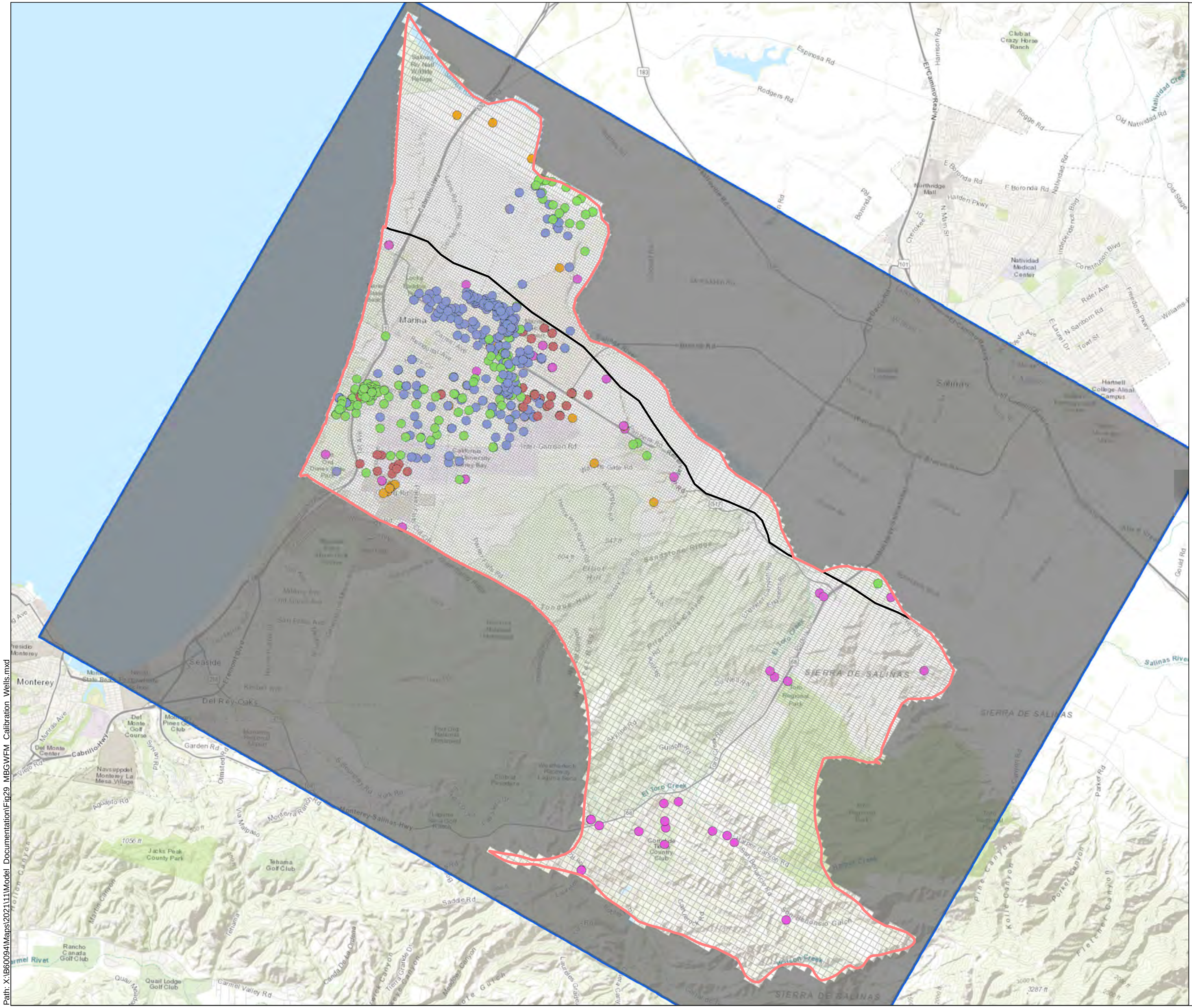
DRAFT

eki environment & water

MBGWFM Pumping Wells

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03
Figure 28

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig28_MBGWFM_Pumping_Wells.mxd



Legend

- □ Monterey Subbasin
- □ MBGWFM Active Area
- □ Grid Extent

MBGWFM Grid

- □ Active Cells
- ■ Inactive Cells

Calibration Wells

- ● Layer 1
- ● Layer 3
- ● Layer 5
- ● Layer 7
- ● Layer 8

Abbreviations
DWR = California Department of Water Resources
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

DRAFT

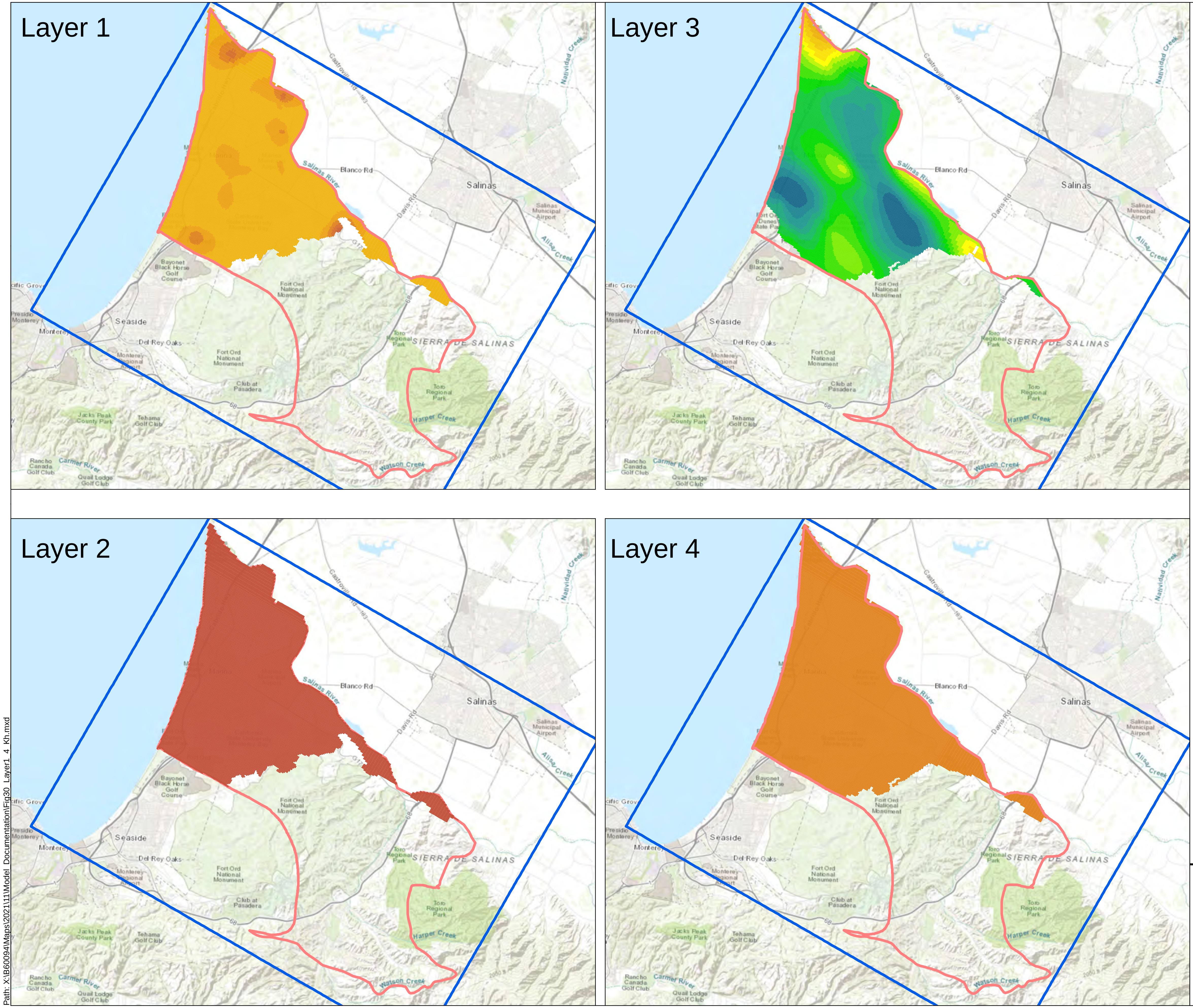
eki environment & water

MBGWFM Calibration Wells

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 29

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig29_MBGWFM_Calibration_Wells.mxd



Legend

▭ Grid Extent

▭ MBGWFM Active Area

Horizontal Hydraulic Conductivity (ft/d)

🟥	< 5
🟥	6 - 10
🟧	11 - 15
🟧	16 - 20
🟧	21 - 25
🟨	26 - 30
🟨	31 - 35
🟨	36 - 40
🟨	41 - 45
🟩	46 - 50
🟩	51 - 55
🟩	56 - 60
🟩	61 - 65
🟩	66 - 70
🟩	71 - 75
🟩	76 - 80
🟦	81 - 85
🟦	86 - 90
🟦	91 - 95
🟦	96 - 100
🟦	> 100

Abbreviations
ft/d = feet per day
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 3 6
(Scale in Miles)

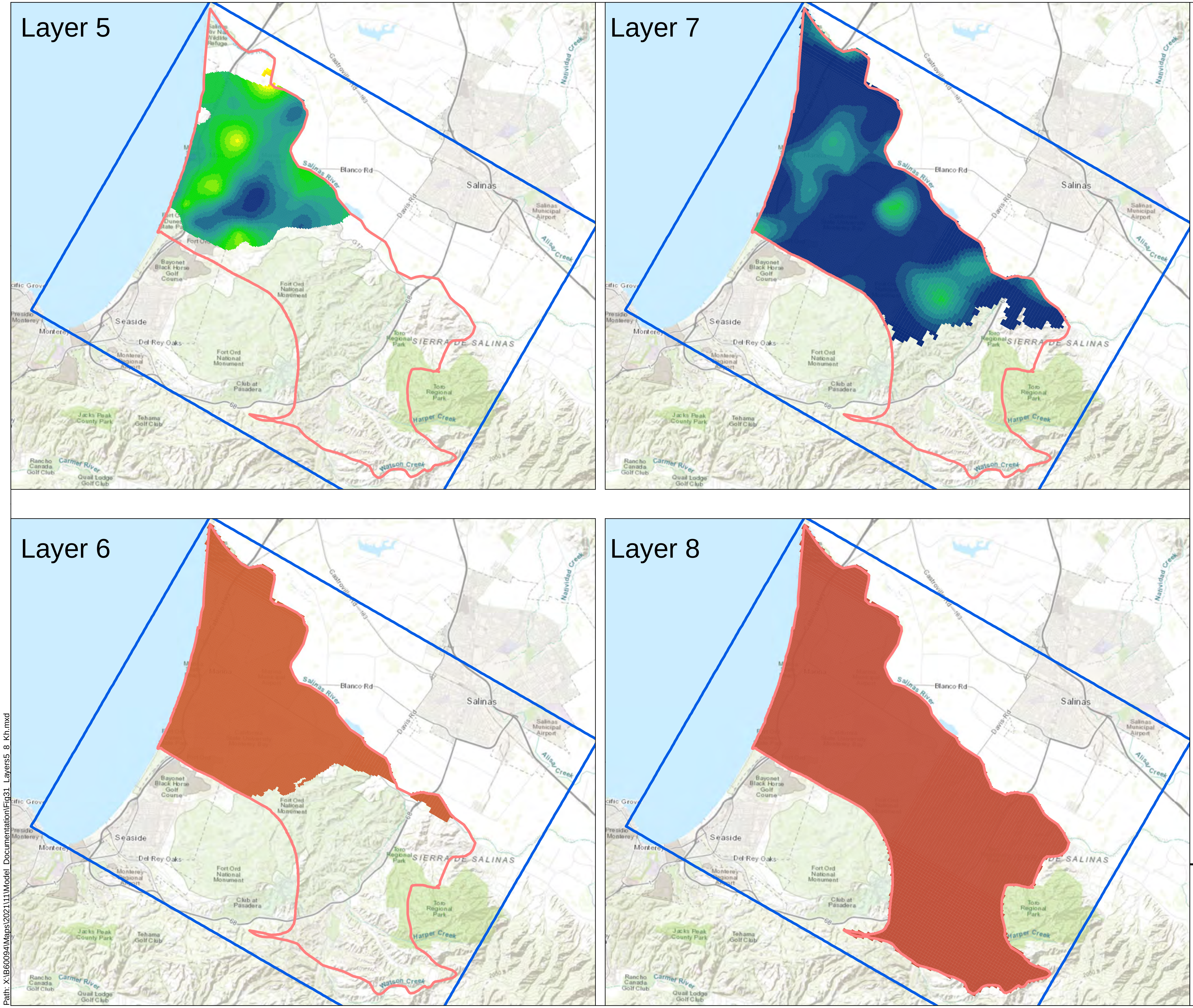
DRAFT

Horizontal Hydraulic Conductivity Layers 1 - 4

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.12
Figure 30

eki environment & water

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig30 Layer1 4 Kh.mxd



Legend

🟦 Grid Extent

🟥 MBGWFM Active Area

Horizontal Hydraulic Conductivity (ft/d)

🟥 < 5
🟥 6 - 10
🟧 11 - 15
🟧 16 - 20
🟧 21 - 25
🟨 26 - 30
🟨 31 - 35
🟨 36 - 40
🟨 41 - 45
🟩 46 - 50
🟩 51 - 55
🟩 56 - 60
🟩 61 - 65
🟩 66 - 70
🟩 71 - 75
🟩 76 - 80
🟦 81 - 85
🟦 86 - 90
🟦 91 - 95
🟦 96 - 100
🟦 > 100

Abbreviations
ft/dl = feet per day
MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes
1. All locations are approximate.

Sources
1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

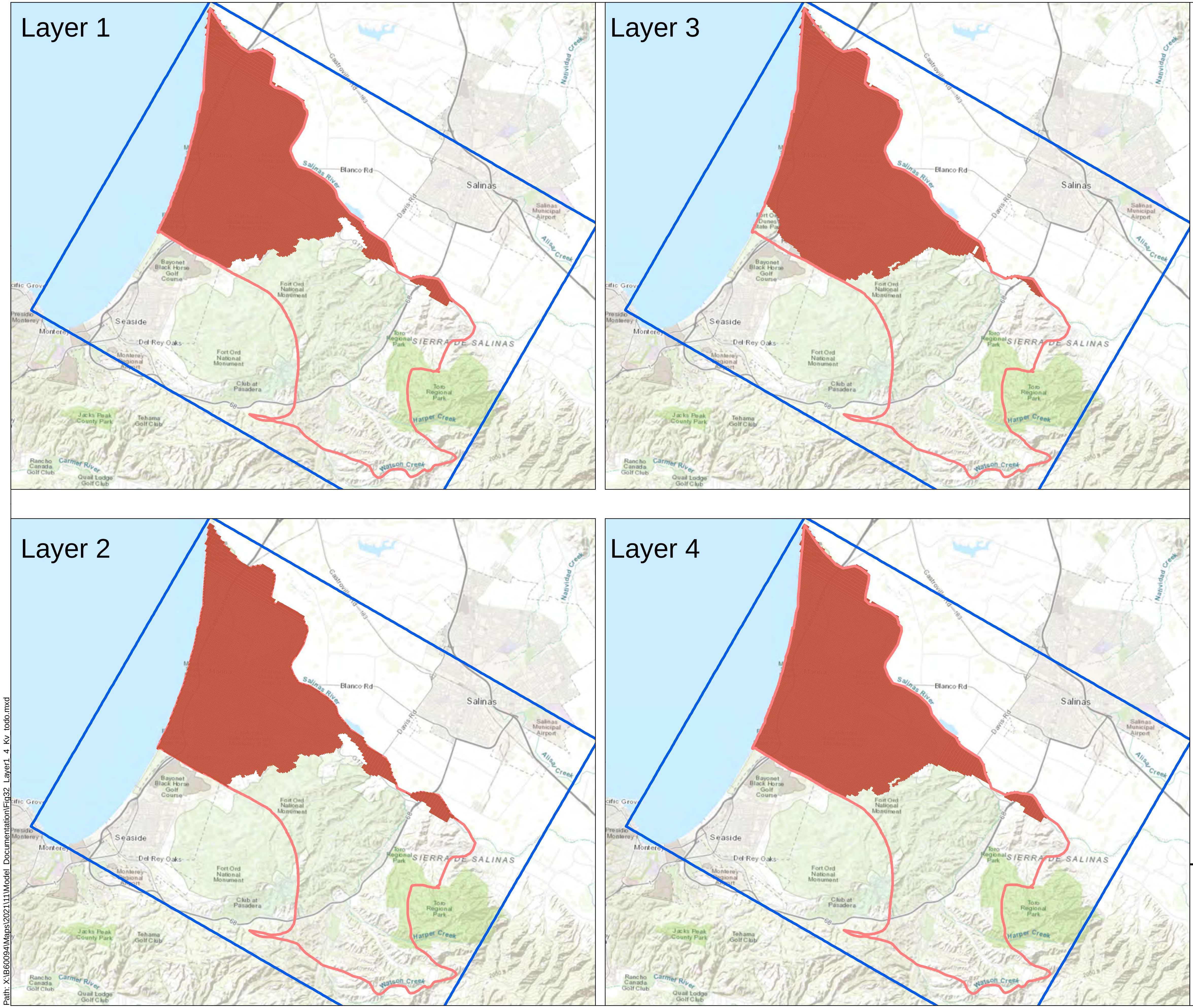
DRAFT

Horizontal Hydraulic Conductivity Layers 5 – 8

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.12
Figure 31

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig31_Layers5_8_Kh.mxd



Legend

▭ Grid Extent

▭ MBGWFM Active Area

Vertical Hydraulic Conductivity (ft/d)

- 🟥 < 5
- 🟧 5 - 10
- 🟧 10 - 15
- 🟨 15 - 20
- 🟨 20 - 25
- 🟨 25 - 30
- 🟩 30 - 35
- 🟩 35 - 40
- 🟩 40 - 45
- 🟩 45 - 50
- 🟦 50 - 55
- 🟦 55 - 60
- 🟦 > 60

Abbreviations

ft/d = feet per day

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

DRAFT

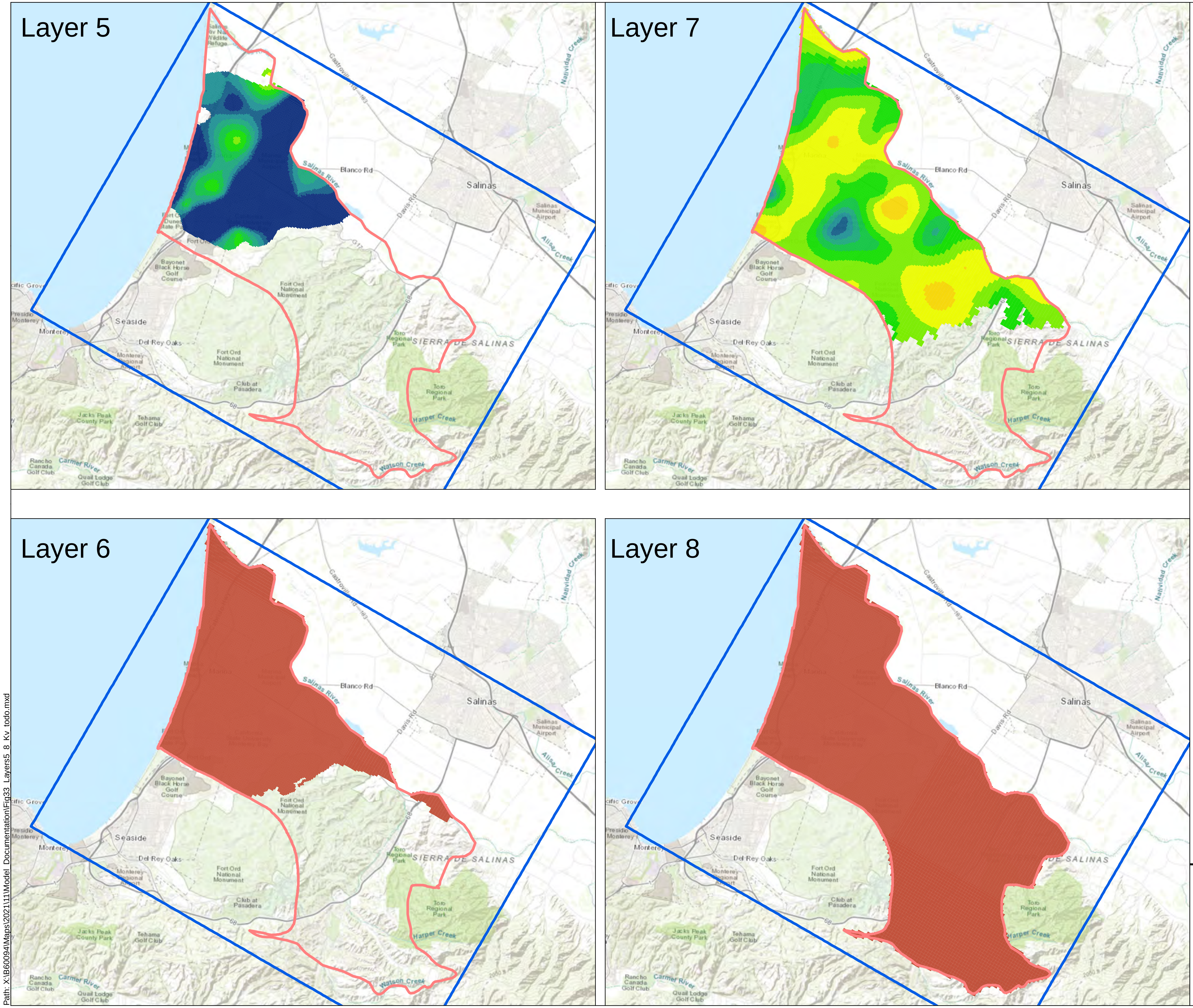
Vertical Hydraulic Conductivity
Layers 1 - 4

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.12

Figure 32

eki environment & water

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig32_Layer1_4_Kv_todo.mxd



Legend

▭ Grid Extent

▭ MBGWFM Active Area

Vertical Hydraulic Conductivity (ft/d)

- 🟥 < 5
- 🟧 5 - 10
- 🟧 10 - 15
- 🟨 15 - 20
- 🟨 20 - 25
- 🟨 25 - 30
- 🟩 30 - 35
- 🟩 35 - 40
- 🟩 40 - 45
- 🟩 45 - 50
- 🟦 50 - 55
- 🟦 55 - 60
- 🟦 > 60

Abbreviations

ft/dl = feet per day

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.

Sources

1. Basemap is ESRI's ArcGIS Online world topographic map, obtained 9 November 2021.

N

0 3 6

(Scale in Miles)

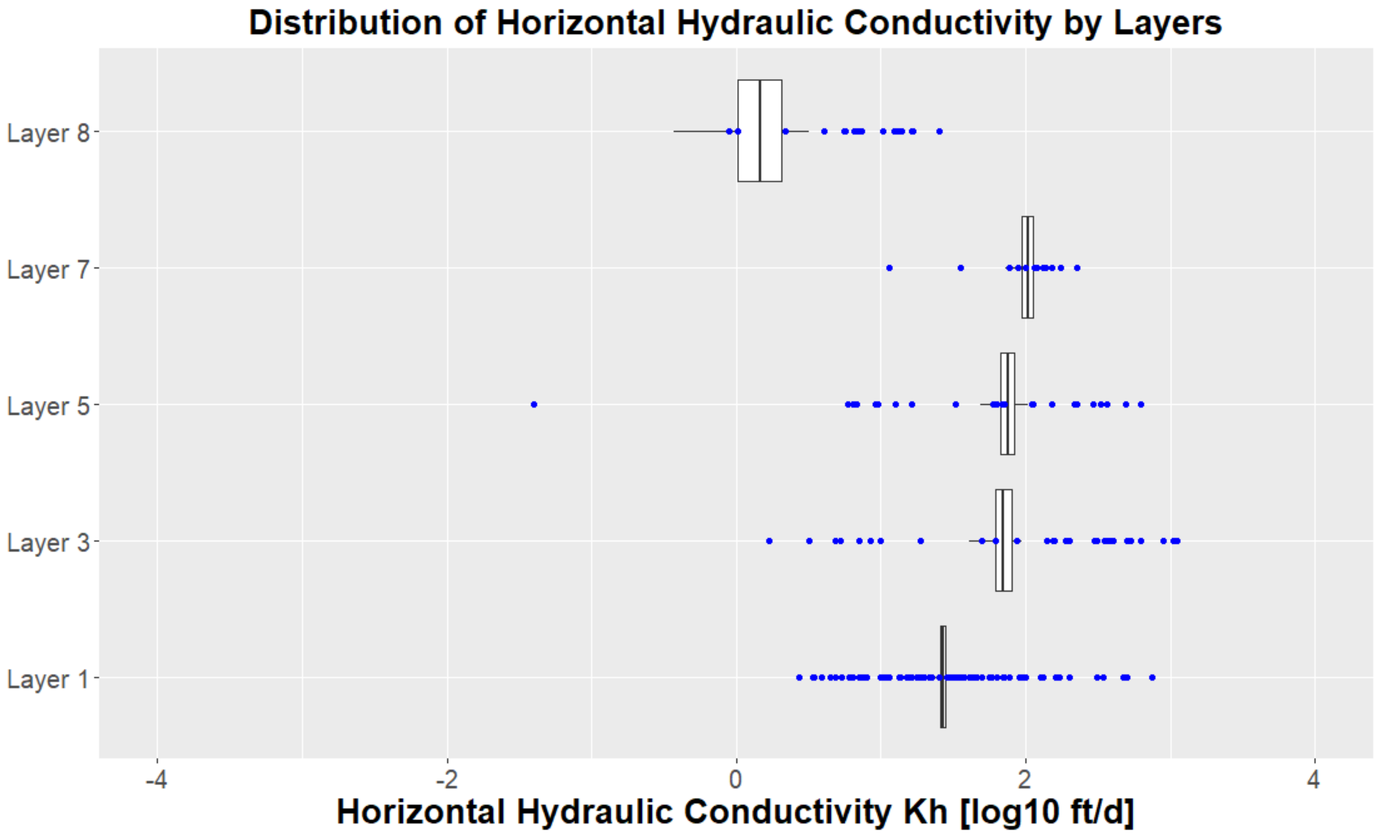
DRAFT

Vertical Hydraulic Conductivity
Layers 5 – 8

Marina Coast Water District
Monterey County, CA
November 2021
EKI B60094.12
Figure 33

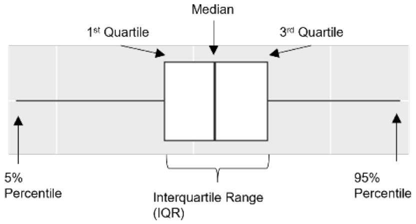
eki environment & water

Path: X:\B60094\Maps\2021\11\Model Documentation\Fig33 Layers5 8 Kv todo.mxd



Legend

● Pumping Test Measurement



Abbreviations

Kh: Horizontal Hydraulic Conductivity

Notes

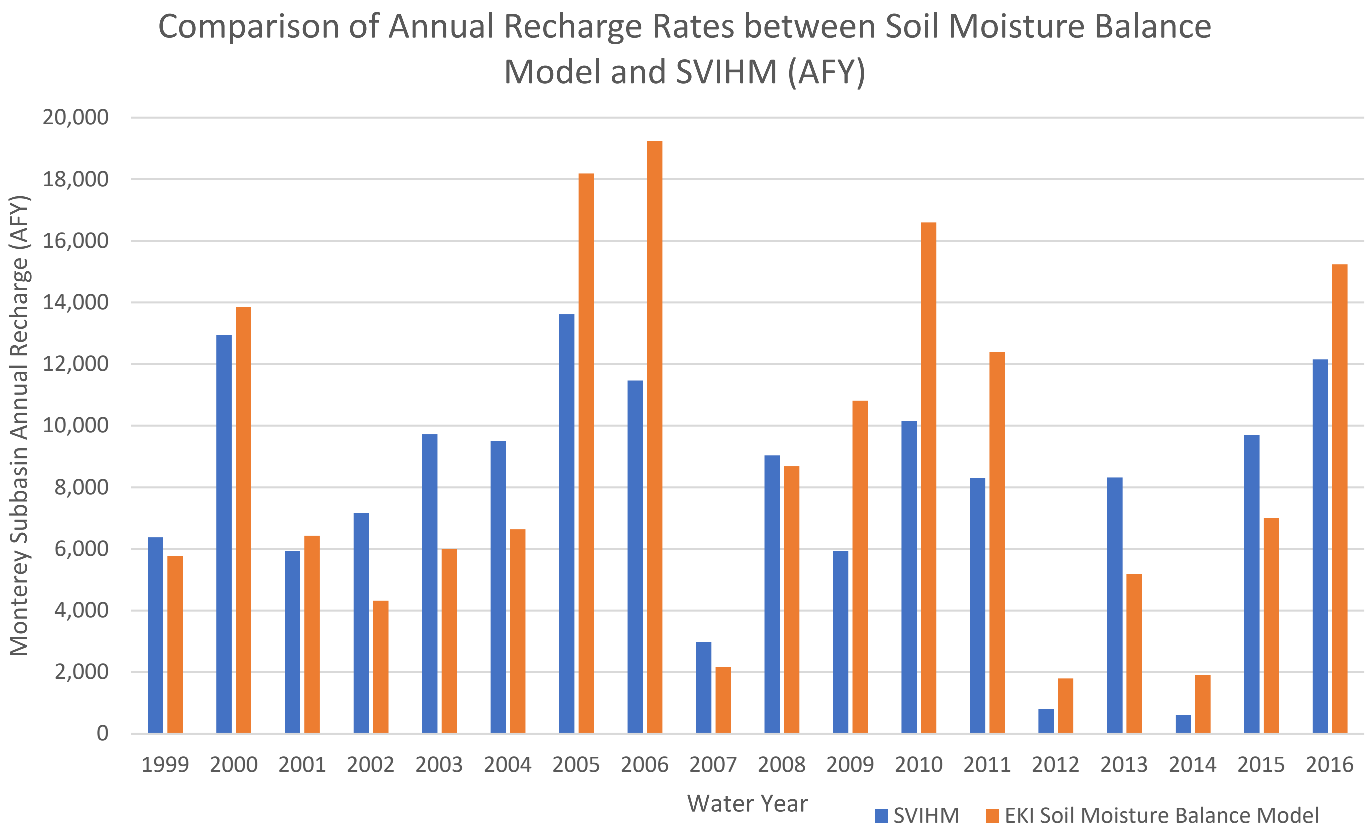
eki environment & water

Comparison of Modeled and Observed Horizontal Hydraulic Conductivity

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

DRAFT

Figure 34



Legend

🟦 = SVIHM (USGS)

🟧 = Soil Moisture Balance Model (EKI)

Abbreviations

AFY	= acre-feet per year
SVIHM	= Salinas Valley Integrated Hydrologic Model
USGS	= United States Geological Survey

Notes
1. Reported annual recharge rates are for the entire Monterey Subbasin.

Sources
1. Soil Moisture Balance Model (EKI)
2. SVIHM (USGS)

eki environment & water

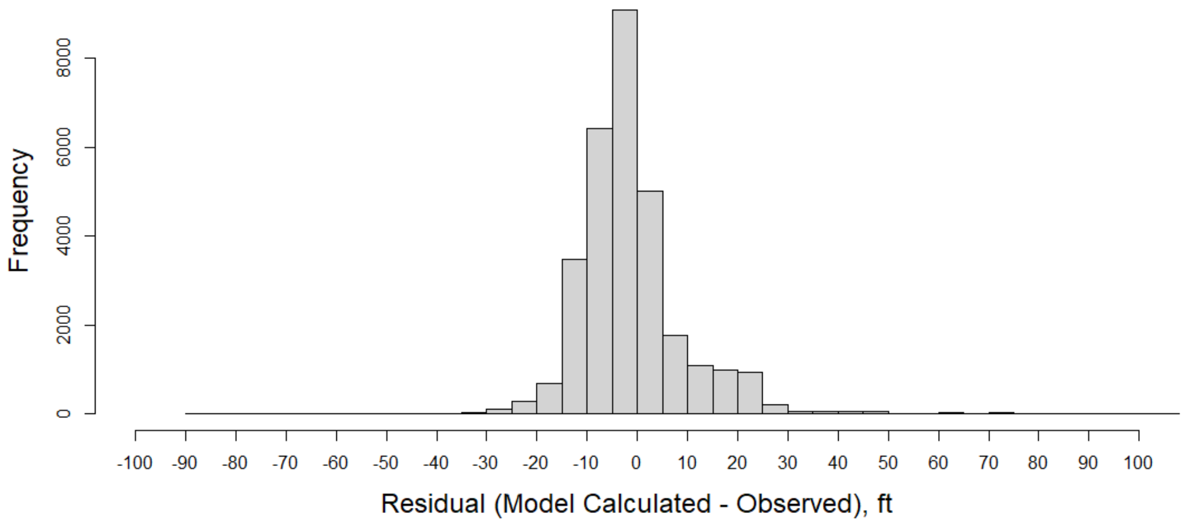
Comparison of Annual Recharge Rates between Soil Moisture Balance Model and SVIHM

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.12

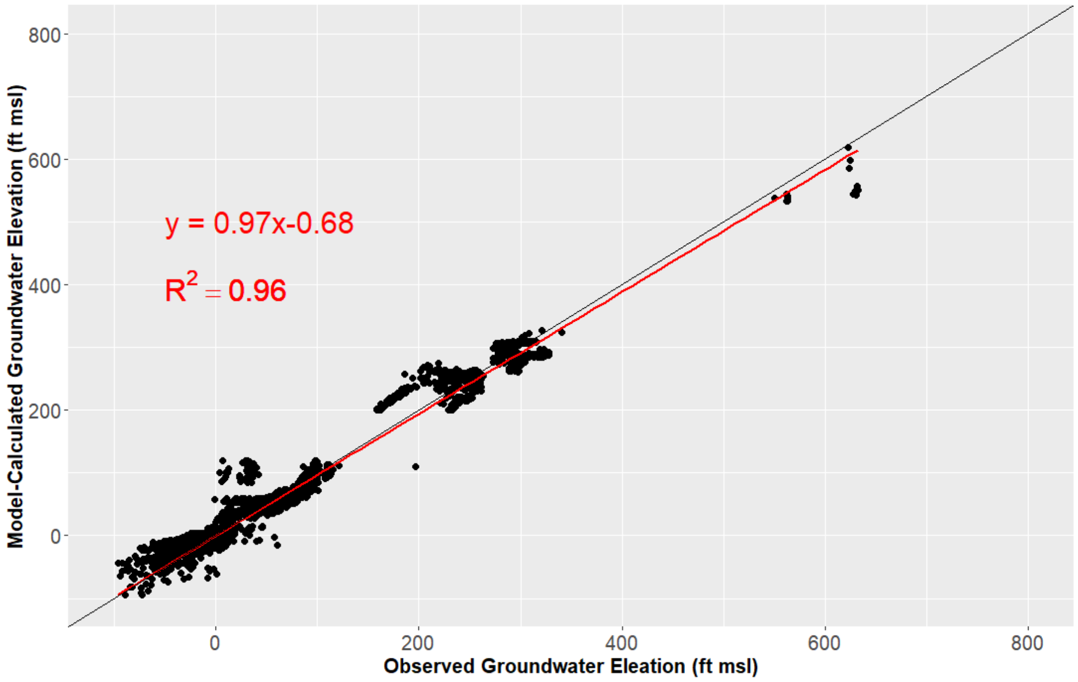
DRAFT

Figure 35

Histogram of Residuals



Simulated vs. Observed Water Level



Legend

— = 1:1

— = Linear (Observed)

● = Oberved Groundwater Elevation

Abbreviations

ft	= feet
ft msl	= feet above mean sea level

Notes

1. Residual is calculated as model-calculated minus observed groundwater elevation

Sources

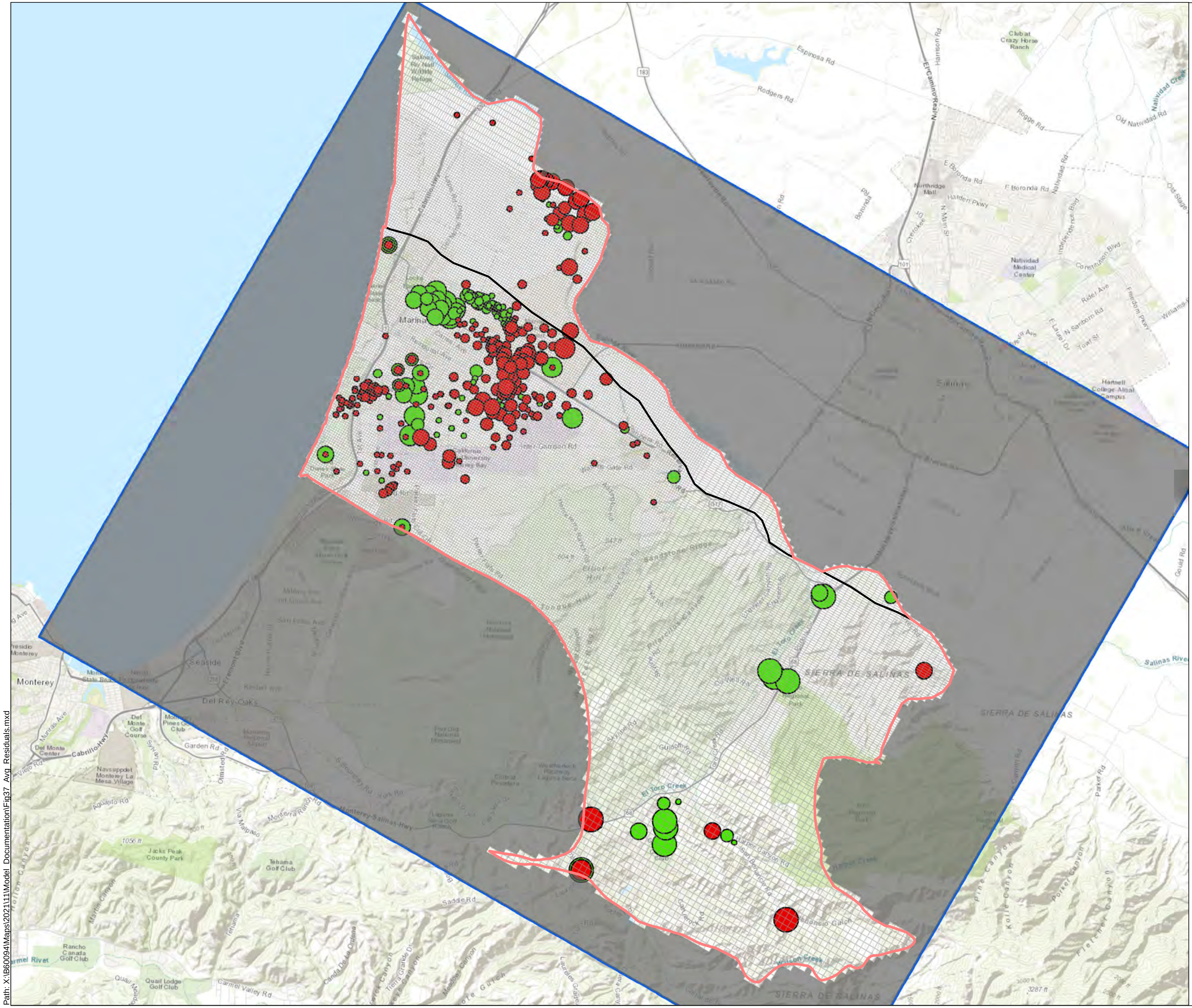
1. Monterey Subbasin Groundwater Flow Model

Calibration Statistics

DRAFT

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.12

Figure 36



Legend

▭ Monterey Subbasin

▭ MBGWFM Active Area

▭ Grid Extent

MBGWFM Grid

▭ Active Cells

■ Inactive Cells

Average Water Level Residual (ft)

🔴 < - 25

🔴 -25 to -20

🔴 -20 to -15

🔴 -15 to -10

🔴 -10 to -5

🔴 -5 to 0

🟢 0 to 5

🟢 5 to 10

🟢 10 to 15

🟢 15 to 20

🟢 20 to 25

🟢 >25

Abbreviations

DWR = California Department of Water Resources

ft = feet

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. All locations are approximate.
2. Average residuals are calculated as the difference between model-calculated and observed water levels. A larger residual magnitude equates to a larger model error at the well.

Sources

1. DWR groundwater basins are based on the boundaries defined in California's Groundwater, Bulletin 118 - 2018 Update.
2. Basemap courtesy of ESRI.

N 0 1 2
(Scale in Miles)

DRAFT

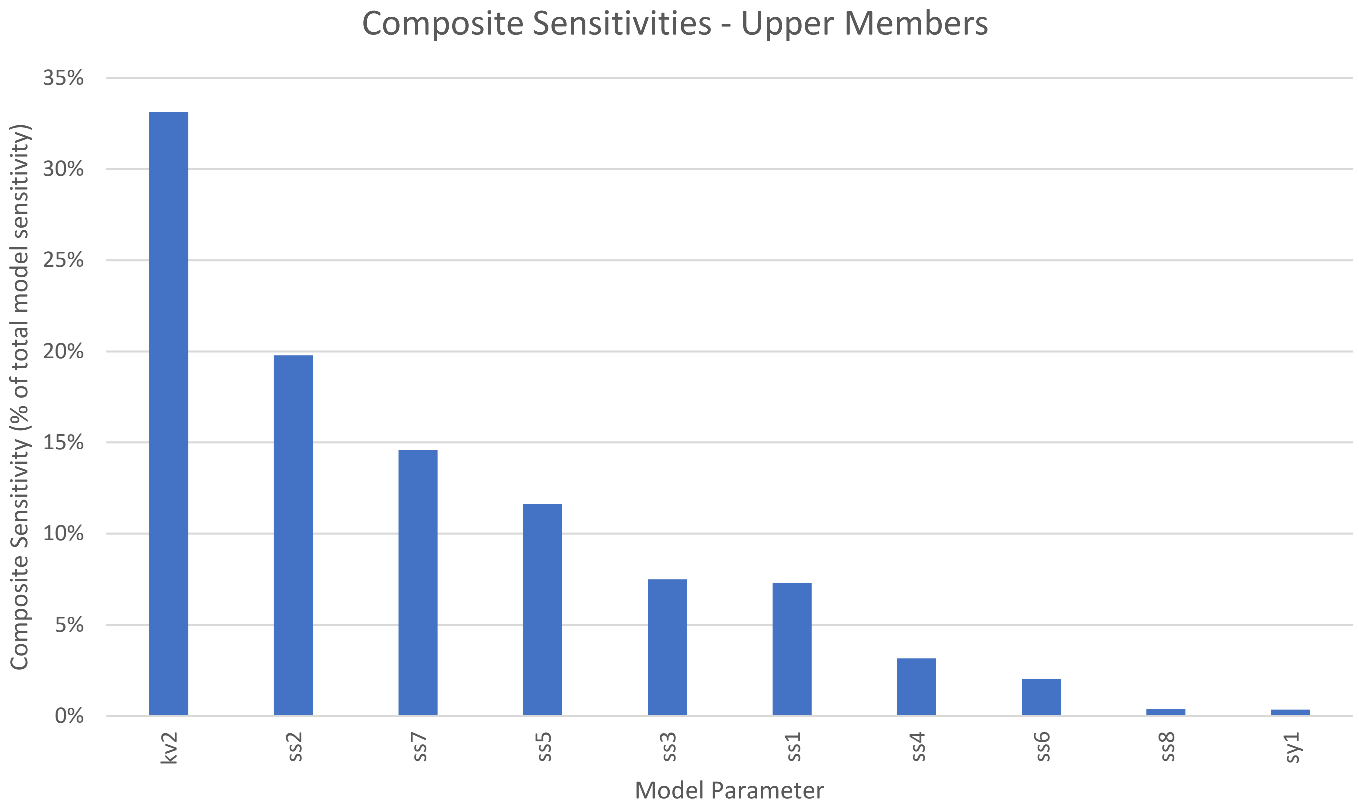
eki environment & water

Average Residuals by Well

Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.03

Figure 37

Path: X:\B60094\Maps\2021\11\Model_Documentation\Fig37_Avg_Residuals.mxd



Legend

🟦 = Composite Sensitivity

Abbreviations

MBGWFM = Monterey Subbasin Groundwater Flow Model

Notes

1. Composite Sensitivites are calculated by dividing the parameter sensitivity by the total sensitivity of all model

Sources

1. MBGWFM

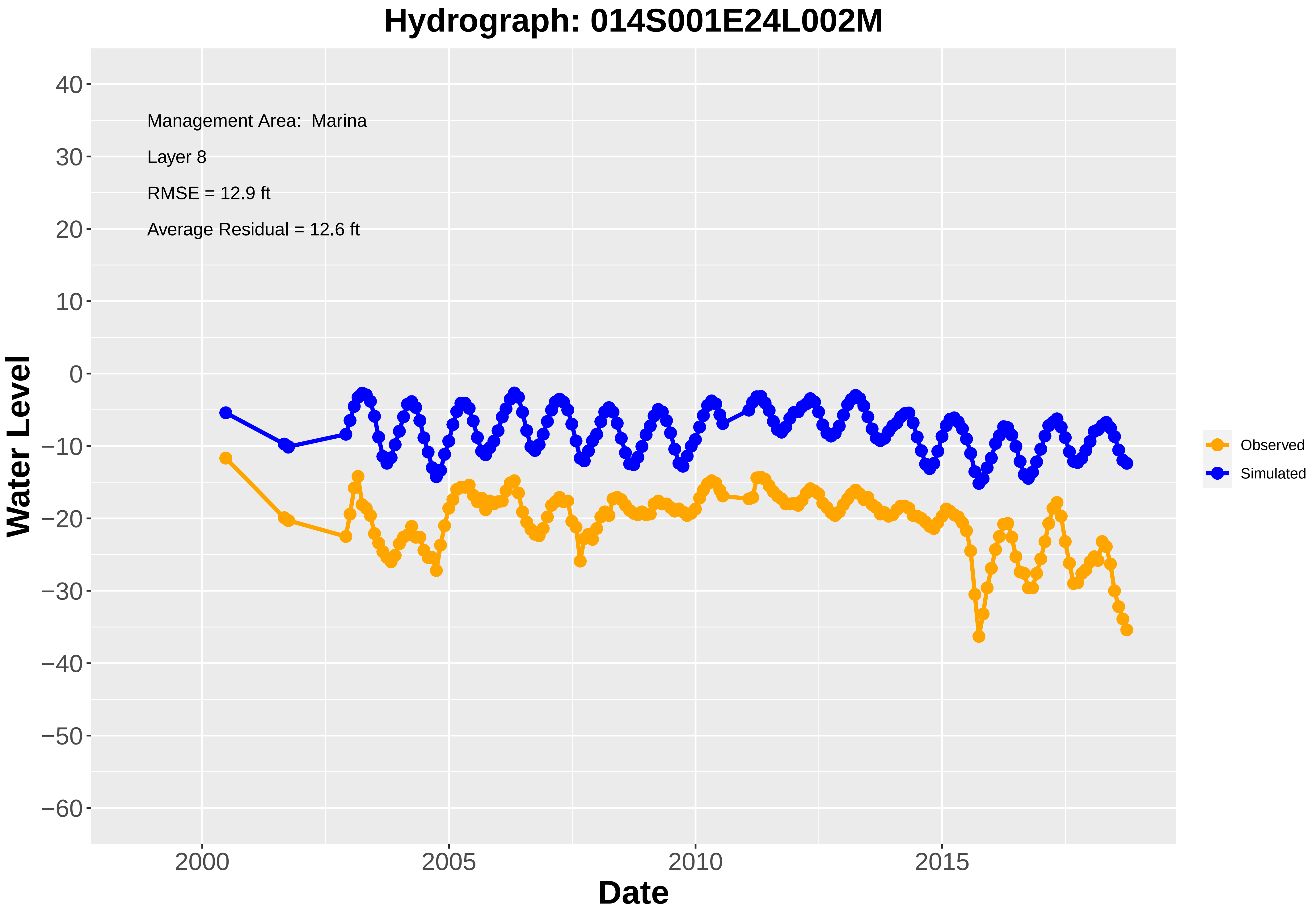
eki environment & water

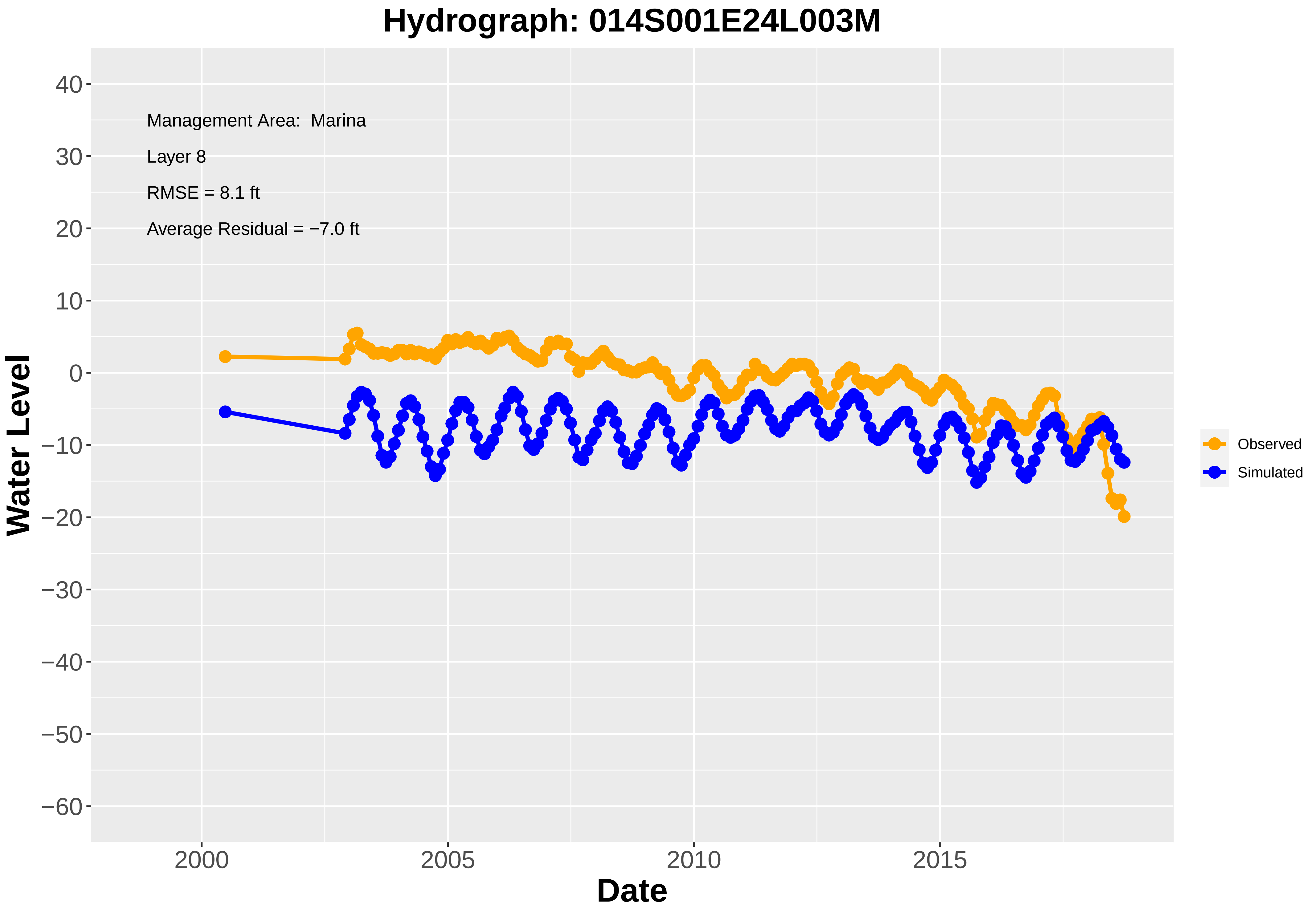
Composite Sensitivities for the Most Sensitive Model Parameters

DRAFT

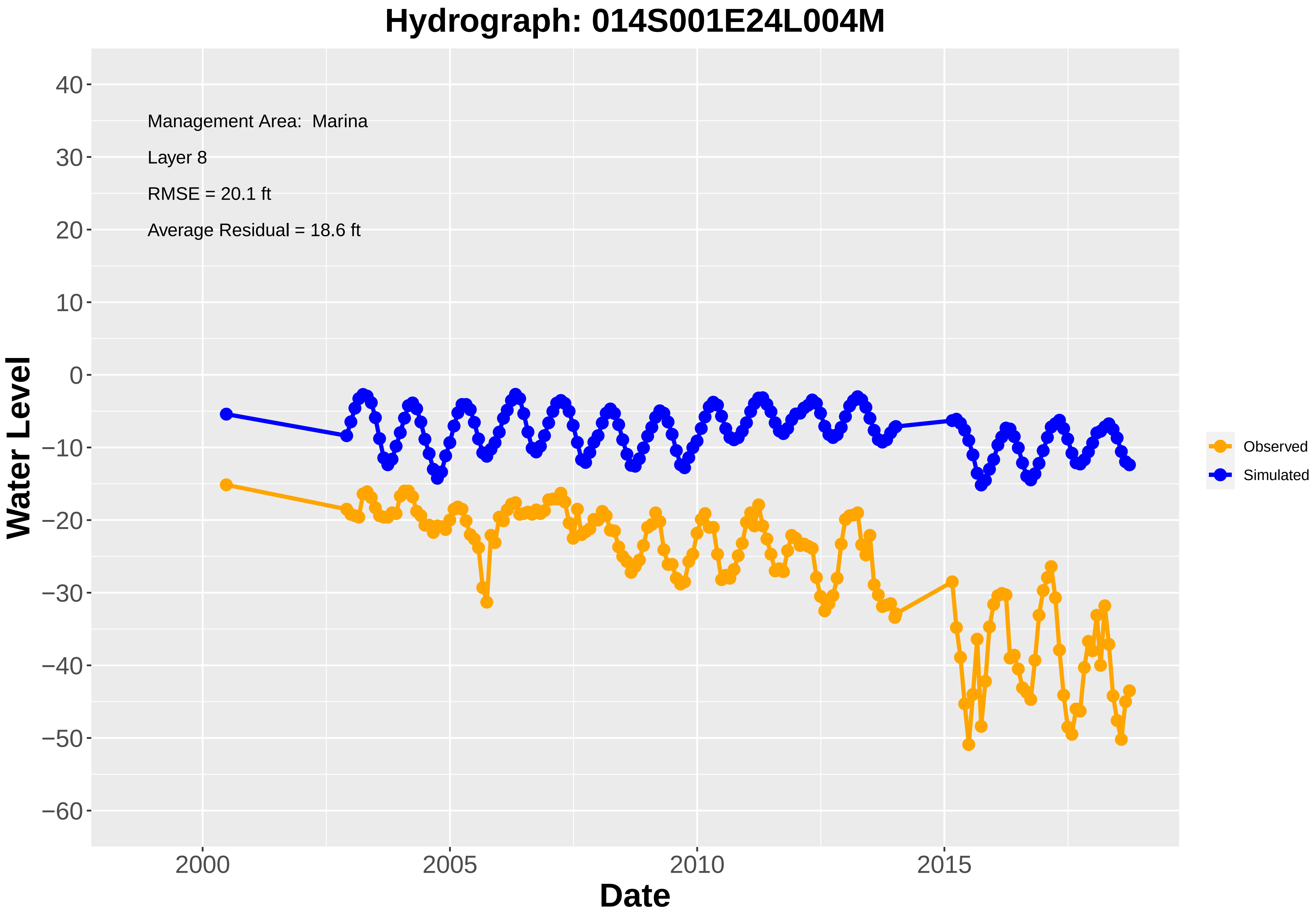
Marina Coast Water District
Monterey County, California
November 2021
EKI B60094.12
Figure 38

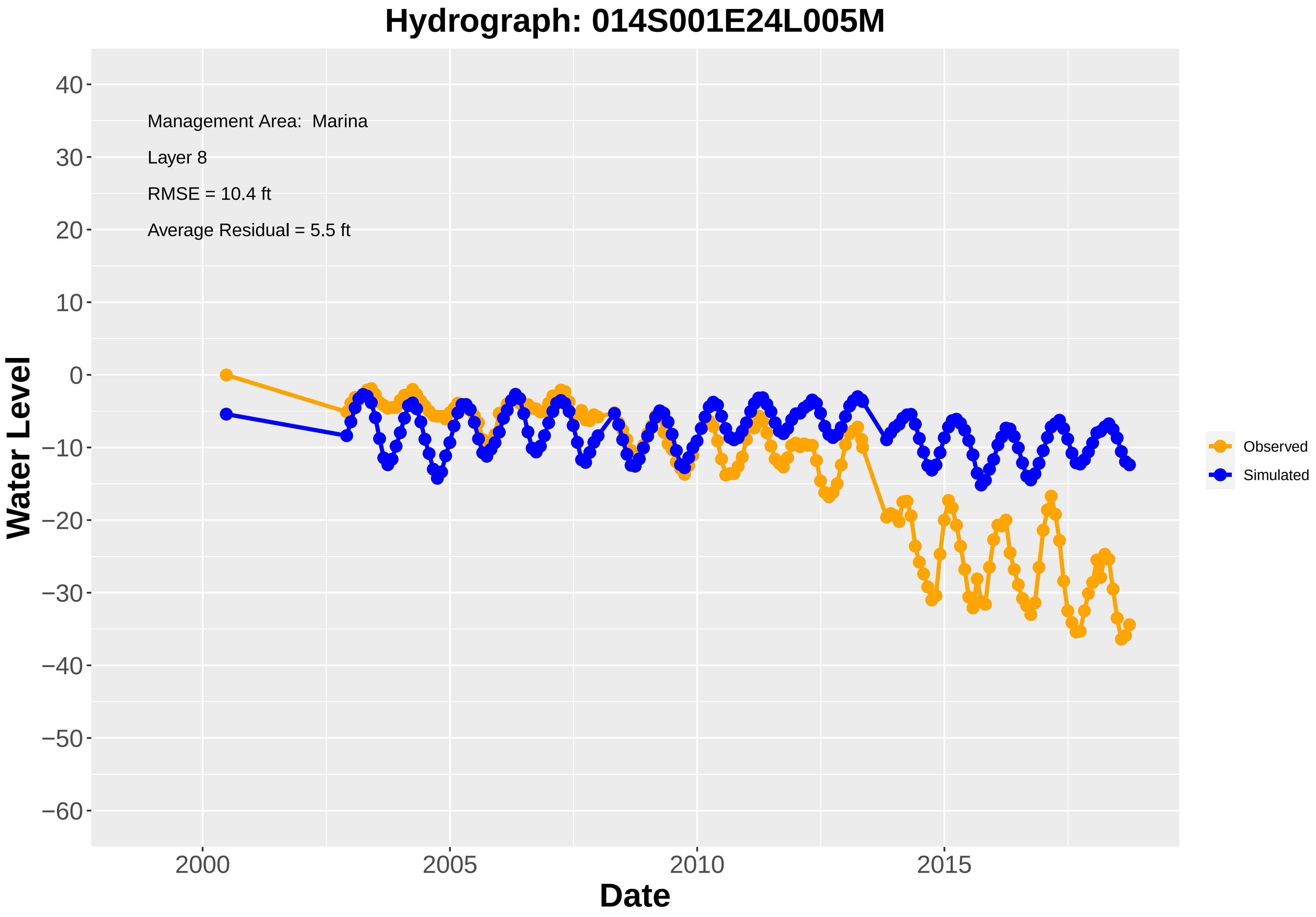
Attachment 1. Hydrographs

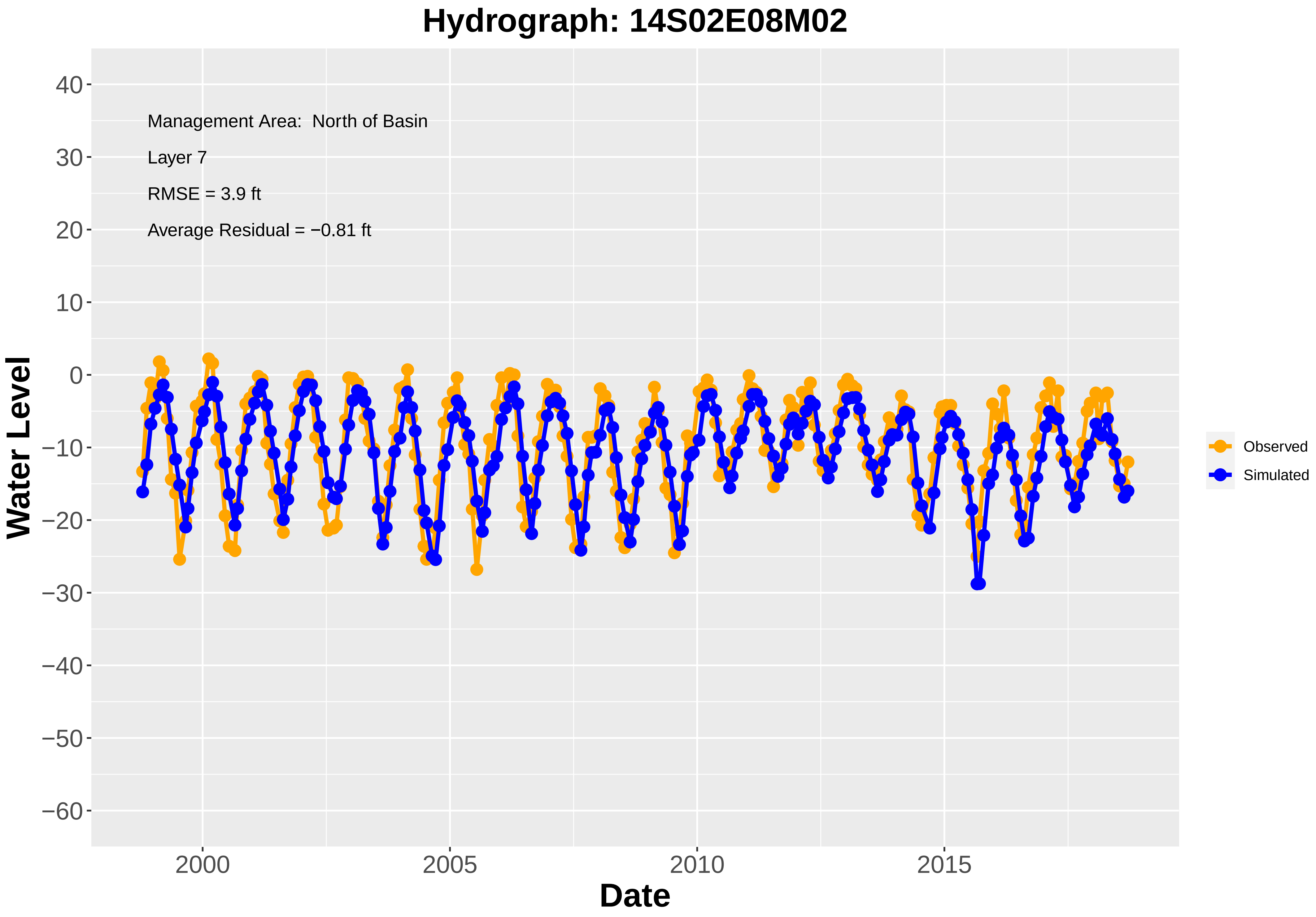

Hydrograph: 014S001E24L002M
Management Area: Marina
Layer 8
RMSE = 12.9 ft
Average Residual = 12.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated



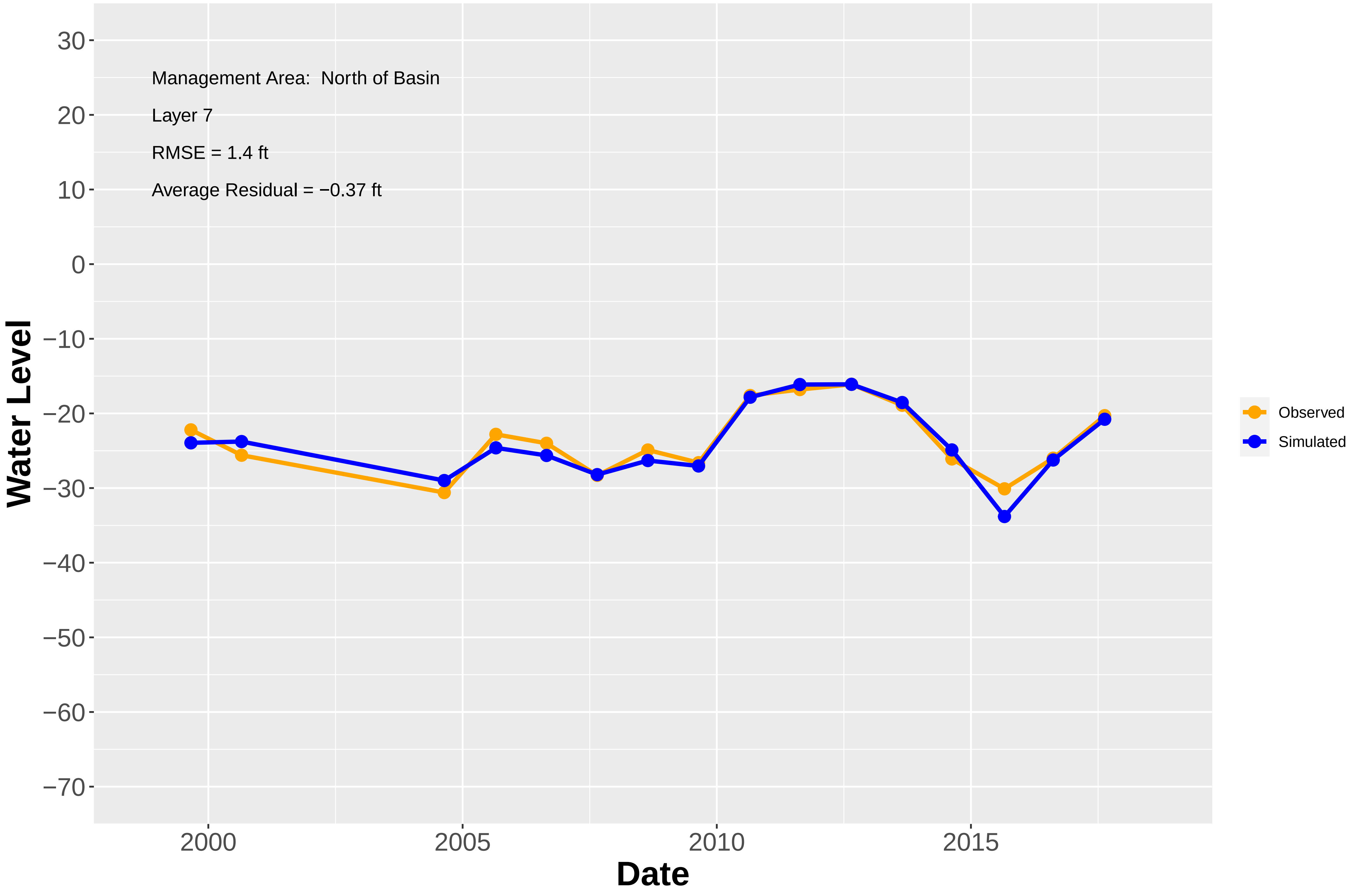
Hydrograph: 014S001E24L003M
Management Area: Marina
Layer 8
RMSE = 8.1 ft
Average Residual = −7.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

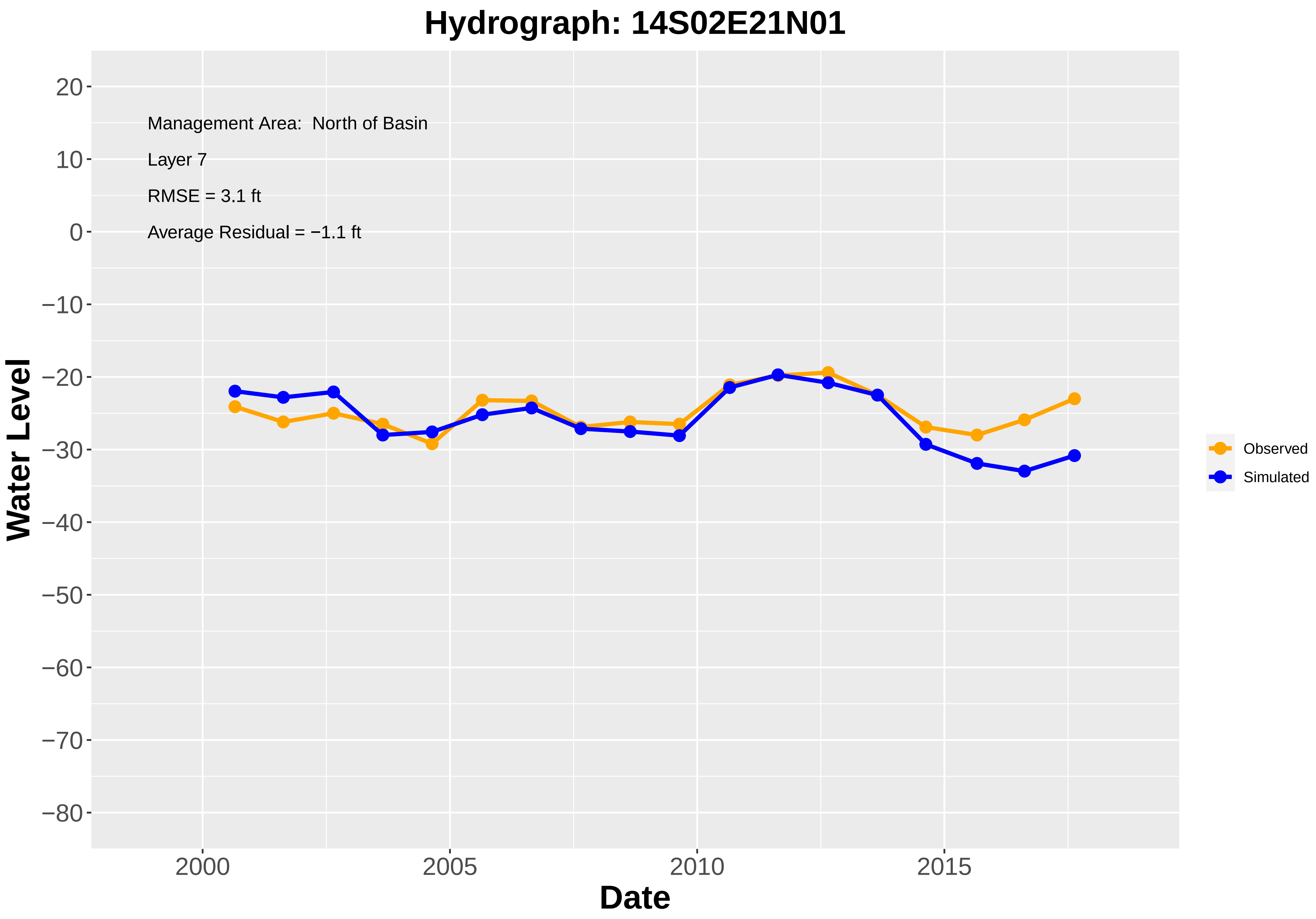

Hydrograph: 014S001E24L004M
Management Area: Marina
Layer 8
RMSE = 20.1 ft
Average Residual = 18.6 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: 014S001E24L005M
Management Area: Marina
Layer 8
RMSE = 10.4 ft
Average Residual = 5.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

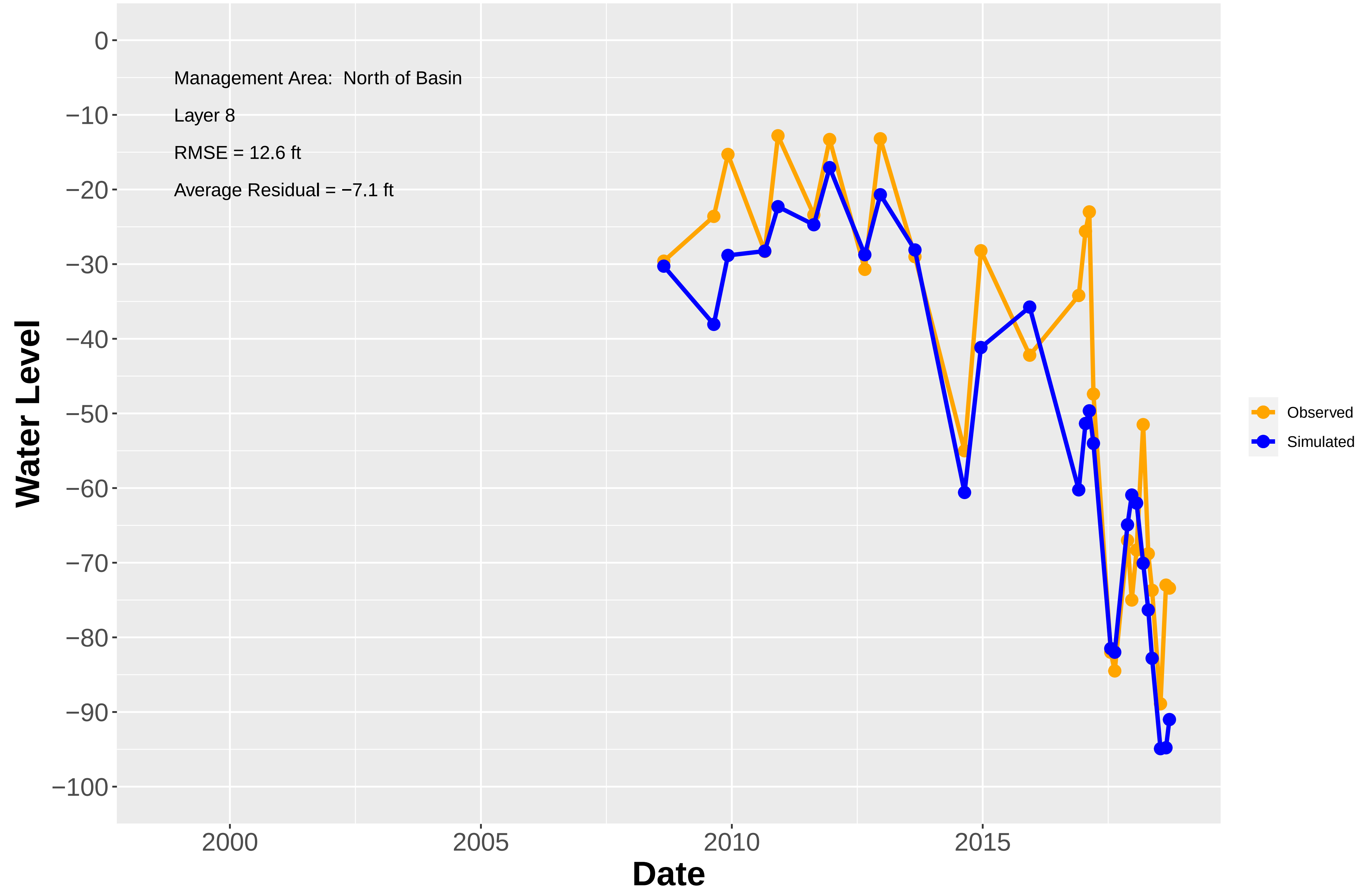
Hydrograph: 14S02E08M02
Management Area: North of Basin
Layer 7
RMSE = 3.9 ft
Average Residual = −0.81 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

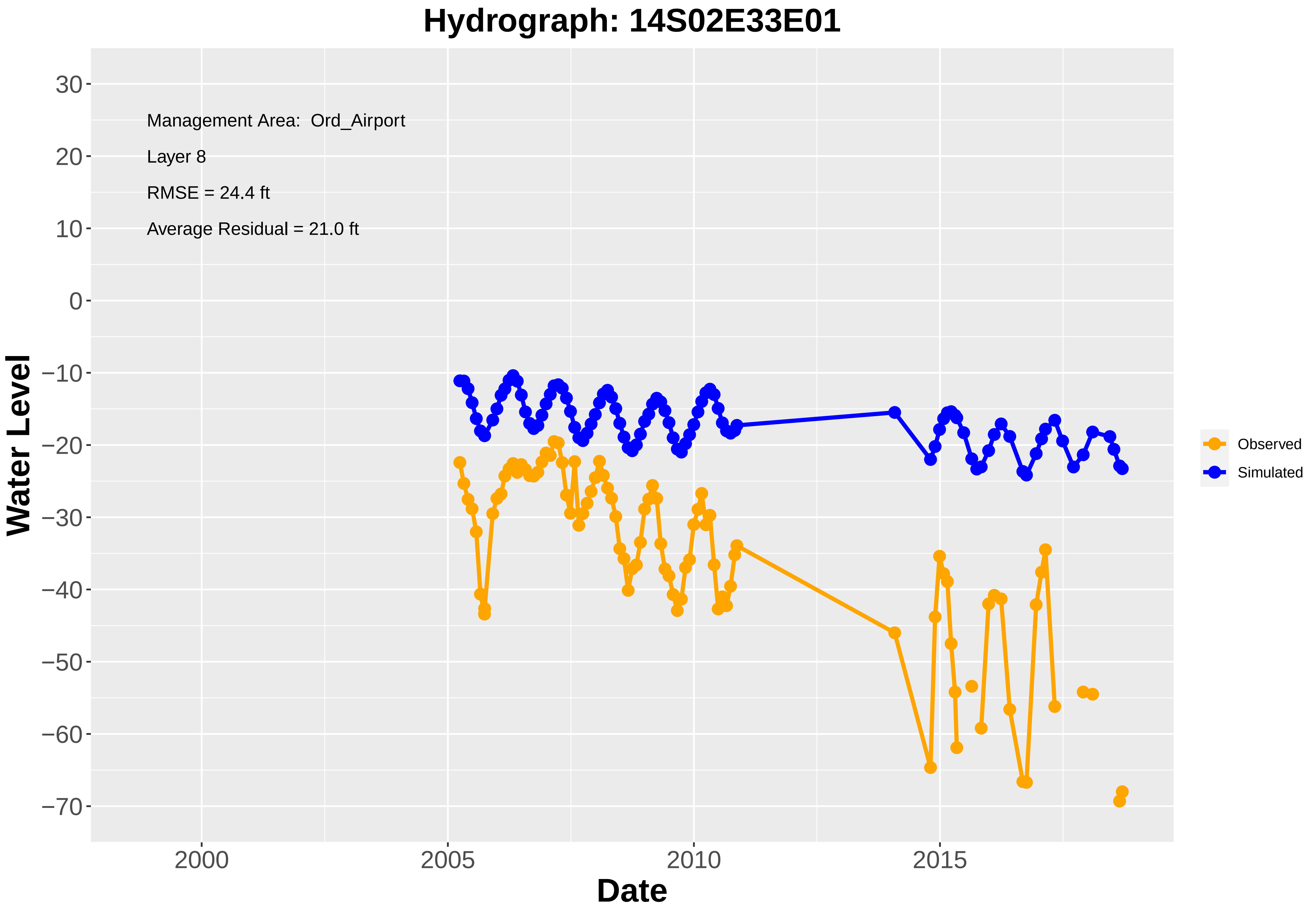
Hydrograph: 14S02E17B03

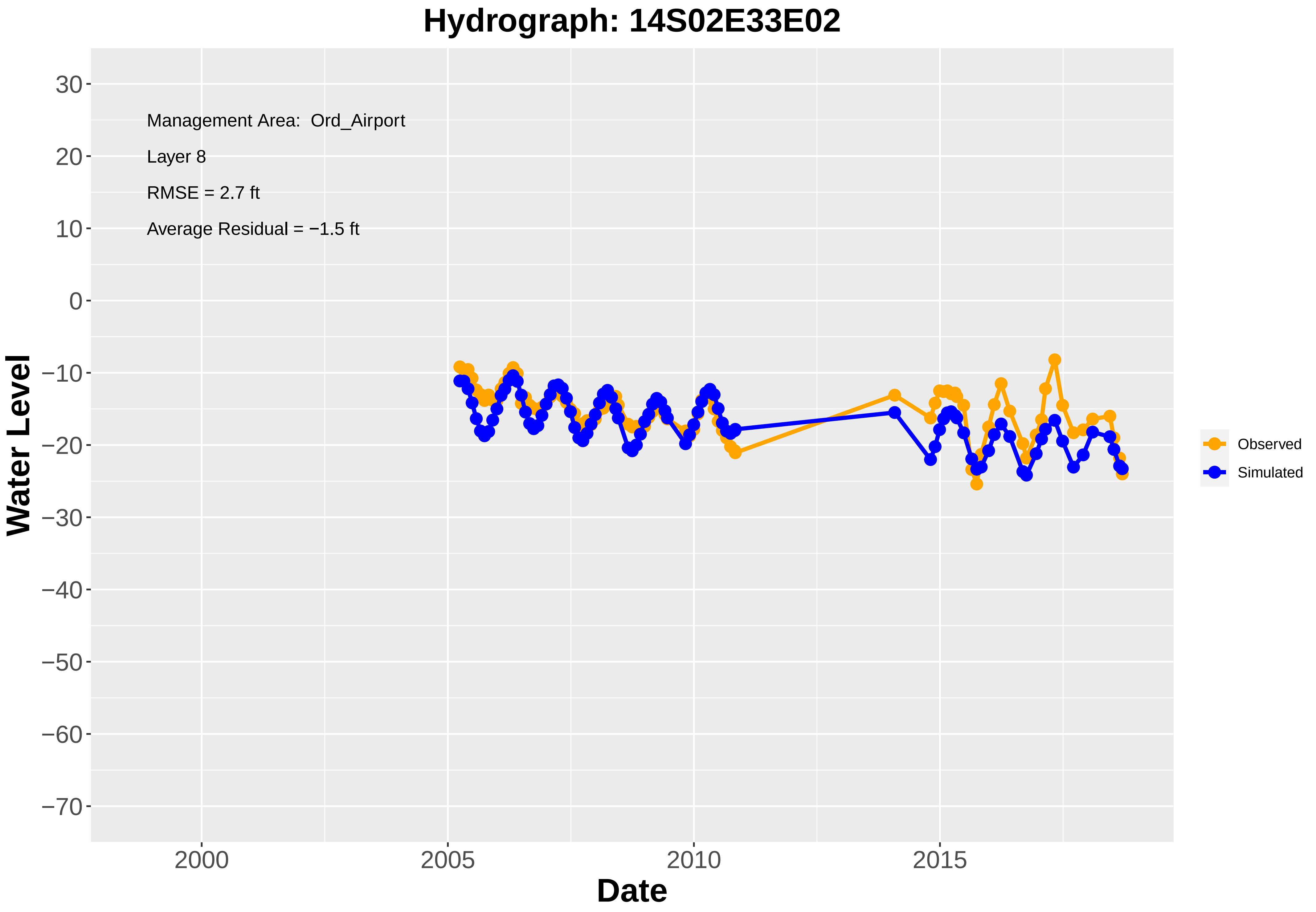


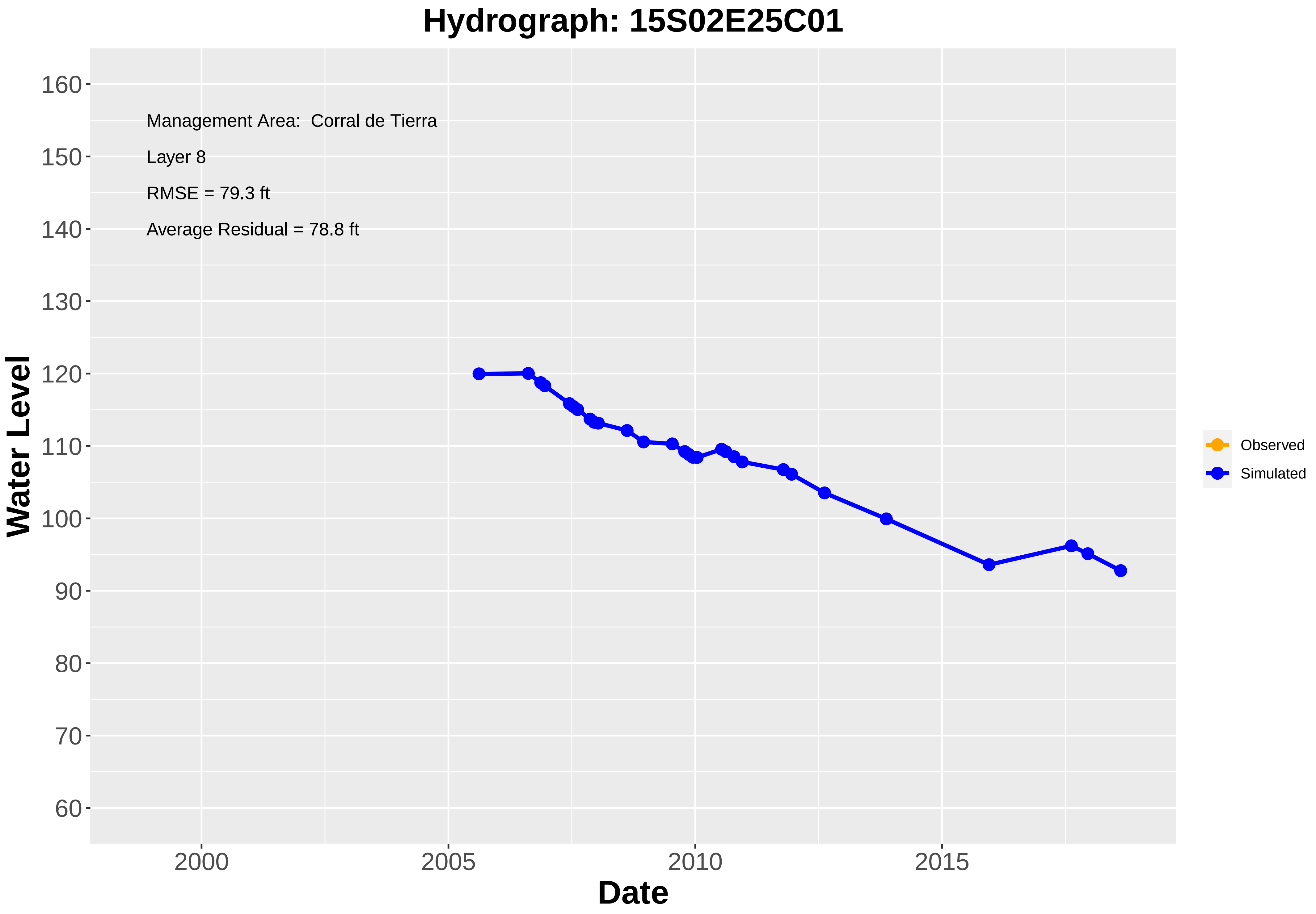

Hydrograph: 14S02E21N01
Management Area: North of Basin
Layer 7
RMSE = 3.1 ft
Average Residual = −1.1 ft
Water Level
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
Date
2000
2005
2010
2015
Observed
Simulated

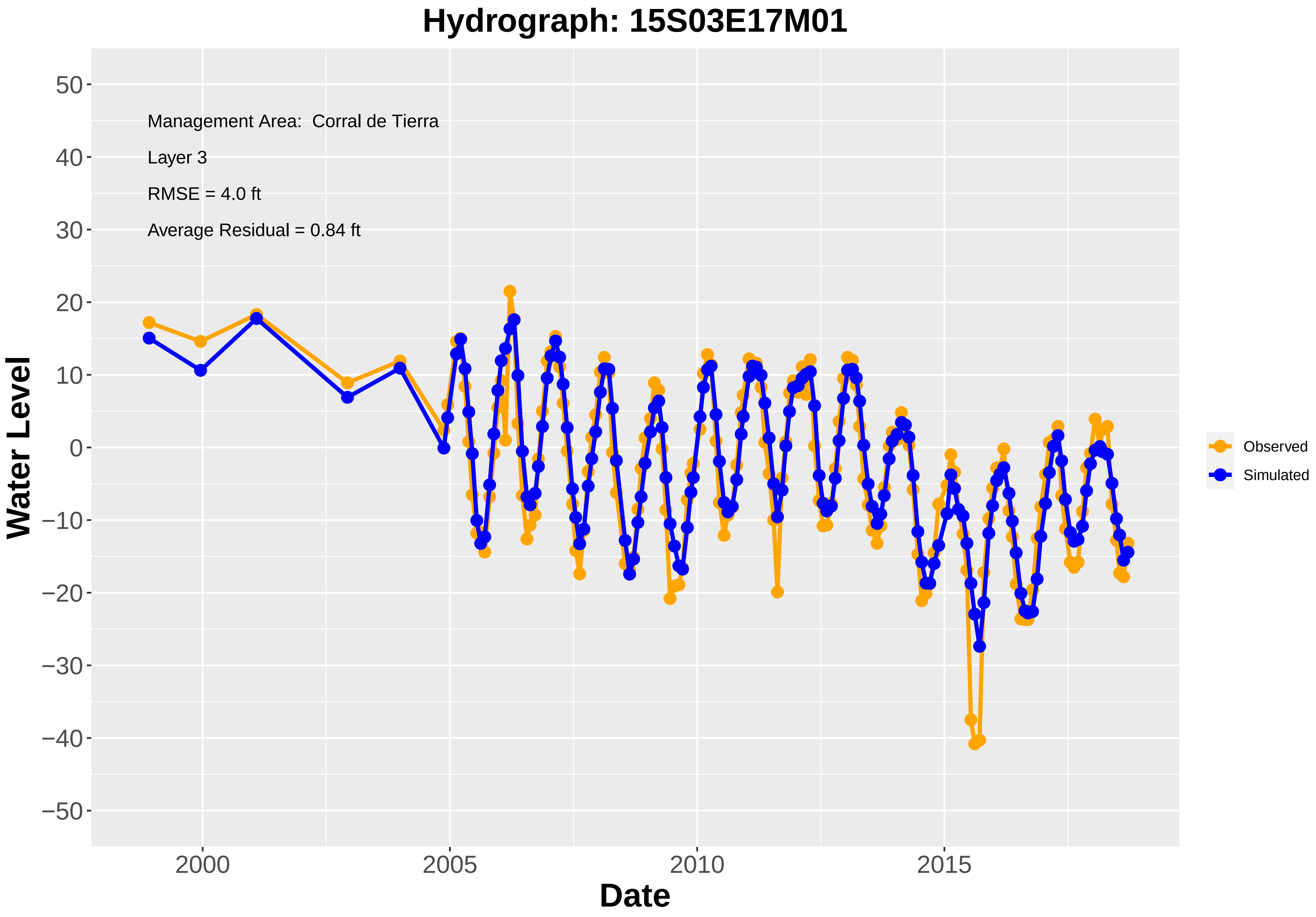
Hydrograph: 14S02E28C02



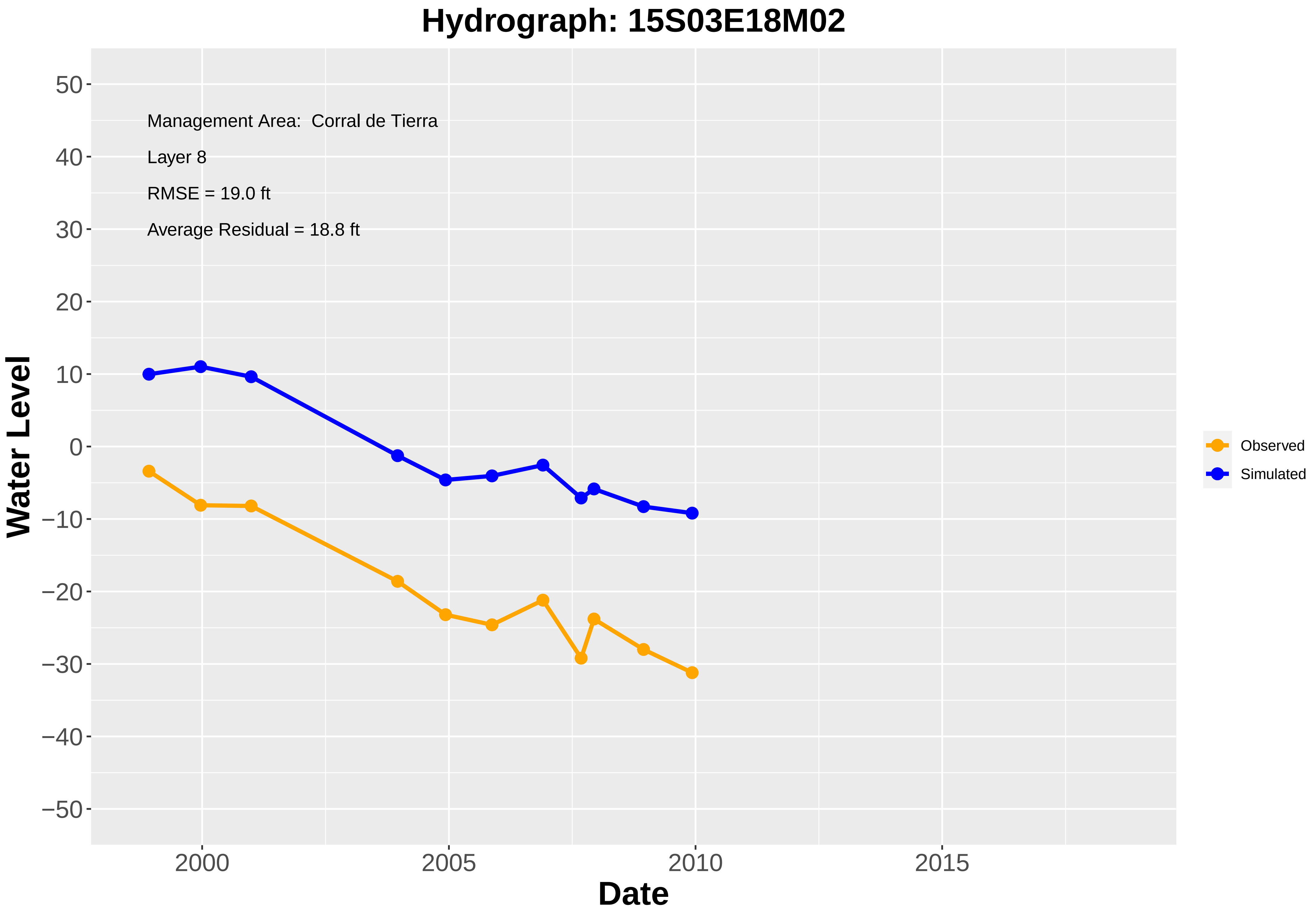

Hydrograph: 14S02E33E01
Management Area: Ord_Airport
Layer 8
RMSE = 24.4 ft
Average Residual = 21.0 ft
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: 14S02E33E02
Management Area: Ord_Airport
Layer 8
RMSE = 2.7 ft
Average Residual = −1.5 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

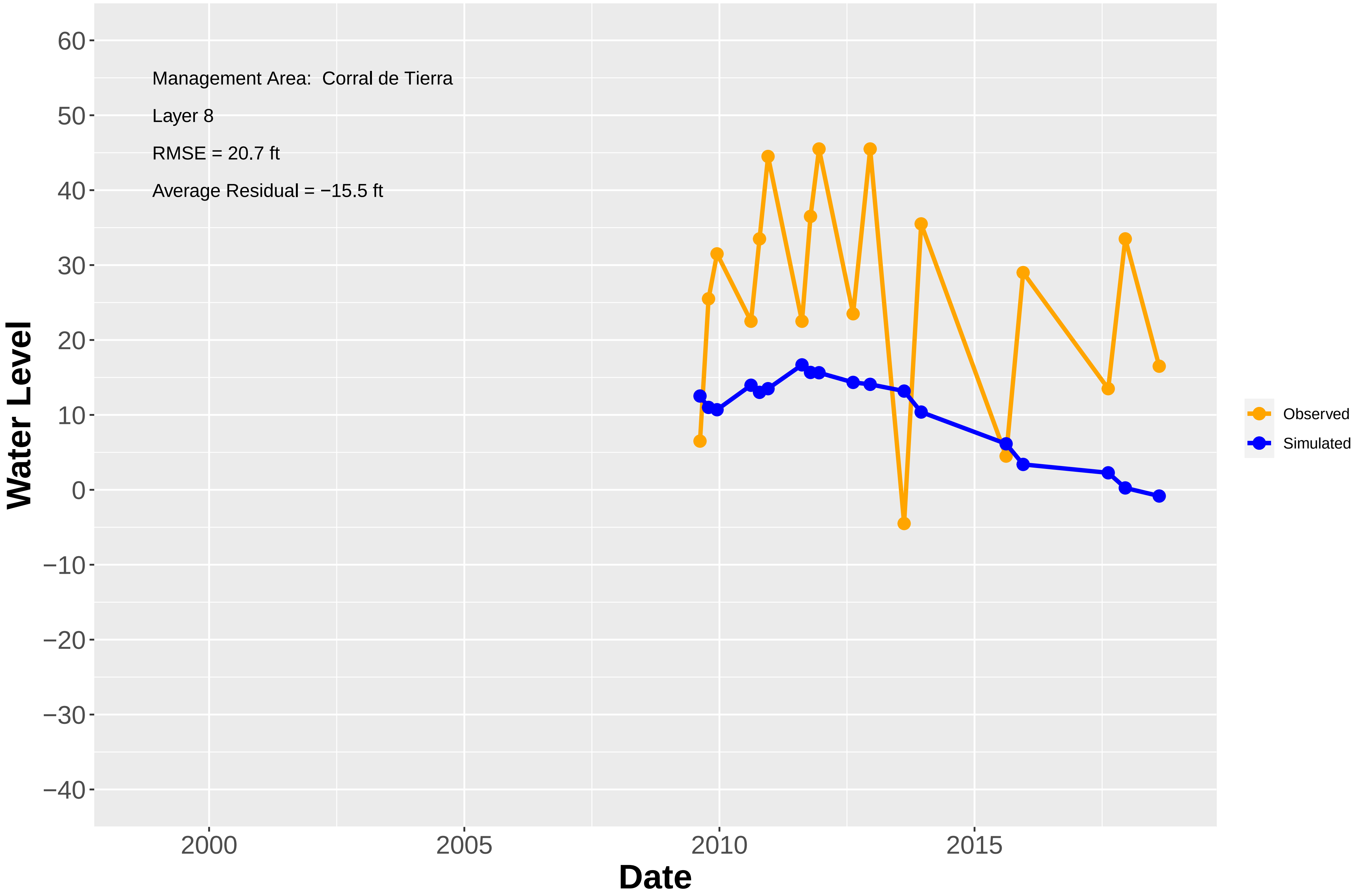
Hydrograph: 15S02E25C01
Management Area: Corral de Tierra
Layer 8
RMSE = 79.3 ft
Average Residual = 78.8 ft
Water Level
160
150
140
130
120
110
100
90
80
70
60
Date
2000
2005
2010
2015
Observed
Simulated



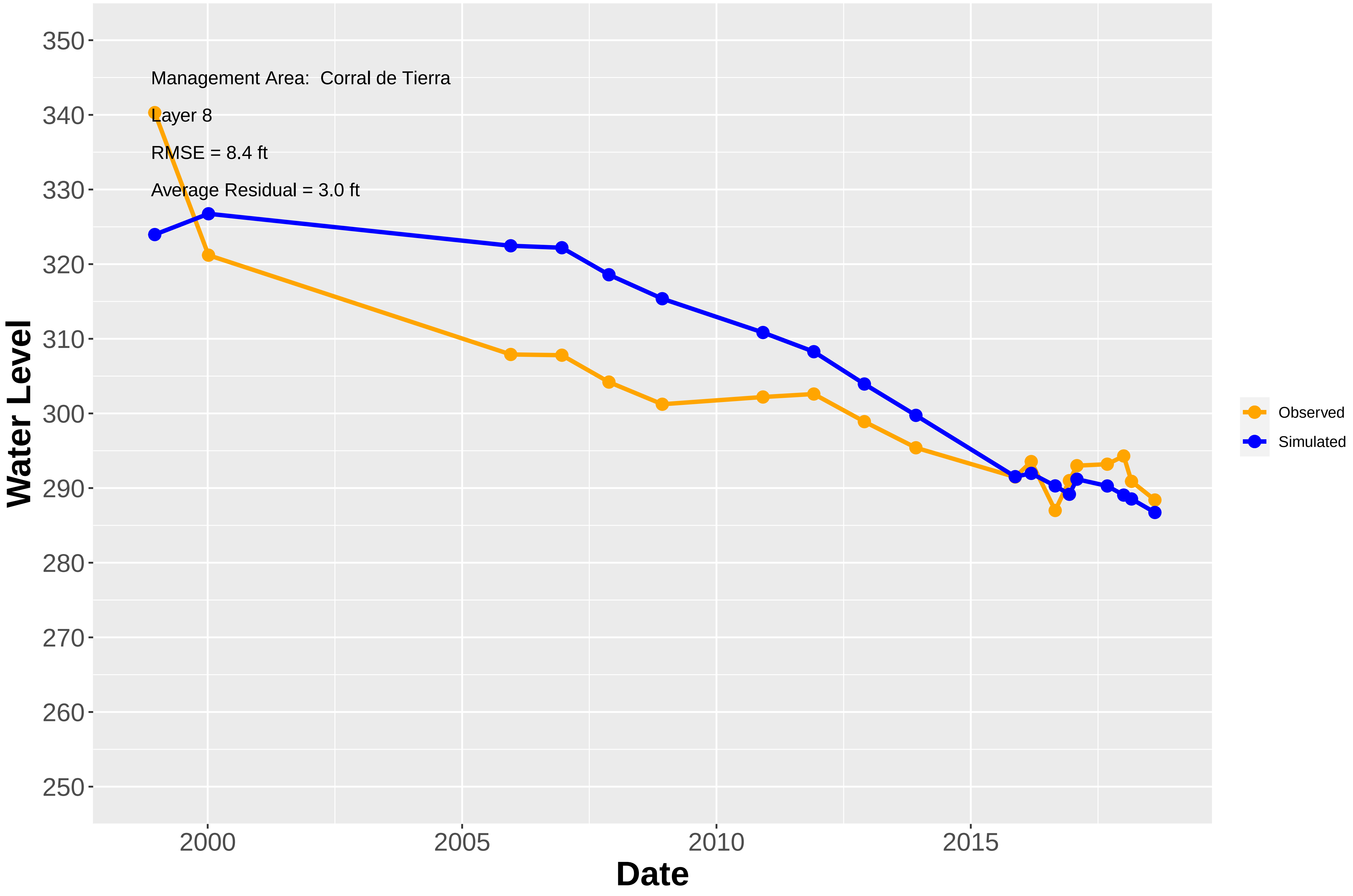
Hydrograph: 15S03E17M01
Management Area: Corral de Tierra
Layer 3
RMSE = 4.0 ft
Average Residual = 0.84 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: 15S03E18M02
Management Area: Corral de Tierra
Layer 8
RMSE = 19.0 ft
Average Residual = 18.8 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

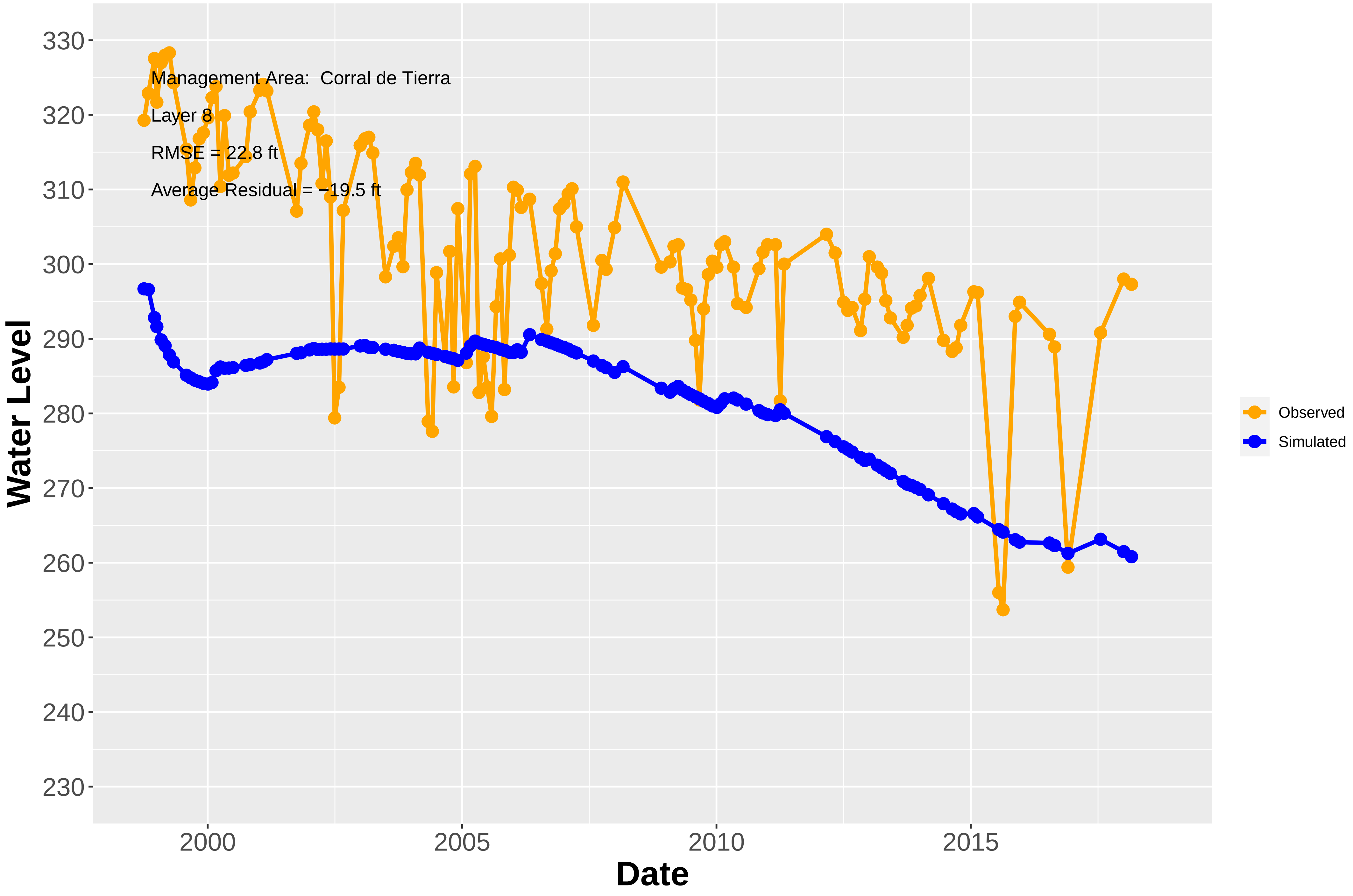
Hydrograph: 15S03E20R50

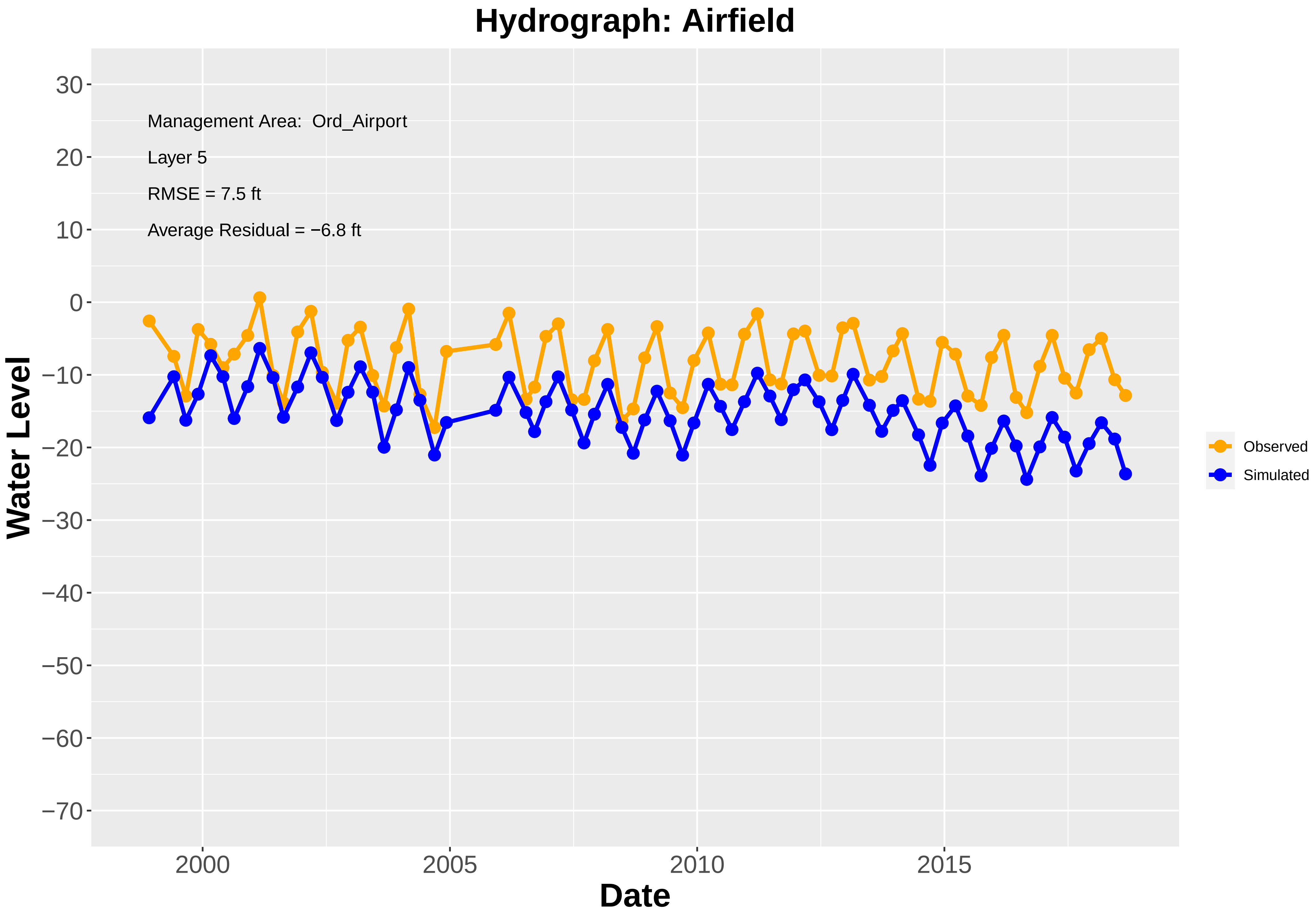


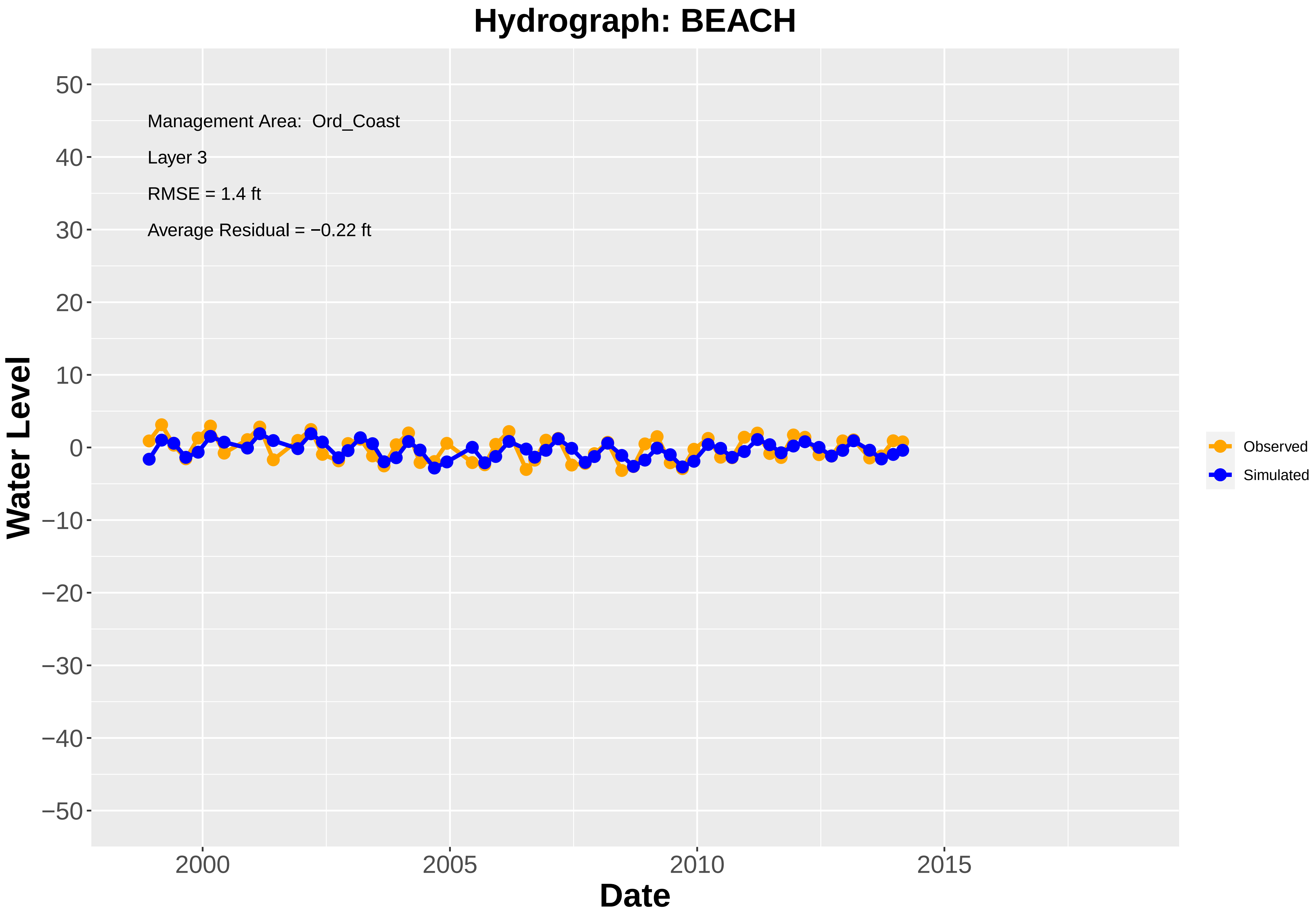
Hydrograph: 16797

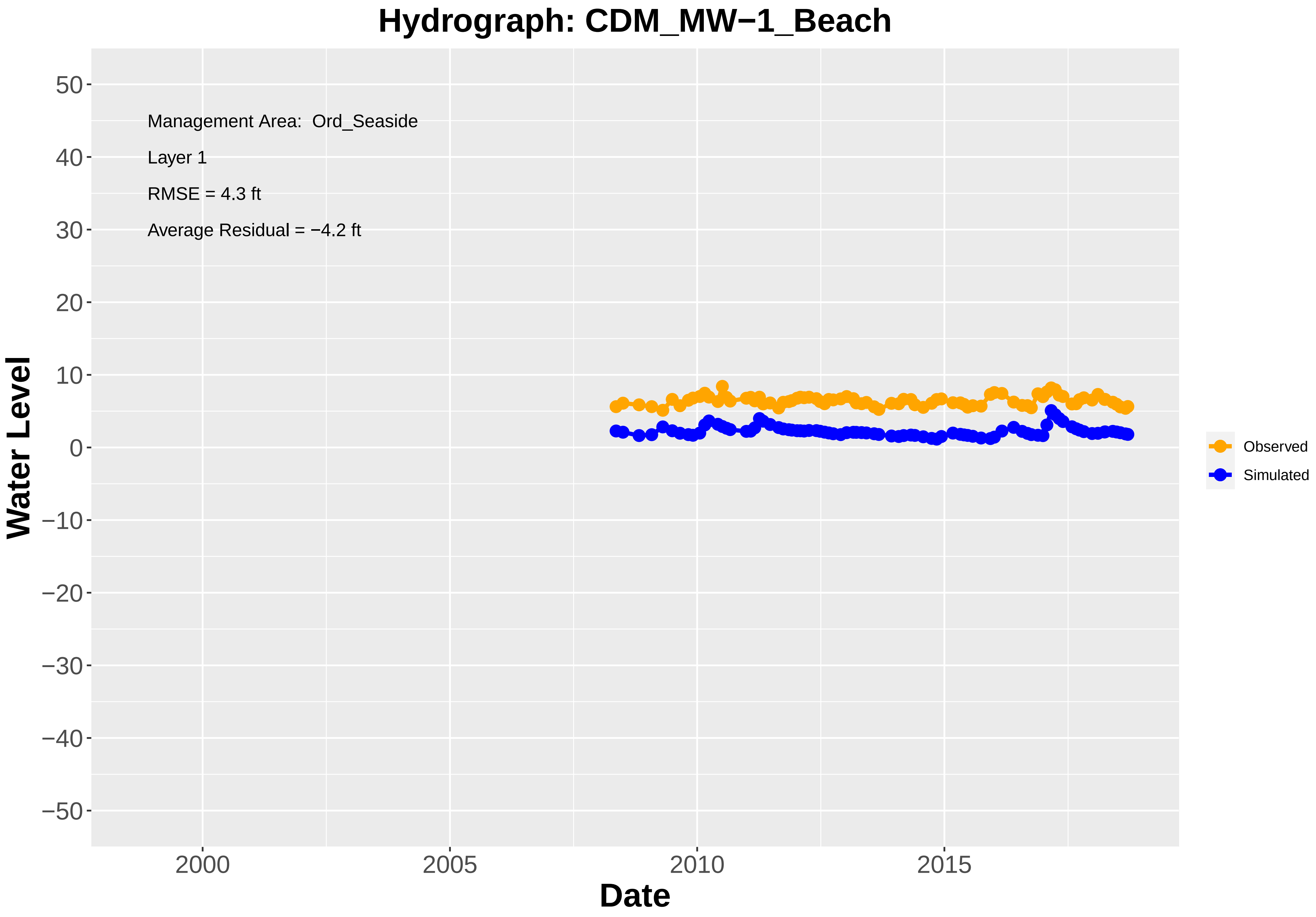


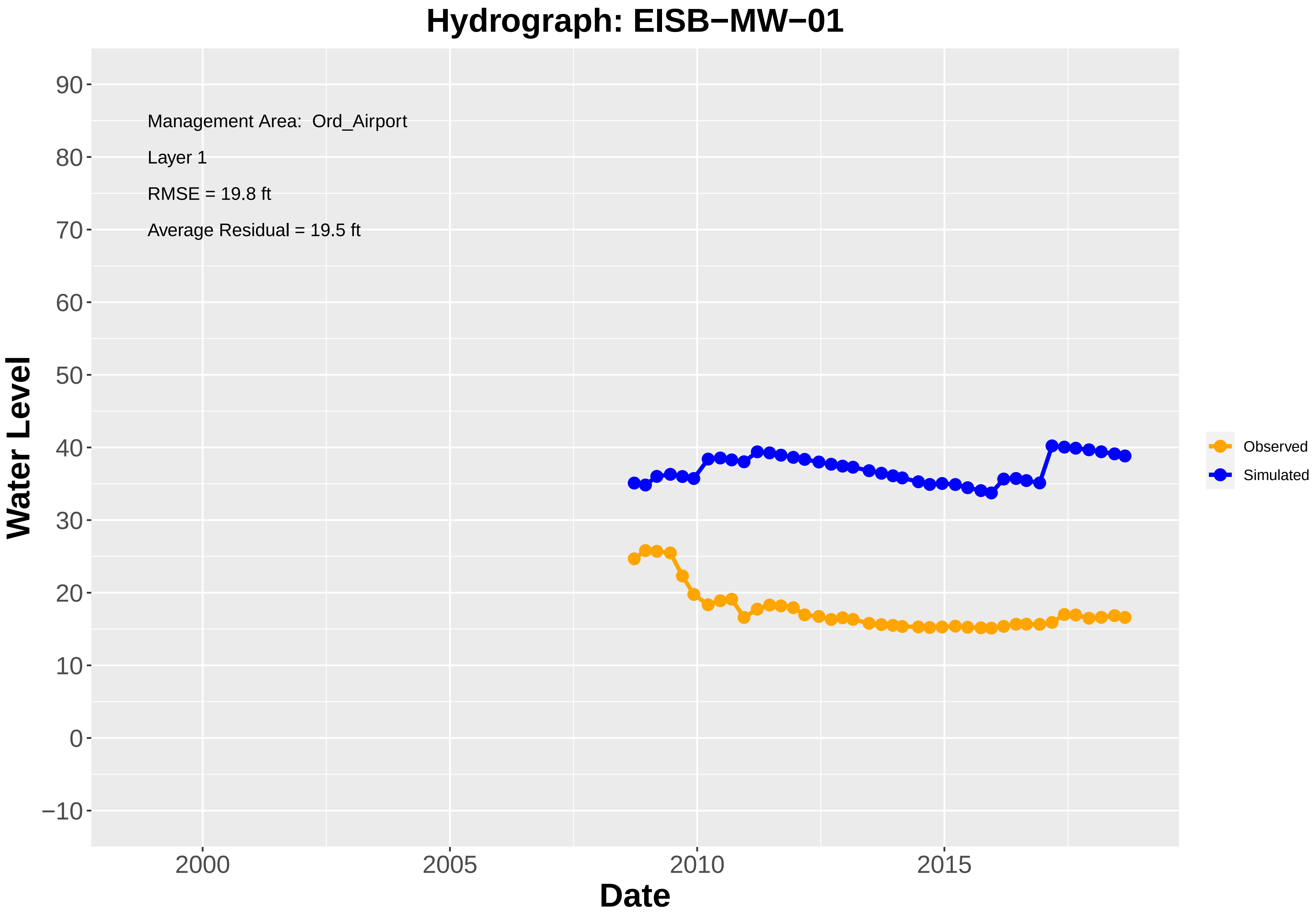
Hydrograph: 16820



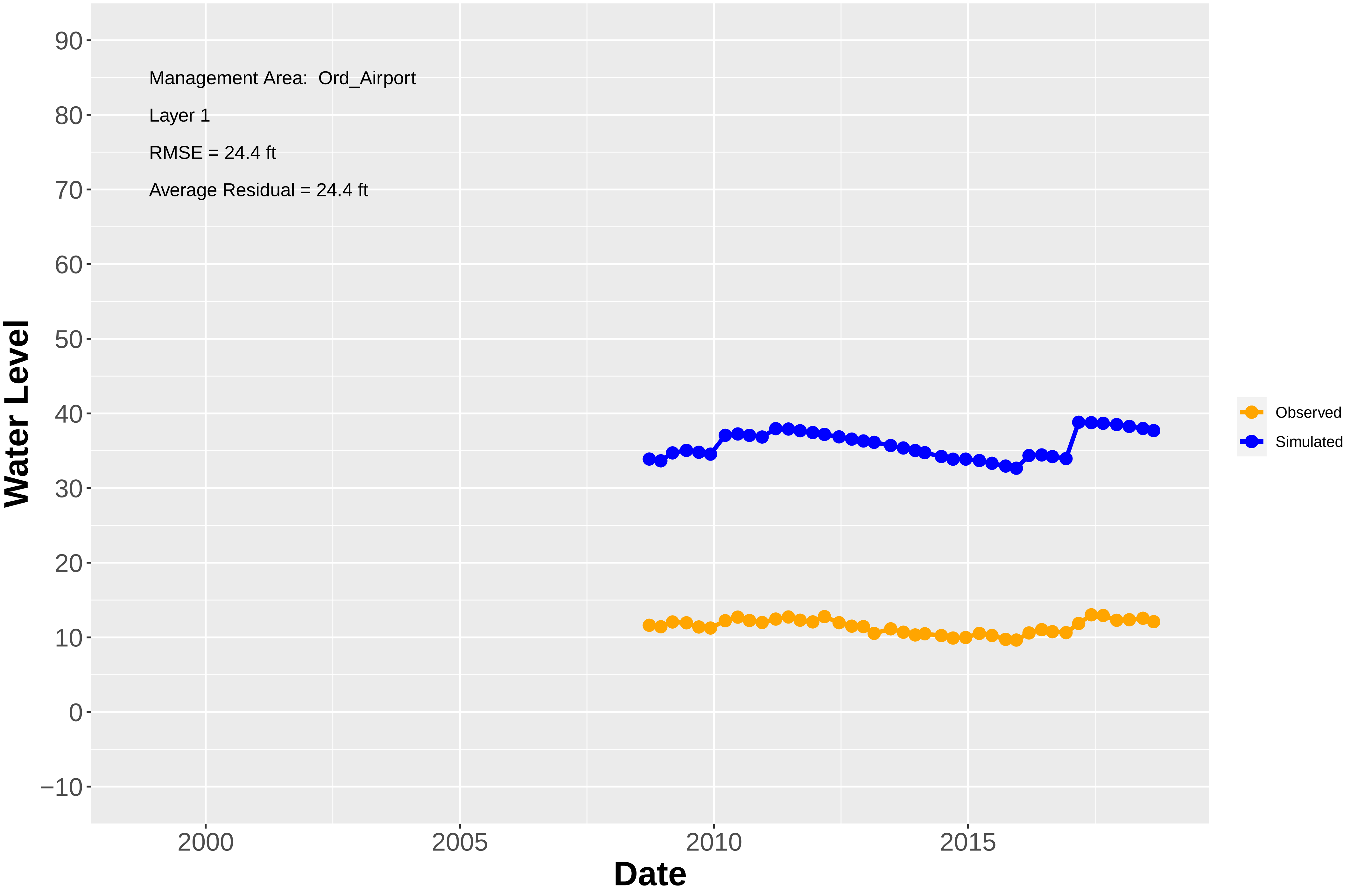

Hydrograph: Airfield
Management Area: Ord_Airport
Layer 5
RMSE = 7.5 ft
Average Residual = −6.8 ft
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: BEACH
Management Area: Ord_Coast
Layer 3
RMSE = 1.4 ft
Average Residual = −0.22 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

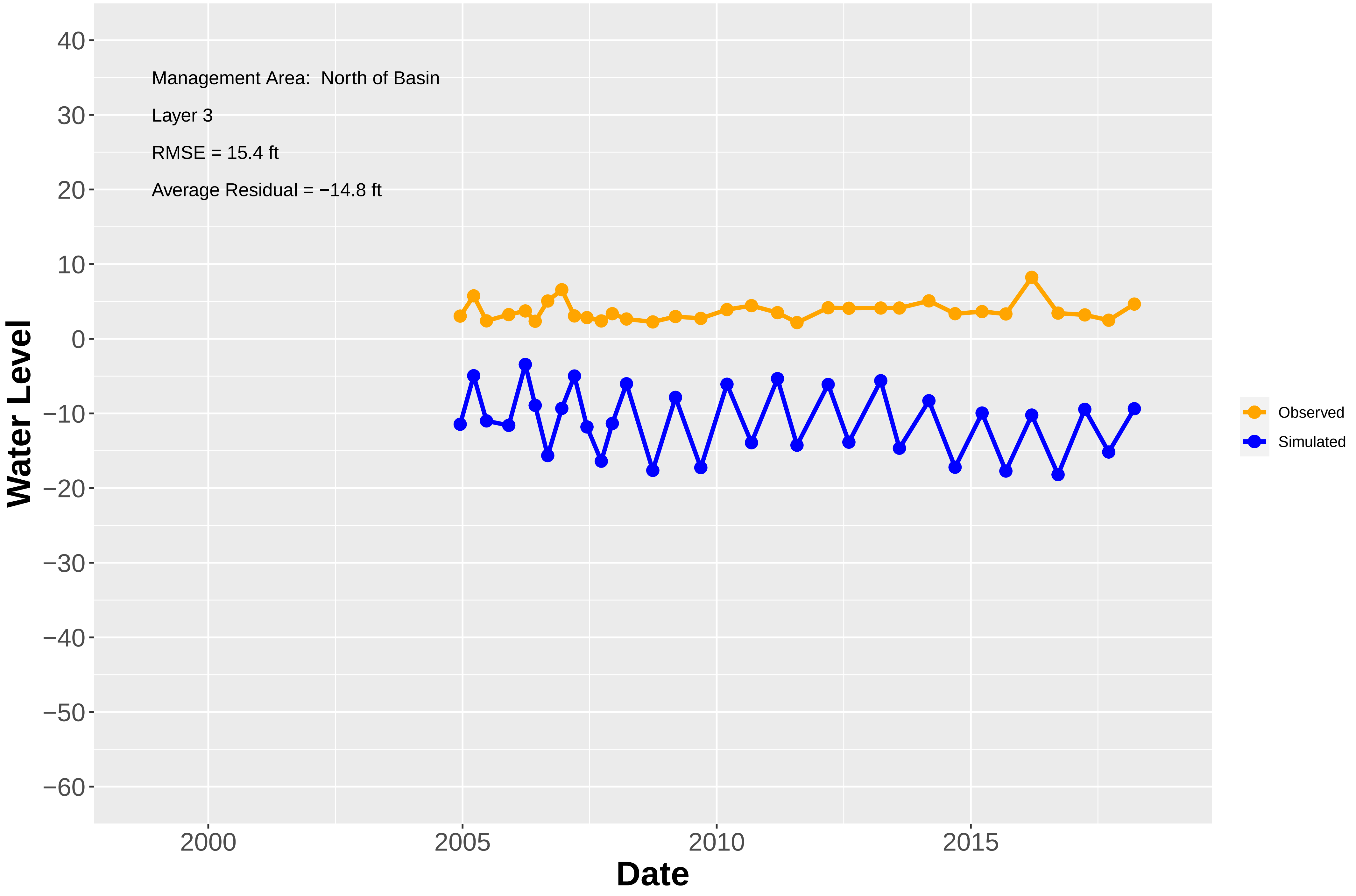

Hydrograph: CDM_MW−1_Beach
Management Area: Ord_Seaside
Layer 1
RMSE = 4.3 ft
Average Residual = −4.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: EISB−MW−01
Management Area: Ord_Airport
Layer 1
RMSE = 19.8 ft
Average Residual = 19.5 ft
Water Level
Date
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Observed
Simulated

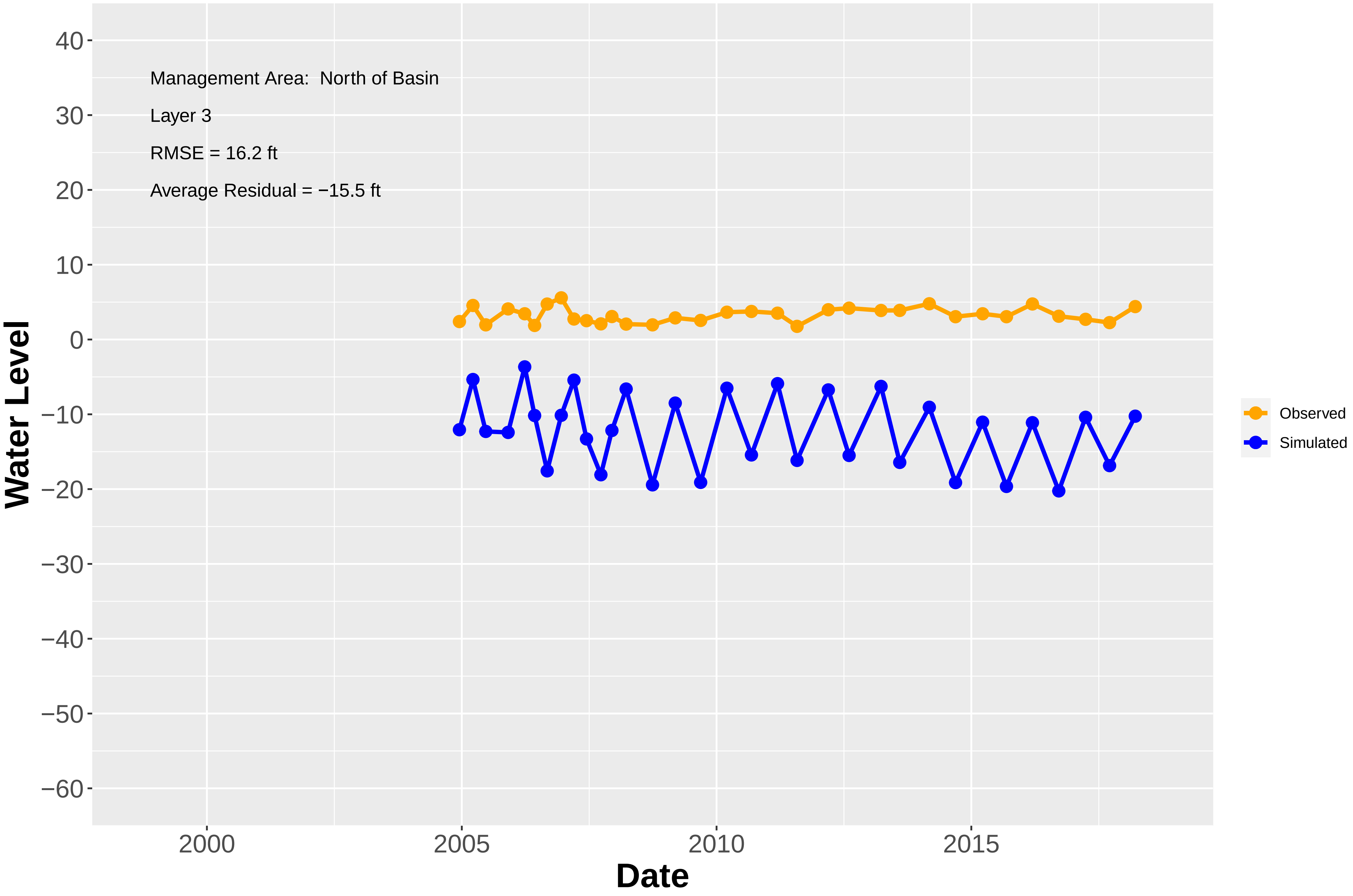
Hydrograph: EISB−MW−04



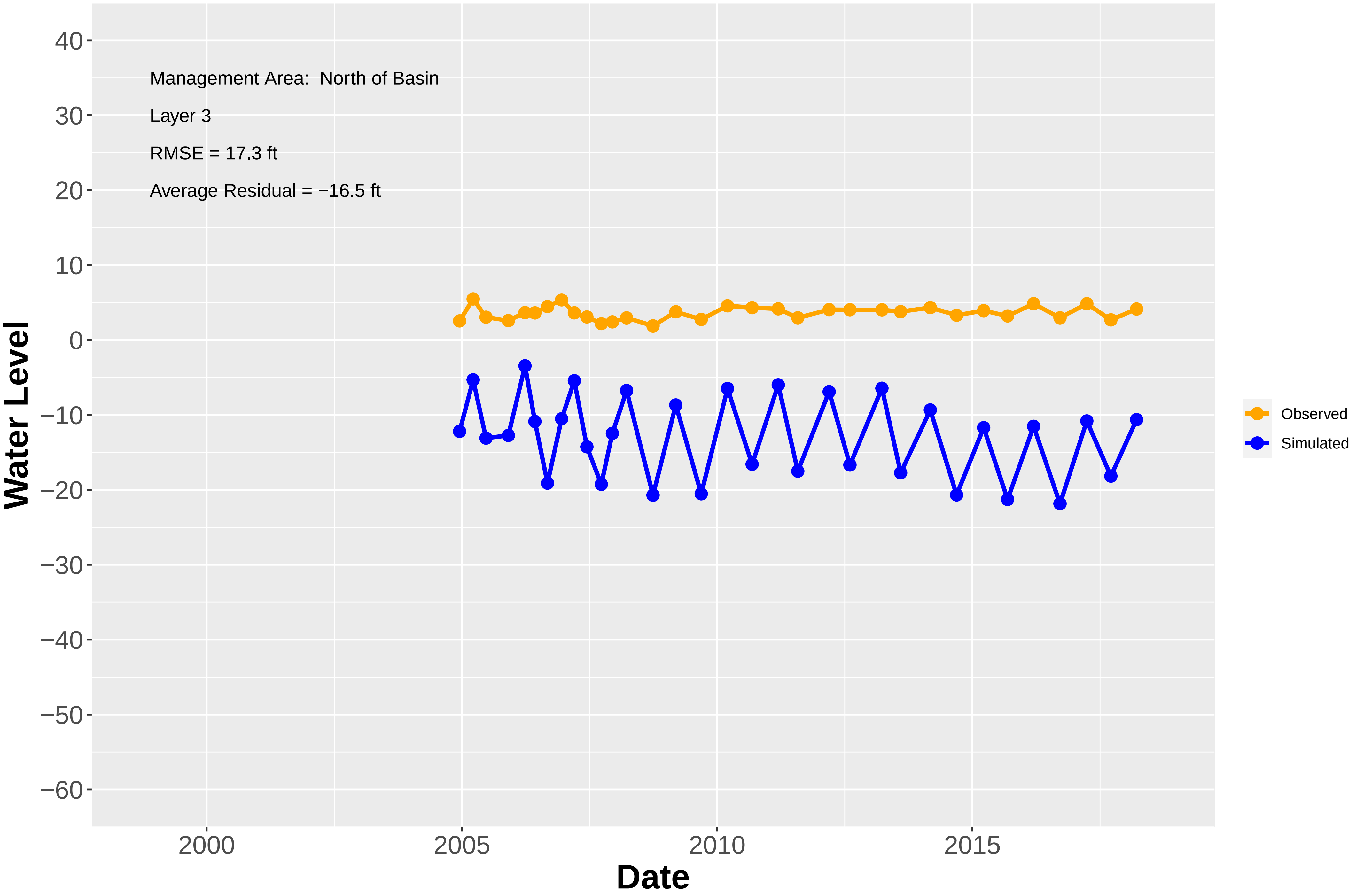
Hydrograph: G−01



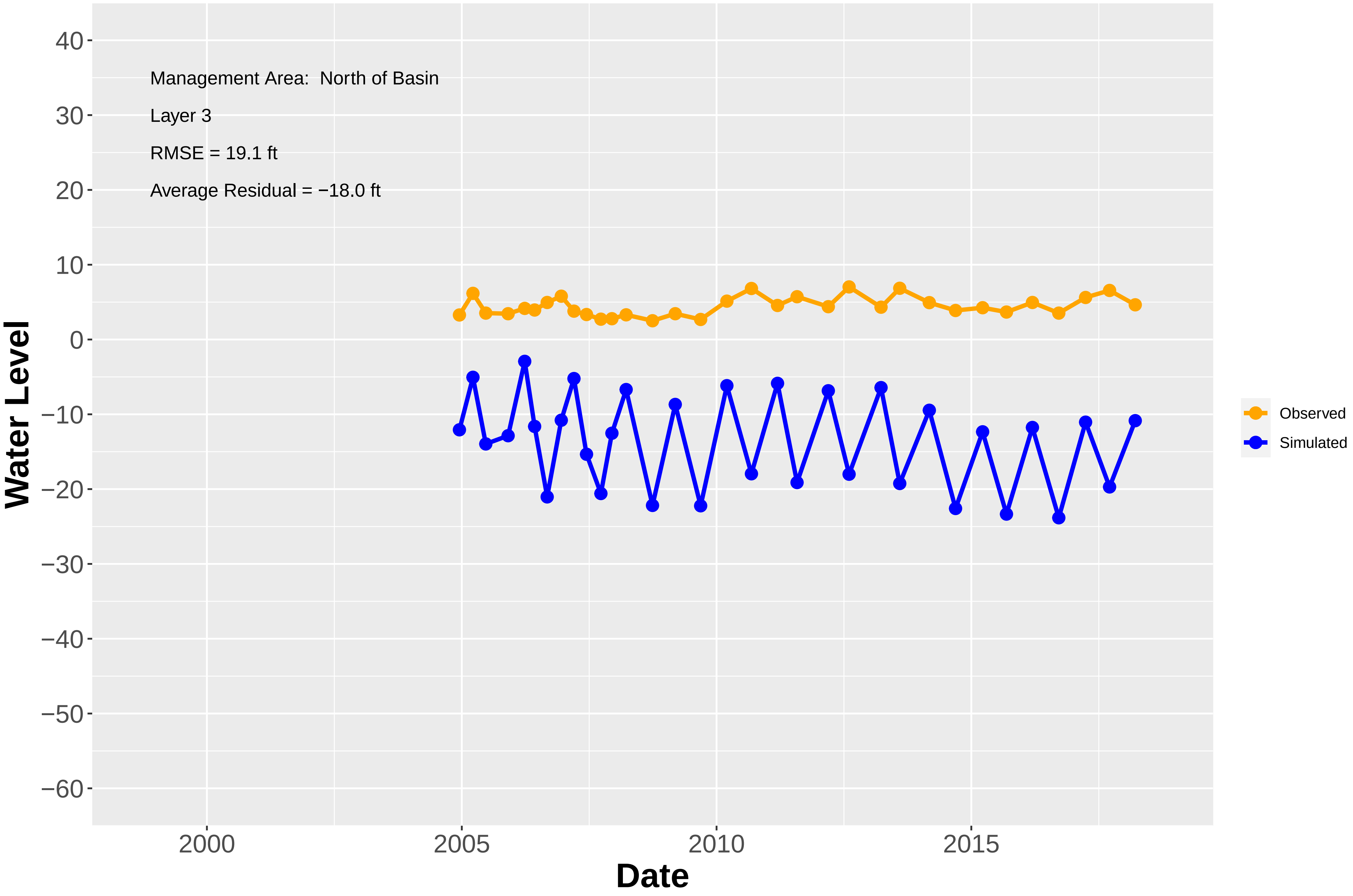
Hydrograph: G−02

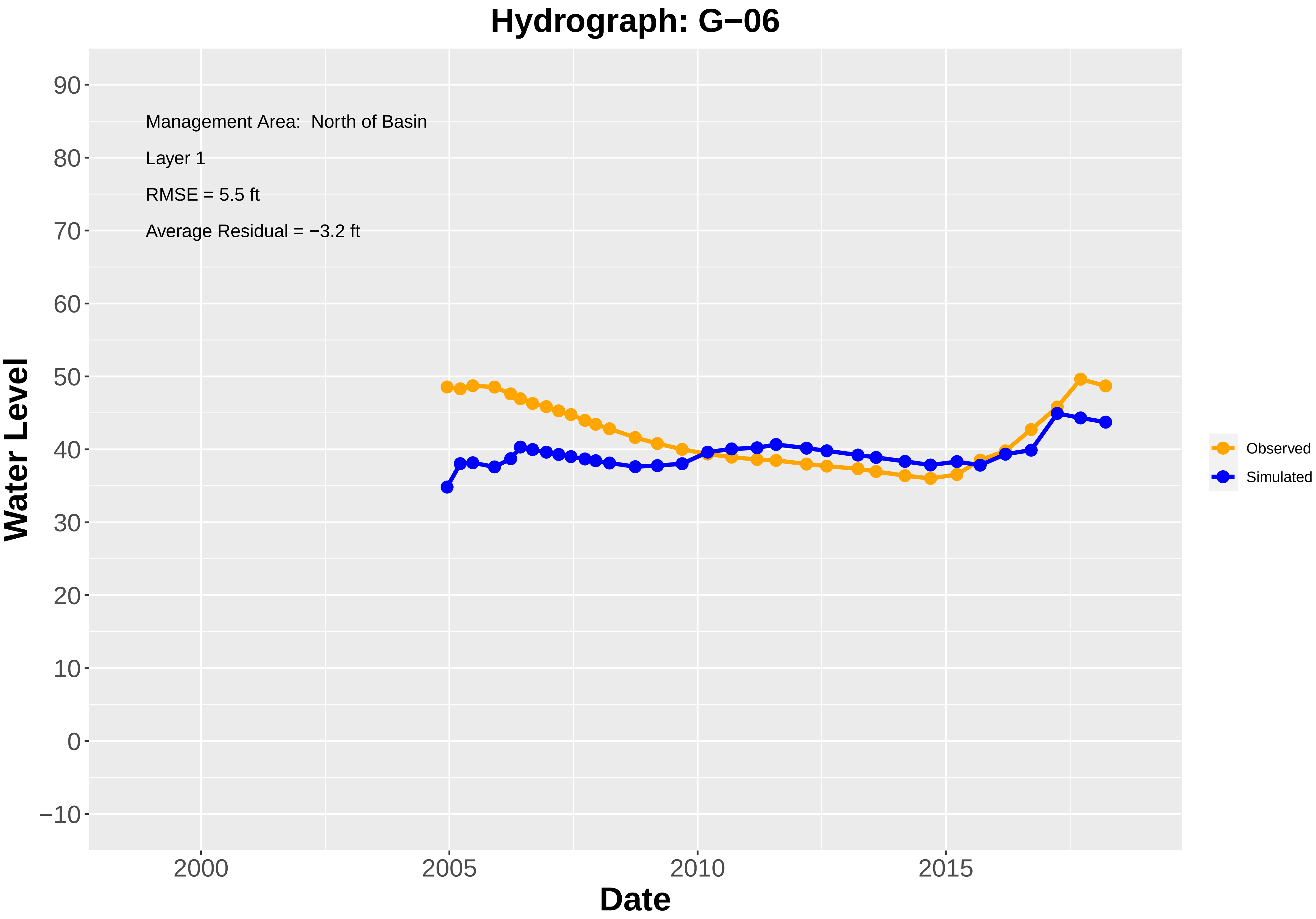


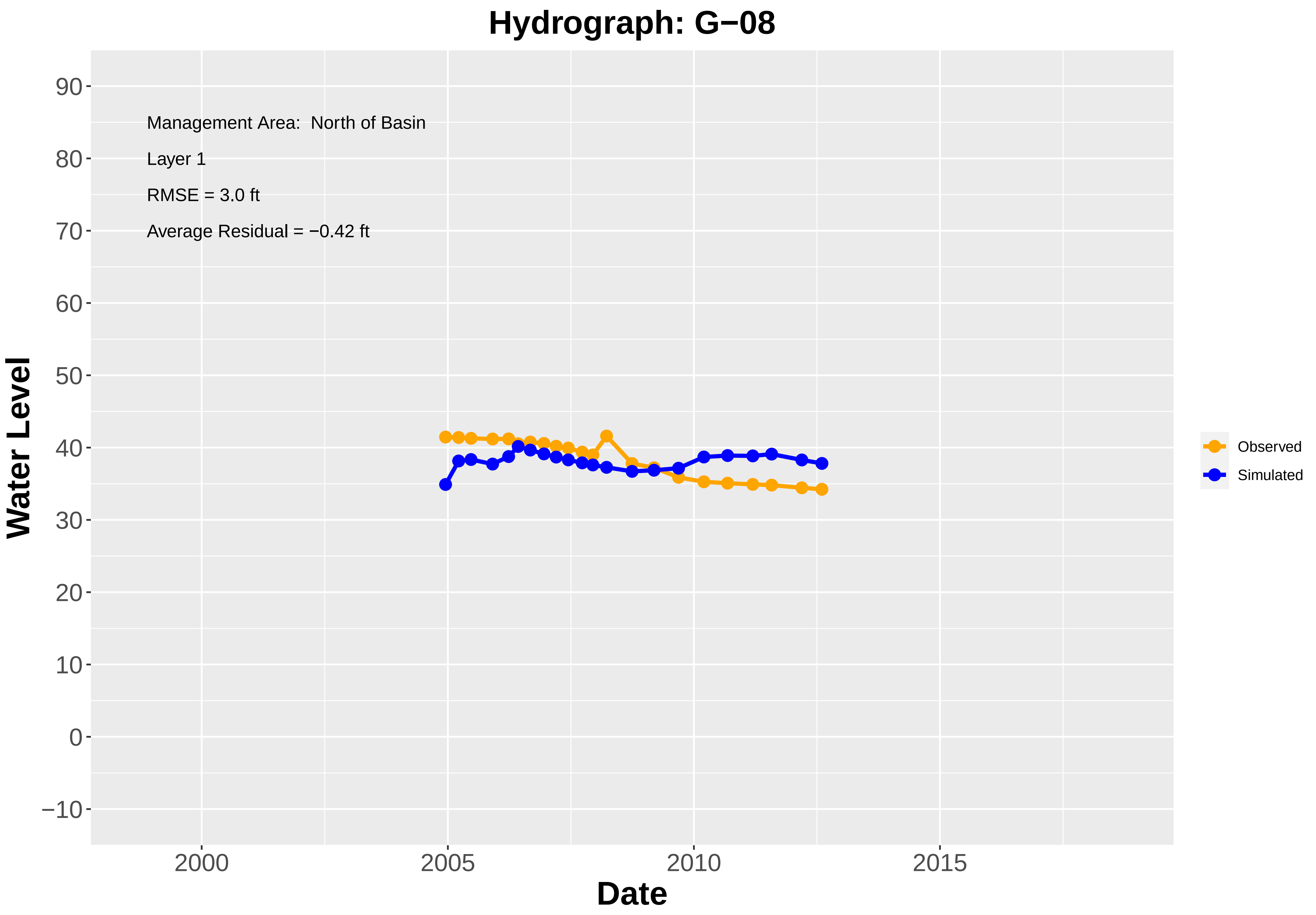
Hydrograph: G−03R

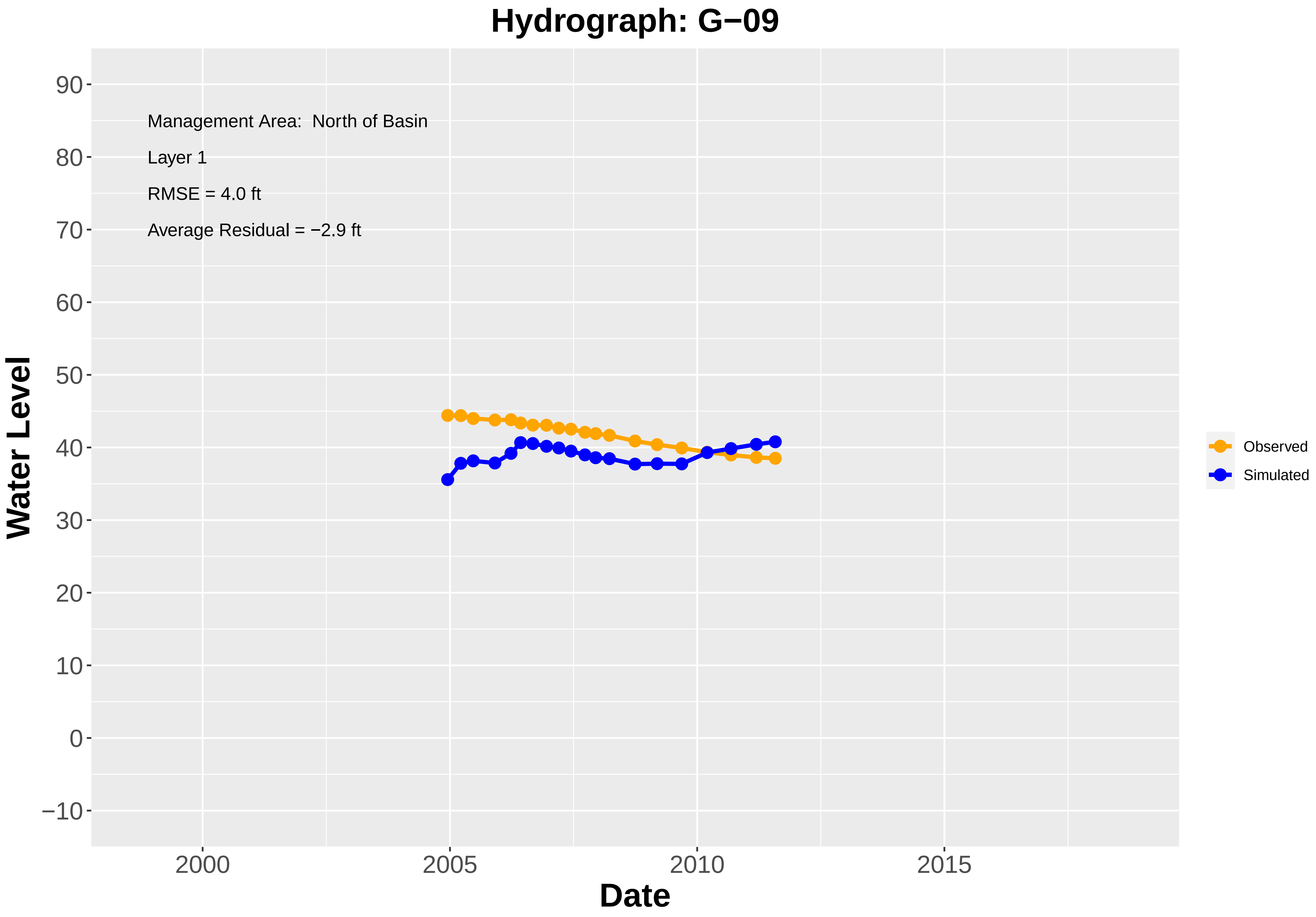


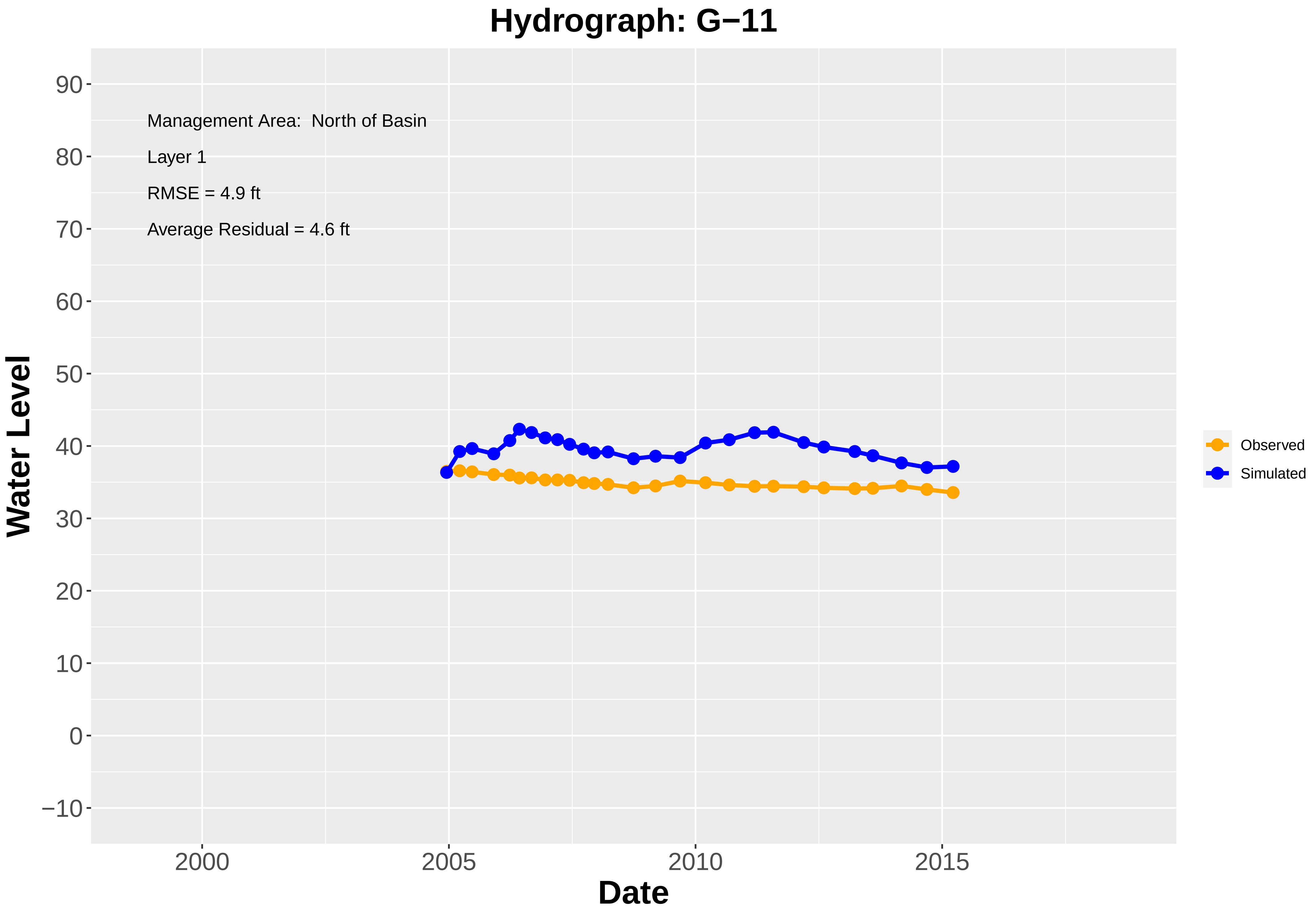
Hydrograph: G−04

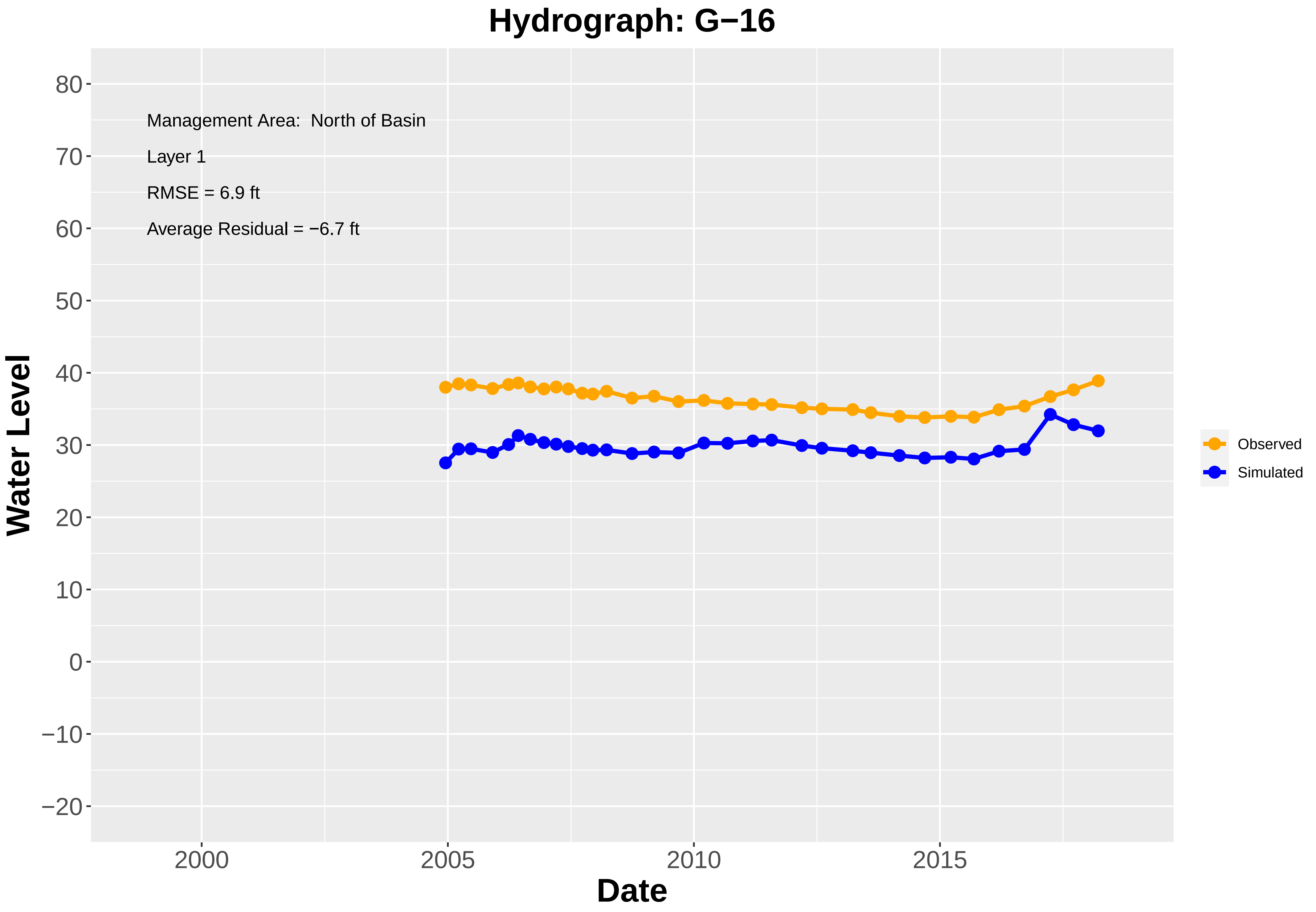


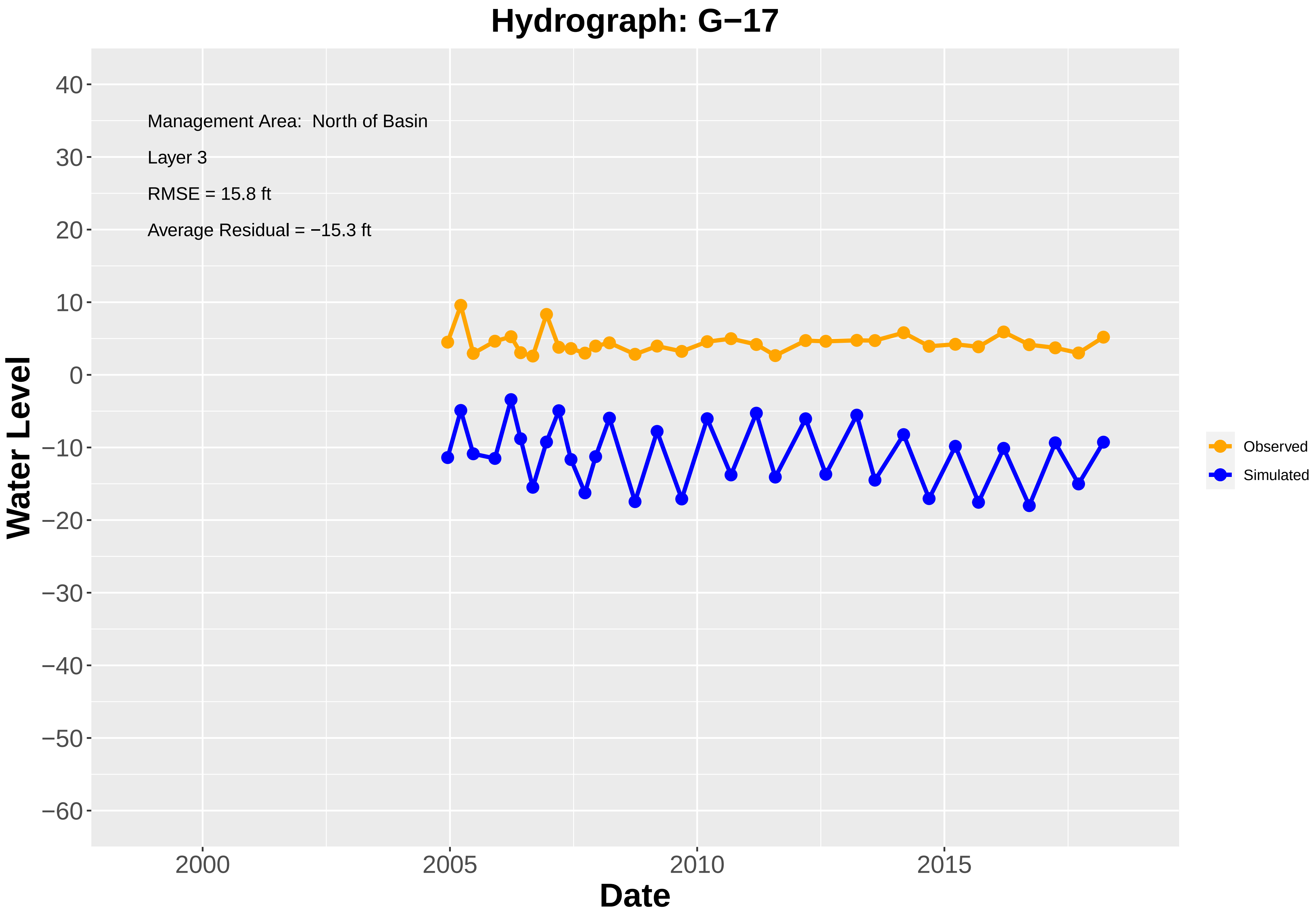

Hydrograph: G−06
Management Area: North of Basin
Layer 1
RMSE = 5.5 ft
Average Residual = −3.2 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

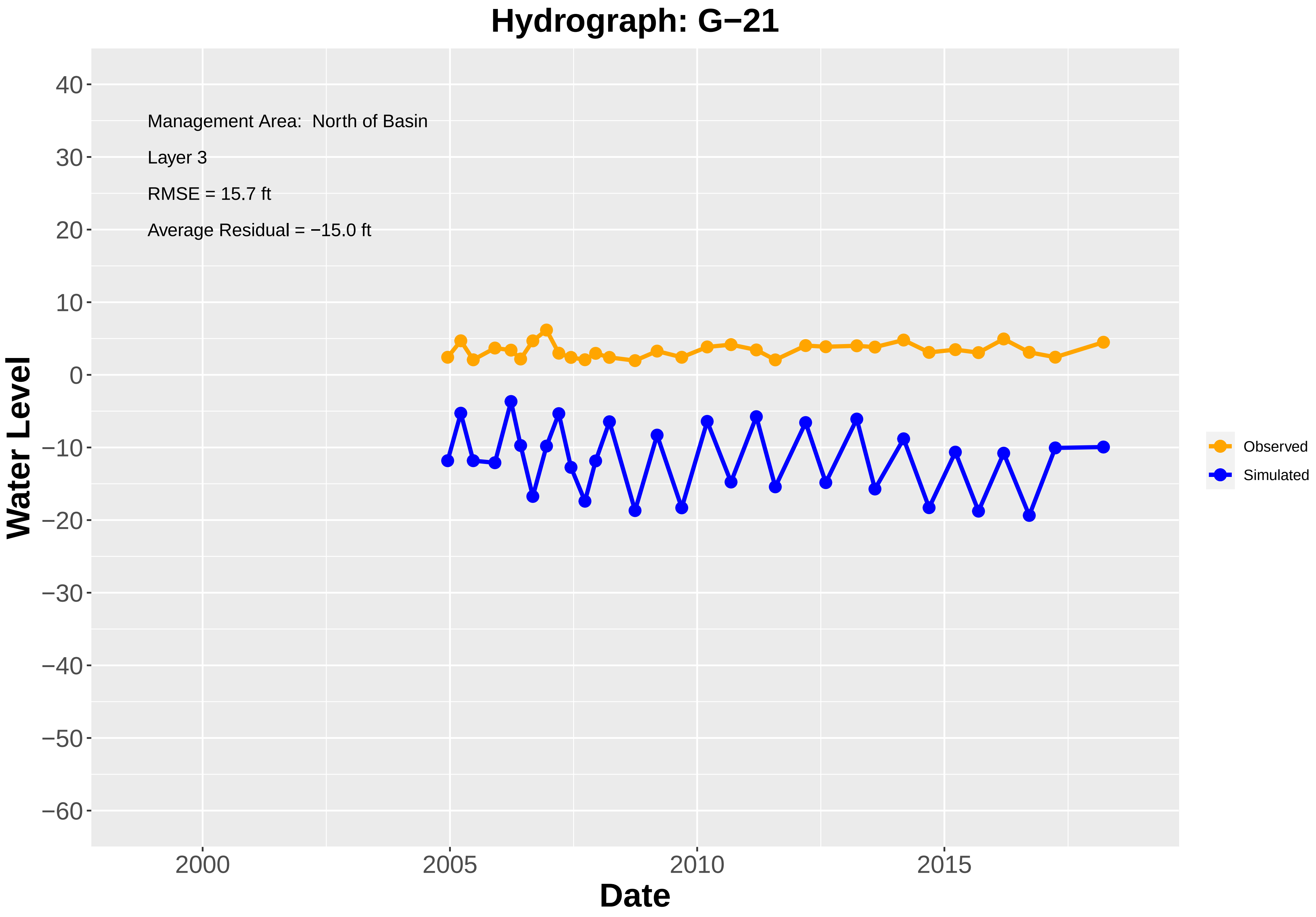

Hydrograph: G−08
Management Area: North of Basin
Layer 1
RMSE = 3.0 ft
Average Residual = −0.42 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated

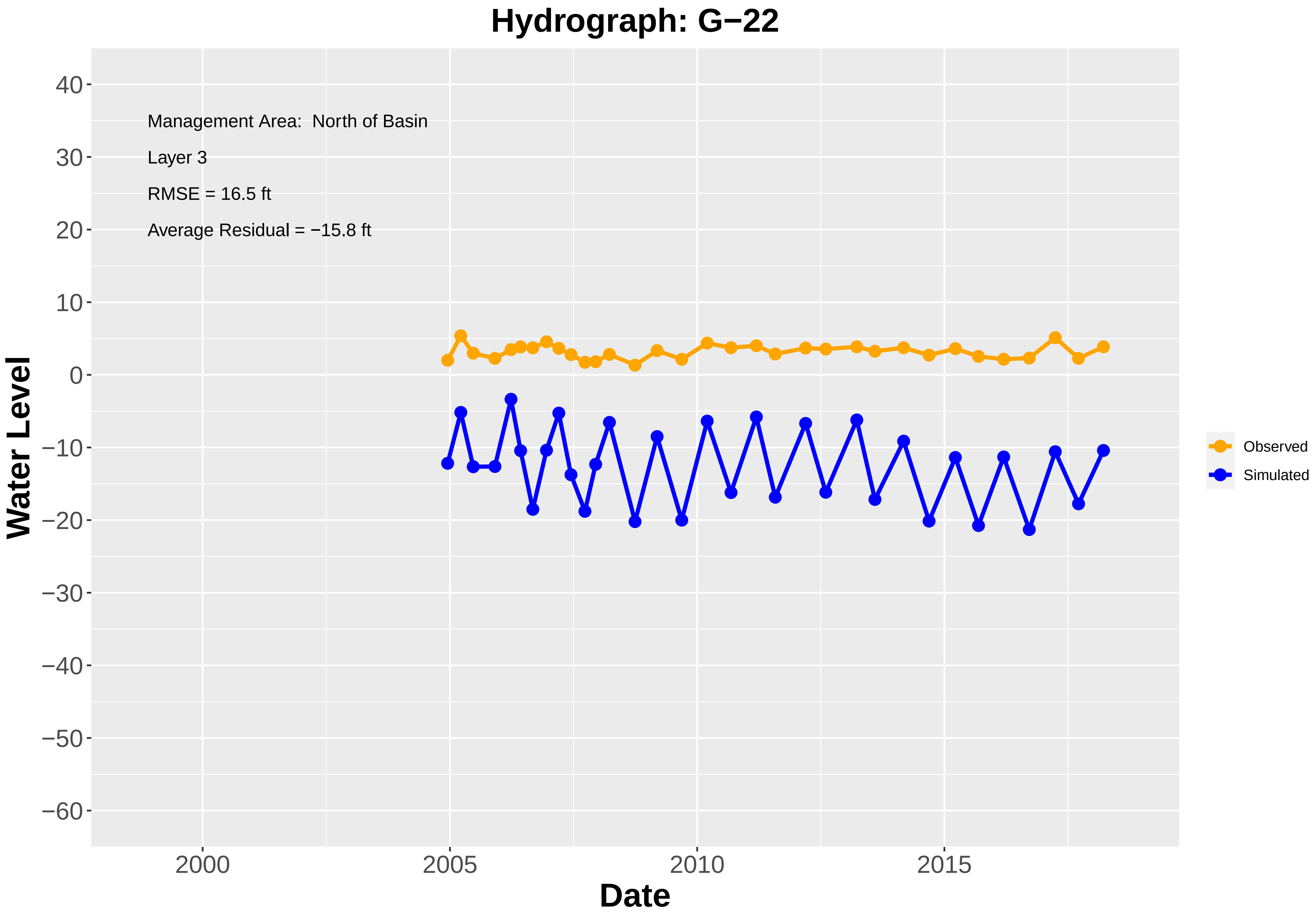

Hydrograph: G−09


Hydrograph: G−11
Management Area: North of Basin
Layer 1
RMSE = 4.9 ft
Average Residual = 4.6 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated

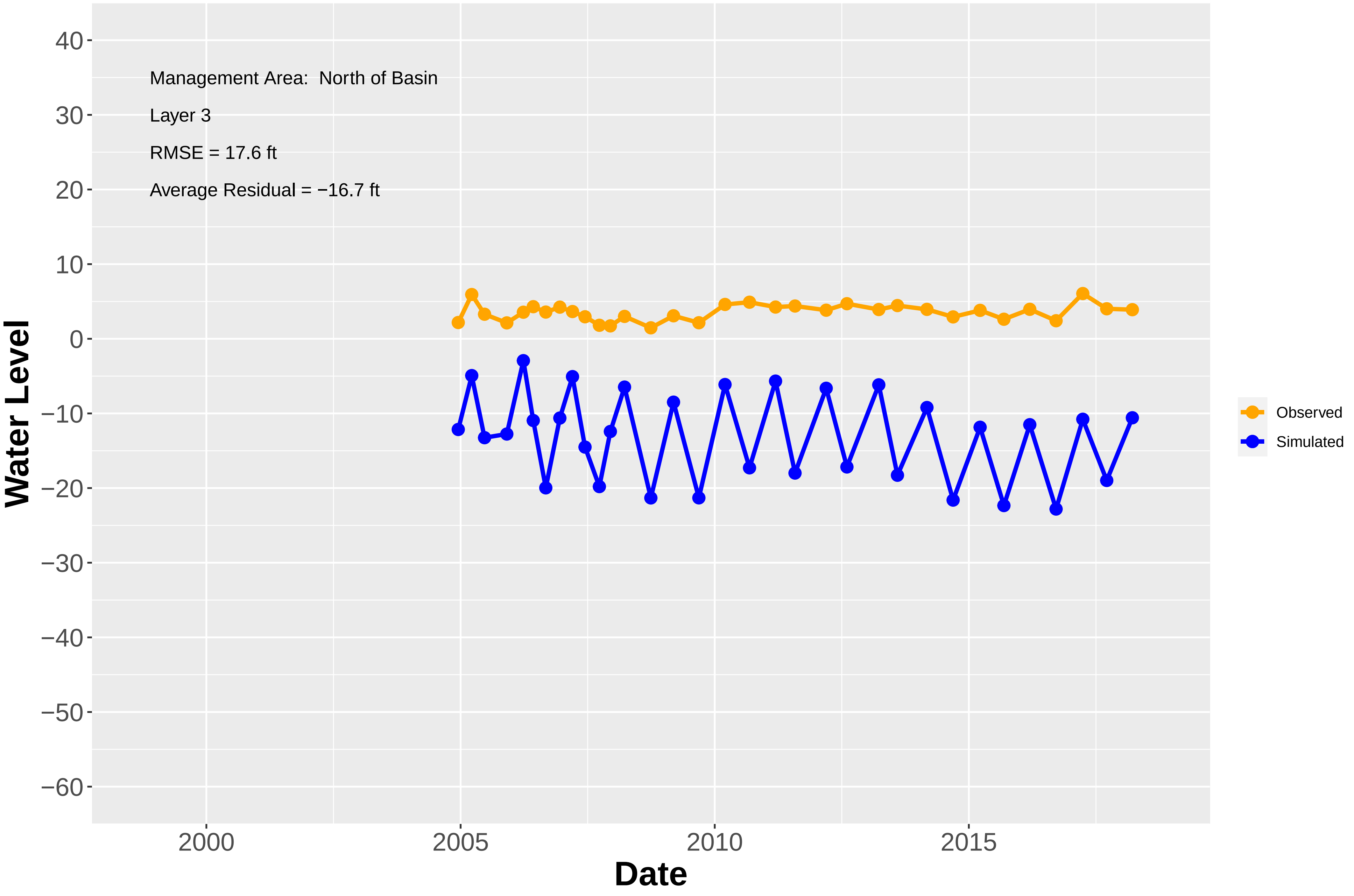

Hydrograph: G−16
Management Area: North of Basin
Layer 1
RMSE = 6.9 ft
Average Residual = −6.7 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: G−17
Management Area: North of Basin
Layer 3
RMSE = 15.8 ft
Average Residual = −15.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

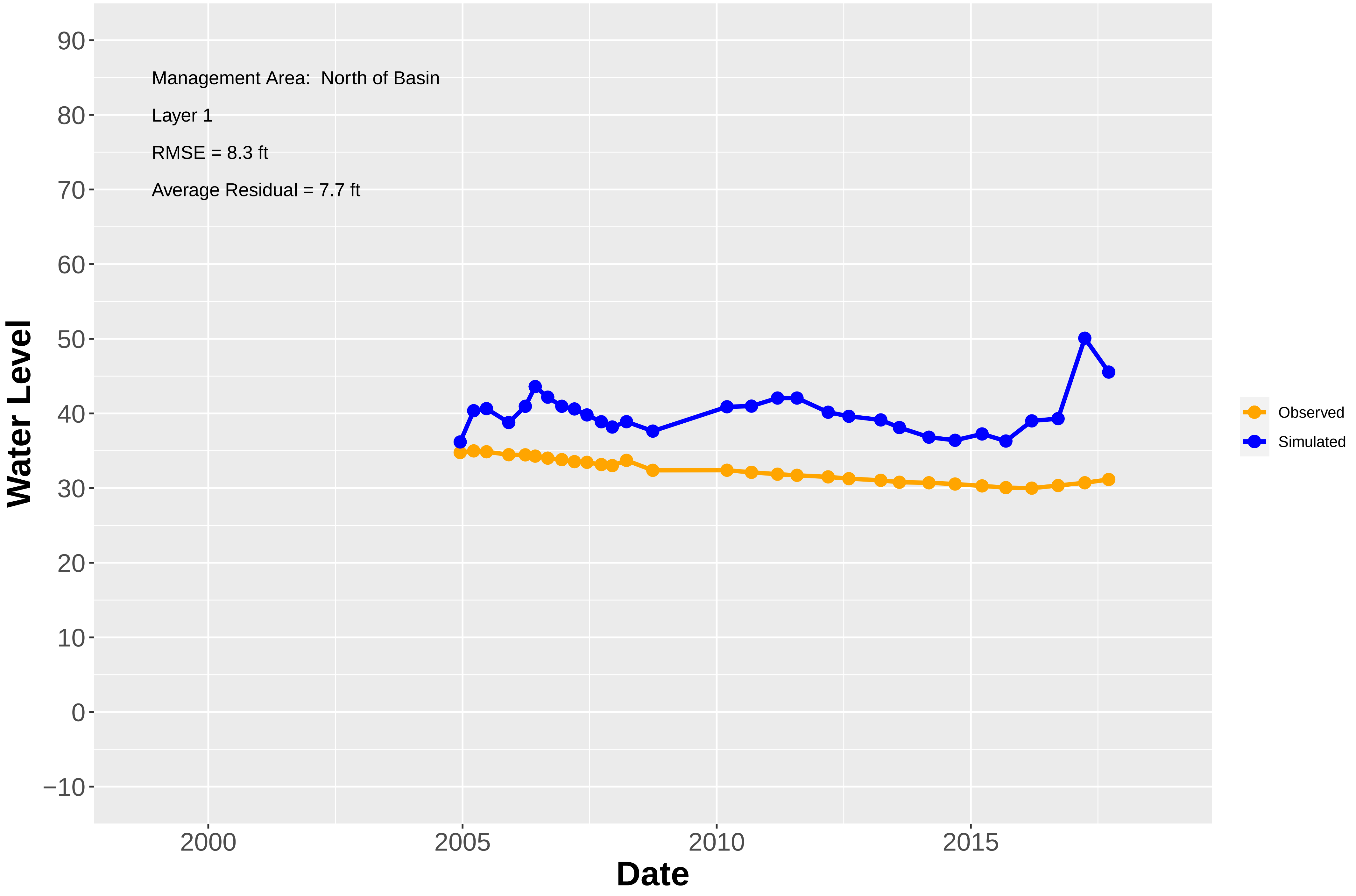

Hydrograph: G−21
Management Area: North of Basin
Layer 3
RMSE = 15.7 ft
Average Residual = −15.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: G−22
Management Area: North of Basin
Layer 3
RMSE = 16.5 ft
Average Residual = −15.8 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

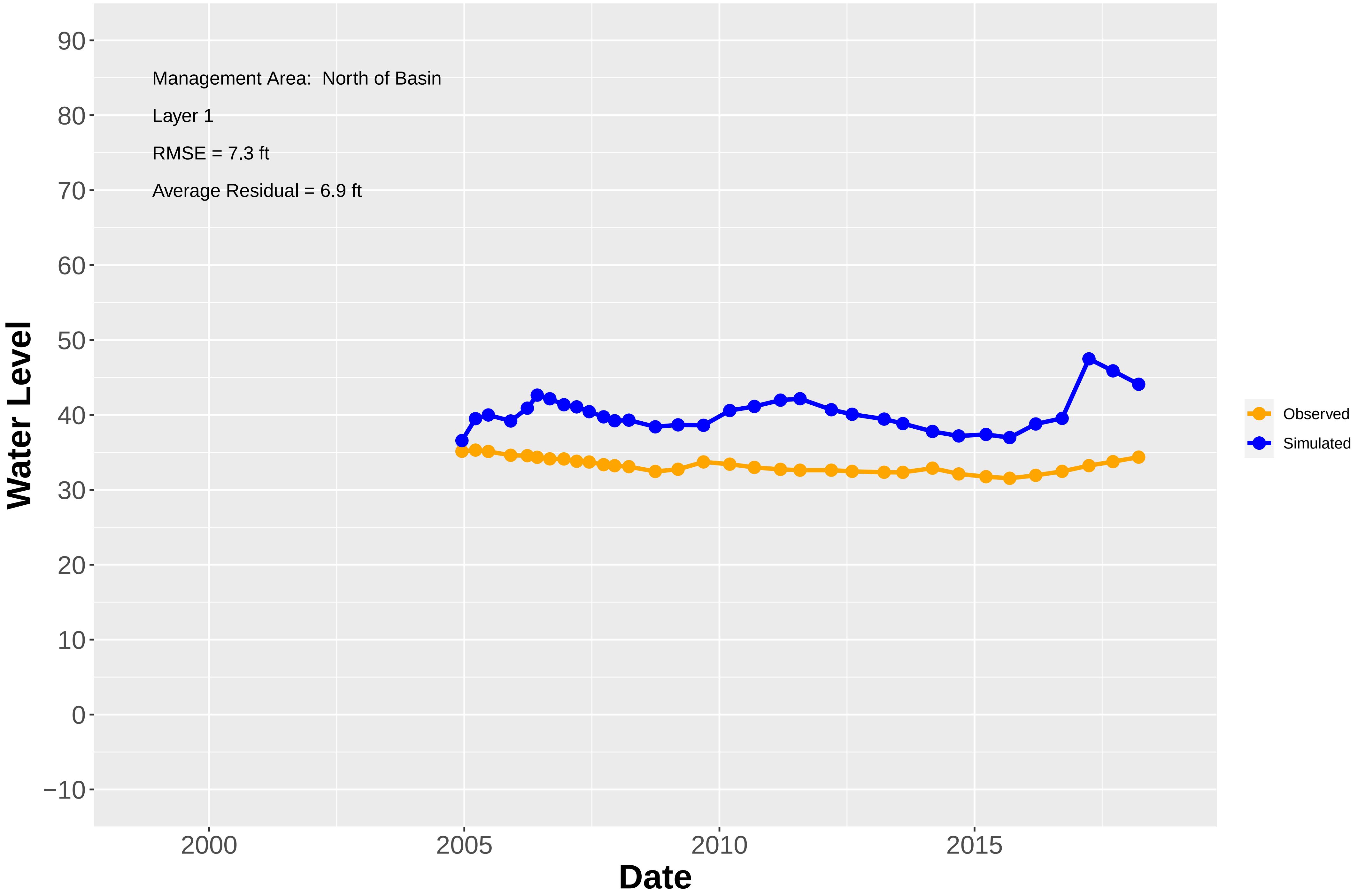
Hydrograph: G−23

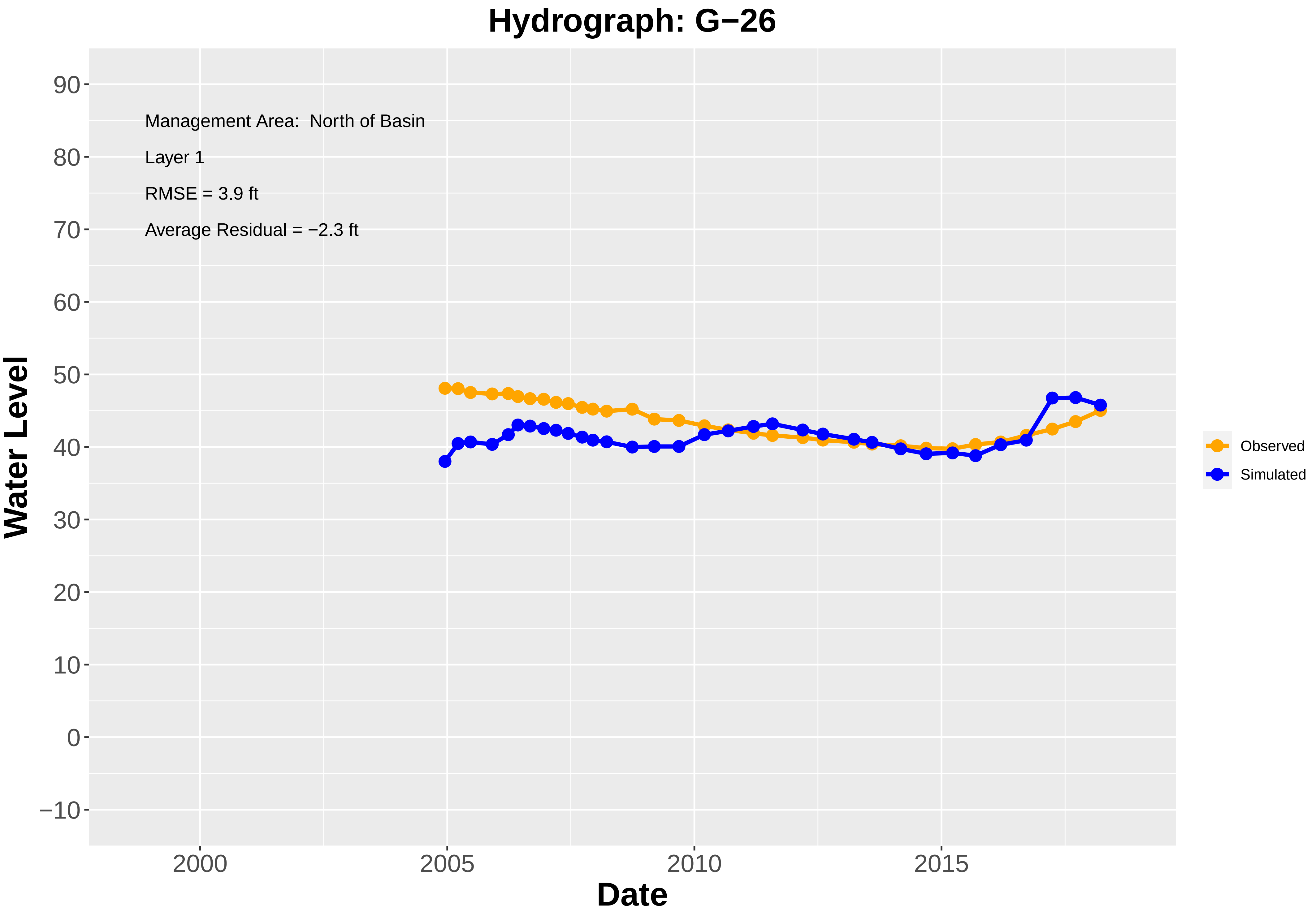


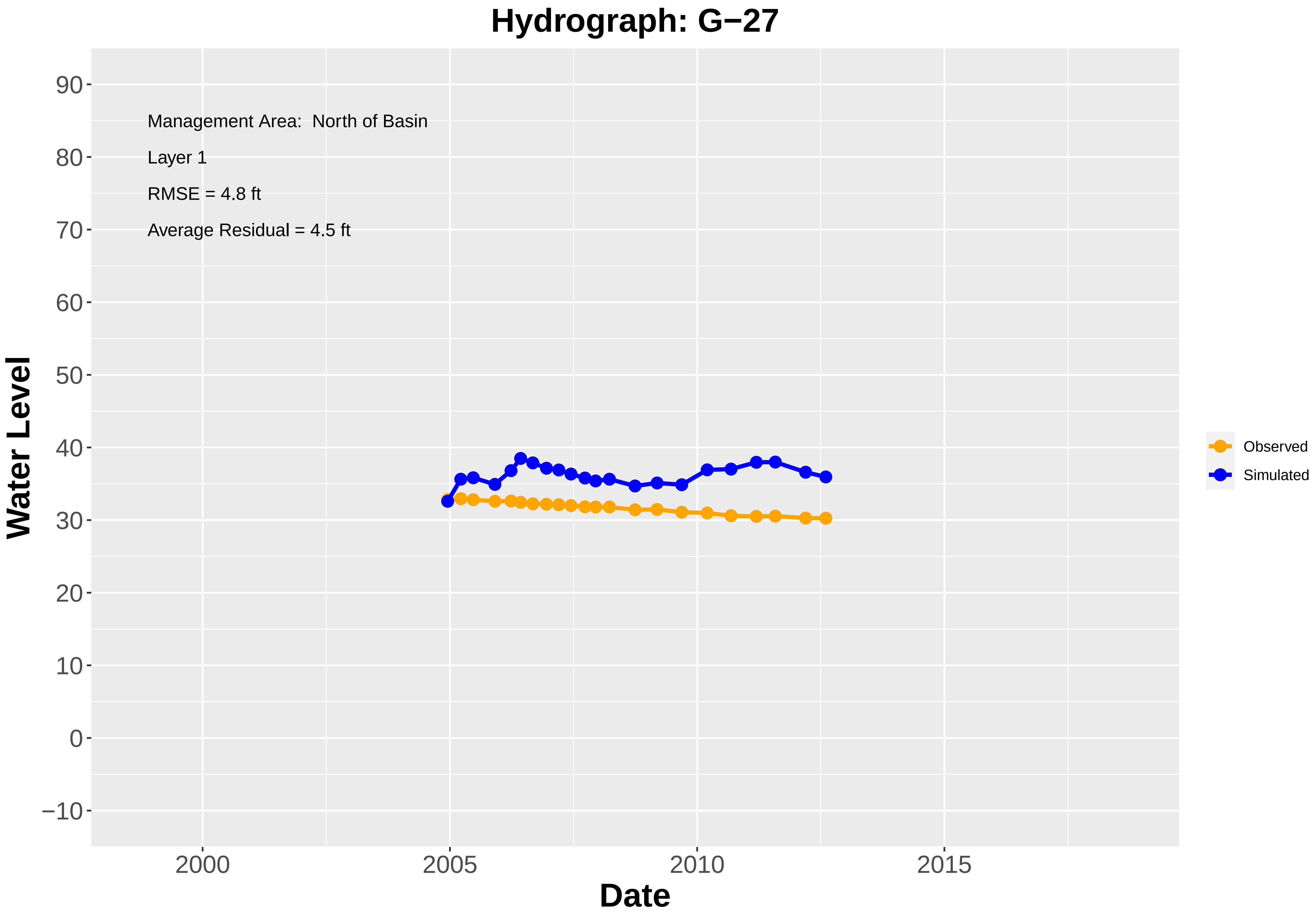
Hydrograph: G−24



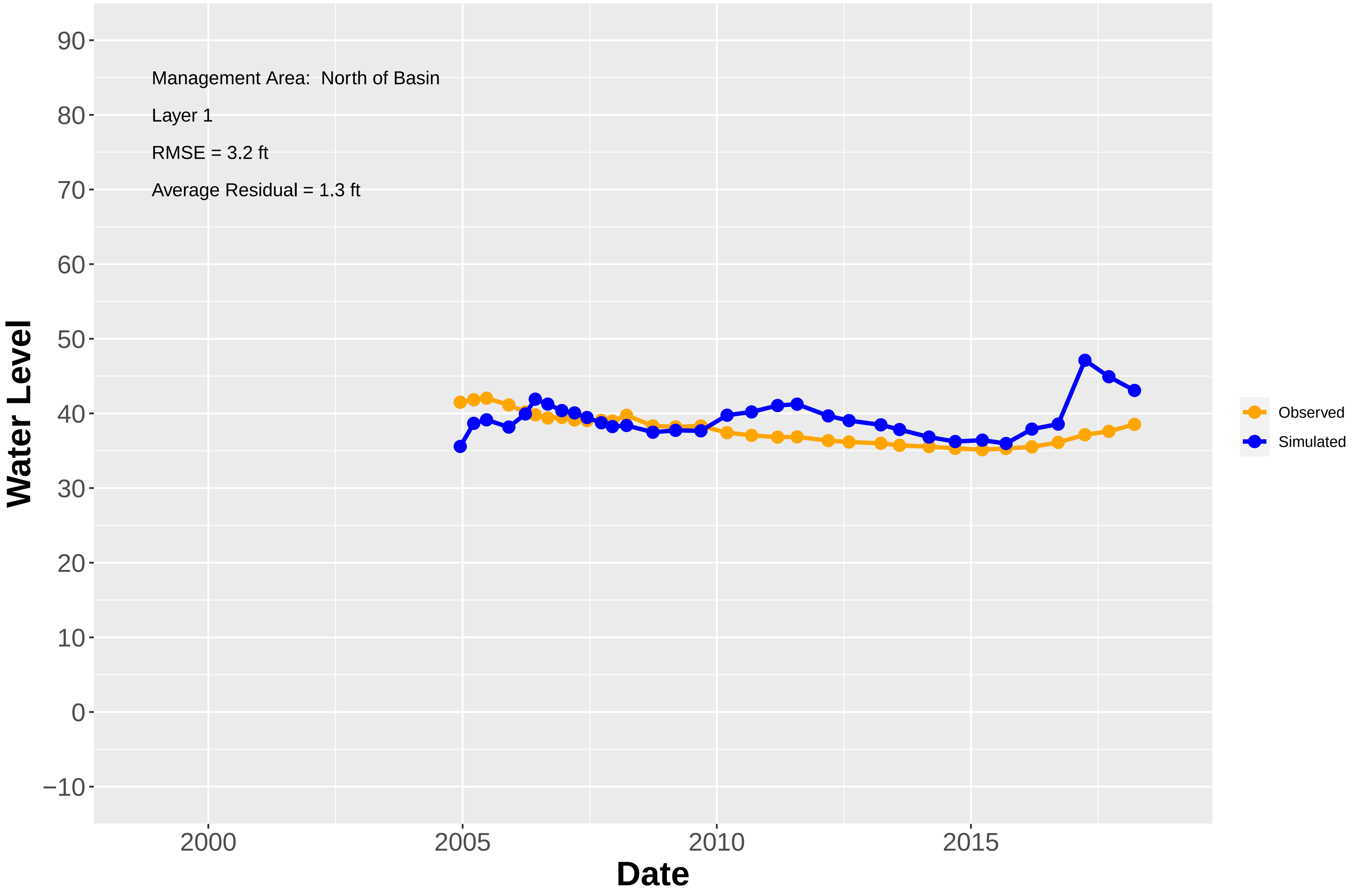
Hydrograph: G−25

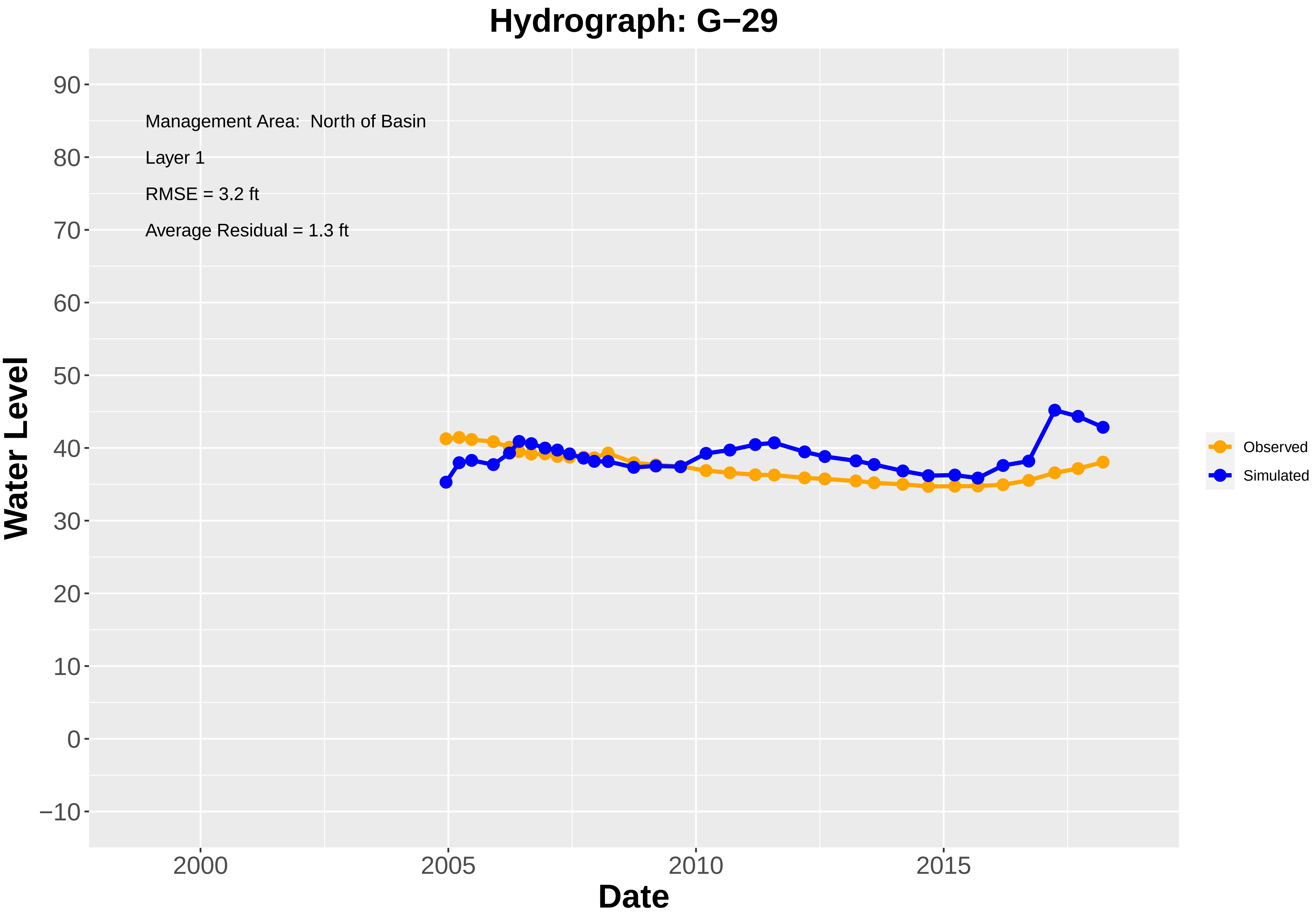


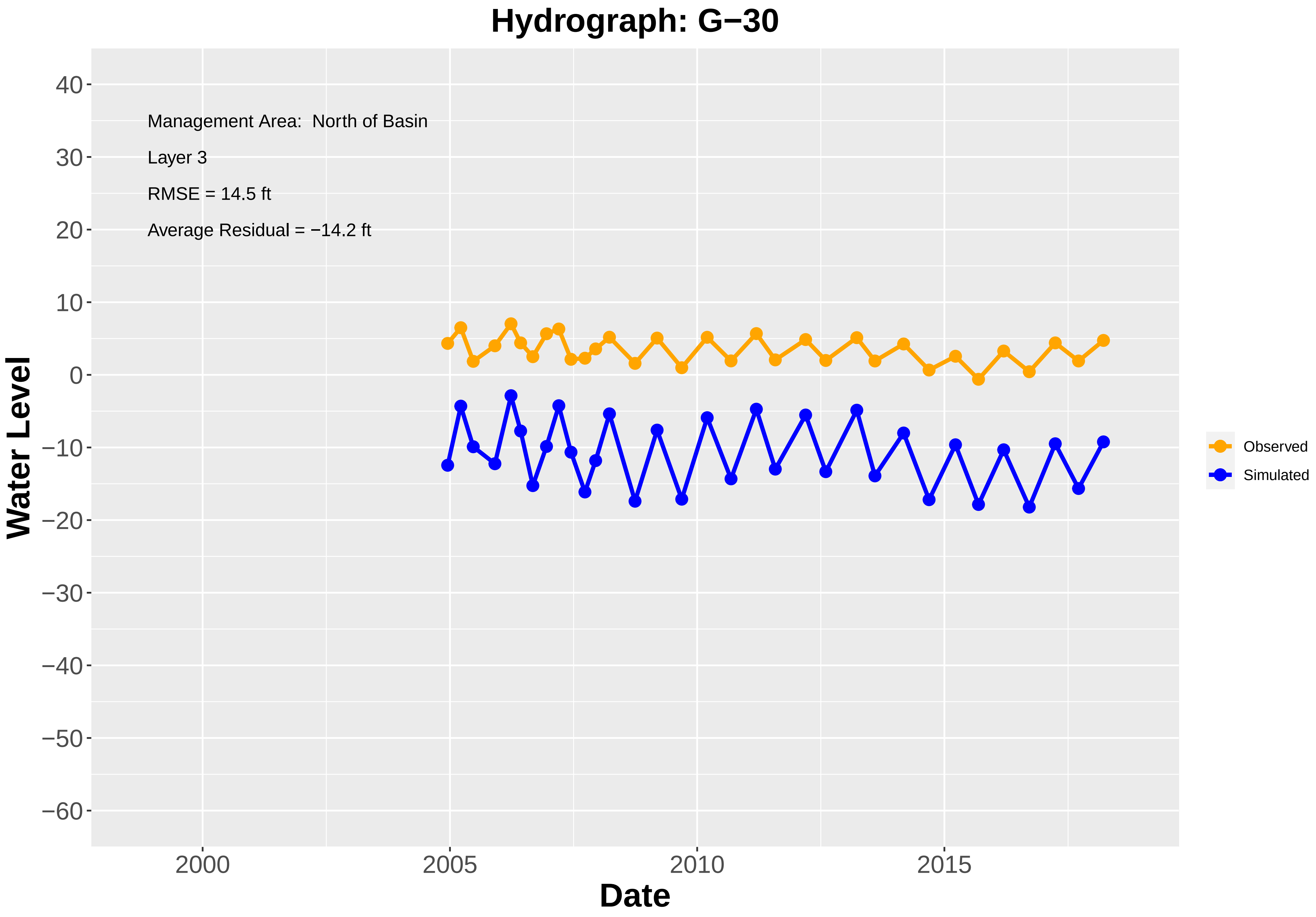

Hydrograph: G−26
Management Area: North of Basin
Layer 1
RMSE = 3.9 ft
Average Residual = −2.3 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

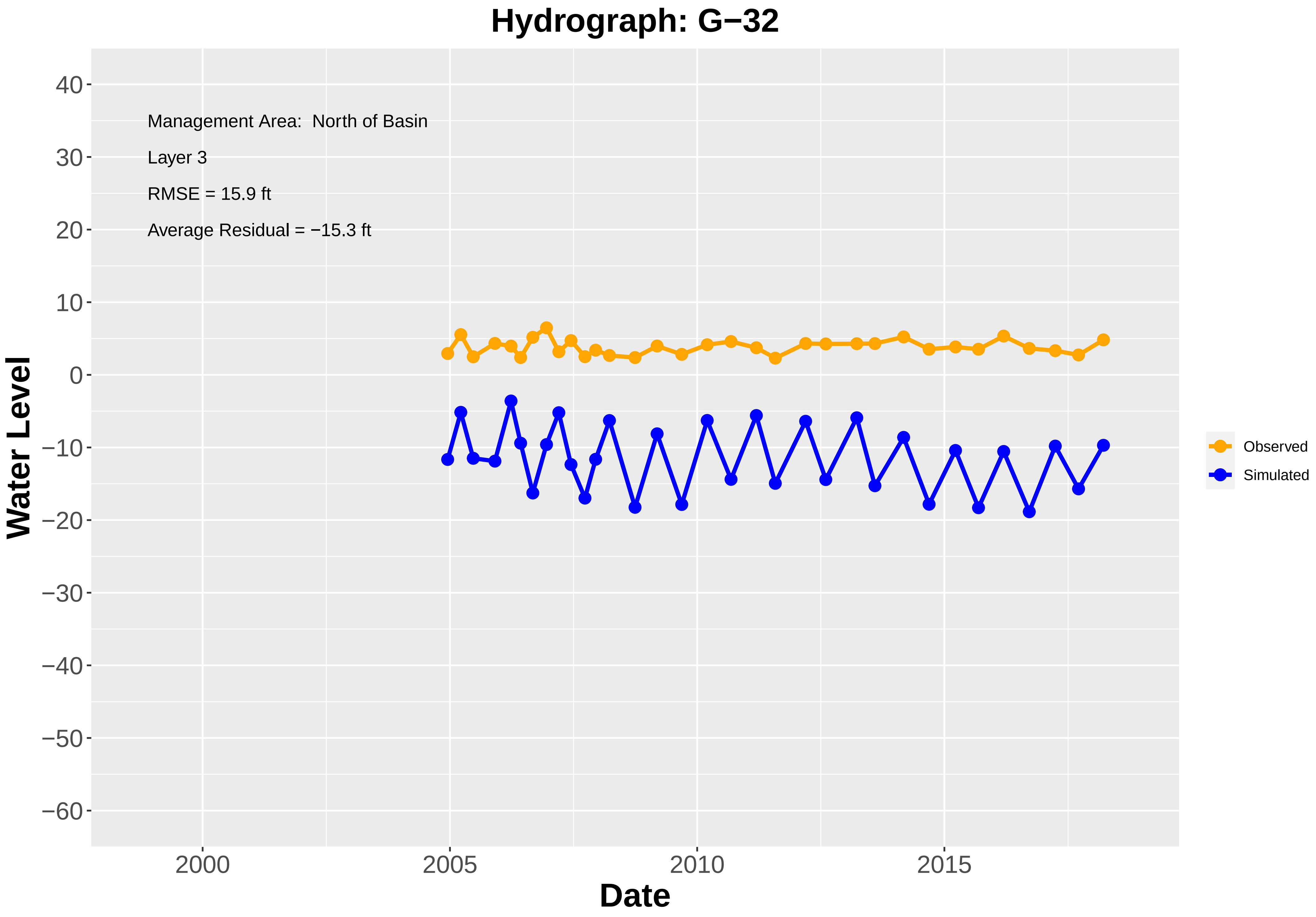
Hydrograph: G−27
Management Area: North of Basin
Layer 1
RMSE = 4.8 ft
Average Residual = 4.5 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

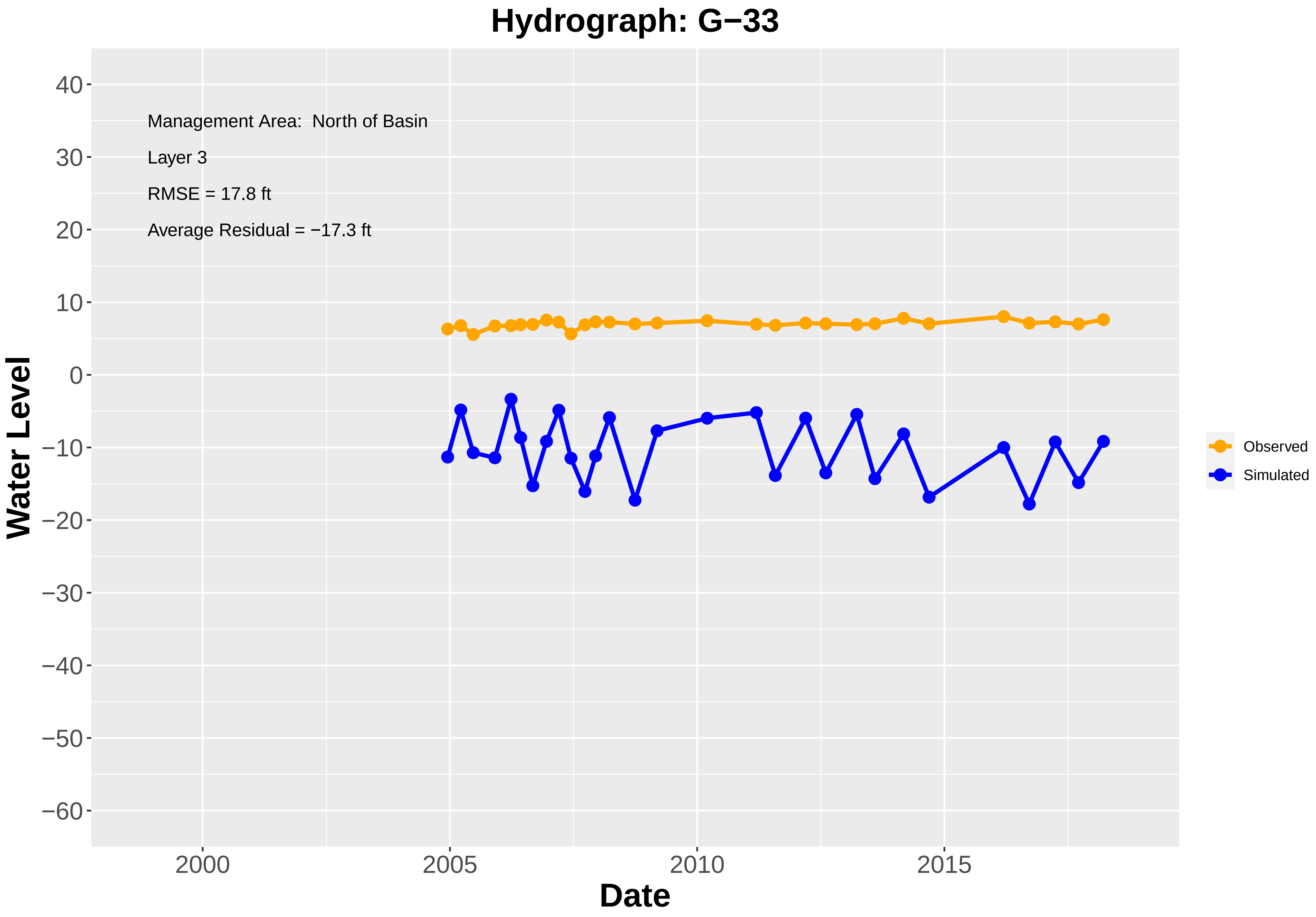
Hydrograph: G−28

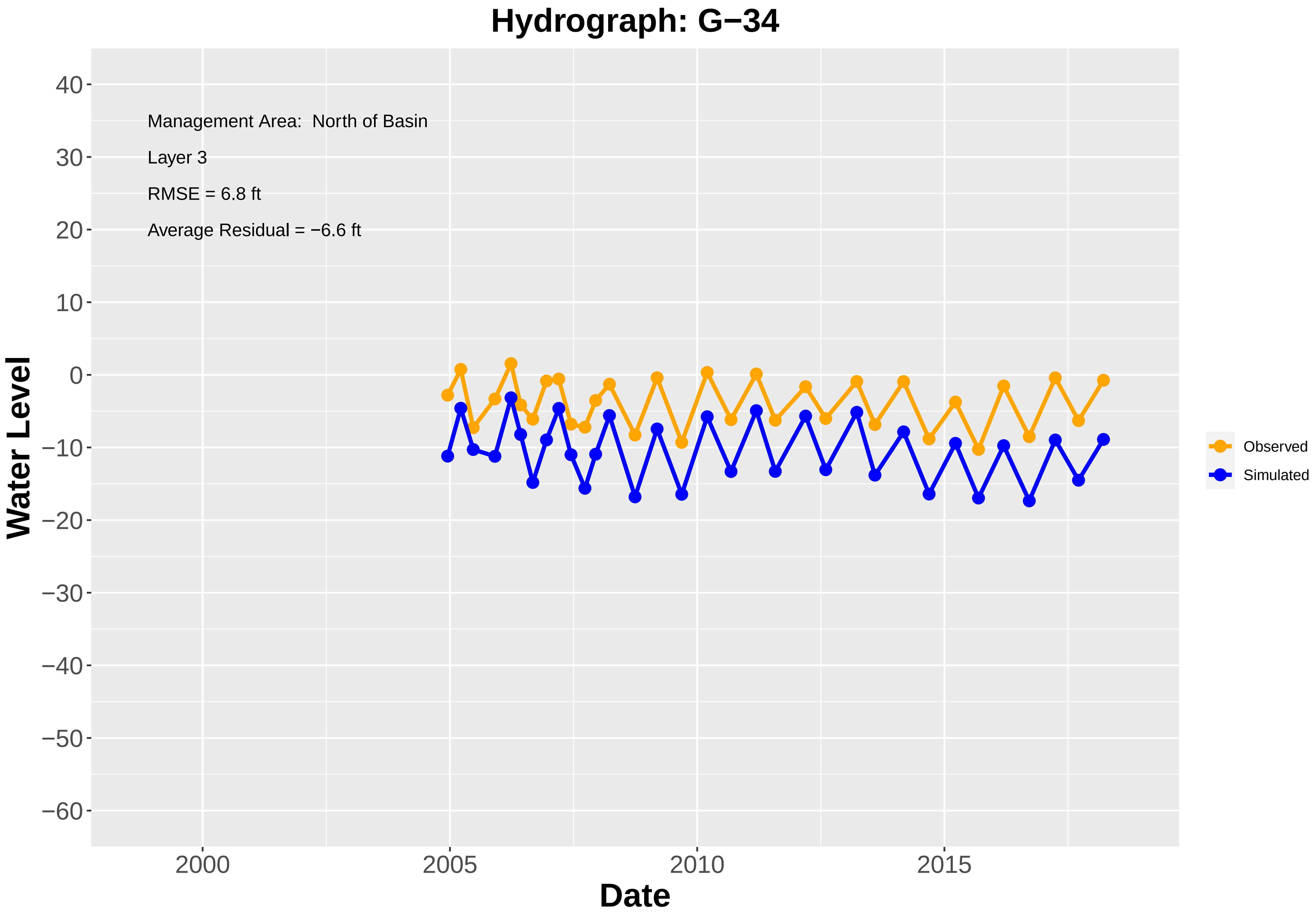



Hydrograph: G−29
Management Area: North of Basin
Layer 1
RMSE = 3.2 ft
Average Residual = 1.3 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

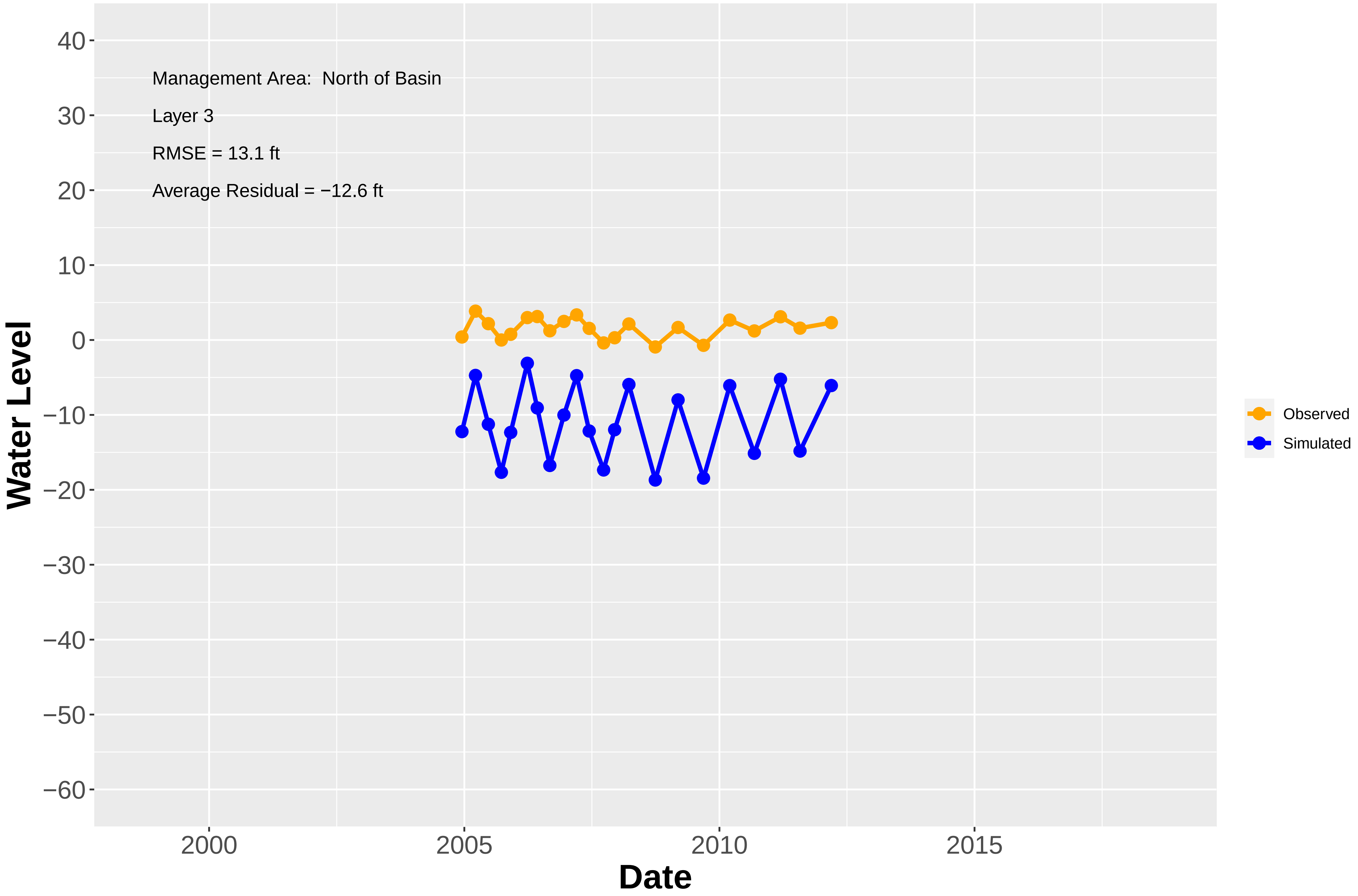

Hydrograph: G−30
Management Area: North of Basin
Layer 3
RMSE = 14.5 ft
Average Residual = −14.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: G−32
Management Area: North of Basin
Layer 3
RMSE = 15.9 ft
Average Residual = −15.3 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

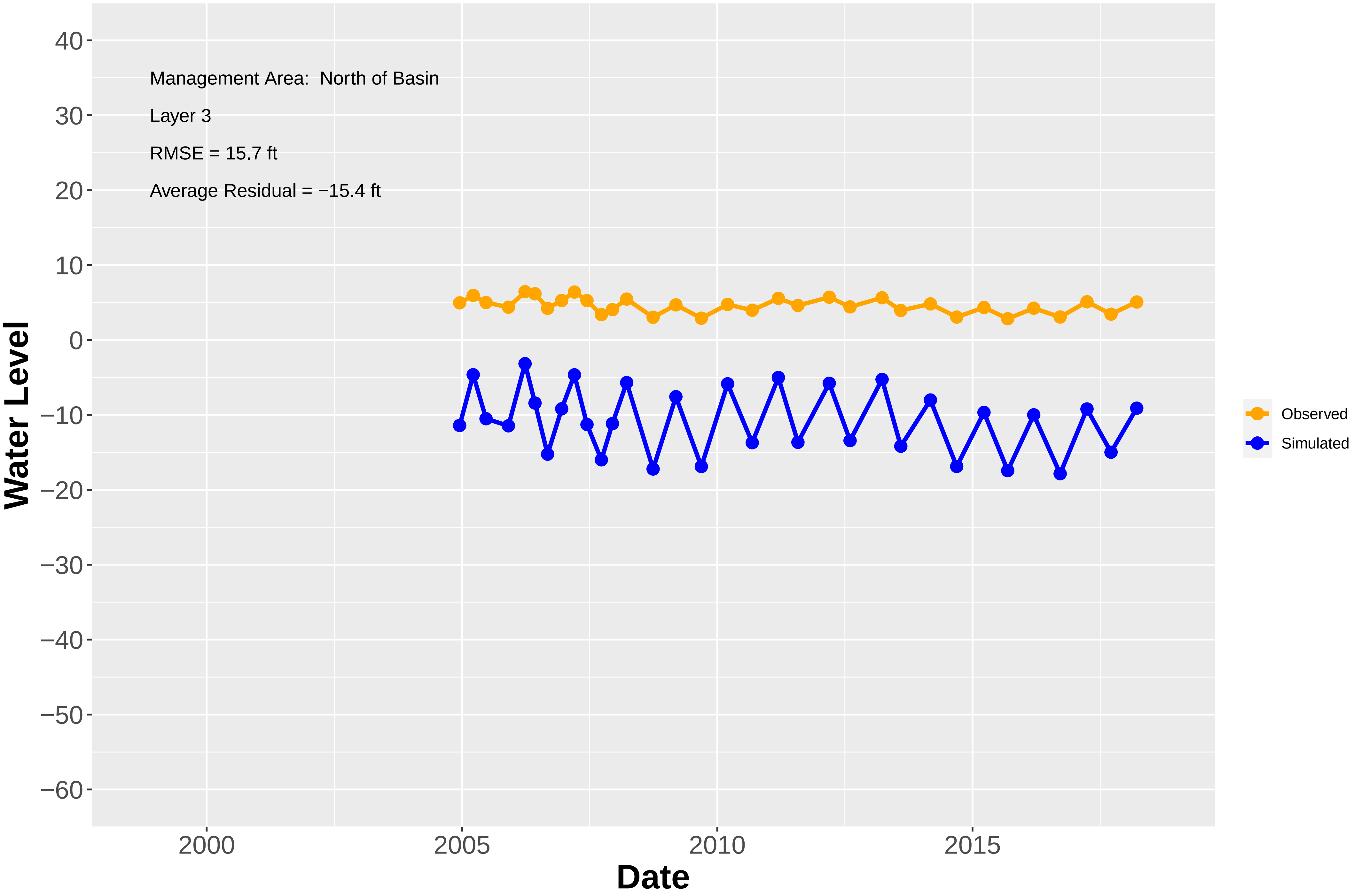

Hydrograph: G−33
Management Area: North of Basin
Layer 3
RMSE = 17.8 ft
Average Residual = −17.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: G−34
Management Area: North of Basin
Layer 3
RMSE = 6.8 ft
Average Residual = −6.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

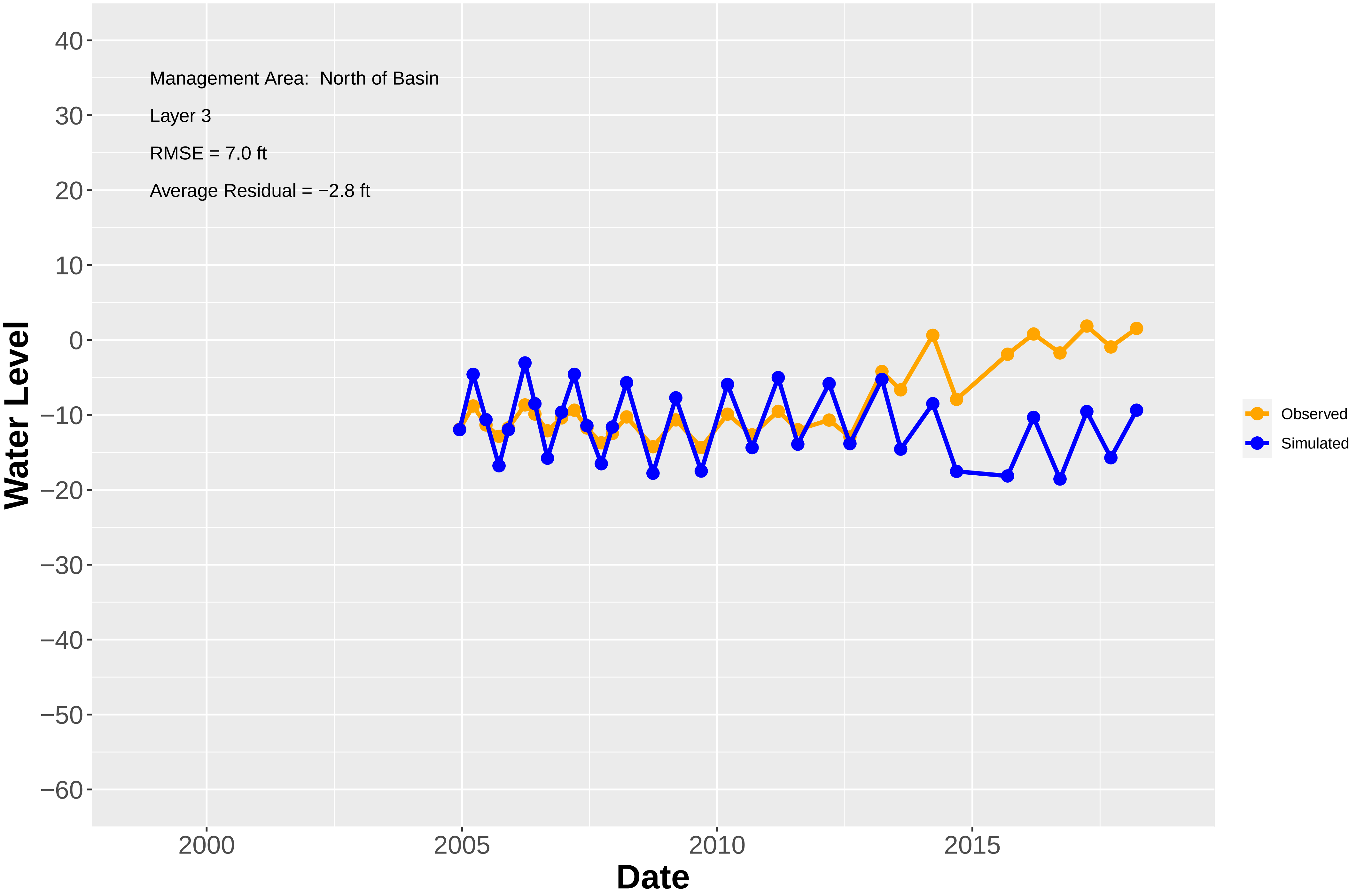
Hydrograph: G−37



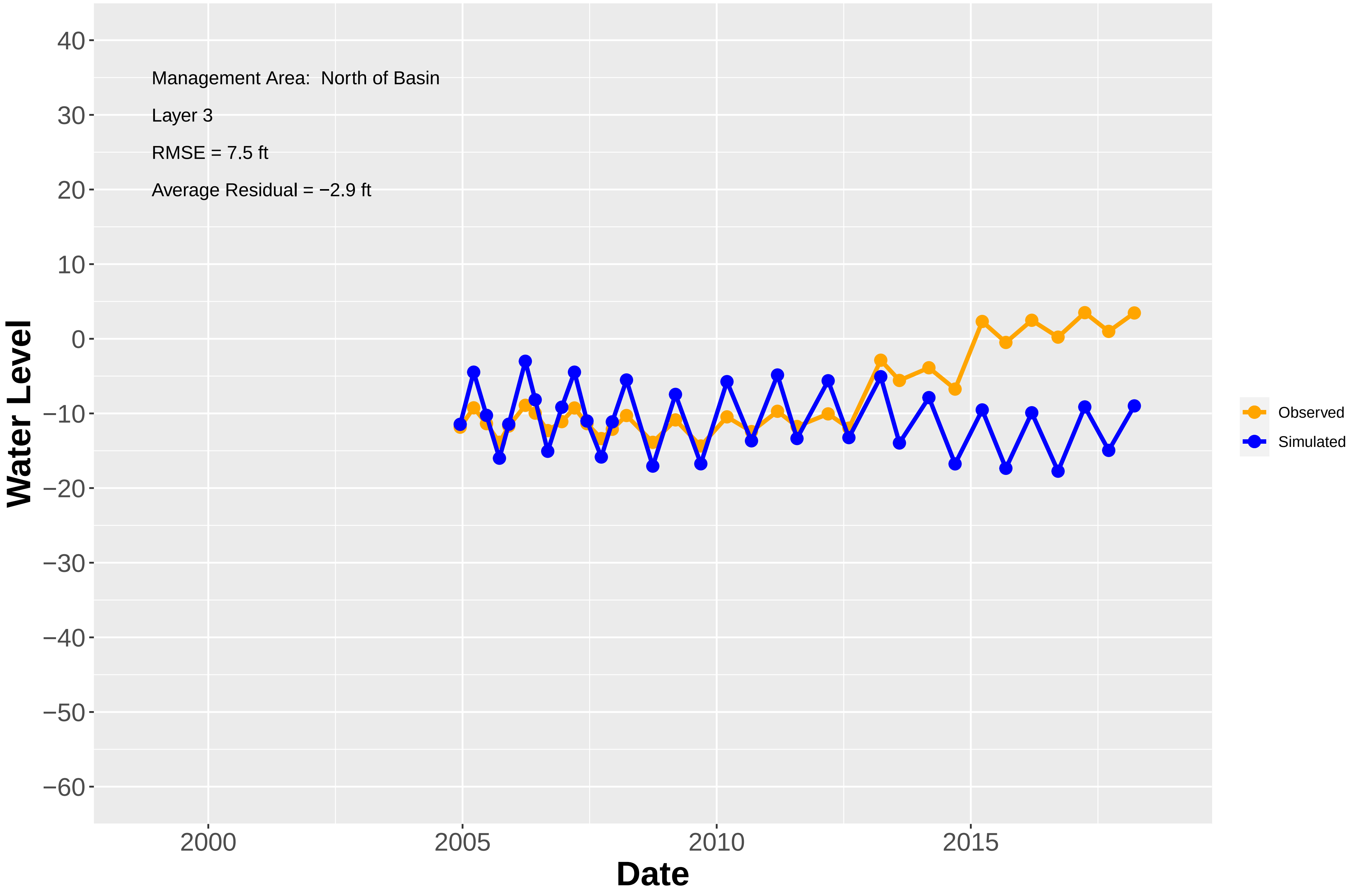
Hydrograph: G−38R

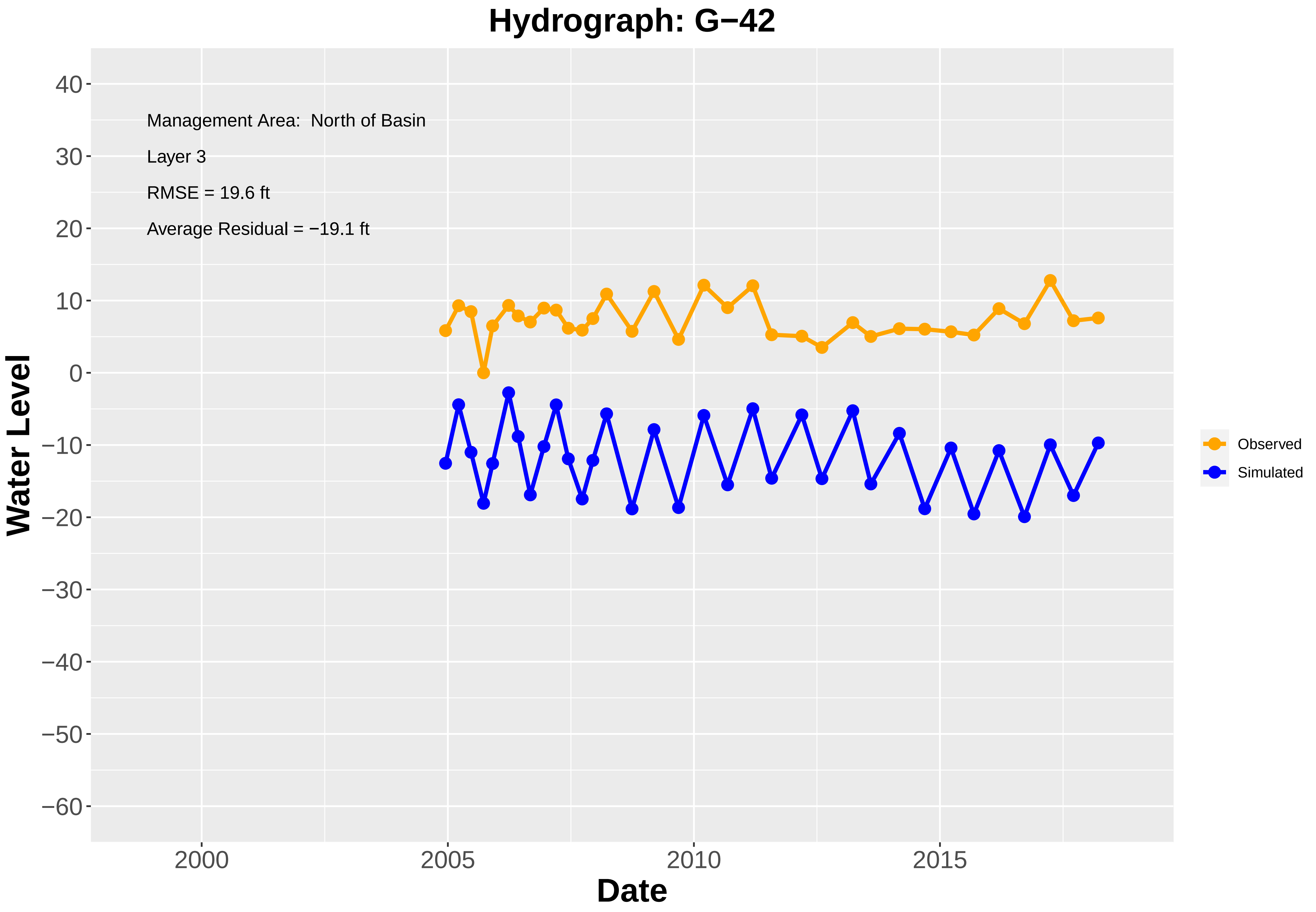


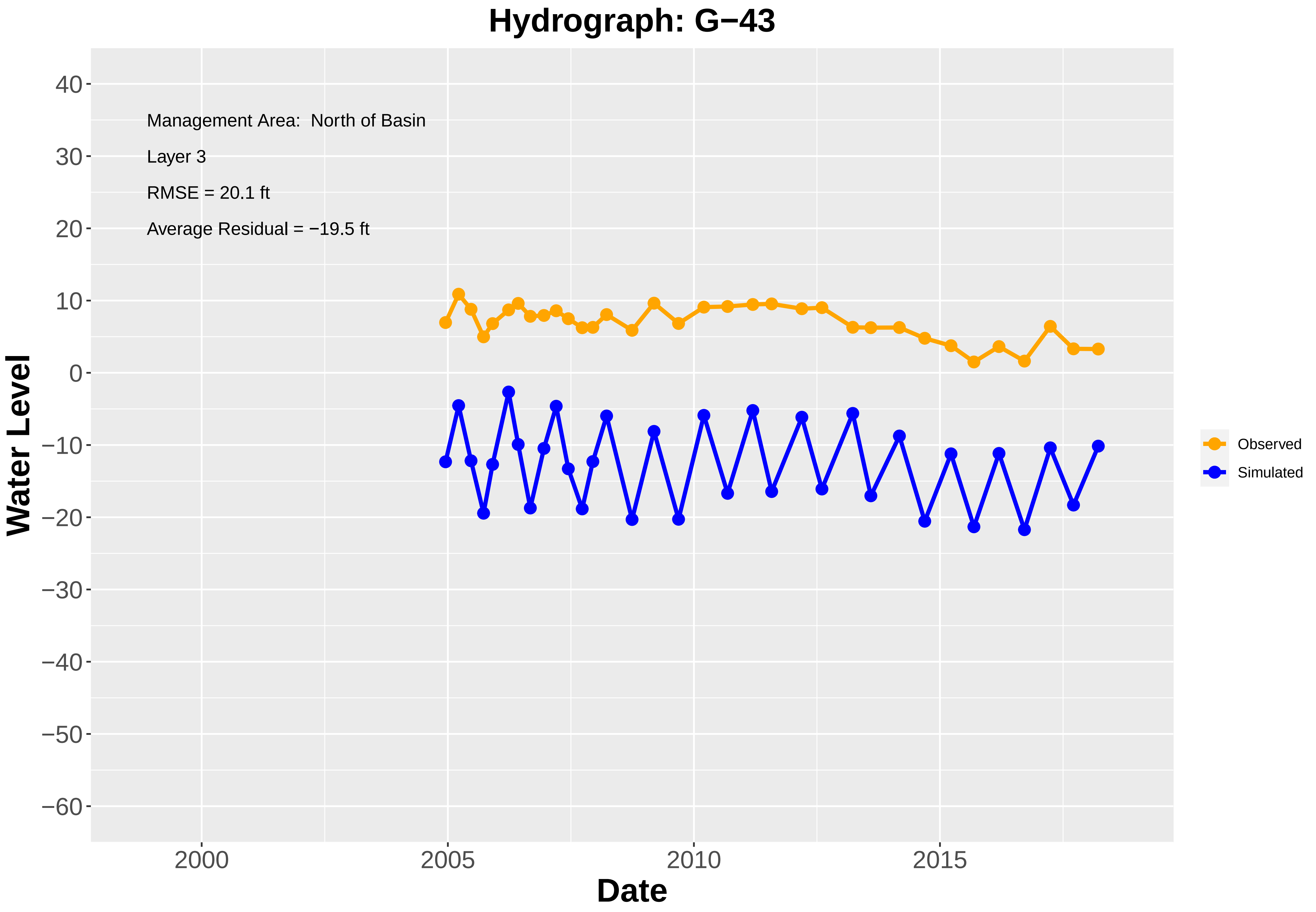
Hydrograph: G−40



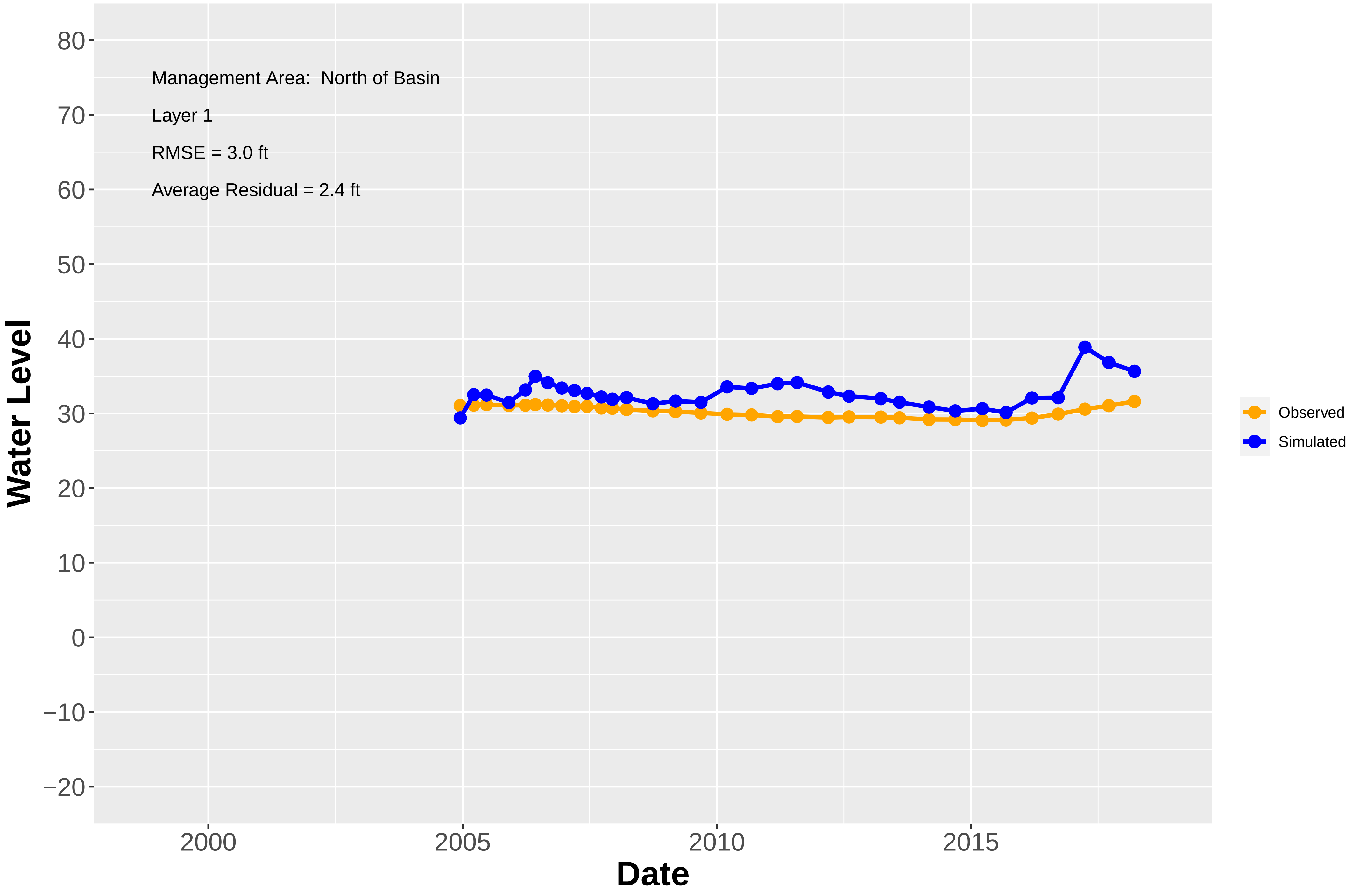
Hydrograph: G−41

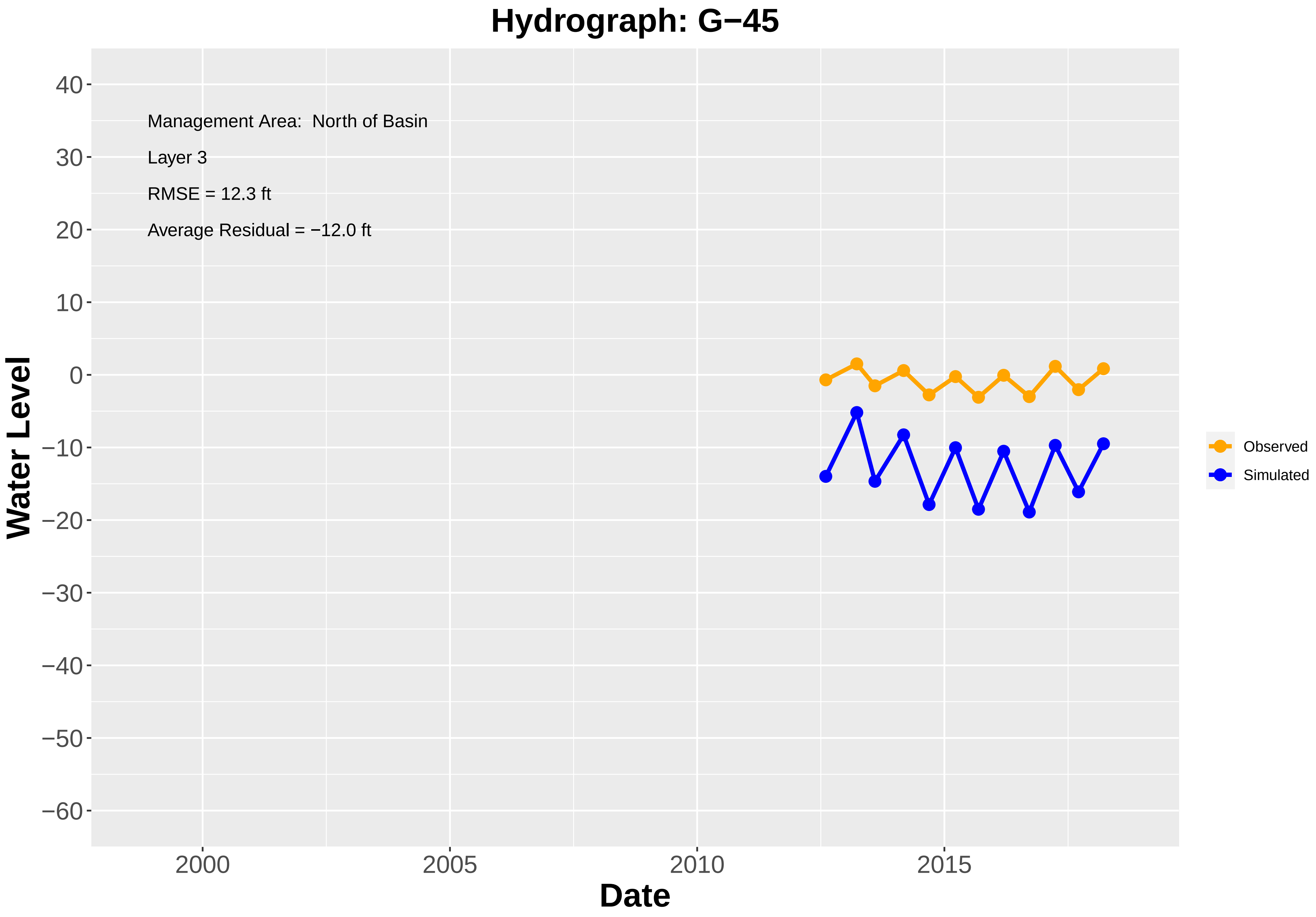


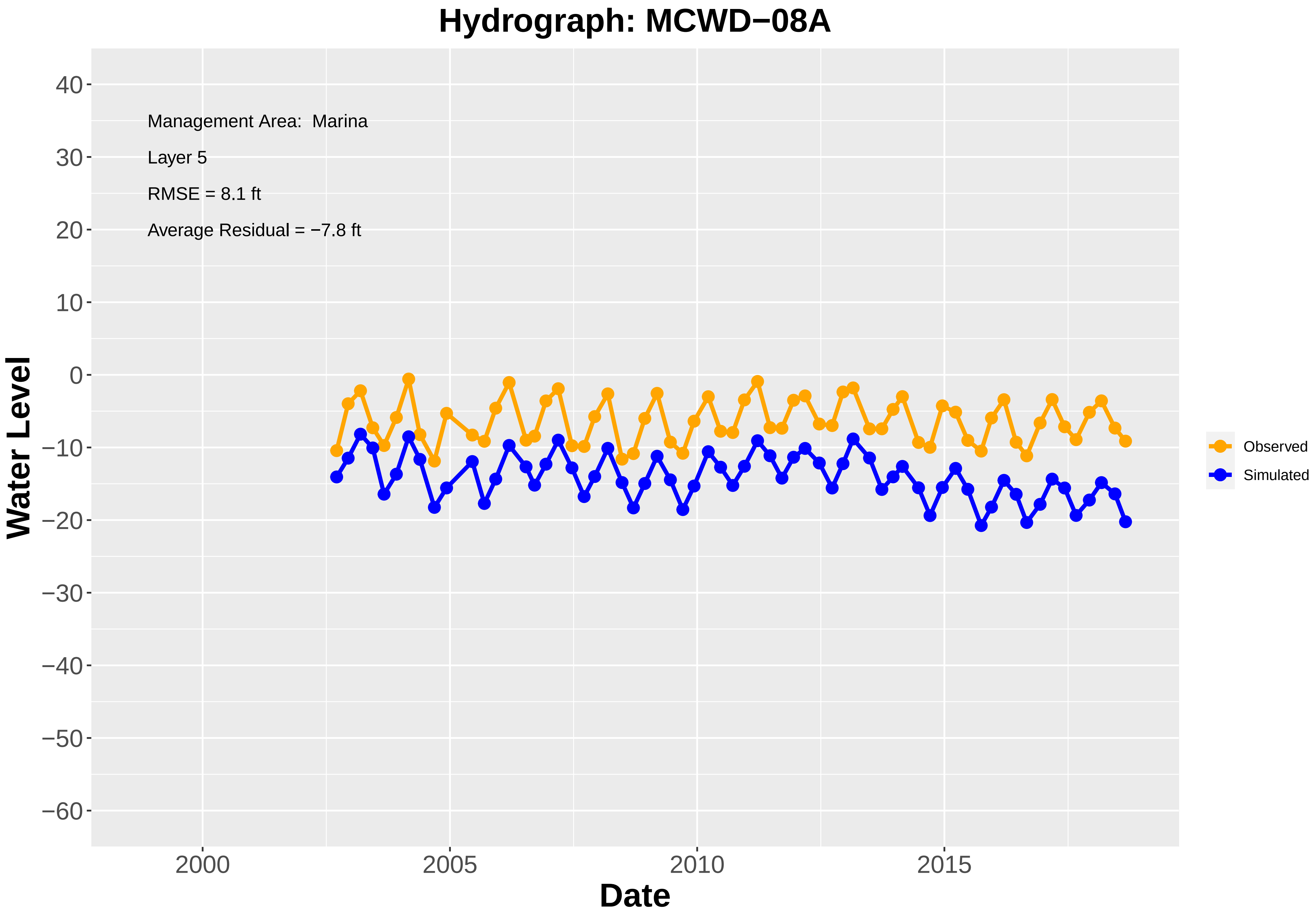

Hydrograph: G−42
Management Area: North of Basin
Layer 3
RMSE = 19.6 ft
Average Residual = −19.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: G−43
Management Area: North of Basin
Layer 3
RMSE = 20.1 ft
Average Residual = −19.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

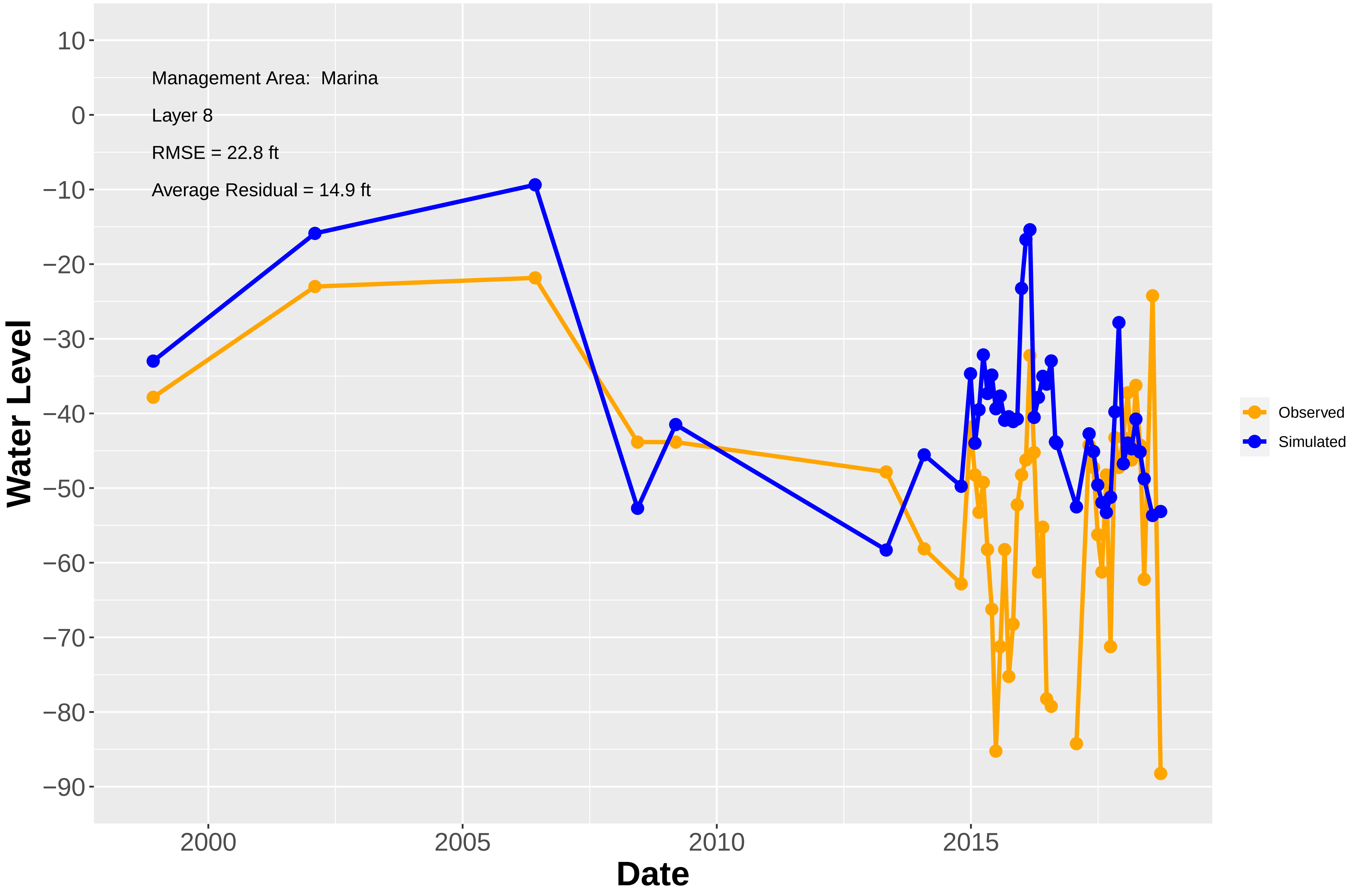
Hydrograph: G−44



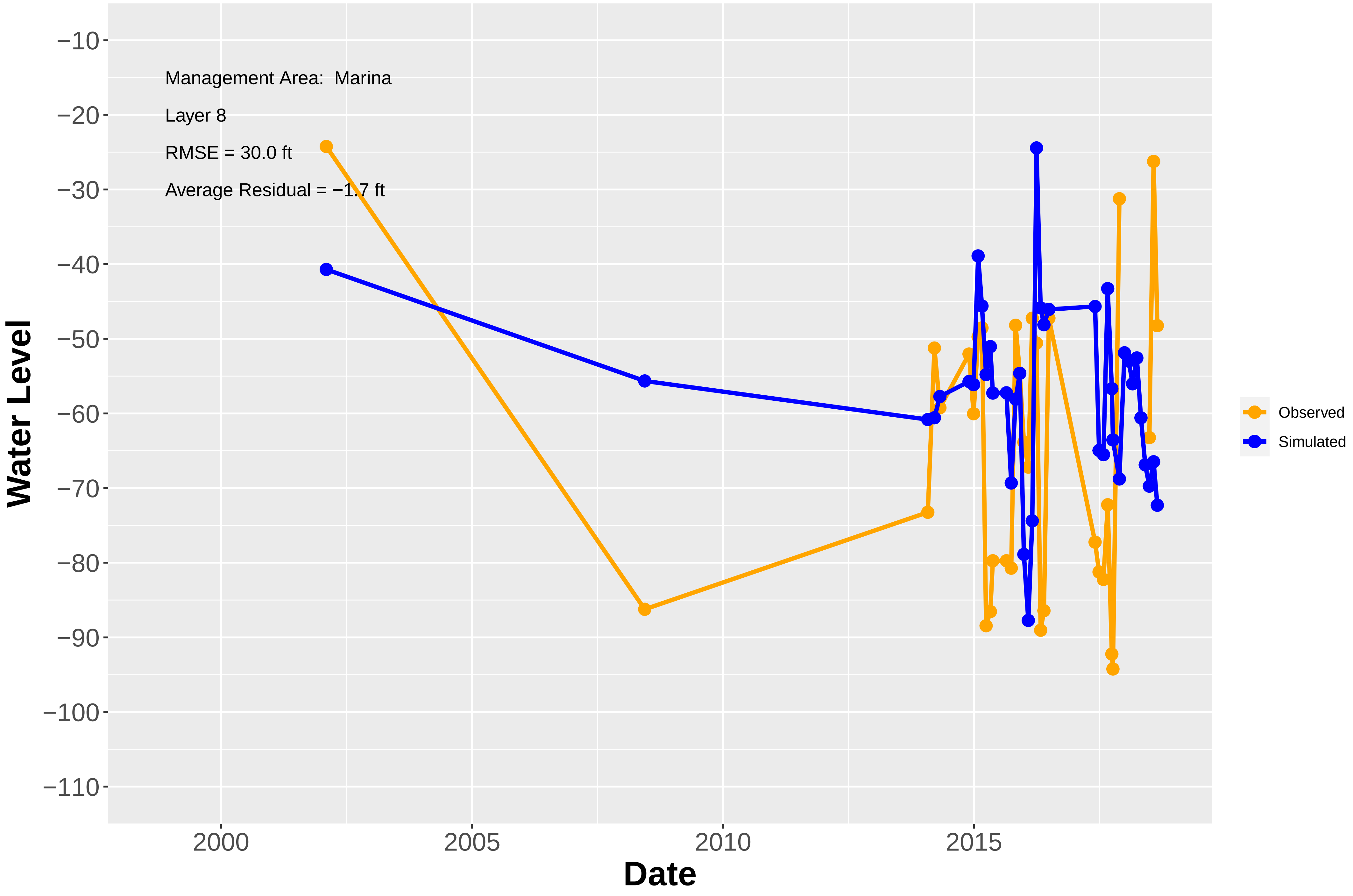

Hydrograph: G−45
Management Area: North of Basin
Layer 3
RMSE = 12.3 ft
Average Residual = −12.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MCWD−08A
Management Area: Marina
Layer 5
RMSE = 8.1 ft
Average Residual = −7.8 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

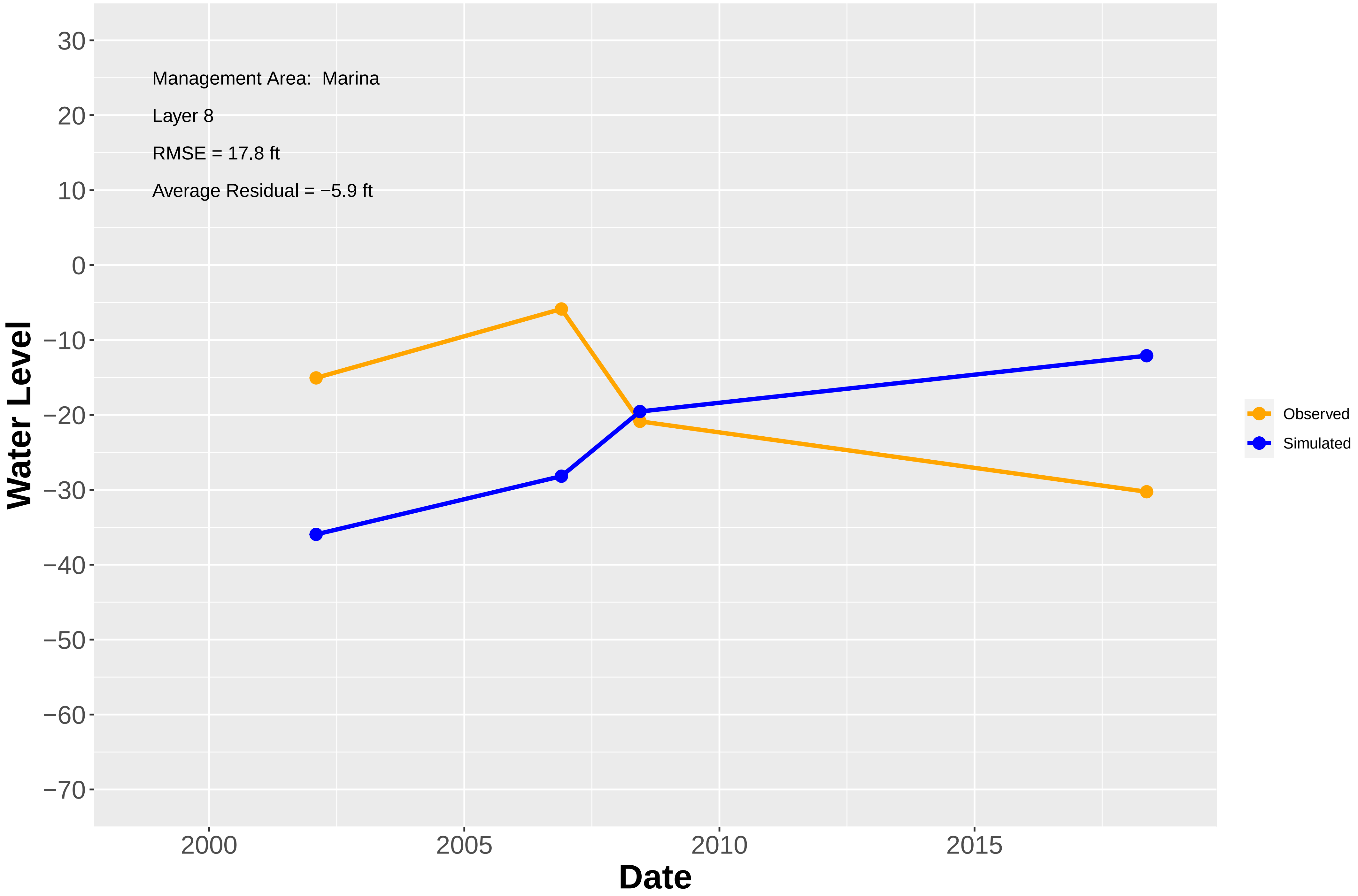
Hydrograph: MCWD−10



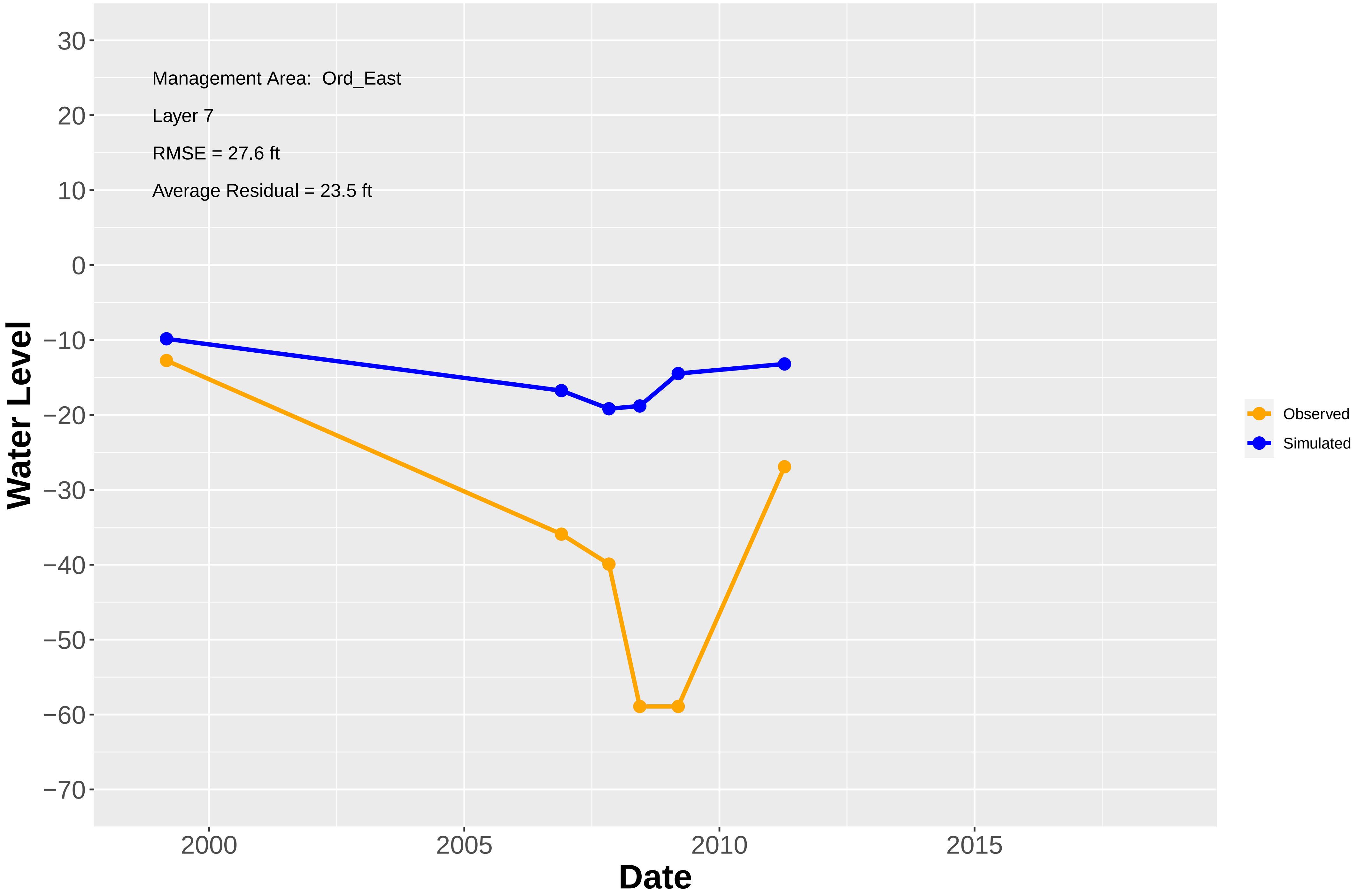
Hydrograph: MCWD−11

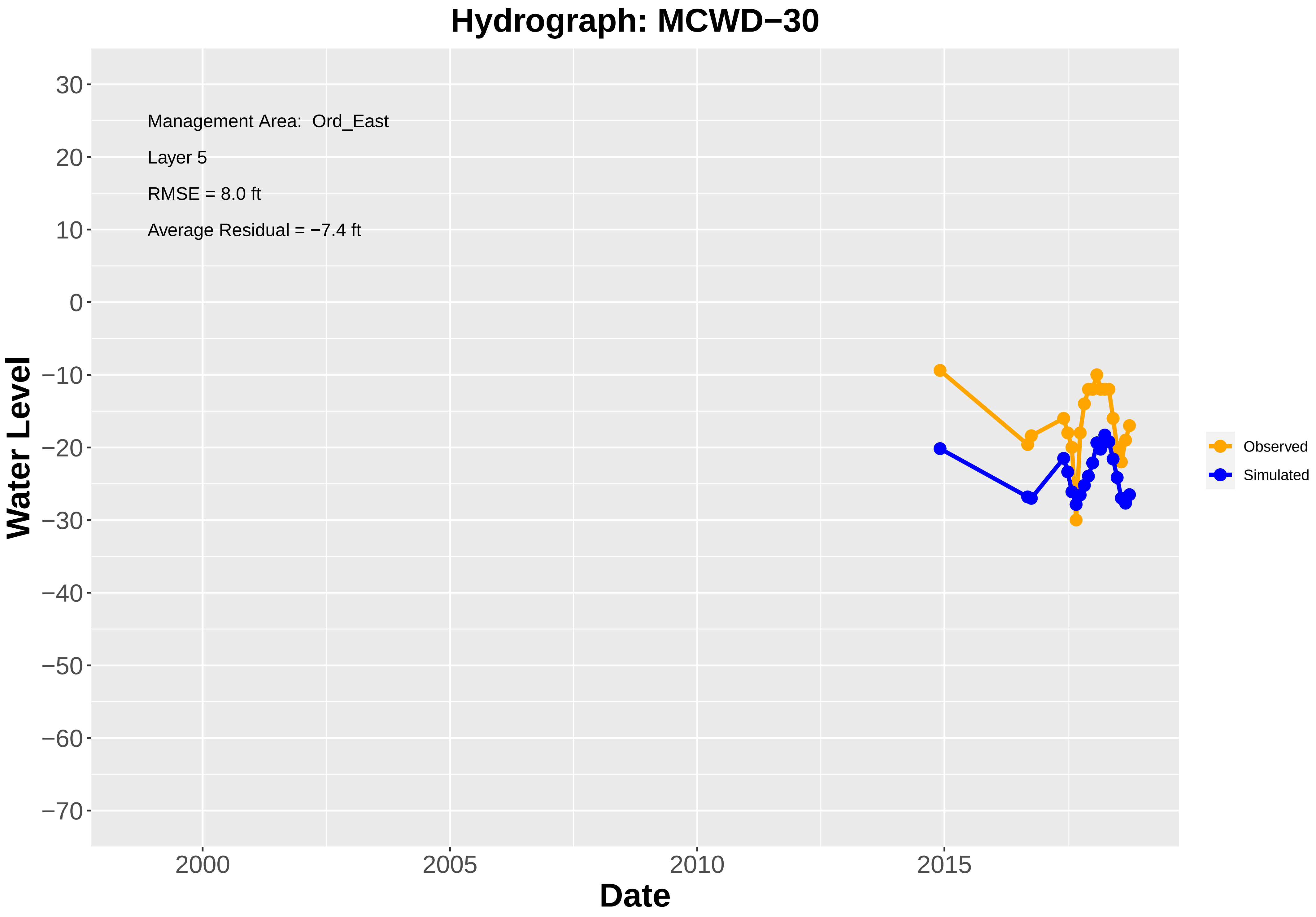


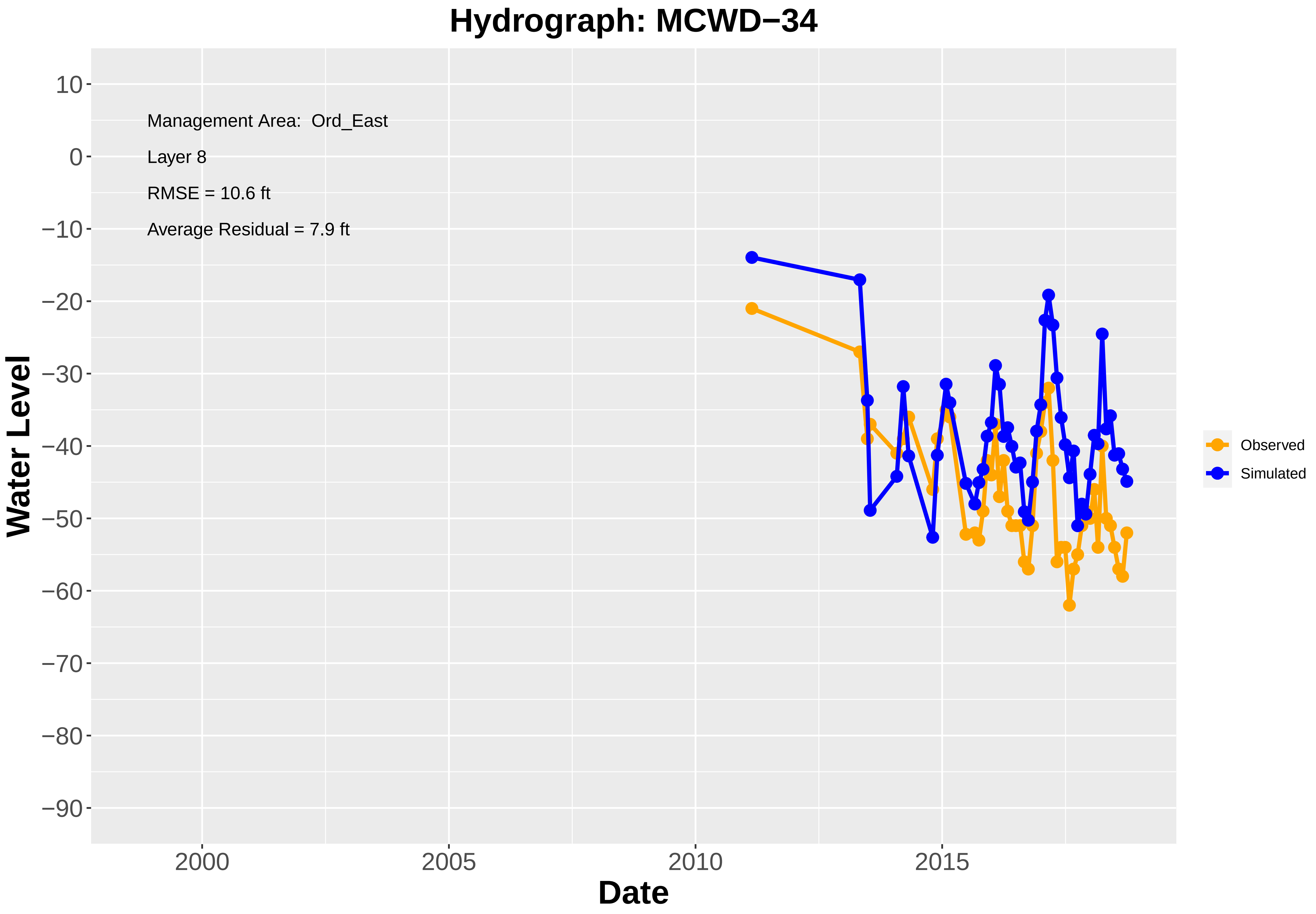
Hydrograph: MCWD−12

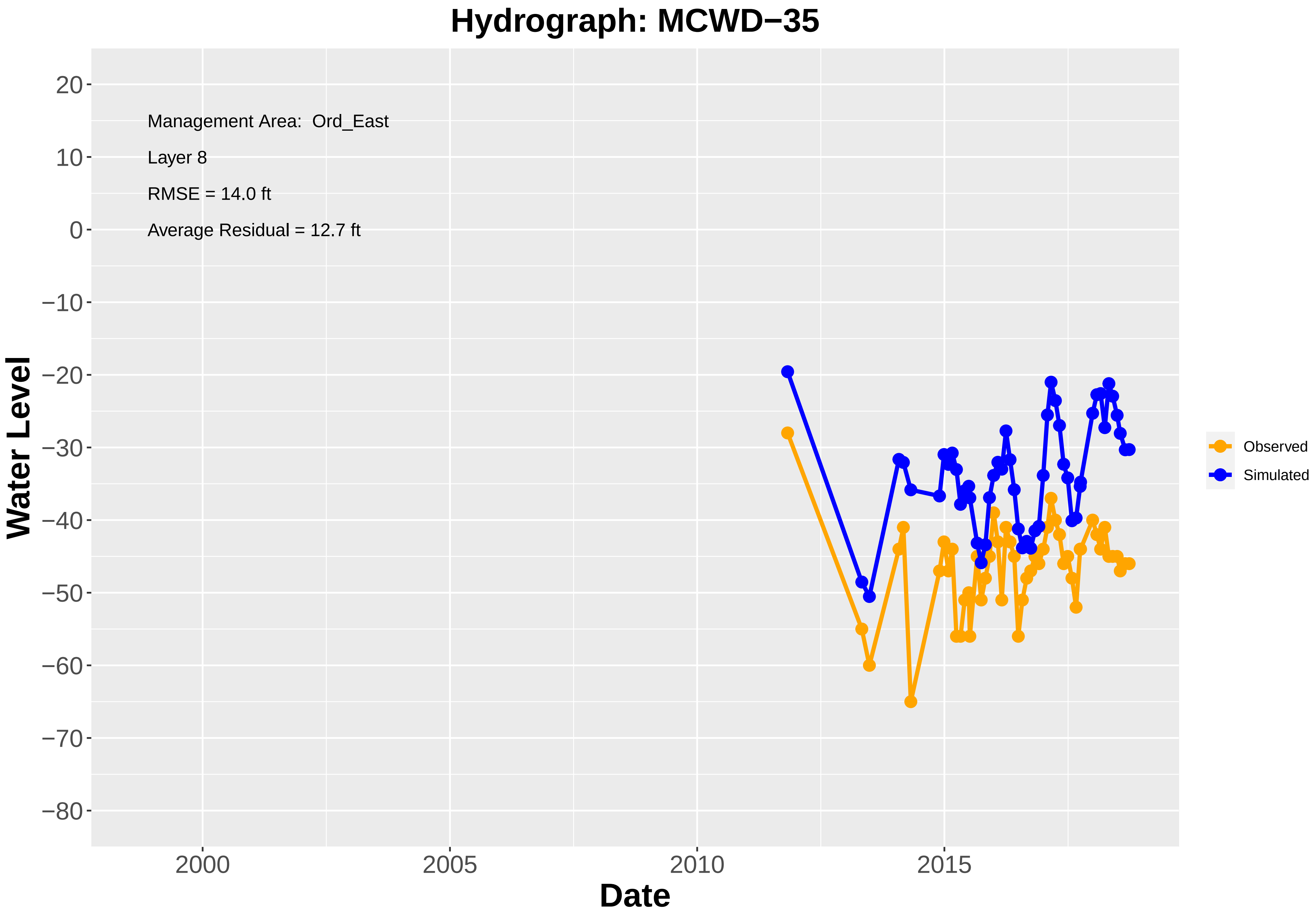


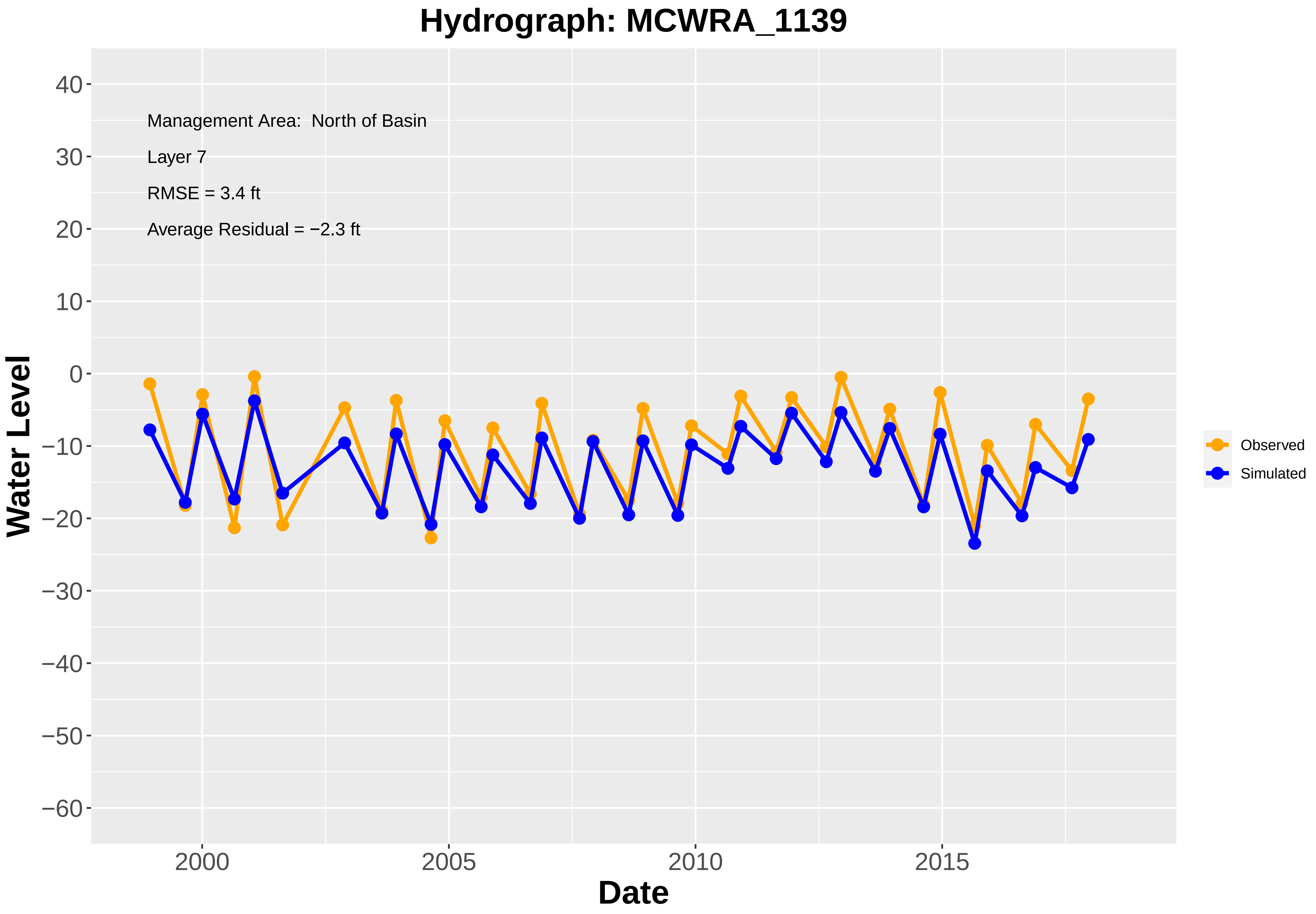
Hydrograph: MCWD−29

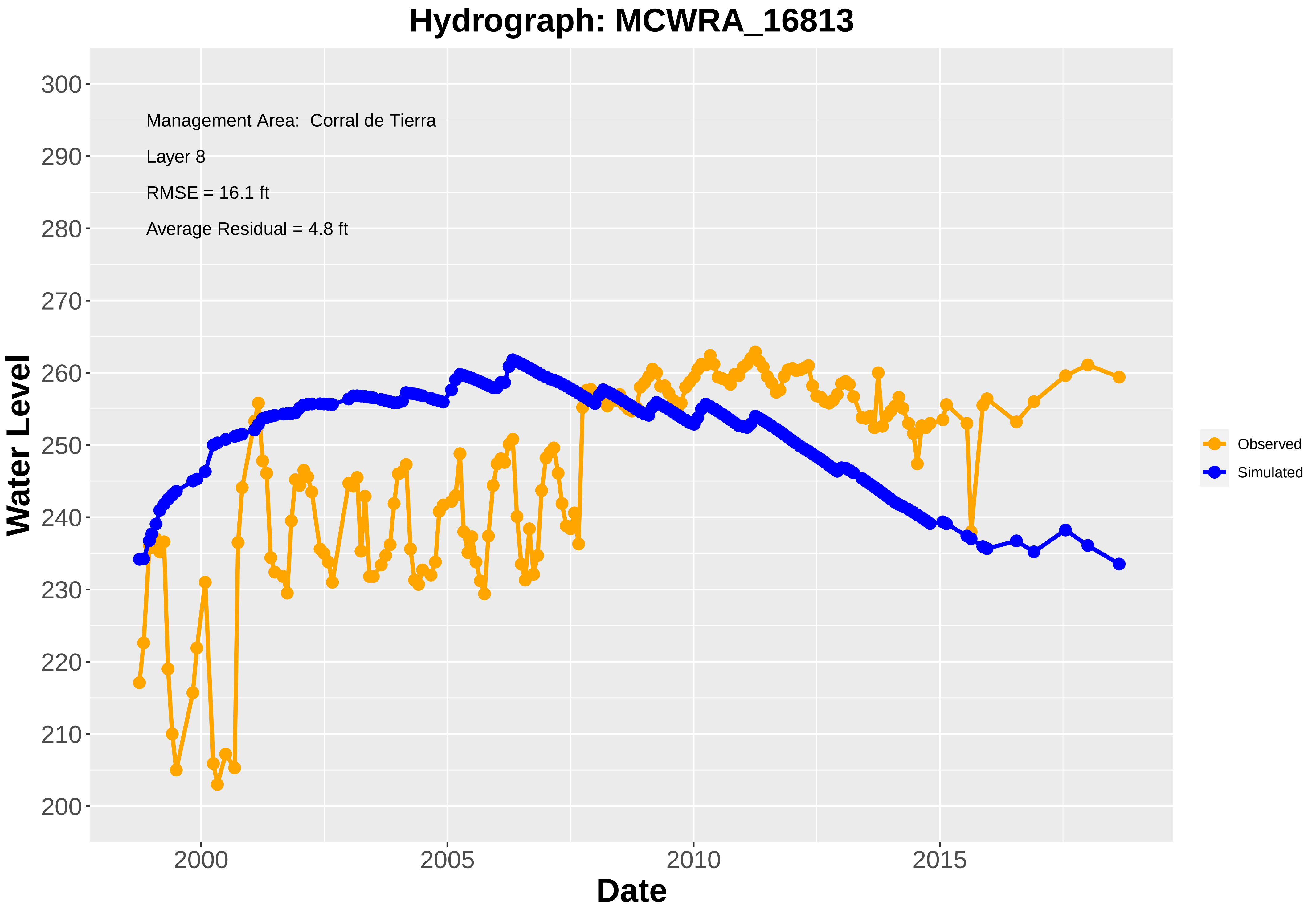


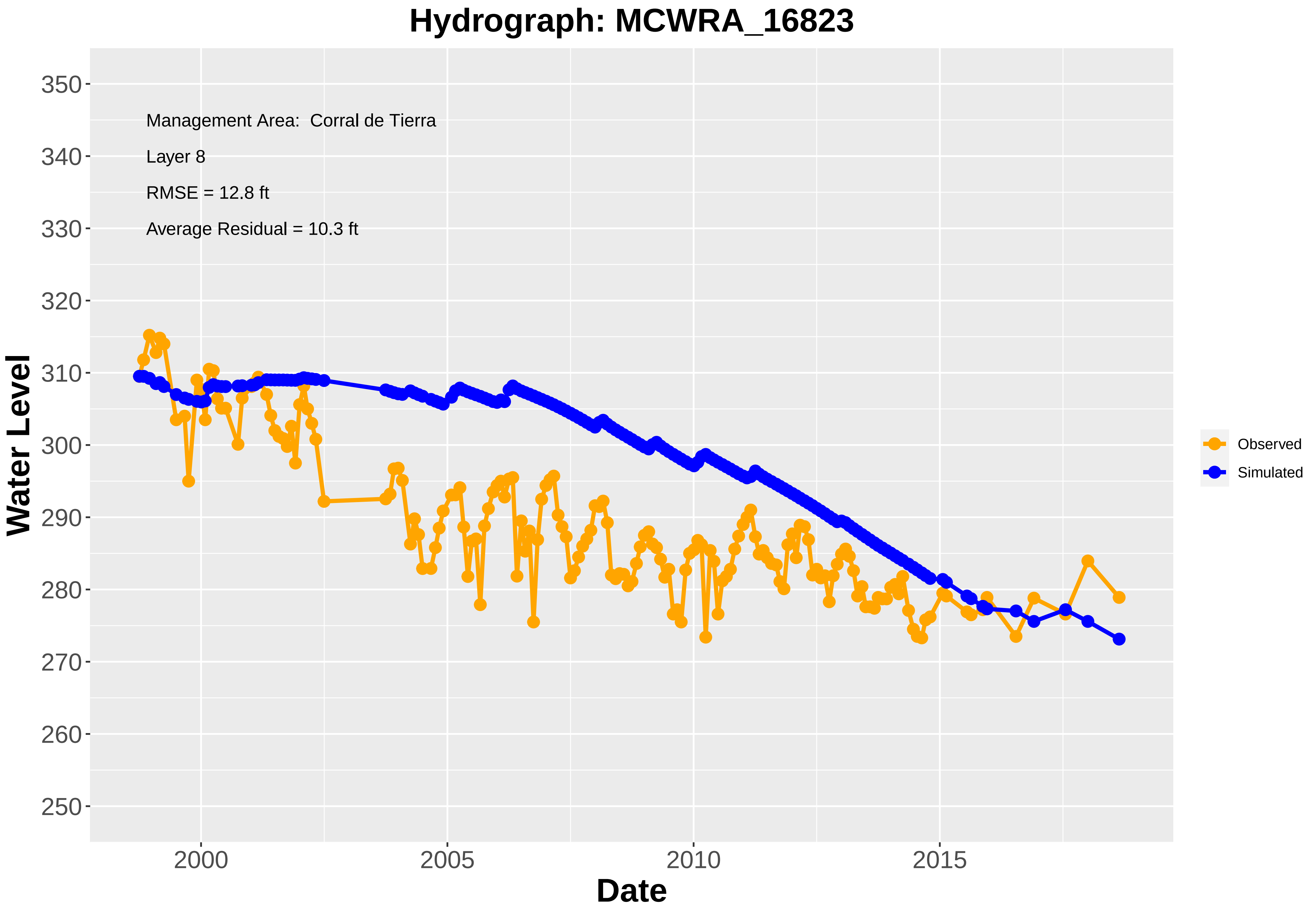

Hydrograph: MCWD−30
Management Area: Ord_East
Layer 5
RMSE = 8.0 ft
Average Residual = −7.4 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MCWD−34
Management Area: Ord_East
Layer 8
RMSE = 10.6 ft
Average Residual = 7.9 ft
Water Level
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
Date
2000
2005
2010
2015
Observed
Simulated

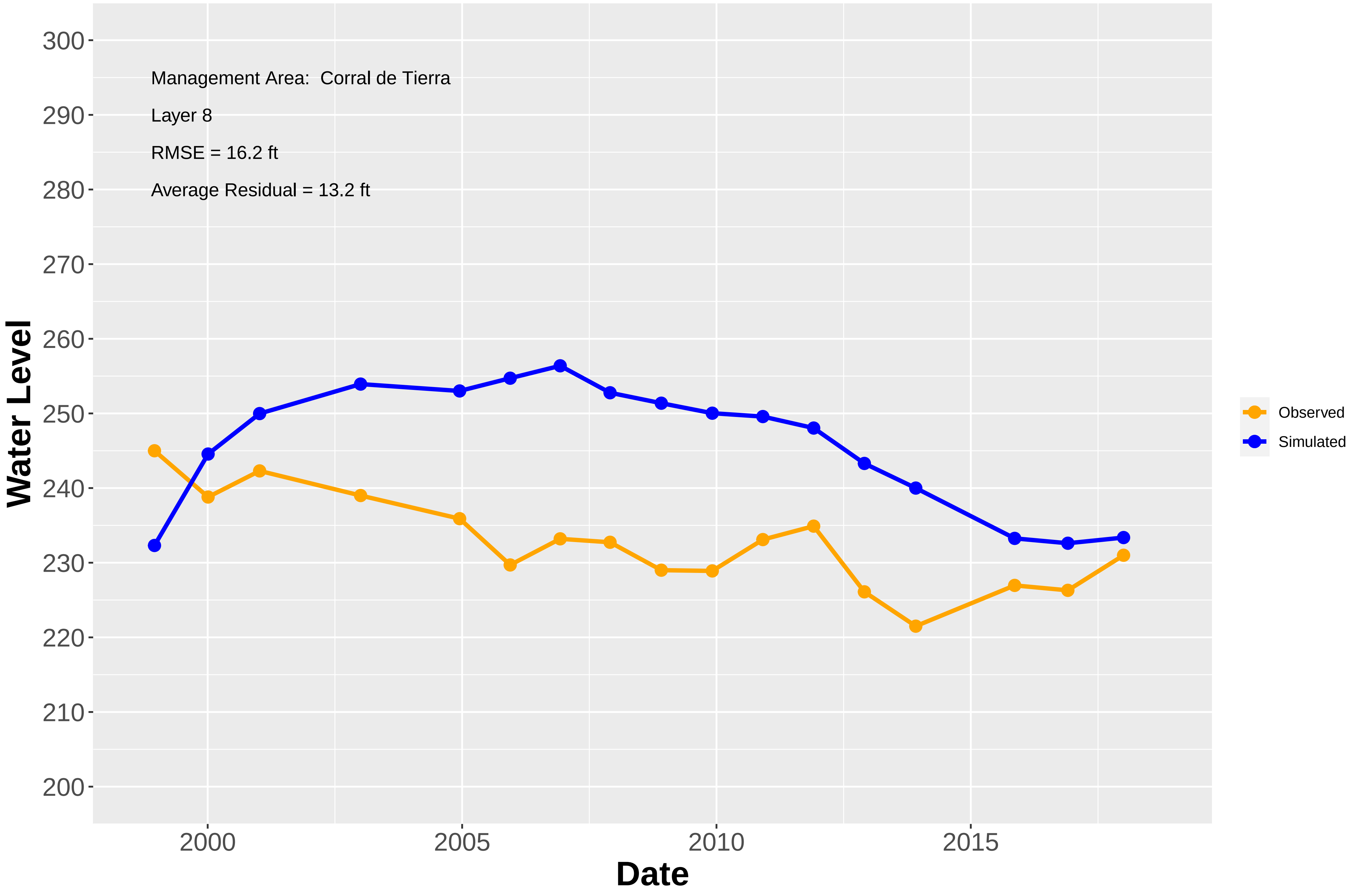

Hydrograph: MCWD−35
Management Area: Ord_East
Layer 8
RMSE = 14.0 ft
Average Residual = 12.7 ft
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

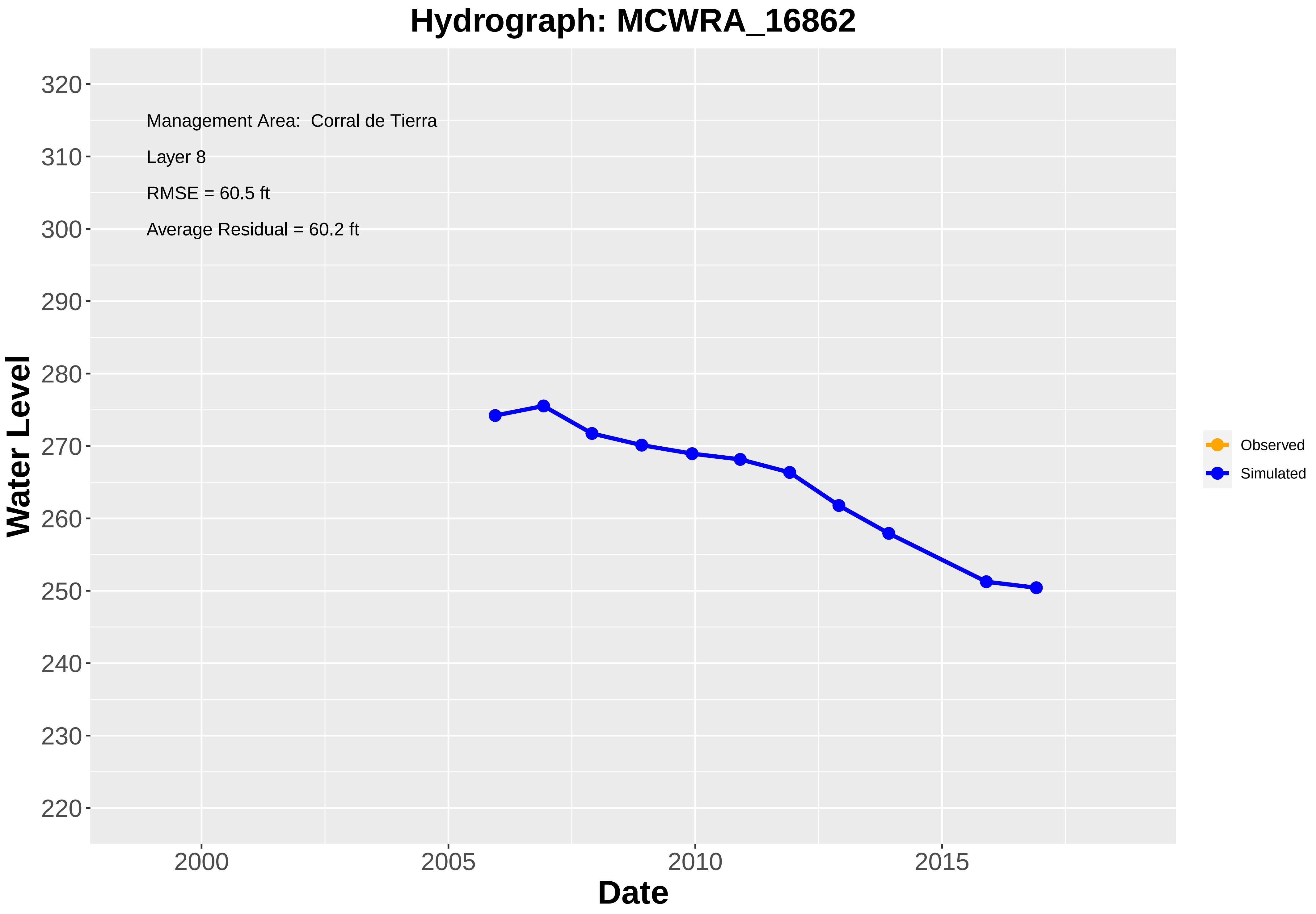

Hydrograph: MCWRA_1139
Management Area: North of Basin
Layer 7
RMSE = 3.4 ft
Average Residual = −2.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

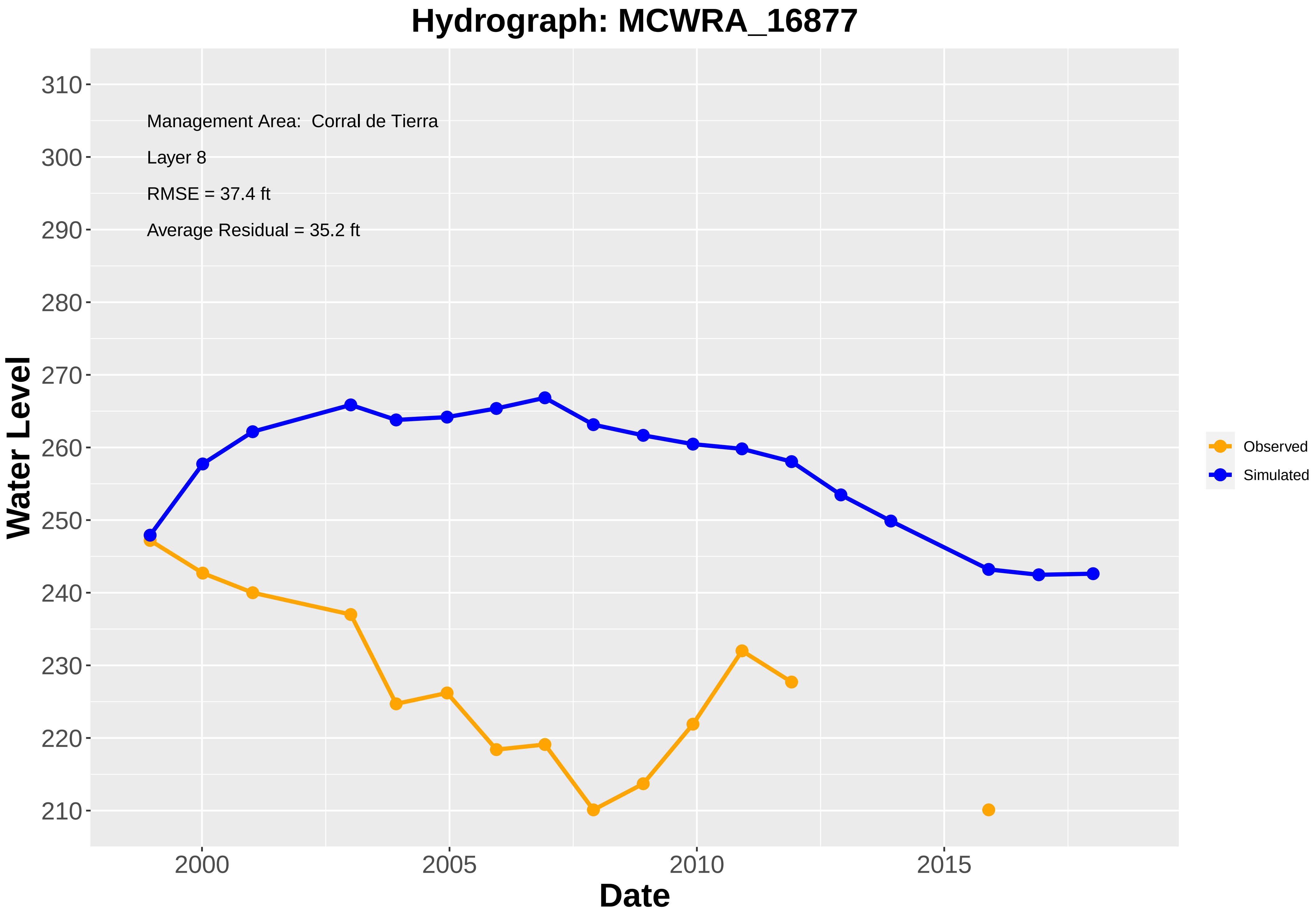

Hydrograph: MCWRA_16813
Management Area: Corral de Tierra
Layer 8
RMSE = 16.1 ft
Average Residual = 4.8 ft
Water Level
300
290
280
270
260
250
240
230
220
210
200
Date
2000
2005
2010
2015
Observed
Simulated

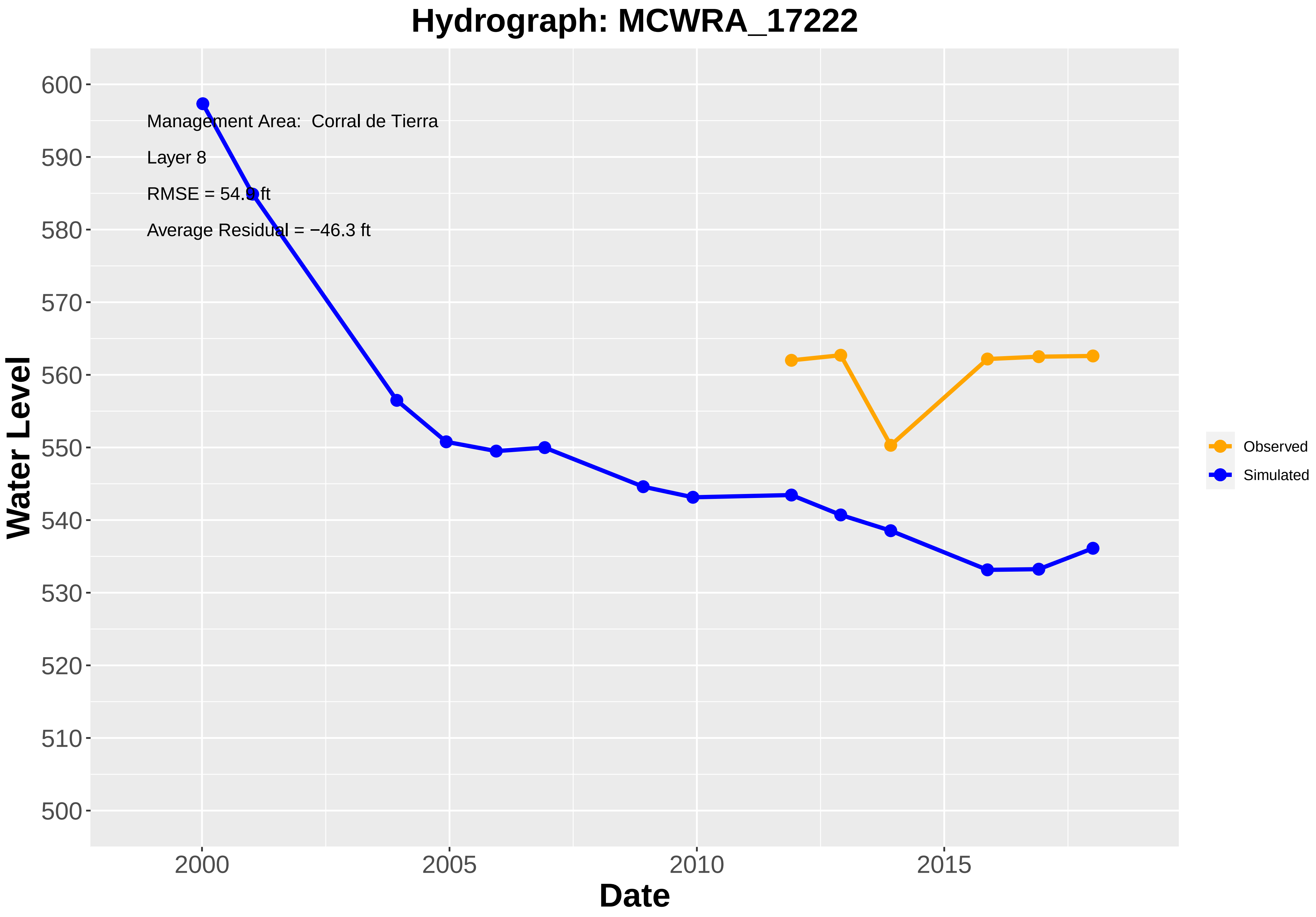

Hydrograph: MCWRA_16823
Management Area: Corral de Tierra
Layer 8
RMSE = 12.8 ft
Average Residual = 10.3 ft
Water Level
350
340
330
320
310
300
290
280
270
260
250
2000
2005
2010
2015
Date
Observed
Simulated

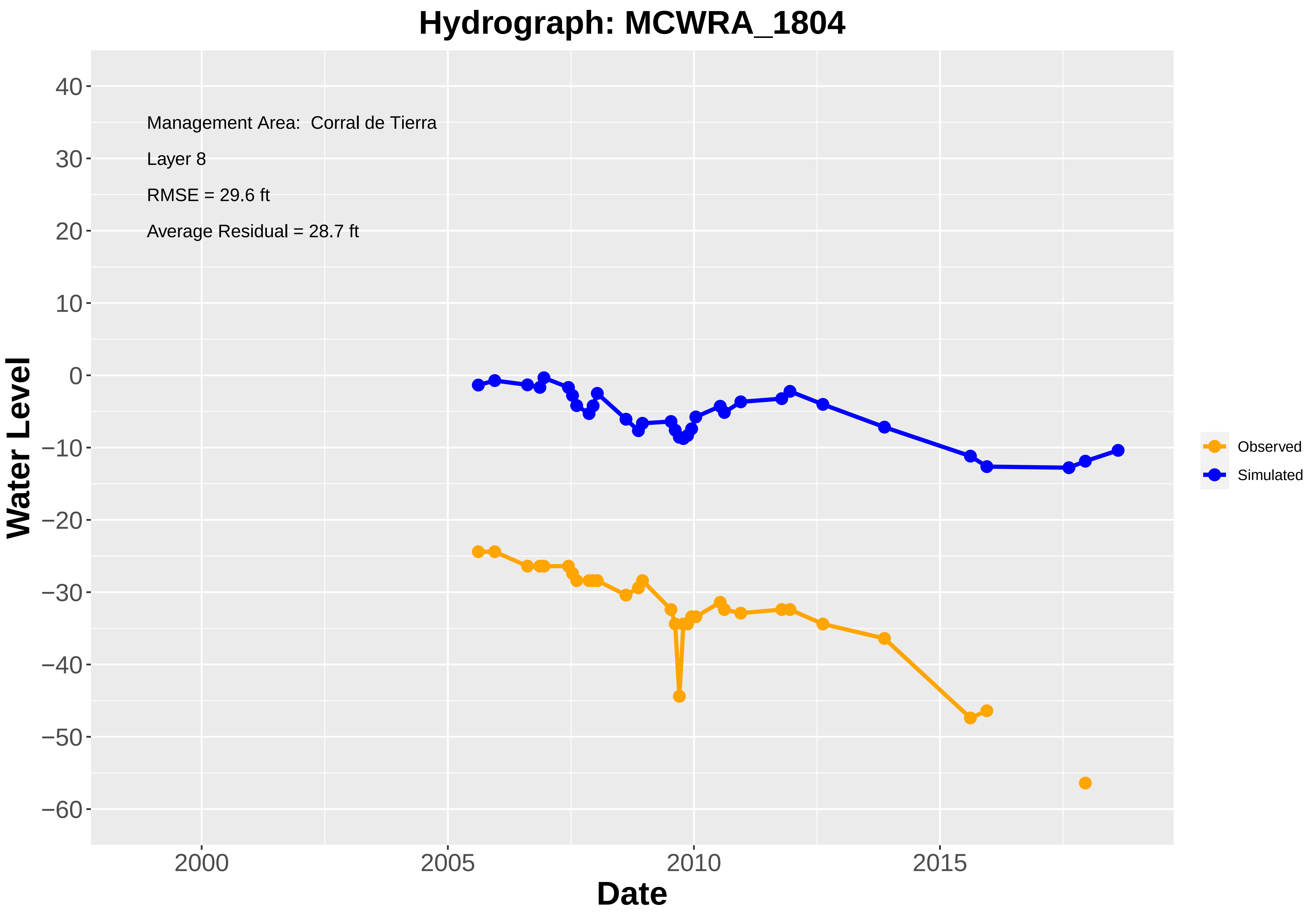
Hydrograph: MCWRA_16842

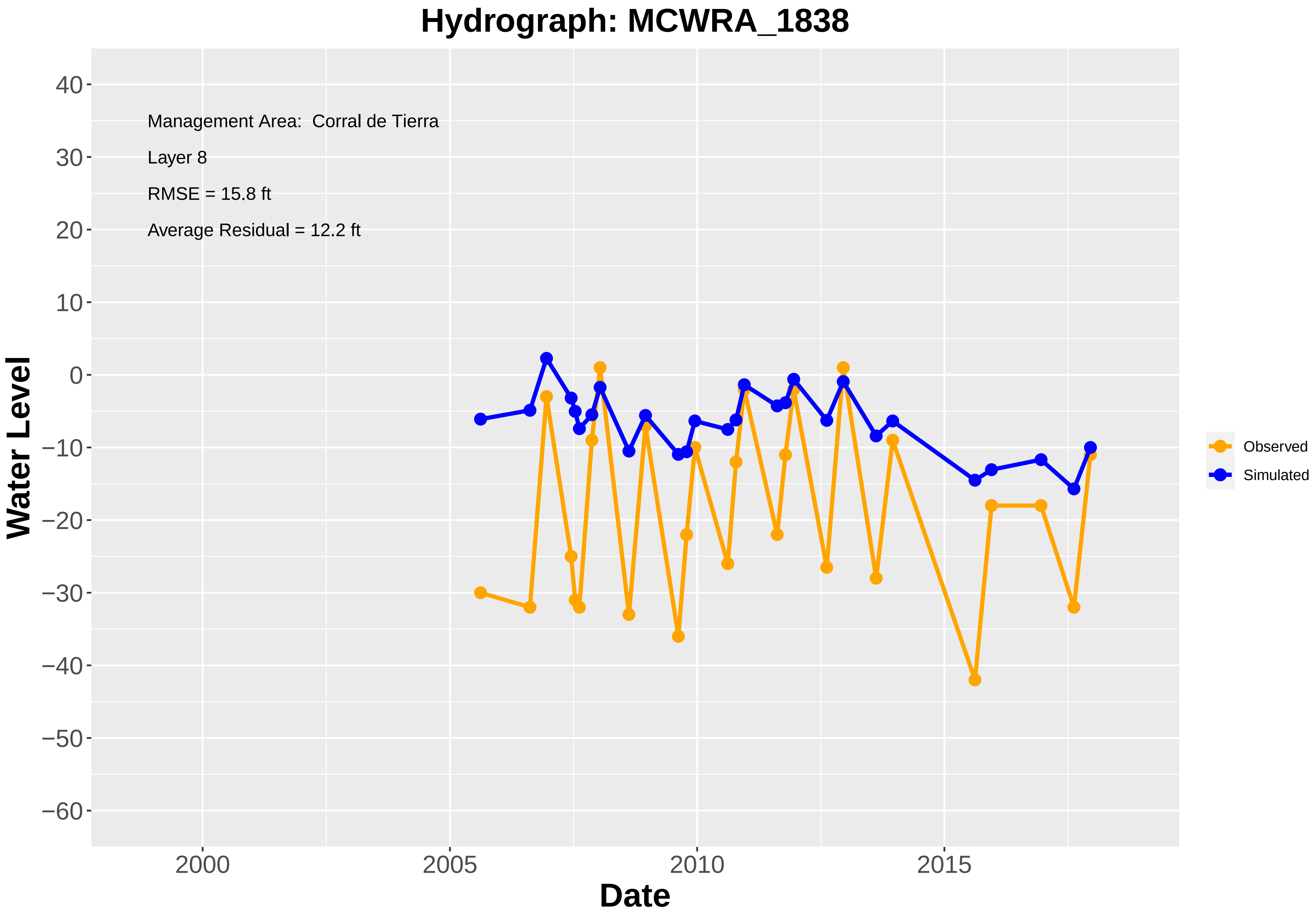


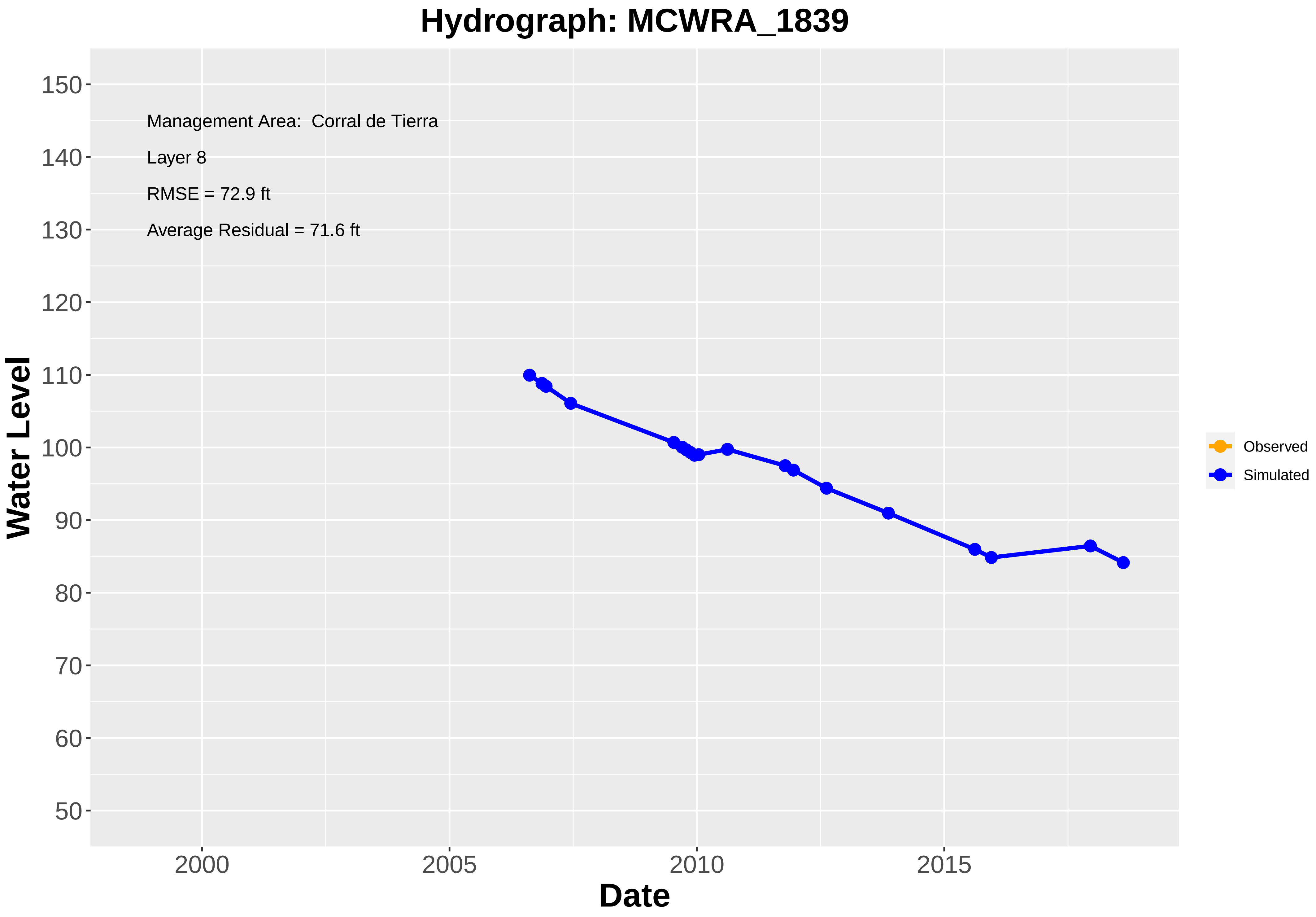

Hydrograph: MCWRA_16862
Management Area: Corral de Tierra
Layer 8
RMSE = 60.5 ft
Average Residual = 60.2 ft
Water Level
320
310
300
290
280
270
260
250
240
230
220
Date
2000
2005
2010
2015
Observed
Simulated

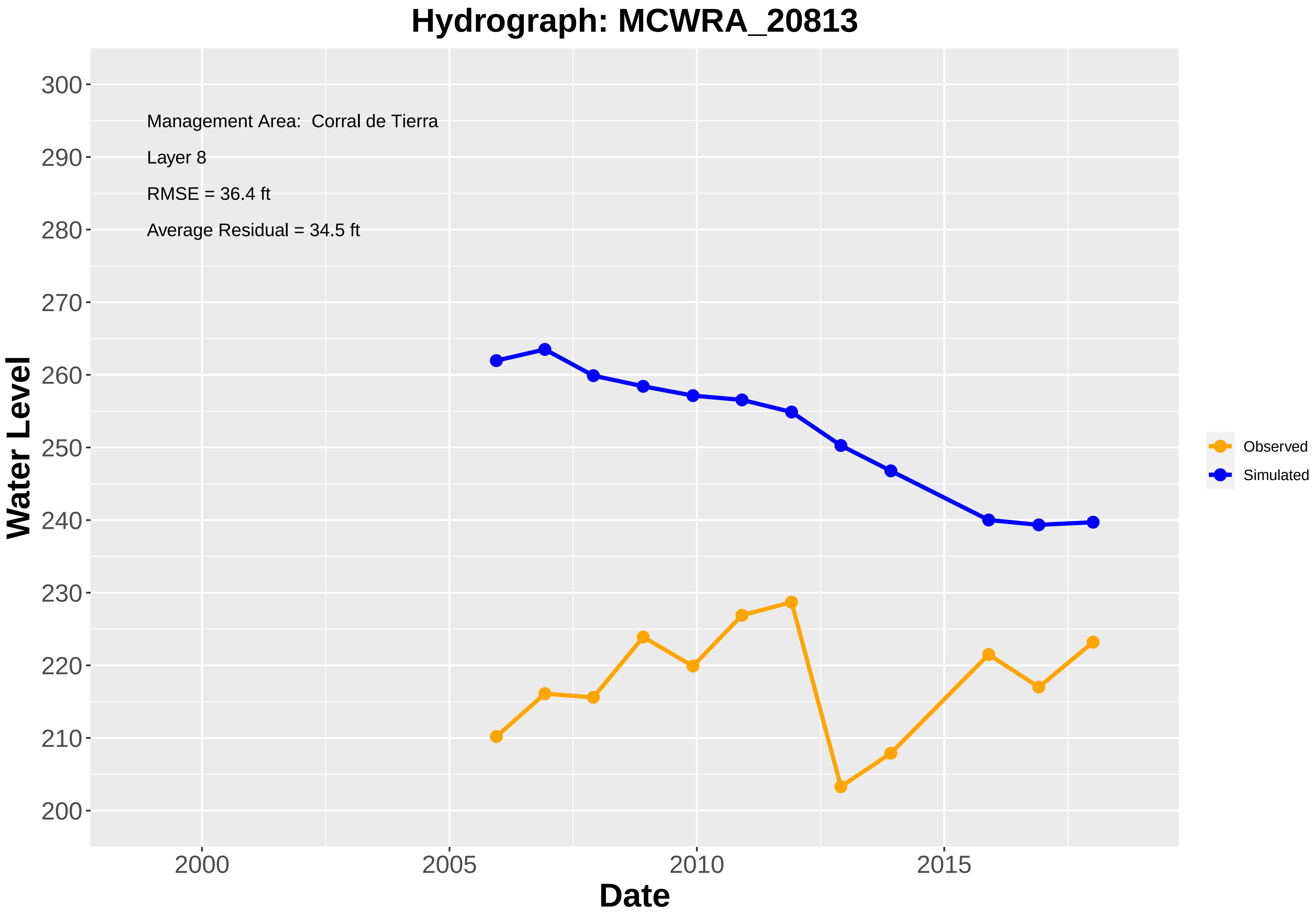

Hydrograph: MCWRA_16877
Management Area: Corral de Tierra
Layer 8
RMSE = 37.4 ft
Average Residual = 35.2 ft
Water Level
310
300
290
280
270
260
250
240
230
220
210
Date
2000
2005
2010
2015
Observed
Simulated

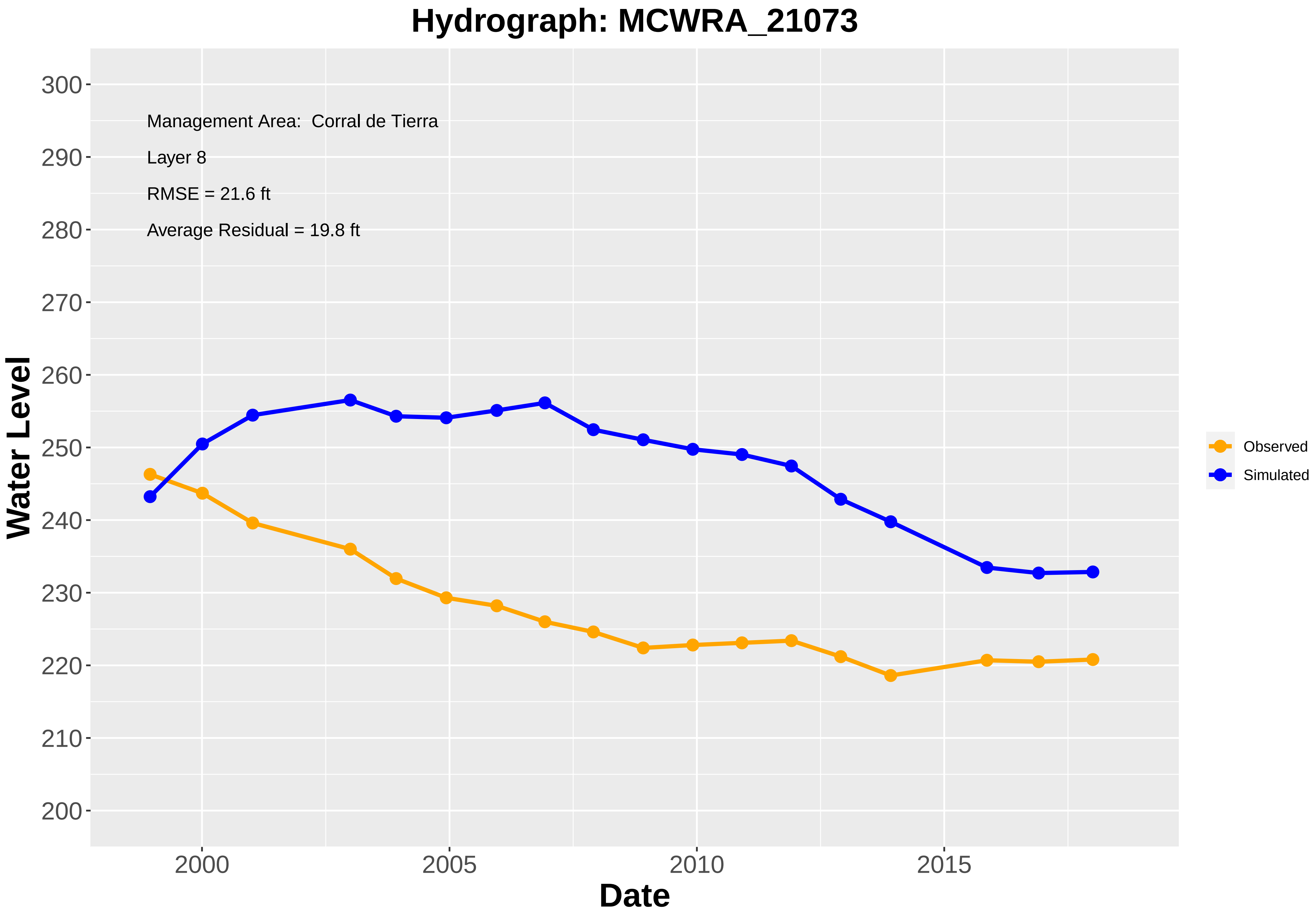

Hydrograph: MCWRA_17222
Management Area: Corral de Tierra
Layer 8
RMSE = 54.9 ft
Average Residual = −46.3 ft
Water Level
600
590
580
570
560
550
540
530
520
510
500
Date
2000
2005
2010
2015
Observed
Simulated

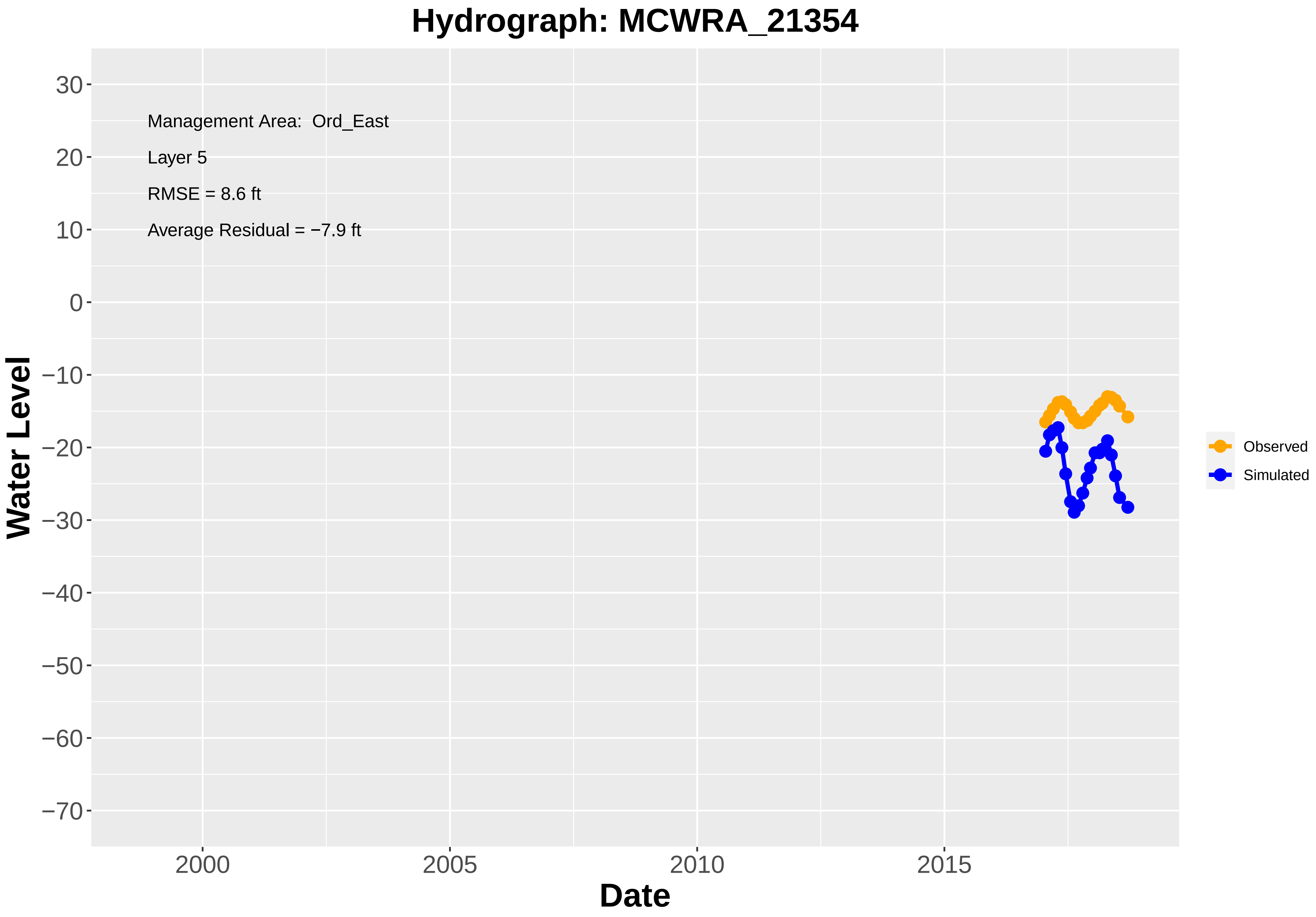

Hydrograph: MCWRA_1804
Management Area: Corral de Tierra
Layer 8
RMSE = 29.6 ft
Average Residual = 28.7 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

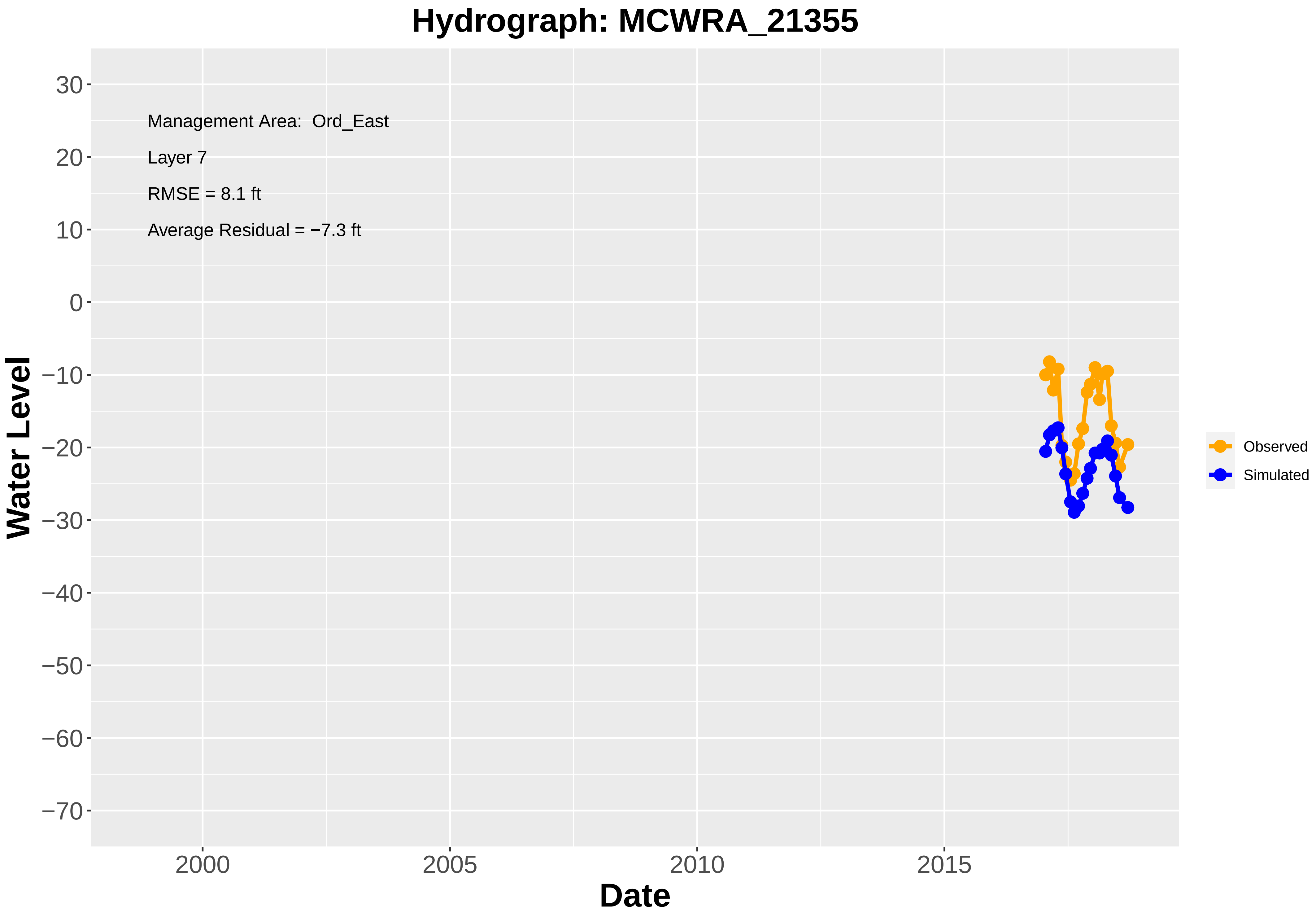

Hydrograph: MCWRA_1838
Management Area: Corral de Tierra
Layer 8
RMSE = 15.8 ft
Average Residual = 12.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

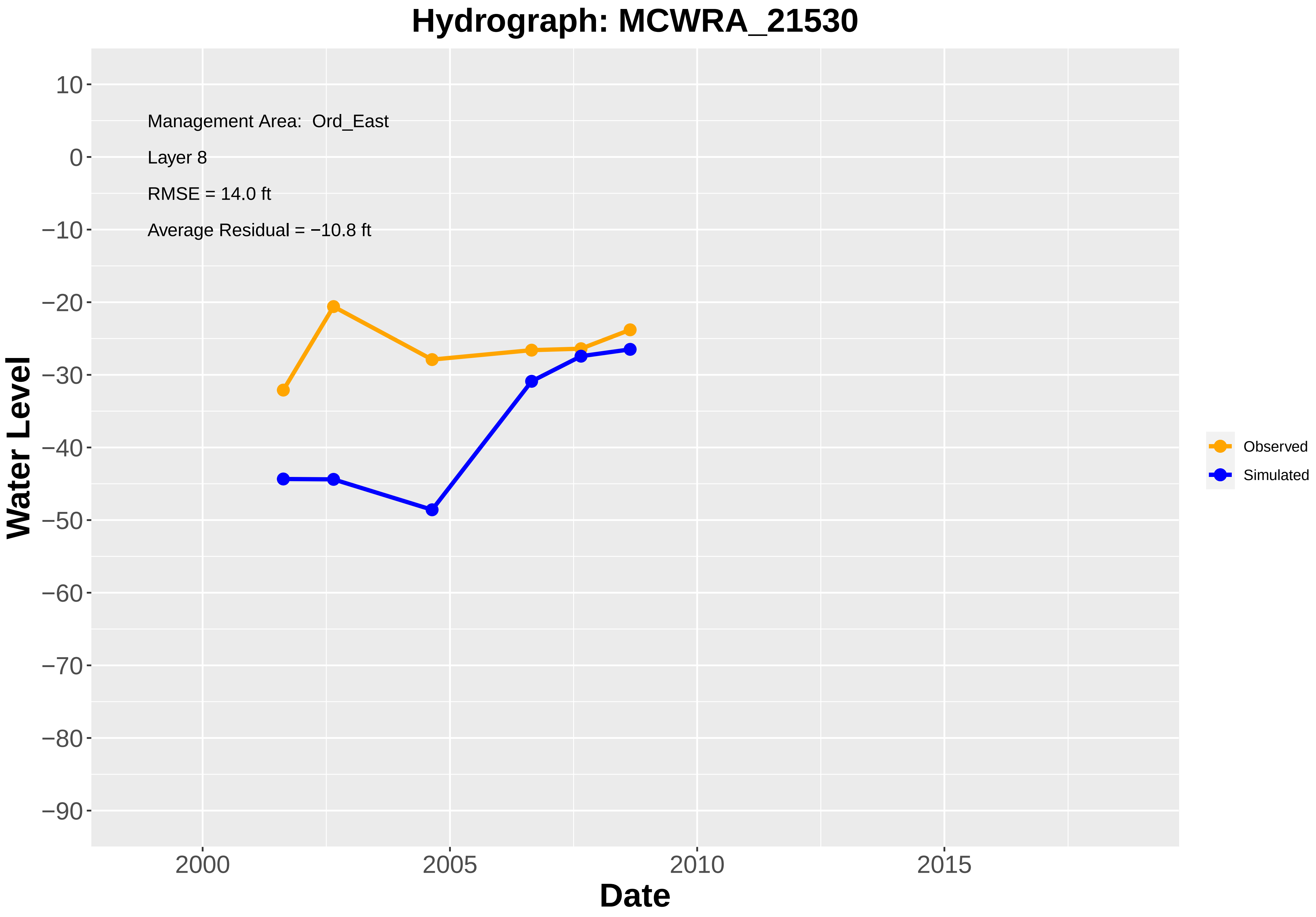

Hydrograph: MCWRA_1839
Management Area: Corral de Tierra
Layer 8
RMSE = 72.9 ft
Average Residual = 71.6 ft
Water Level
150
140
130
120
110
100
90
80
70
60
50
Date
2000
2005
2010
2015
Observed
Simulated

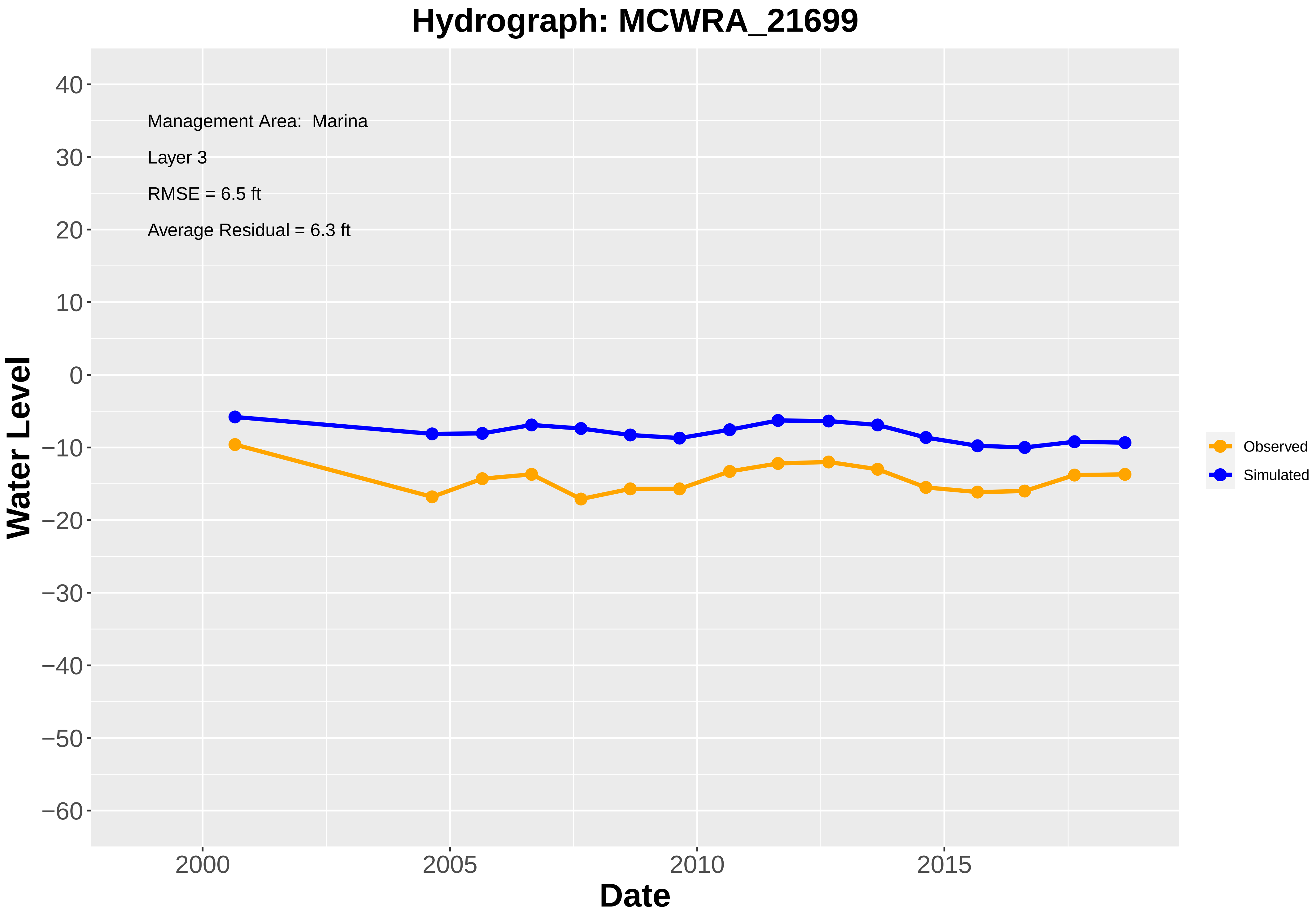

Hydrograph: MCWRA_20813
Management Area: Corral de Tierra
Layer 8
RMSE = 36.4 ft
Average Residual = 34.5 ft
Water Level
300
290
280
270
260
250
240
230
220
210
200
Date
2000
2005
2010
2015
Observed
Simulated

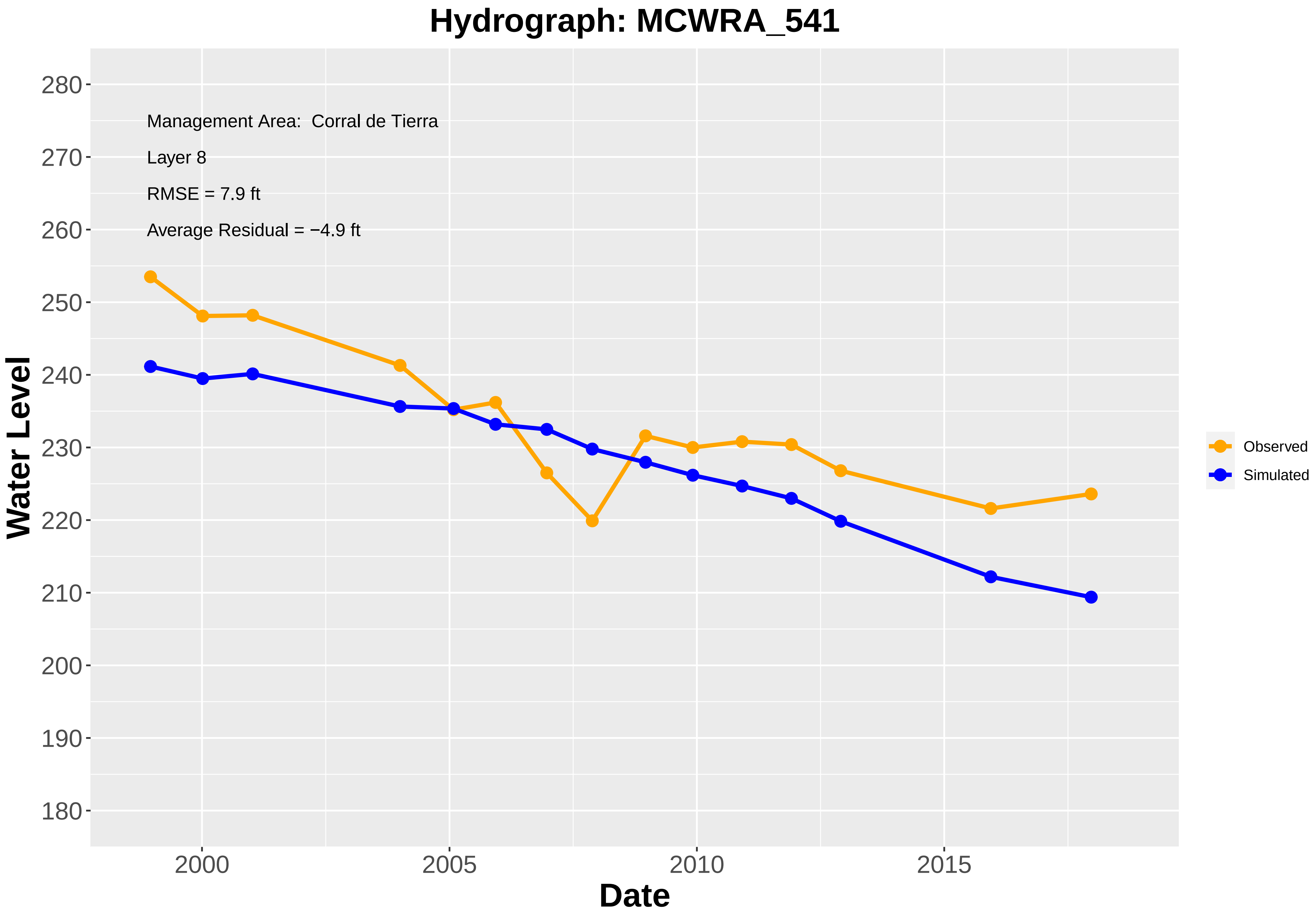

Hydrograph: MCWRA_21073
Management Area: Corral de Tierra
Layer 8
RMSE = 21.6 ft
Average Residual = 19.8 ft
Water Level
300
290
280
270
260
250
240
230
220
210
200
2000
2005
2010
2015
Date
Observed
Simulated

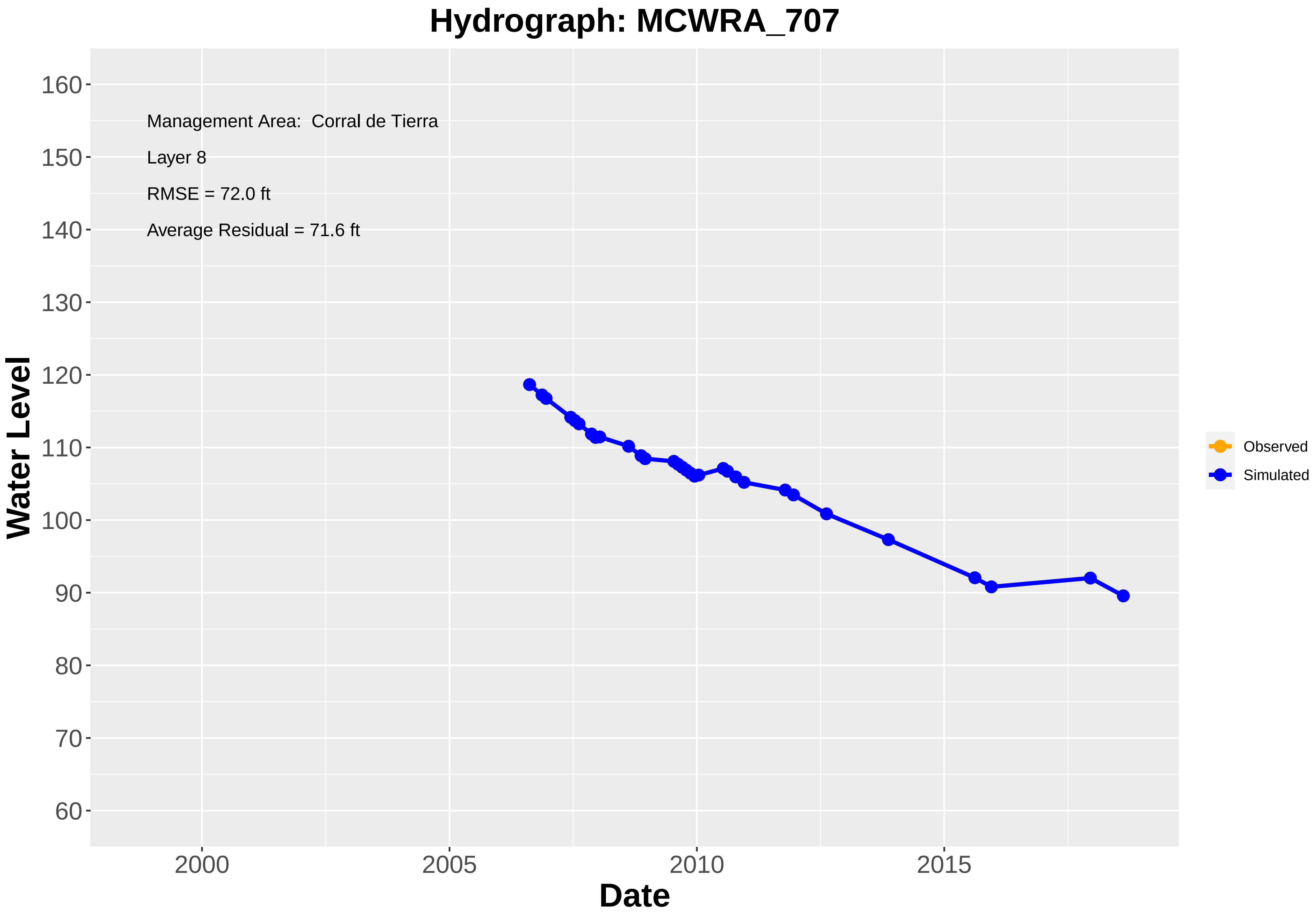

Hydrograph: MCWRA_21354
Management Area: Ord_East
Layer 5
RMSE = 8.6 ft
Average Residual = −7.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

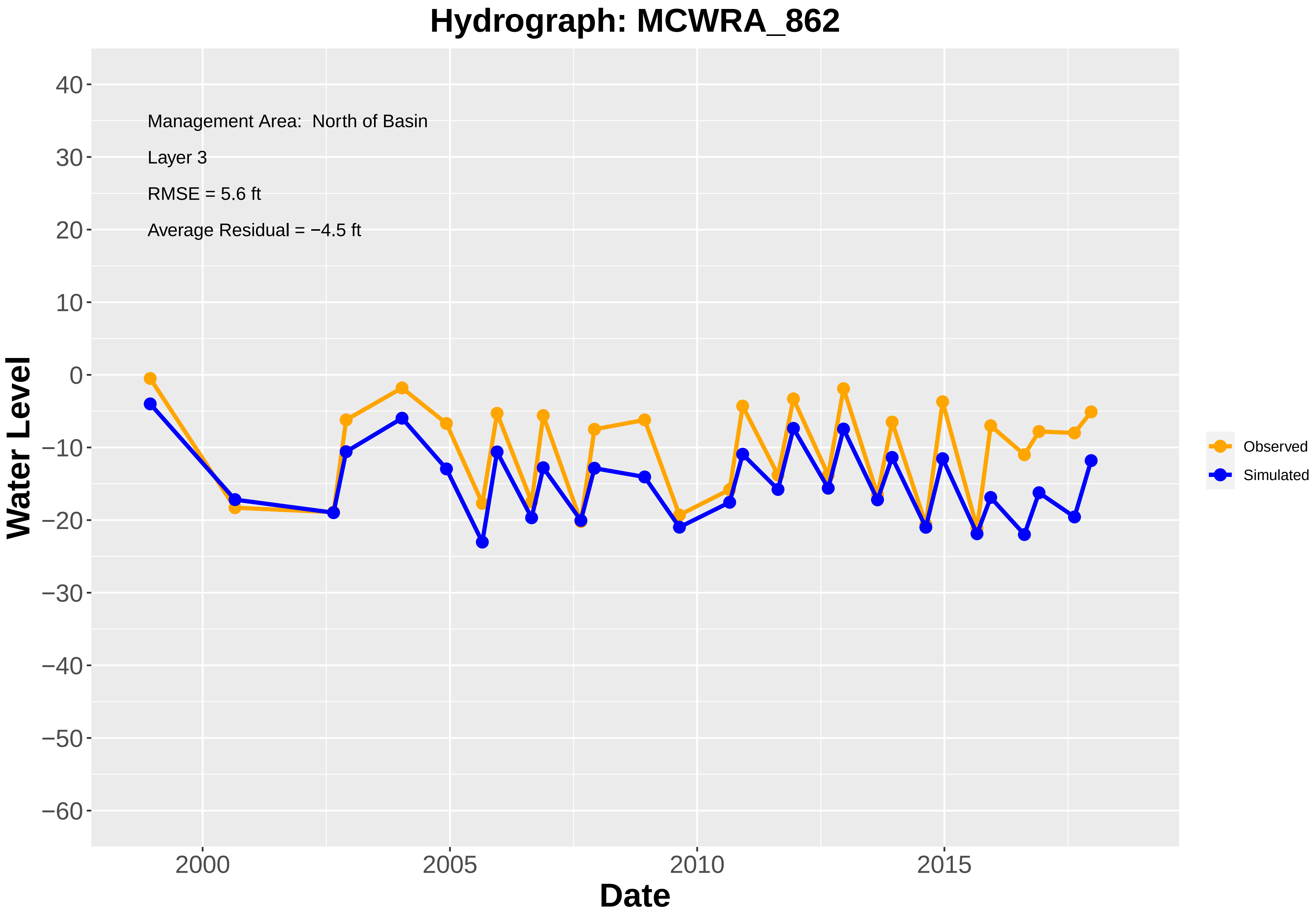

Hydrograph: MCWRA_21355
Management Area: Ord_East
Layer 7
RMSE = 8.1 ft
Average Residual = −7.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MCWRA_21530
Management Area: Ord_East
Layer 8
RMSE = 14.0 ft
Average Residual = −10.8 ft
Water Level
10
0
−10
−20
−30
−40
−50
−60
−70
−80
−90
2000
2005
2010
2015
Date
Observed
Simulated

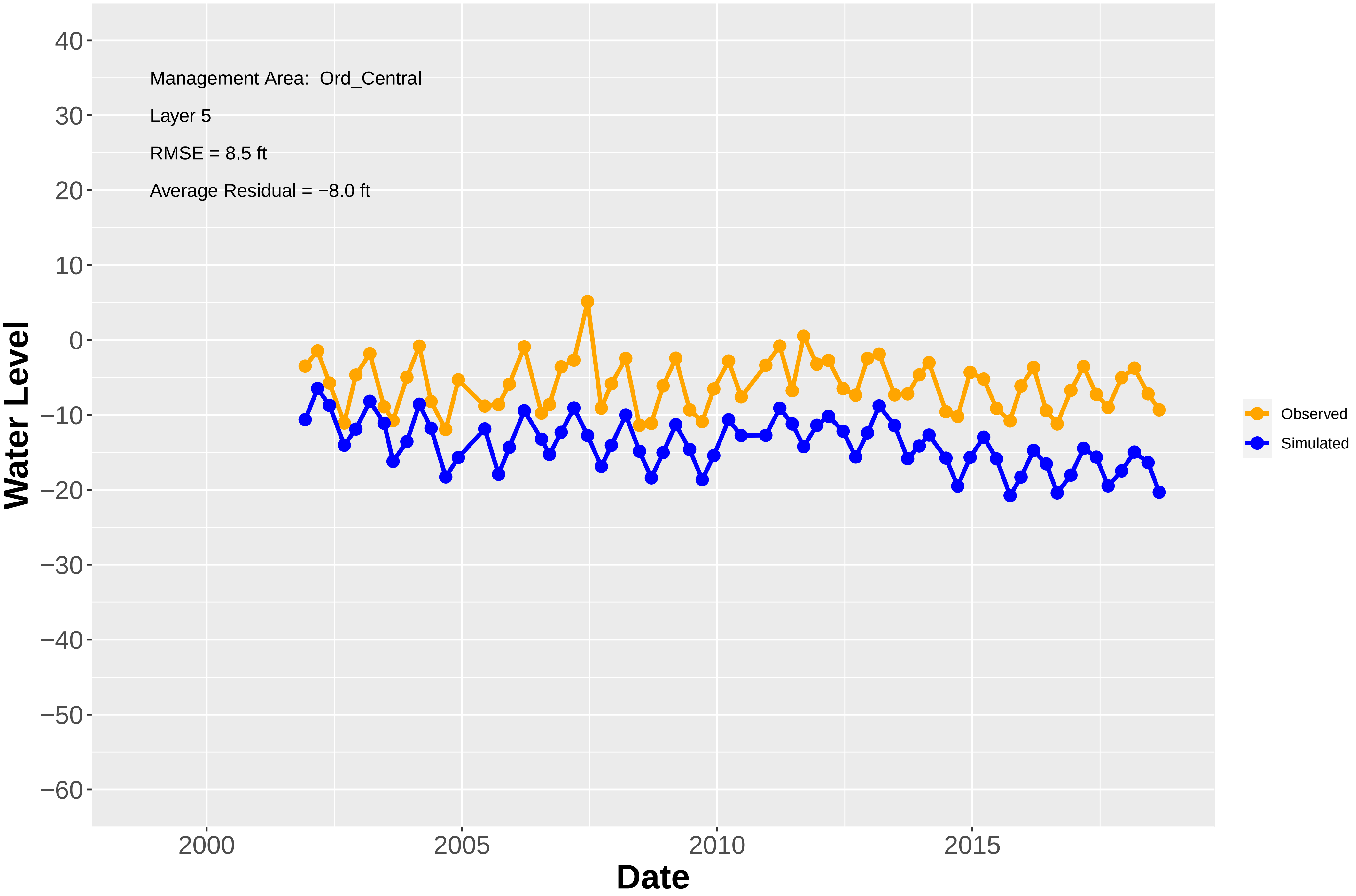

Hydrograph: MCWRA_21699
Management Area: Marina
Layer 3
RMSE = 6.5 ft
Average Residual = 6.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MCWRA_541
Management Area: Corral de Tierra
Layer 8
RMSE = 7.9 ft
Average Residual = −4.9 ft
Water Level
280
270
260
250
240
230
220
210
200
190
180
Date
2000
2005
2010
2015
Observed
Simulated

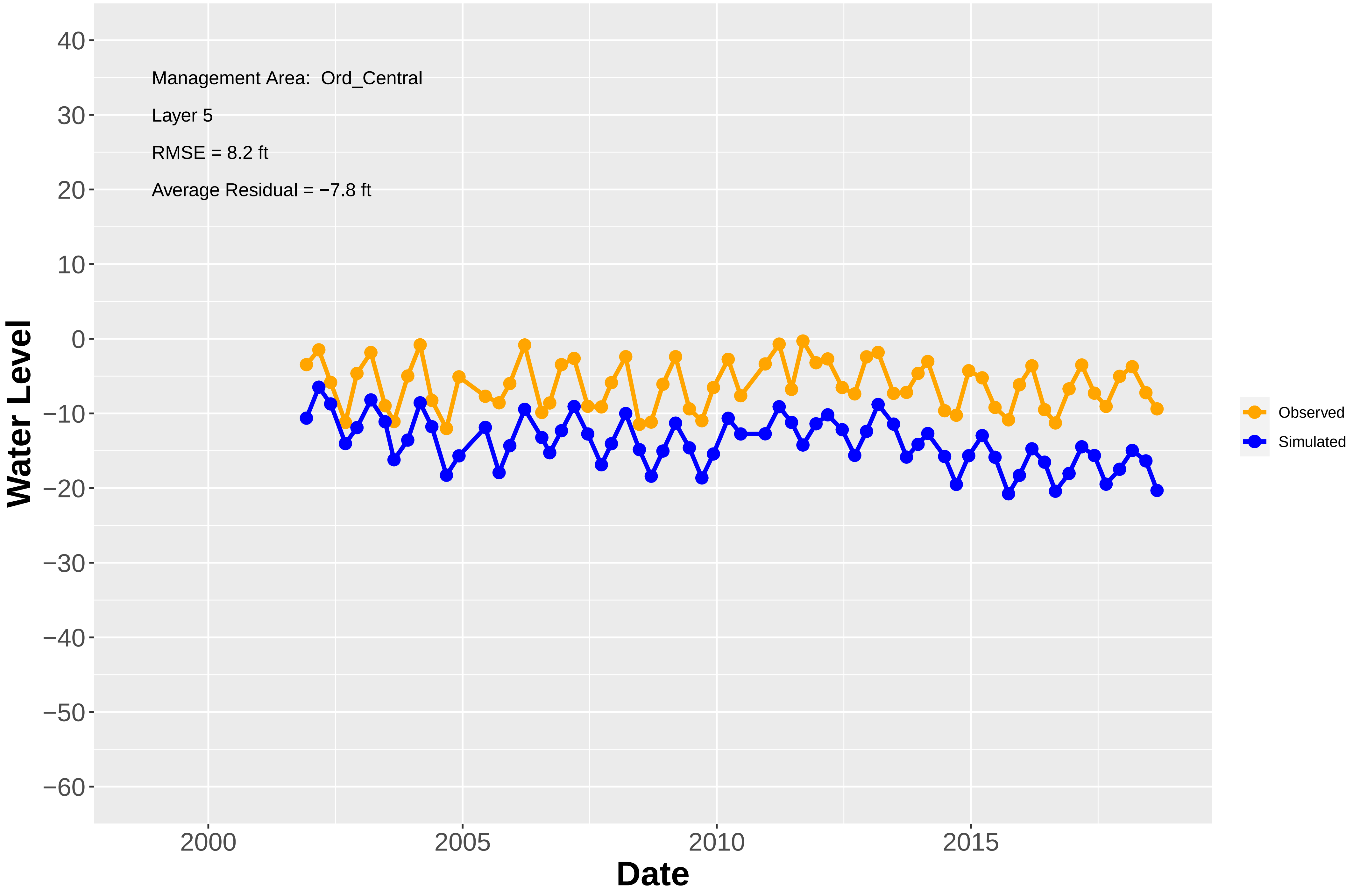

Hydrograph: MCWRA_707
Management Area: Corral de Tierra
Layer 8
RMSE = 72.0 ft
Average Residual = 71.6 ft
Water Level
160
150
140
130
120
110
100
90
80
70
60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MCWRA_862
Management Area: North of Basin
Layer 3
RMSE = 5.6 ft
Average Residual = −4.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

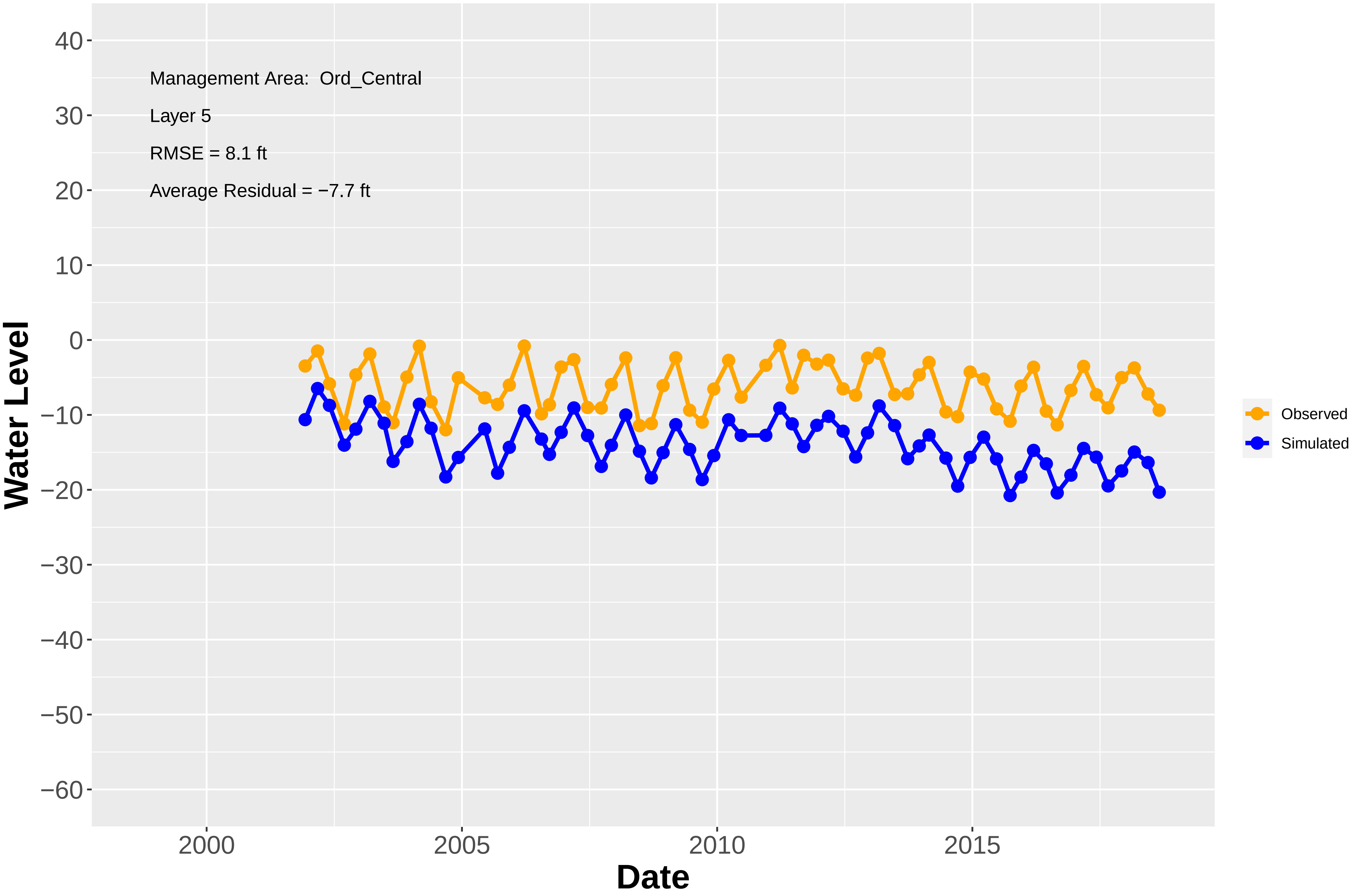
Hydrograph: MP−BW−30−282

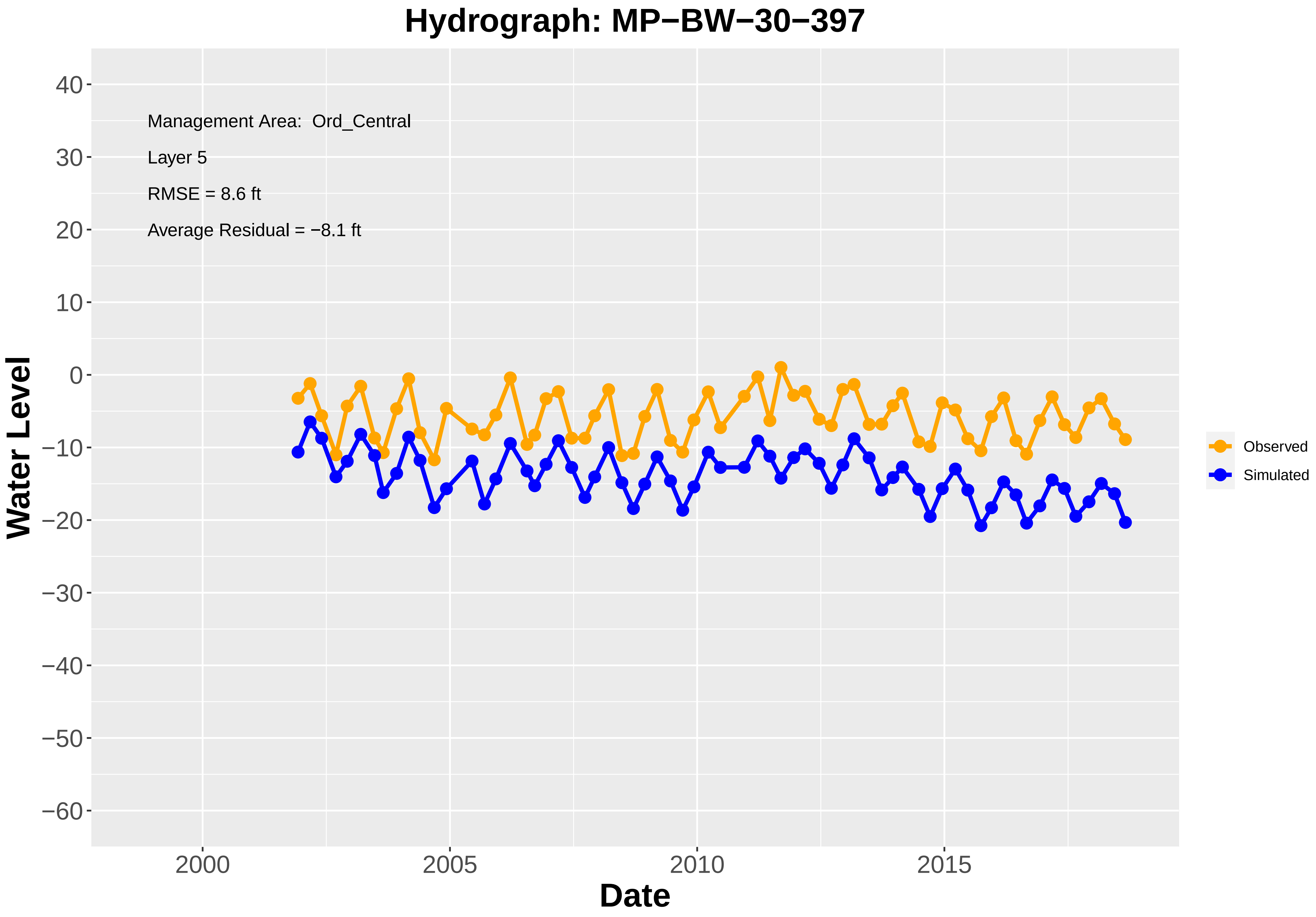


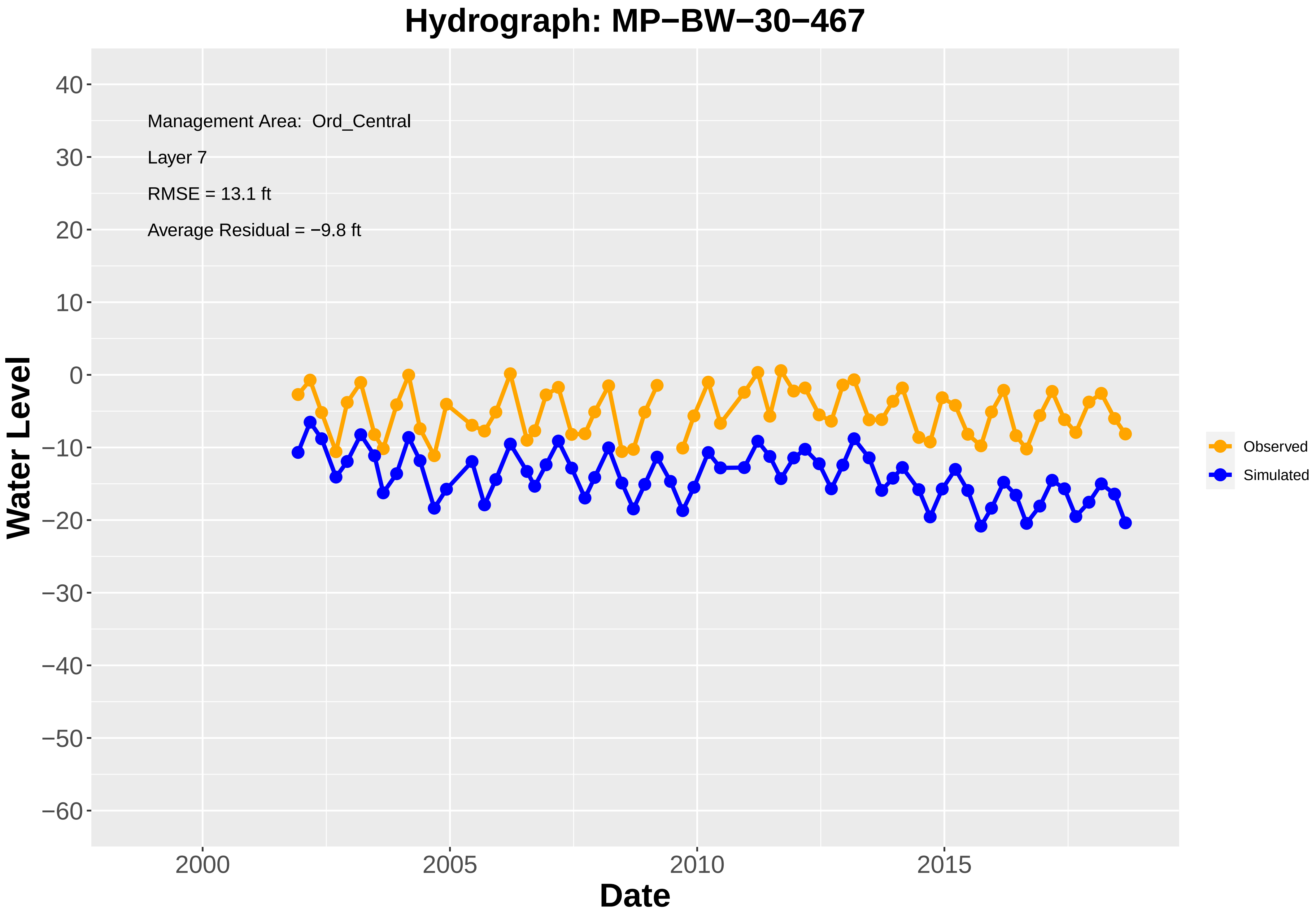
Hydrograph: MP−BW−30−317

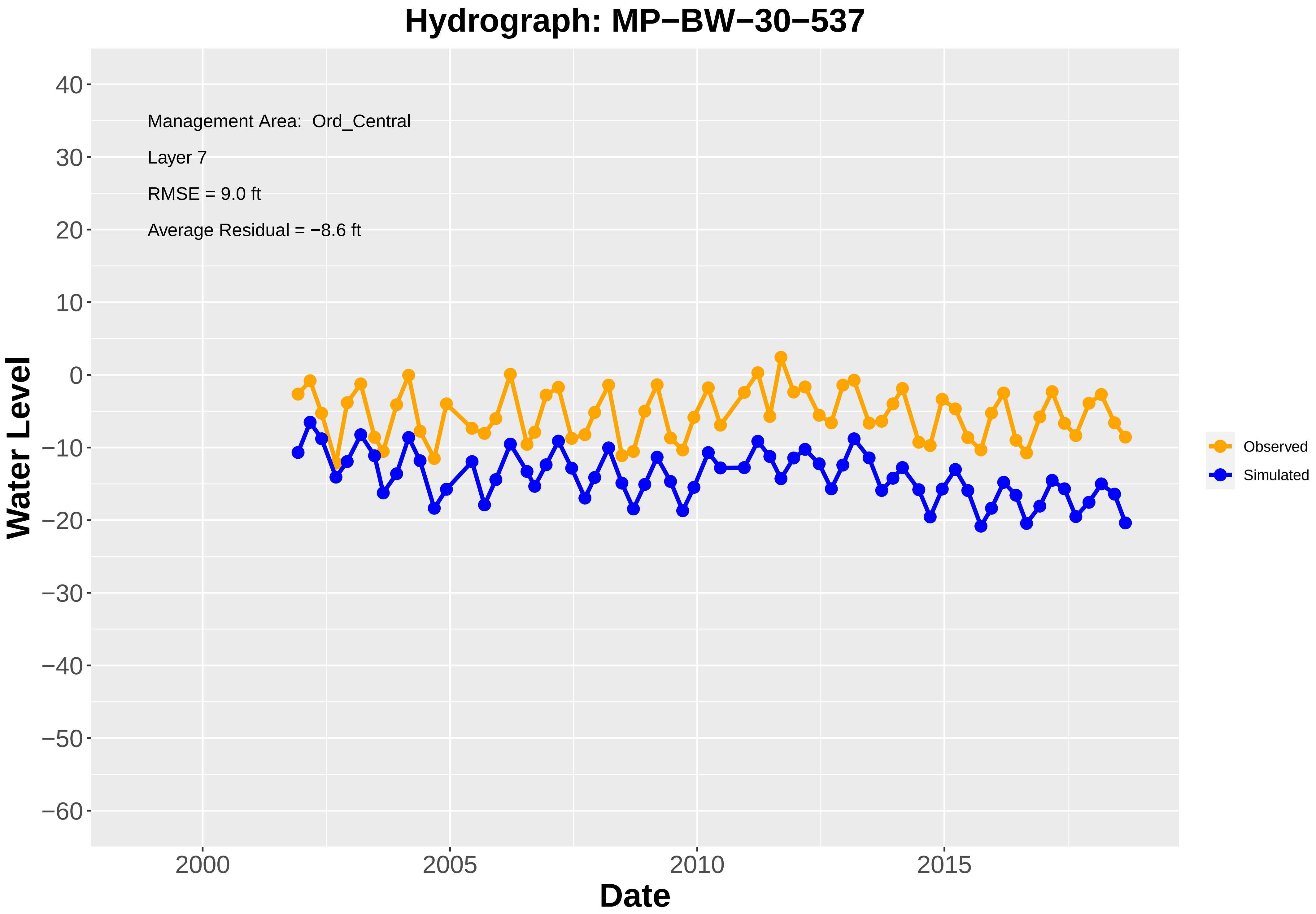


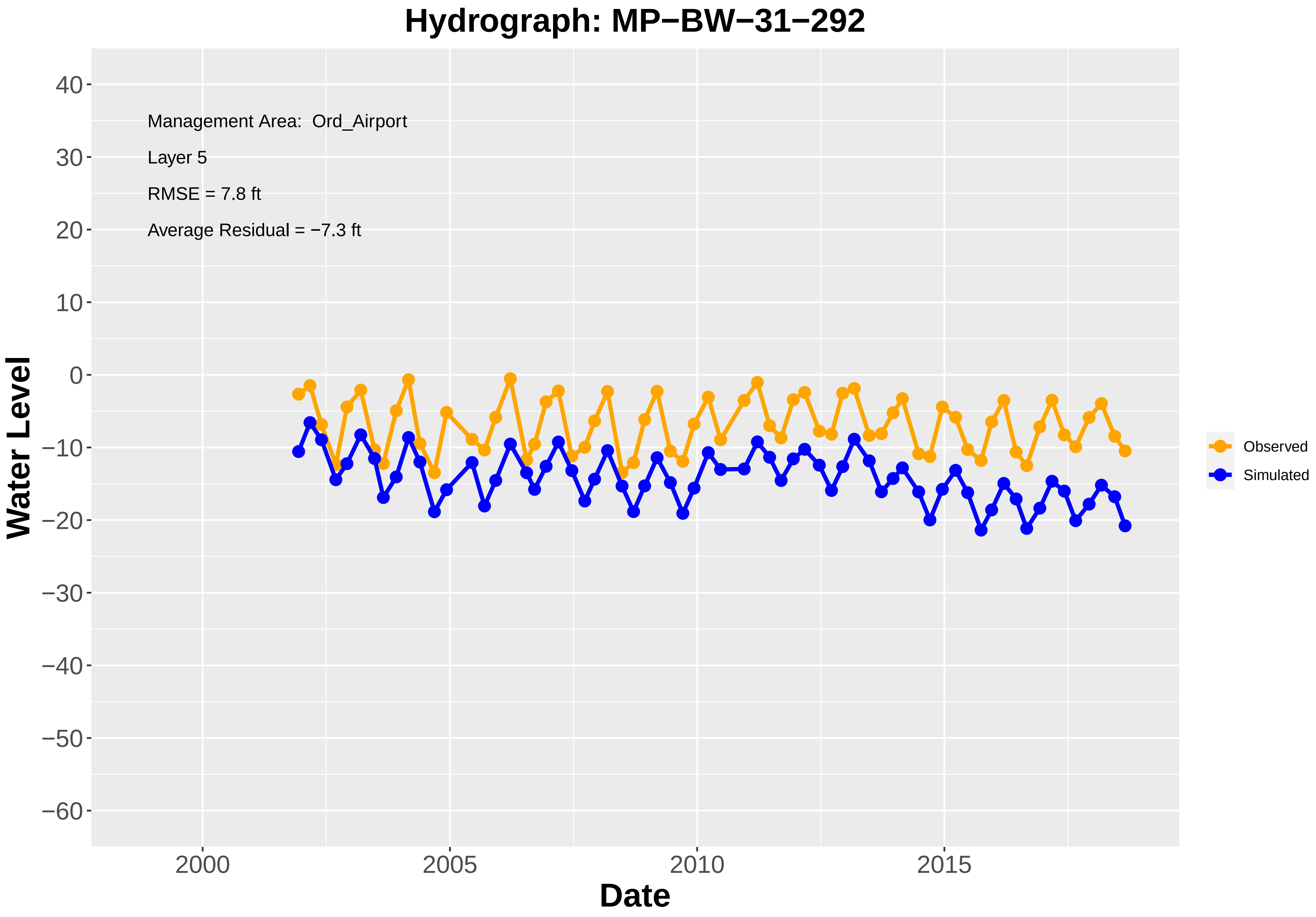
Hydrograph: MP−BW−30−342

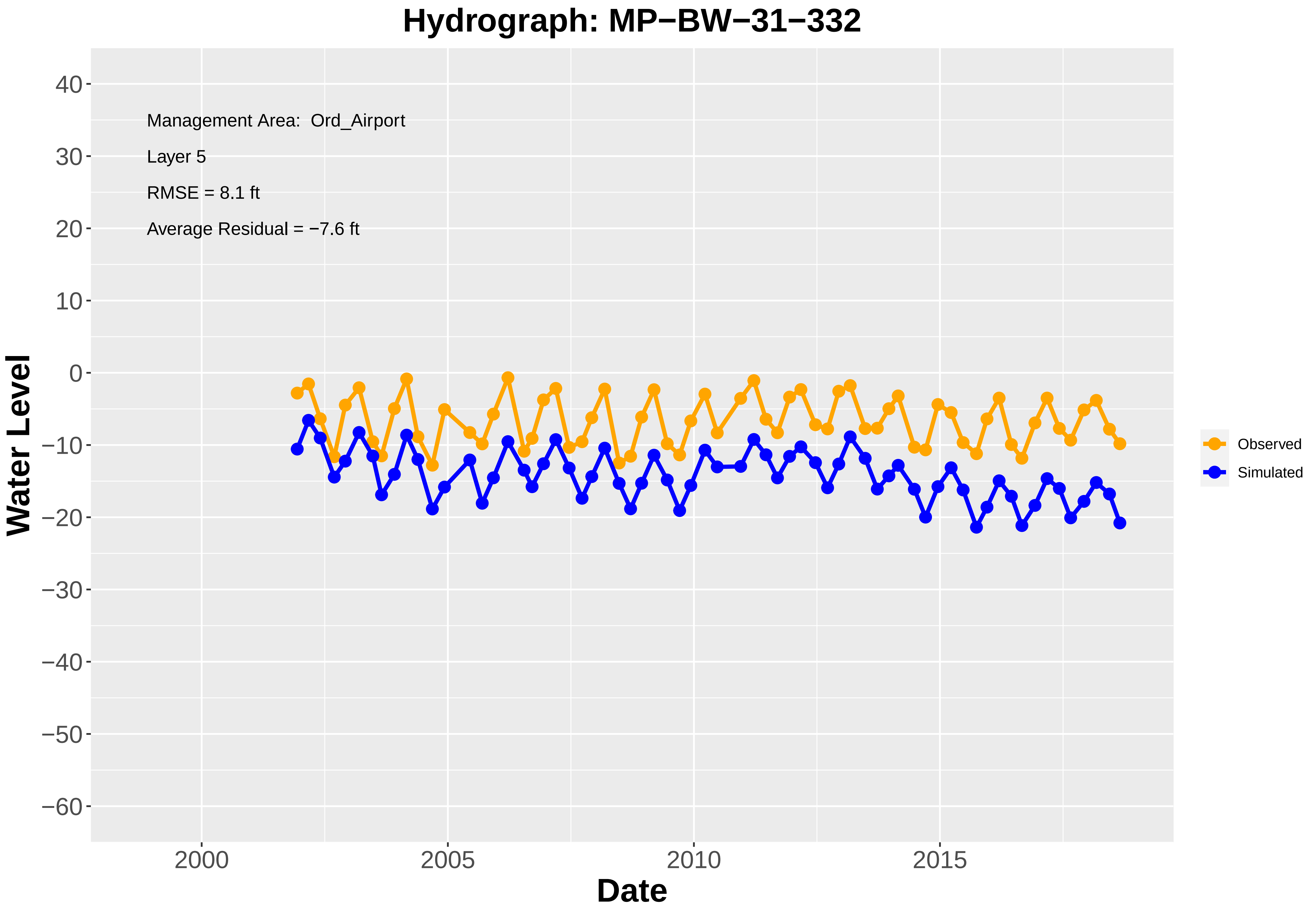


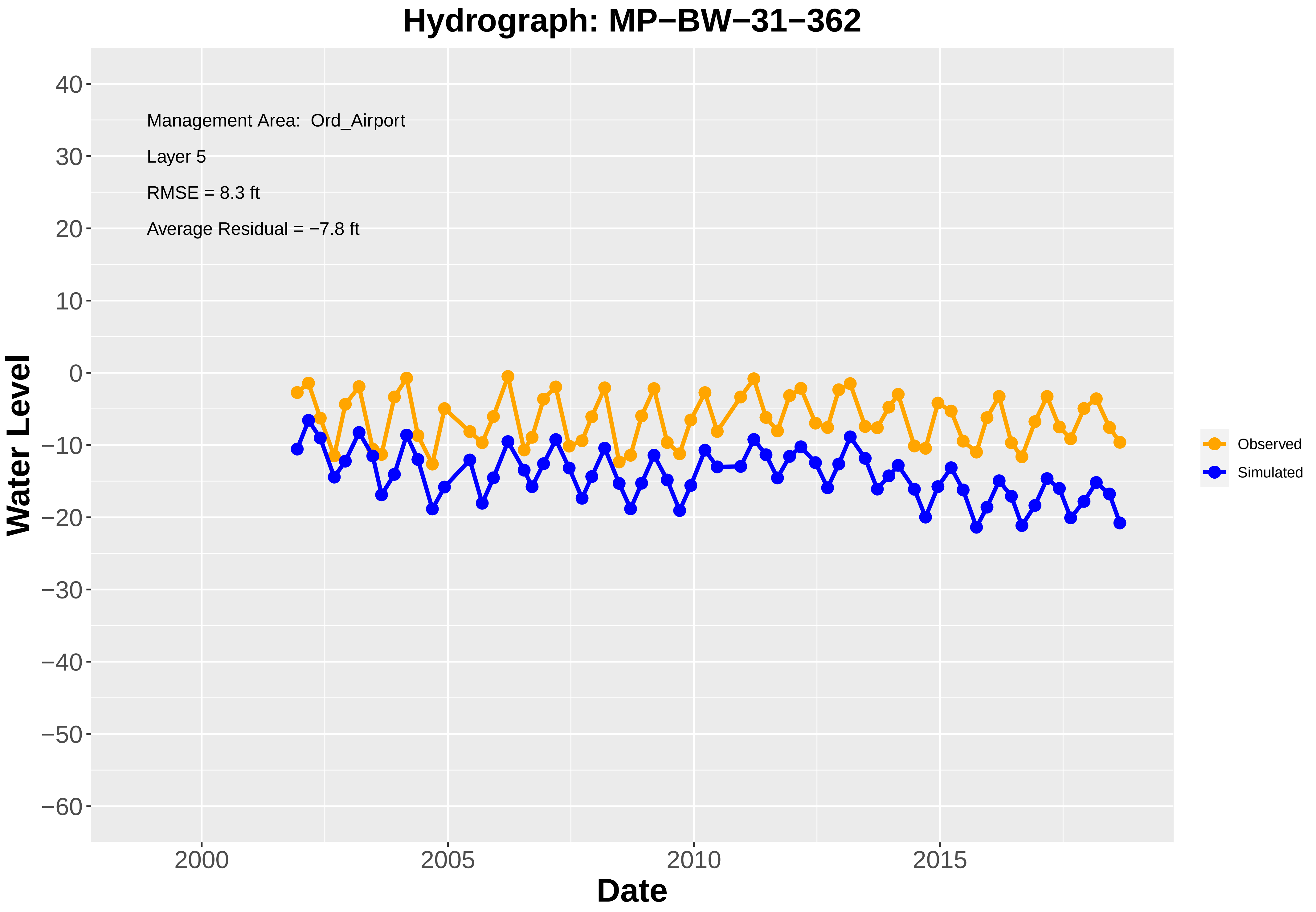

Hydrograph: MP−BW−30−397
Management Area: Ord_Central
Layer 5
RMSE = 8.6 ft
Average Residual = −8.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

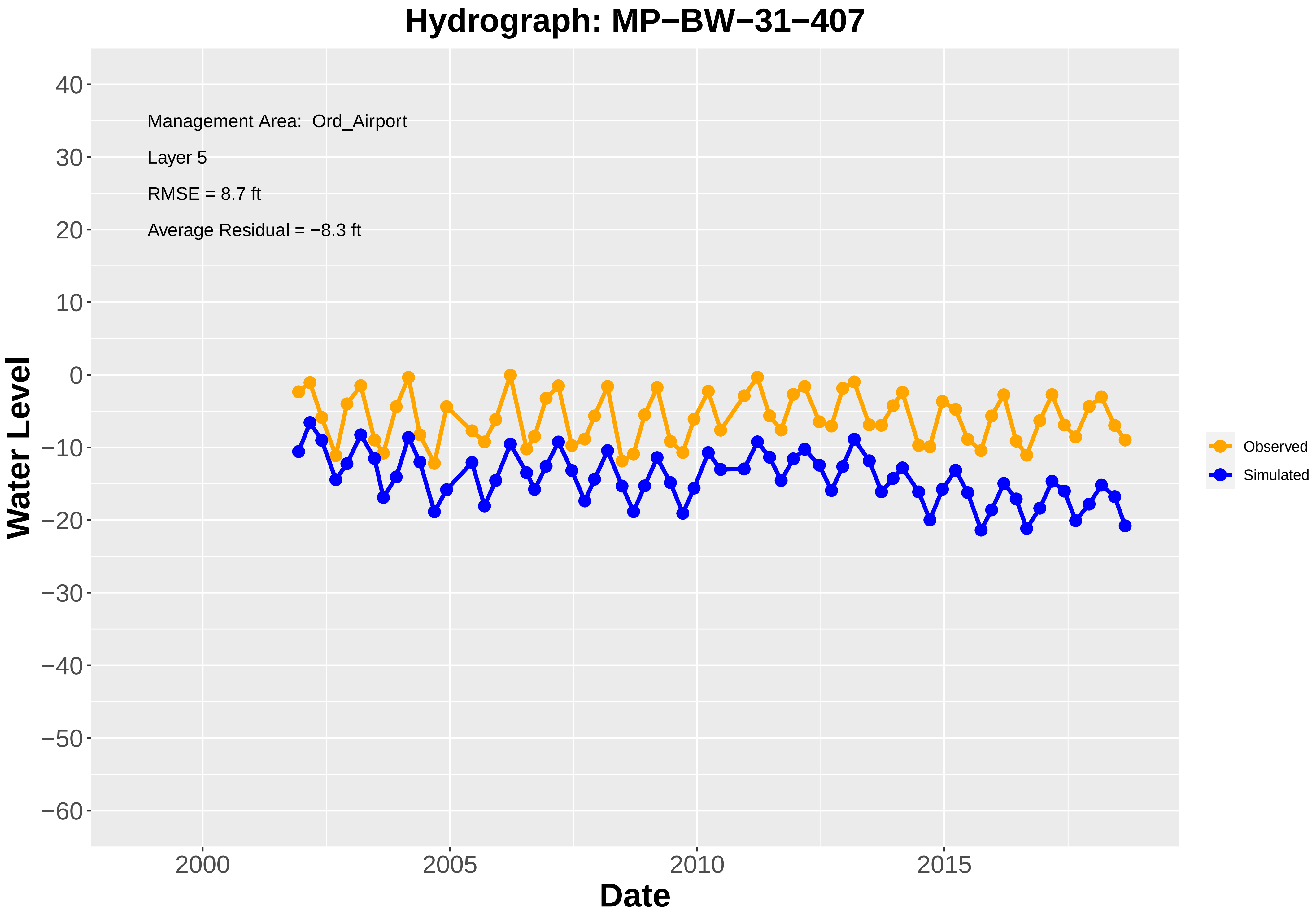

Hydrograph: MP−BW−30−467
Management Area: Ord_Central
Layer 7
RMSE = 13.1 ft
Average Residual = −9.8 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

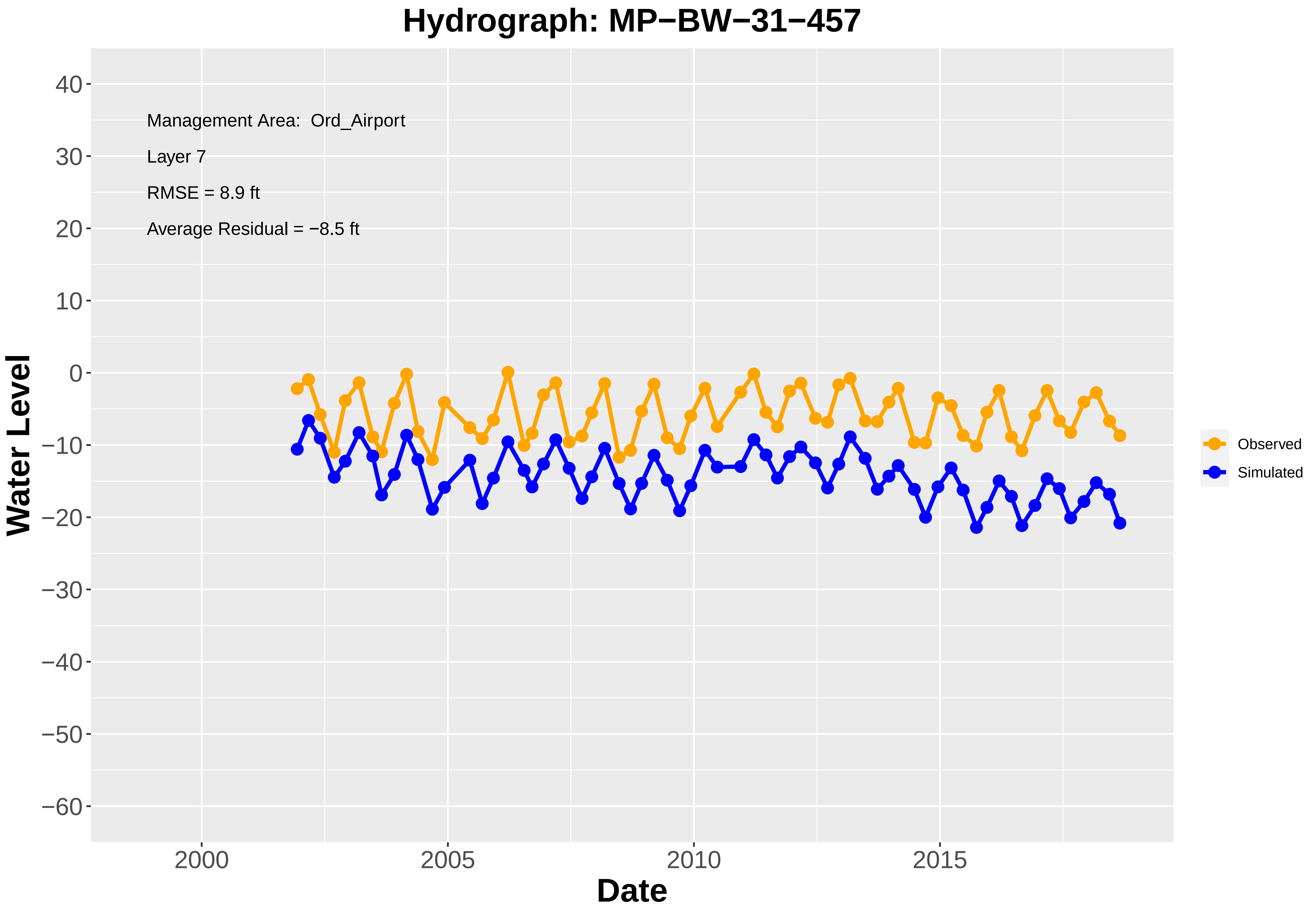

Hydrograph: MP−BW−30−537
Management Area: Ord_Central
Layer 7
RMSE = 9.0 ft
Average Residual = −8.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

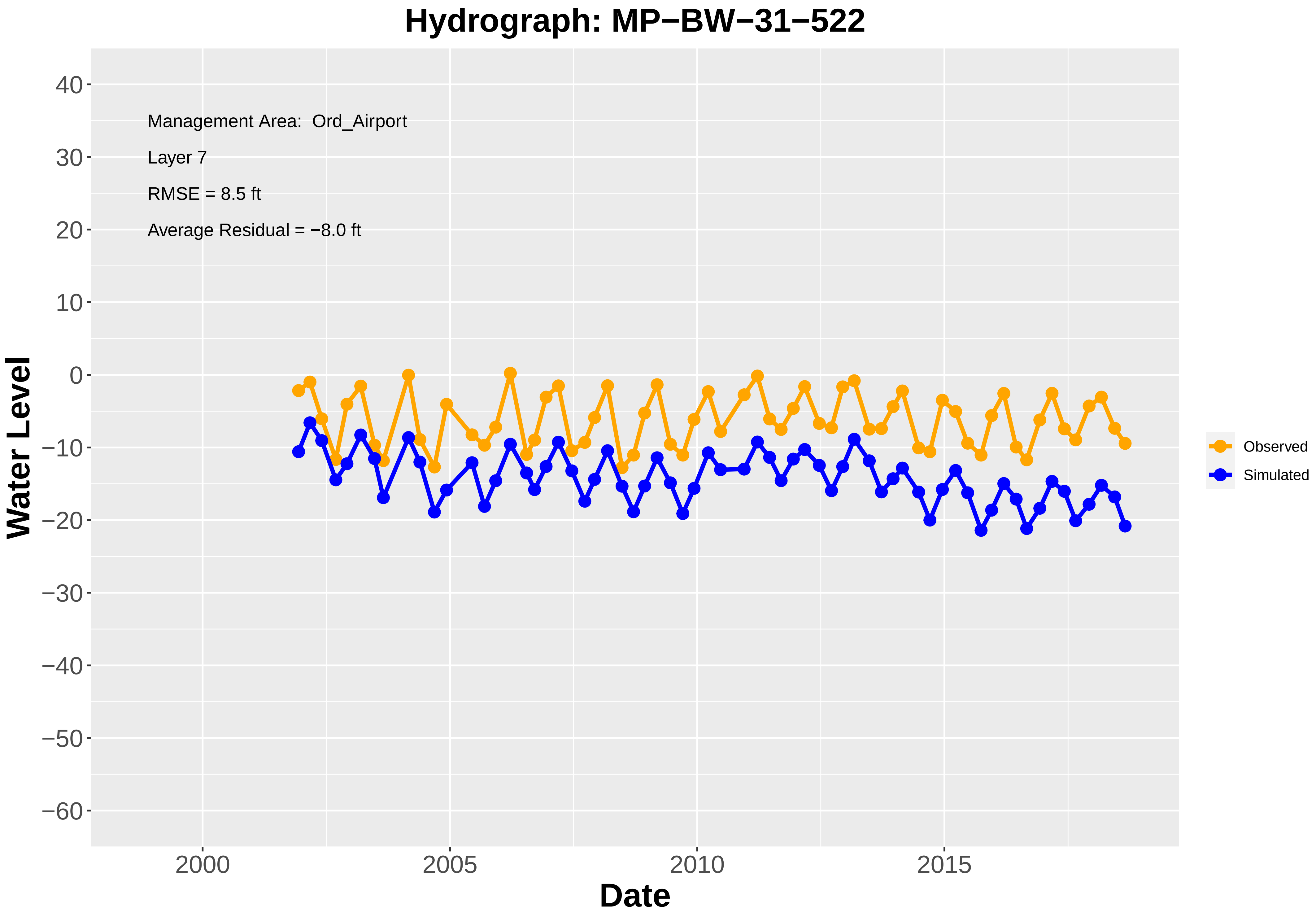

Hydrograph: MP−BW−31−292
Management Area: Ord_Airport
Layer 5
RMSE = 7.8 ft
Average Residual = −7.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

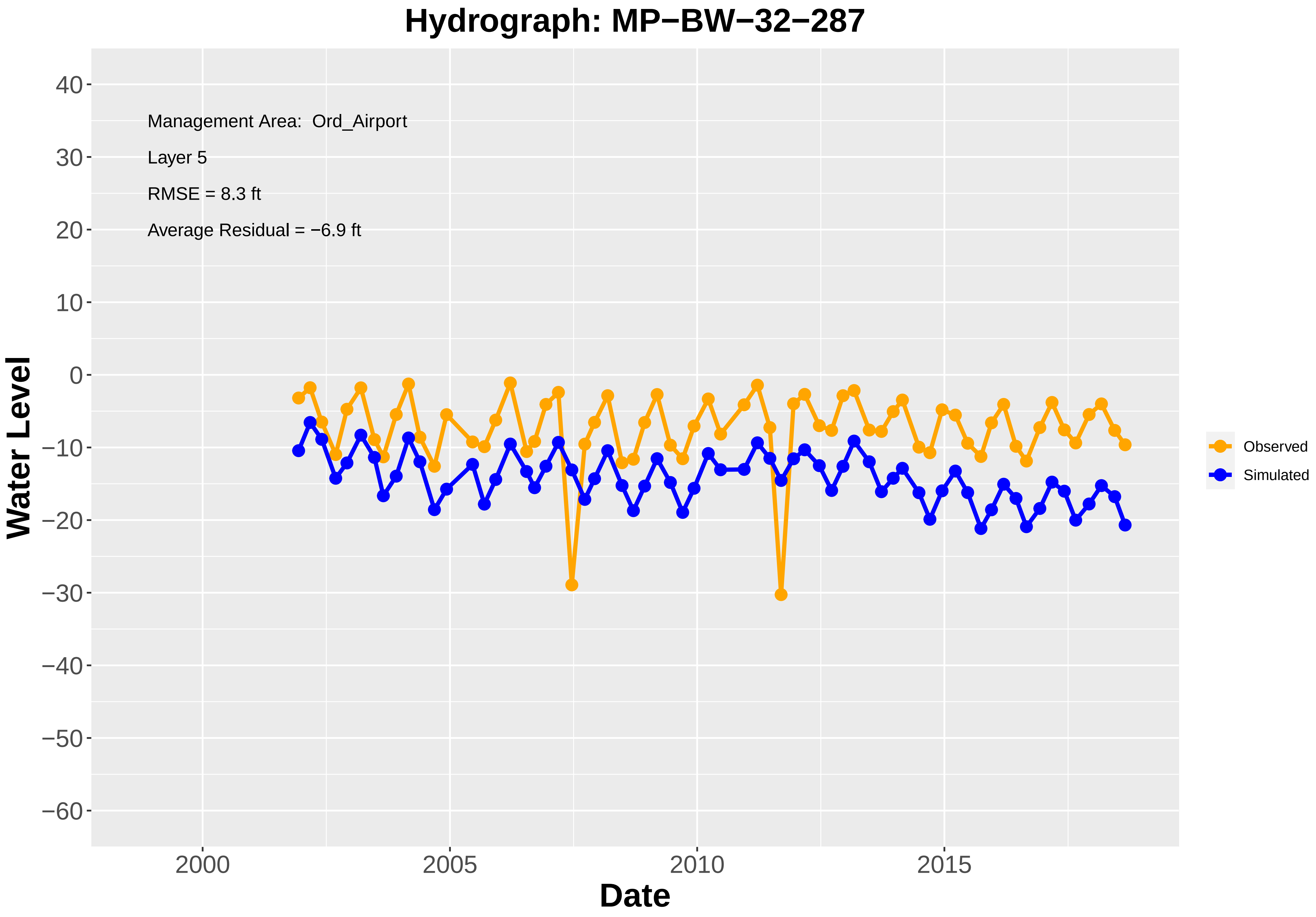

Hydrograph: MP−BW−31−332
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.6 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

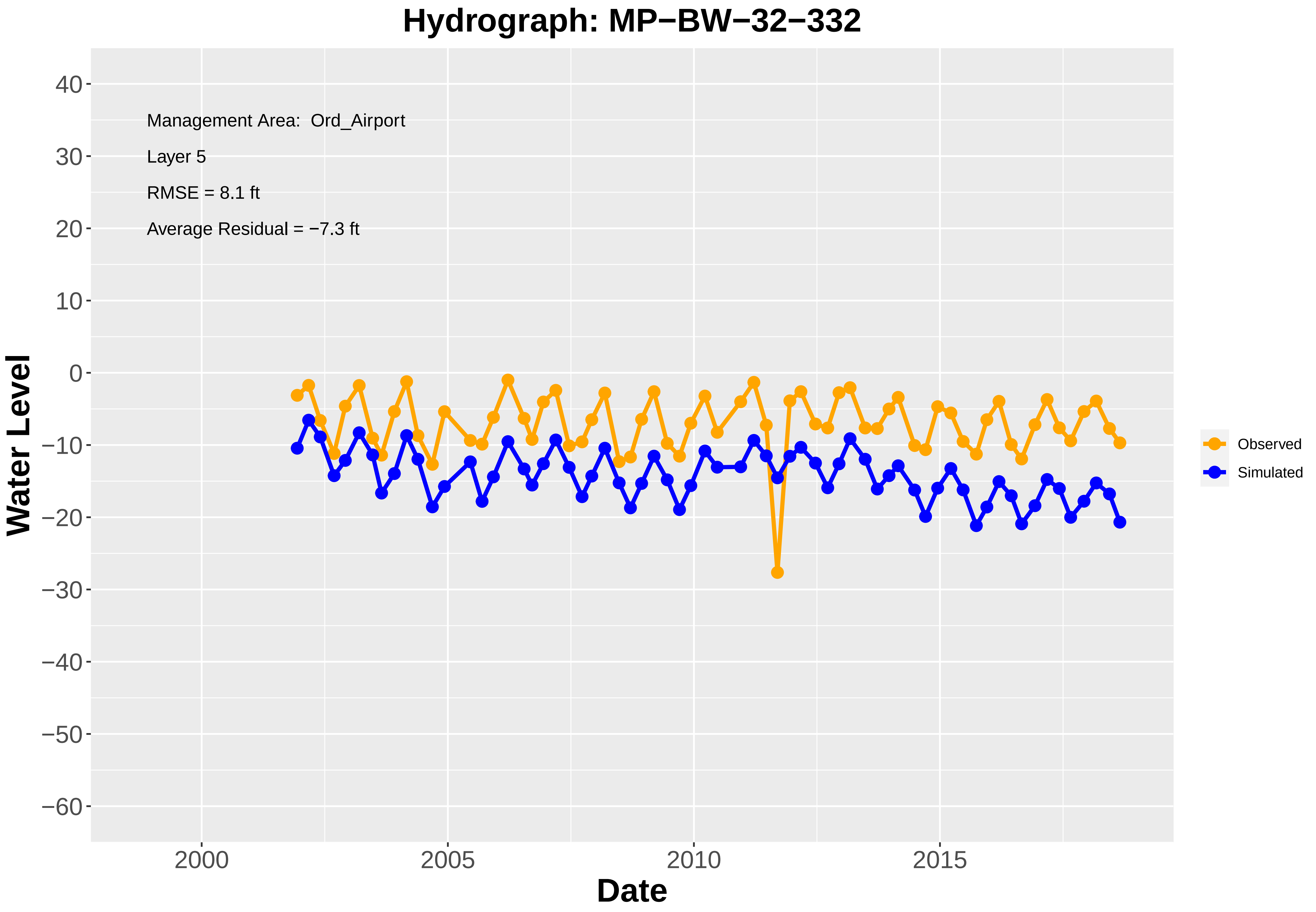

Hydrograph: MP−BW−31−362
Management Area: Ord_Airport
Layer 5
RMSE = 8.3 ft
Average Residual = −7.8 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

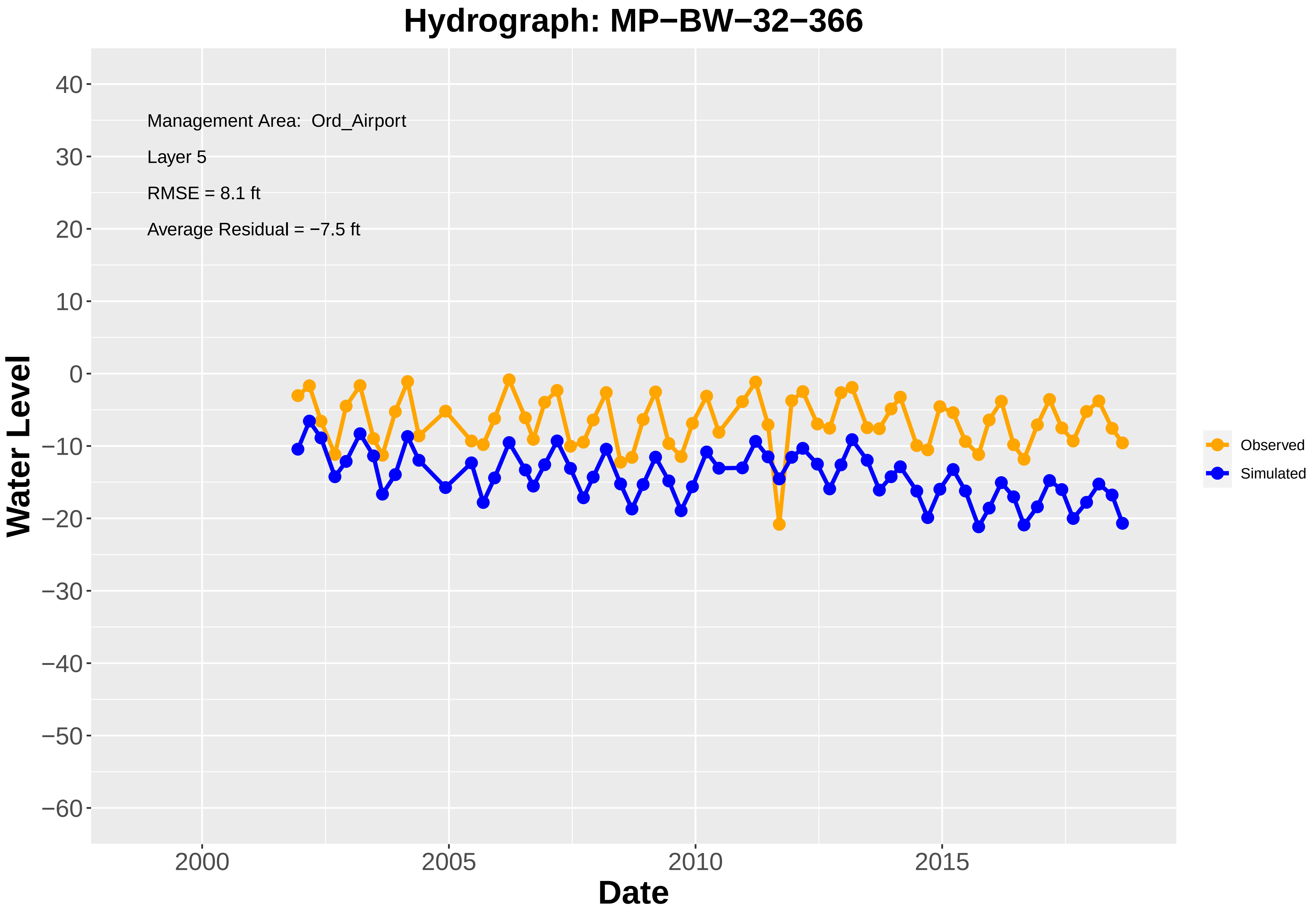

Hydrograph: MP−BW−31−407
Management Area: Ord_Airport
Layer 5
RMSE = 8.7 ft
Average Residual = −8.3 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MP−BW−31−457
Management Area: Ord_Airport
Layer 7
RMSE = 8.9 ft
Average Residual = −8.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

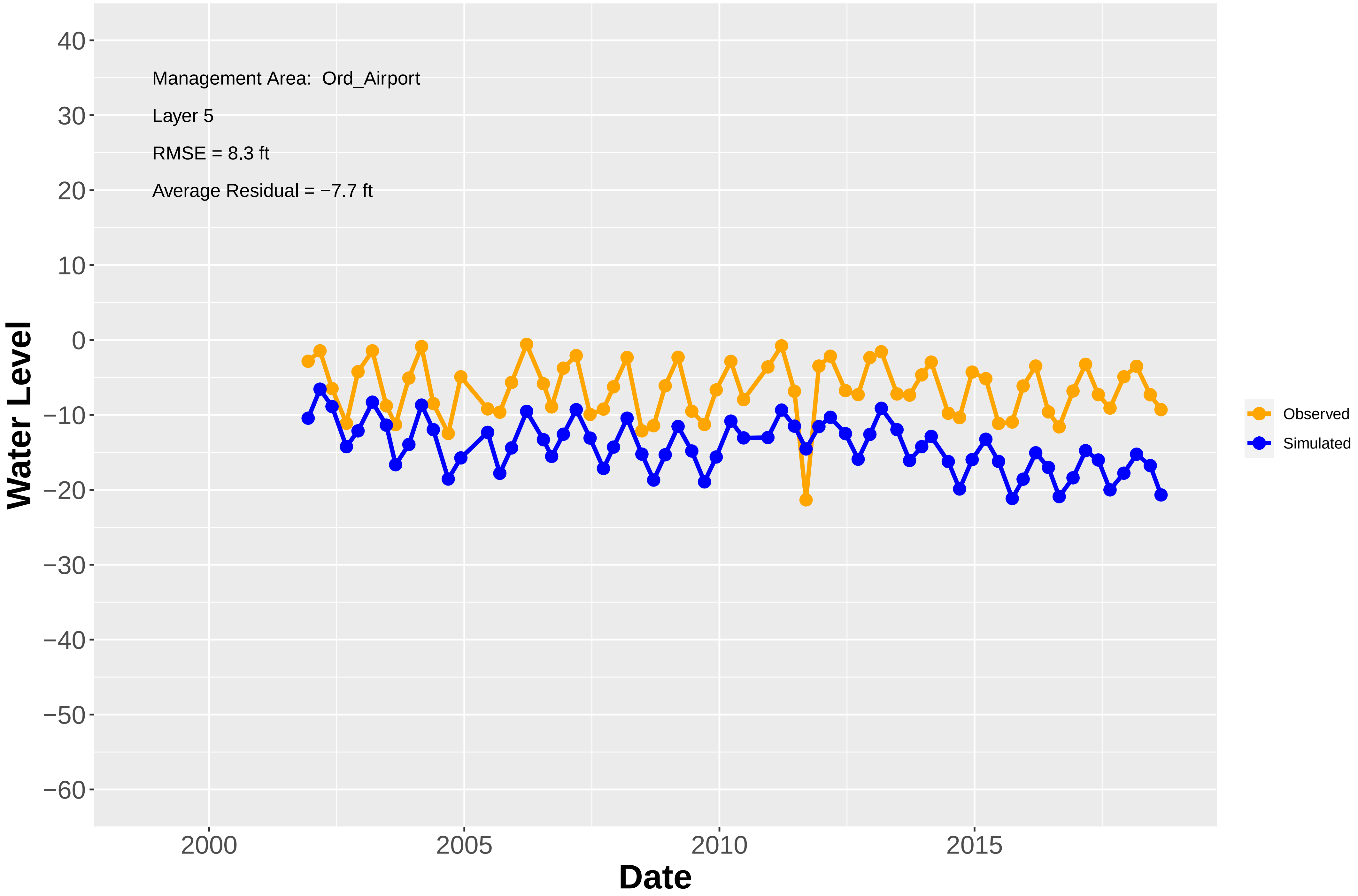

Hydrograph: MP−BW−31−522
Management Area: Ord_Airport
Layer 7
RMSE = 8.5 ft
Average Residual = −8.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

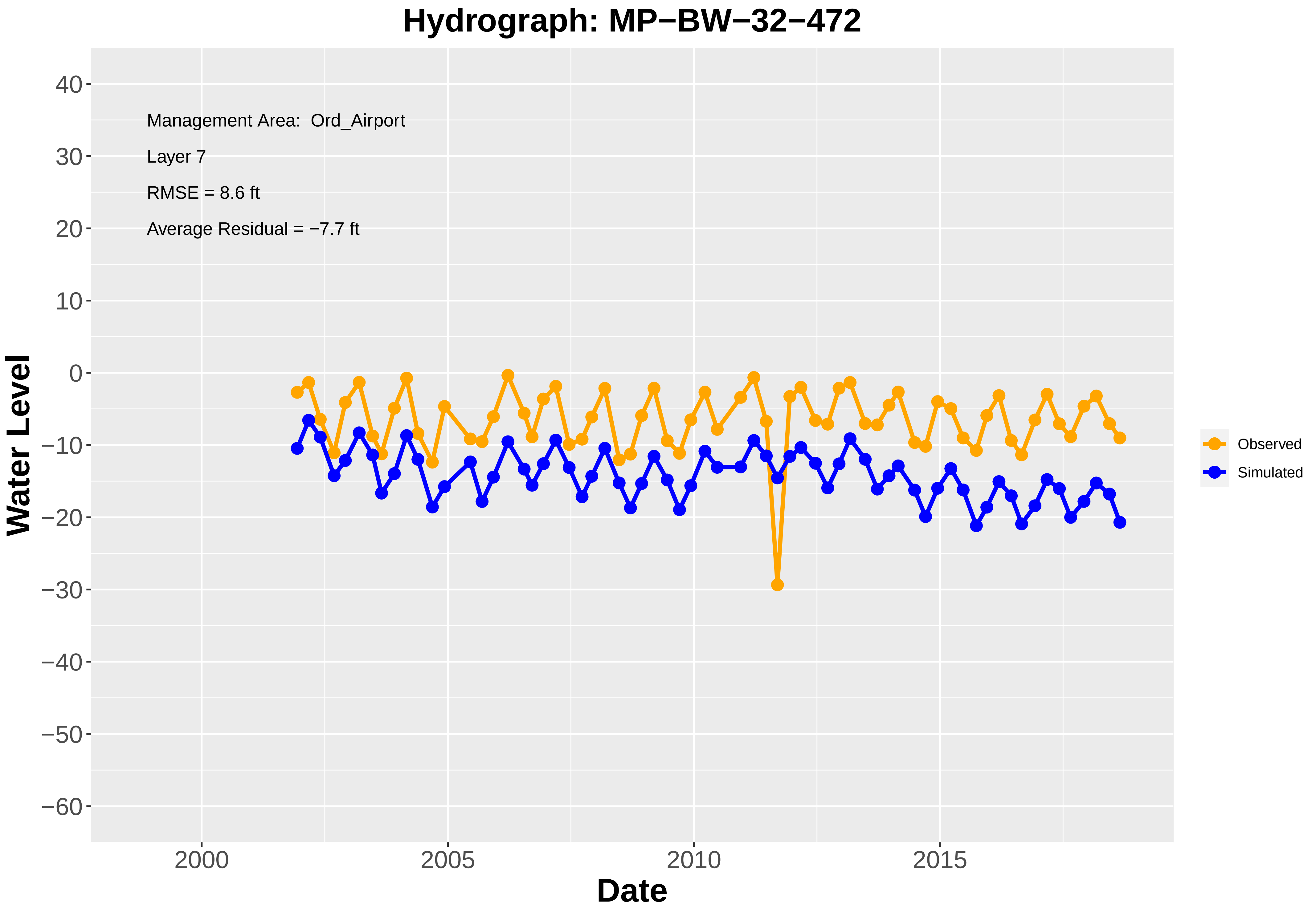

Hydrograph: MP−BW−32−287
Management Area: Ord_Airport
Layer 5
RMSE = 8.3 ft
Average Residual = −6.9 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

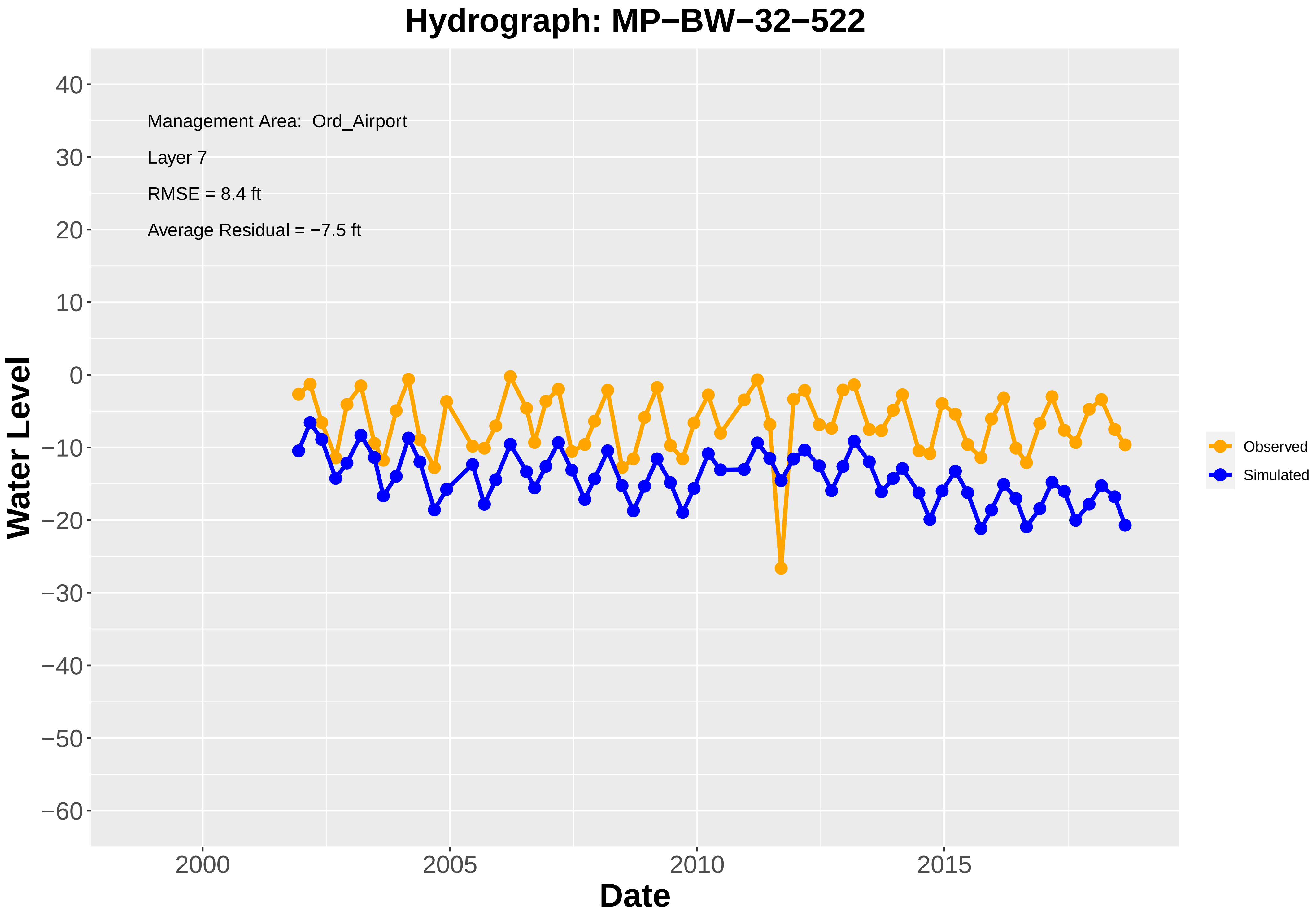

Hydrograph: MP−BW−32−332
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−32−366
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

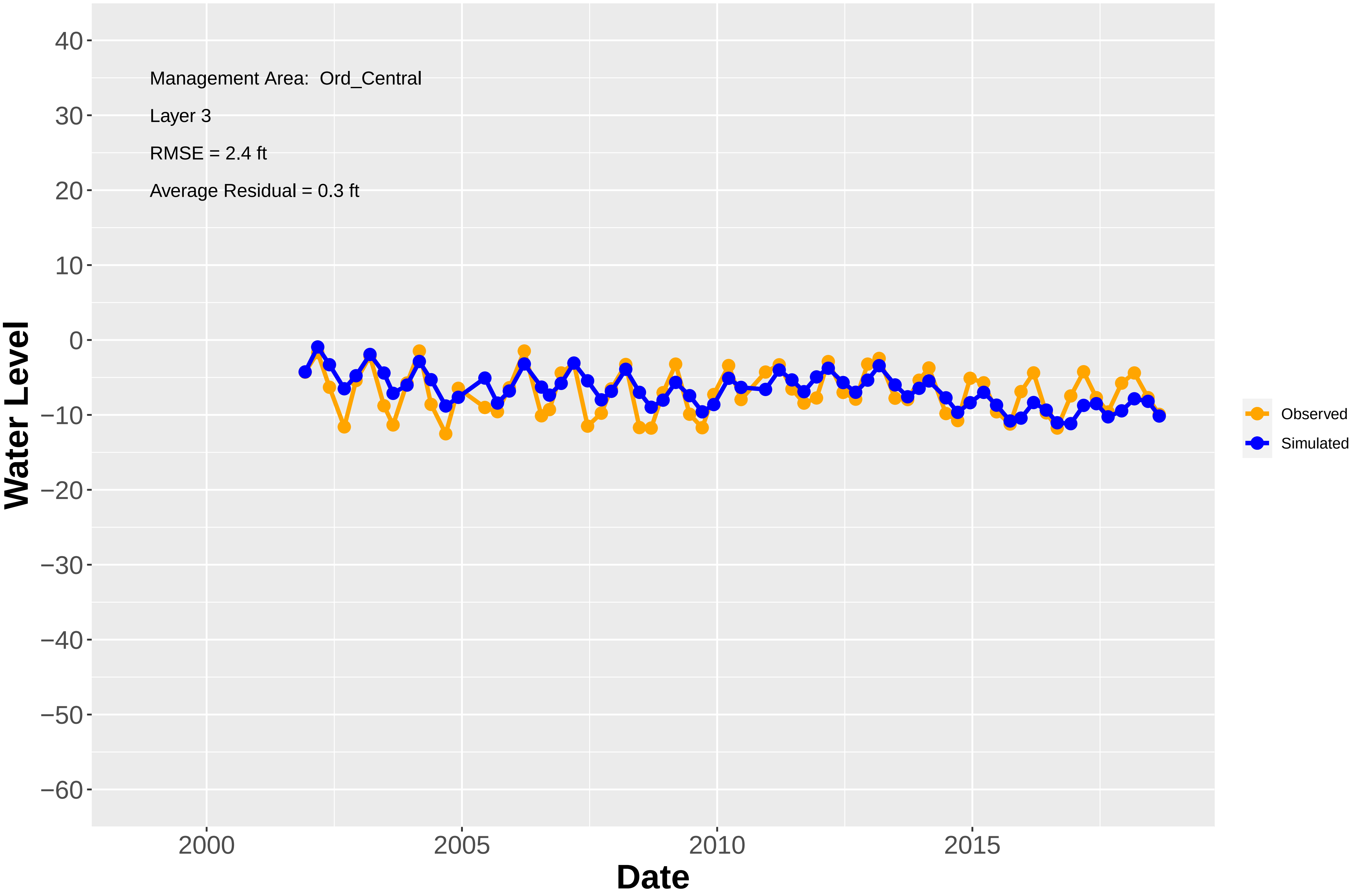
Hydrograph: MP−BW−32−412

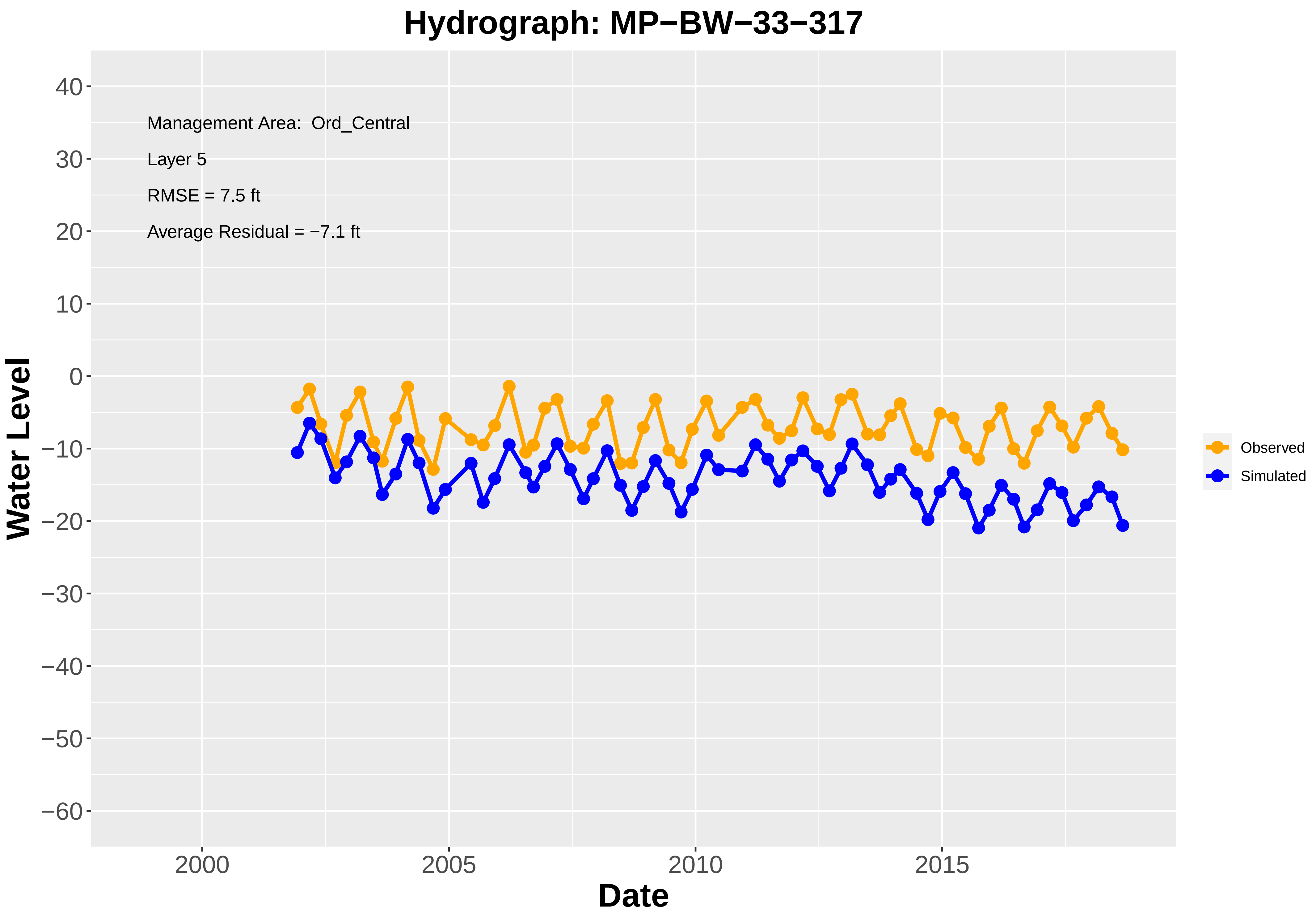



Hydrograph: MP−BW−32−472
Management Area: Ord_Airport
Layer 7
RMSE = 8.6 ft
Average Residual = −7.7 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

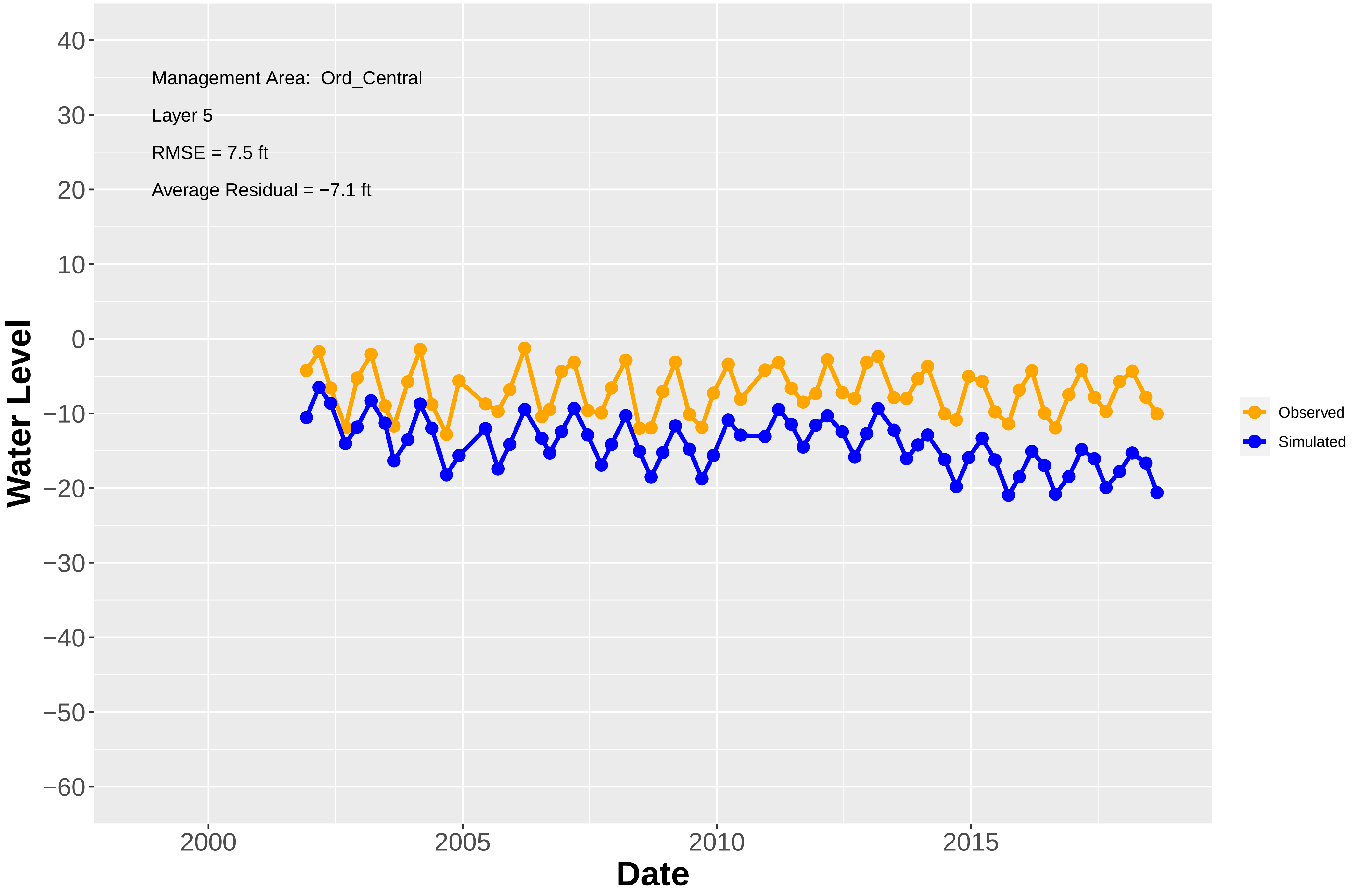

Hydrograph: MP−BW−32−522
Management Area: Ord_Airport
Layer 7
RMSE = 8.4 ft
Average Residual = −7.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

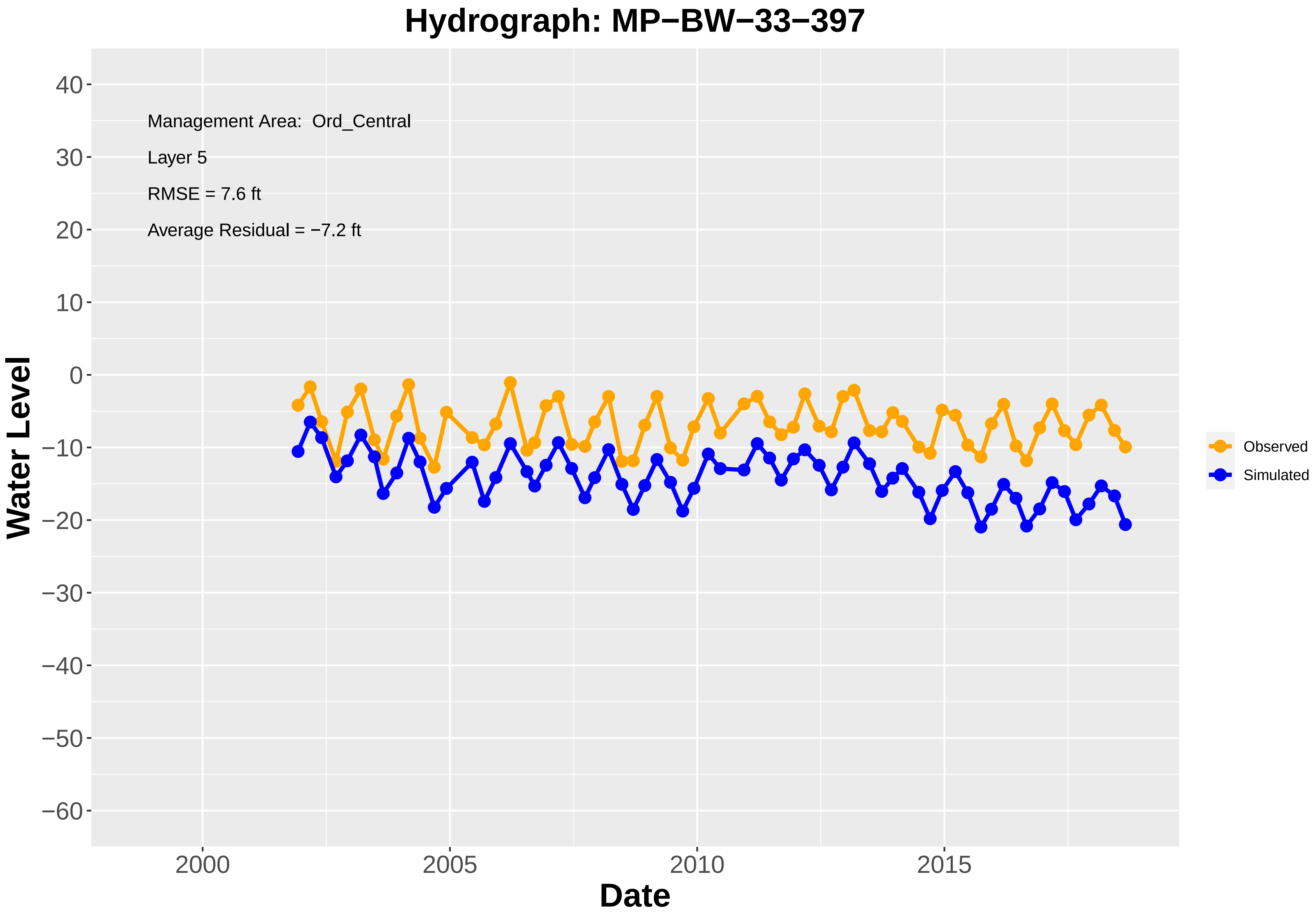
Hydrograph: MP−BW−33−272



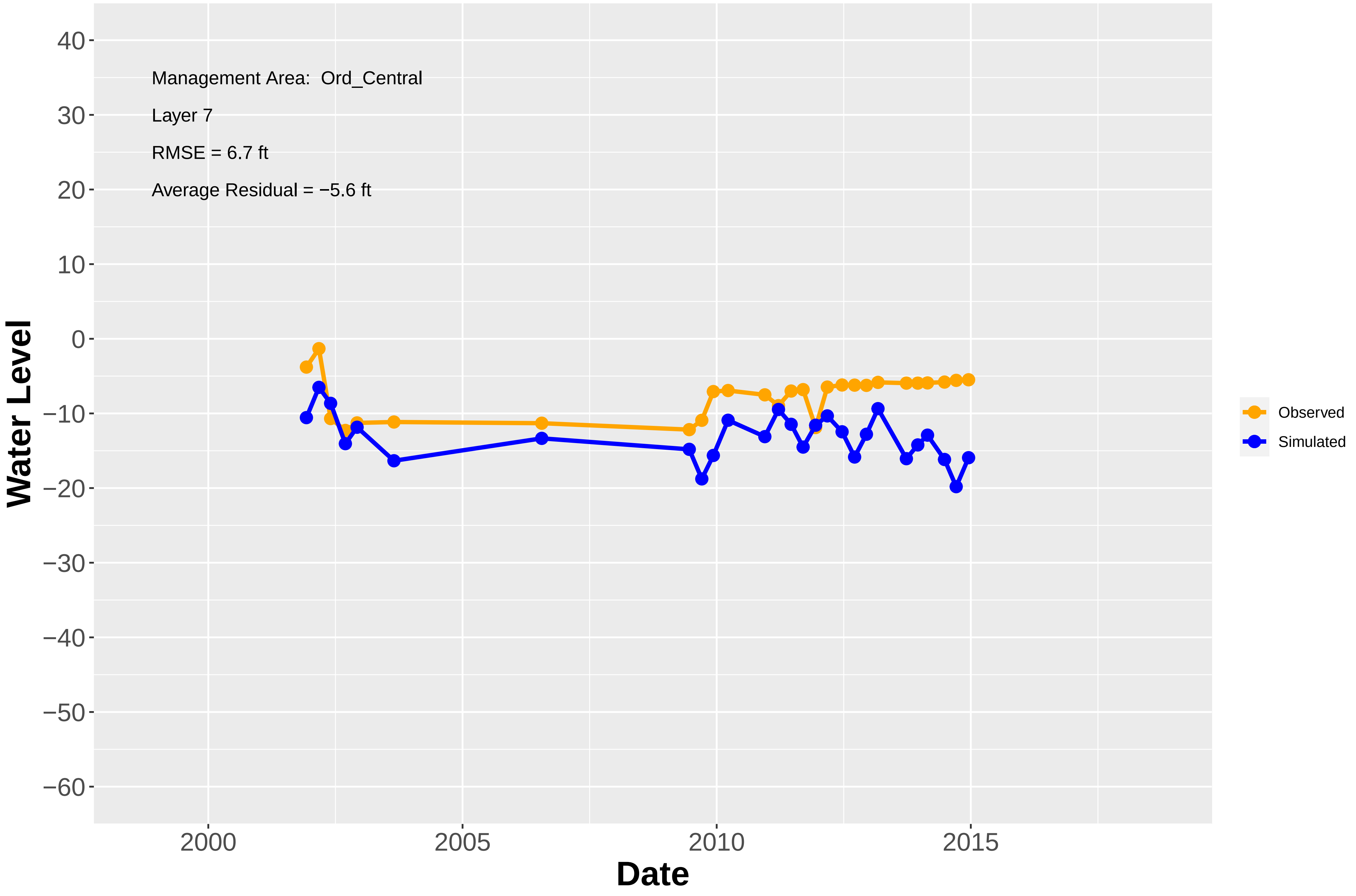

Hydrograph: MP−BW−33−317
Management Area: Ord_Central
Layer 5
RMSE = 7.5 ft
Average Residual = −7.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

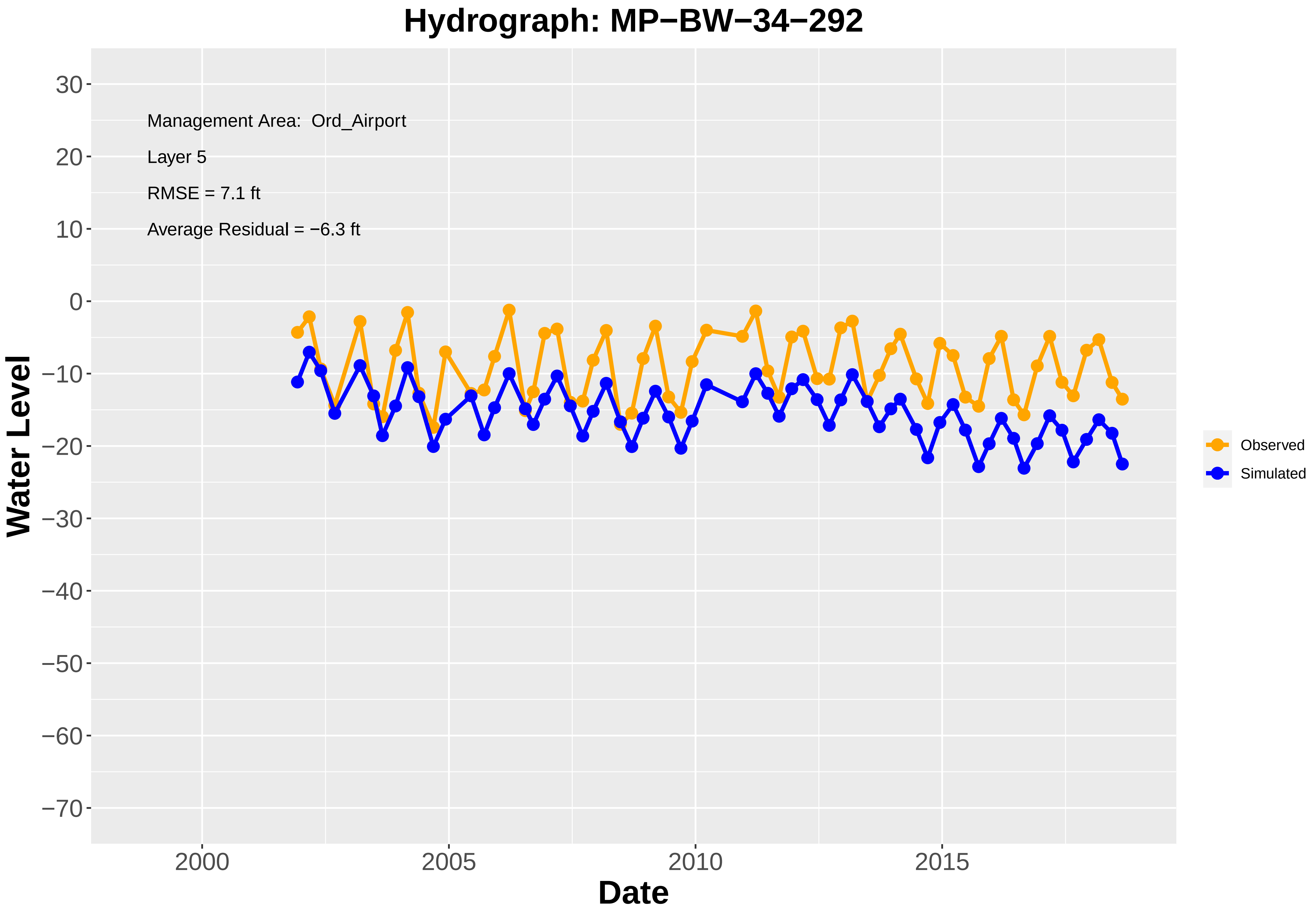
Hydrograph: MP−BW−33−352

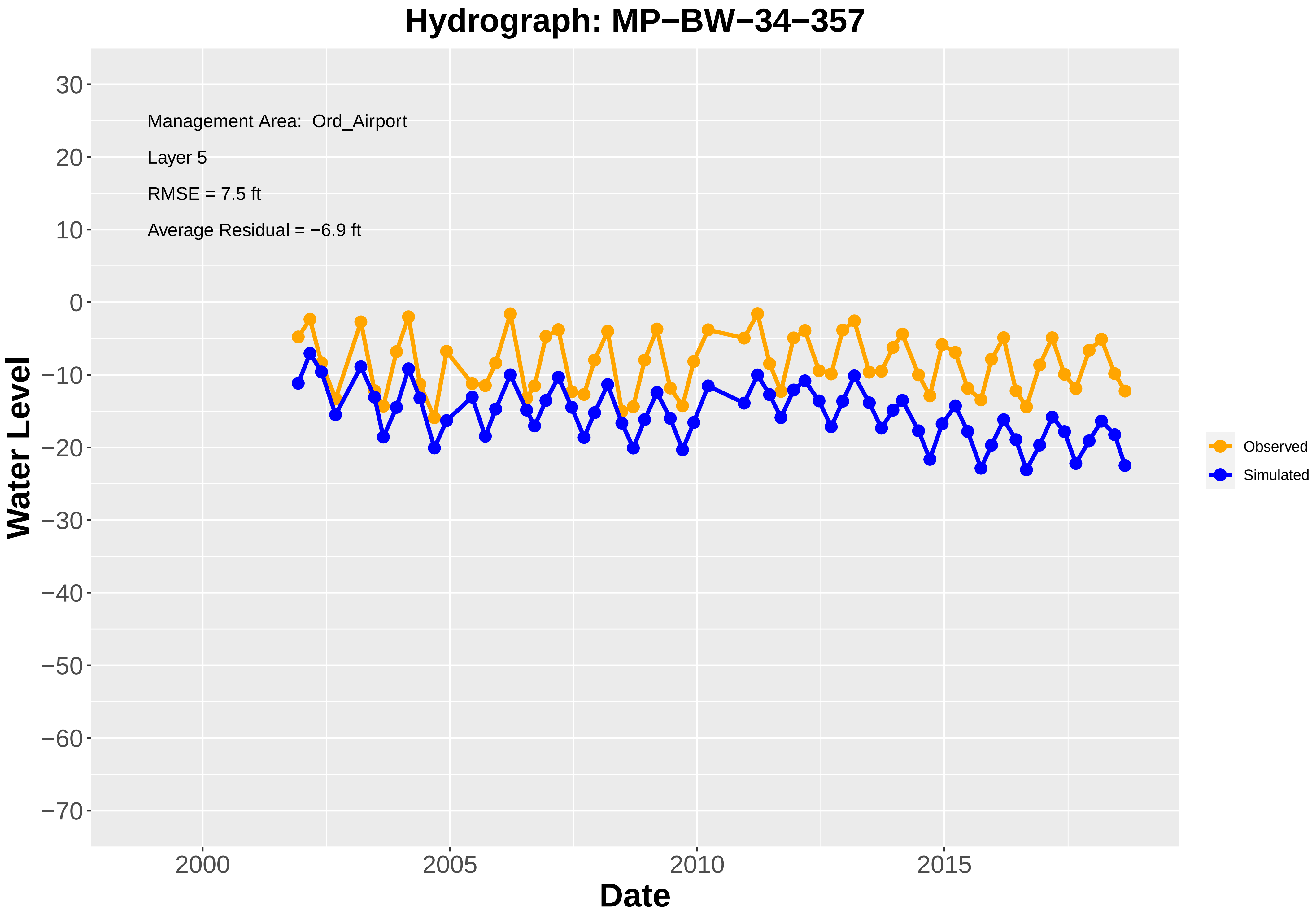


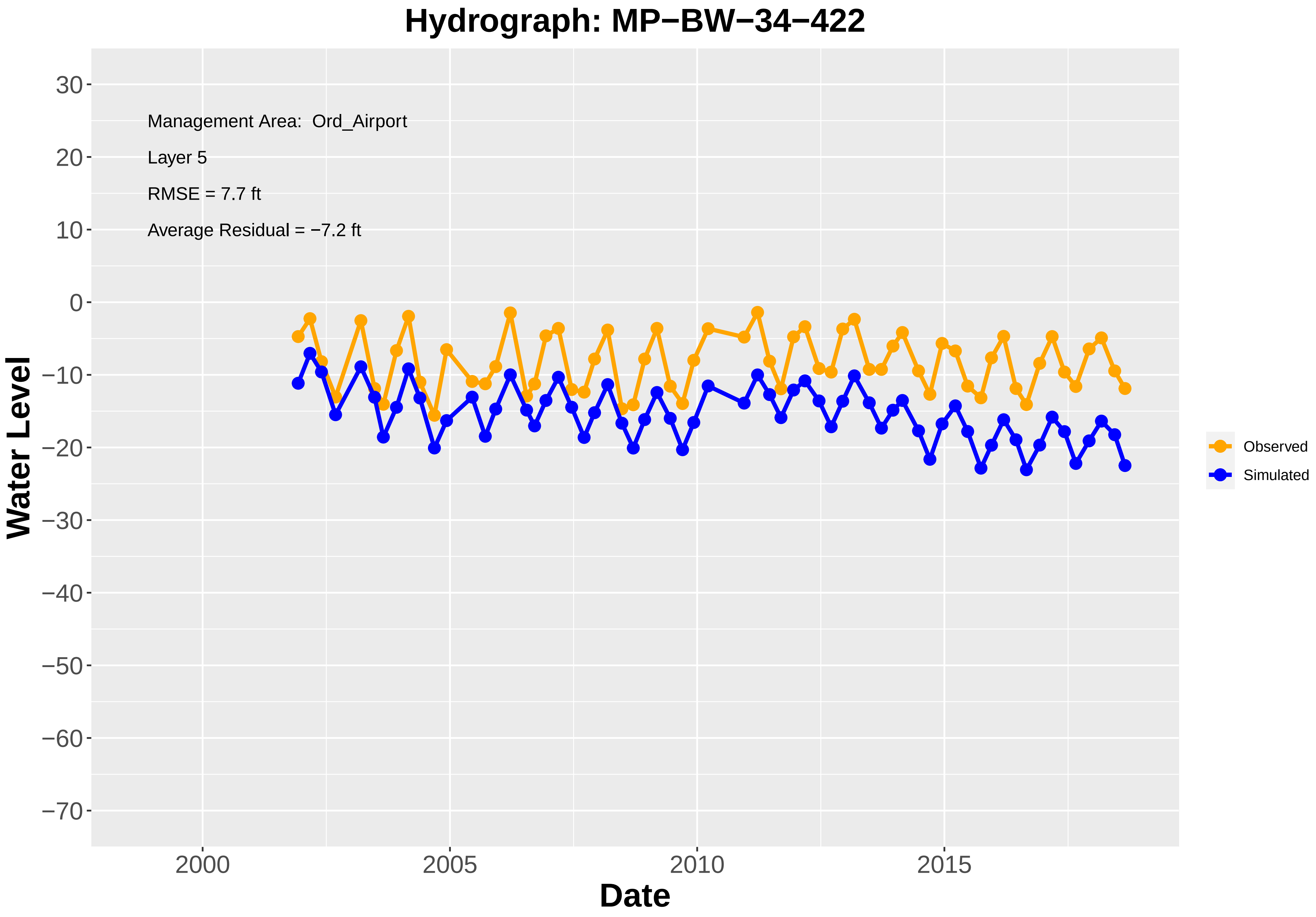

Hydrograph: MP−BW−33−397
Management Area: Ord_Central
Layer 5
RMSE = 7.6 ft
Average Residual = −7.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

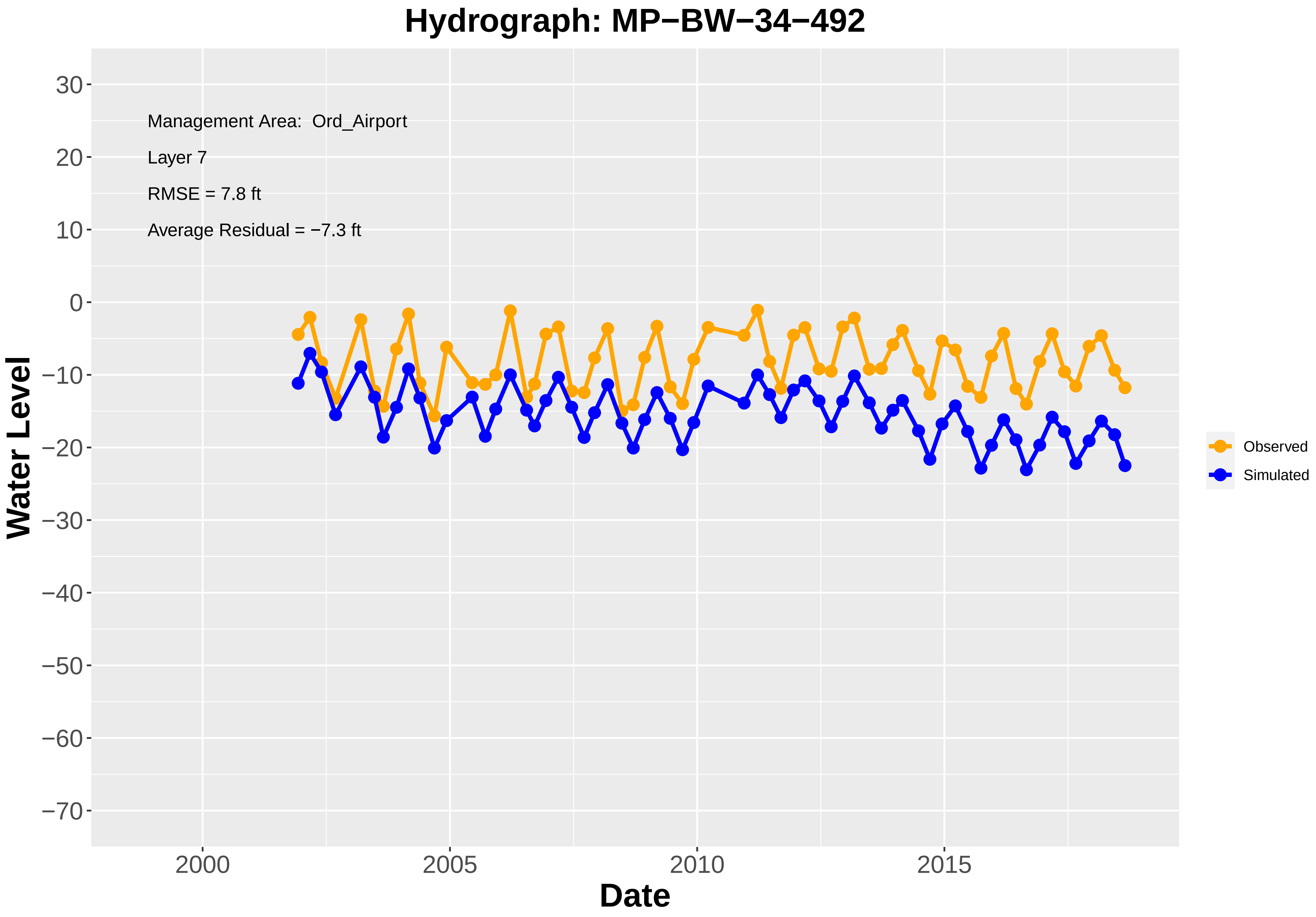
Hydrograph: MP−BW−33−462



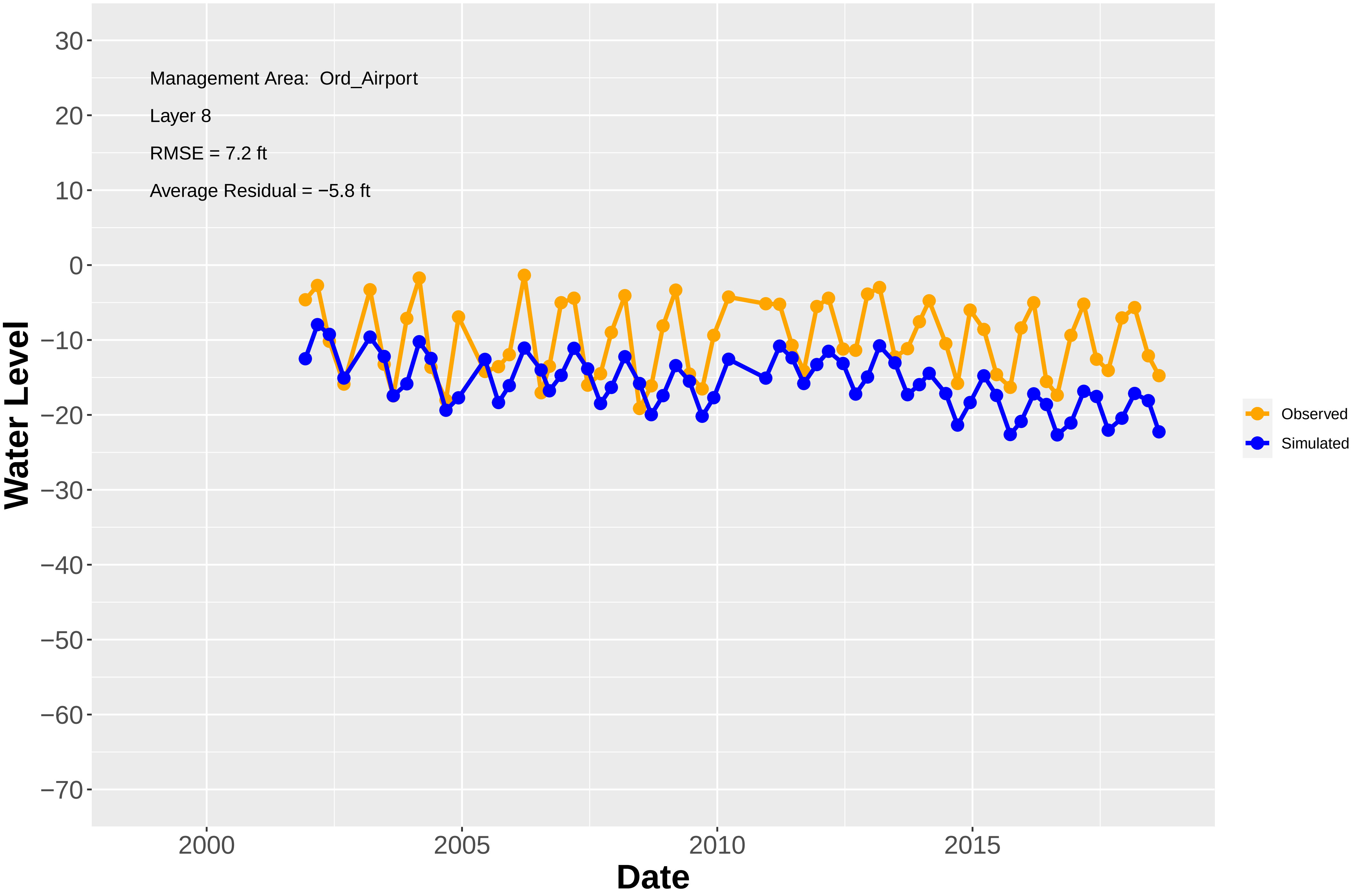

Hydrograph: MP−BW−34−292
Management Area: Ord_Airport
Layer 5
RMSE = 7.1 ft
Average Residual = −6.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

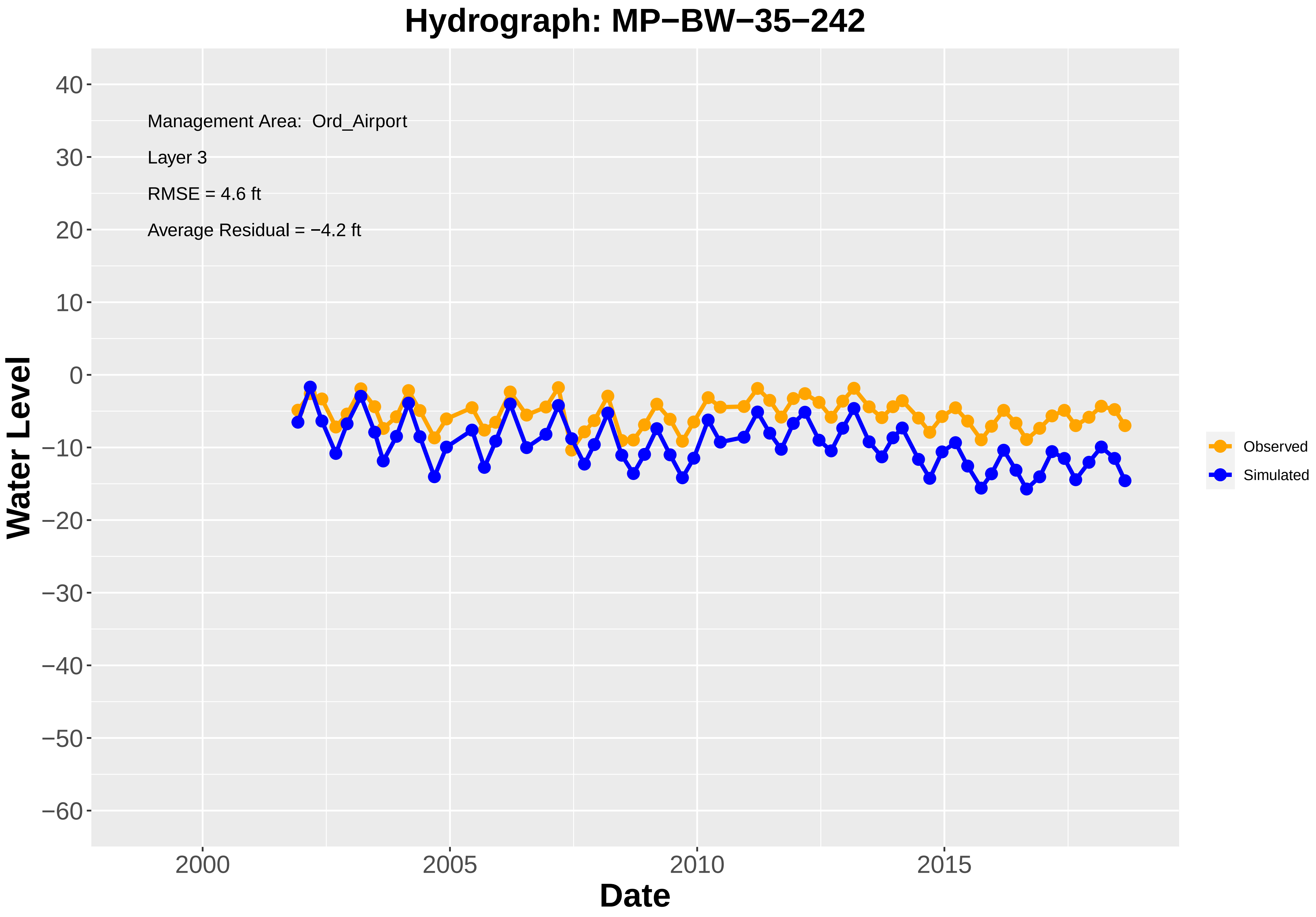

Hydrograph: MP−BW−34−357
Management Area: Ord_Airport
Layer 5
RMSE = 7.5 ft
Average Residual = −6.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

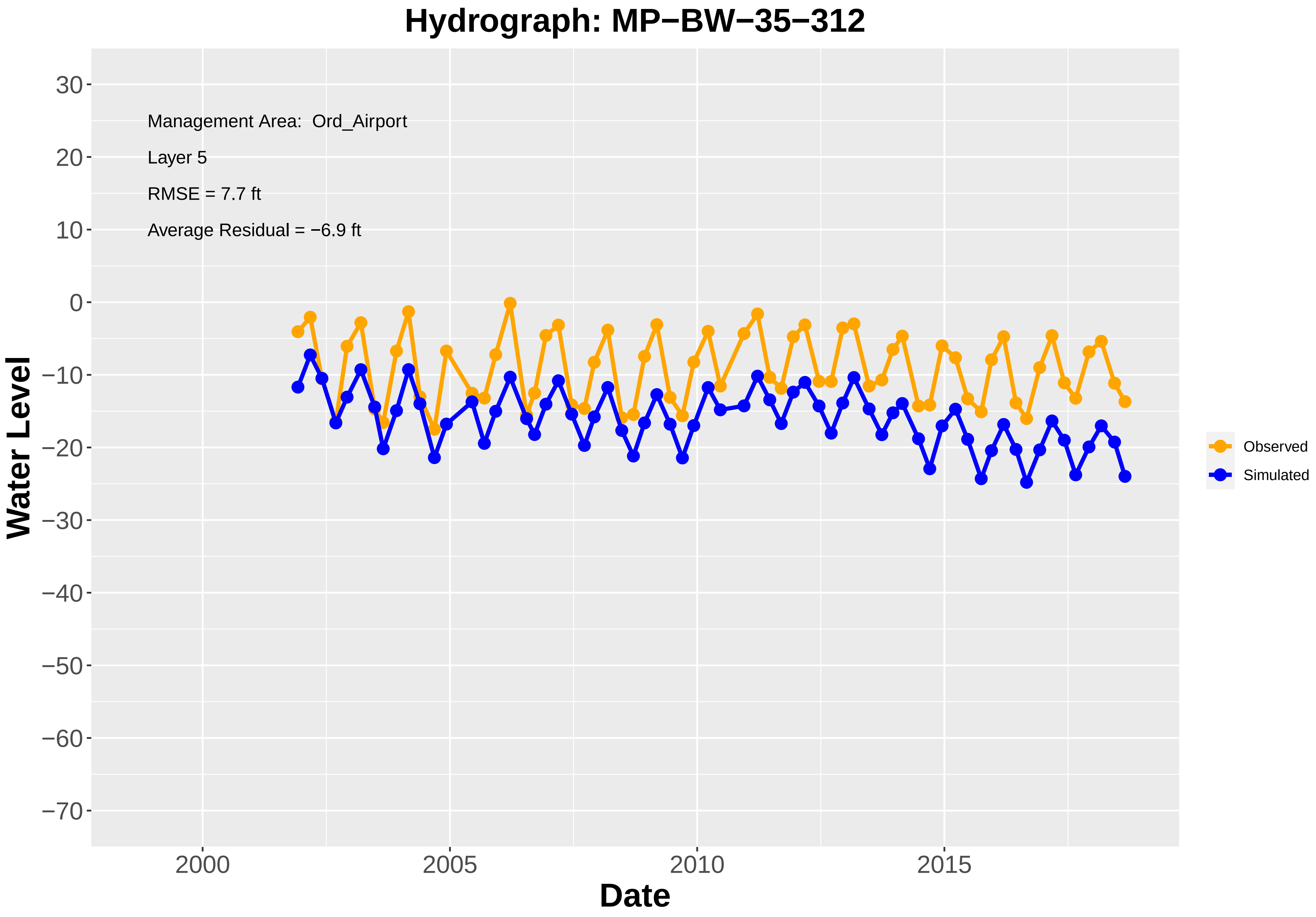
Hydrograph: MP−BW−34−422
Management Area: Ord_Airport
Layer 5
RMSE = 7.7 ft
Average Residual = −7.2 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

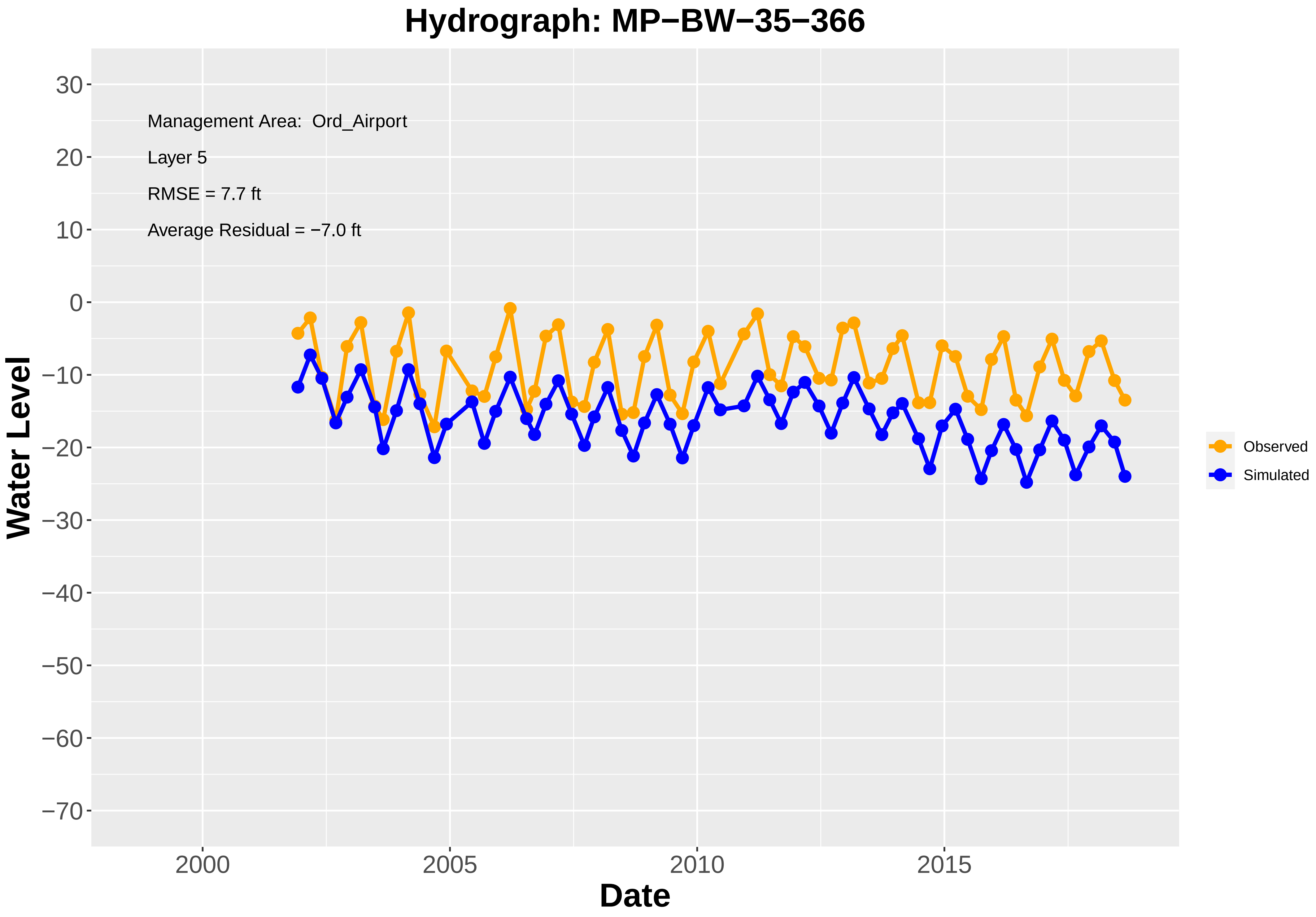

Hydrograph: MP−BW−34−492
Management Area: Ord_Airport
Layer 7
RMSE = 7.8 ft
Average Residual = −7.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

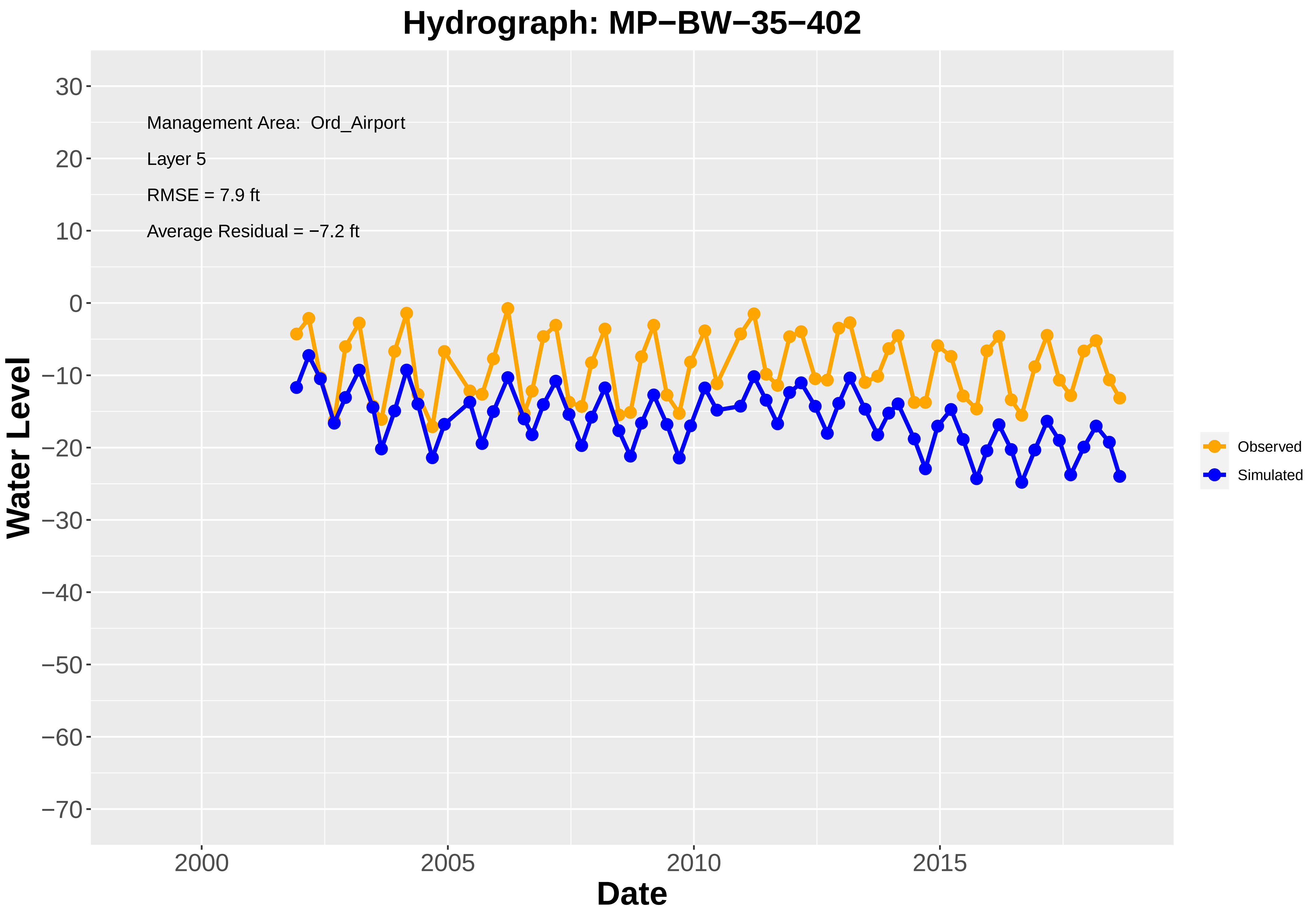
Hydrograph: MP−BW−34−537

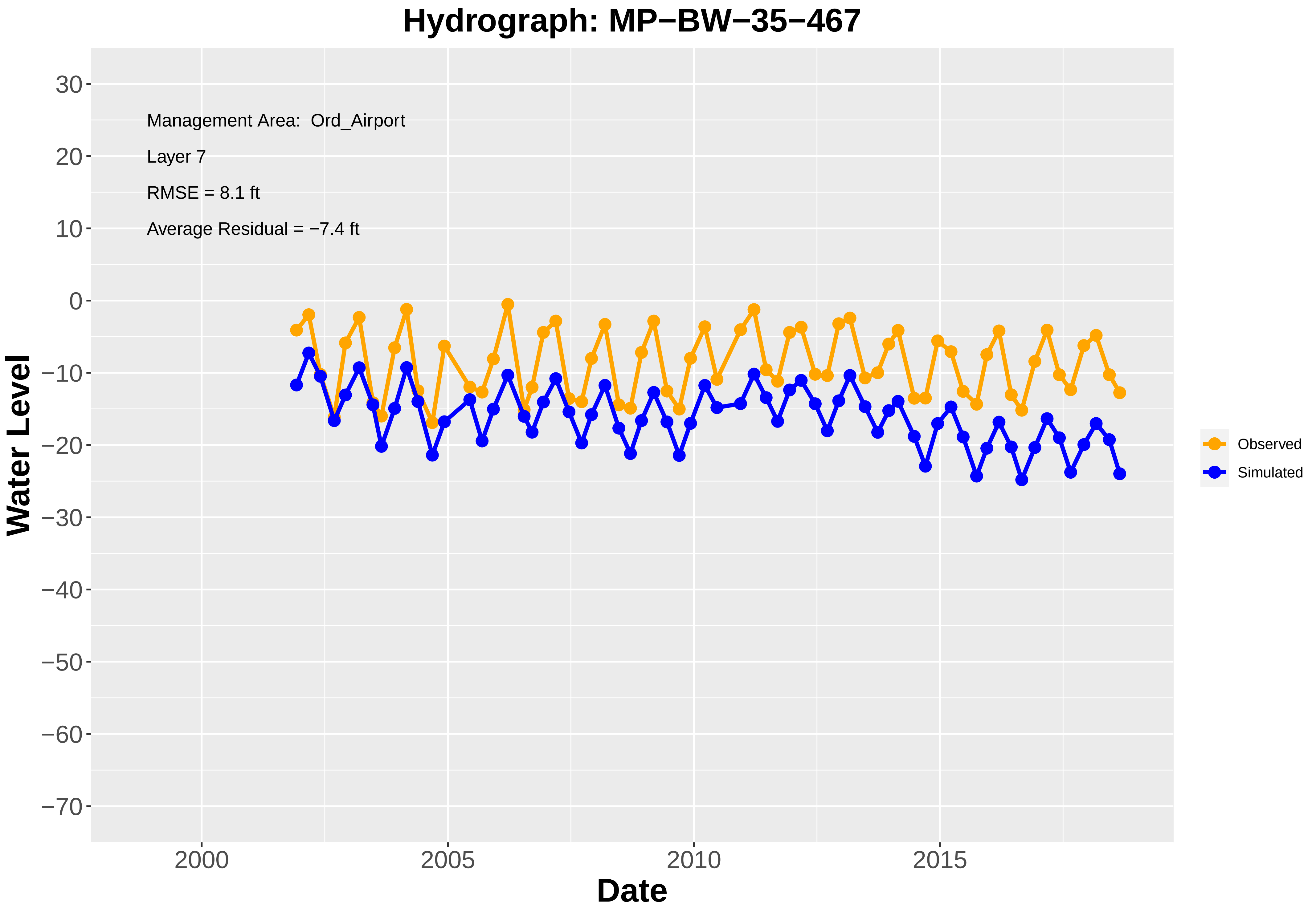


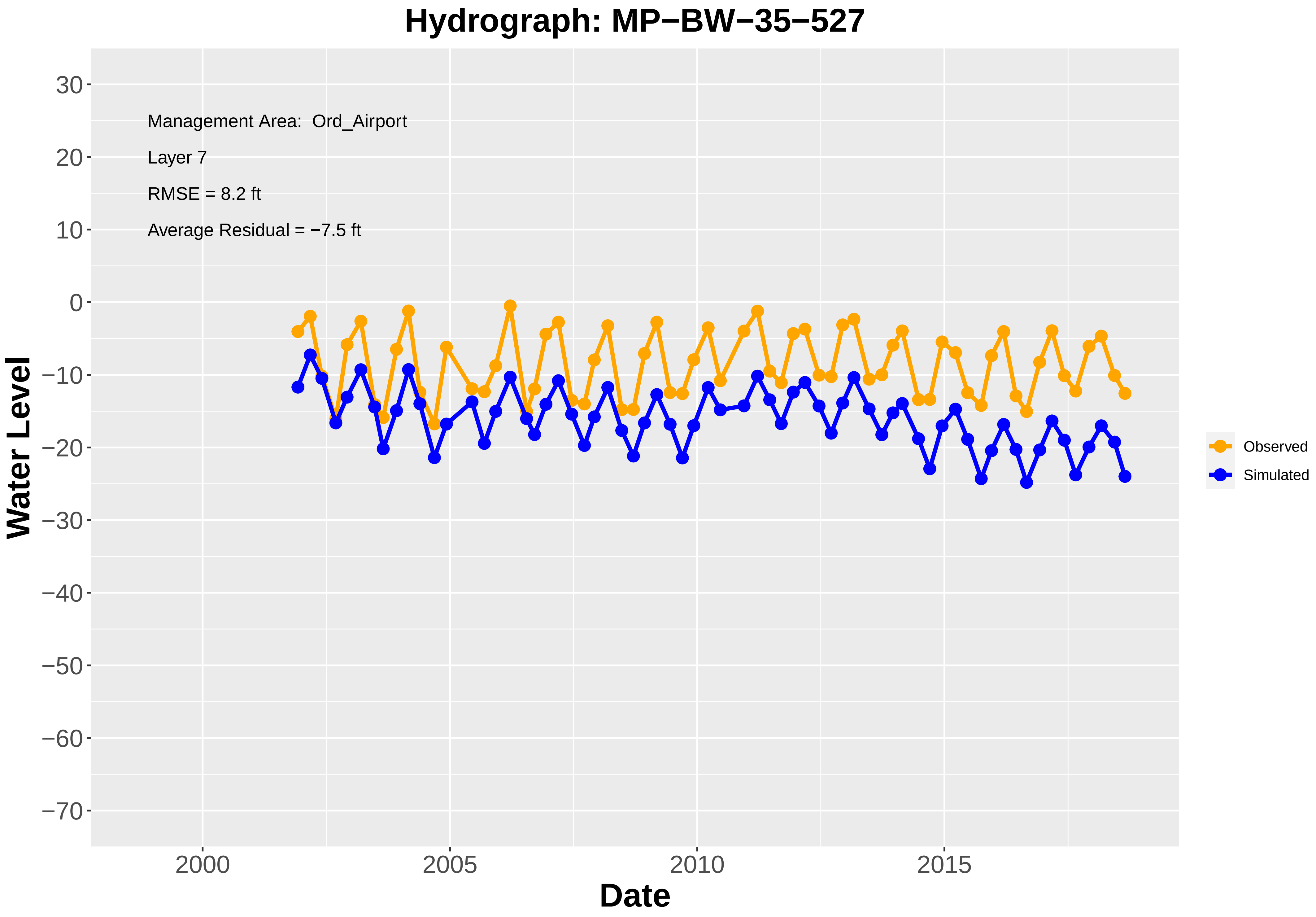

Hydrograph: MP−BW−35−242
Management Area: Ord_Airport
Layer 3
RMSE = 4.6 ft
Average Residual = −4.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

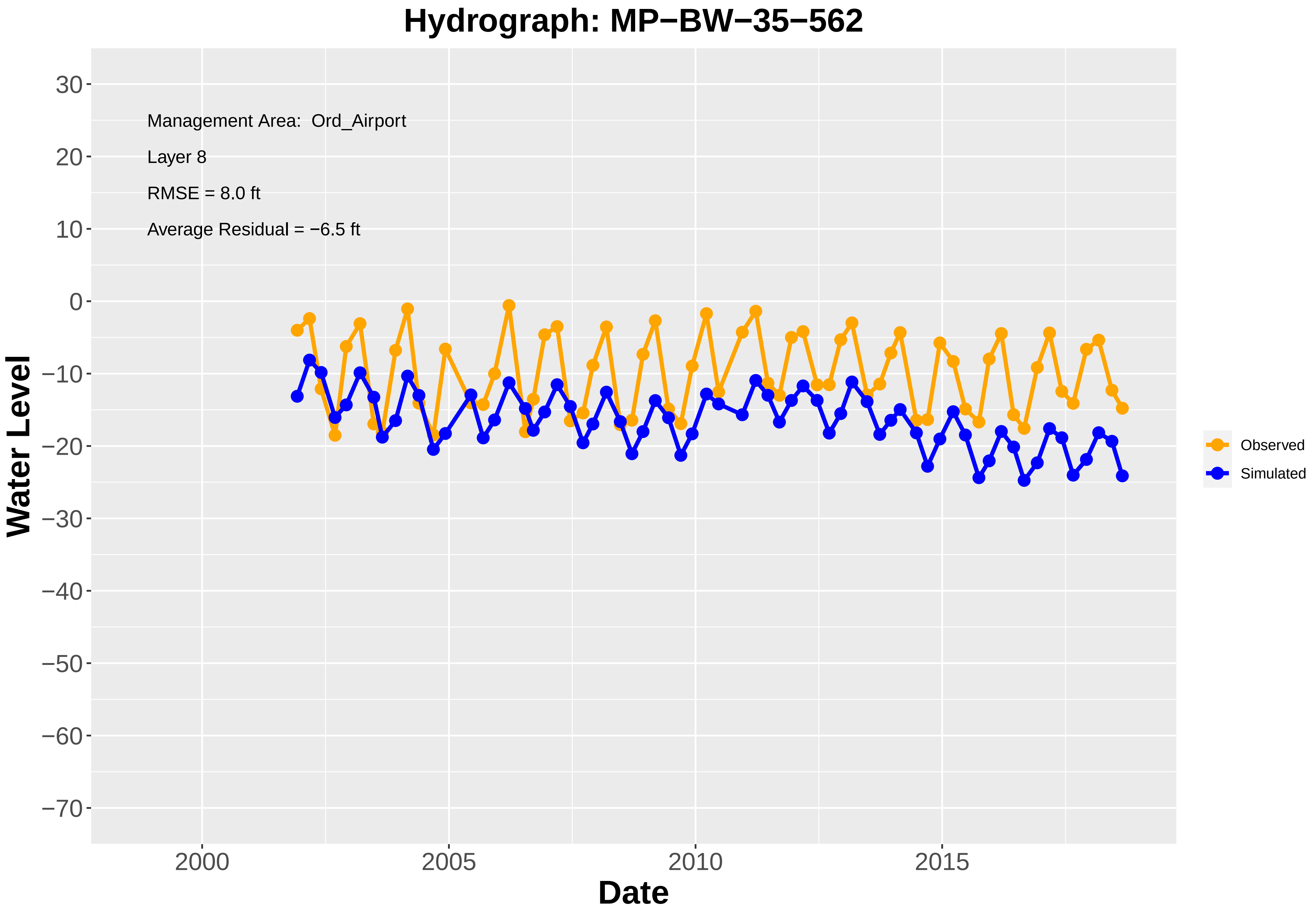
Hydrograph: MP−BW−35−312
Management Area: Ord_Airport
Layer 5
RMSE = 7.7 ft
Average Residual = −6.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

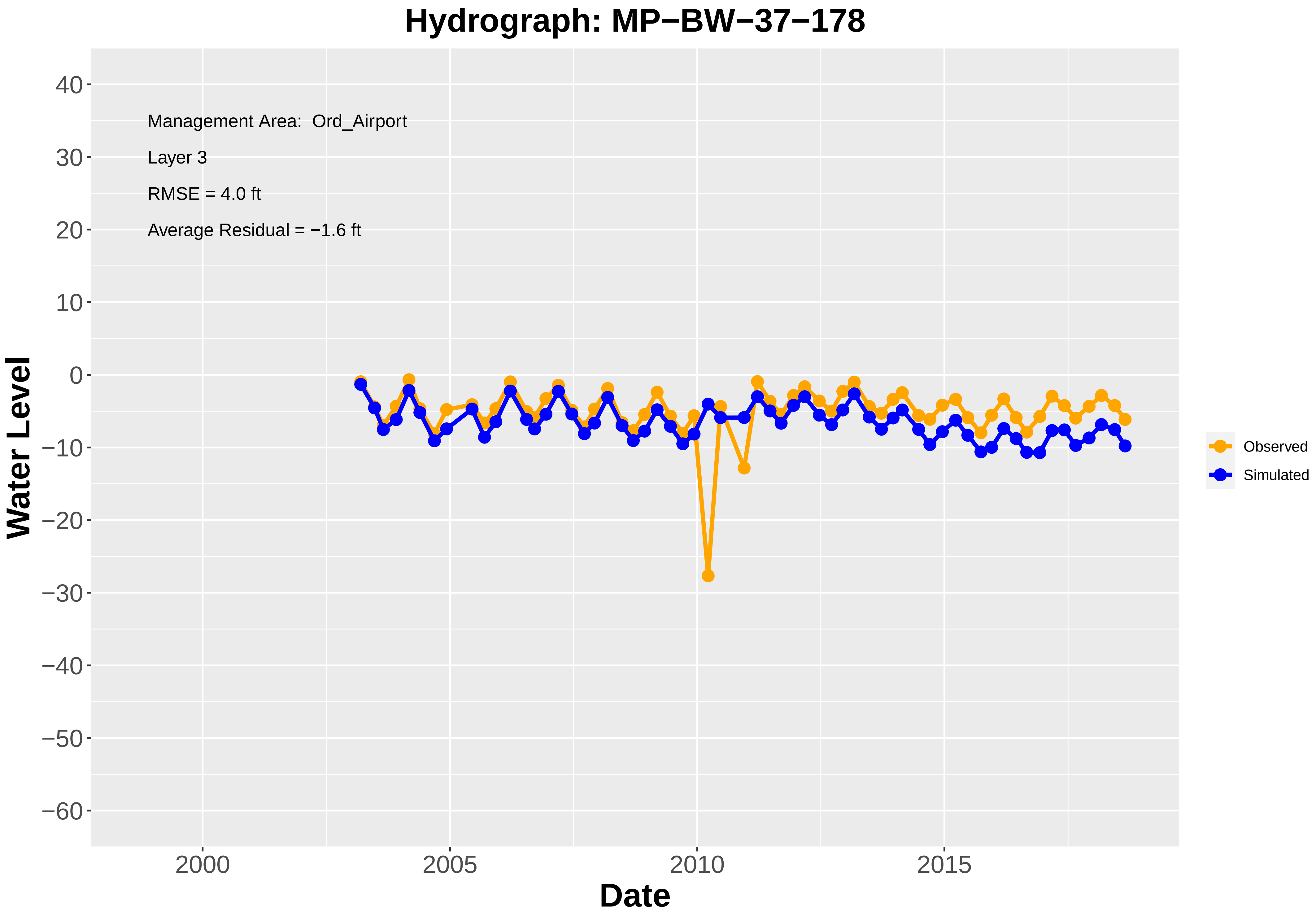

Hydrograph: MP−BW−35−366
Management Area: Ord_Airport
Layer 5
RMSE = 7.7 ft
Average Residual = −7.0 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−35−402
Management Area: Ord_Airport
Layer 5
RMSE = 7.9 ft
Average Residual = −7.2 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

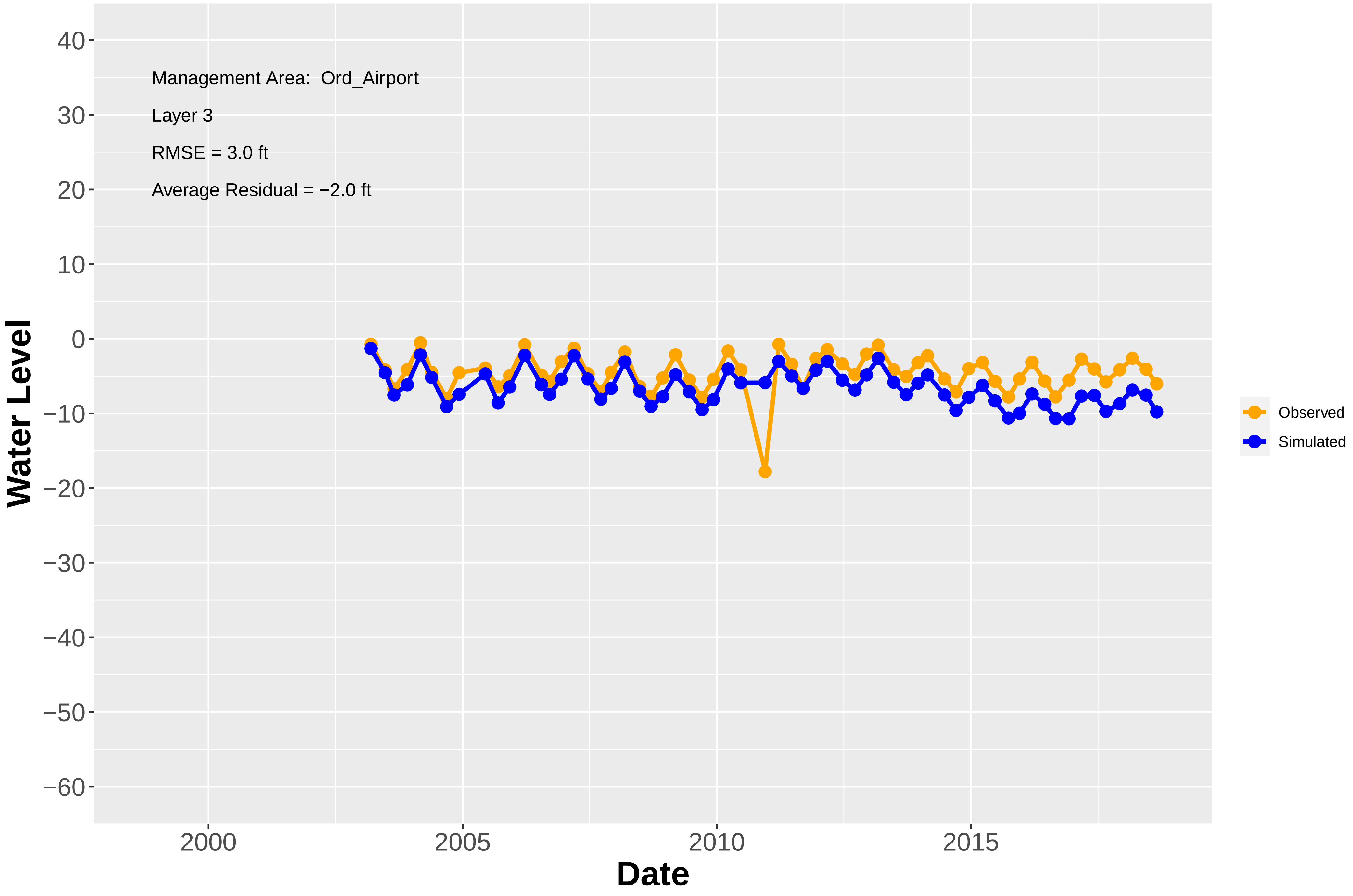

Hydrograph: MP−BW−35−467
Management Area: Ord_Airport
Layer 7
RMSE = 8.1 ft
Average Residual = −7.4 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

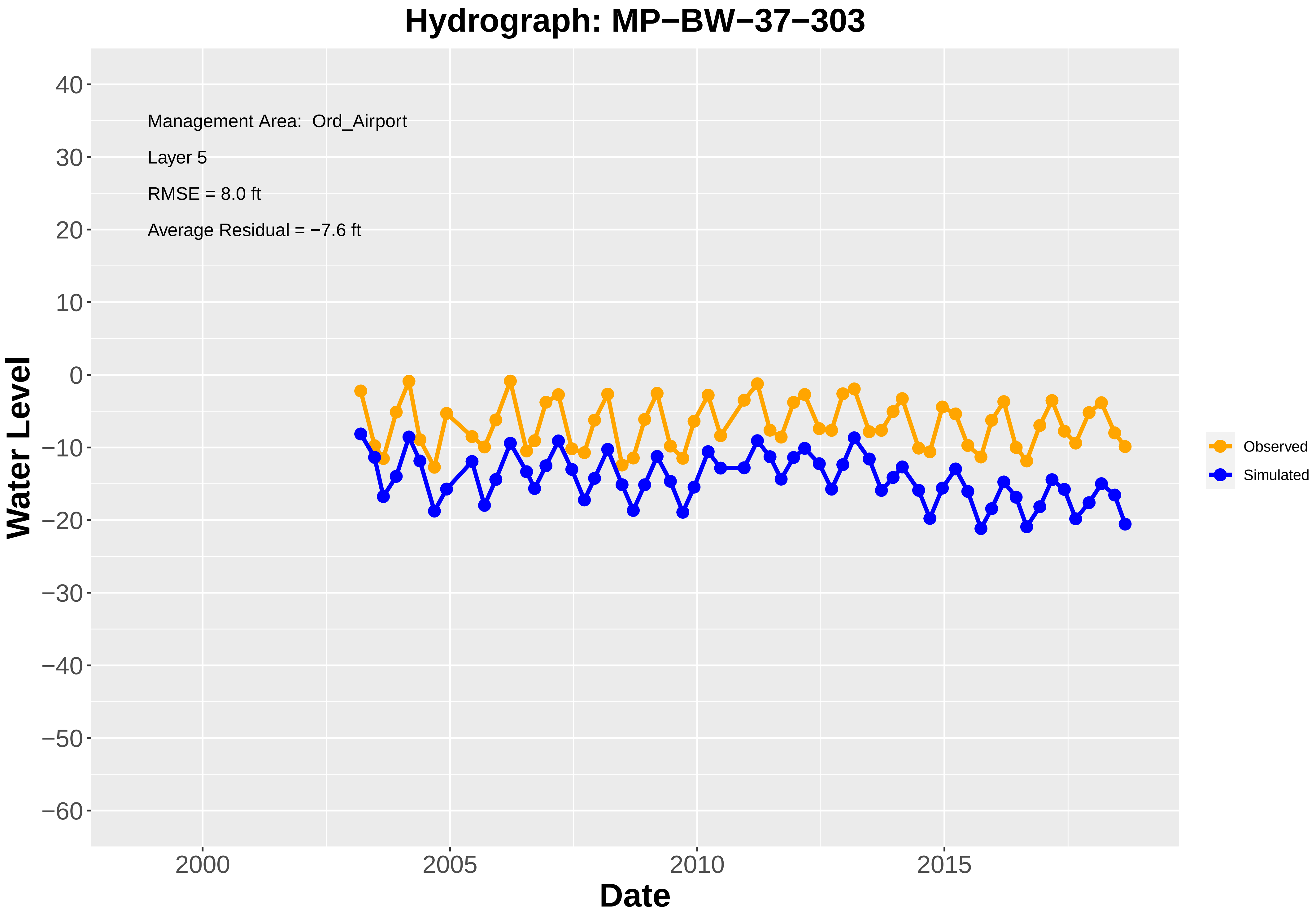
Hydrograph: MP−BW−35−527
Management Area: Ord_Airport
Layer 7
RMSE = 8.2 ft
Average Residual = −7.5 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

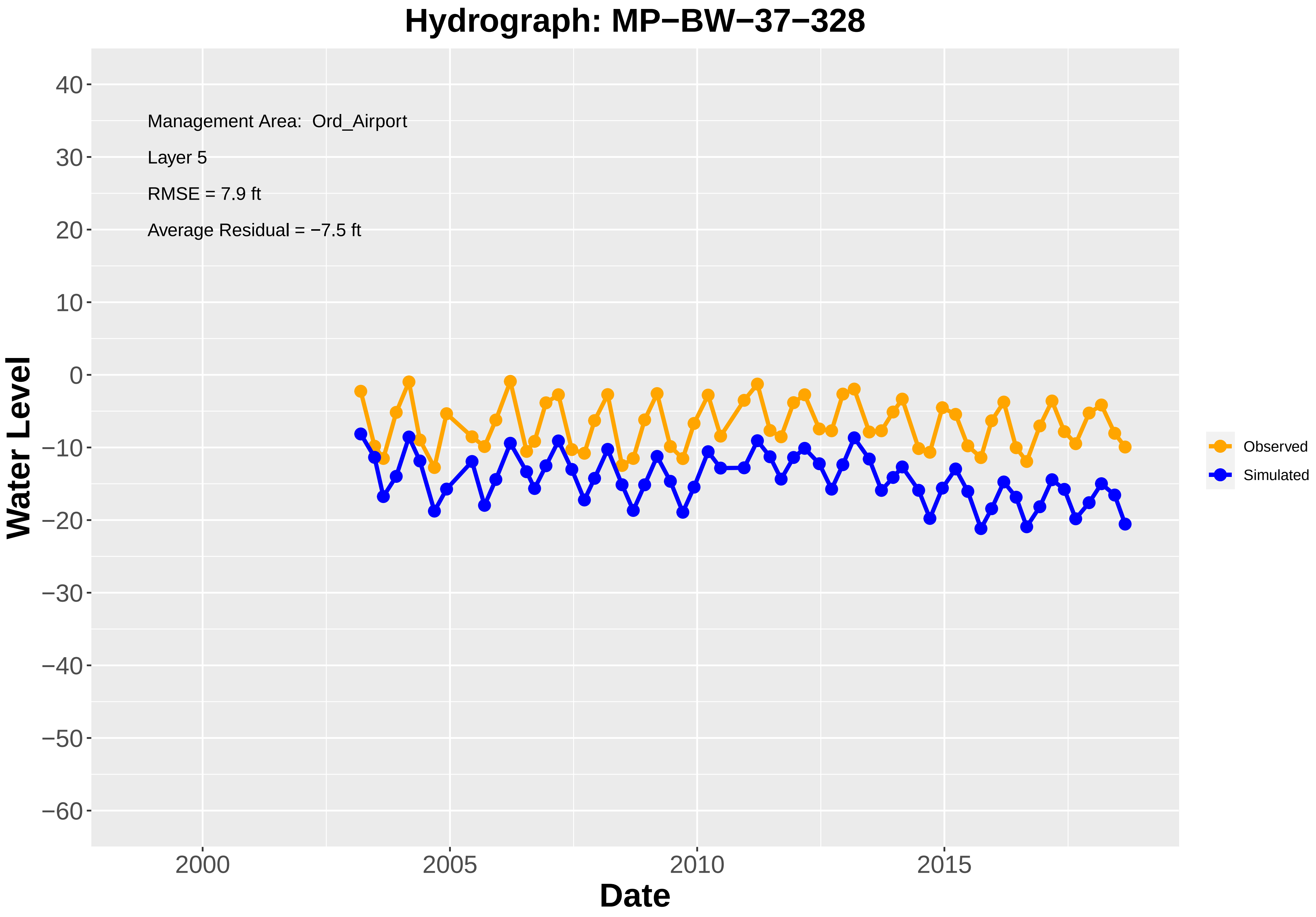

Hydrograph: MP−BW−35−562
Management Area: Ord_Airport
Layer 8
RMSE = 8.0 ft
Average Residual = −6.5 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−37−178
Management Area: Ord_Airport
Layer 3
RMSE = 4.0 ft
Average Residual = −1.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

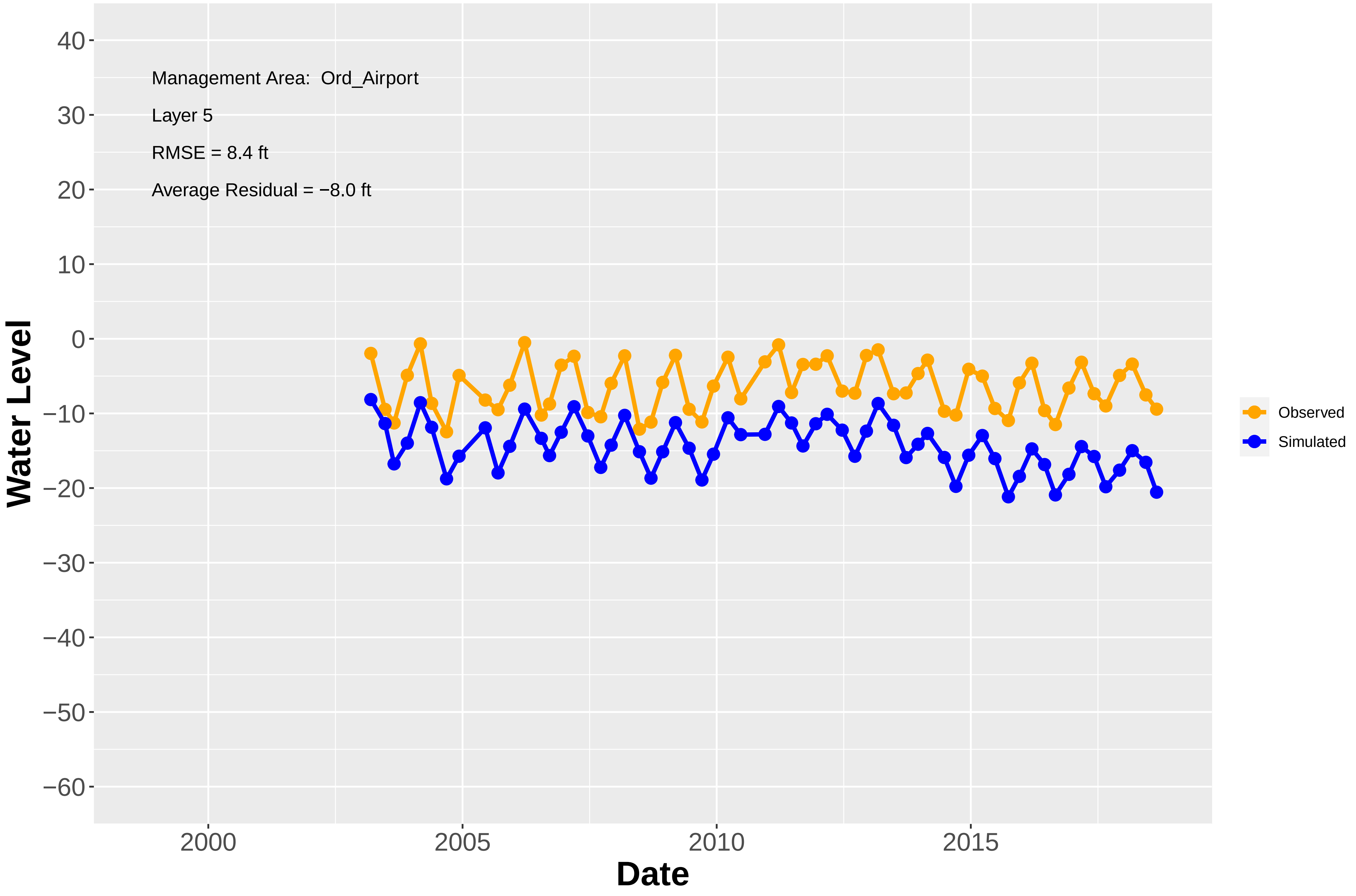
Hydrograph: MP−BW−37−193

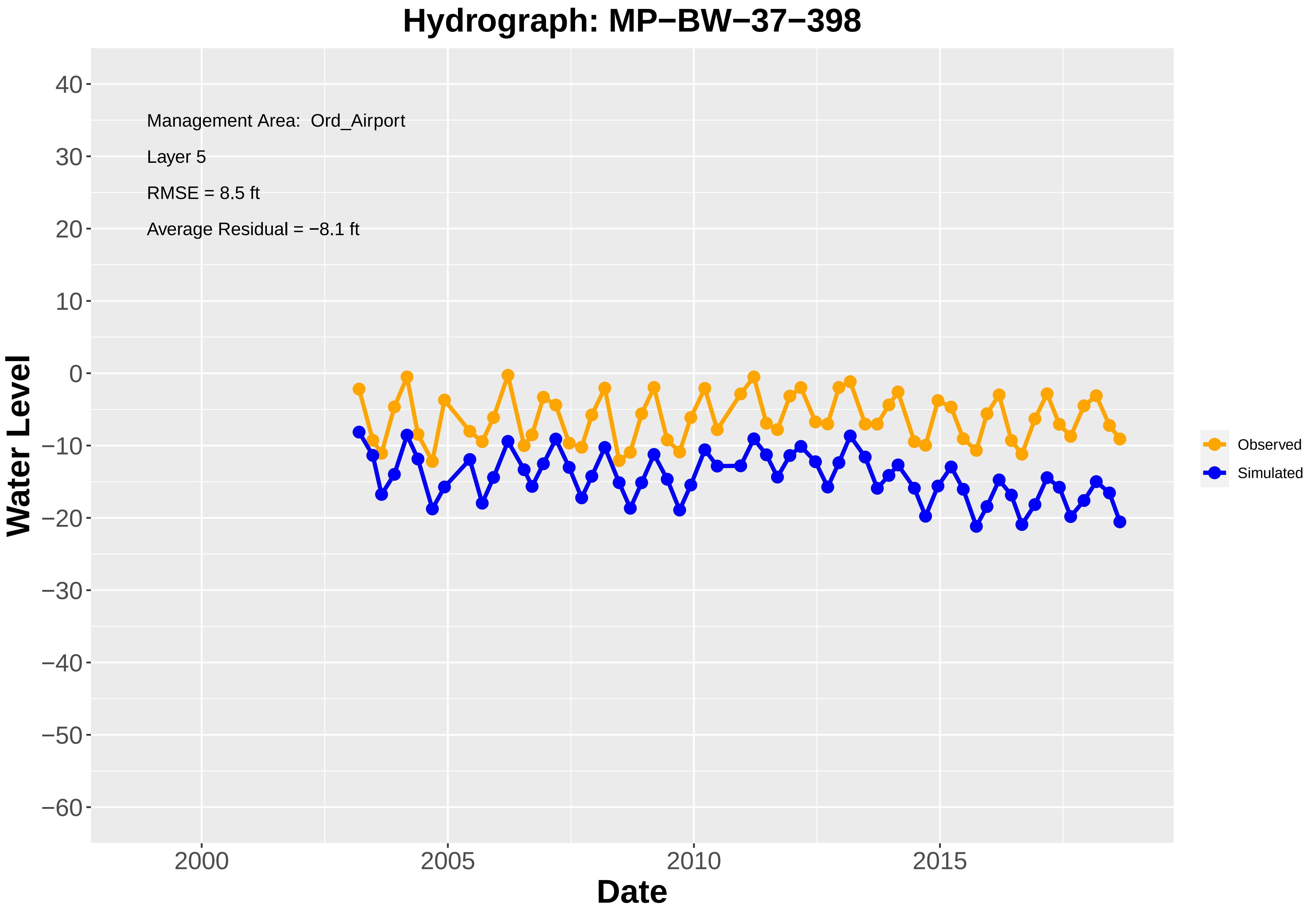



Hydrograph: MP−BW−37−303
Management Area: Ord_Airport
Layer 5
RMSE = 8.0 ft
Average Residual = −7.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

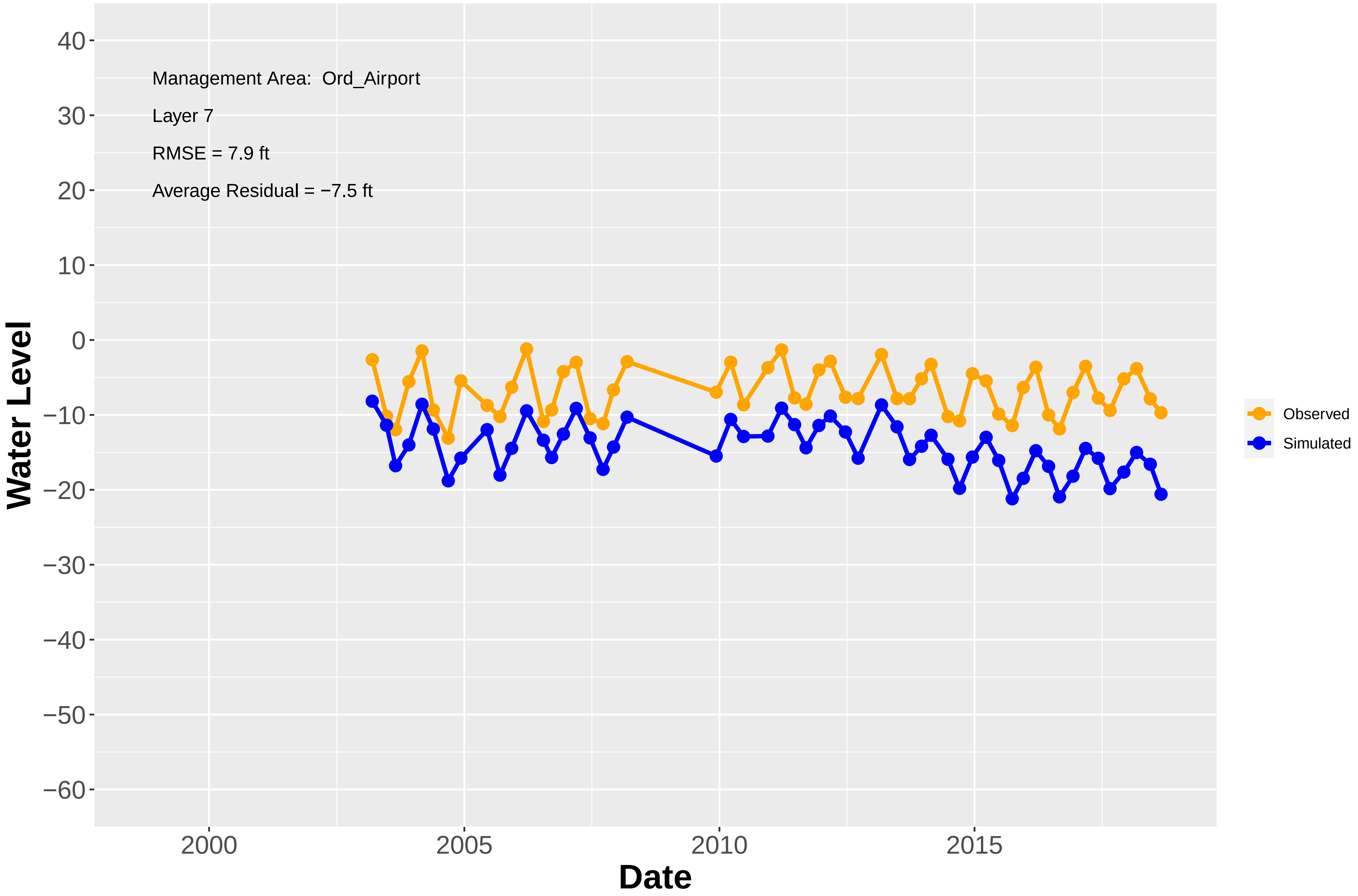

Hydrograph: MP−BW−37−328
Management Area: Ord_Airport
Layer 5
RMSE = 7.9 ft
Average Residual = −7.5 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

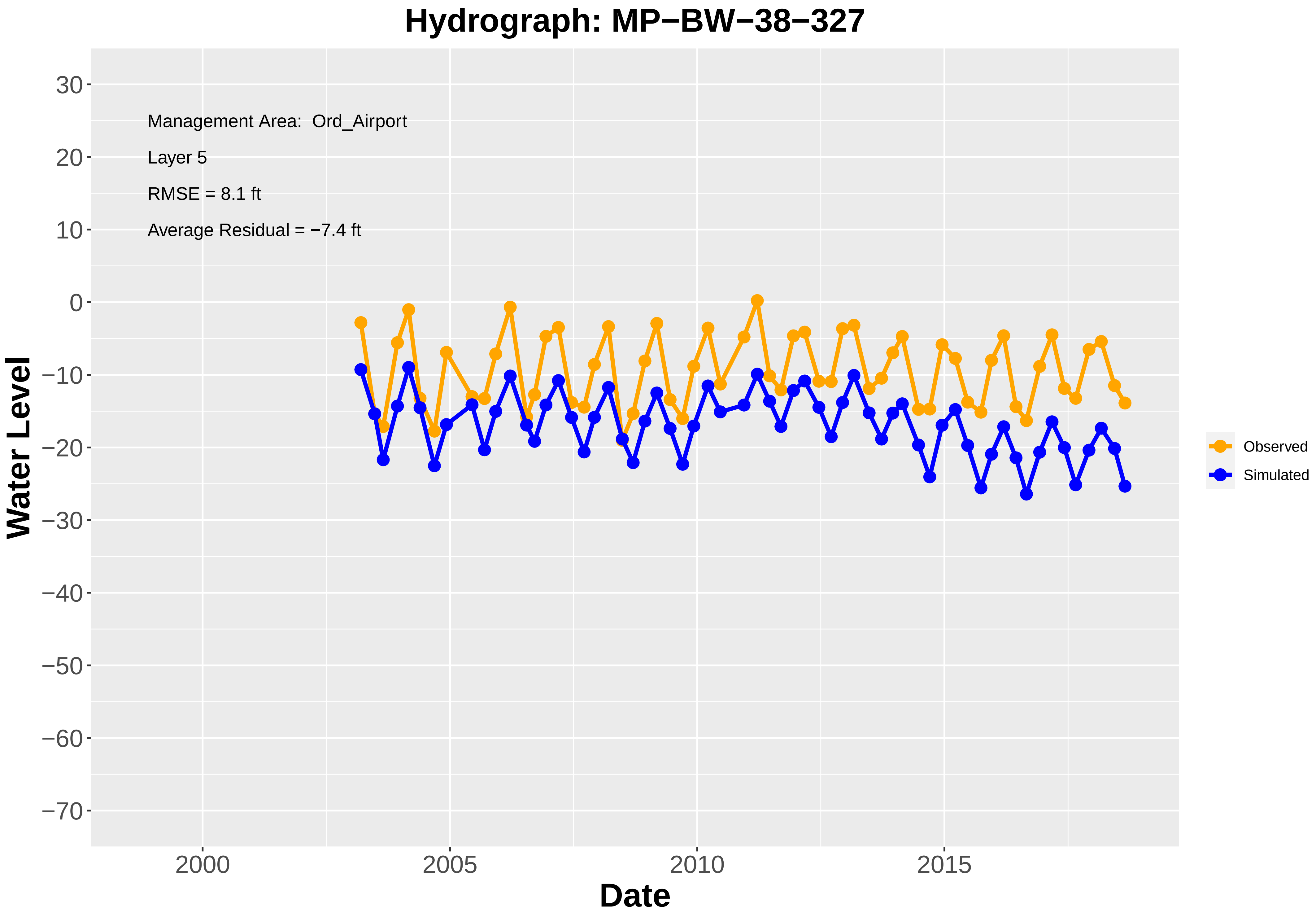
Hydrograph: MP−BW−37−368

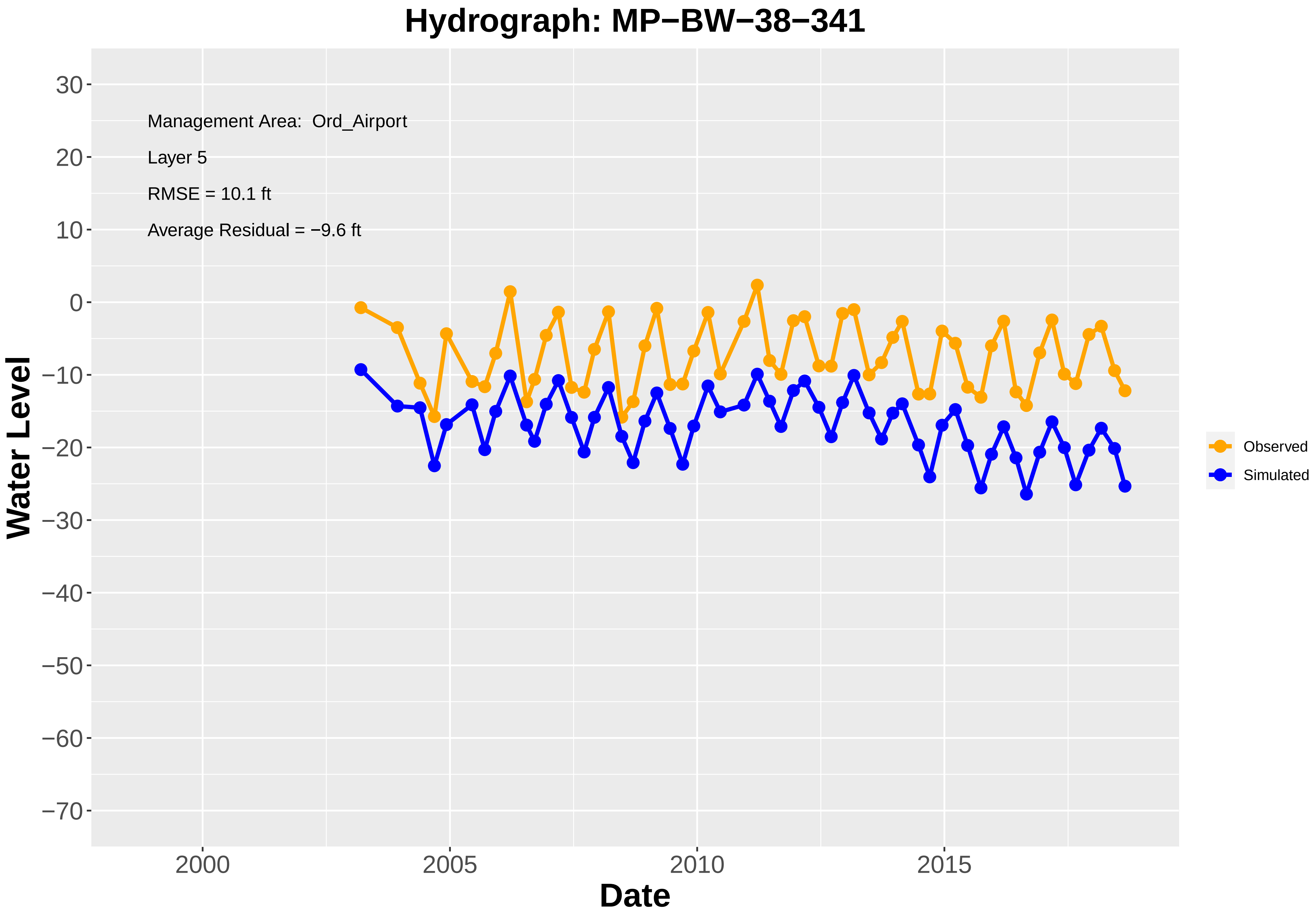


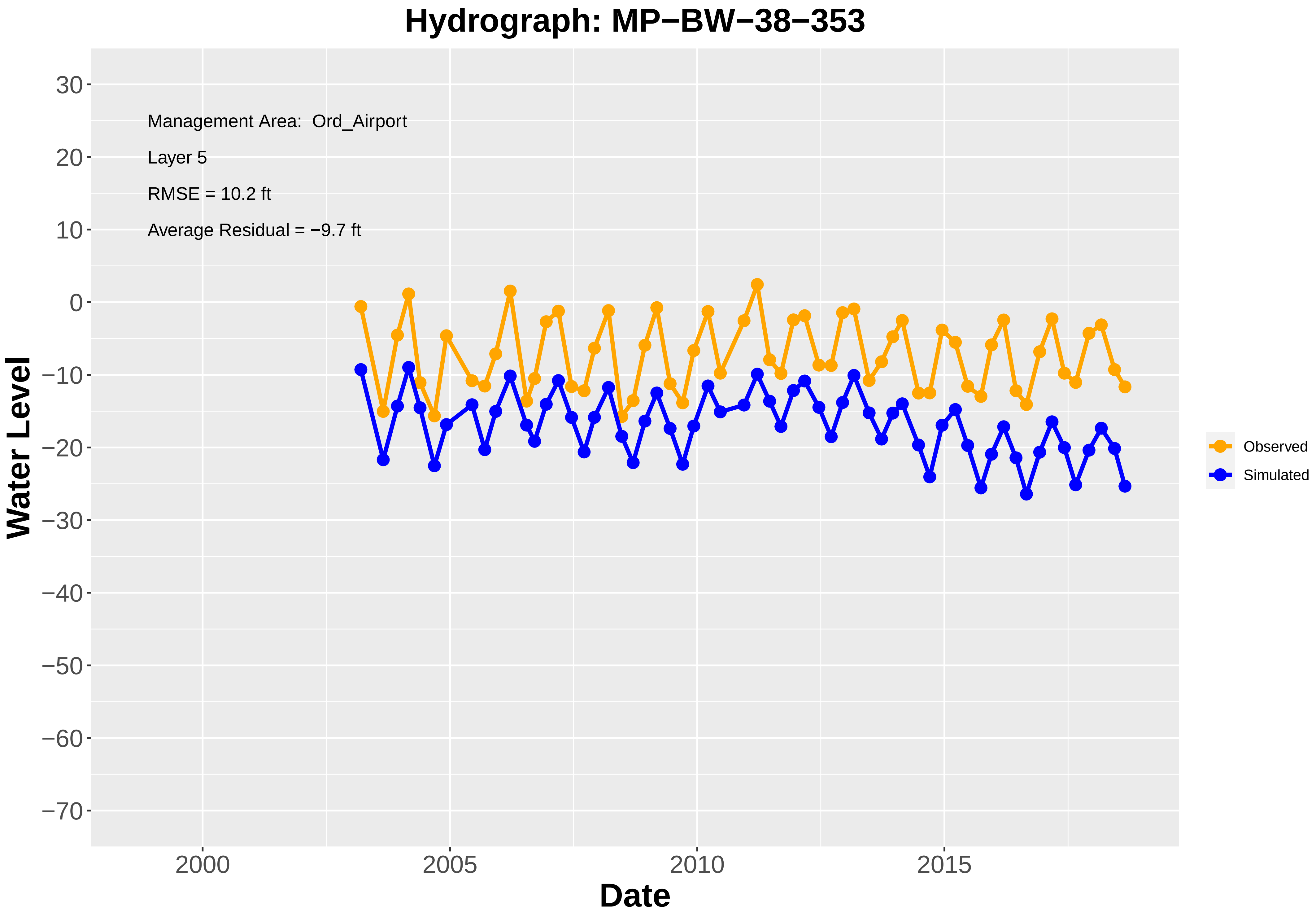

Hydrograph: MP−BW−37−398
Management Area: Ord_Airport
Layer 5
RMSE = 8.5 ft
Average Residual = −8.1 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

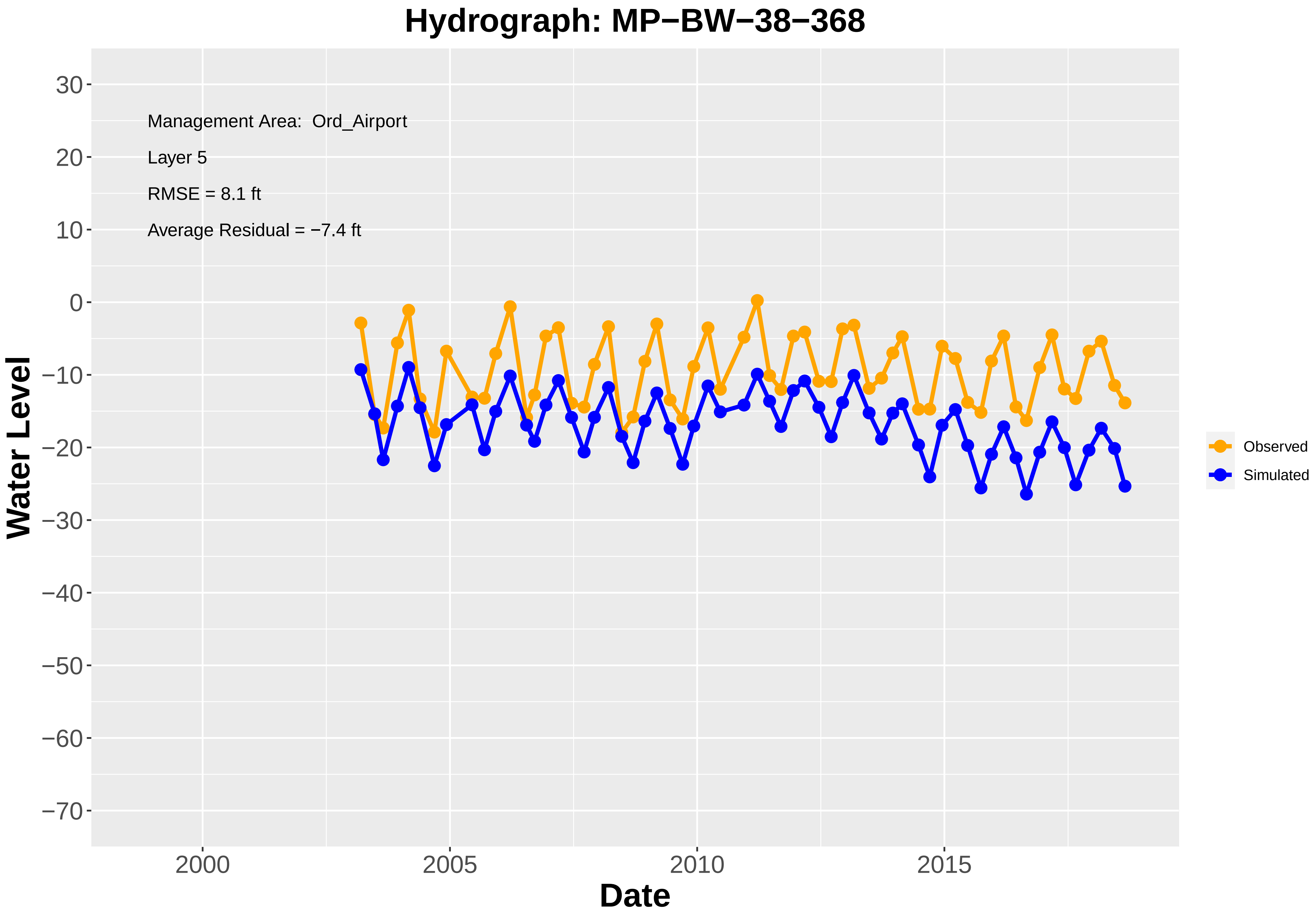
Hydrograph: MP−BW−37−460

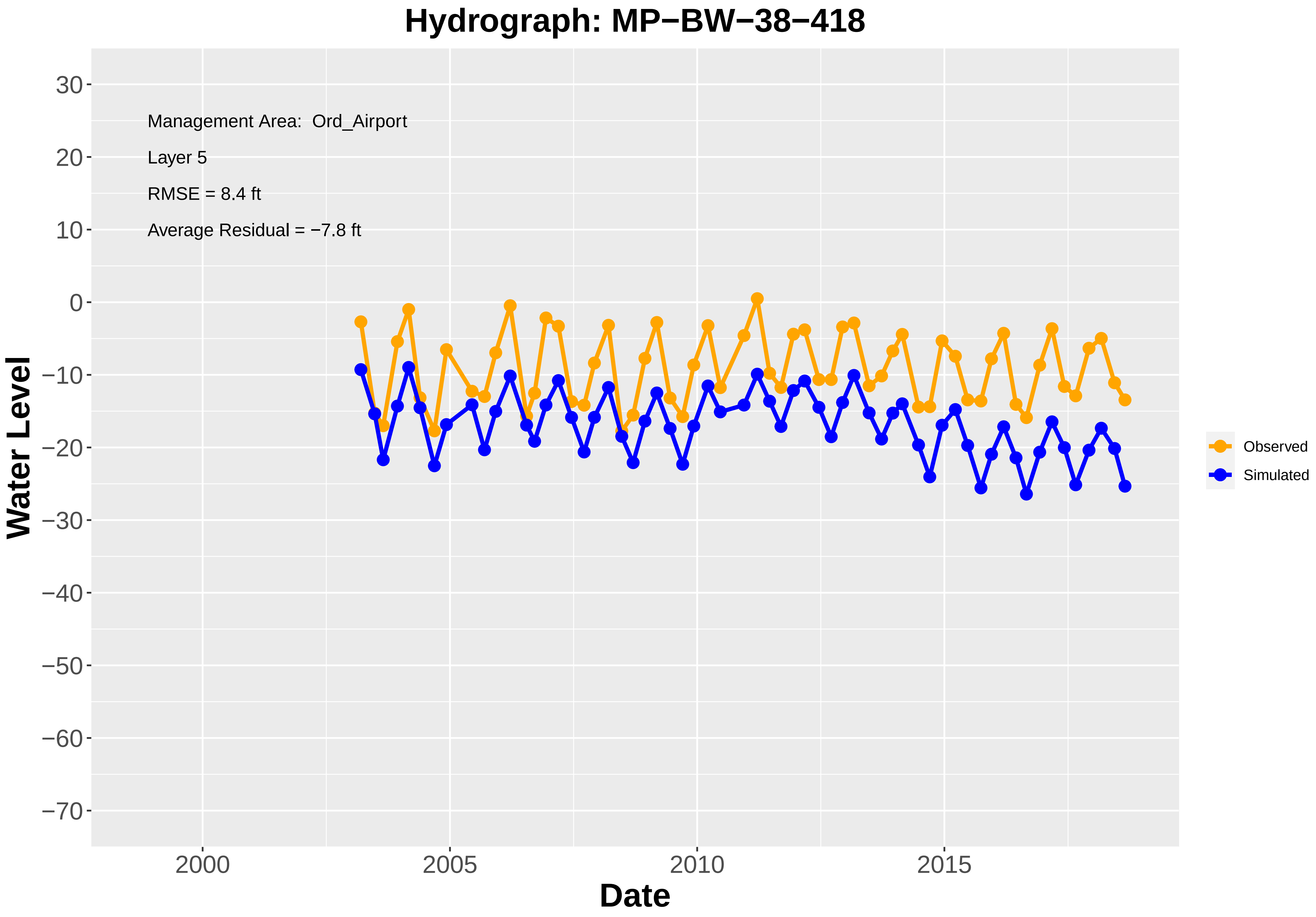


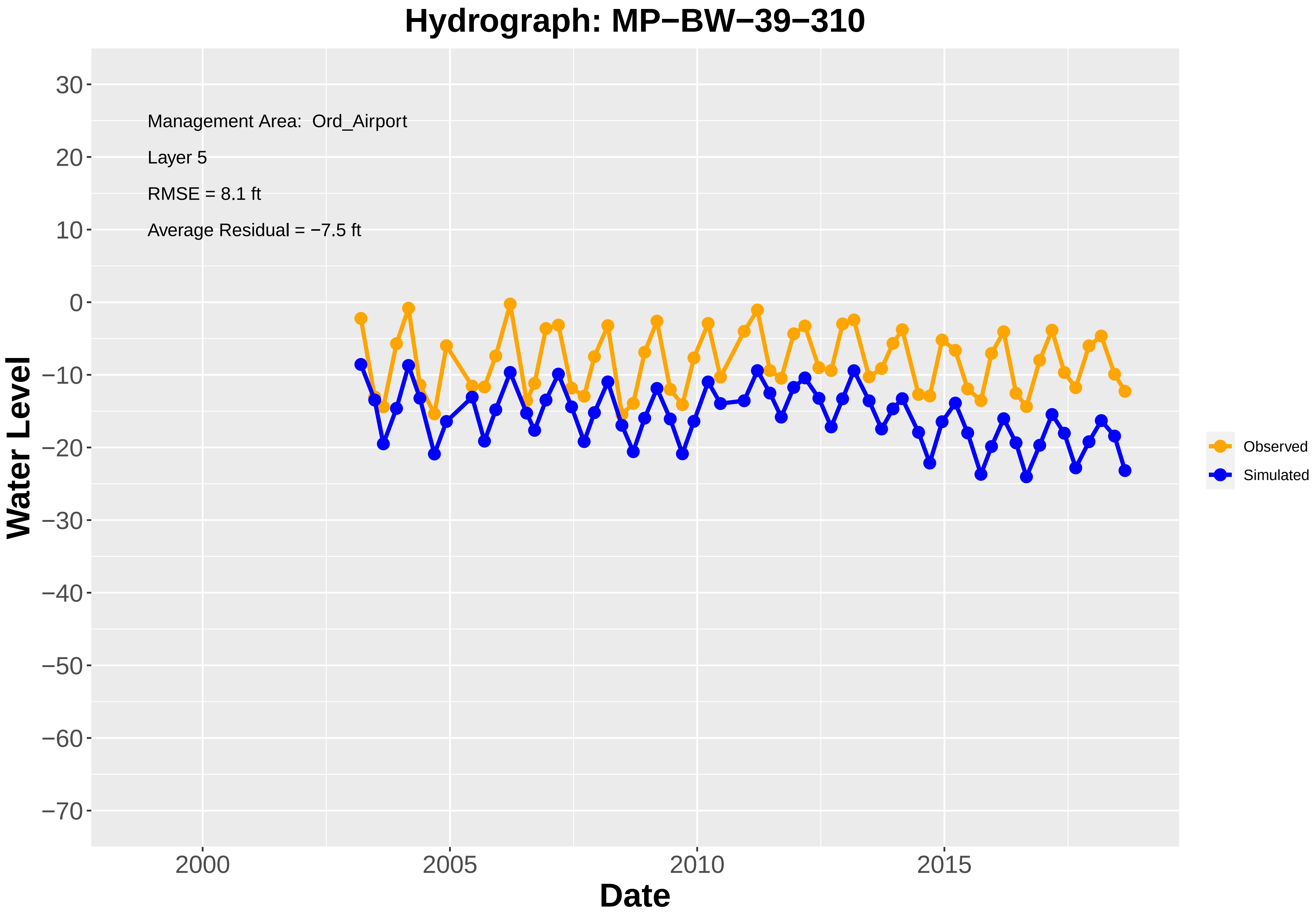

Hydrograph: MP−BW−38−327
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.4 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

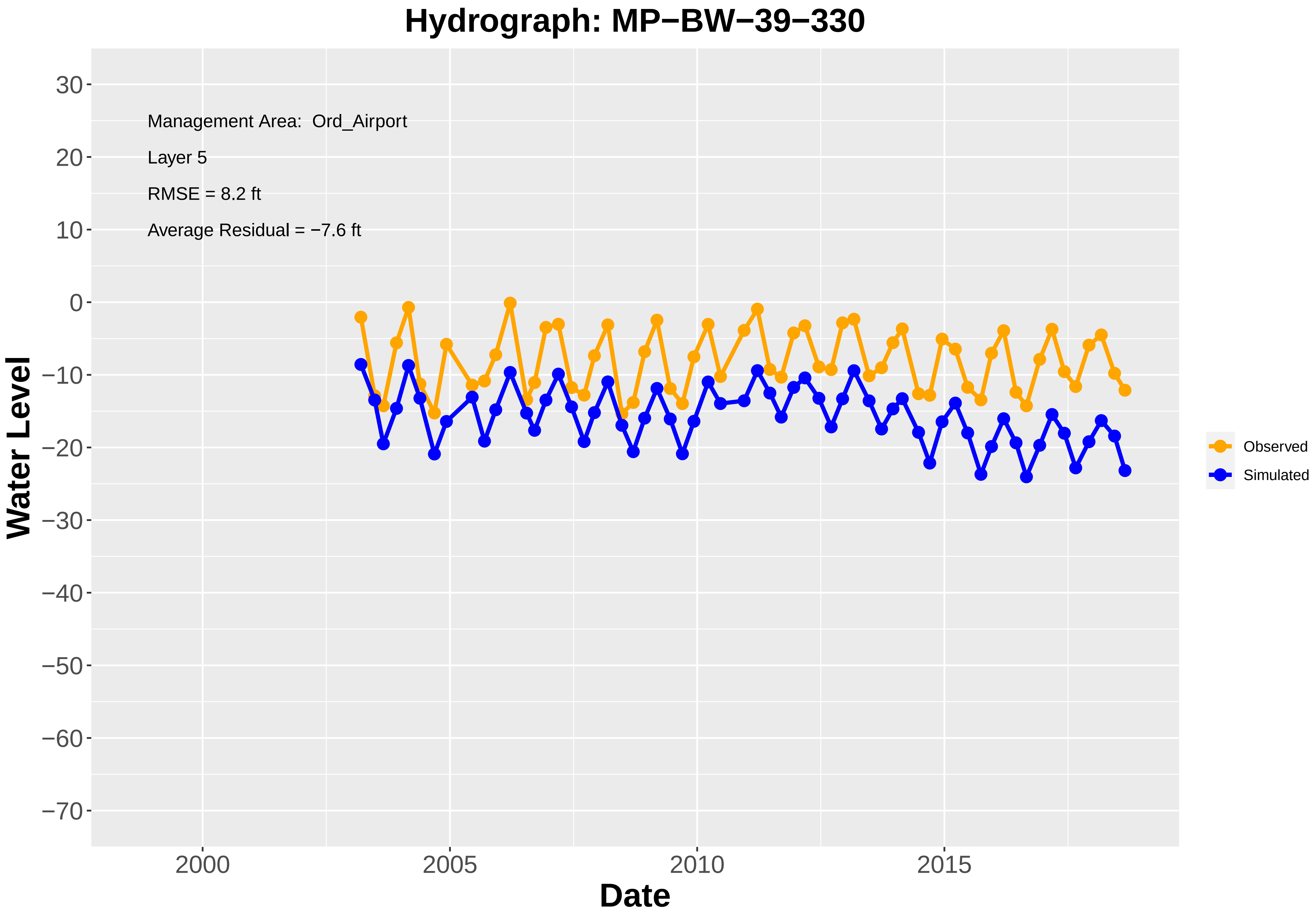

Hydrograph: MP−BW−38−341
Management Area: Ord_Airport
Layer 5
RMSE = 10.1 ft
Average Residual = −9.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

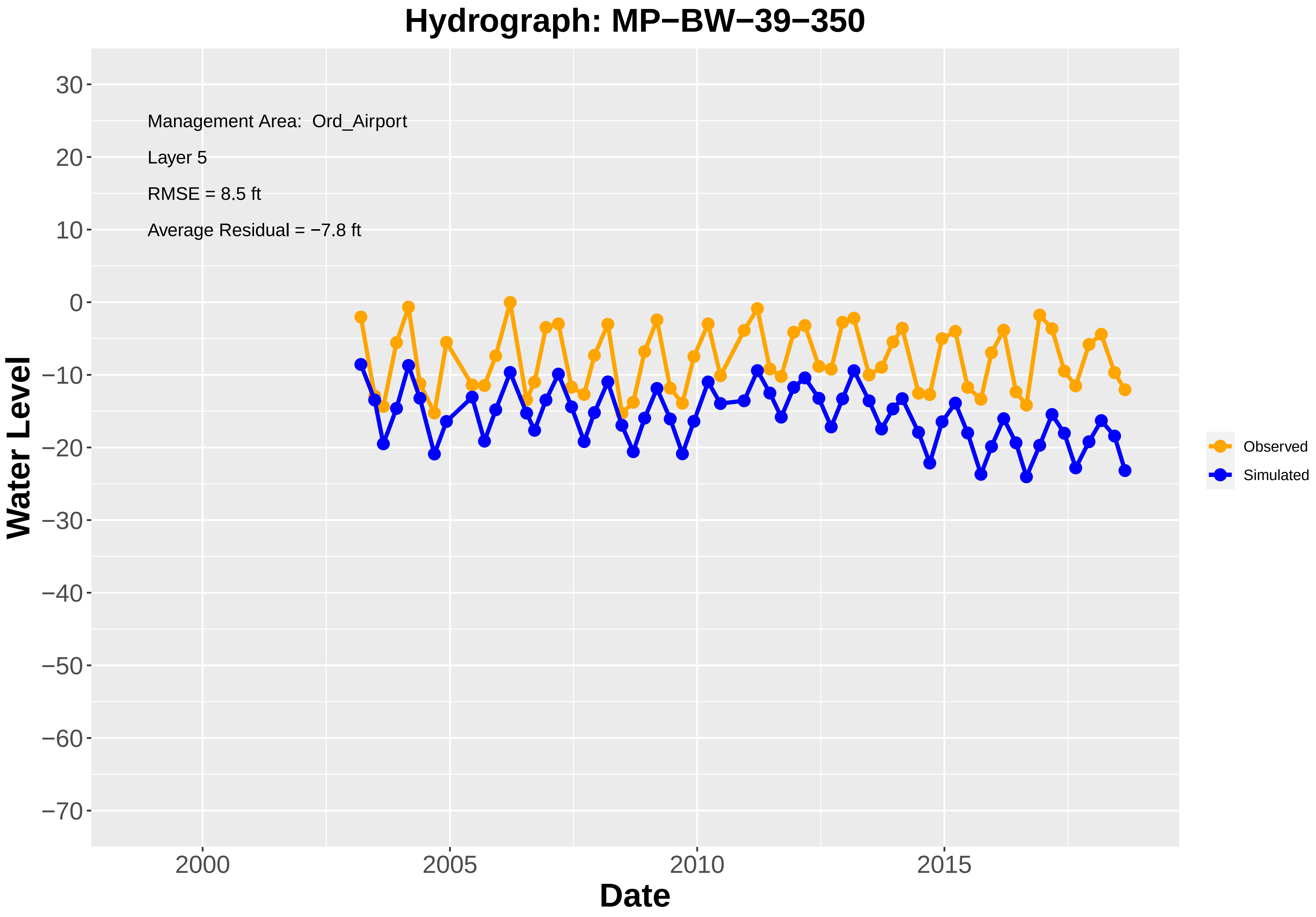

Hydrograph: MP−BW−38−353
Management Area: Ord_Airport
Layer 5
RMSE = 10.2 ft
Average Residual = −9.7 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

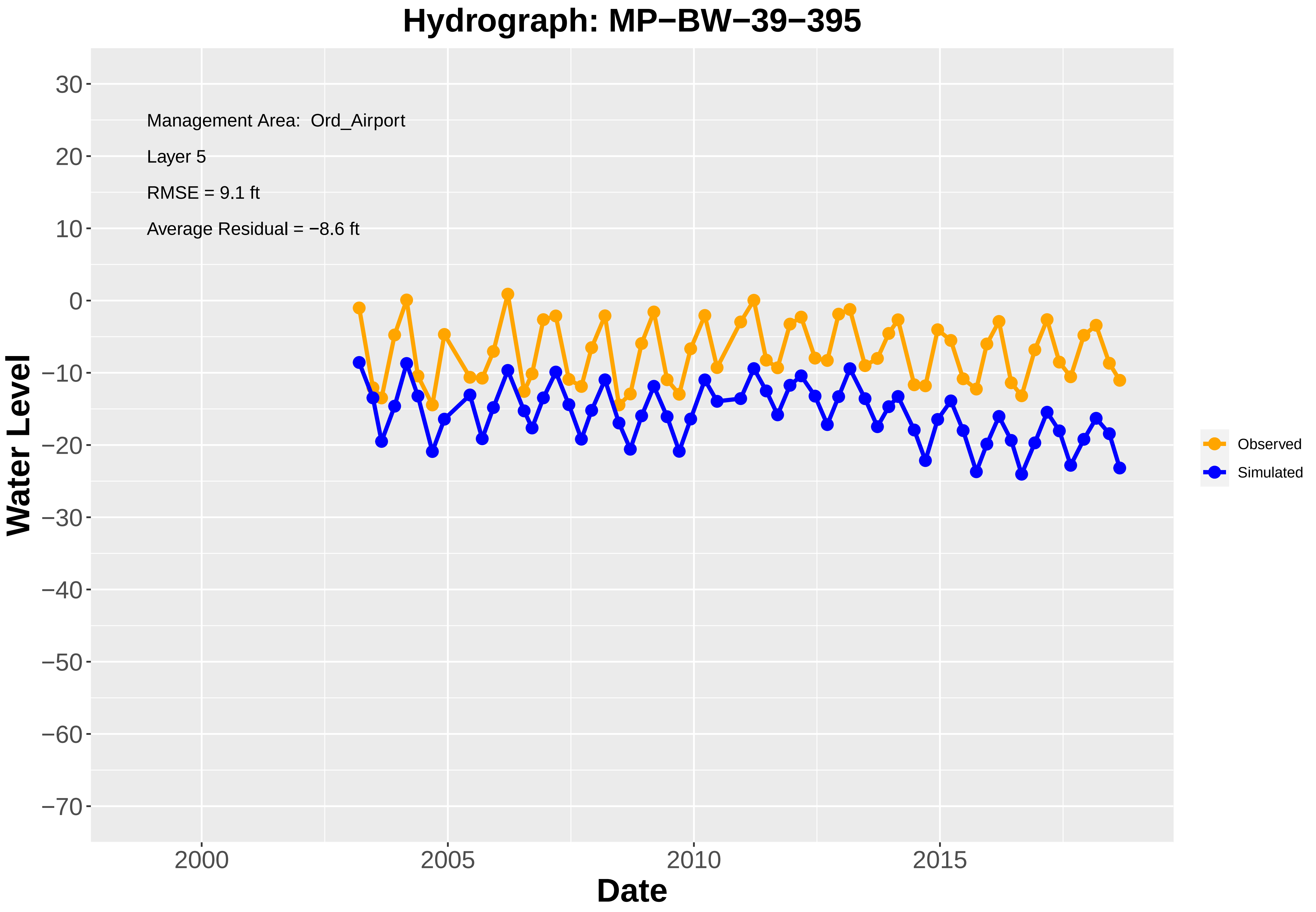

Hydrograph: MP−BW−38−368
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.4 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−38−418
Management Area: Ord_Airport
Layer 5
RMSE = 8.4 ft
Average Residual = −7.8 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

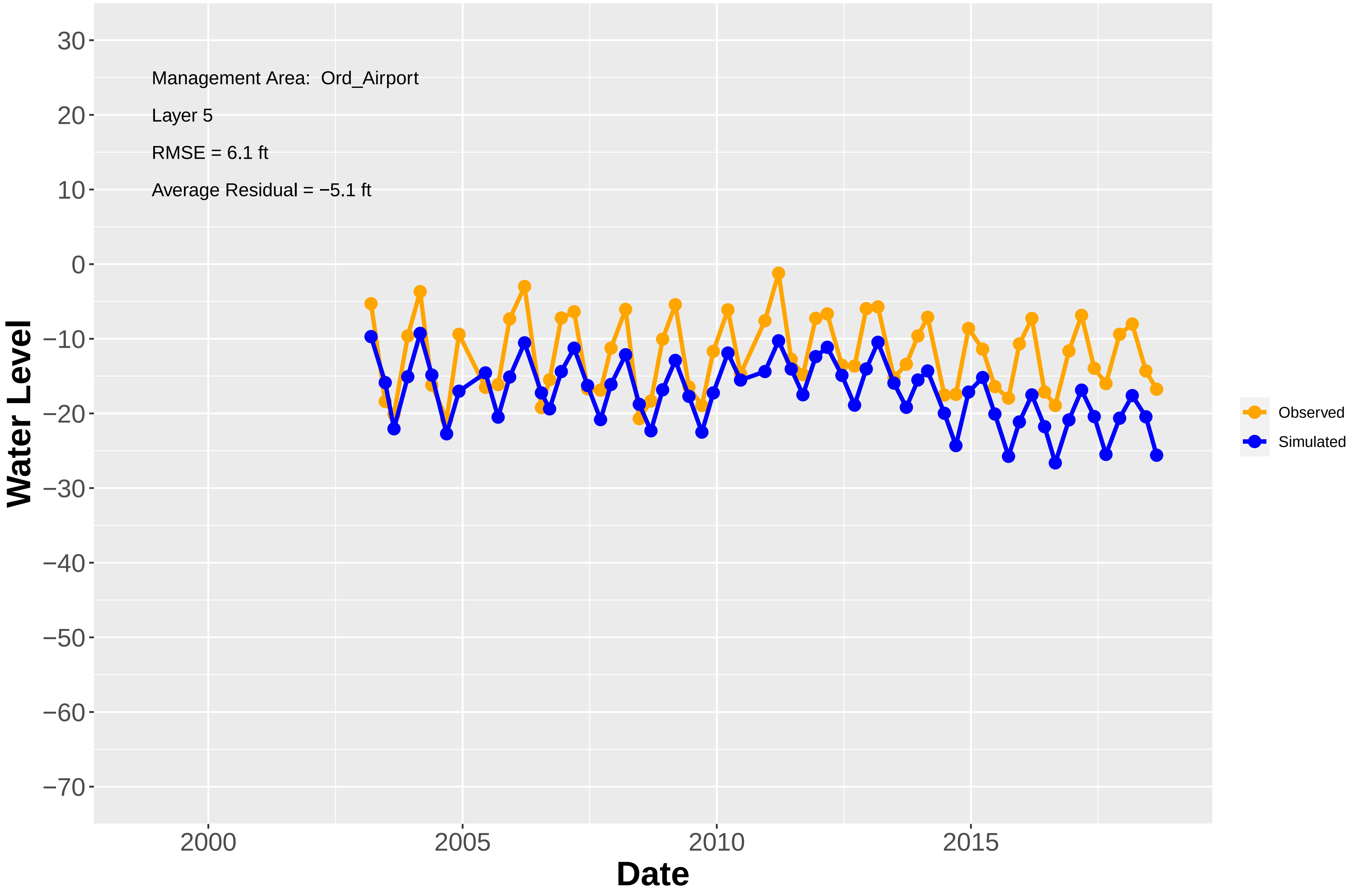

Hydrograph: MP−BW−39−310
Management Area: Ord_Airport
Layer 5
RMSE = 8.1 ft
Average Residual = −7.5 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−39−330
Management Area: Ord_Airport
Layer 5
RMSE = 8.2 ft
Average Residual = −7.6 ft
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

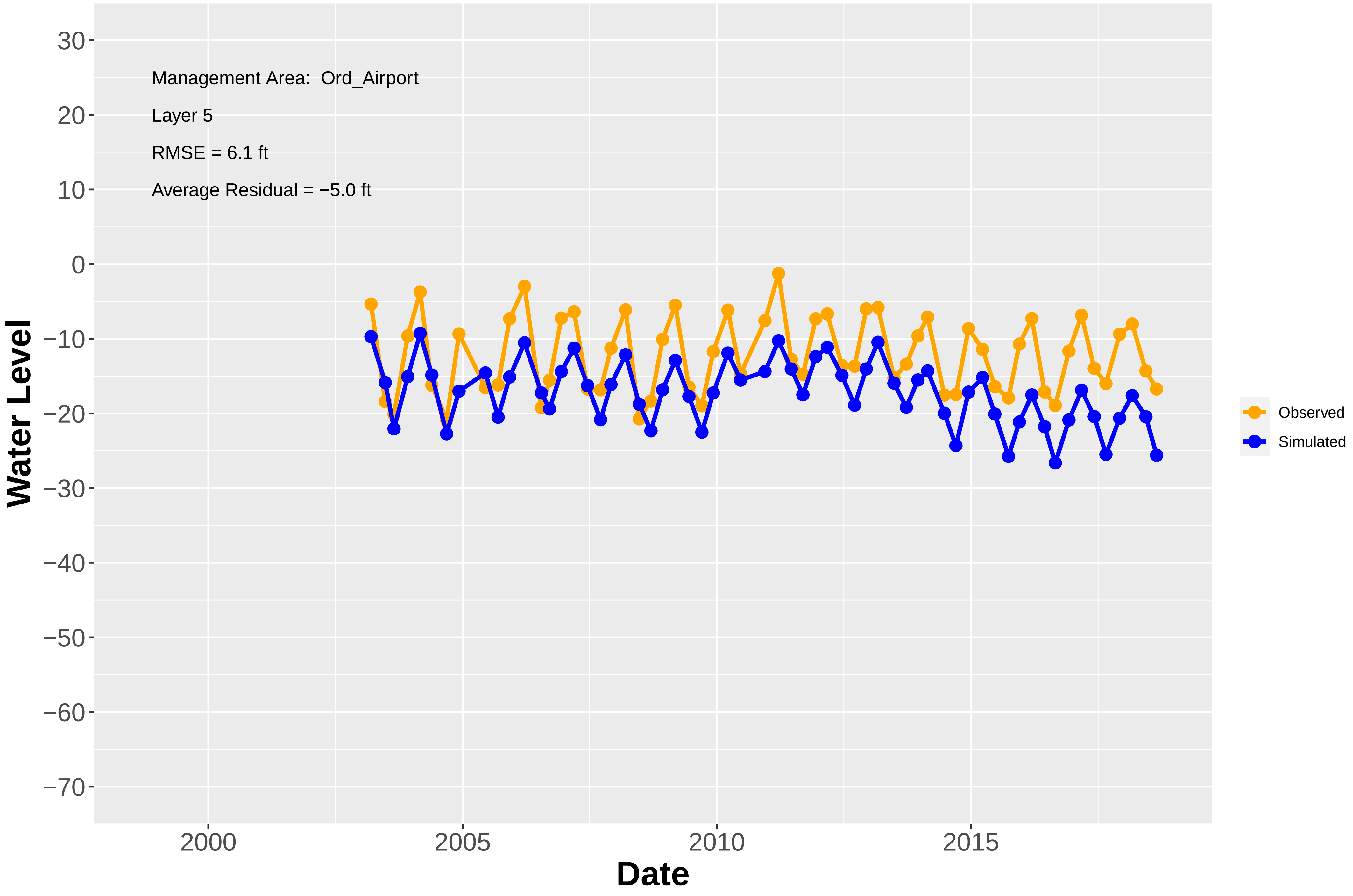

Hydrograph: MP−BW−39−350
Management Area: Ord_Airport
Layer 5
RMSE = 8.5 ft
Average Residual = −7.8 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

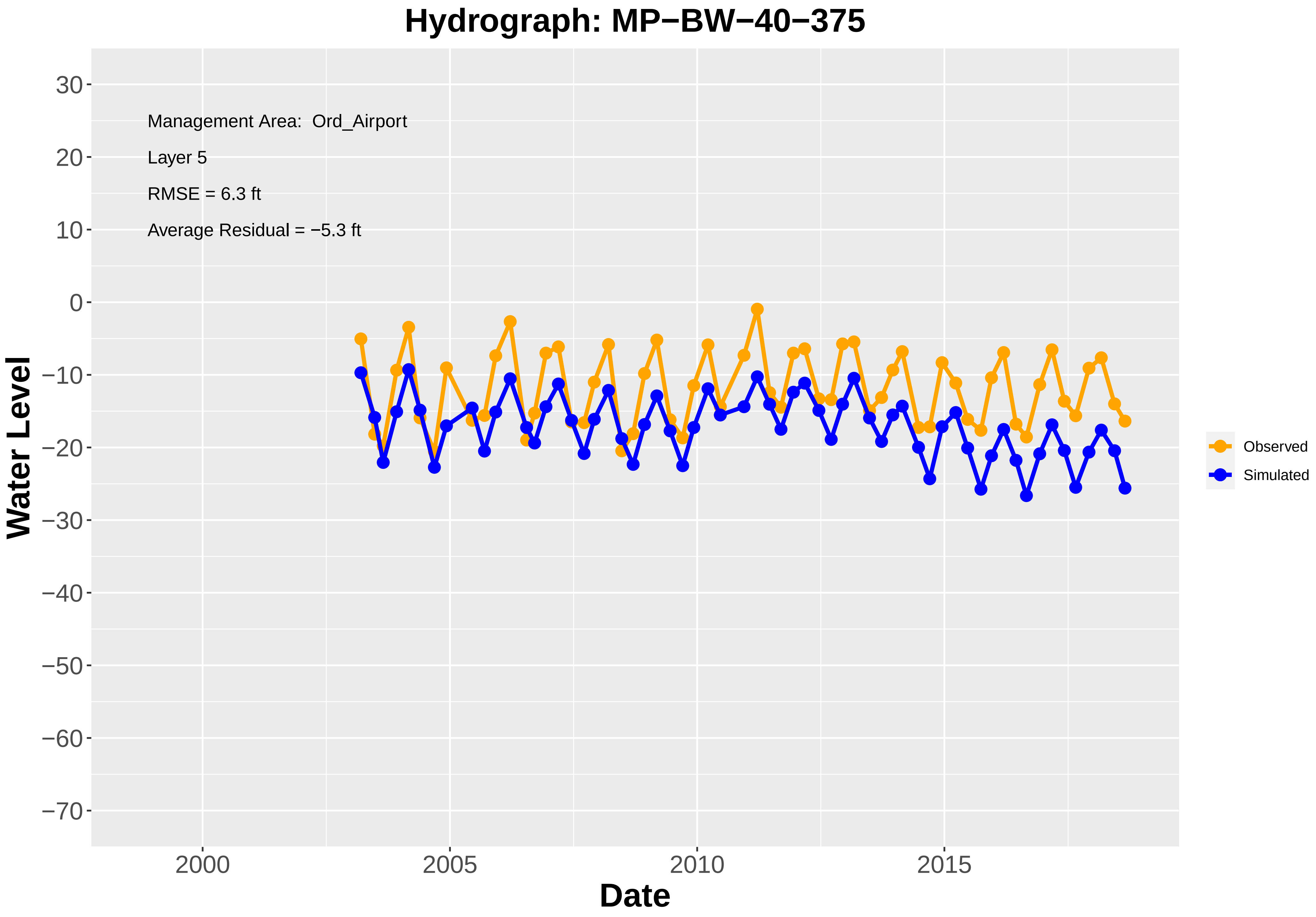

Hydrograph: MP−BW−39−395
Management Area: Ord_Airport
Layer 5
RMSE = 9.1 ft
Average Residual = −8.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

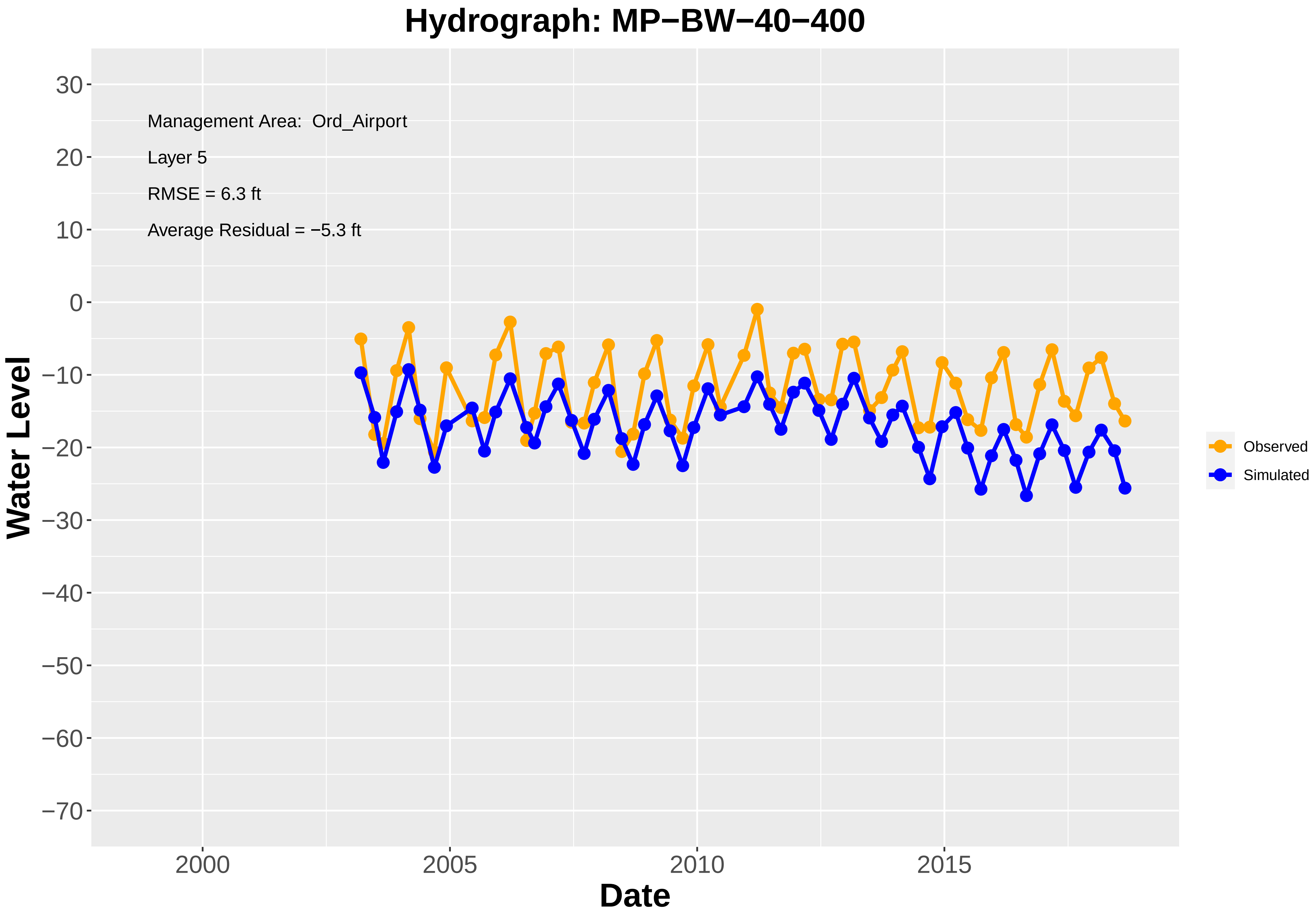
Hydrograph: MP−BW−40−333

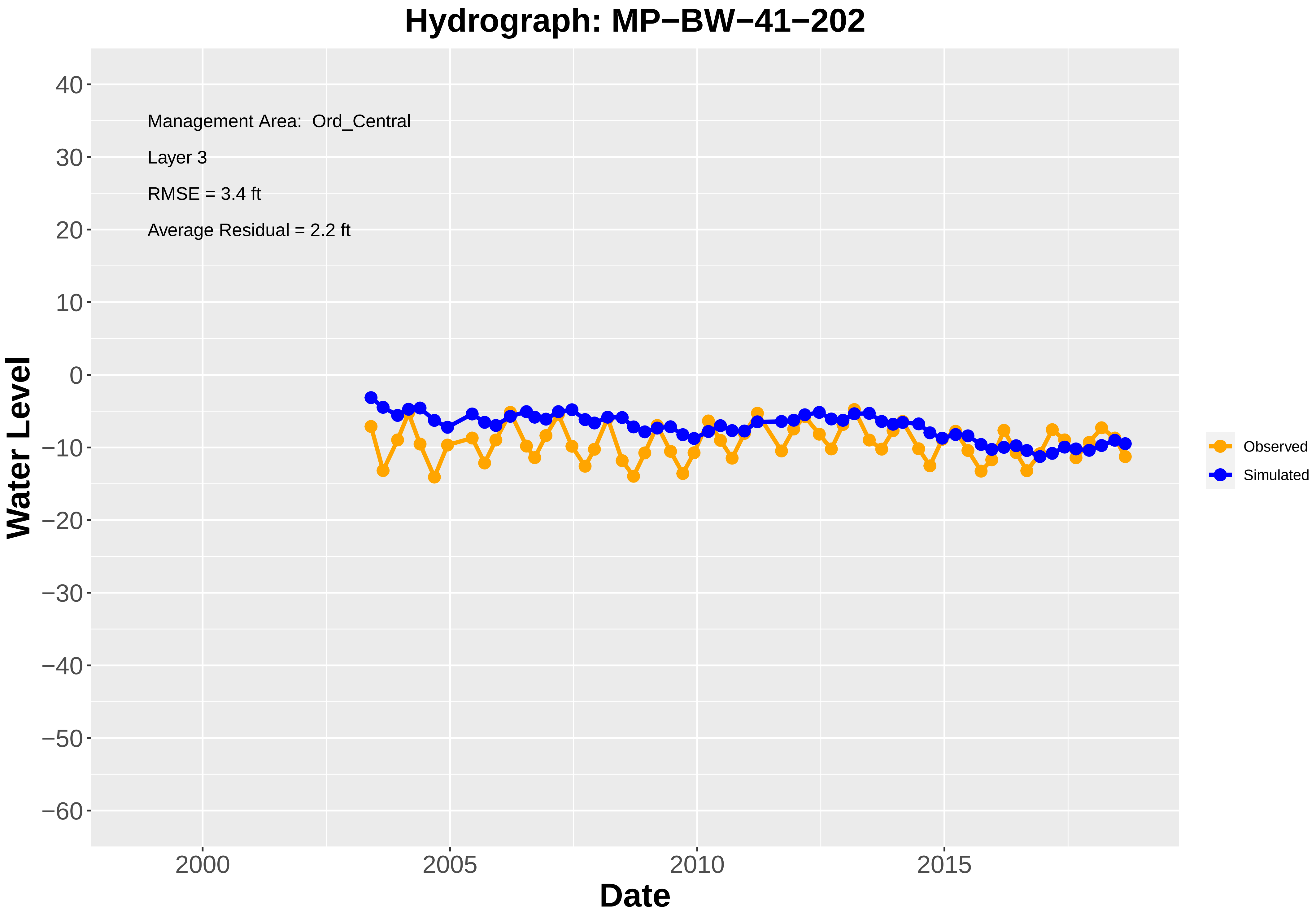


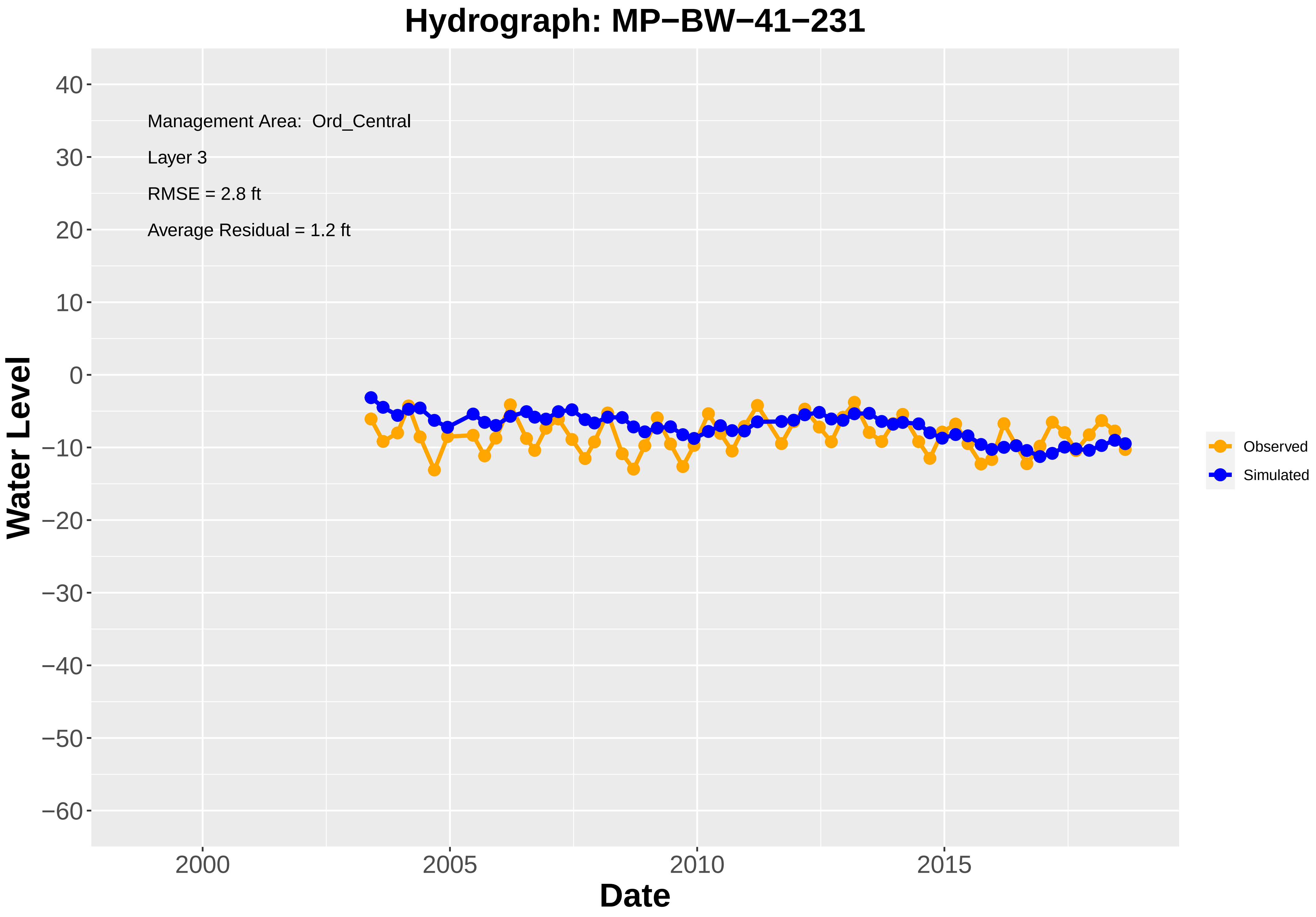
Hydrograph: MP−BW−40−353



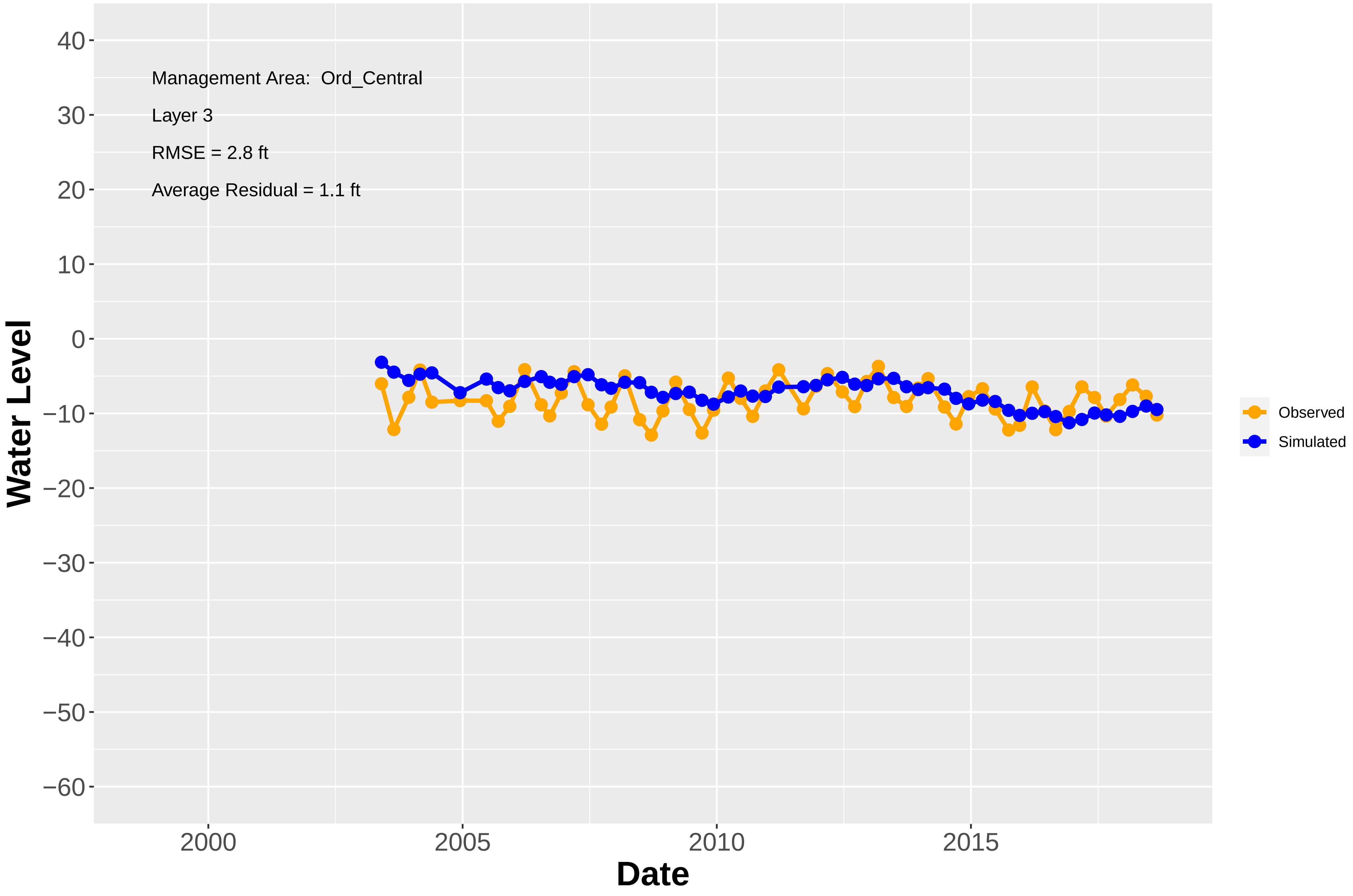

Hydrograph: MP−BW−40−375
Management Area: Ord_Airport
Layer 5
RMSE = 6.3 ft
Average Residual = −5.3 ft
Water Level
Date
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Observed
Simulated

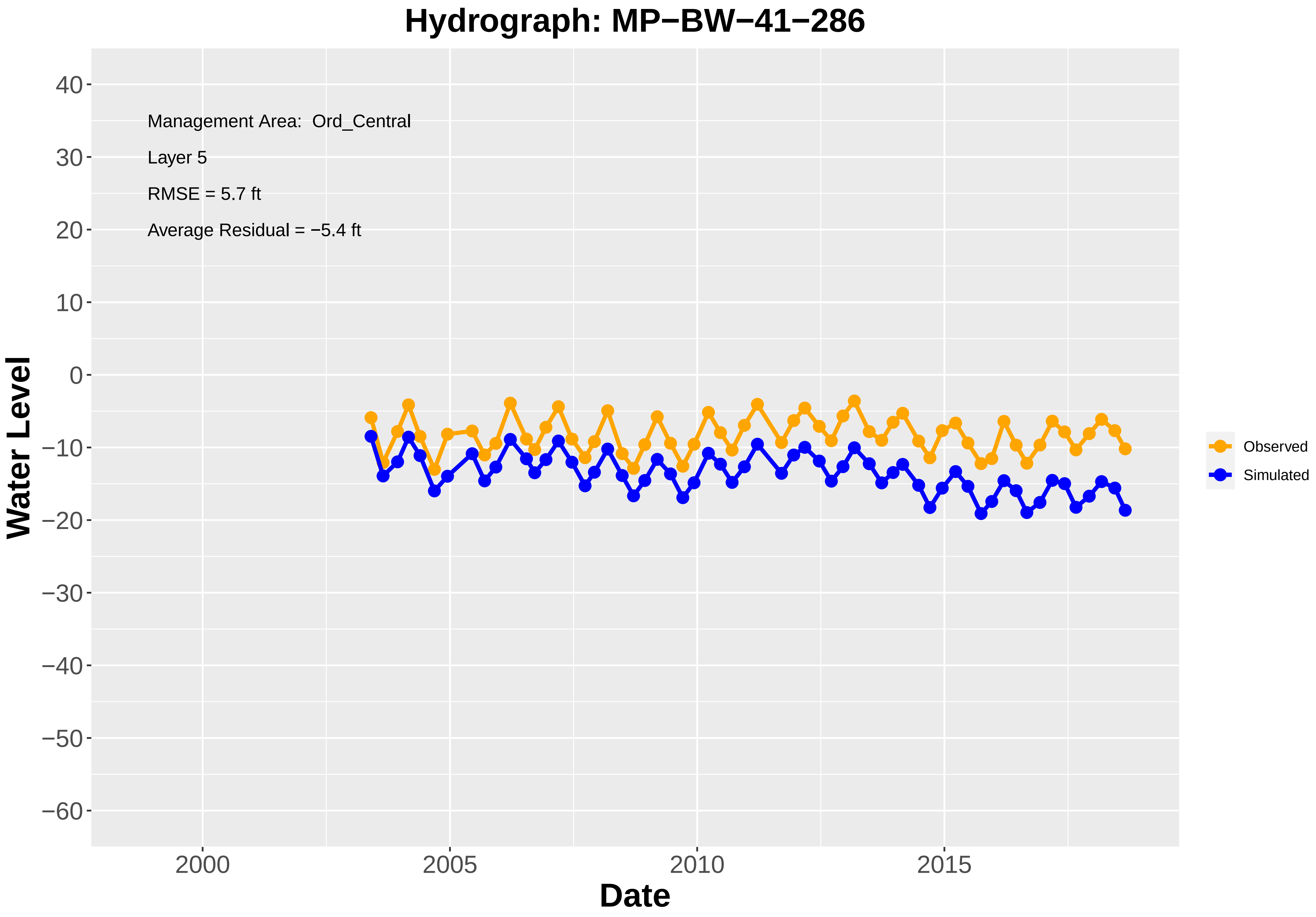

Hydrograph: MP−BW−40−400
Management Area: Ord_Airport
Layer 5
RMSE = 6.3 ft
Average Residual = −5.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

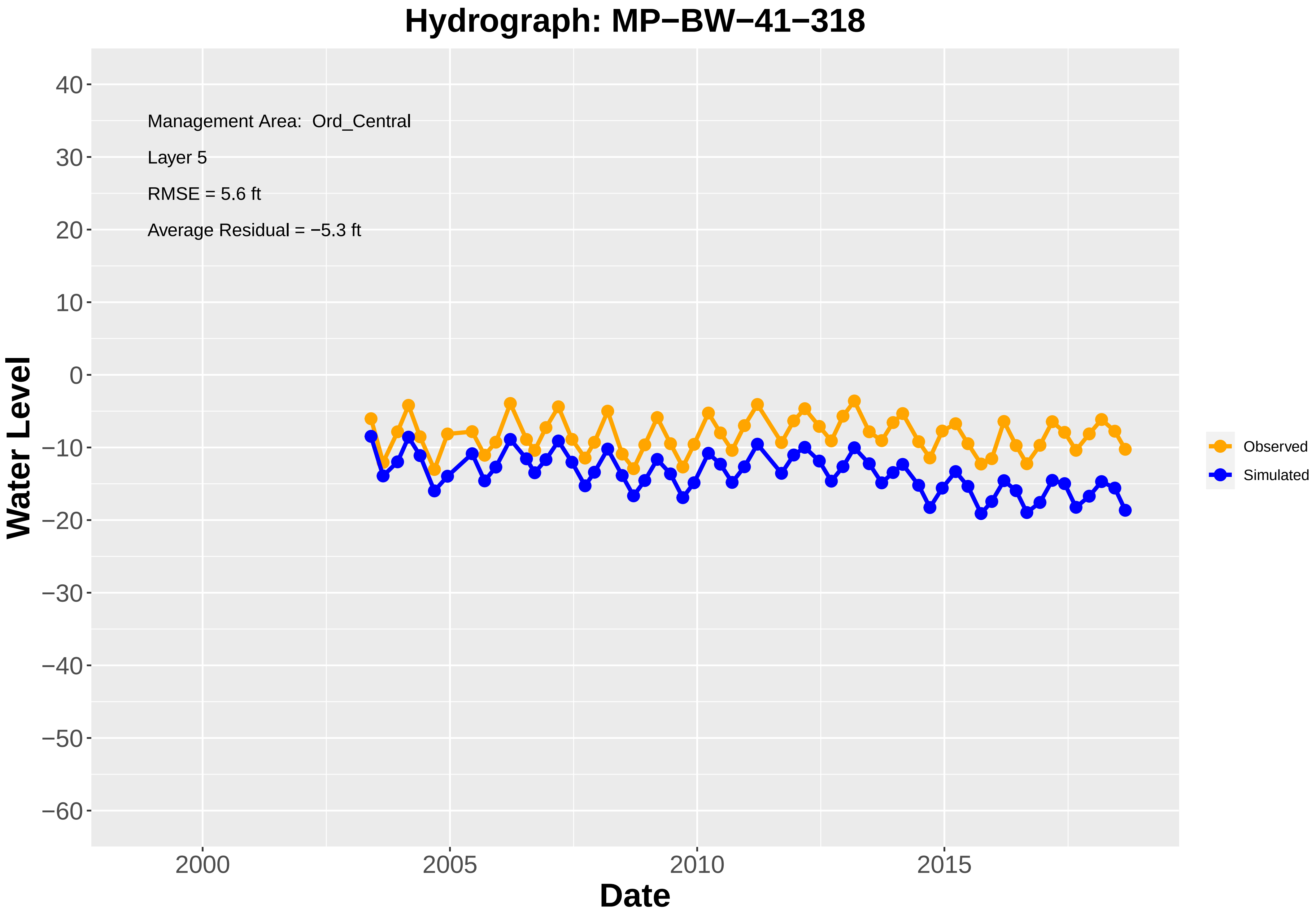

Hydrograph: MP−BW−41−202
Management Area: Ord_Central
Layer 3
RMSE = 3.4 ft
Average Residual = 2.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

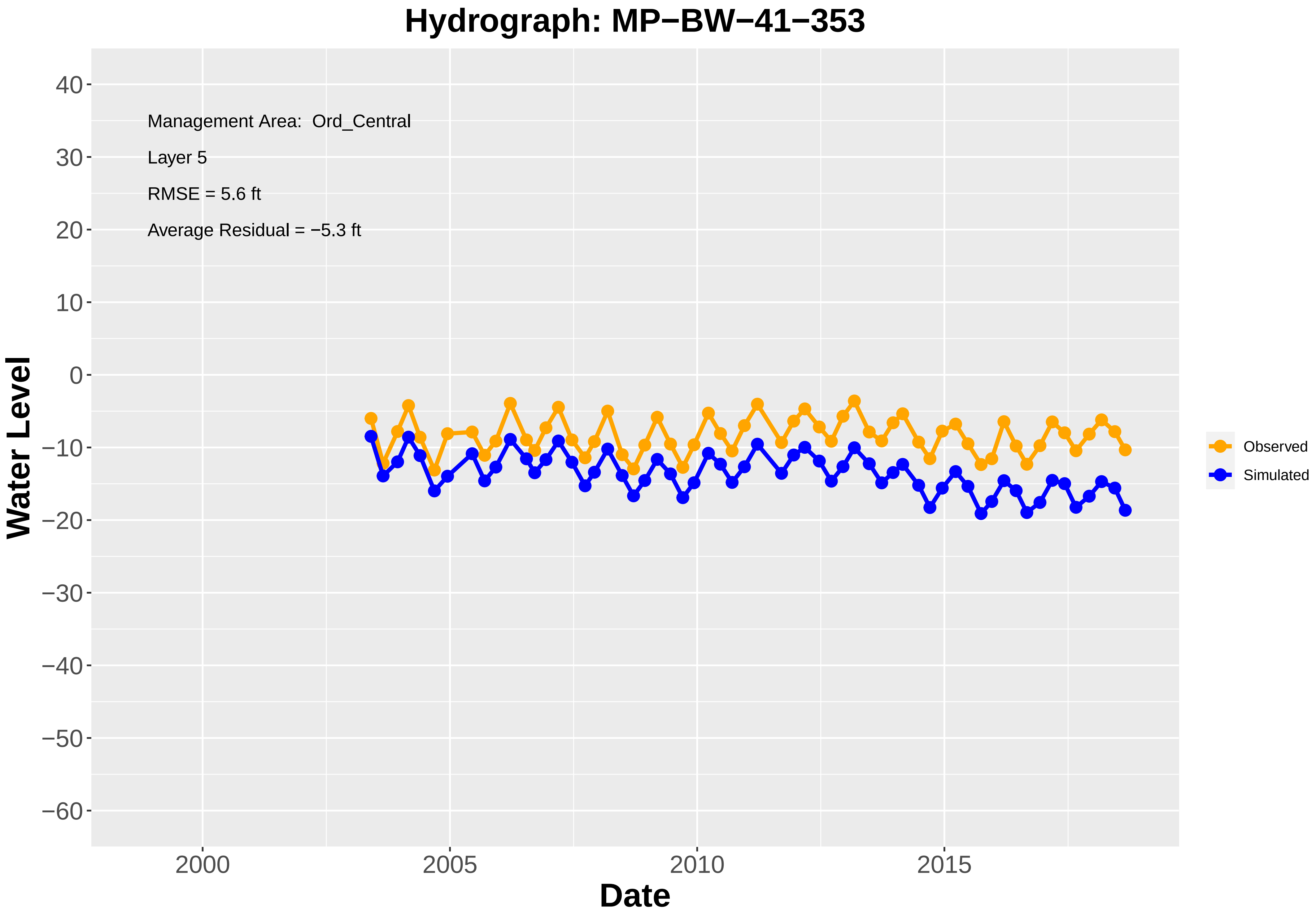

Hydrograph: MP−BW−41−231
Management Area: Ord_Central
Layer 3
RMSE = 2.8 ft
Average Residual = 1.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MP−BW−41−256

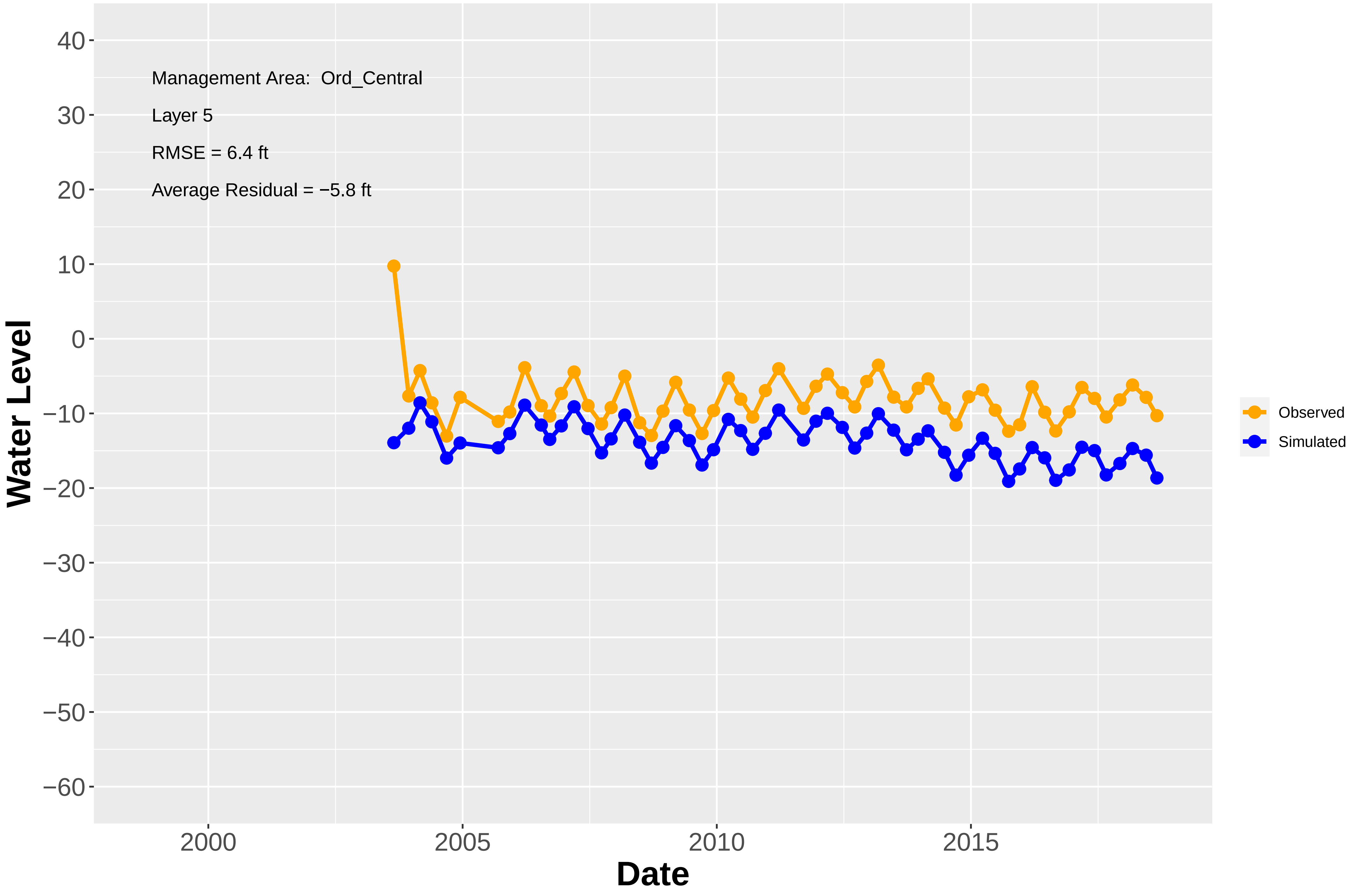


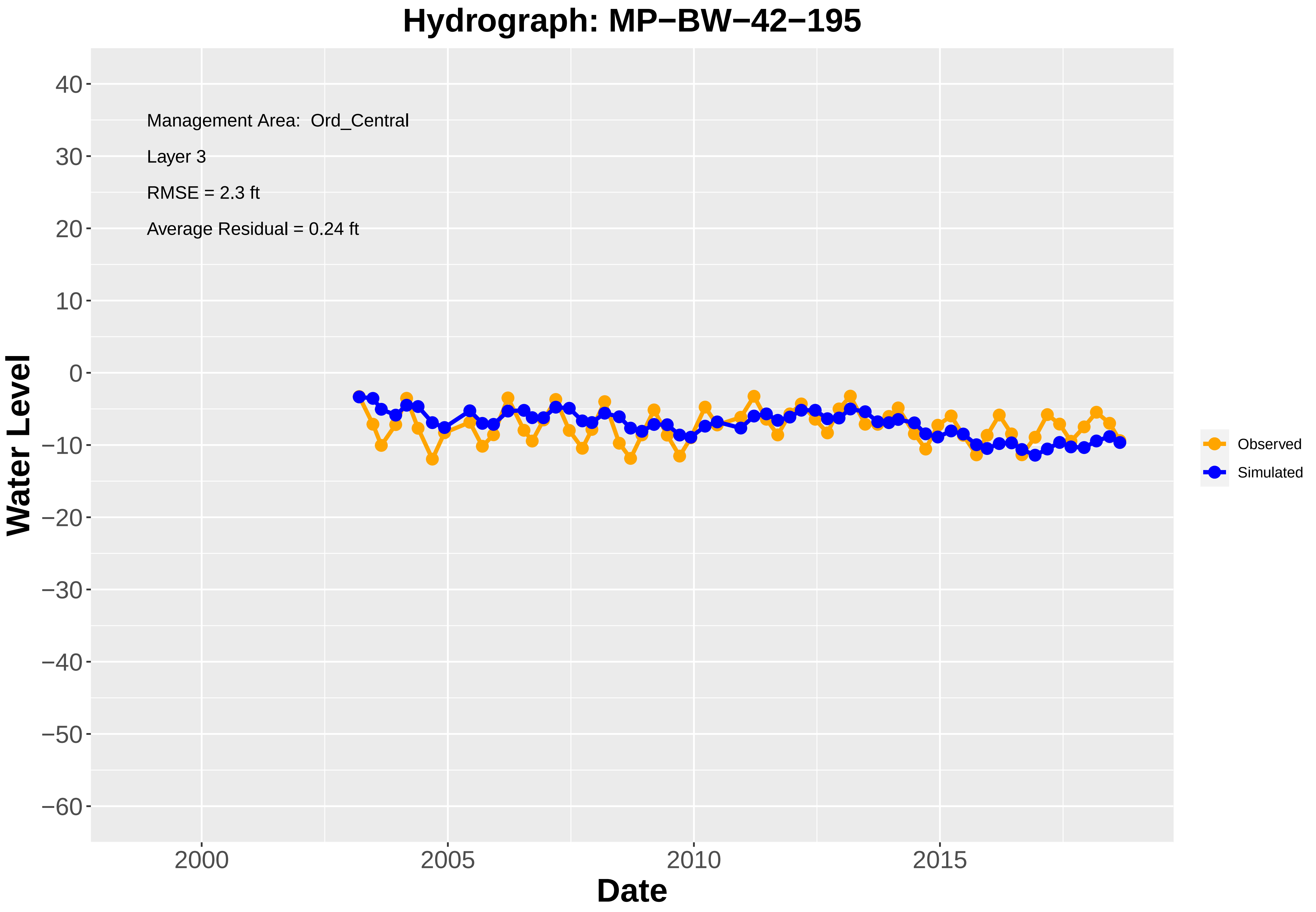

Hydrograph: MP−BW−41−286
Management Area: Ord_Central
Layer 5
RMSE = 5.7 ft
Average Residual = −5.4 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MP−BW−41−318
Management Area: Ord_Central
Layer 5
RMSE = 5.6 ft
Average Residual = −5.3 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

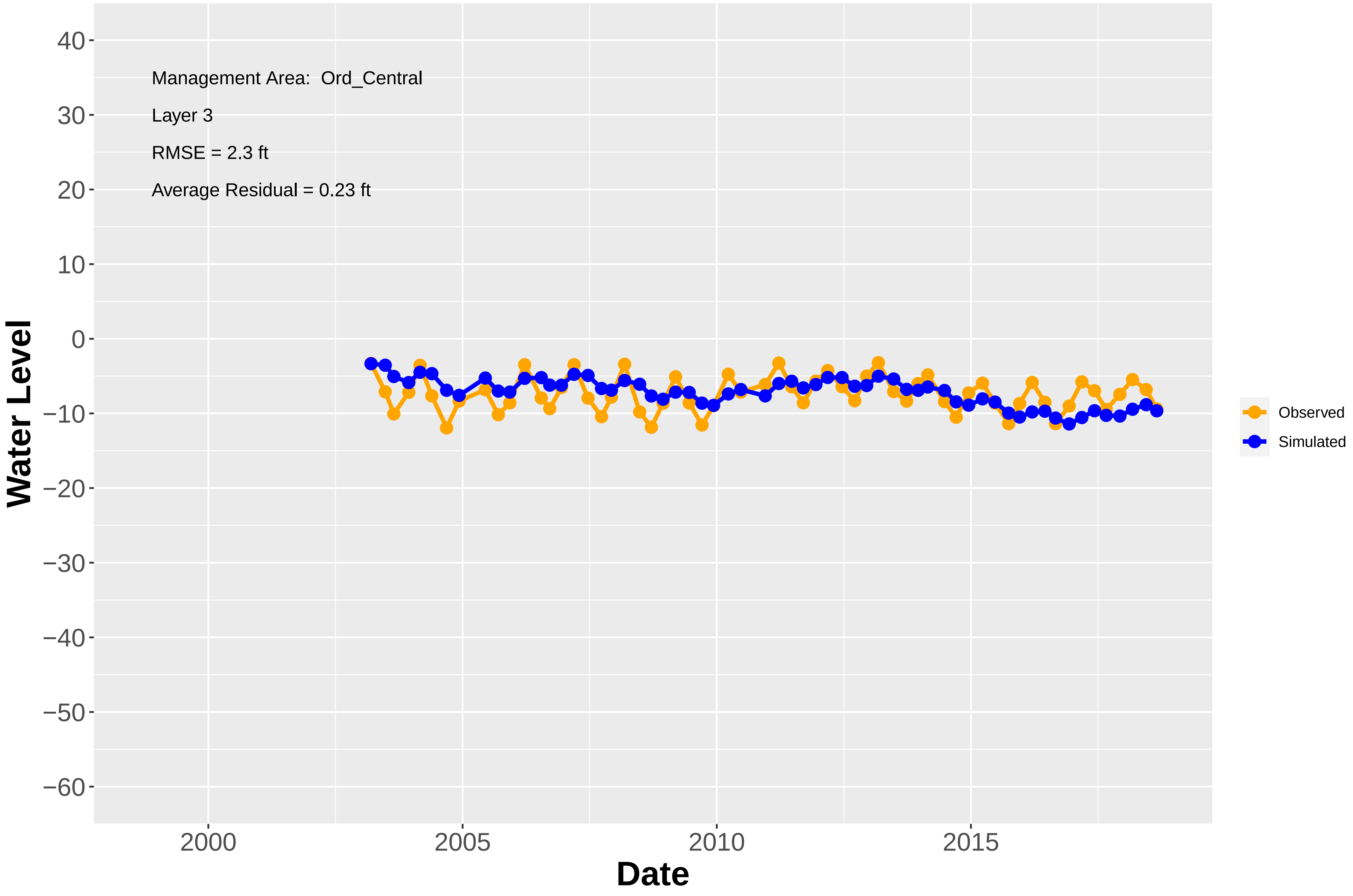

Hydrograph: MP−BW−41−353
Management Area: Ord_Central
Layer 5
RMSE = 5.6 ft
Average Residual = −5.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MP−BW−41−396

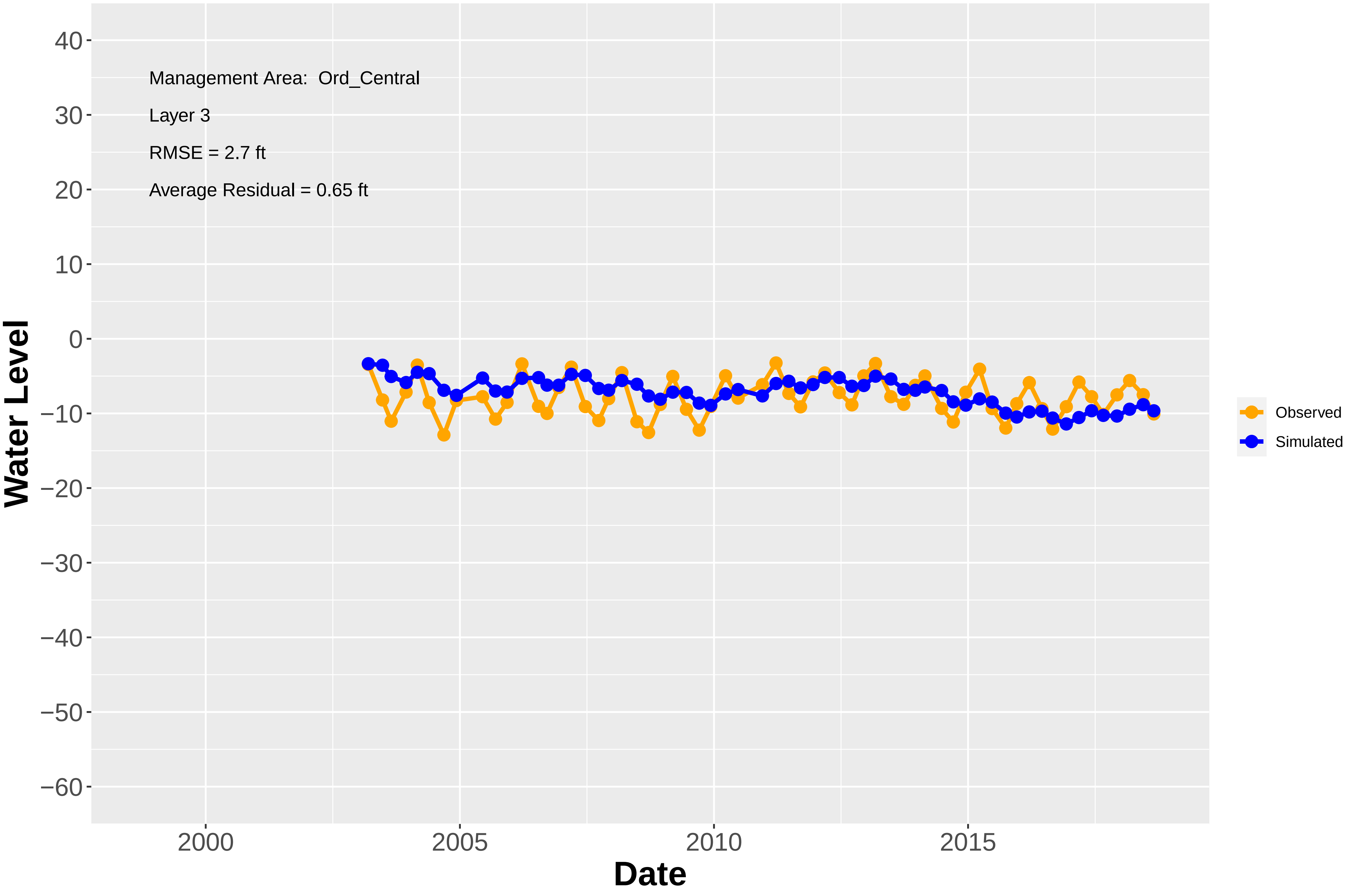


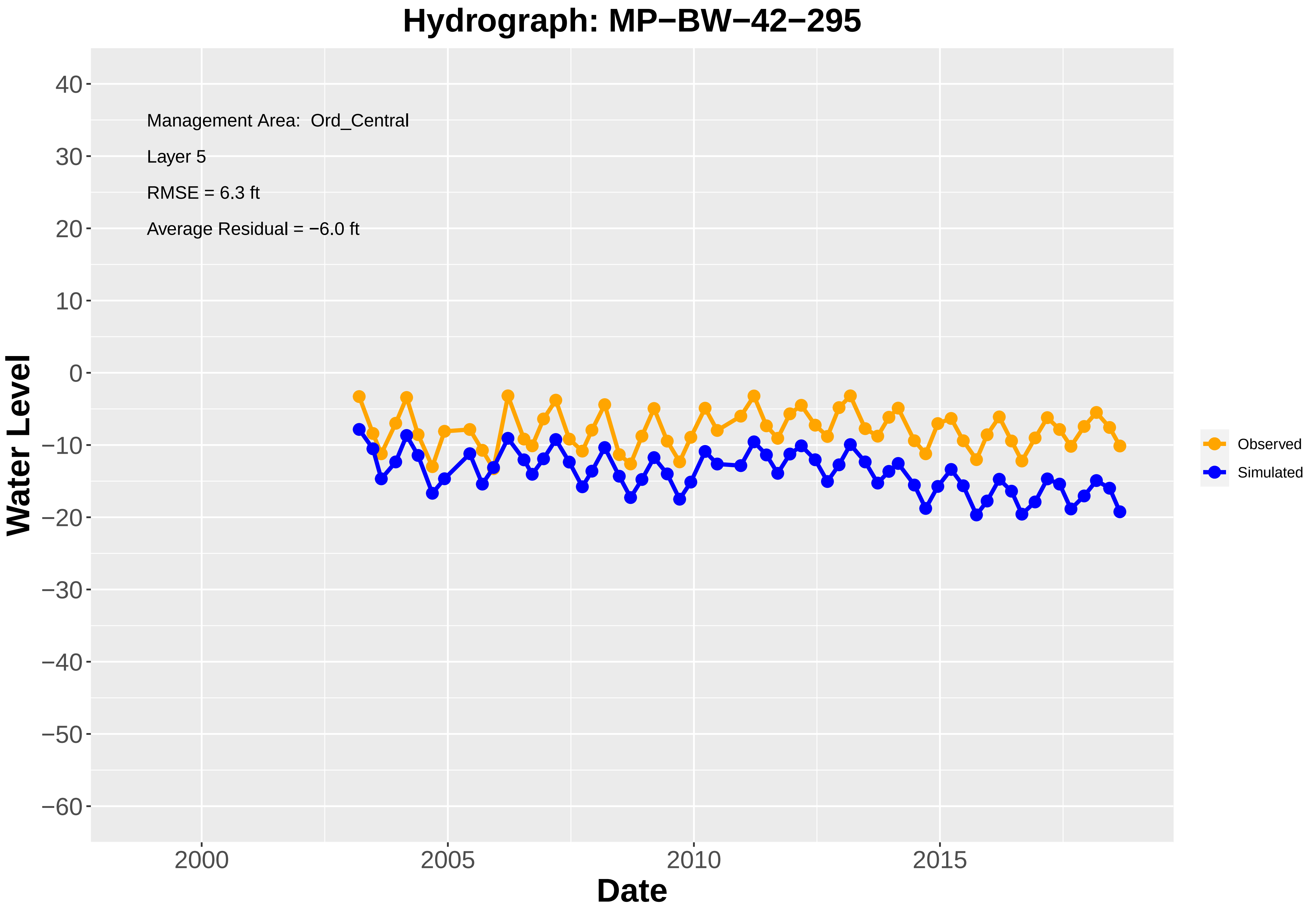

Hydrograph: MP−BW−42−195
Management Area: Ord_Central
Layer 3
RMSE = 2.3 ft
Average Residual = 0.24 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

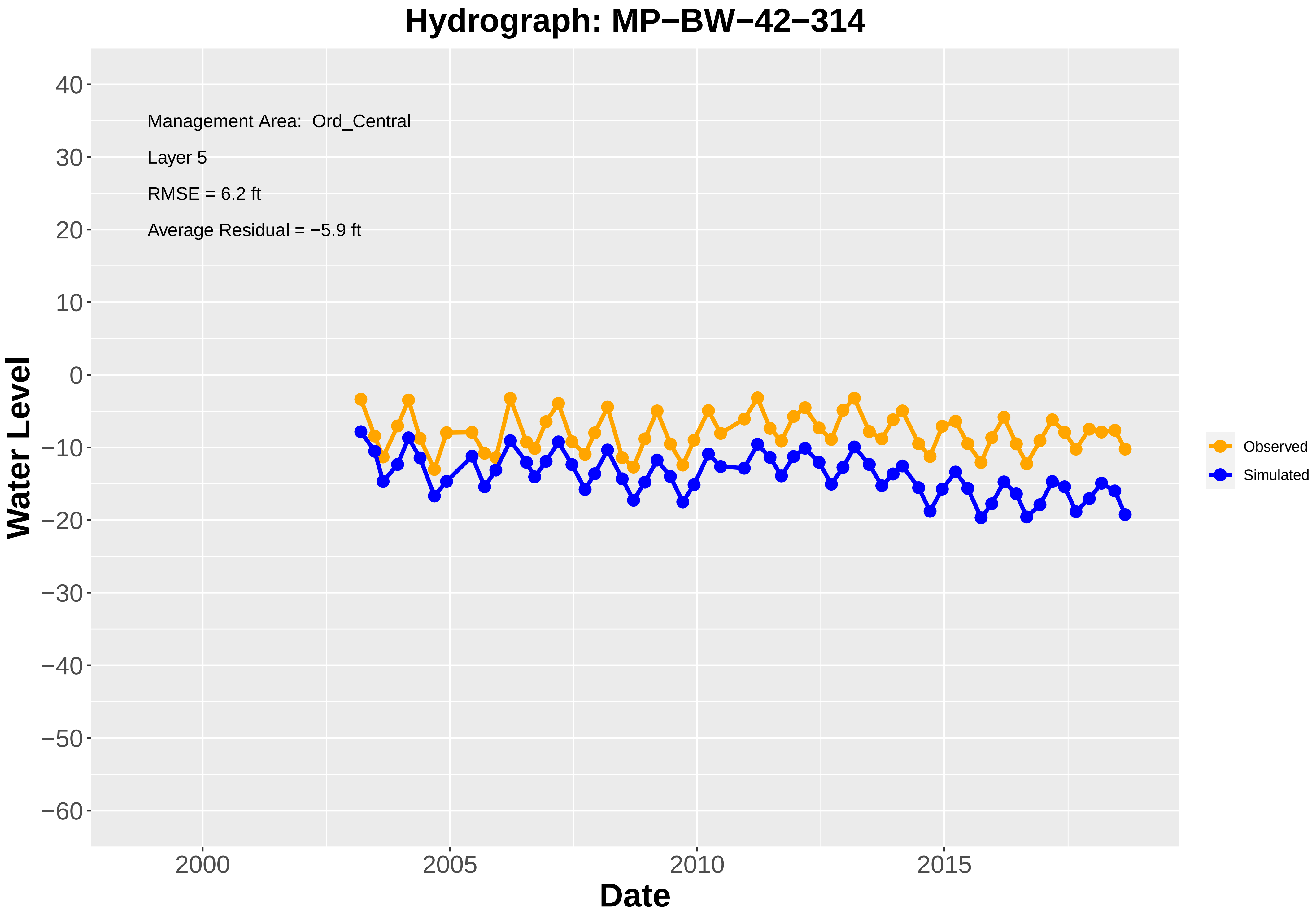
Hydrograph: MP−BW−42−215

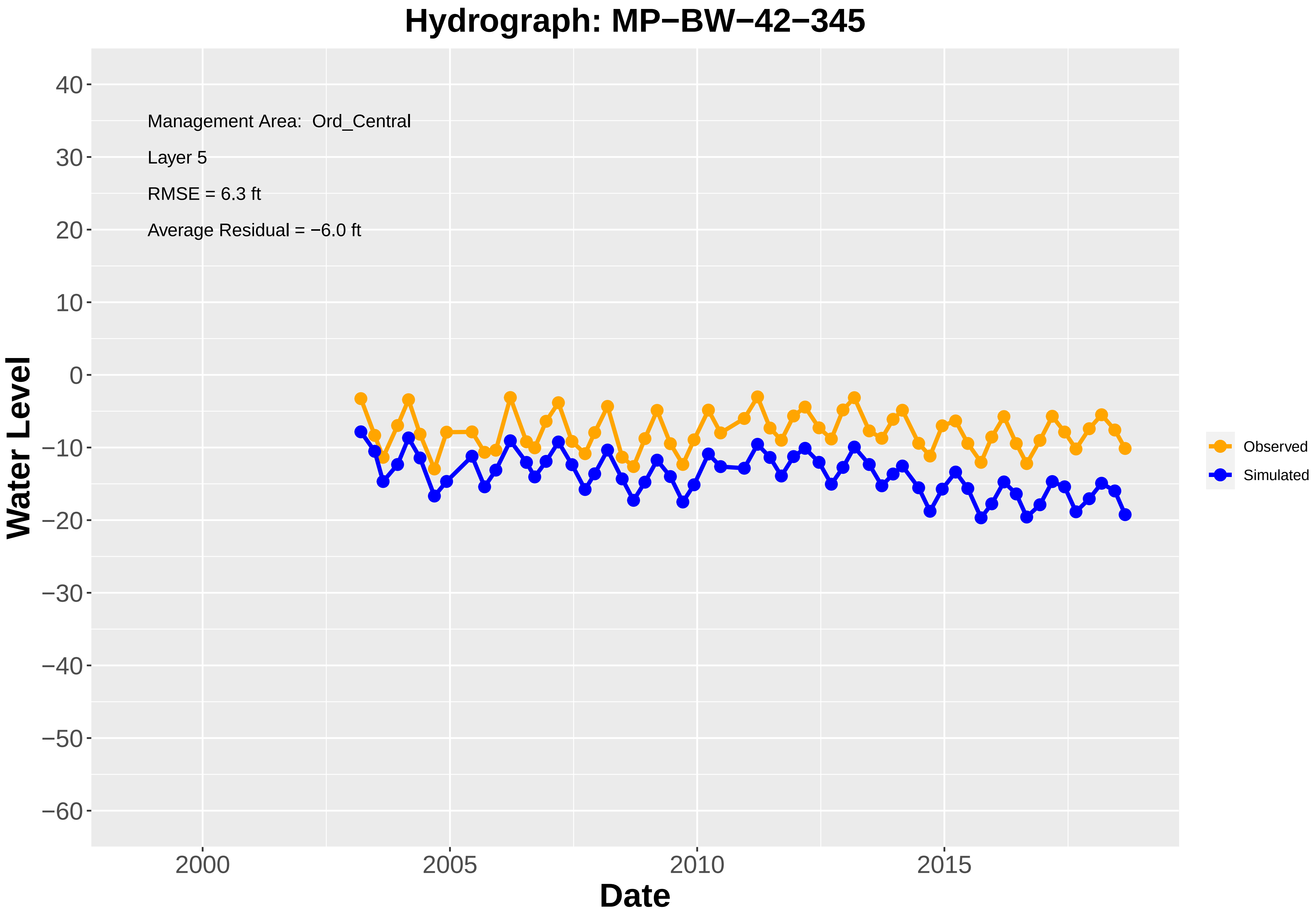


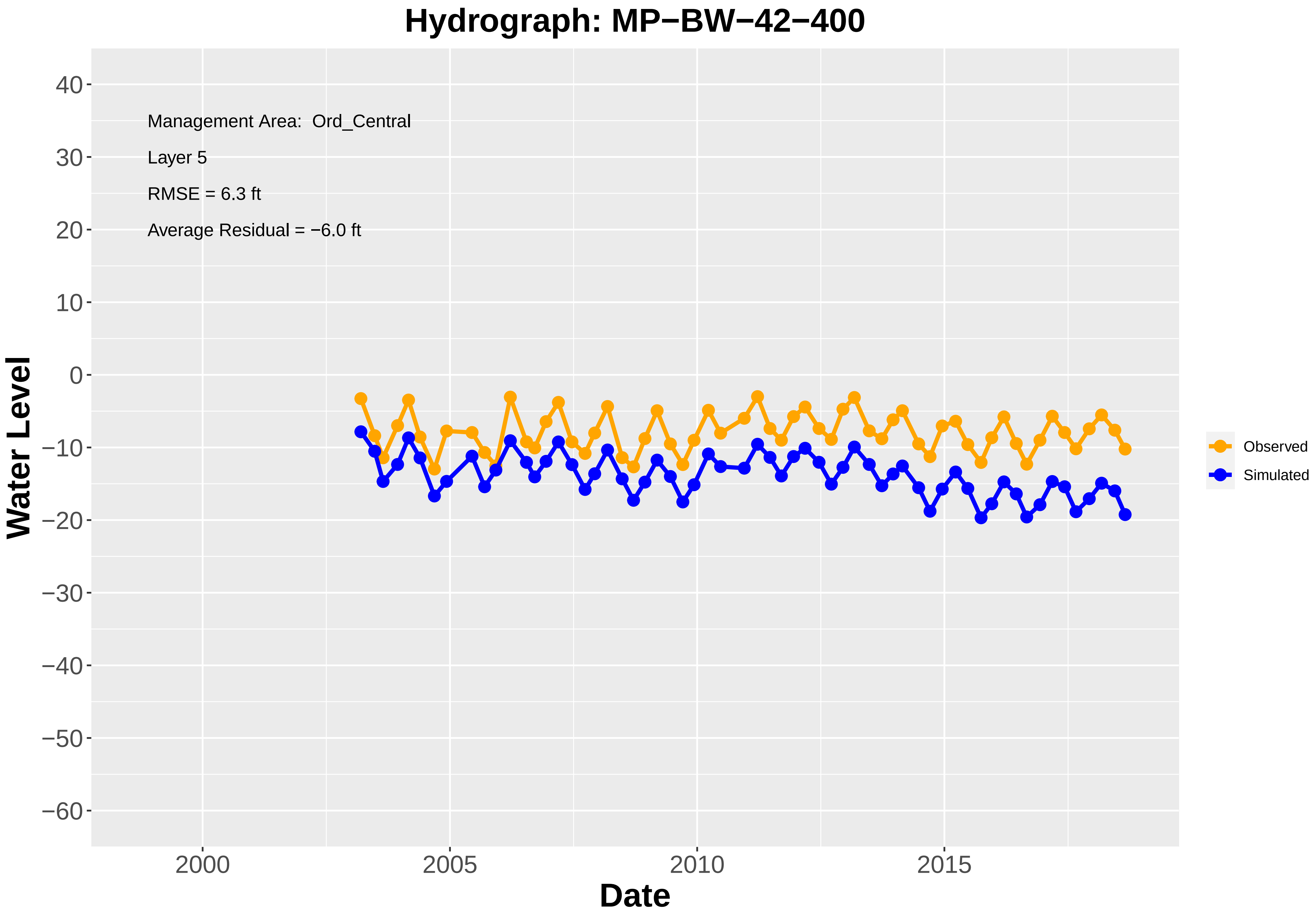
Hydrograph: MP−BW−42−235

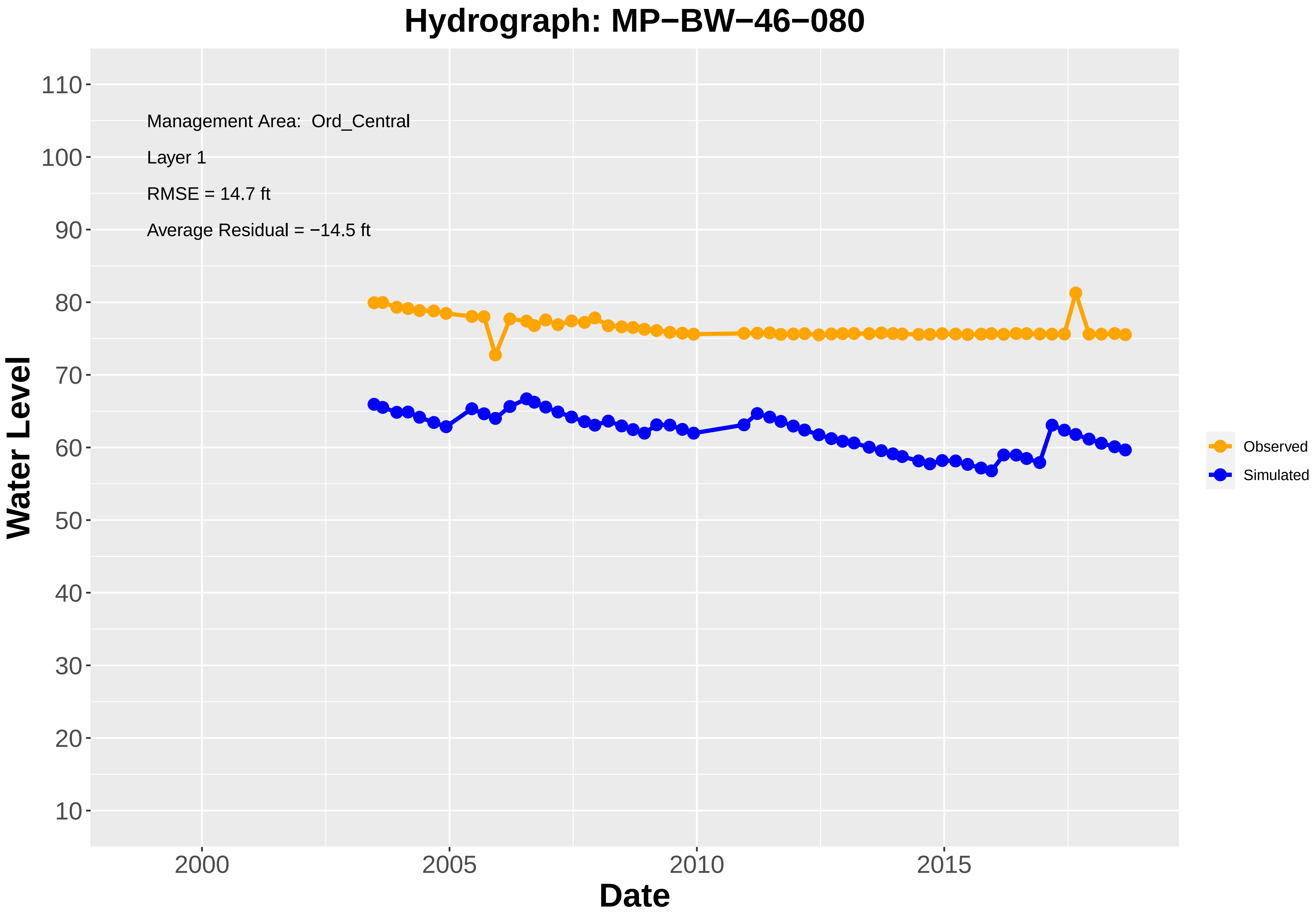



Hydrograph: MP−BW−42−295
Management Area: Ord_Central
Layer 5
RMSE = 6.3 ft
Average Residual = −6.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

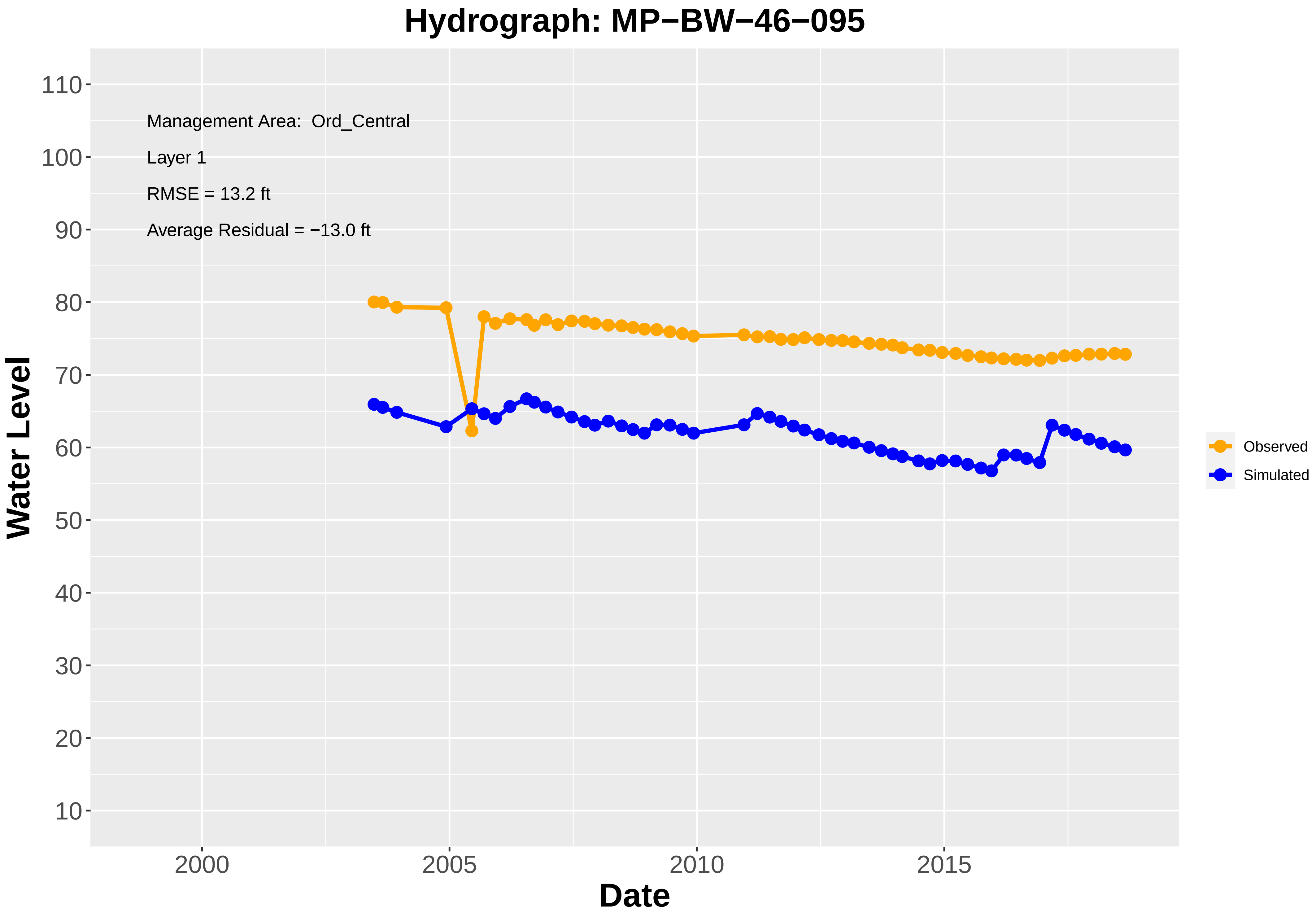

Hydrograph: MP−BW−42−314
Management Area: Ord_Central
Layer 5
RMSE = 6.2 ft
Average Residual = −5.9 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

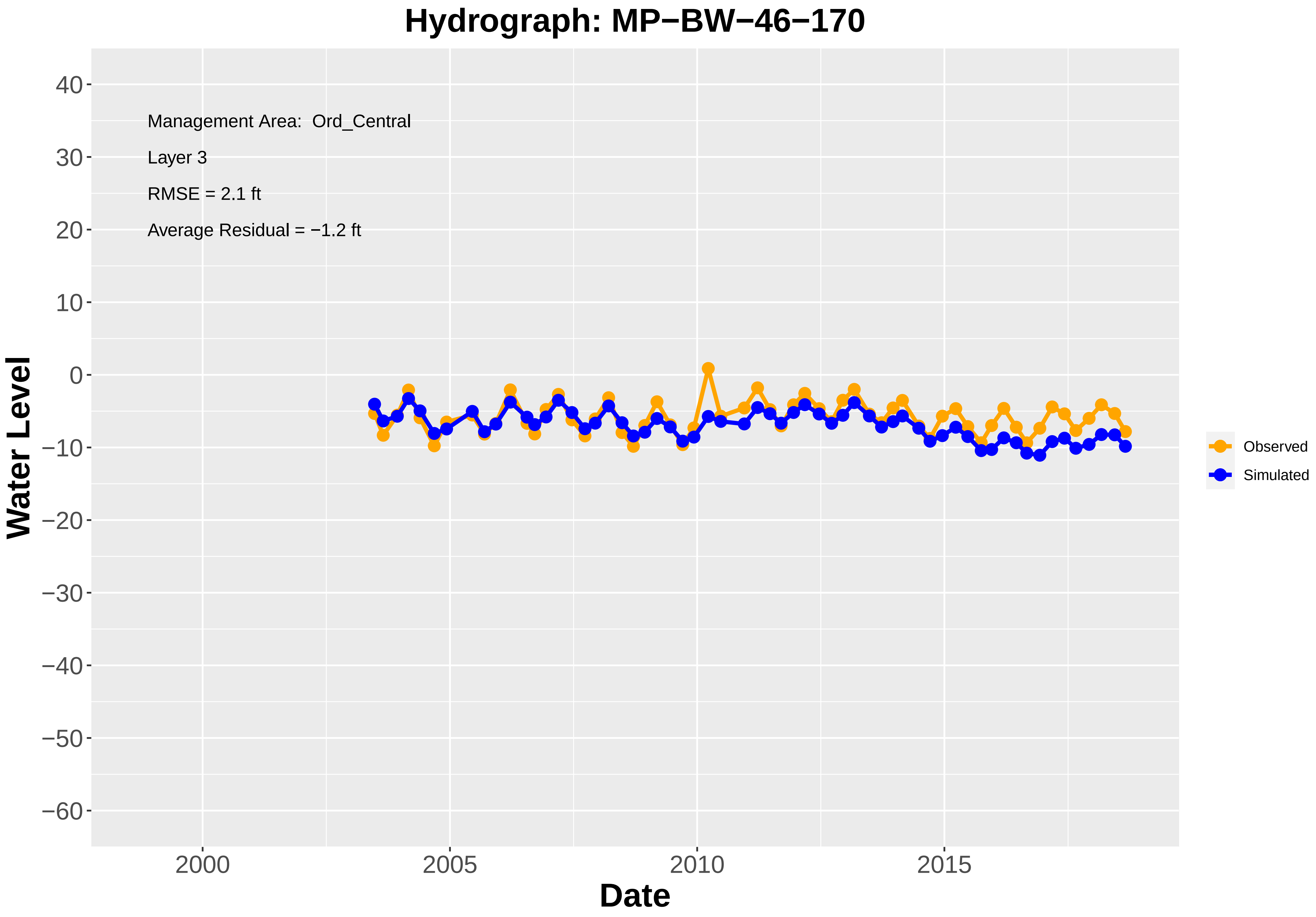

Hydrograph: MP−BW−42−345
Management Area: Ord_Central
Layer 5
RMSE = 6.3 ft
Average Residual = −6.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

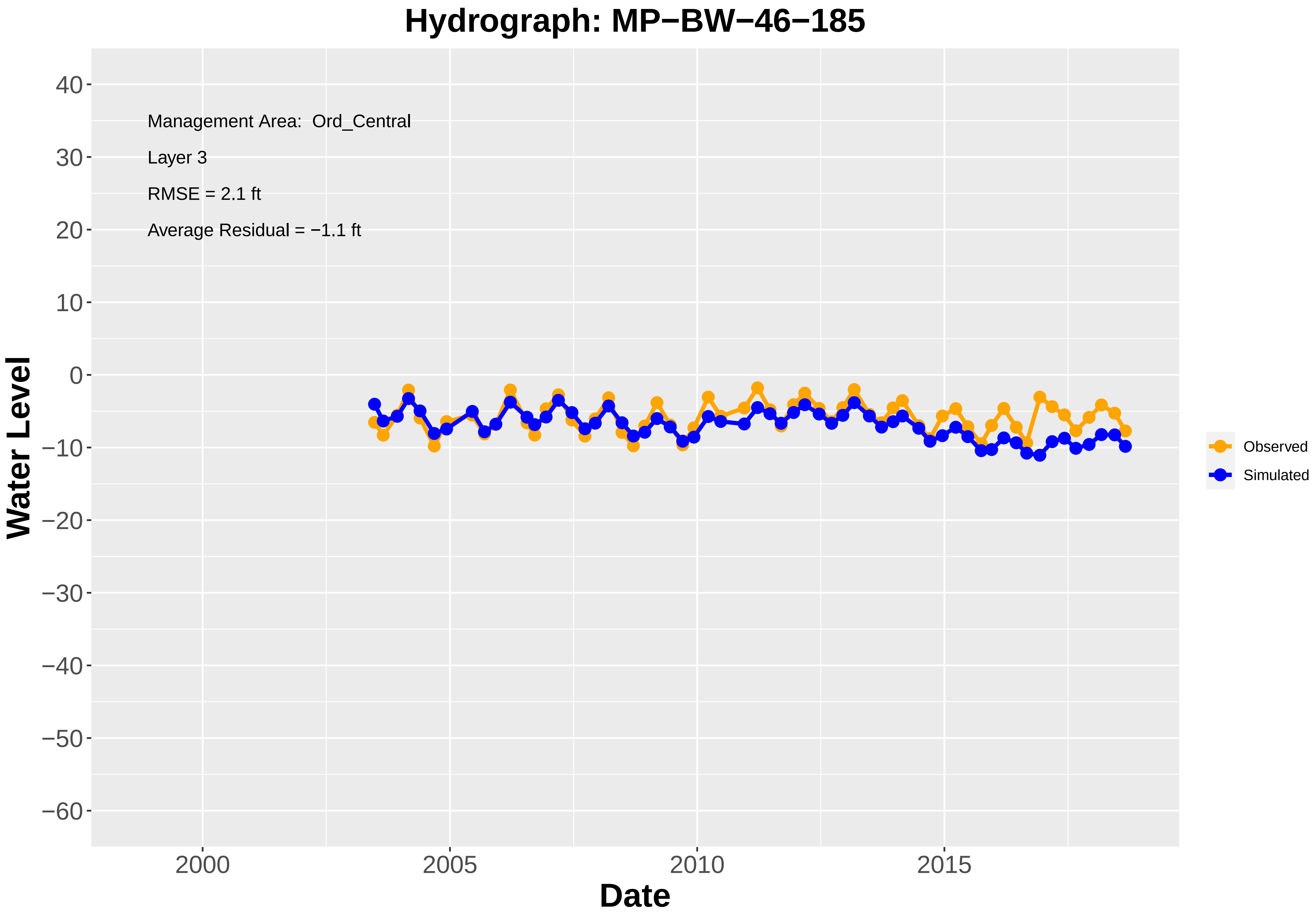

Hydrograph: MP−BW−42−400
Management Area: Ord_Central
Layer 5
RMSE = 6.3 ft
Average Residual = −6.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated



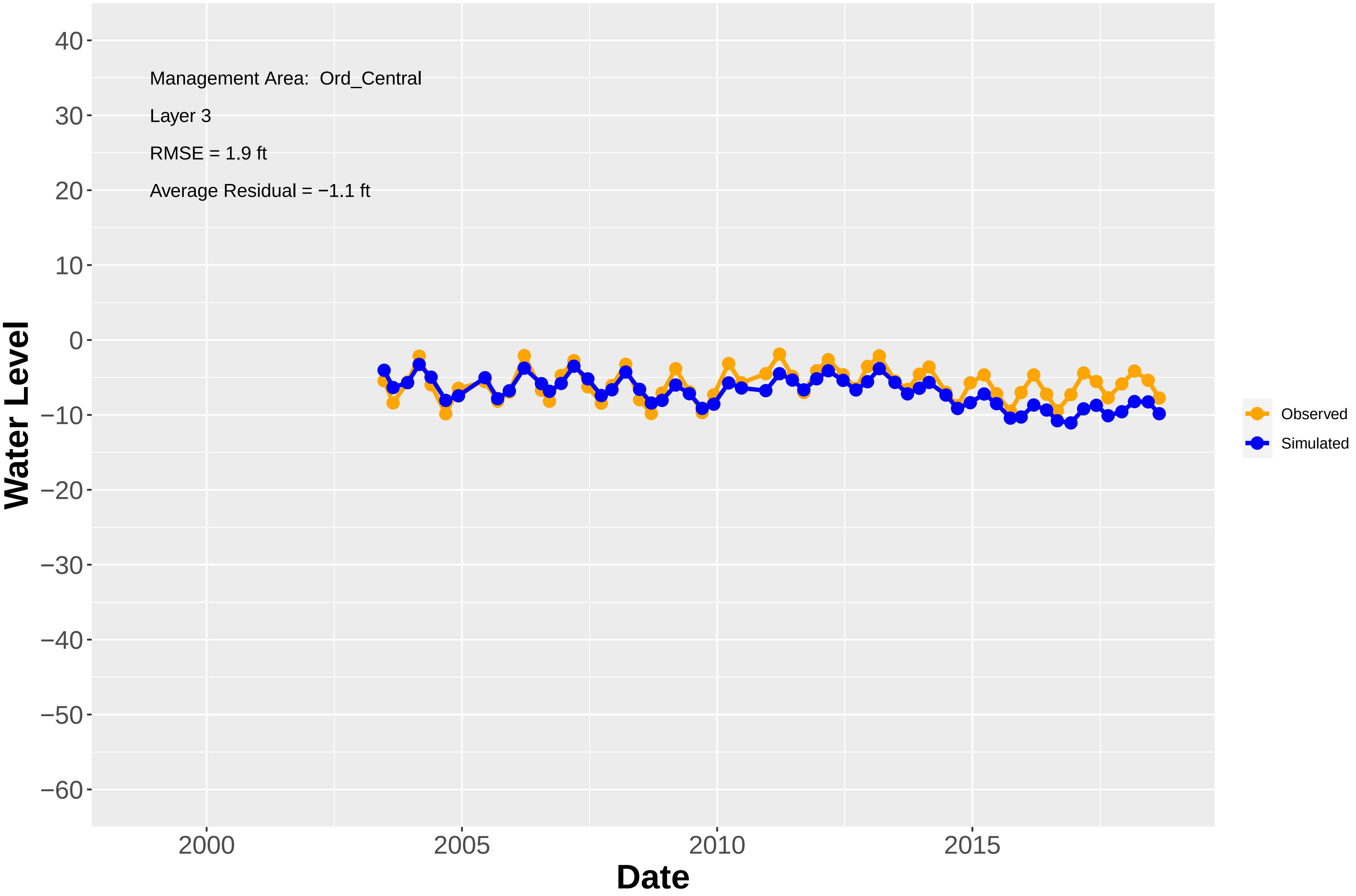
Hydrograph: MP−BW−46−080
Management Area: Ord_Central
Layer 1
RMSE = 14.7 ft
Average Residual = −14.5 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

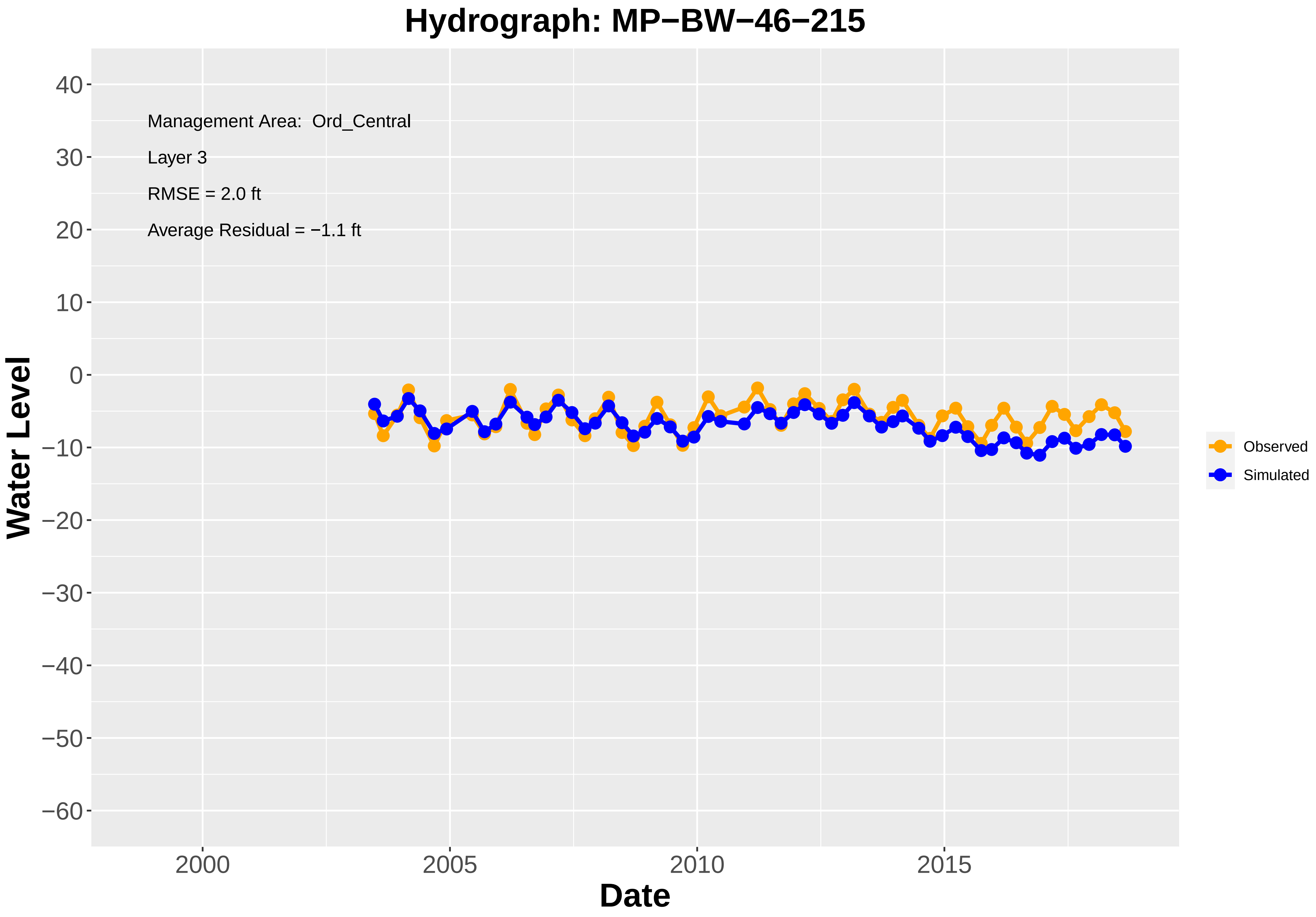

Hydrograph: MP−BW−46−095
Management Area: Ord_Central
Layer 1
RMSE = 13.2 ft
Average Residual = −13.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MP−BW−46−170
Management Area: Ord_Central
Layer 3
RMSE = 2.1 ft
Average Residual = −1.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

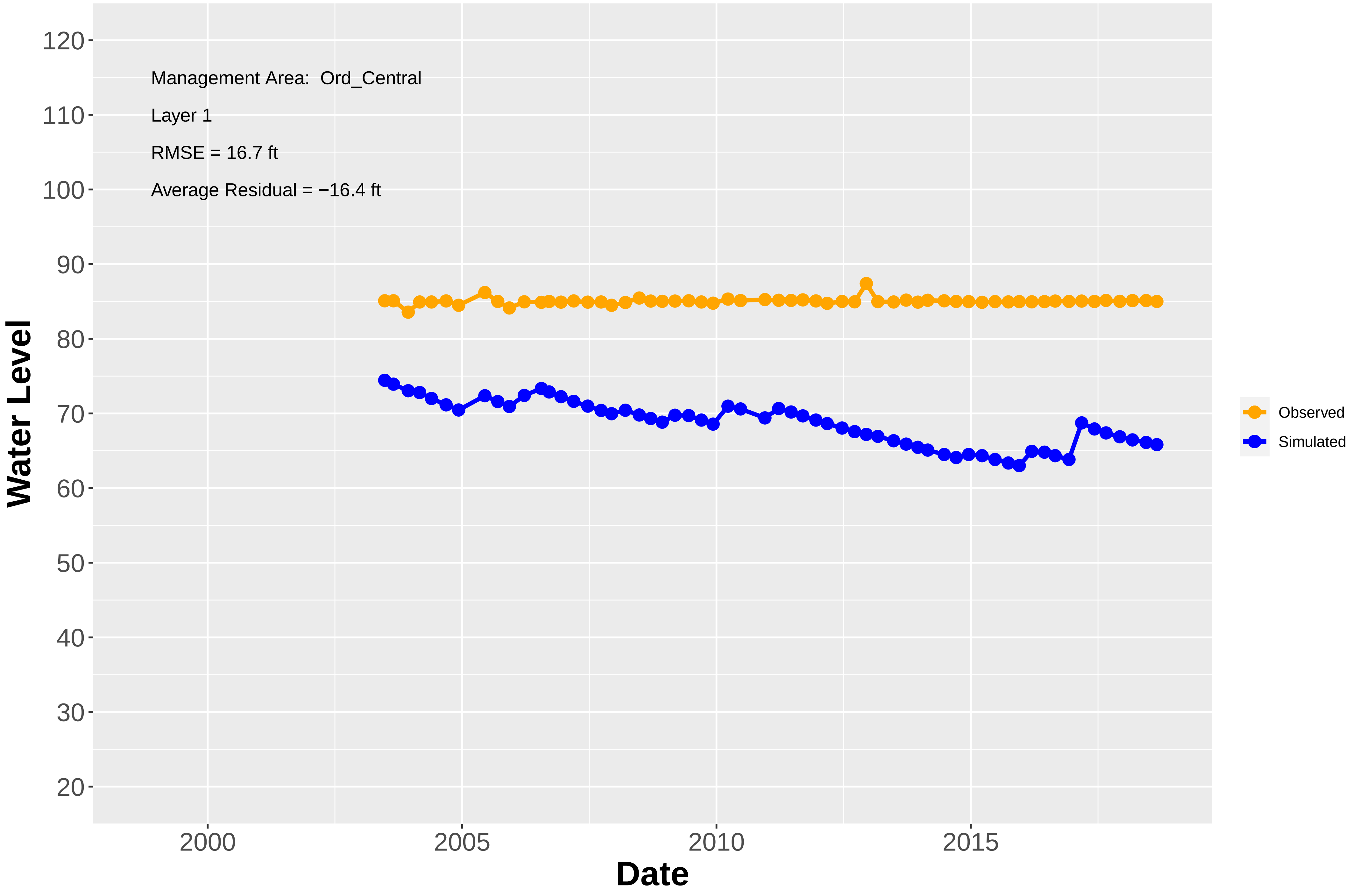

Hydrograph: MP−BW−46−185
Management Area: Ord_Central
Layer 3
RMSE = 2.1 ft
Average Residual = −1.1 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

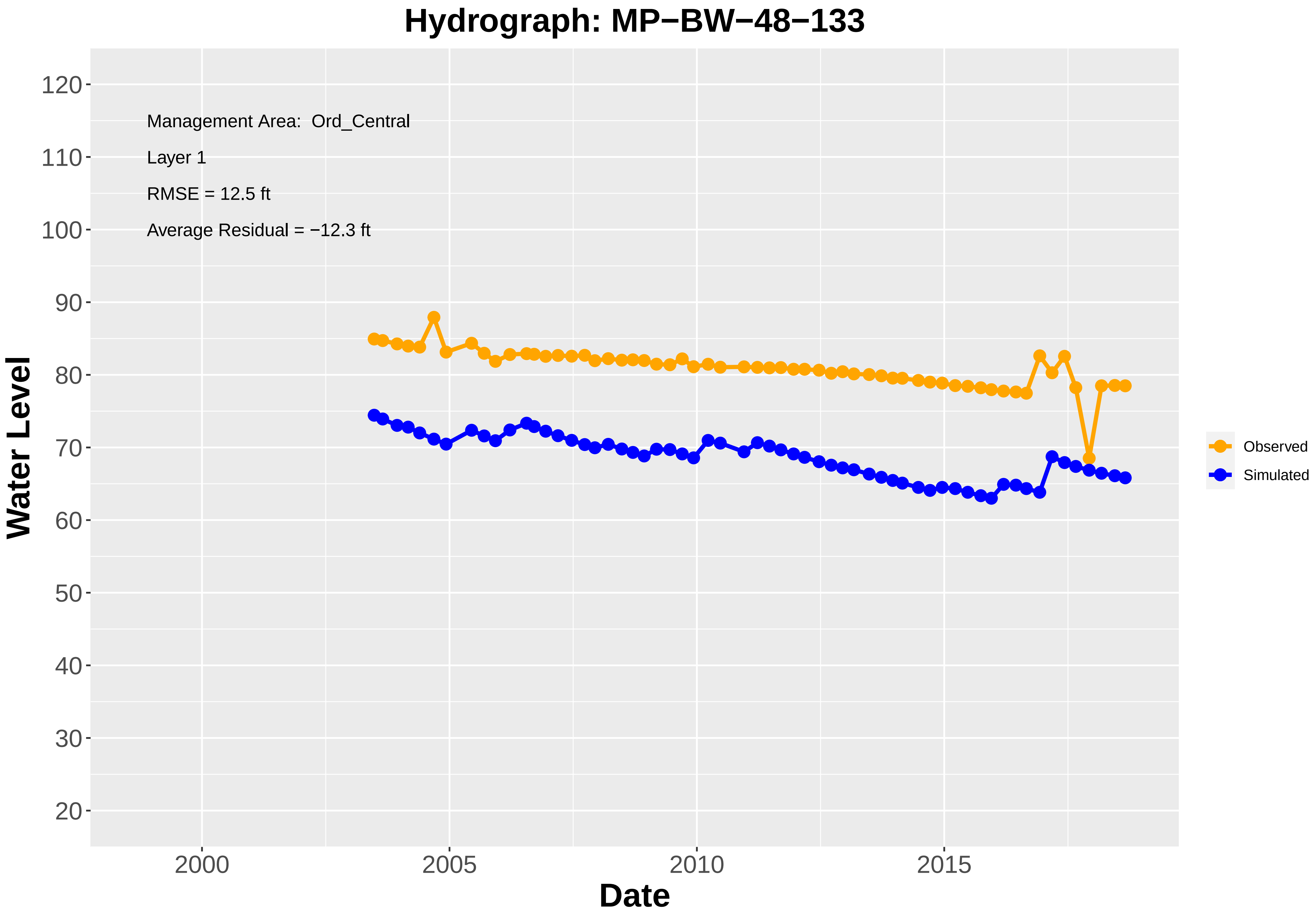
Hydrograph: MP−BW−46−200

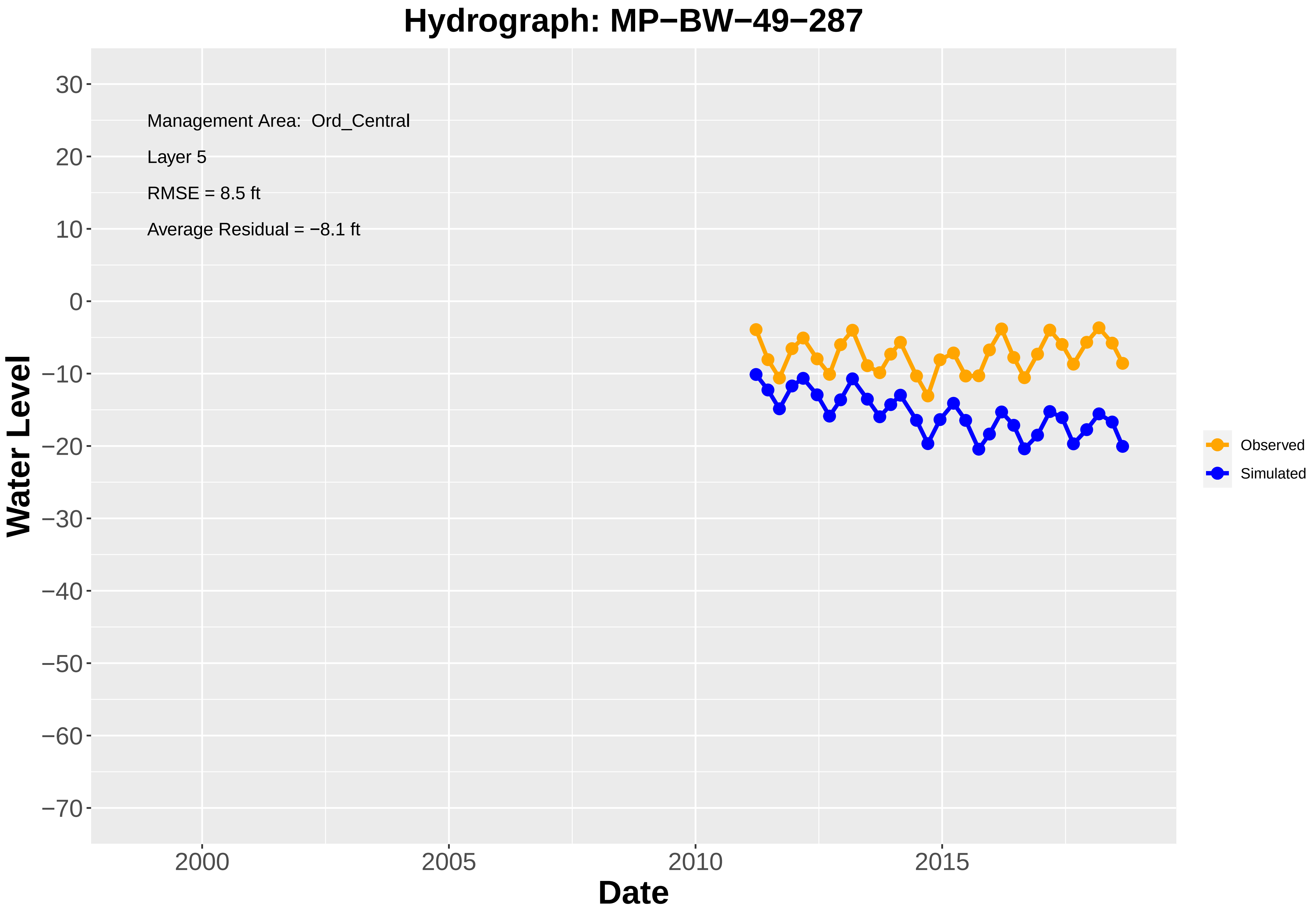



Hydrograph: MP−BW−46−215
Management Area: Ord_Central
Layer 3
RMSE = 2.0 ft
Average Residual = −1.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

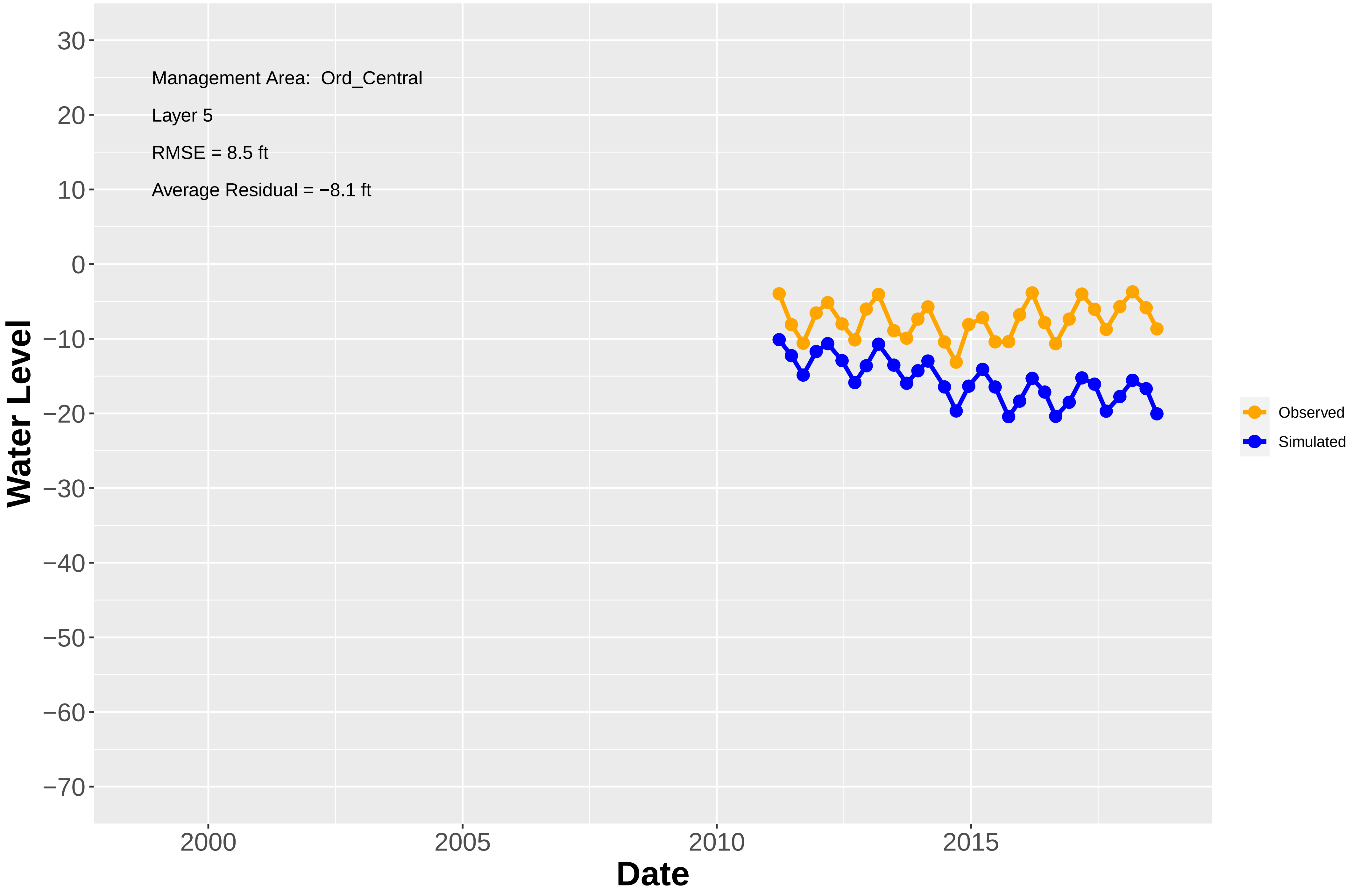
Hydrograph: MP−BW−48−113



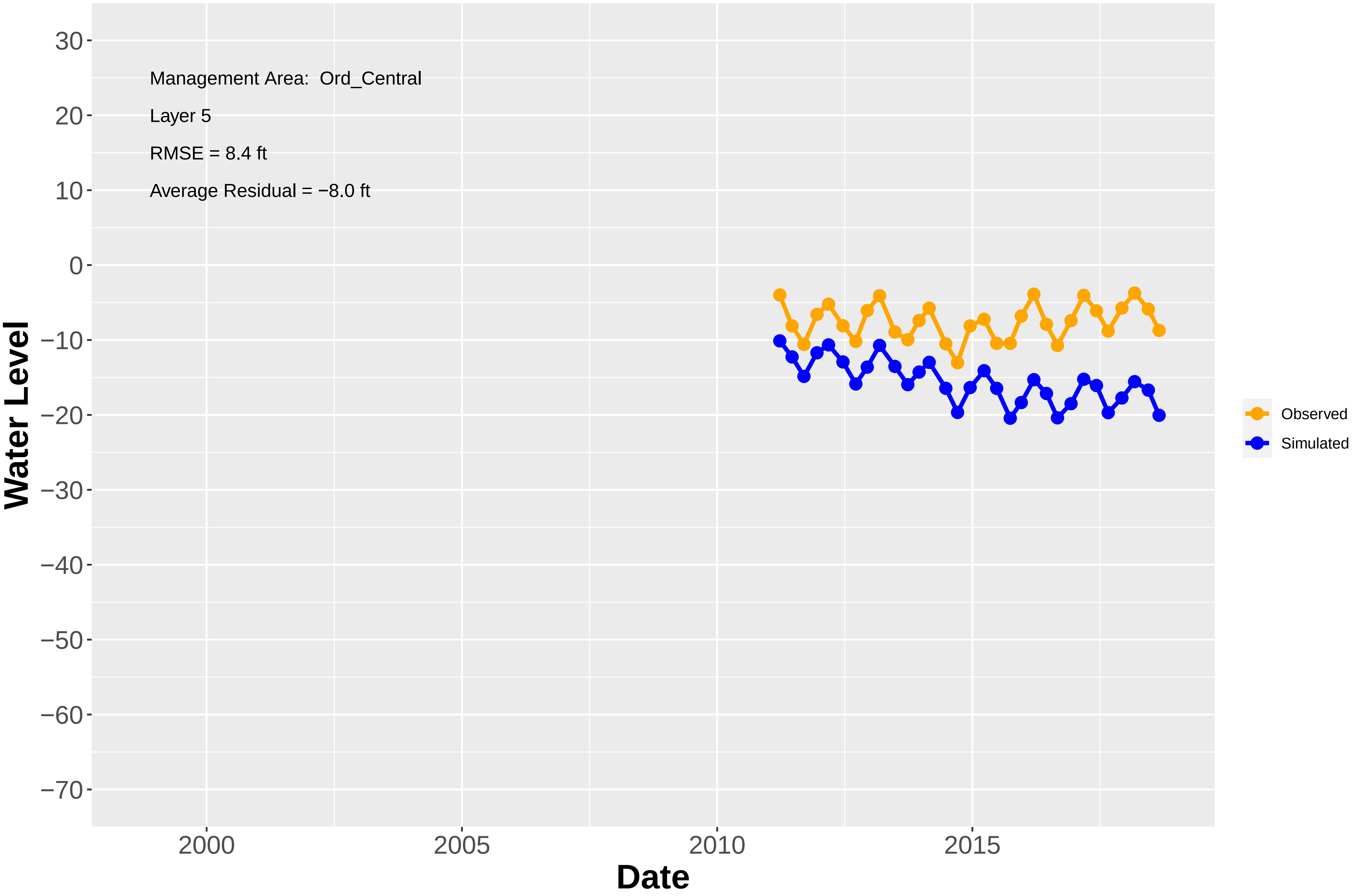

Hydrograph: MP−BW−48−133
Management Area: Ord_Central
Layer 1
RMSE = 12.5 ft
Average Residual = −12.3 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

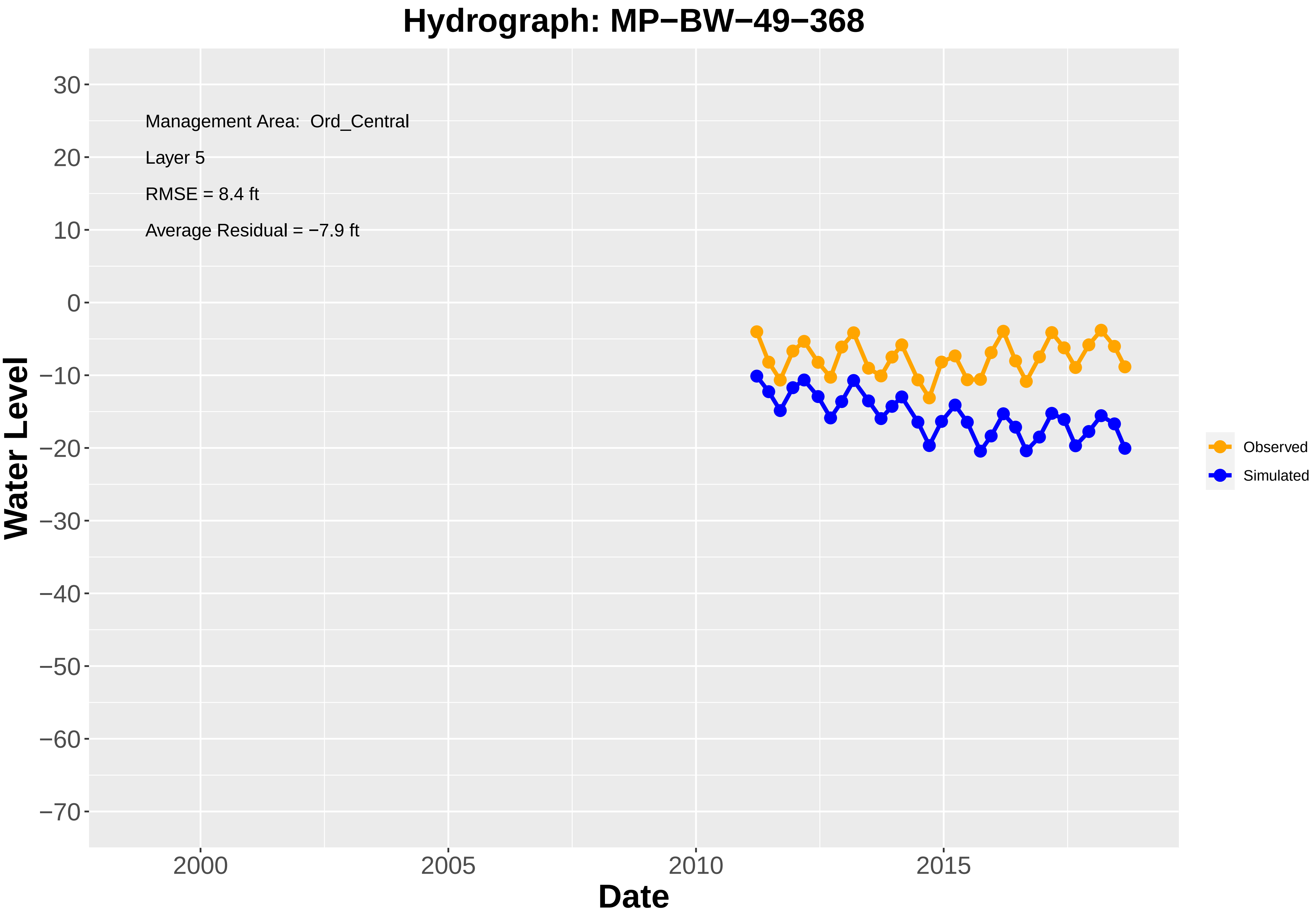

Hydrograph: MP−BW−49−287
Management Area: Ord_Central
Layer 5
RMSE = 8.5 ft
Average Residual = −8.1 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

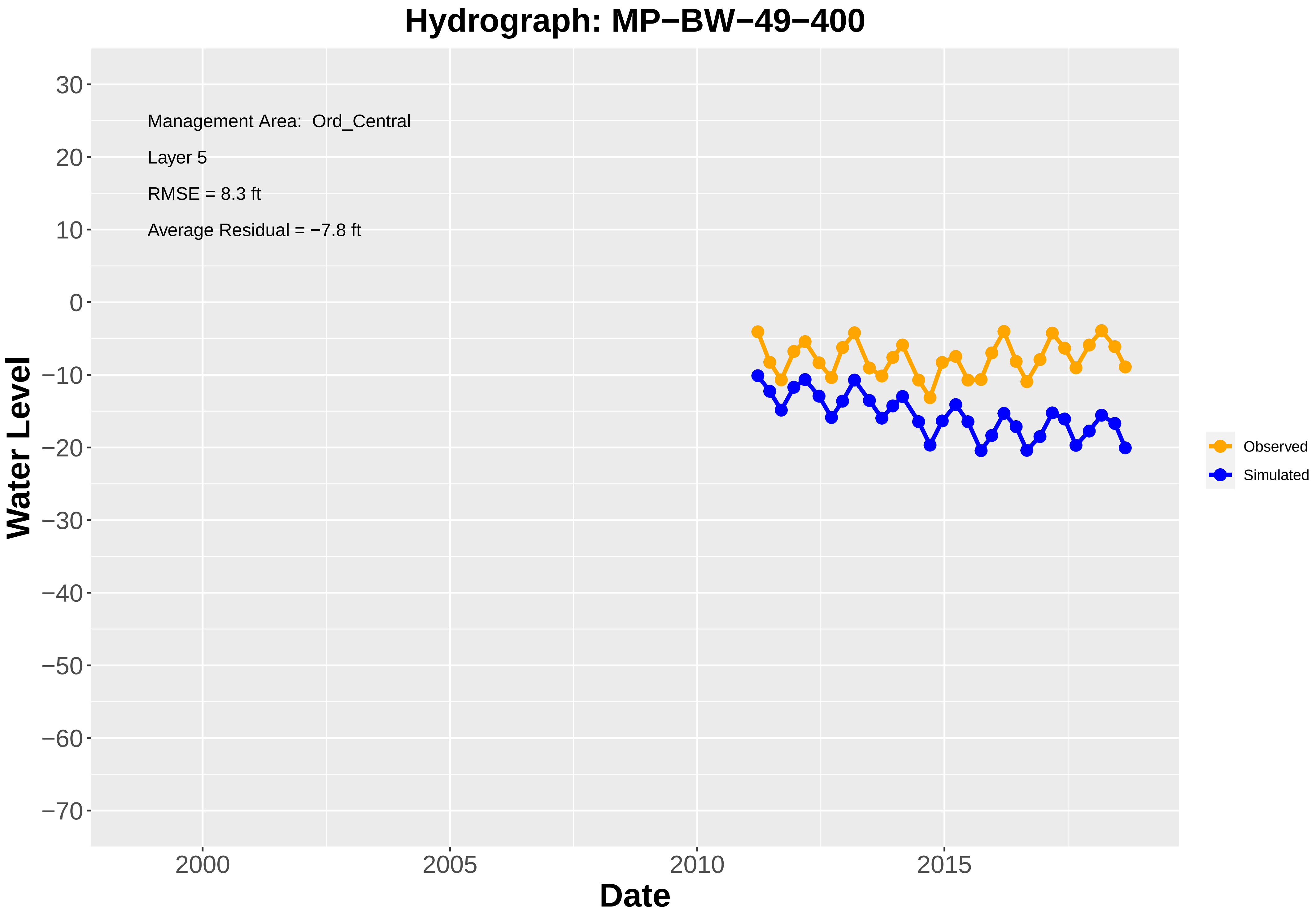
Hydrograph: MP−BW−49−316

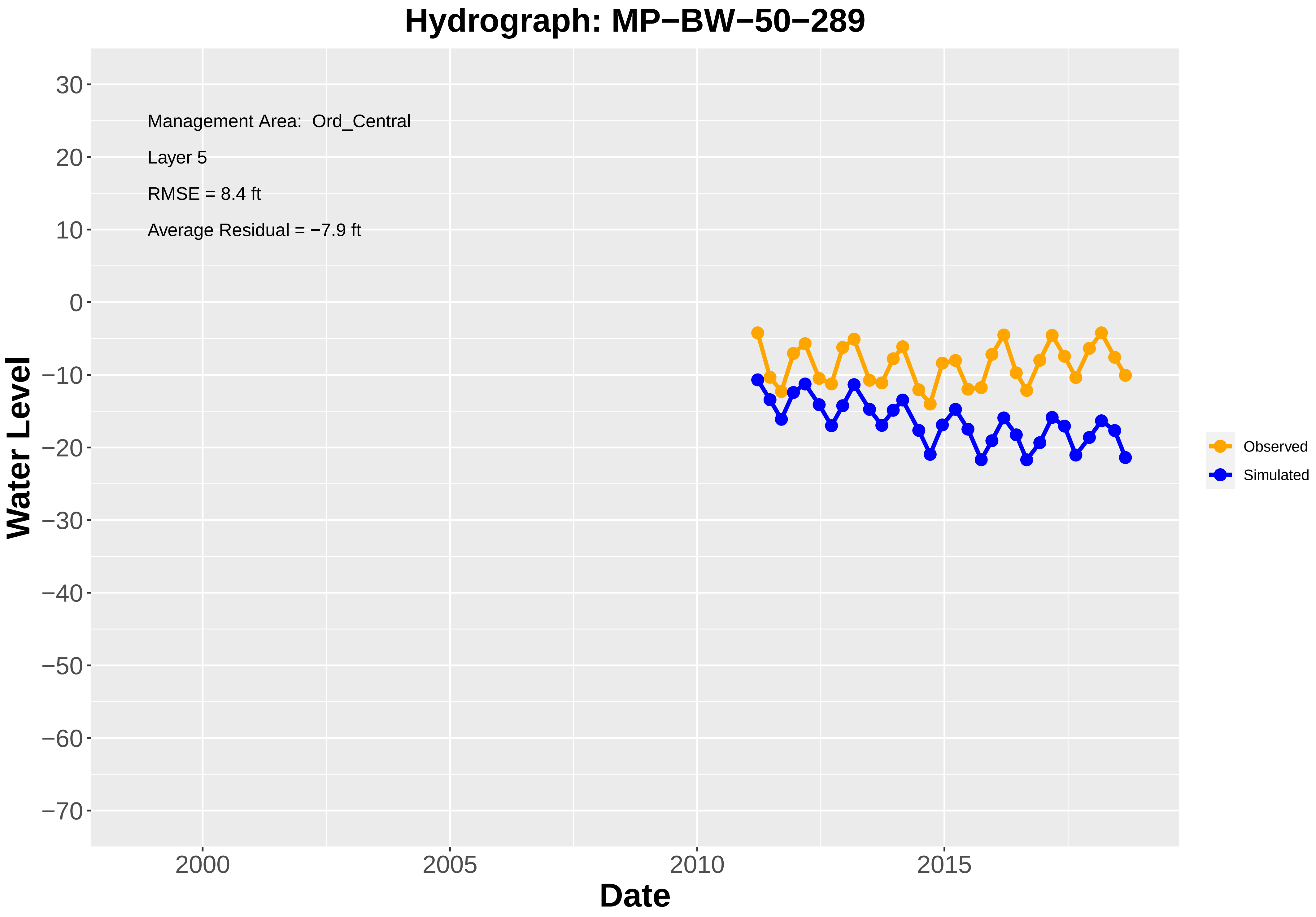


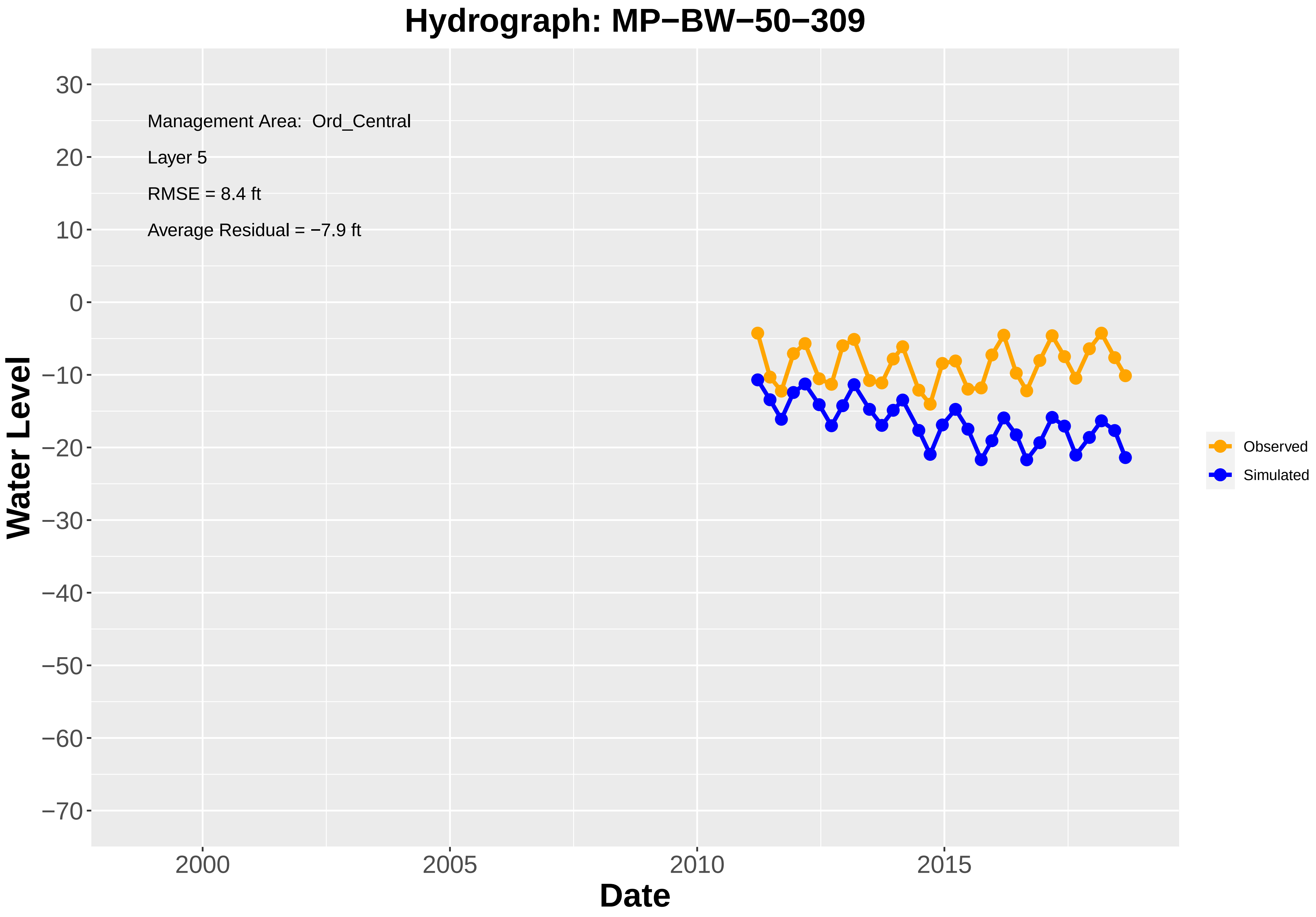
Hydrograph: MP−BW−49−336



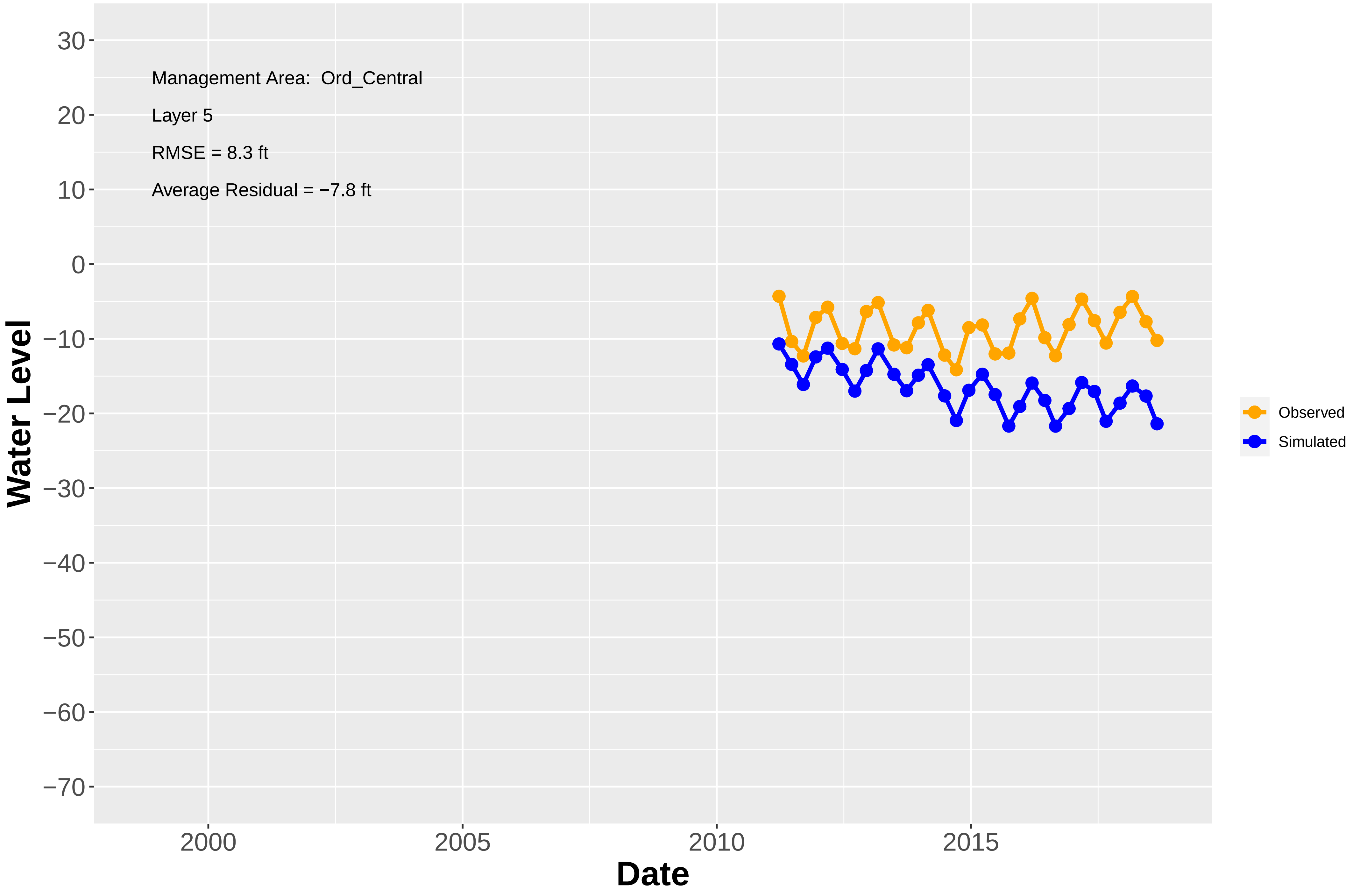

Hydrograph: MP−BW−49−368
Management Area: Ord_Central
Layer 5
RMSE = 8.4 ft
Average Residual = −7.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

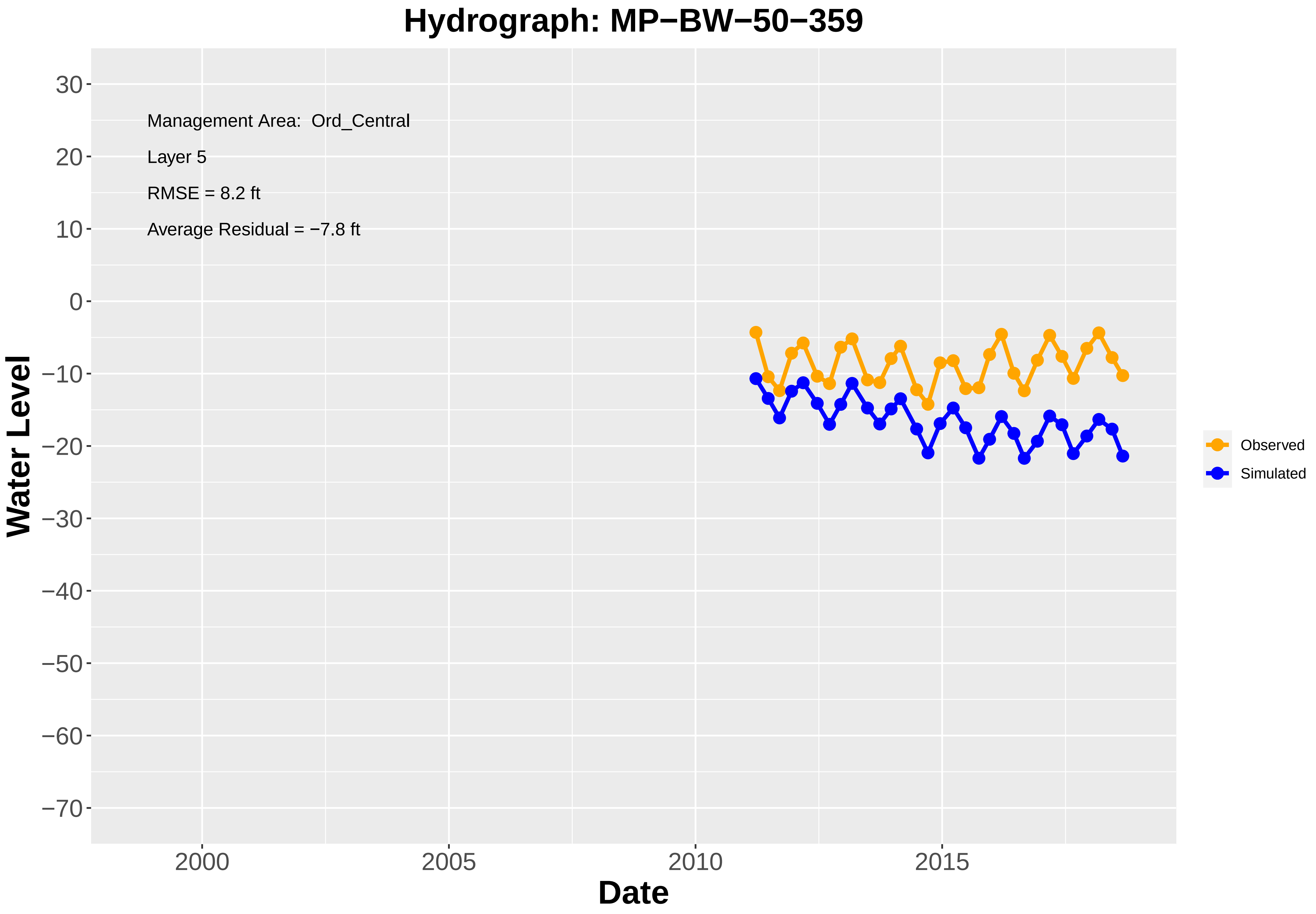

Hydrograph: MP−BW−49−400
Management Area: Ord_Central
Layer 5
RMSE = 8.3 ft
Average Residual = −7.8 ft
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

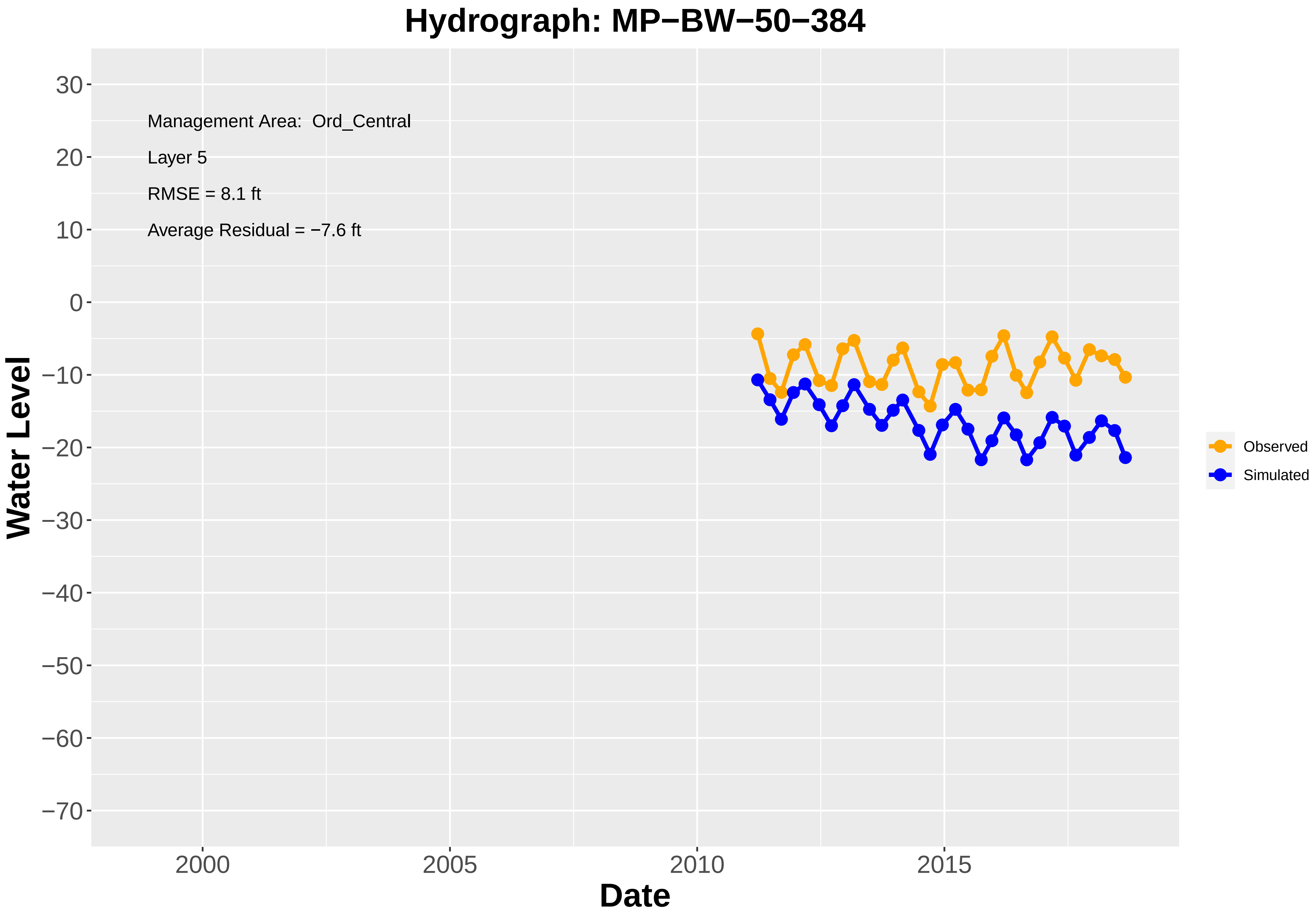

Hydrograph: MP−BW−50−289
Management Area: Ord_Central
Layer 5
RMSE = 8.4 ft
Average Residual = −7.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MP−BW−50−309
Management Area: Ord_Central
Layer 5
RMSE = 8.4 ft
Average Residual = −7.9 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

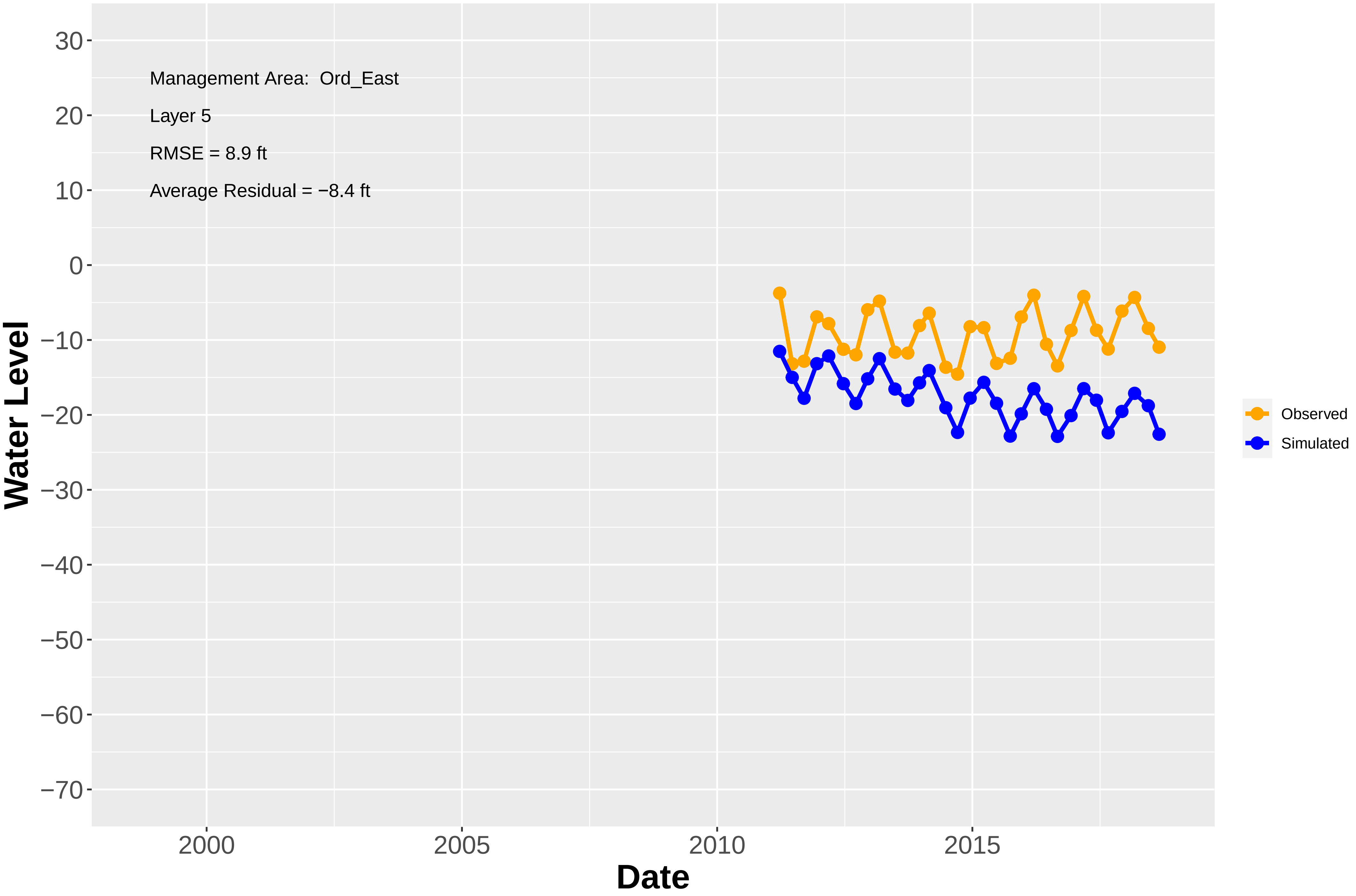
Hydrograph: MP−BW−50−339



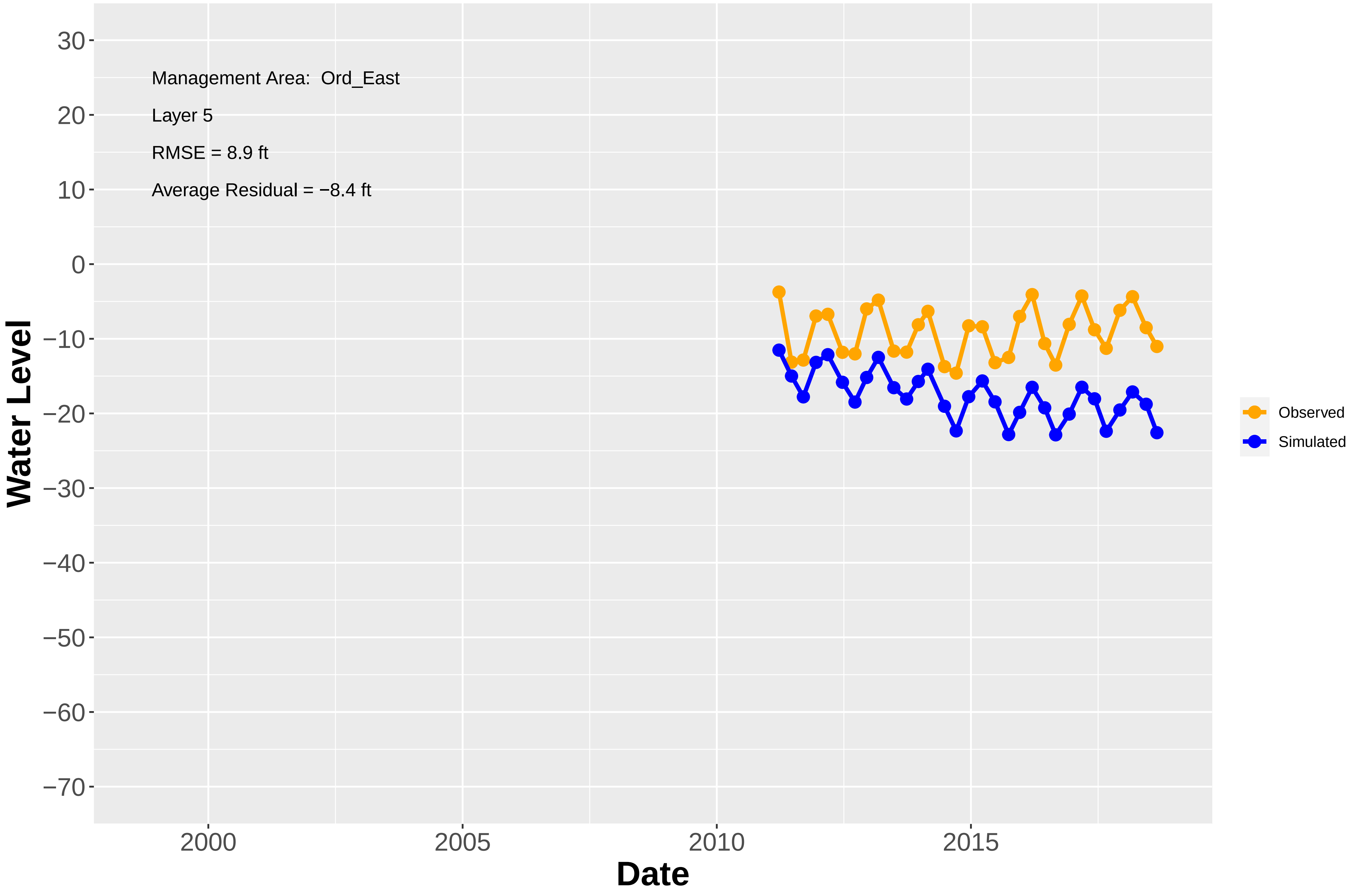

Hydrograph: MP−BW−50−359
Management Area: Ord_Central
Layer 5
RMSE = 8.2 ft
Average Residual = −7.8 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

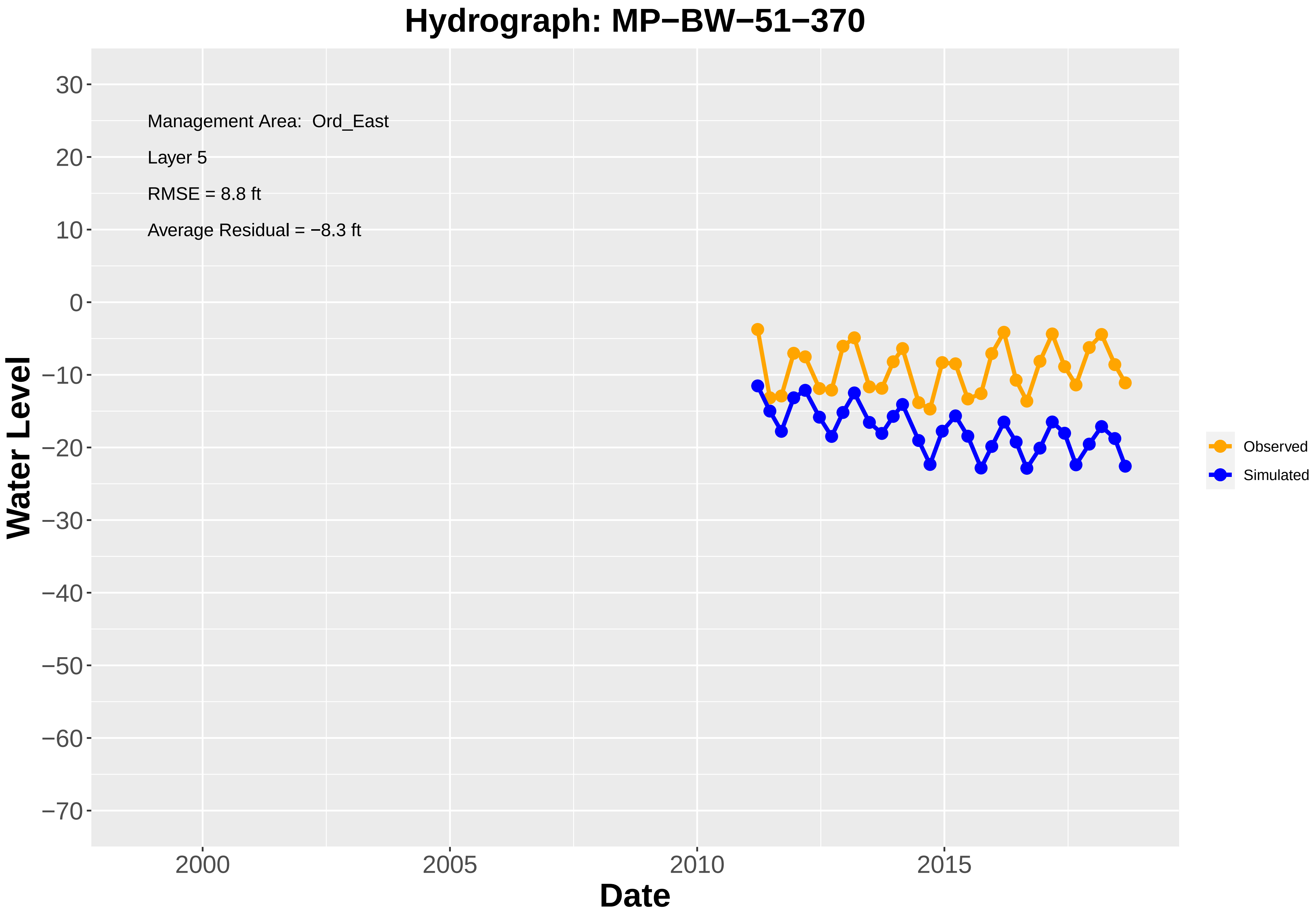

Hydrograph: MP−BW−50−384
Management Area: Ord_Central
Layer 5
RMSE = 8.1 ft
Average Residual = −7.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

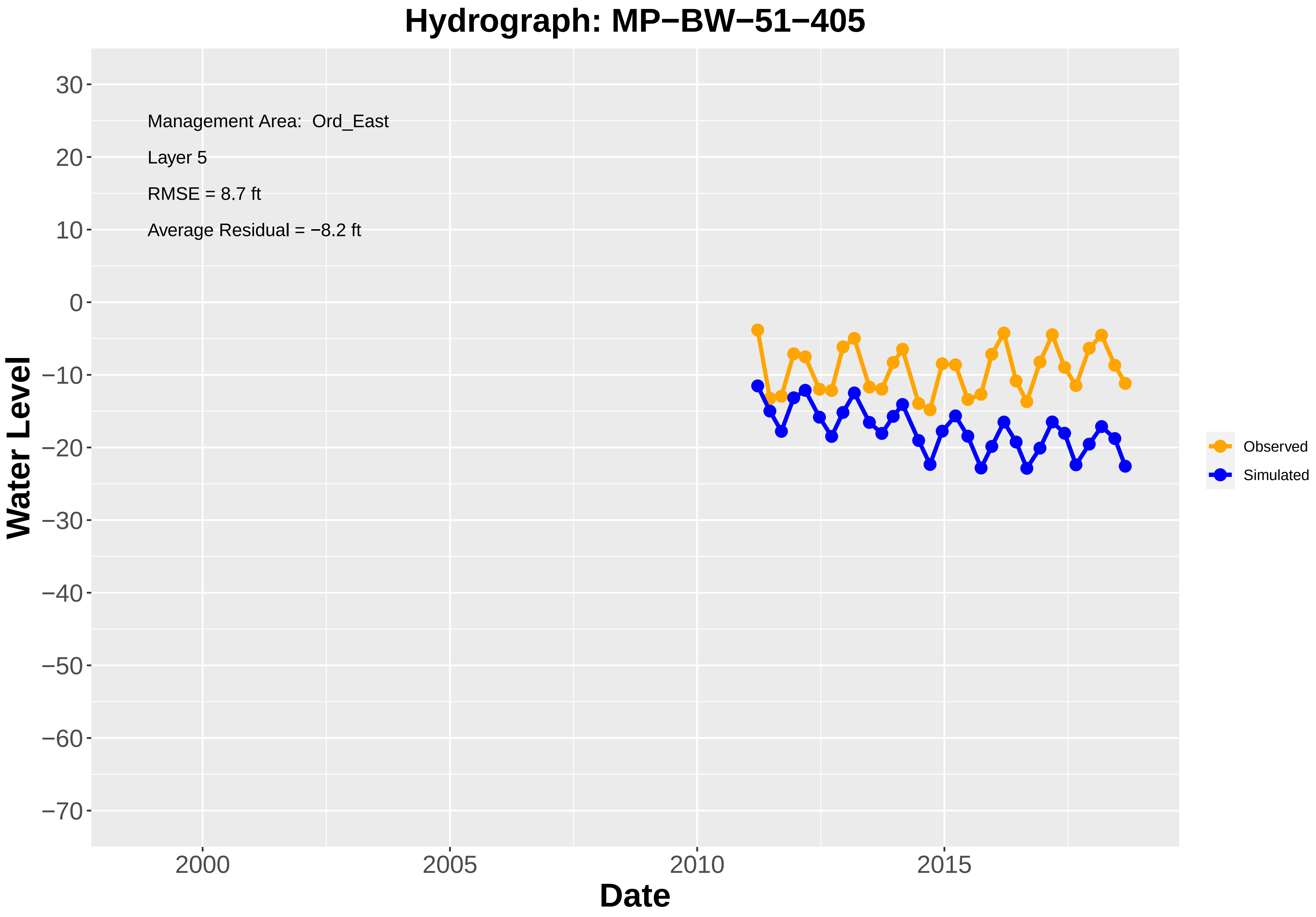
Hydrograph: MP−BW−51−315

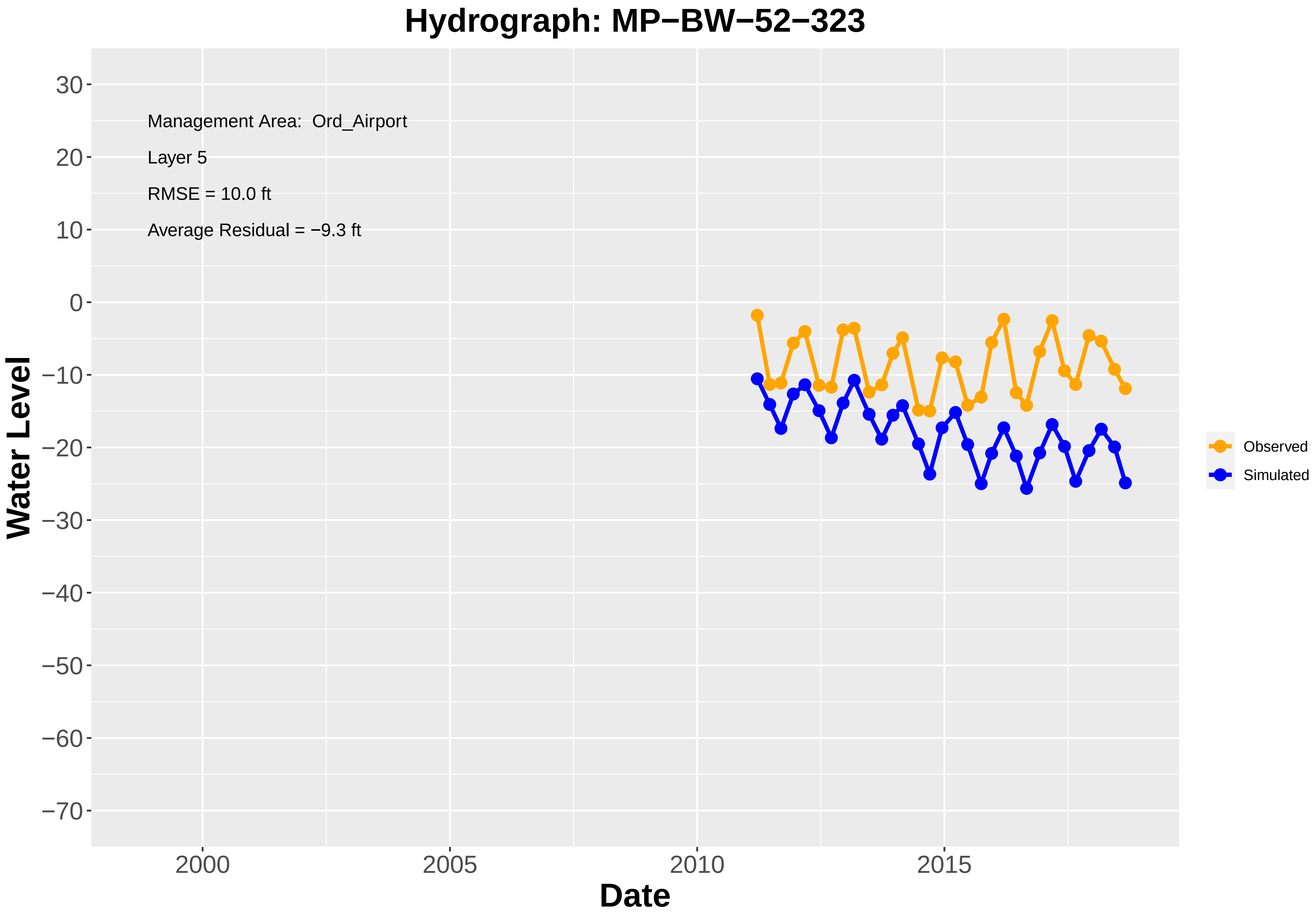


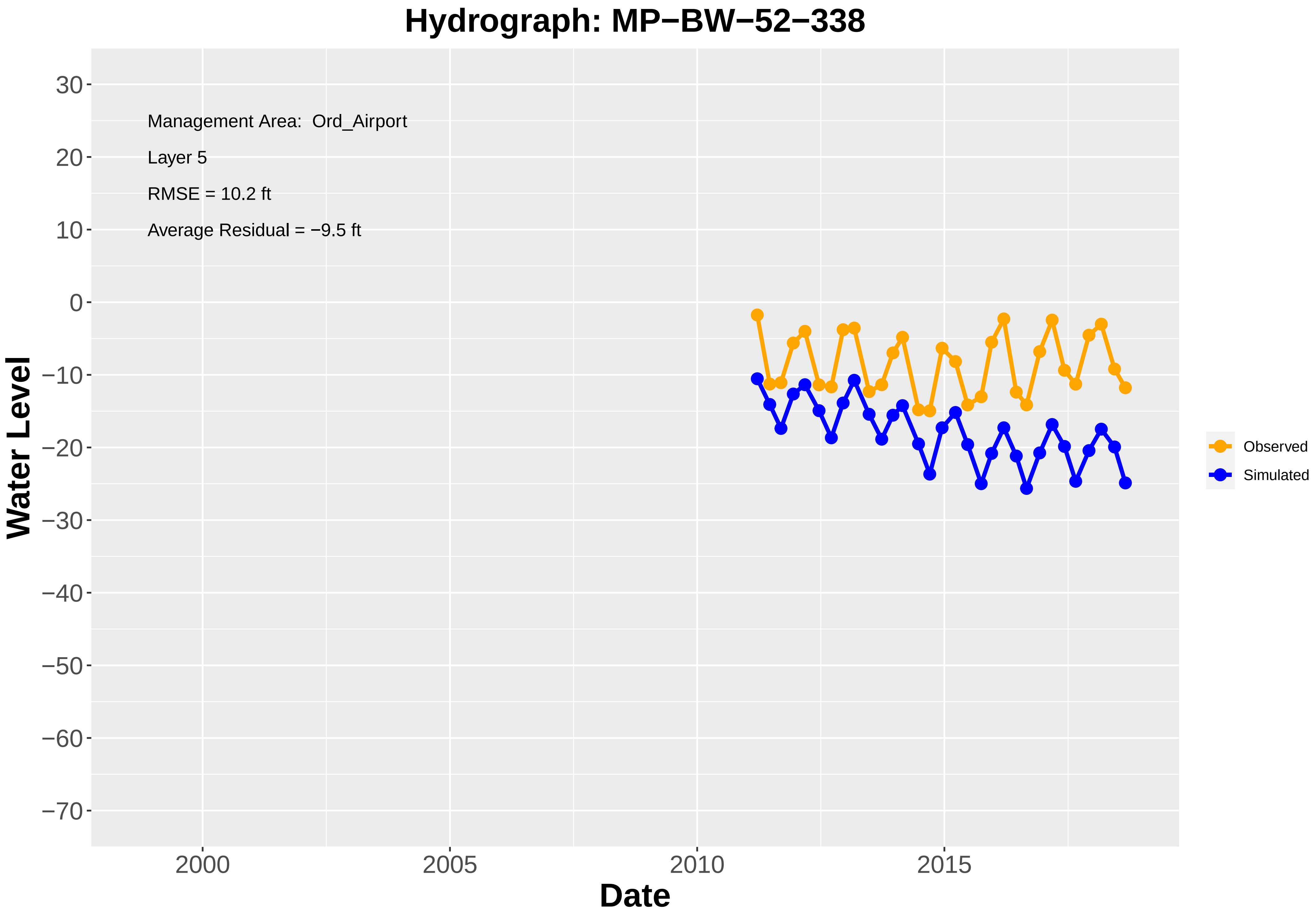
Hydrograph: MP−BW−51−340

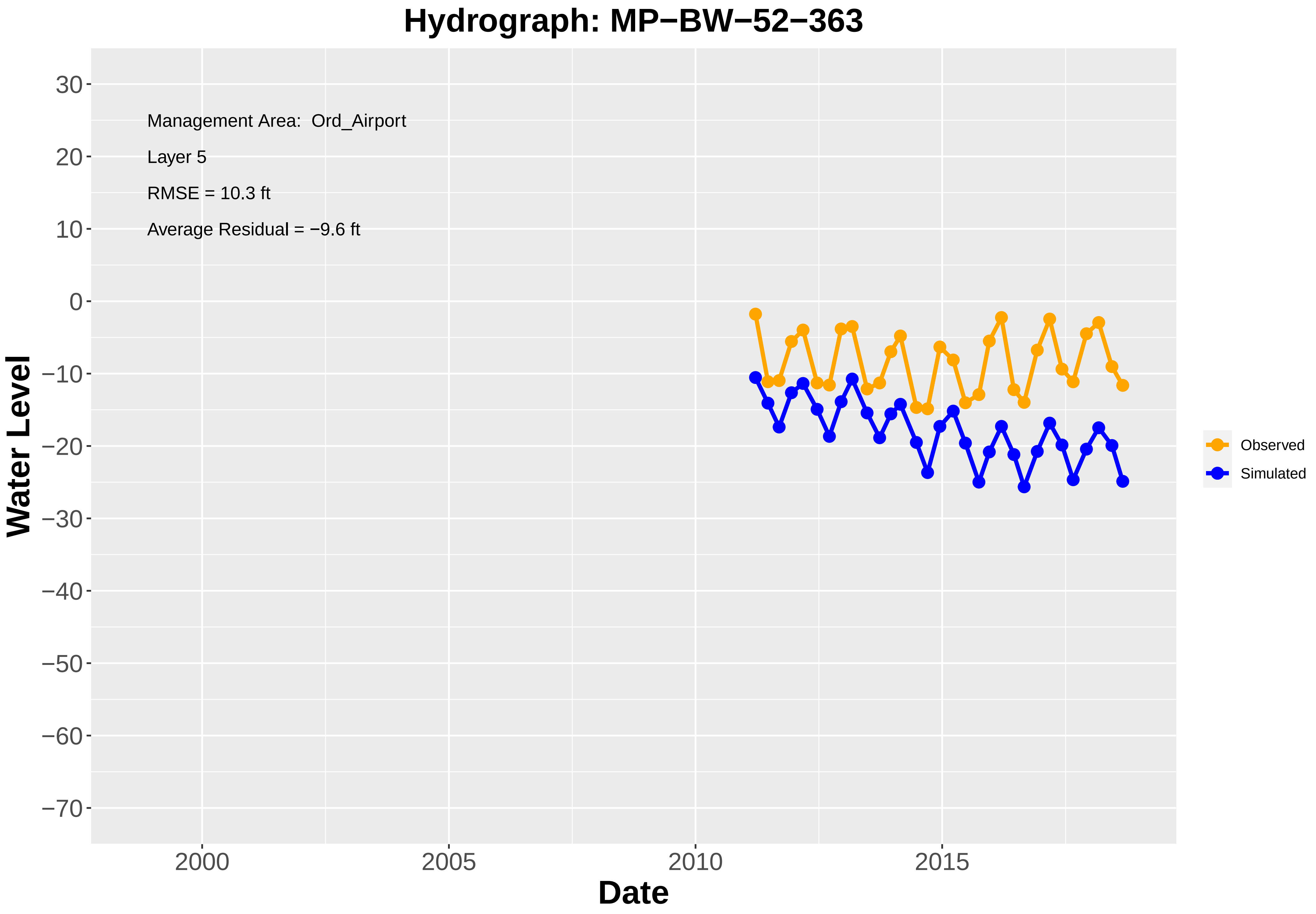


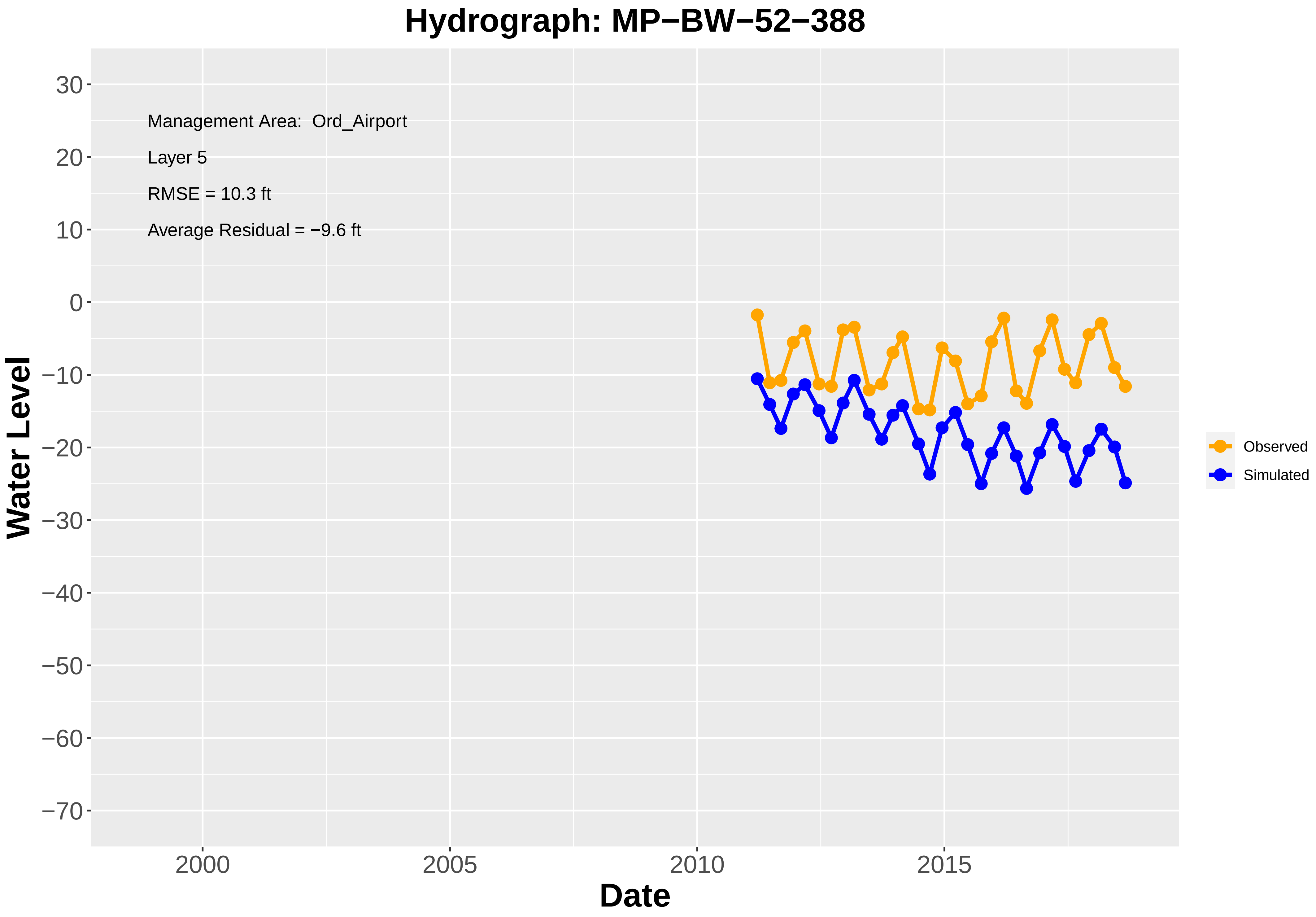

Hydrograph: MP−BW−51−370
Management Area: Ord_East
Layer 5
RMSE = 8.8 ft
Average Residual = −8.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

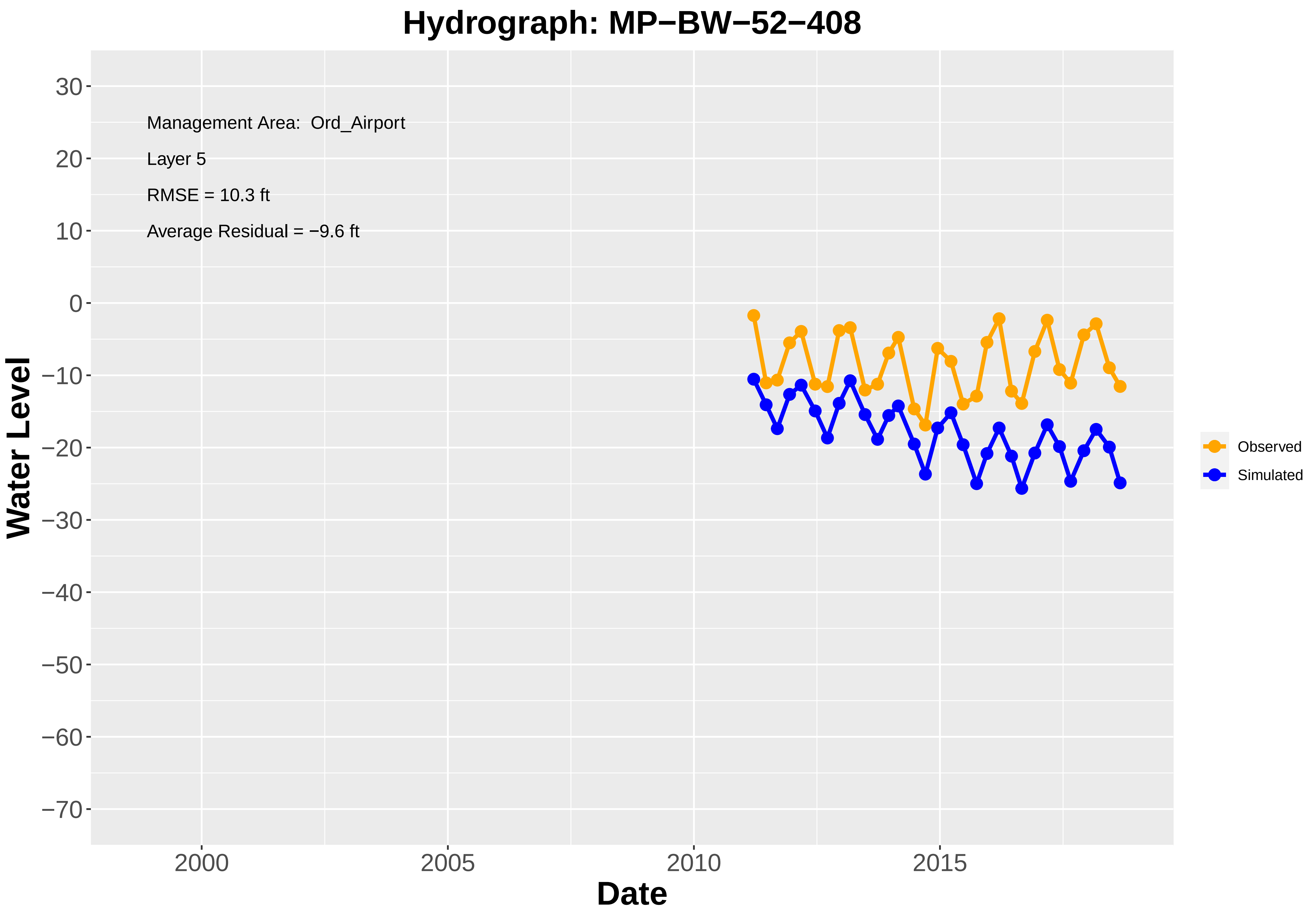

Hydrograph: MP−BW−51−405
Management Area: Ord_East
Layer 5
RMSE = 8.7 ft
Average Residual = −8.2 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Date
Observed
Simulated

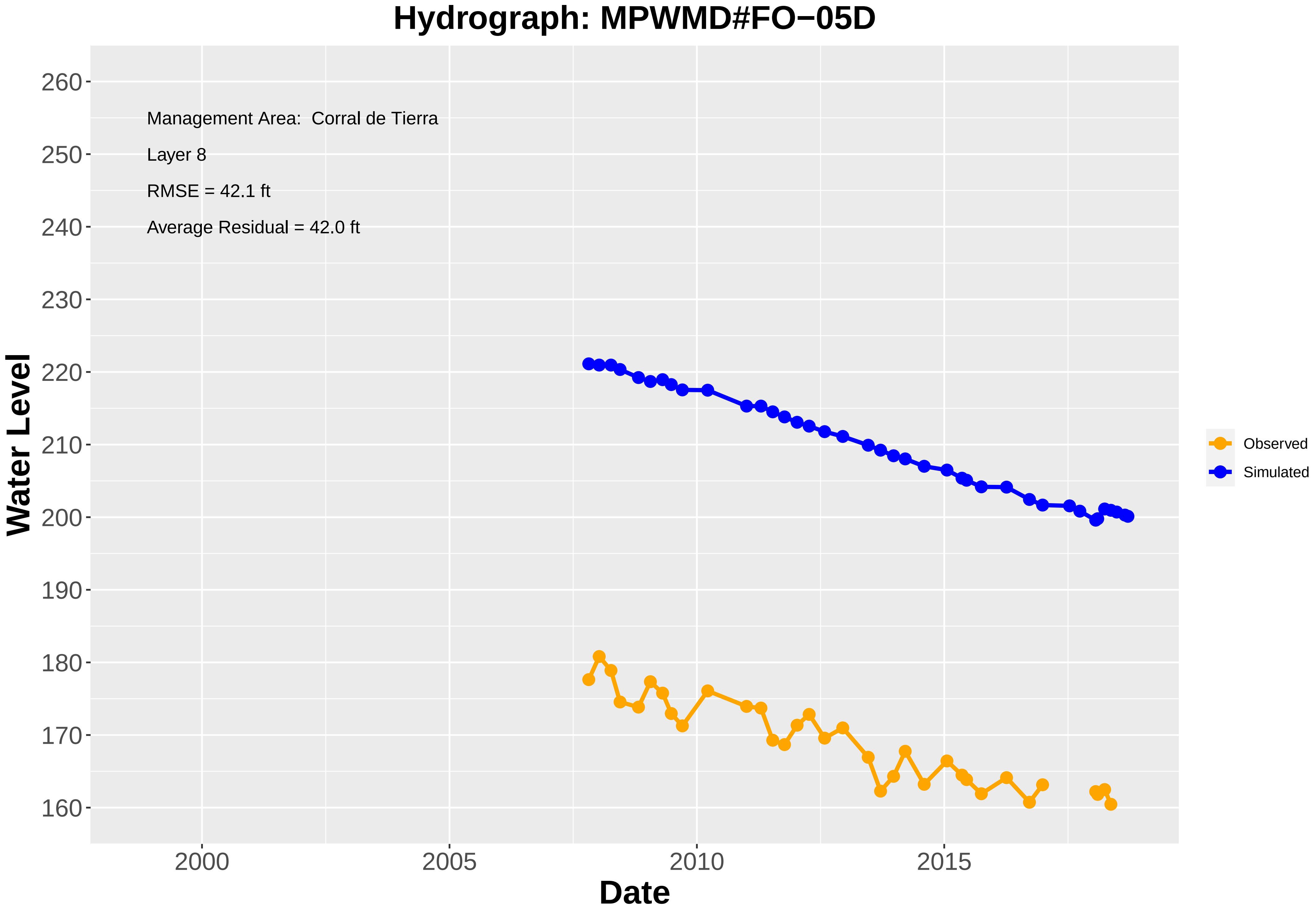

Hydrograph: MP−BW−52−323
Management Area: Ord_Airport
Layer 5
RMSE = 10.0 ft
Average Residual = −9.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

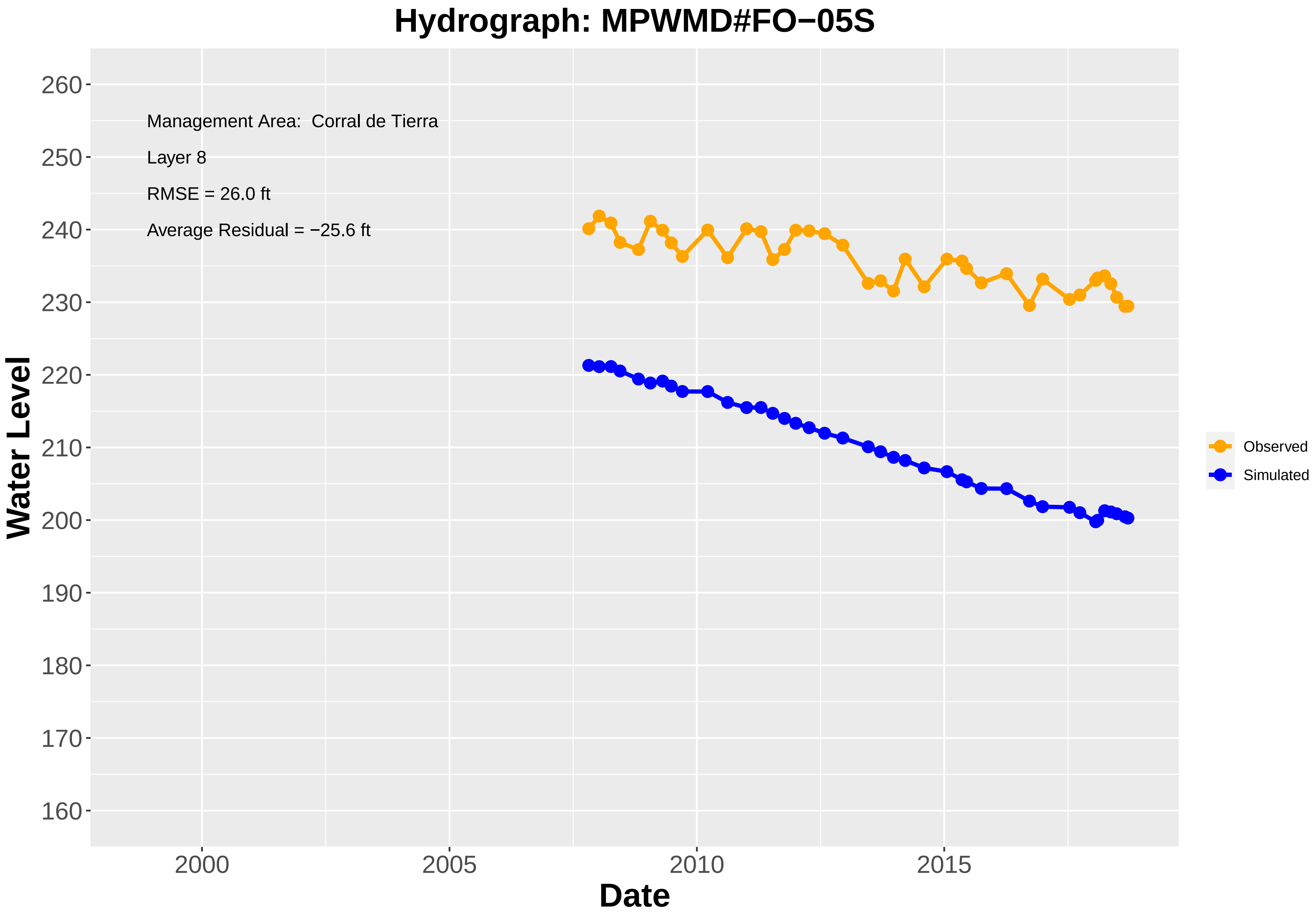

Hydrograph: MP−BW−52−338
Management Area: Ord_Airport
Layer 5
RMSE = 10.2 ft
Average Residual = −9.5 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

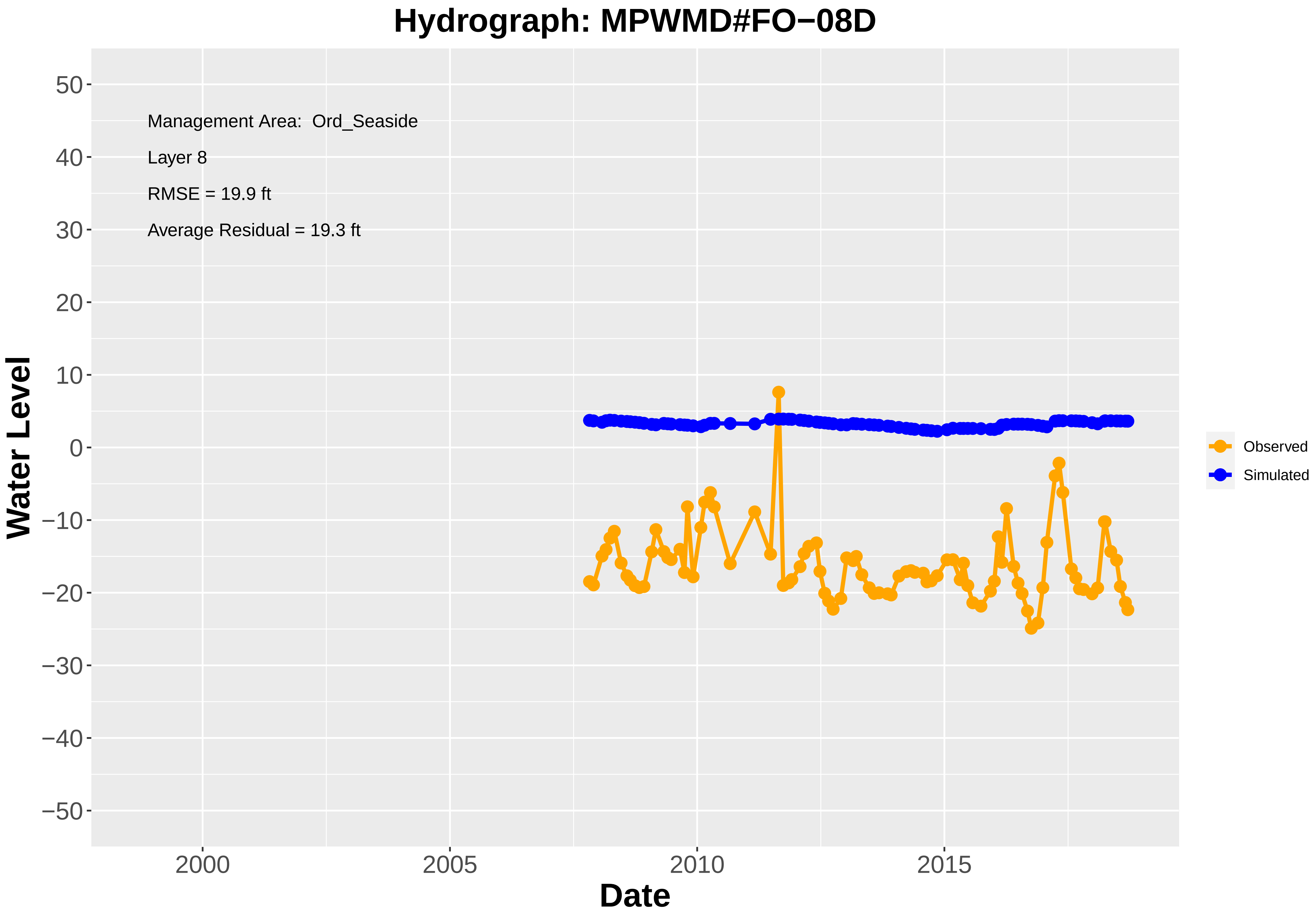

Hydrograph: MP−BW−52−363
Management Area: Ord_Airport
Layer 5
RMSE = 10.3 ft
Average Residual = −9.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

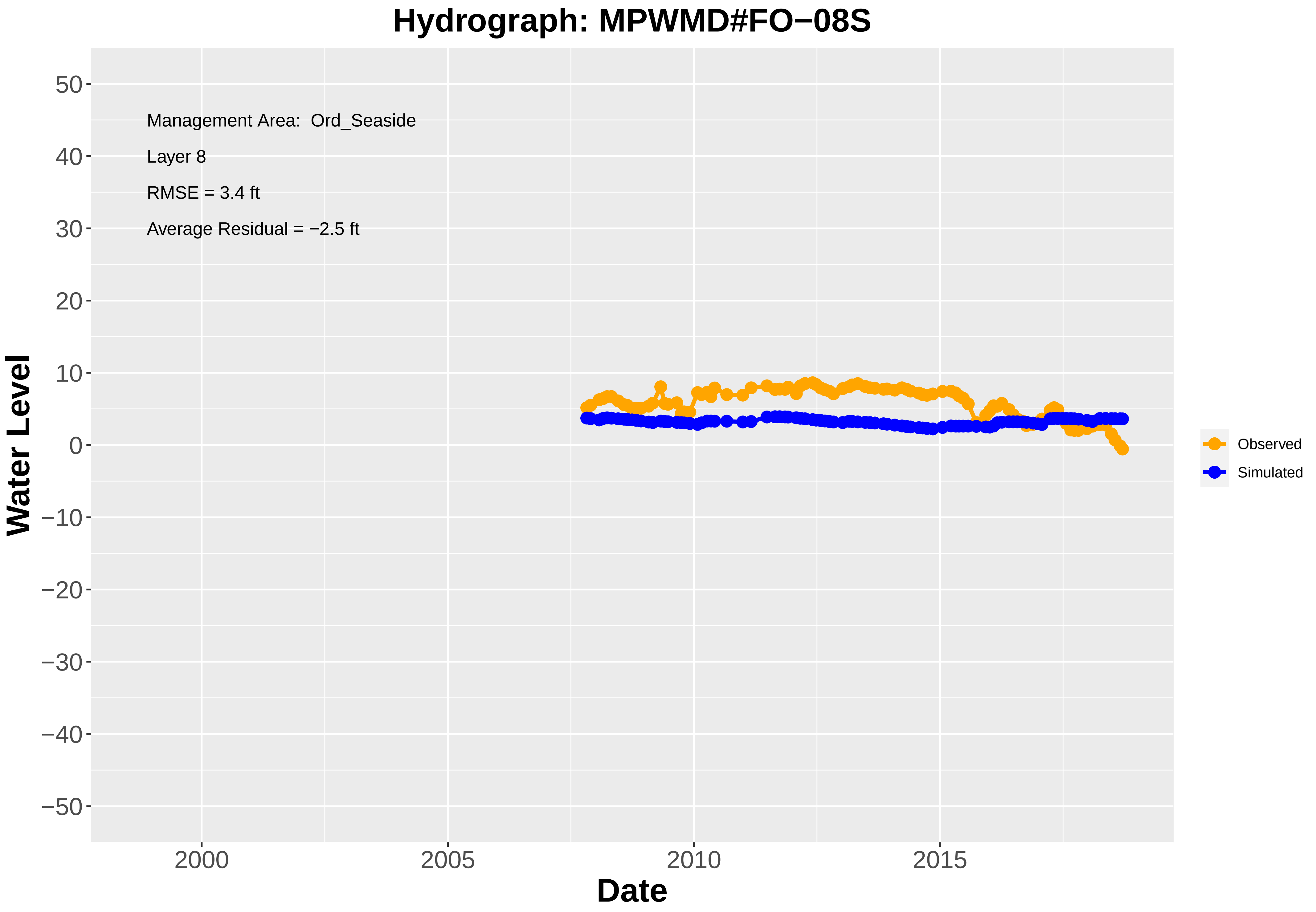

Hydrograph: MP−BW−52−388
Management Area: Ord_Airport
Layer 5
RMSE = 10.3 ft
Average Residual = −9.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

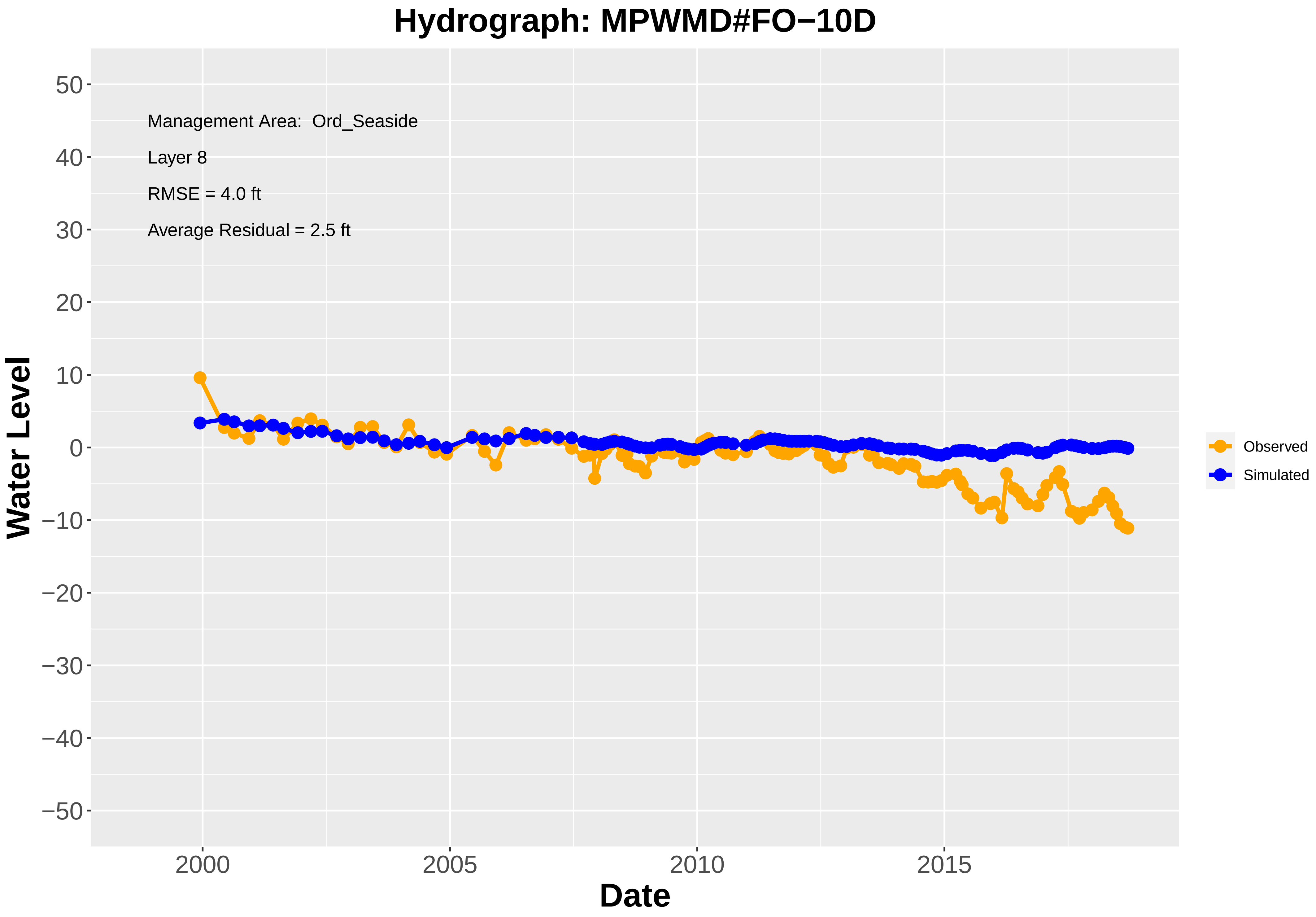

Hydrograph: MP−BW−52−408
Management Area: Ord_Airport
Layer 5
RMSE = 10.3 ft
Average Residual = −9.6 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

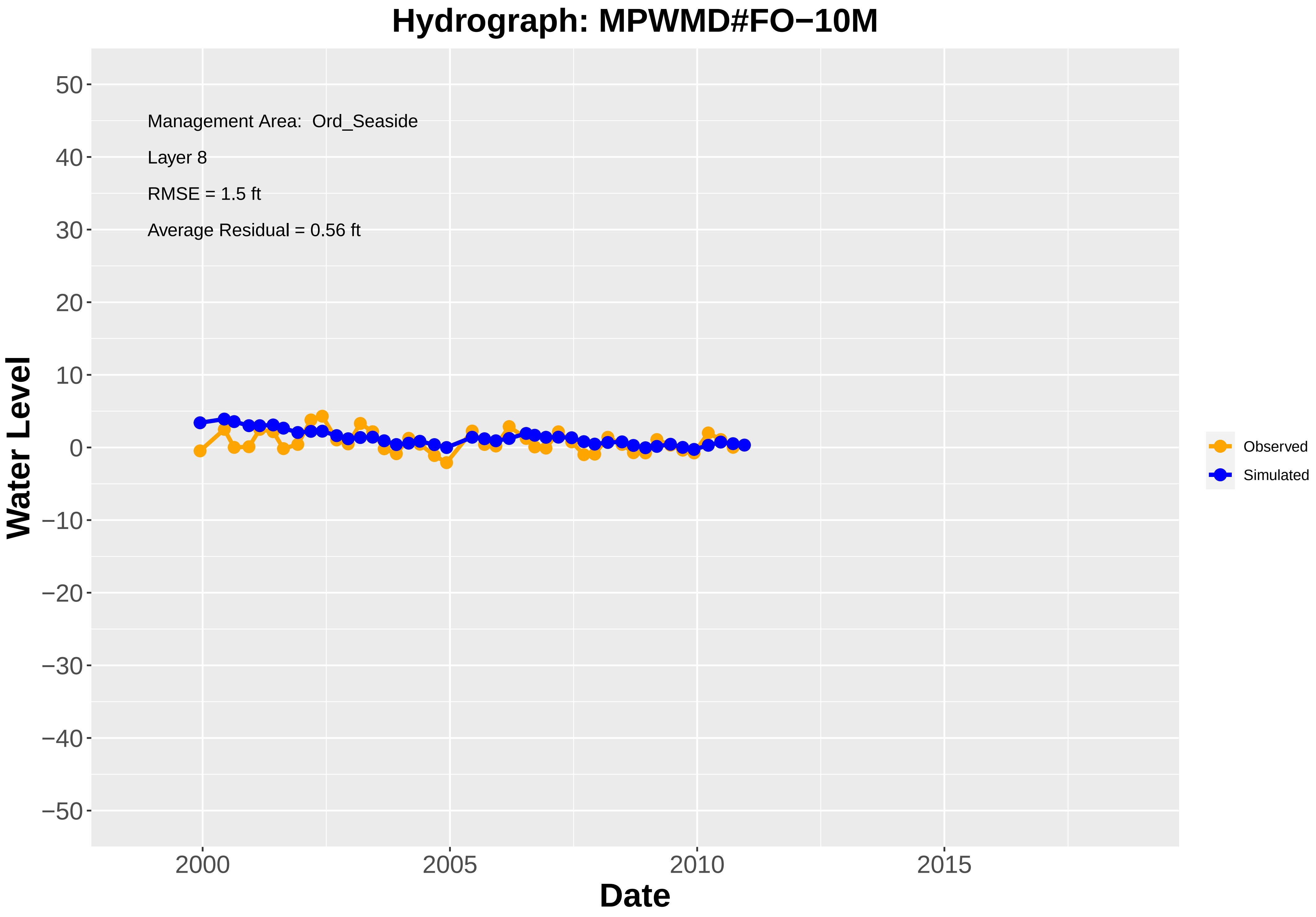

Hydrograph: MPWMD#FO−05D
Management Area: Corral de Tierra
Layer 8
RMSE = 42.1 ft
Average Residual = 42.0 ft
Water Level
260
250
240
230
220
210
200
190
180
170
160
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MPWMD#FO−05S
Management Area: Corral de Tierra
Layer 8
RMSE = 26.0 ft
Average Residual = −25.6 ft
Water Level
260
250
240
230
220
210
200
190
180
170
160
Date
2000
2005
2010
2015
Observed
Simulated

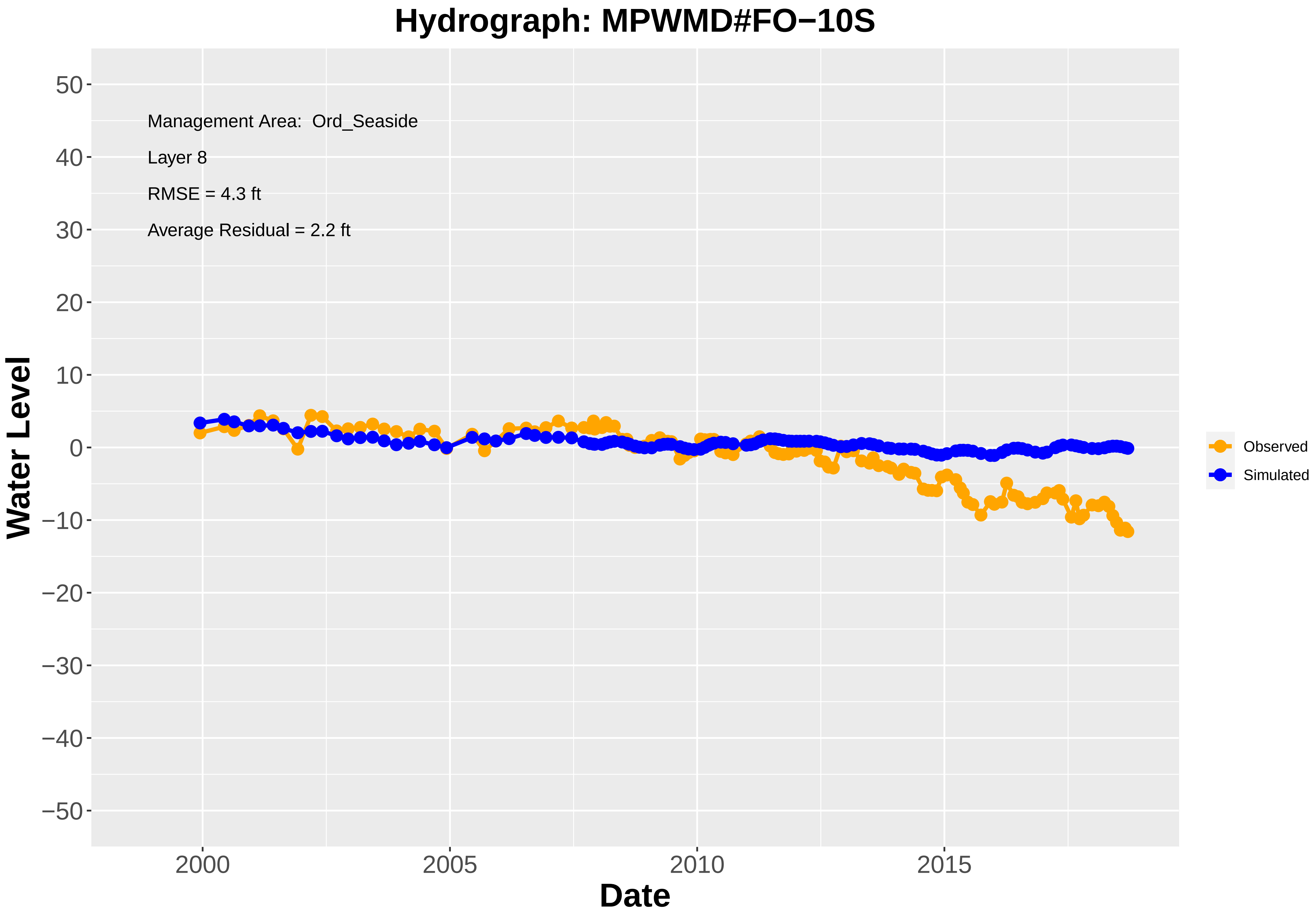

Hydrograph: MPWMD#FO−08D
Management Area: Ord_Seaside
Layer 8
RMSE = 19.9 ft
Average Residual = 19.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

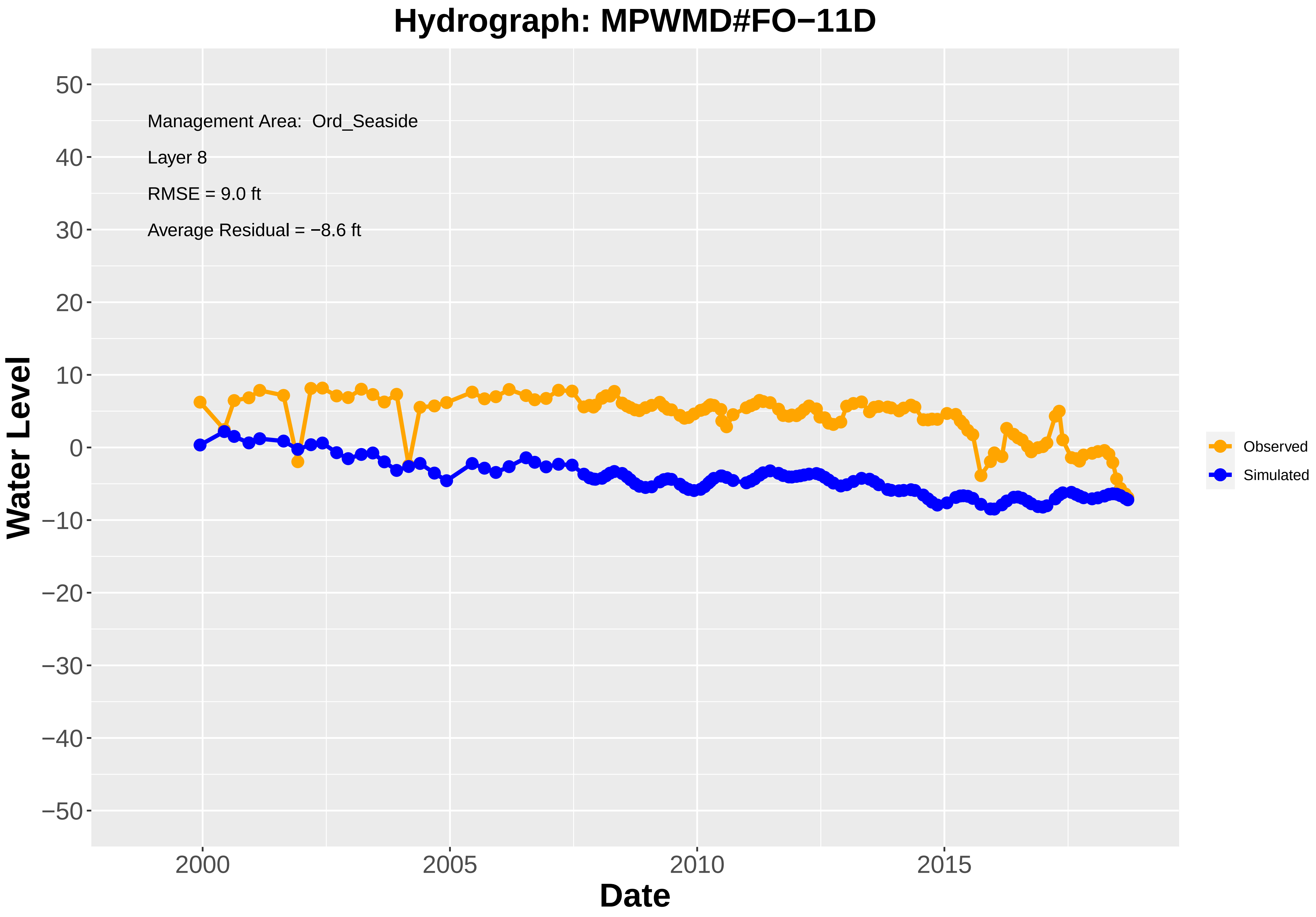

Hydrograph: MPWMD#FO−08S
Management Area: Ord_Seaside
Layer 8
RMSE = 3.4 ft
Average Residual = −2.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

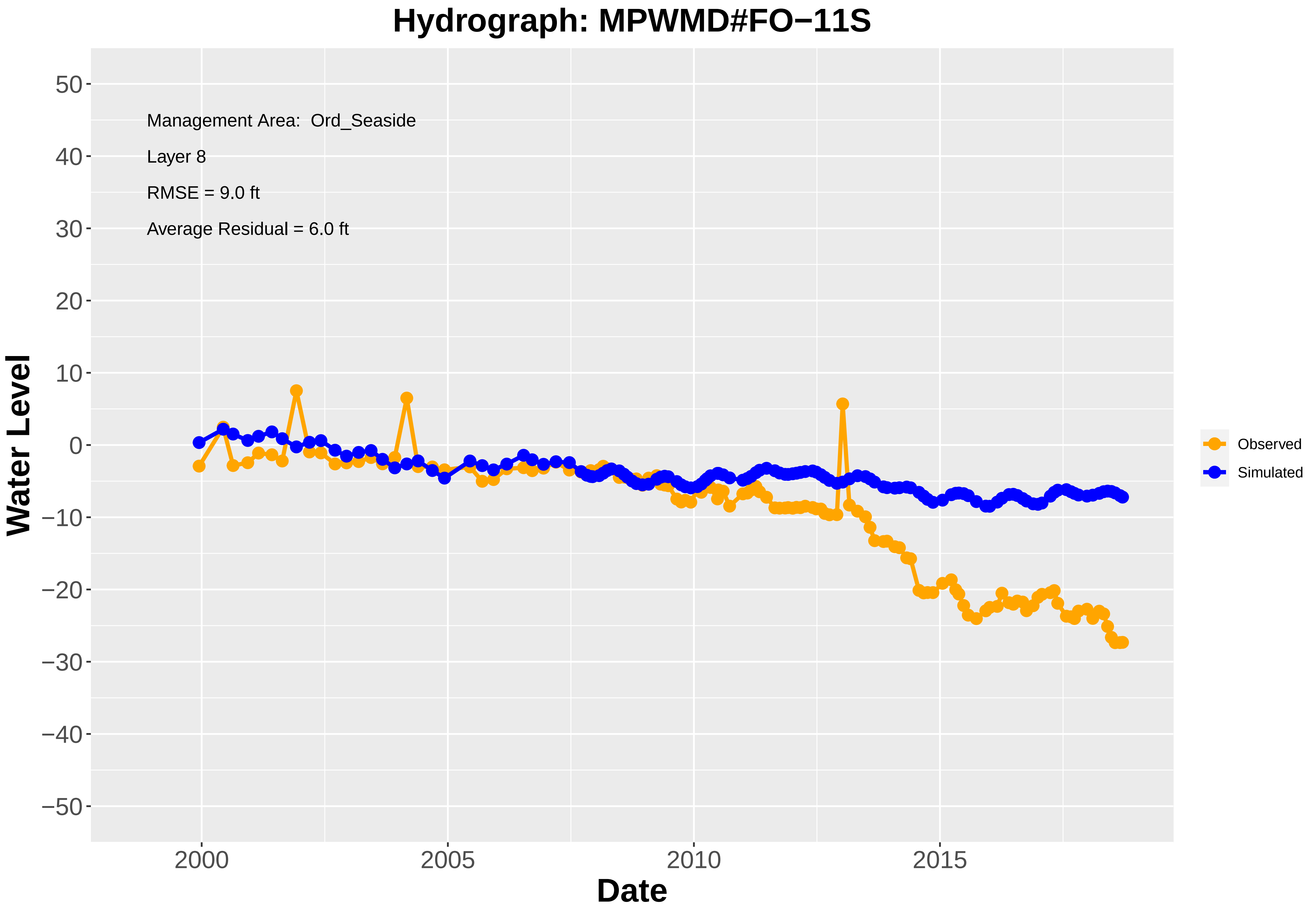

Hydrograph: MPWMD#FO−10D
Management Area: Ord_Seaside
Layer 8
RMSE = 4.0 ft
Average Residual = 2.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated



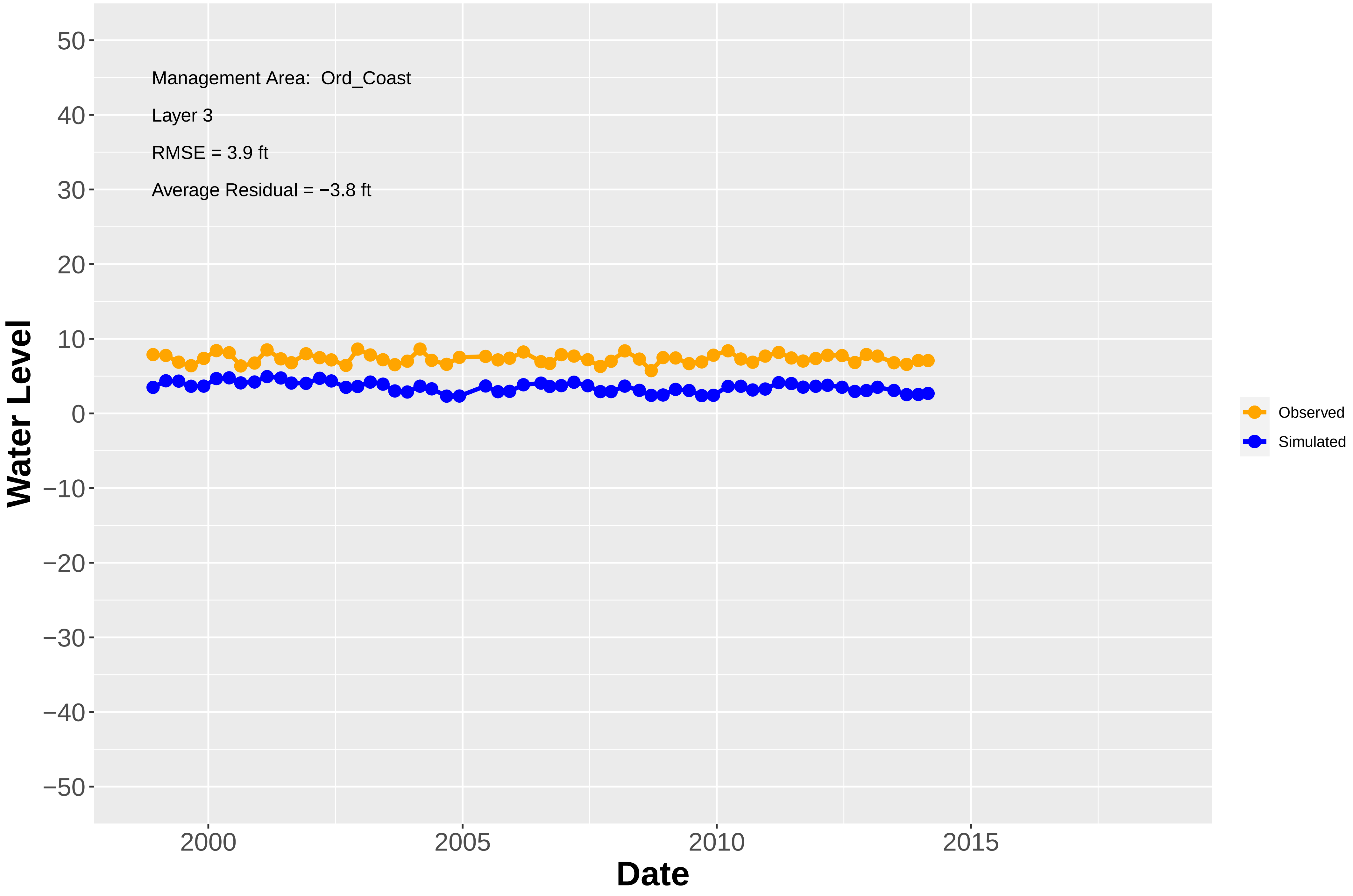
Hydrograph: MPWMD#FO−10M
Management Area: Ord_Seaside
Layer 8
RMSE = 1.5 ft
Average Residual = 0.56 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

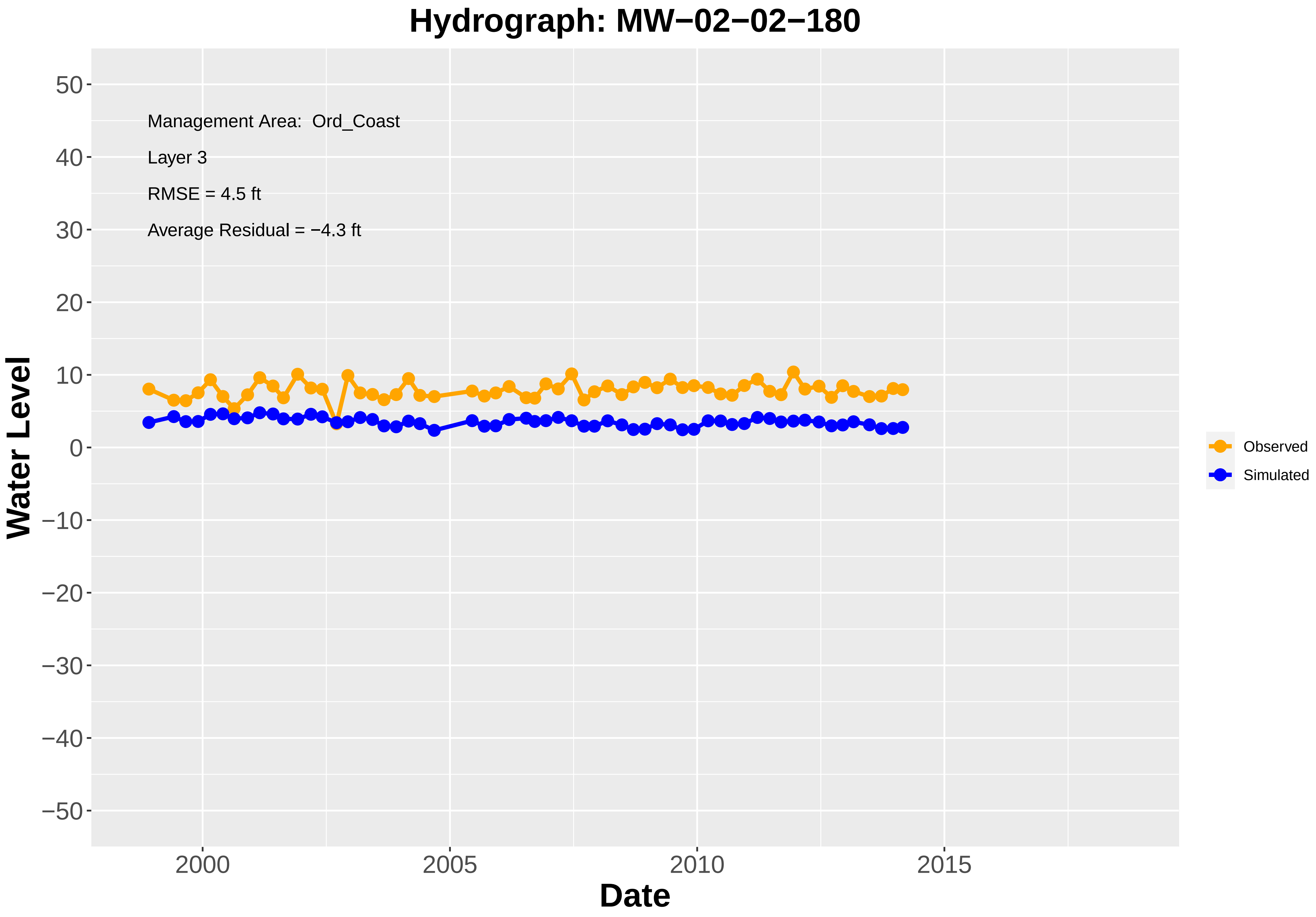

Hydrograph: MPWMD#FO−10S
Management Area: Ord_Seaside
Layer 8
RMSE = 4.3 ft
Average Residual = 2.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

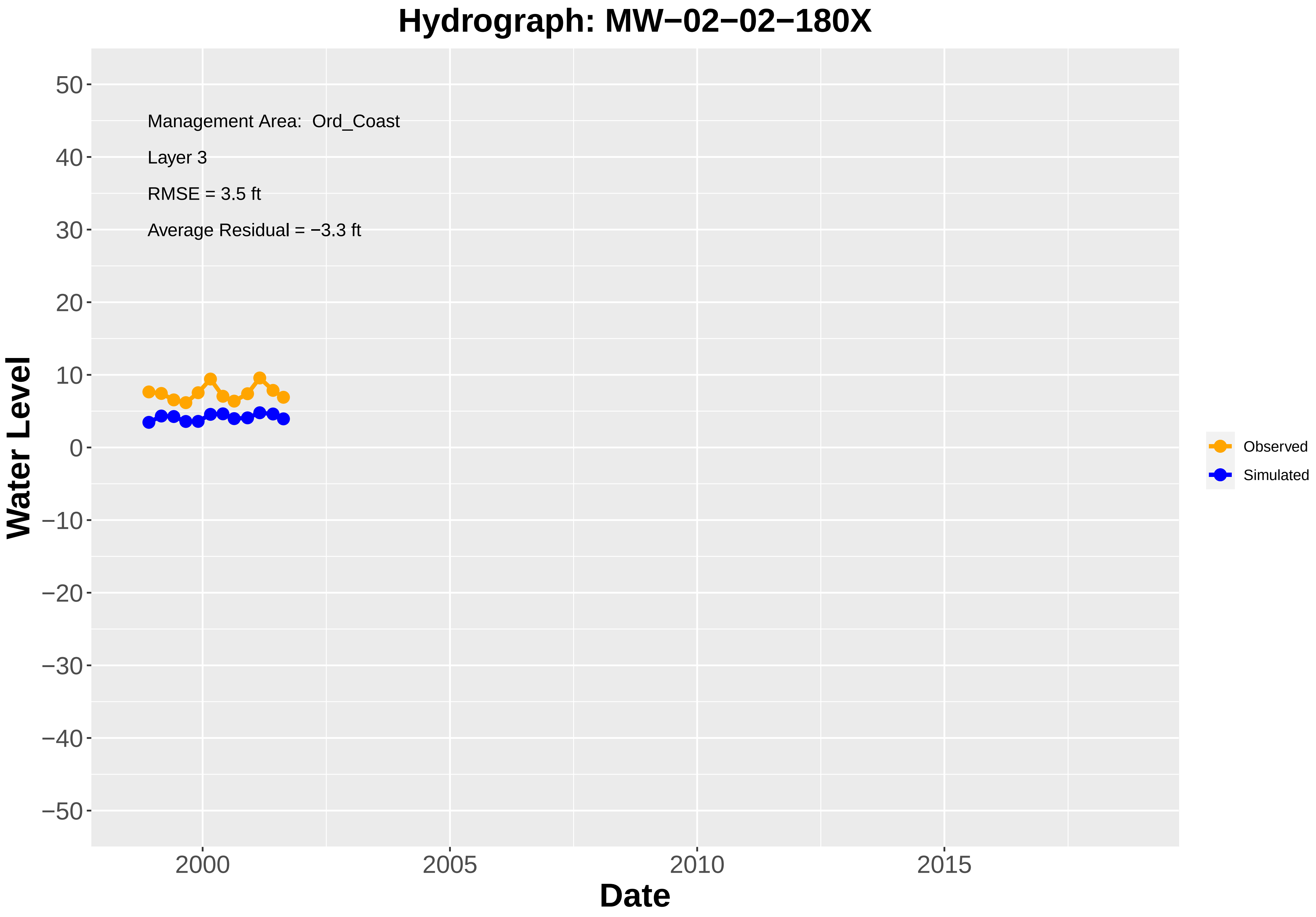

Hydrograph: MPWMD#FO−11D
Management Area: Ord_Seaside
Layer 8
RMSE = 9.0 ft
Average Residual = −8.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

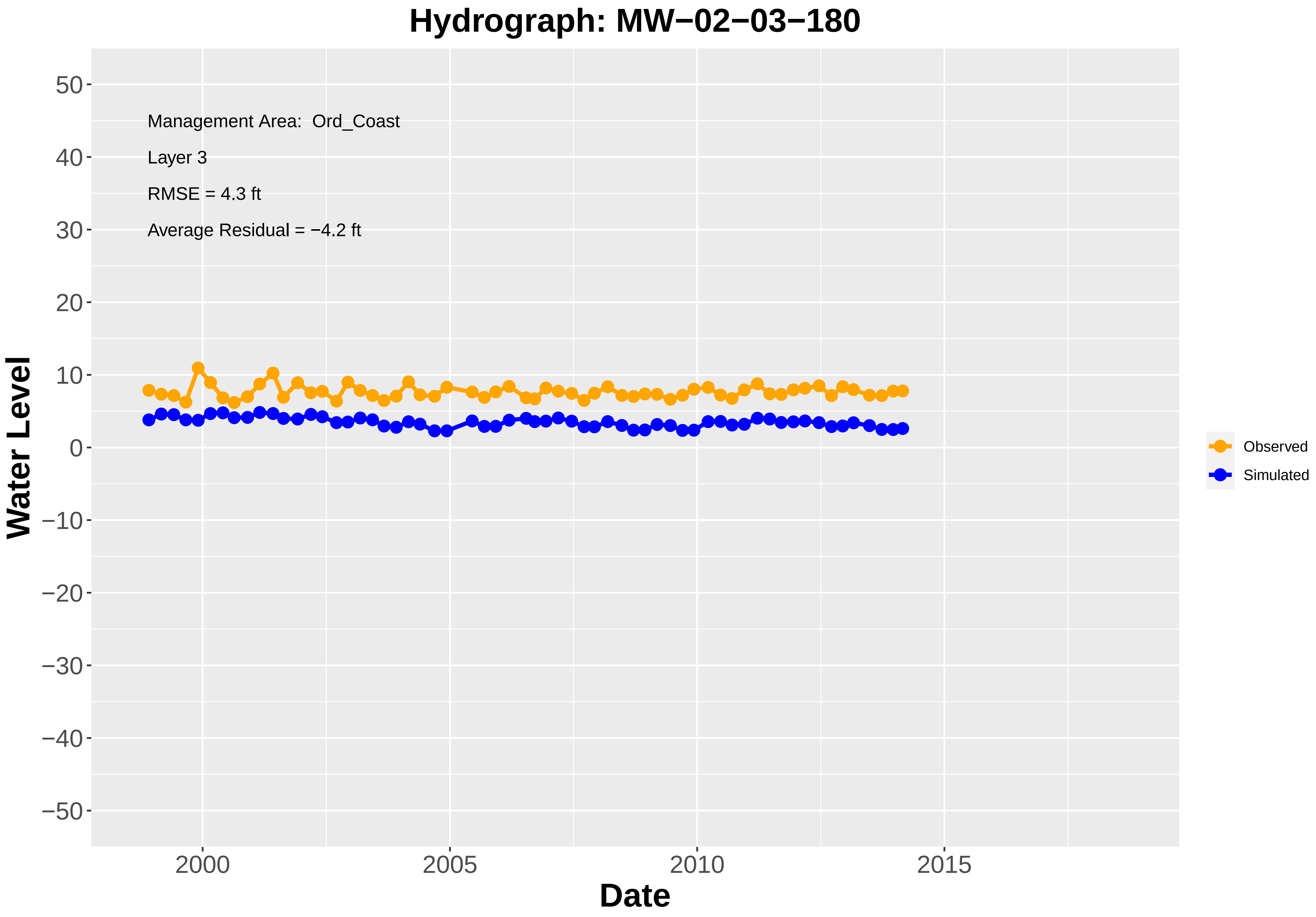

Hydrograph: MPWMD#FO−11S
Management Area: Ord_Seaside
Layer 8
RMSE = 9.0 ft
Average Residual = 6.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

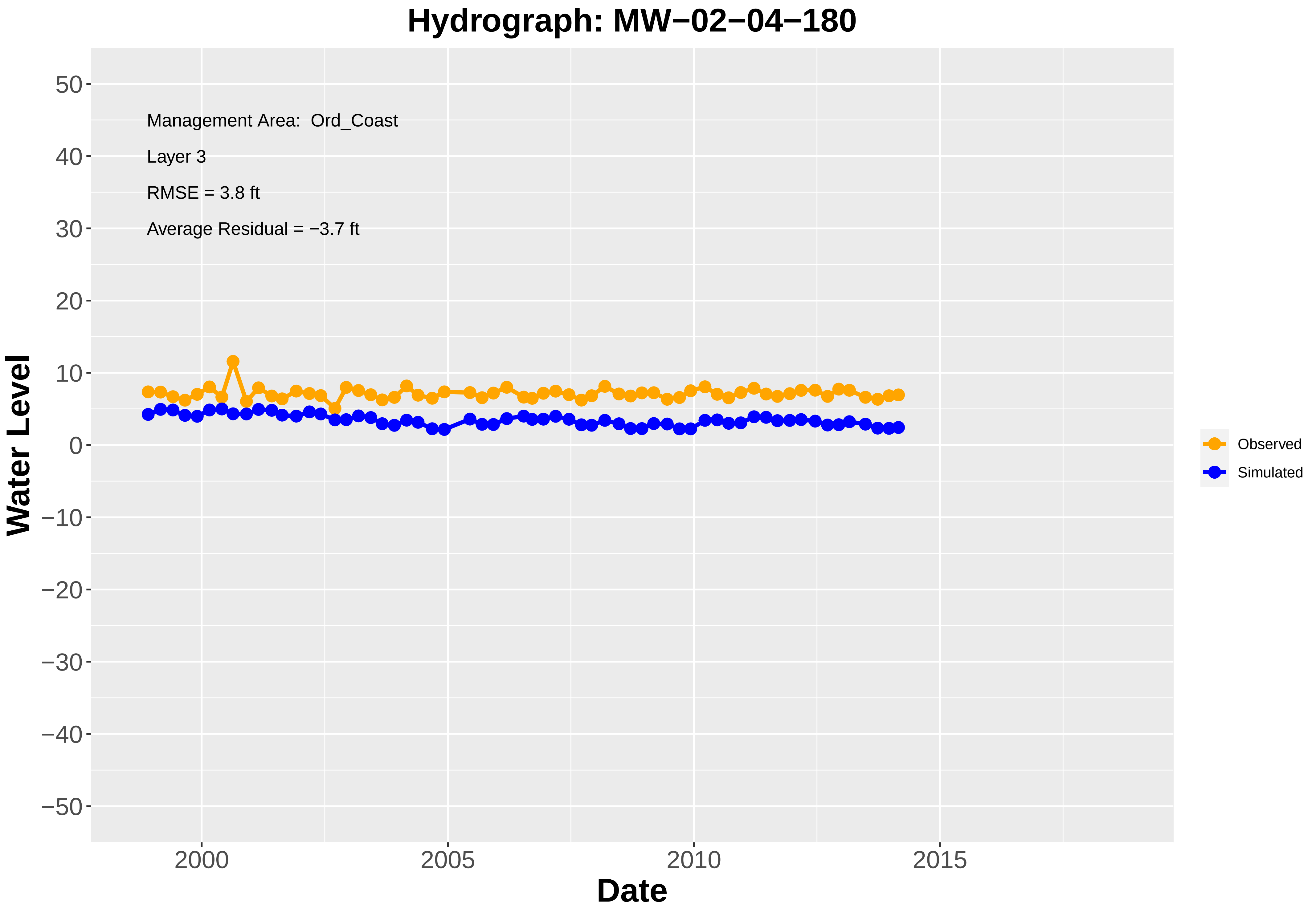
Hydrograph: MW−02−01−180

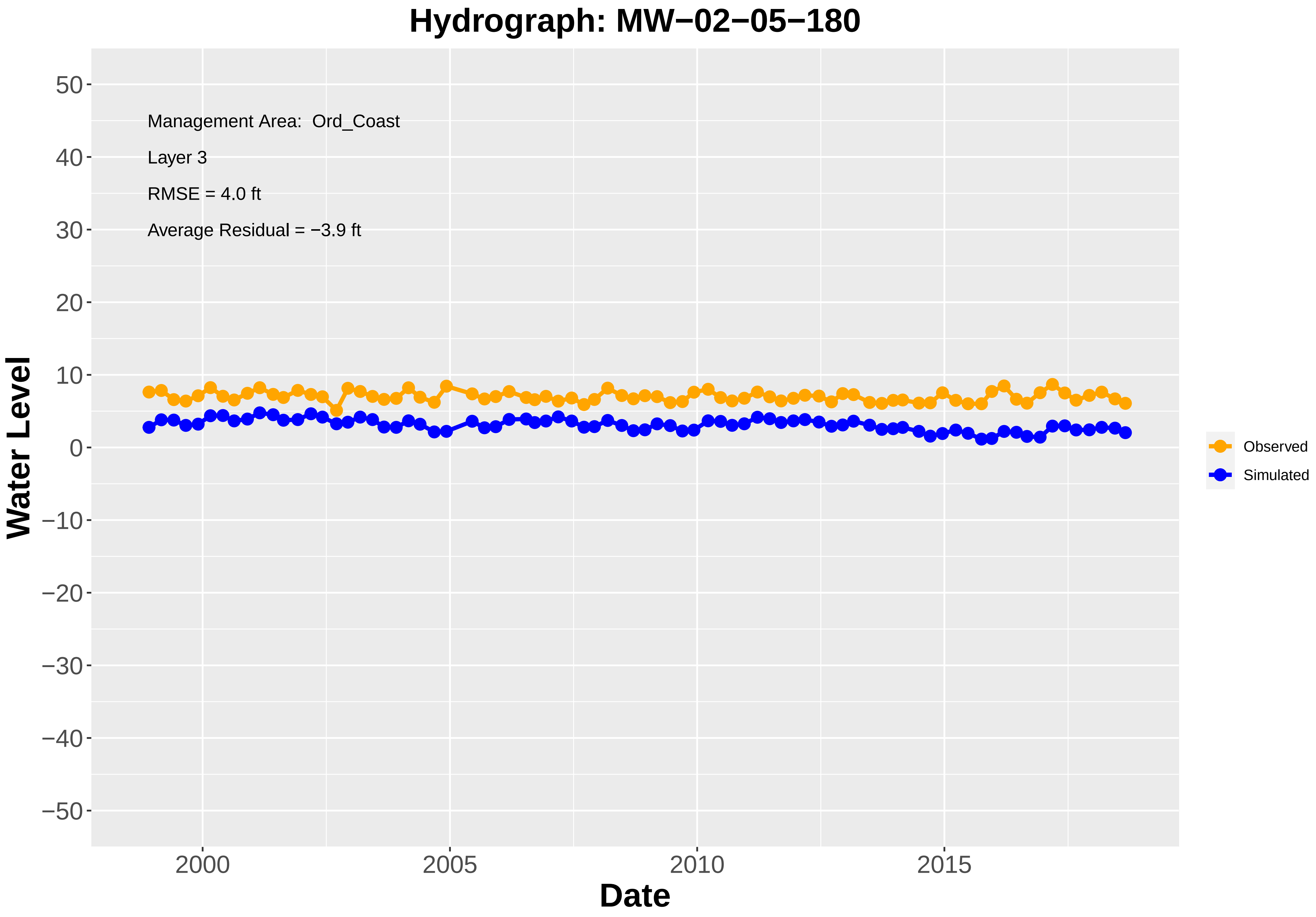



Hydrograph: MW−02−02−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.5 ft
Average Residual = −4.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

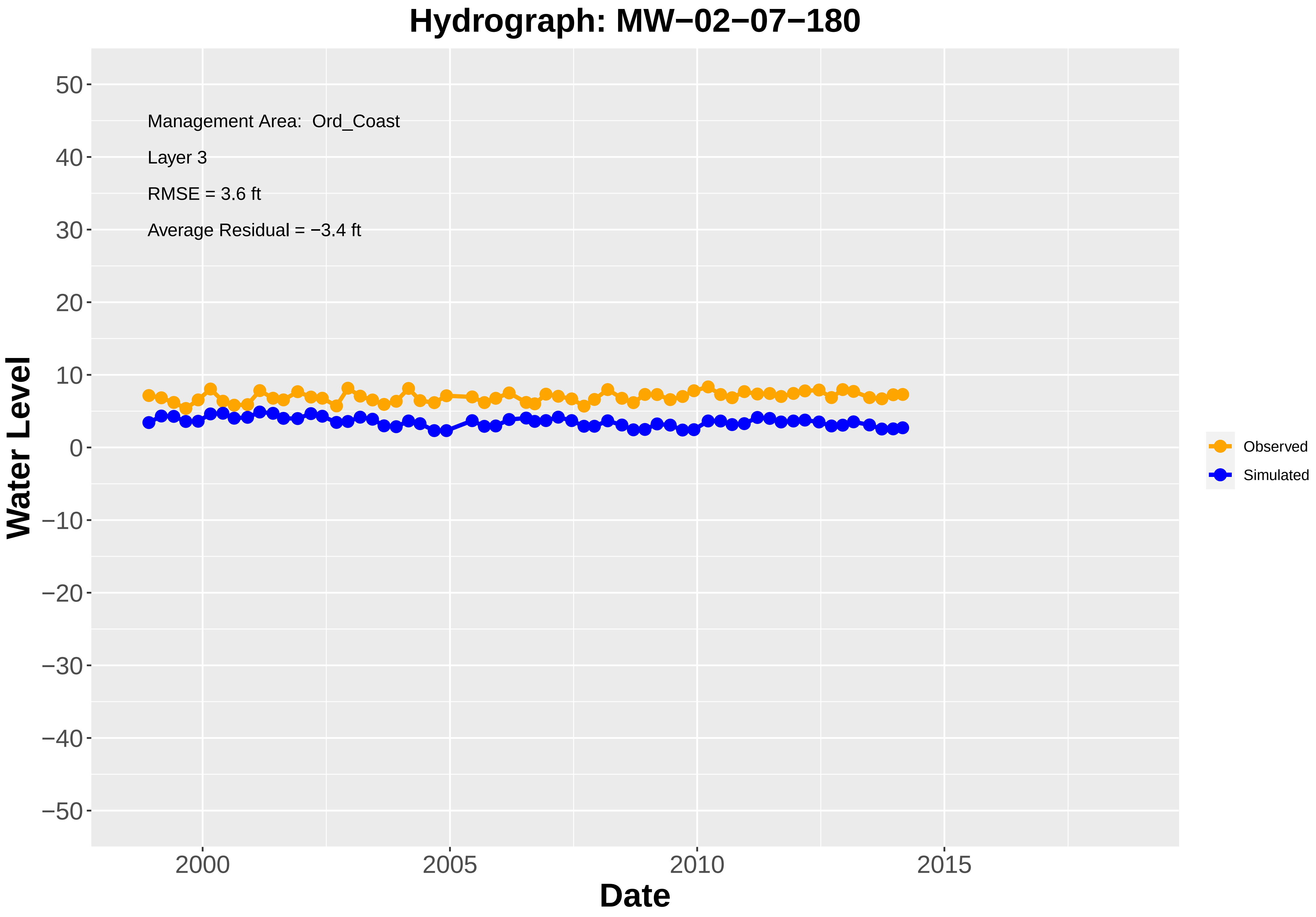

Hydrograph: MW−02−02−180X
Management Area: Ord_Coast
Layer 3
RMSE = 3.5 ft
Average Residual = −3.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

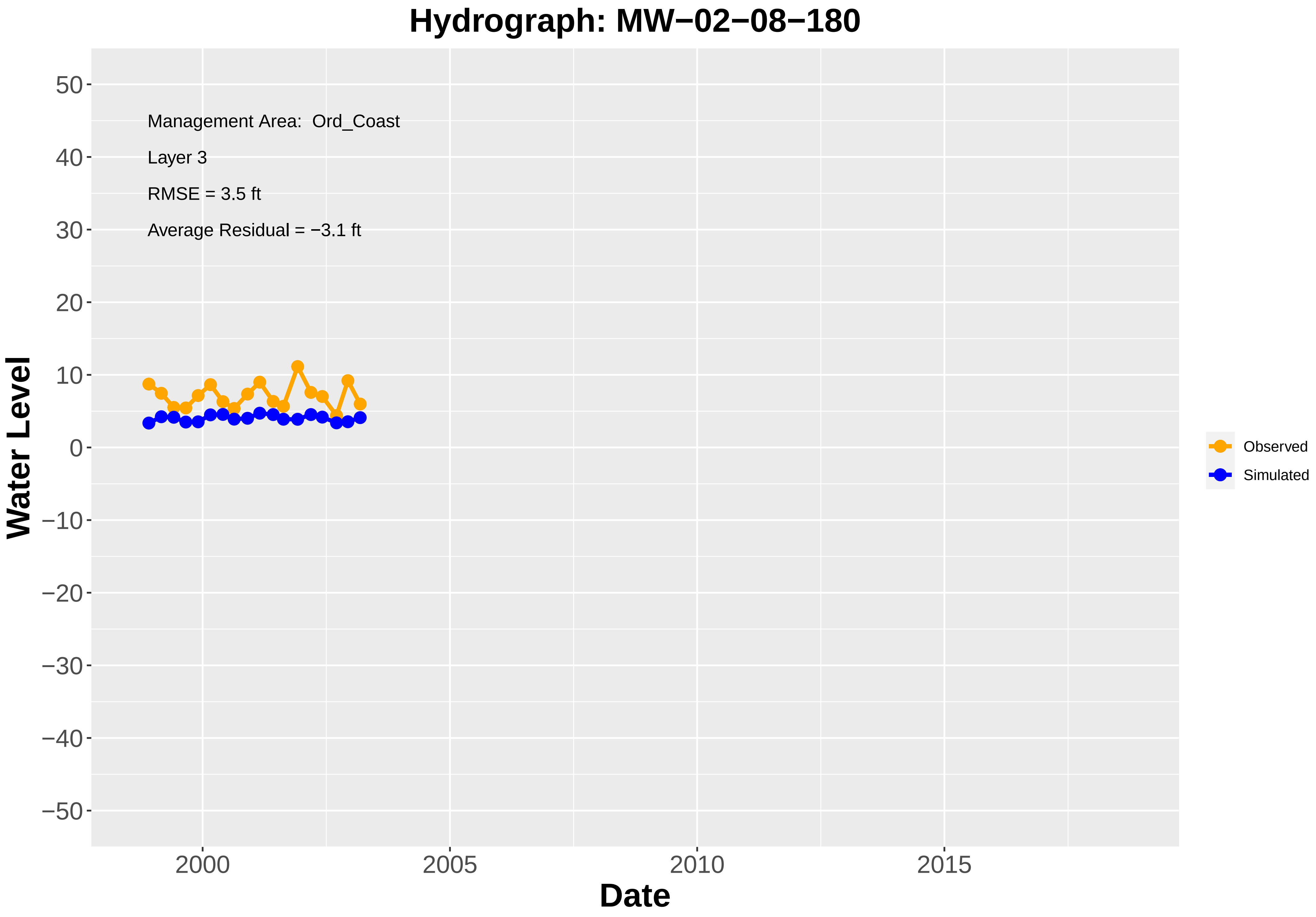

Hydrograph: MW−02−03−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.3 ft
Average Residual = −4.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

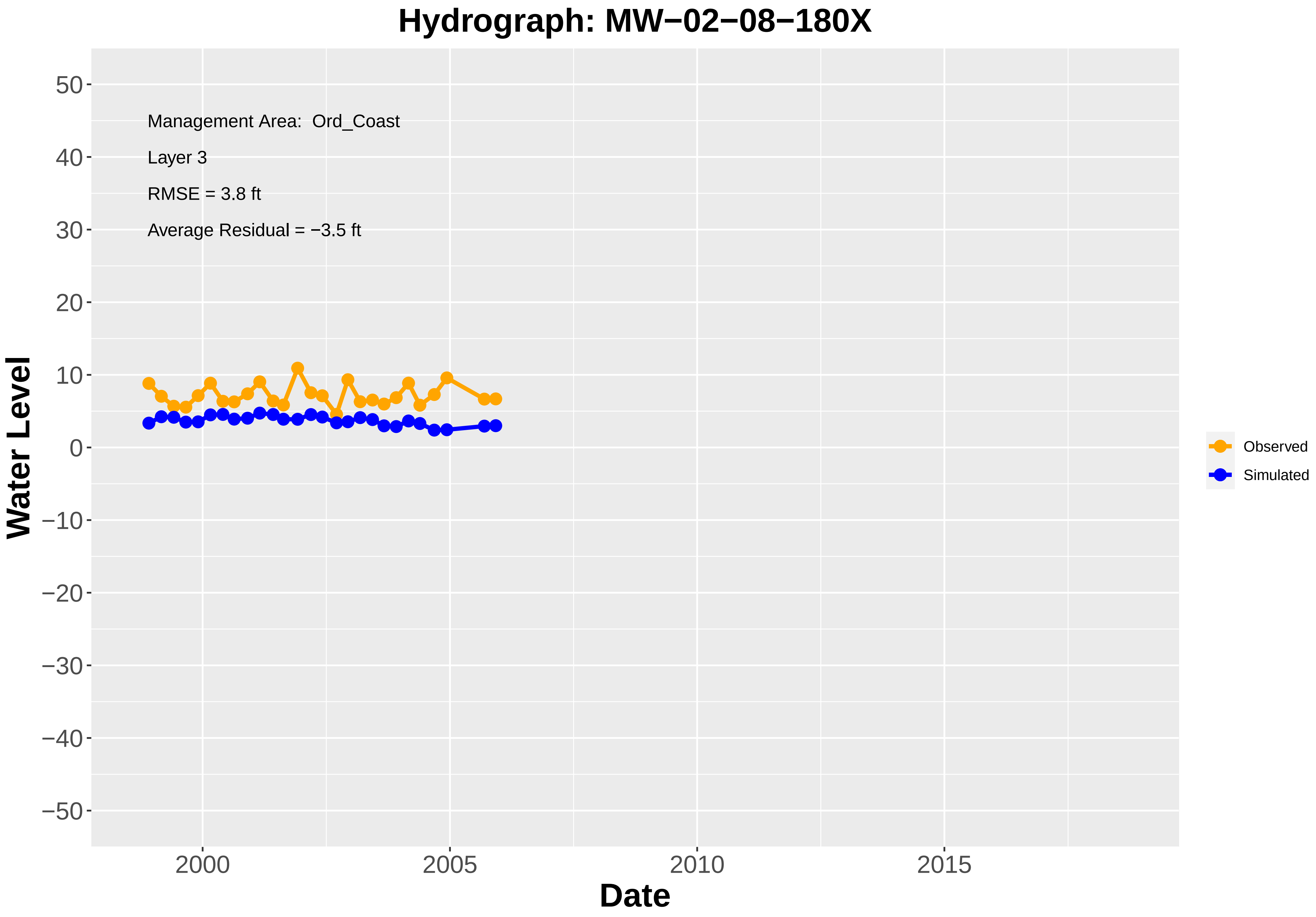

Hydrograph: MW−02−04−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

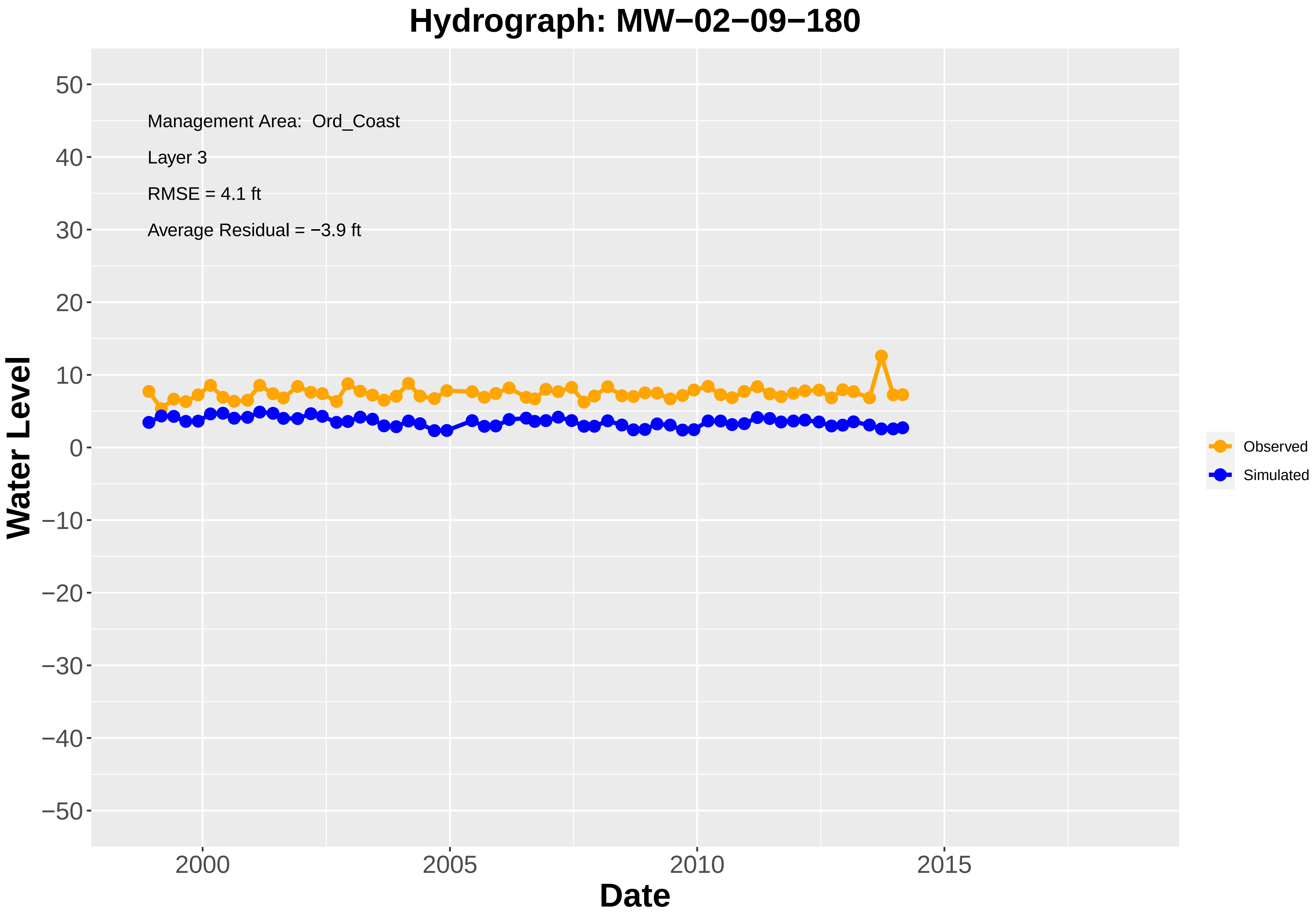

Hydrograph: MW−02−05−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.0 ft
Average Residual = −3.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−02−06−180

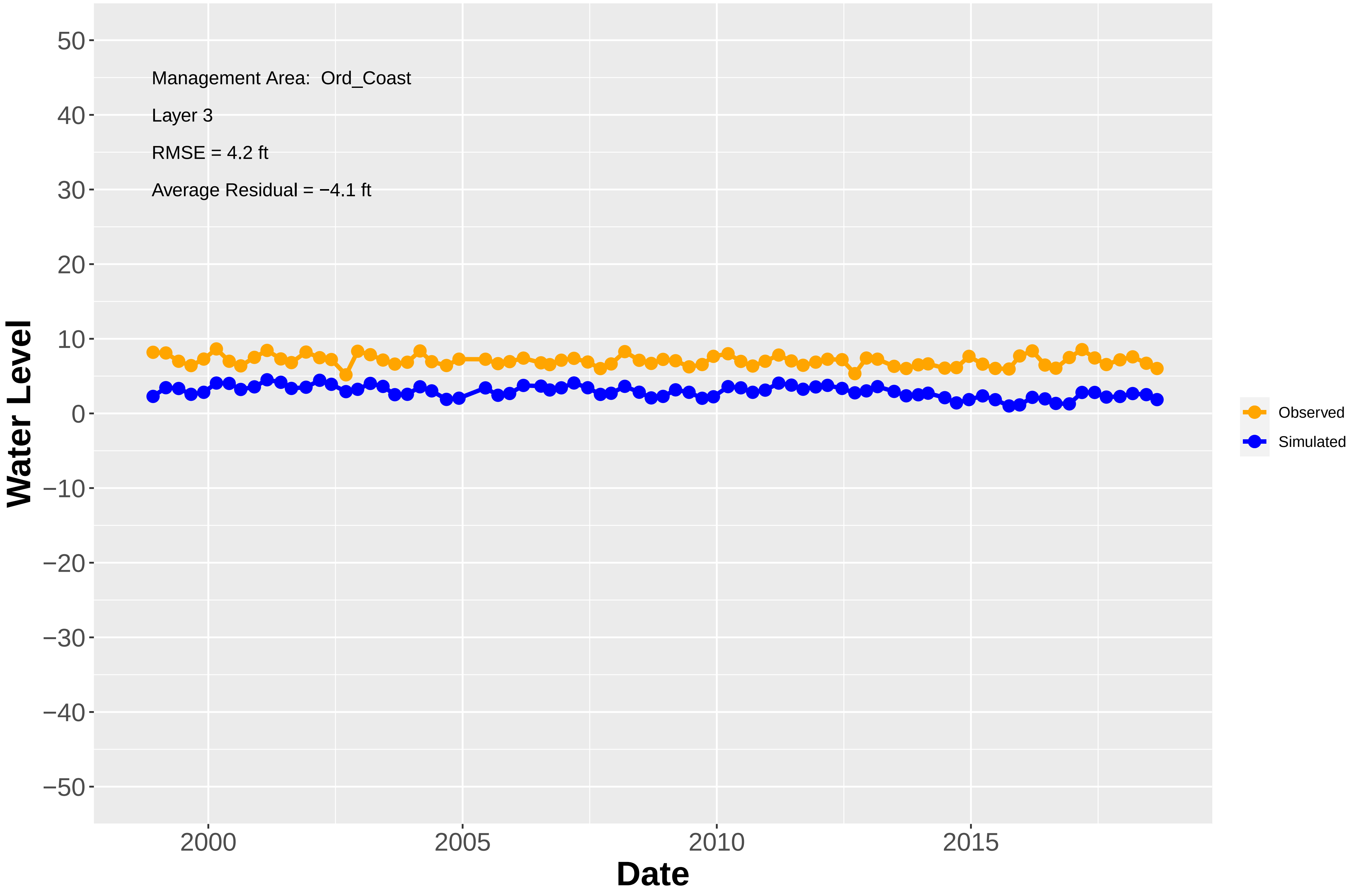

Hydrograph: MW−02−07−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.6 ft
Average Residual = −3.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

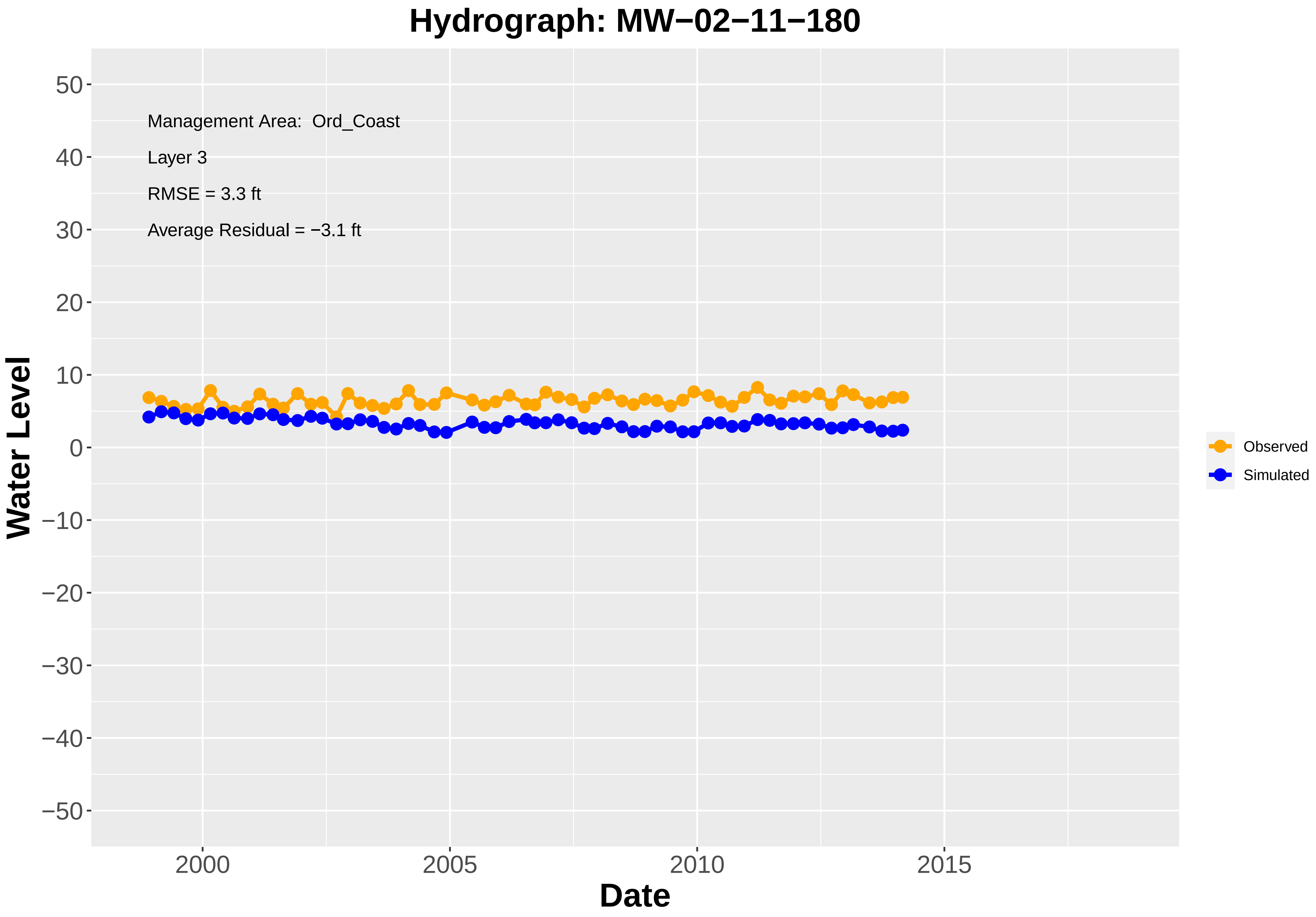

Hydrograph: MW−02−08−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.5 ft
Average Residual = −3.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

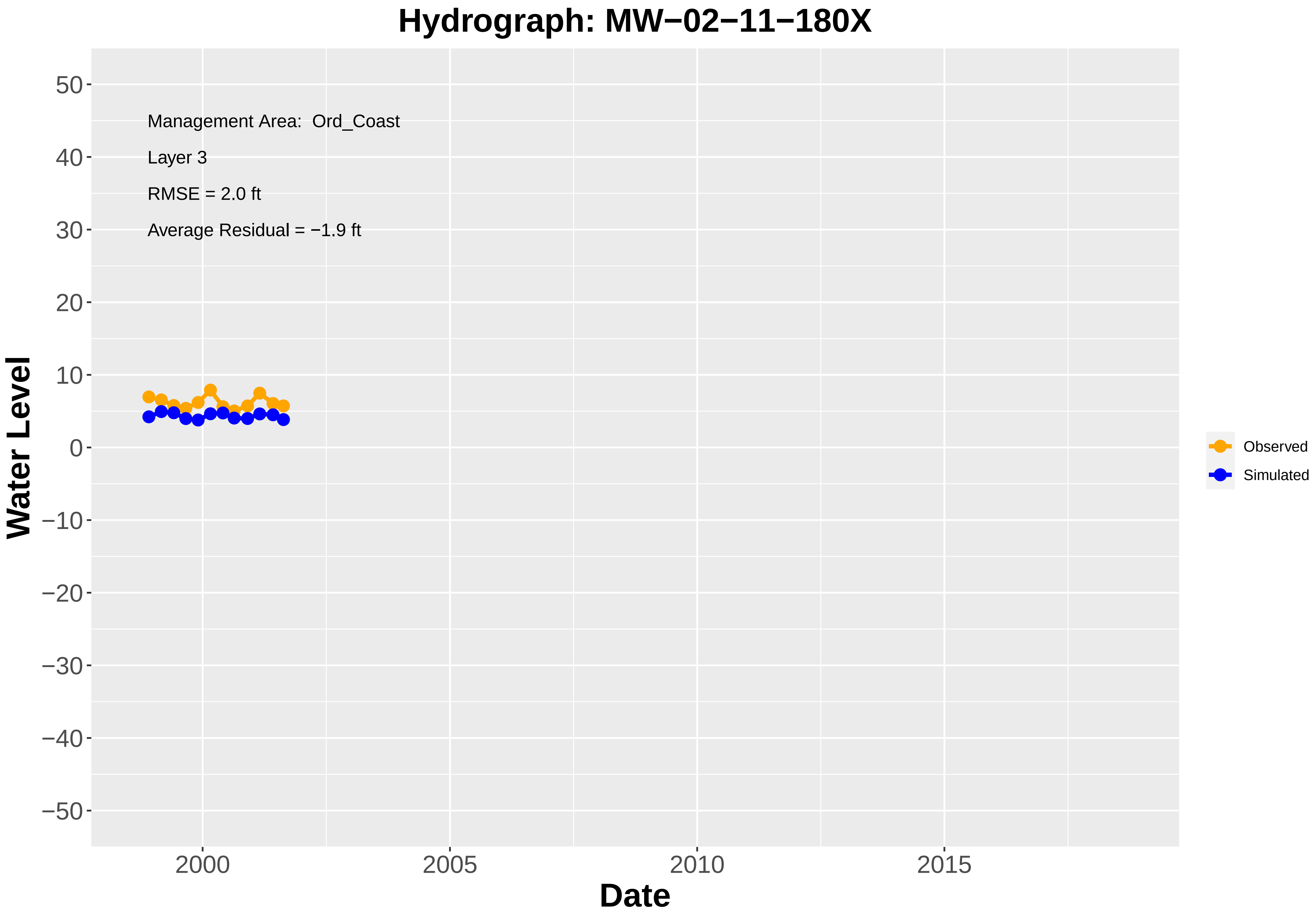

Hydrograph: MW−02−08−180X
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

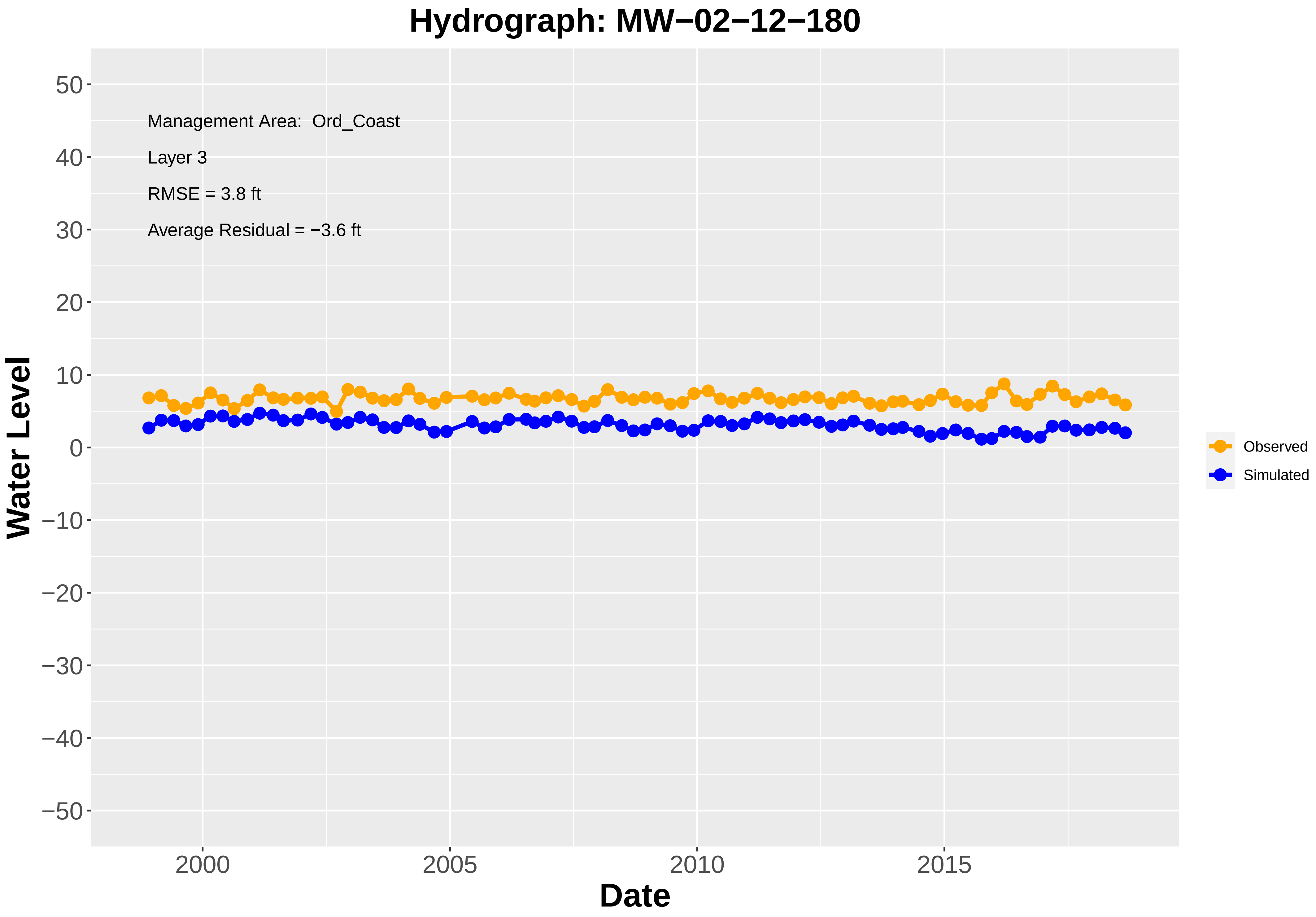

Hydrograph: MW−02−09−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.1 ft
Average Residual = −3.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

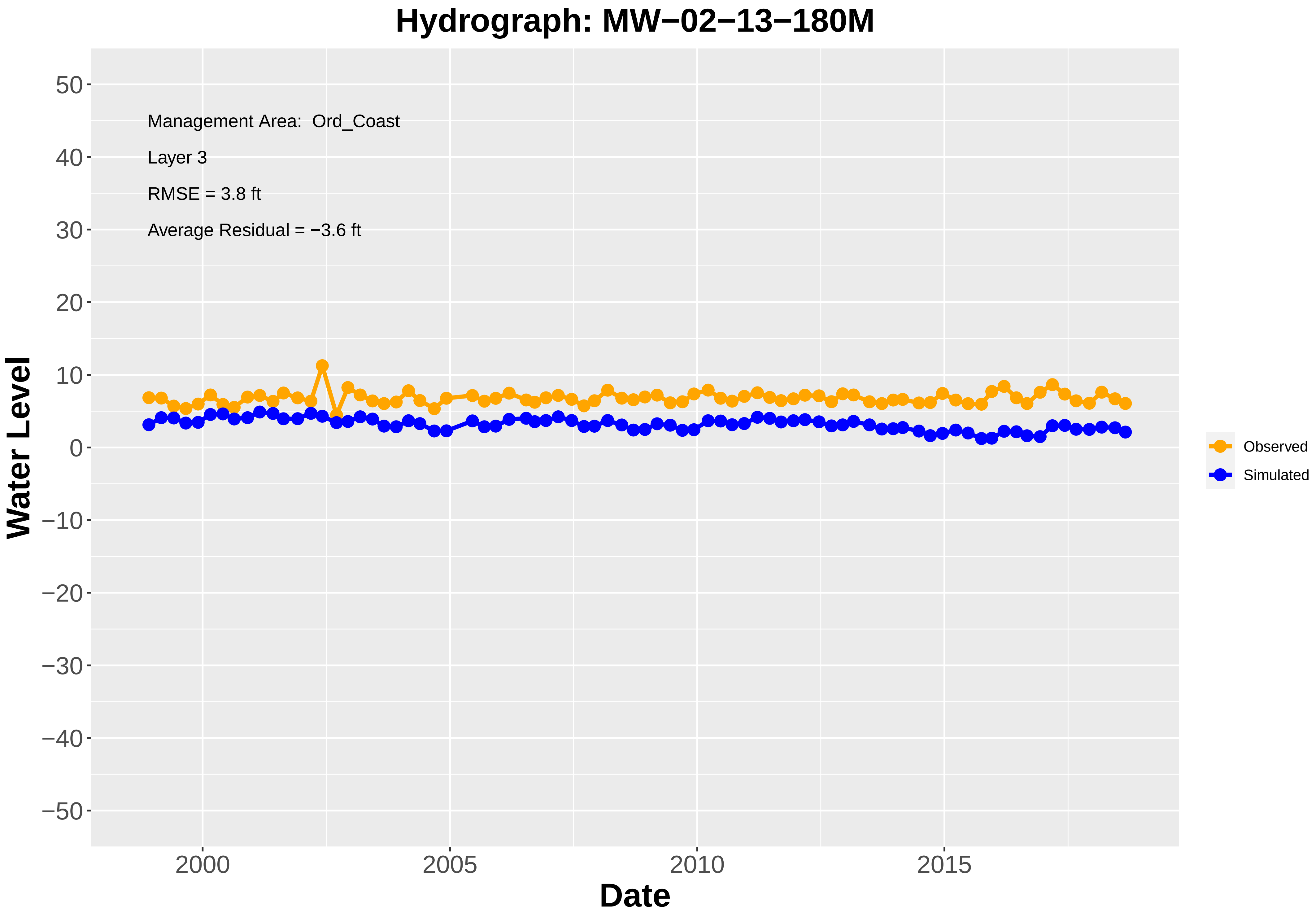
Hydrograph: MW−02−10−180

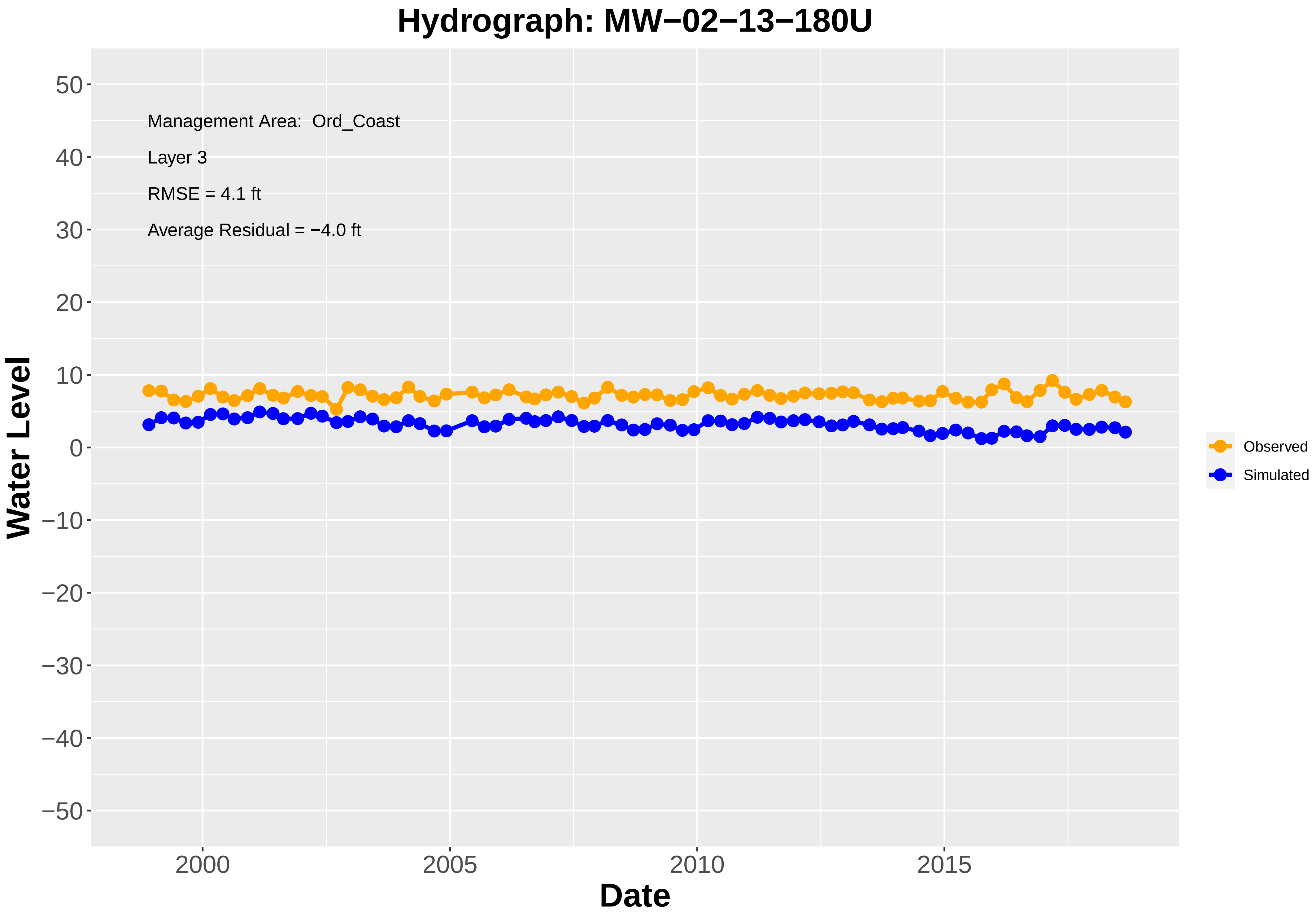


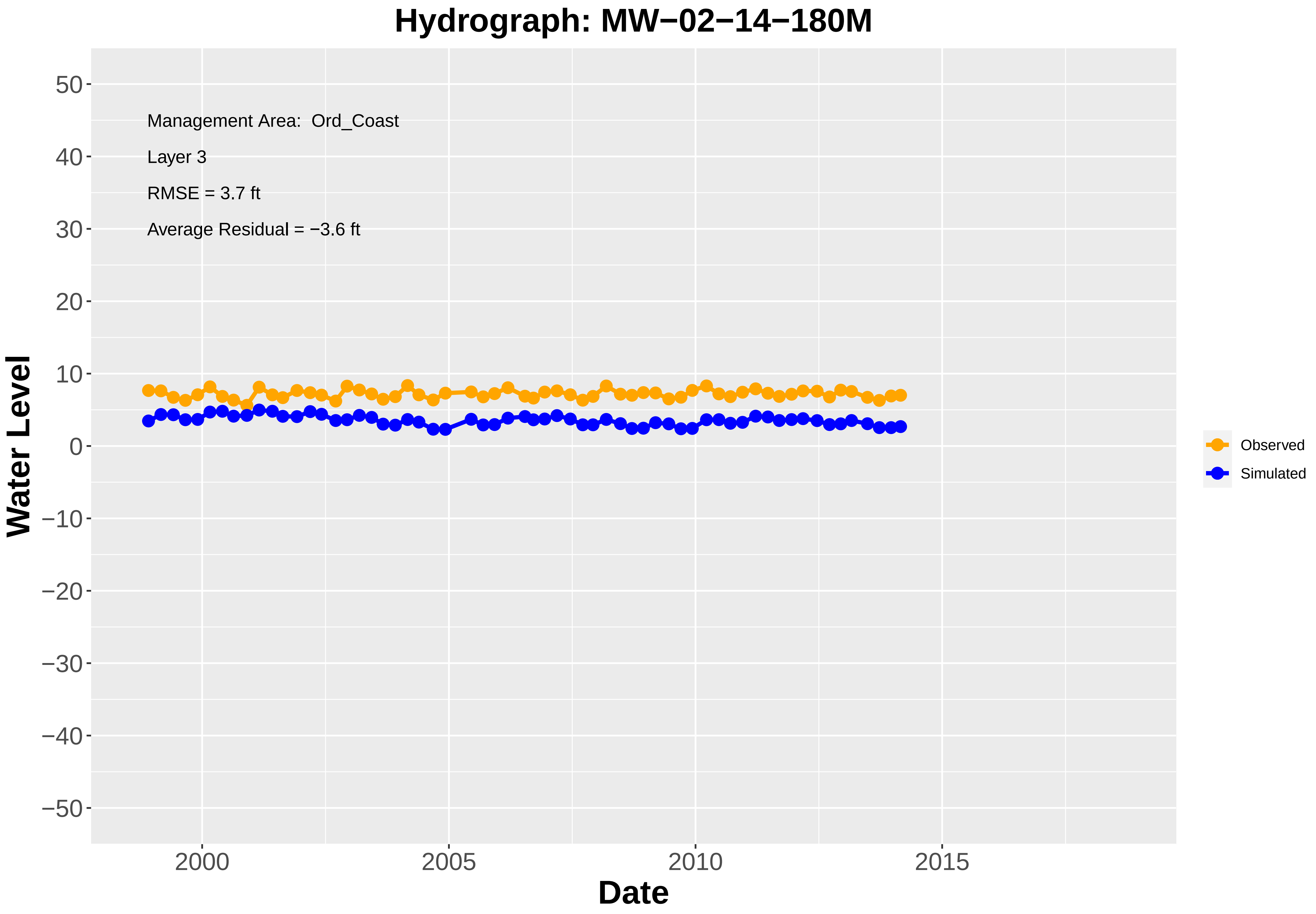

Hydrograph: MW−02−11−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.3 ft
Average Residual = −3.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

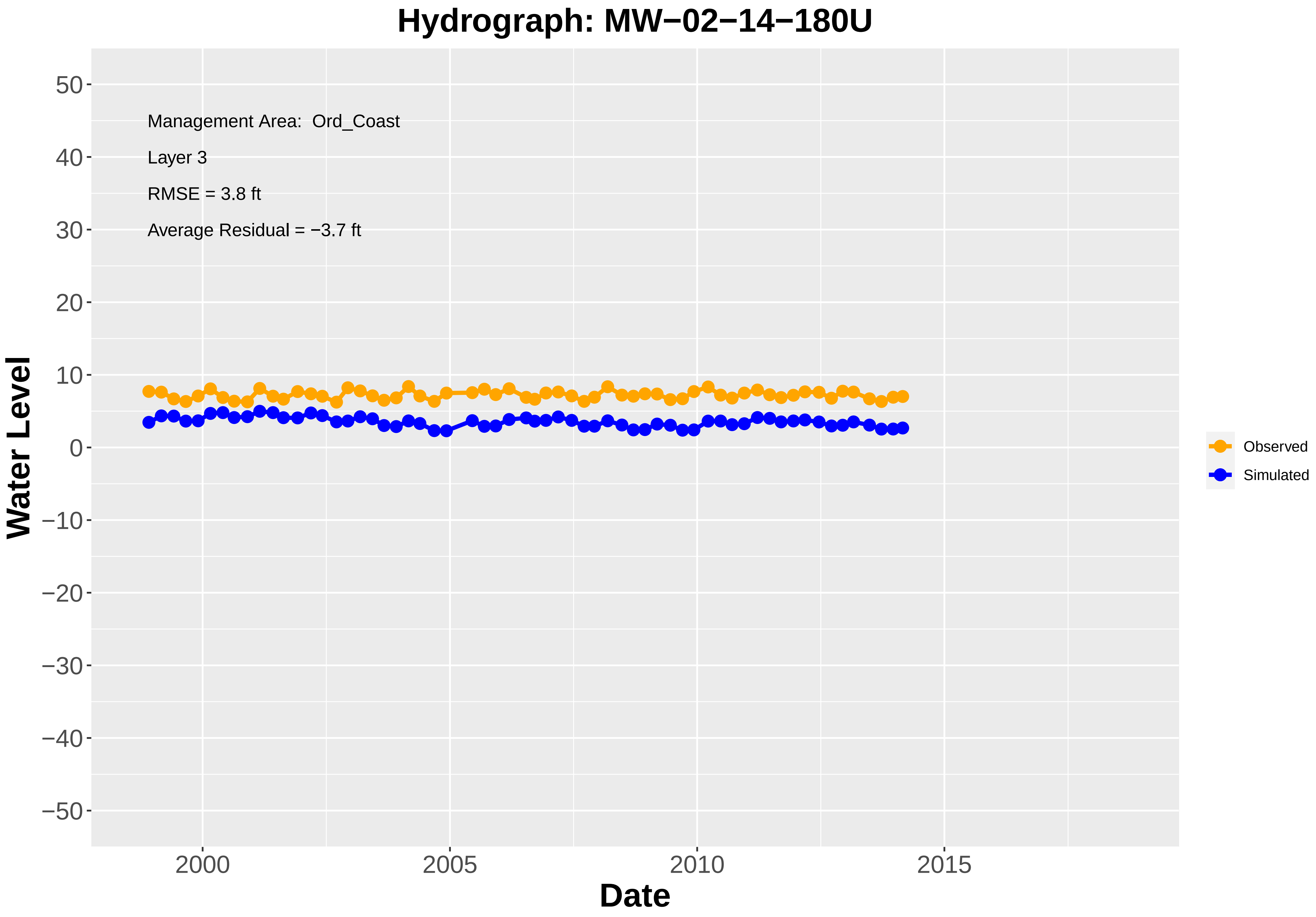

Hydrograph: MW−02−11−180X
Management Area: Ord_Coast
Layer 3
RMSE = 2.0 ft
Average Residual = −1.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

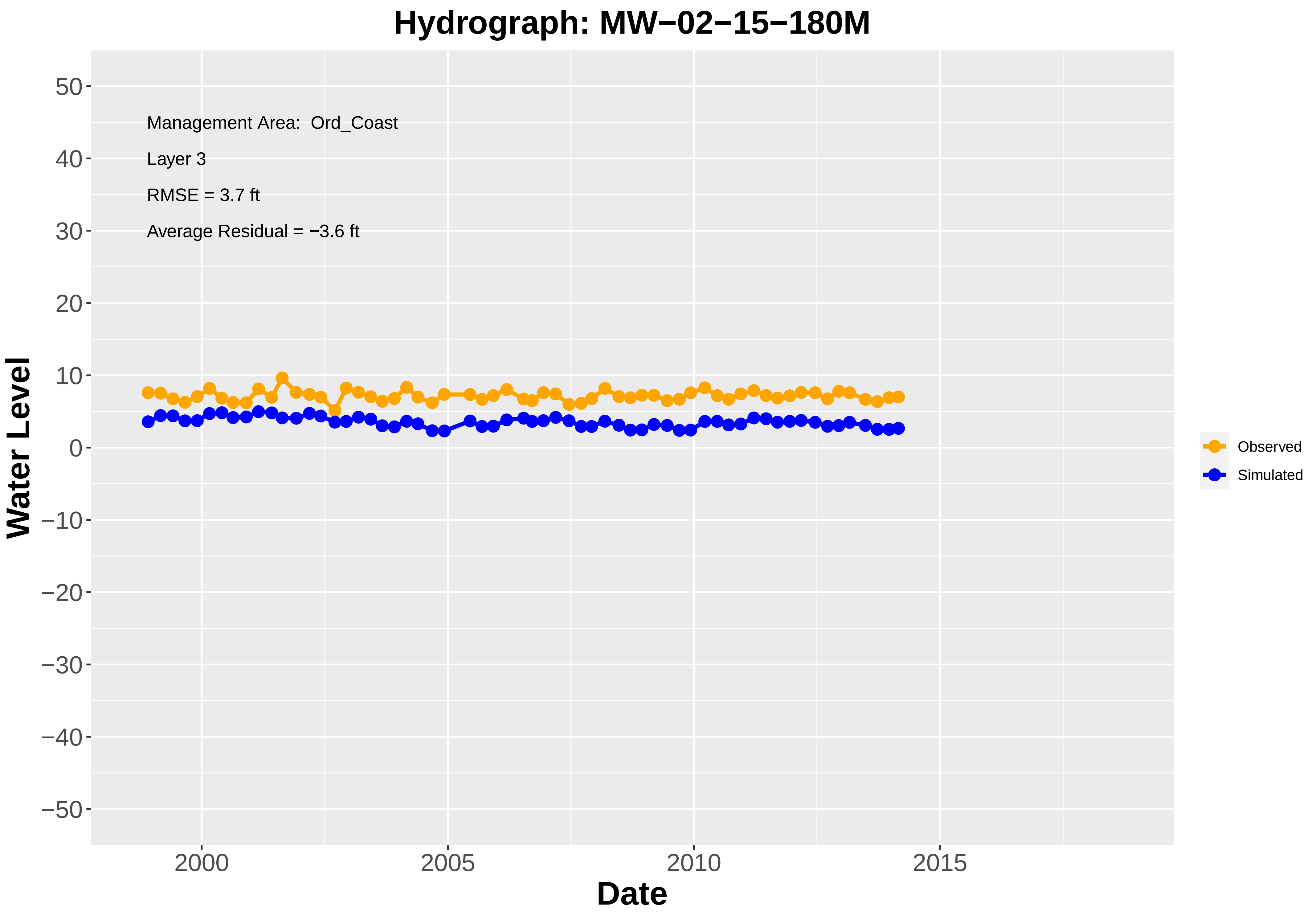

Hydrograph: MW−02−12−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−02−13−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

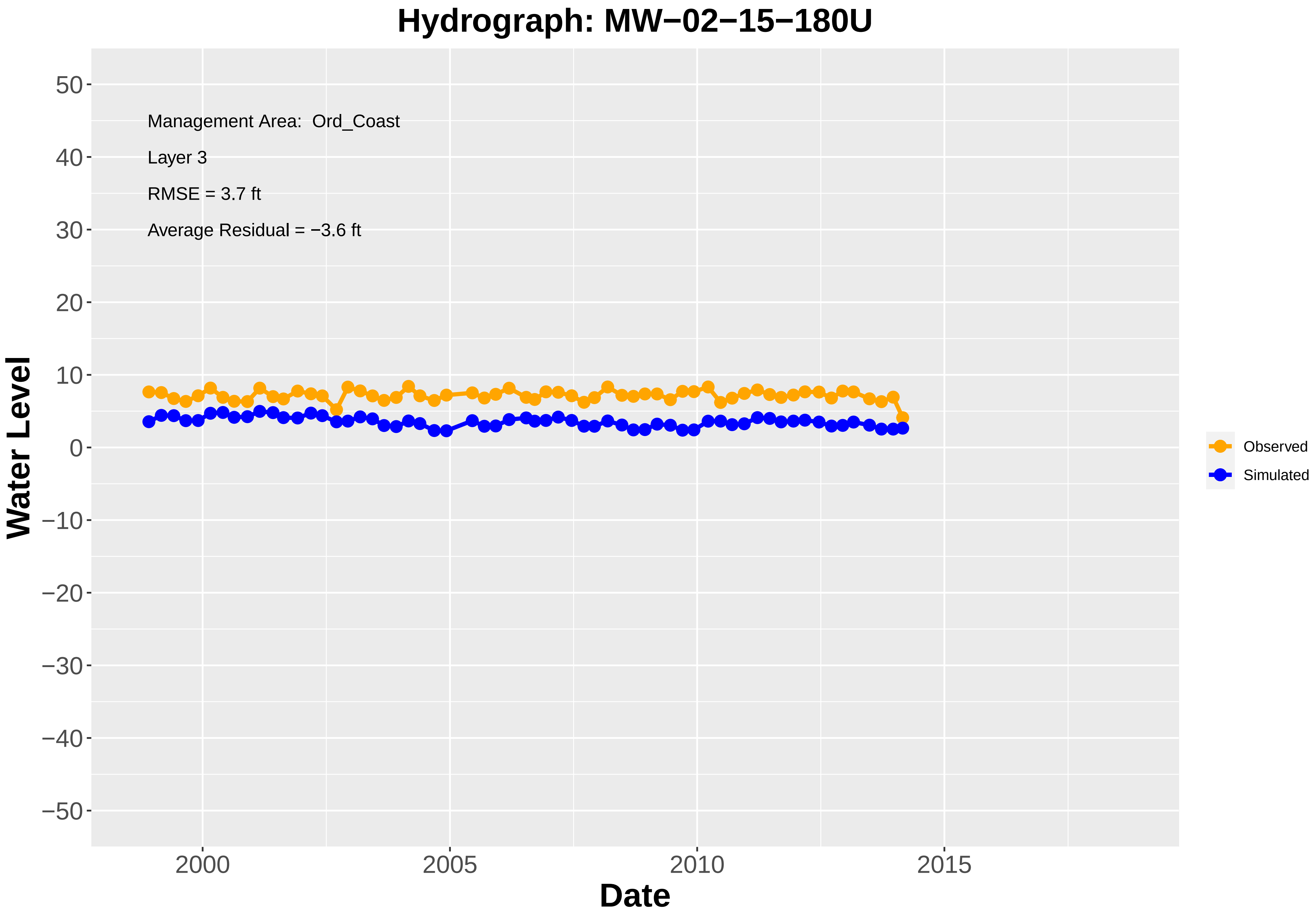

Hydrograph: MW−02−13−180U
Management Area: Ord_Coast
Layer 3
RMSE = 4.1 ft
Average Residual = −4.0 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

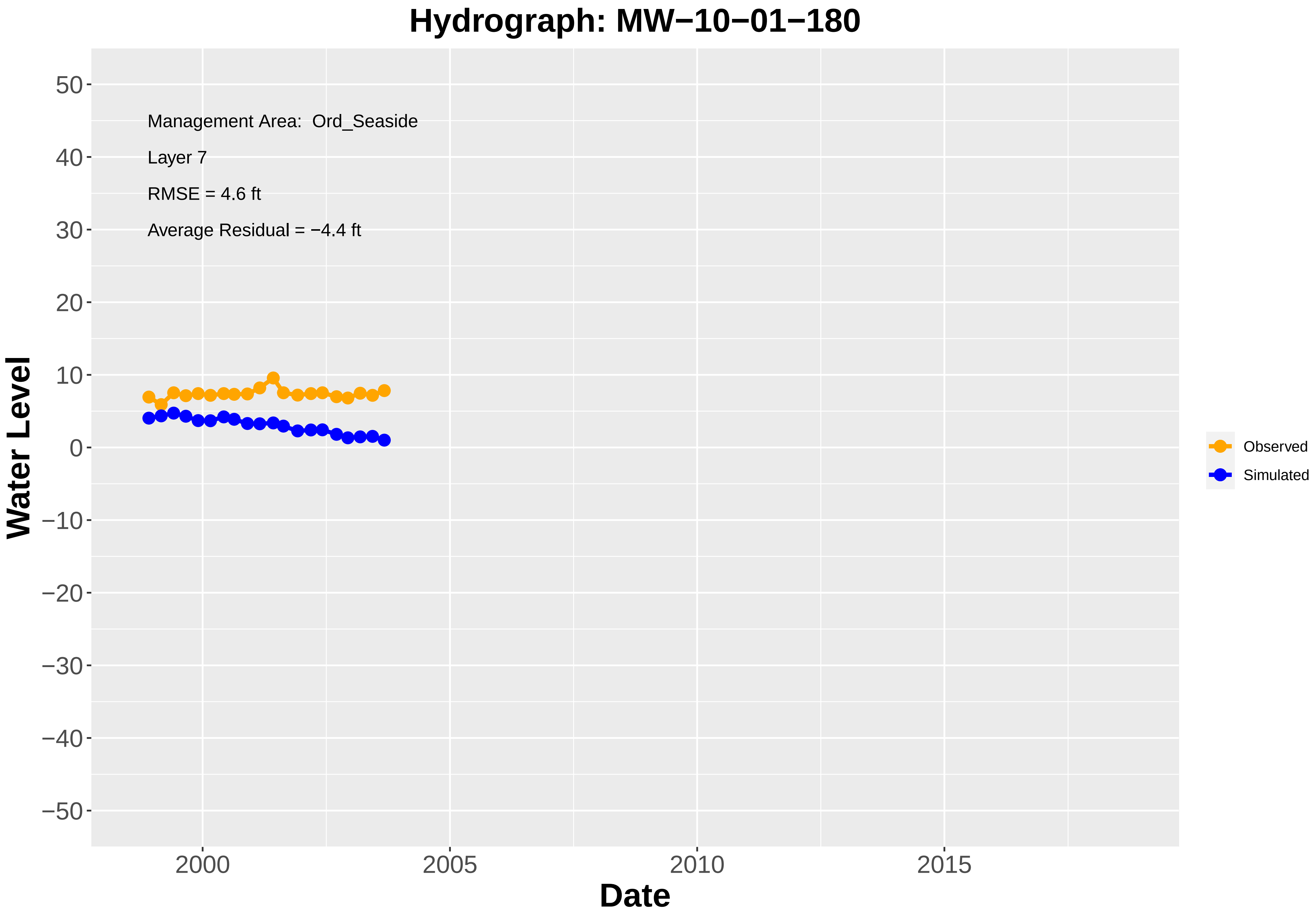

Hydrograph: MW−02−14−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.7 ft
Average Residual = −3.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

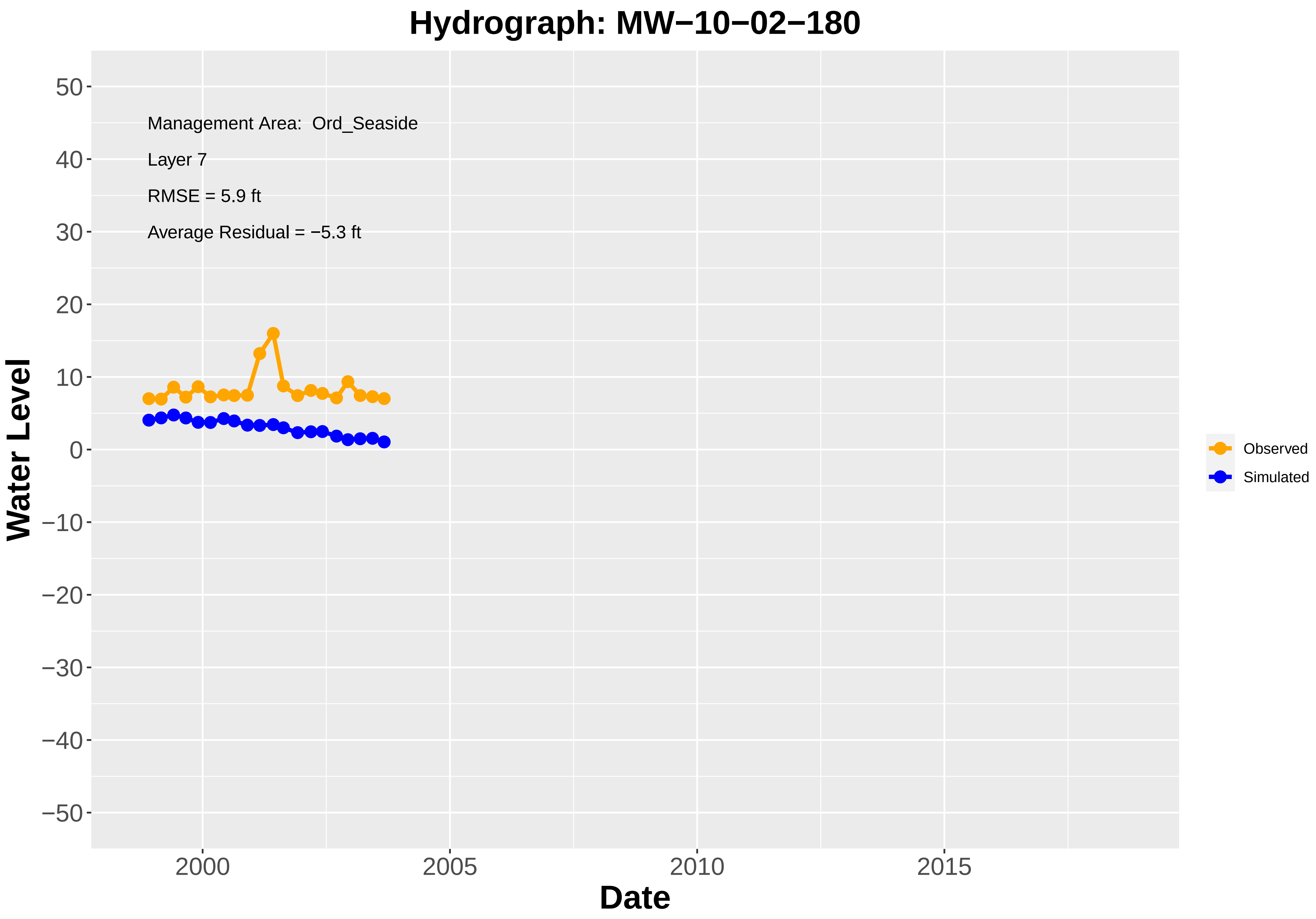

Hydrograph: MW−02−14−180U
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.7 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

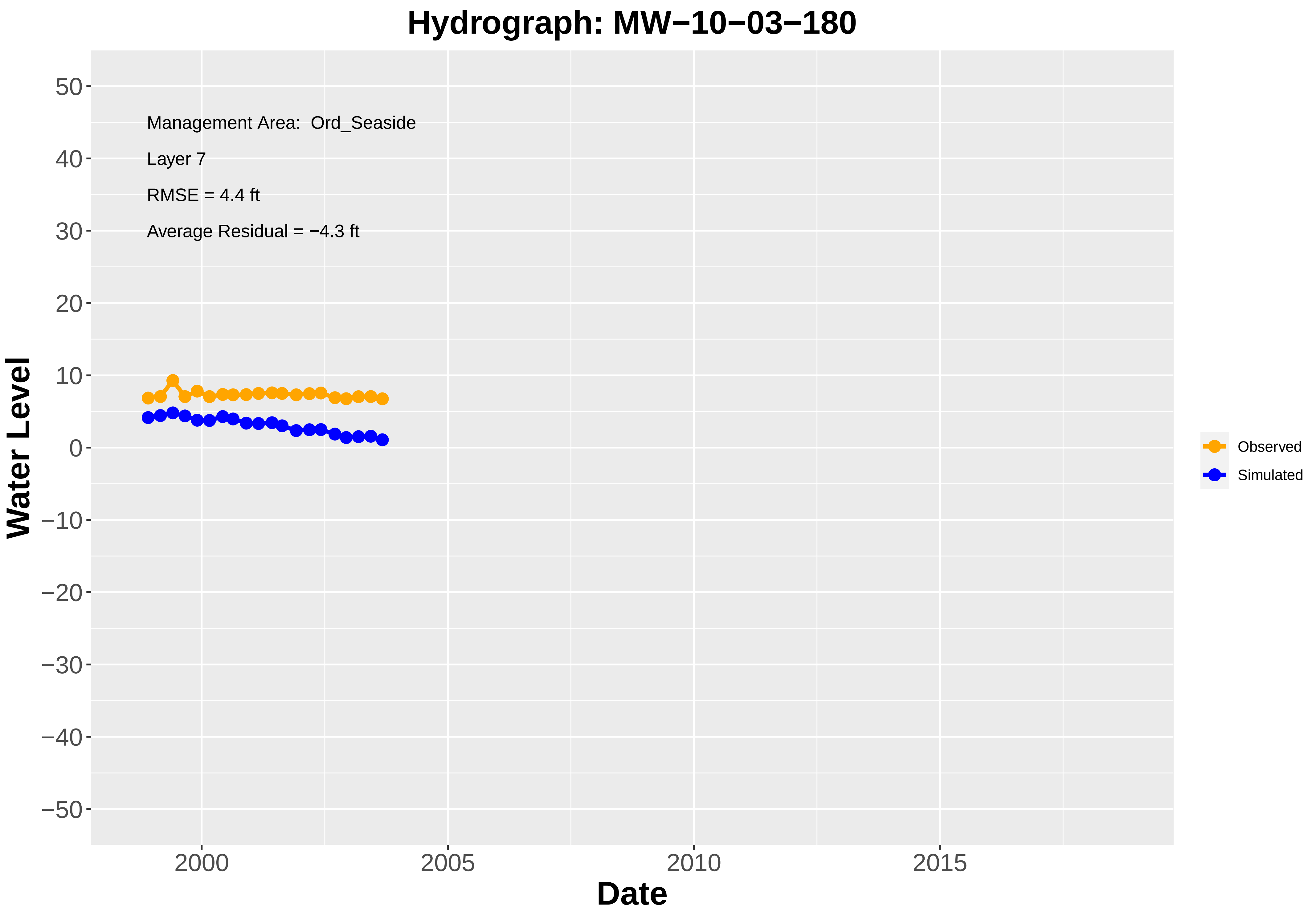


Hydrograph: MW−02−15−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.7 ft
Average Residual = −3.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

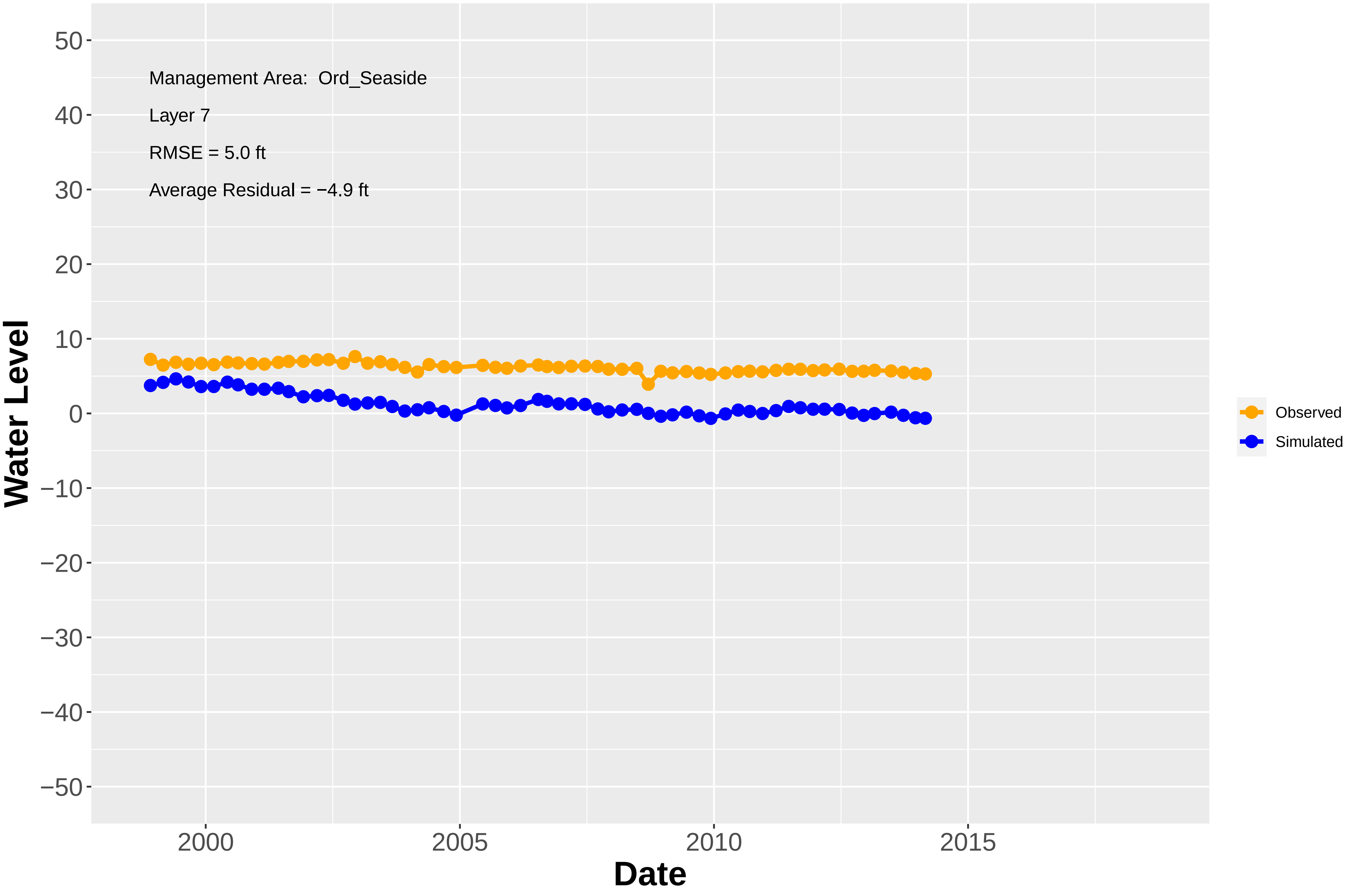

Hydrograph: MW−02−15−180U
Management Area: Ord_Coast
Layer 3
RMSE = 3.7 ft
Average Residual = −3.6 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

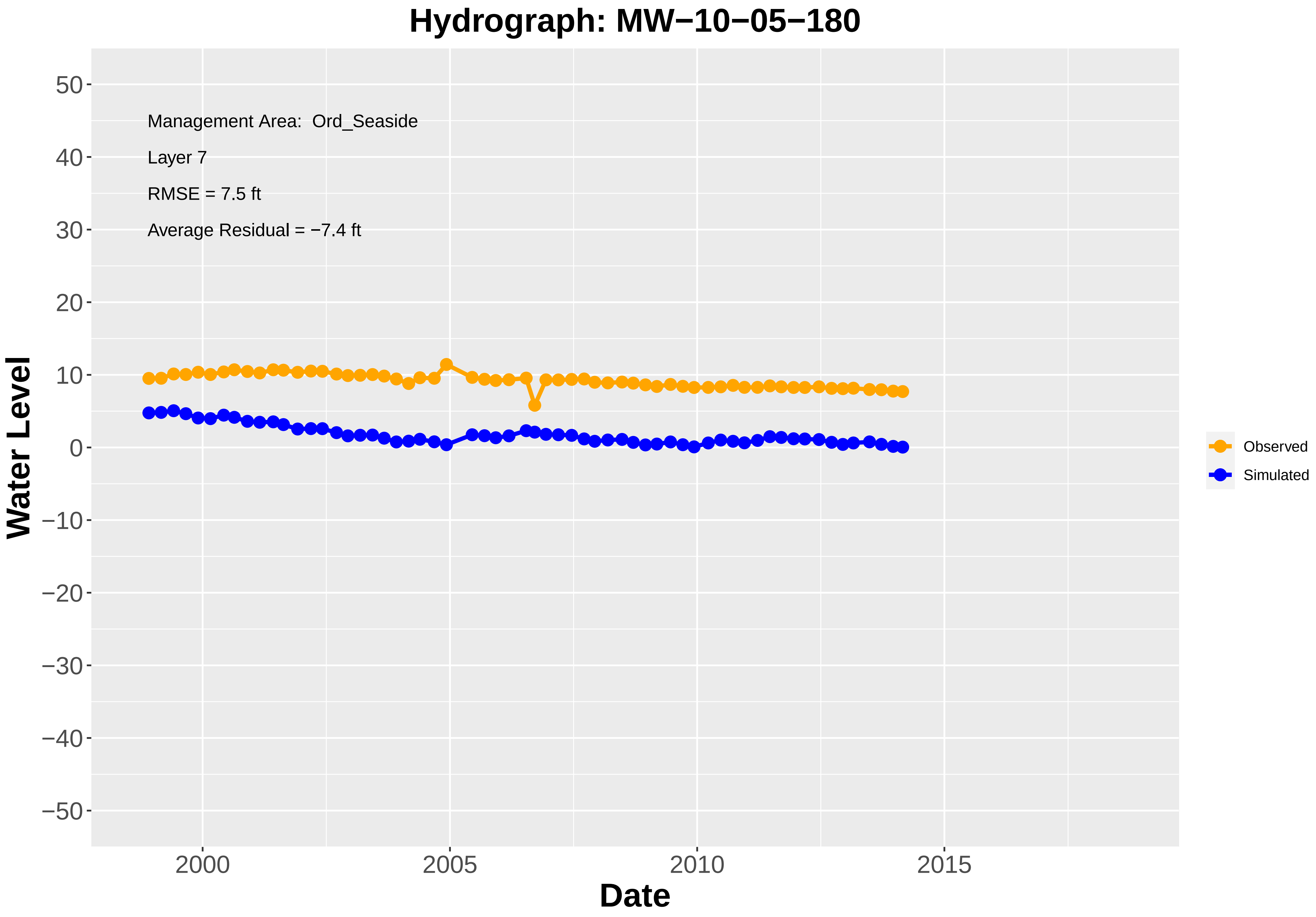

Hydrograph: MW−10−01−180
Management Area: Ord_Seaside
Layer 7
RMSE = 4.6 ft
Average Residual = −4.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

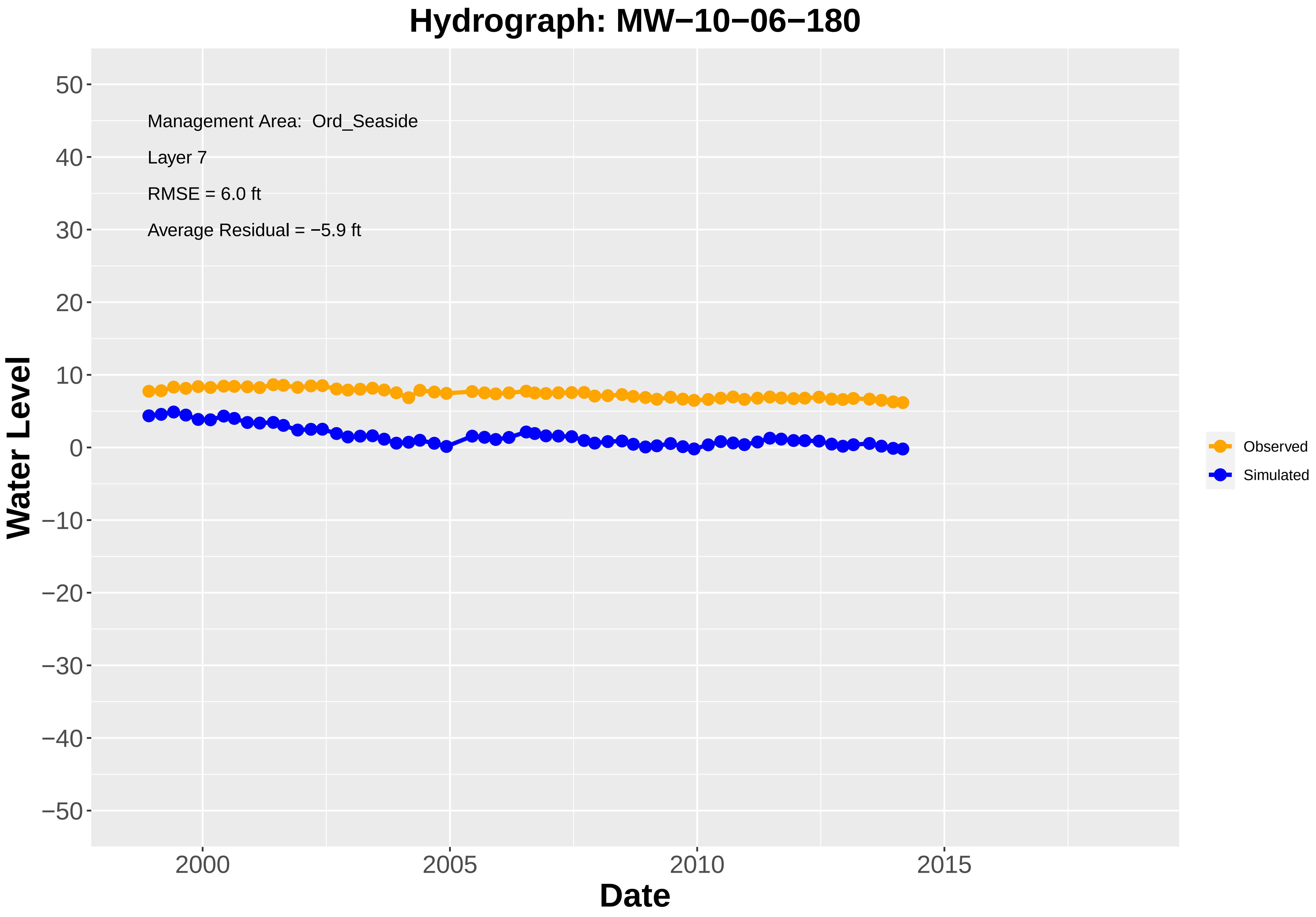

Hydrograph: MW−10−02−180
Management Area: Ord_Seaside
Layer 7
RMSE = 5.9 ft
Average Residual = −5.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

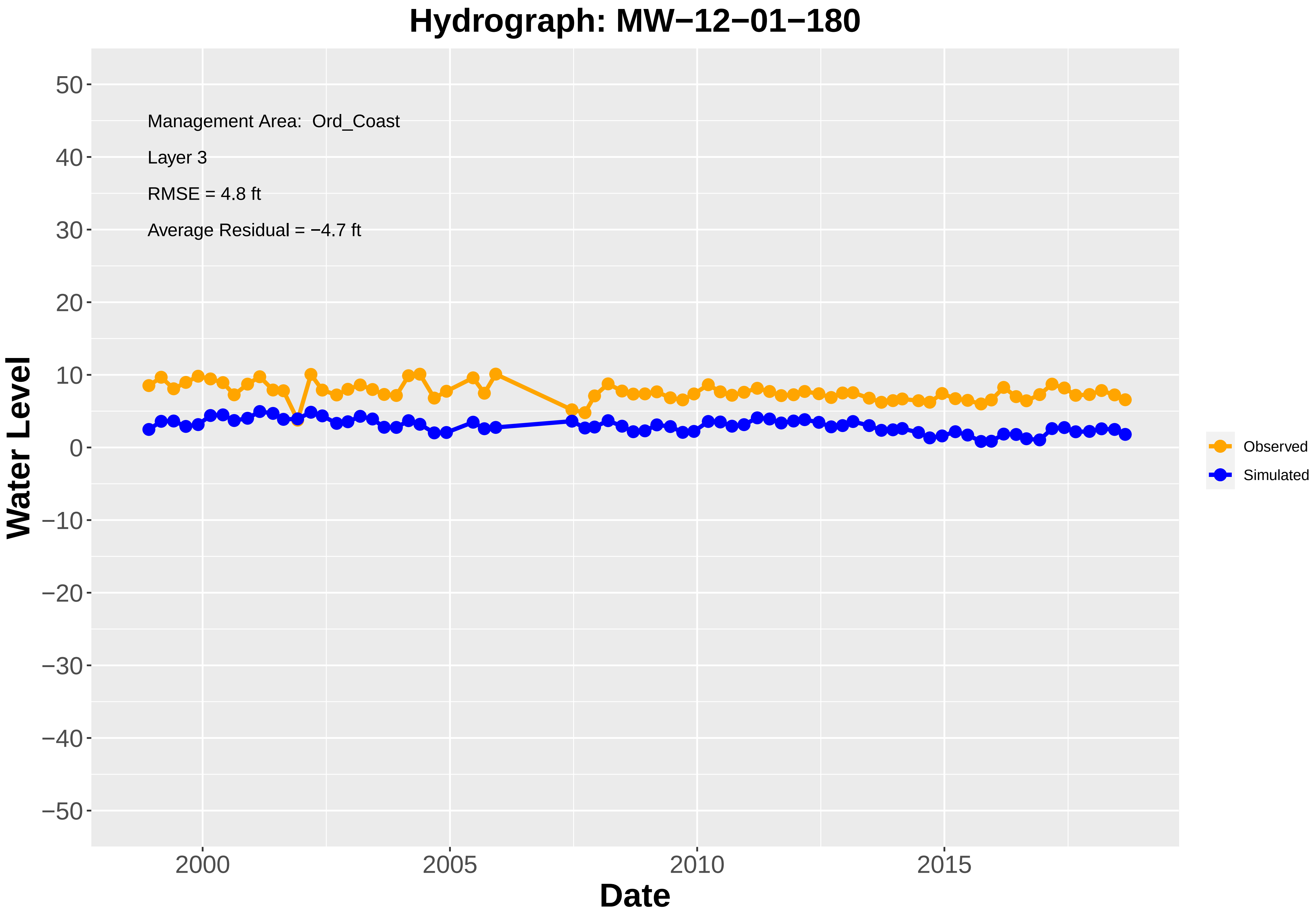

Hydrograph: MW−10−03−180
Management Area: Ord_Seaside
Layer 7
RMSE = 4.4 ft
Average Residual = −4.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

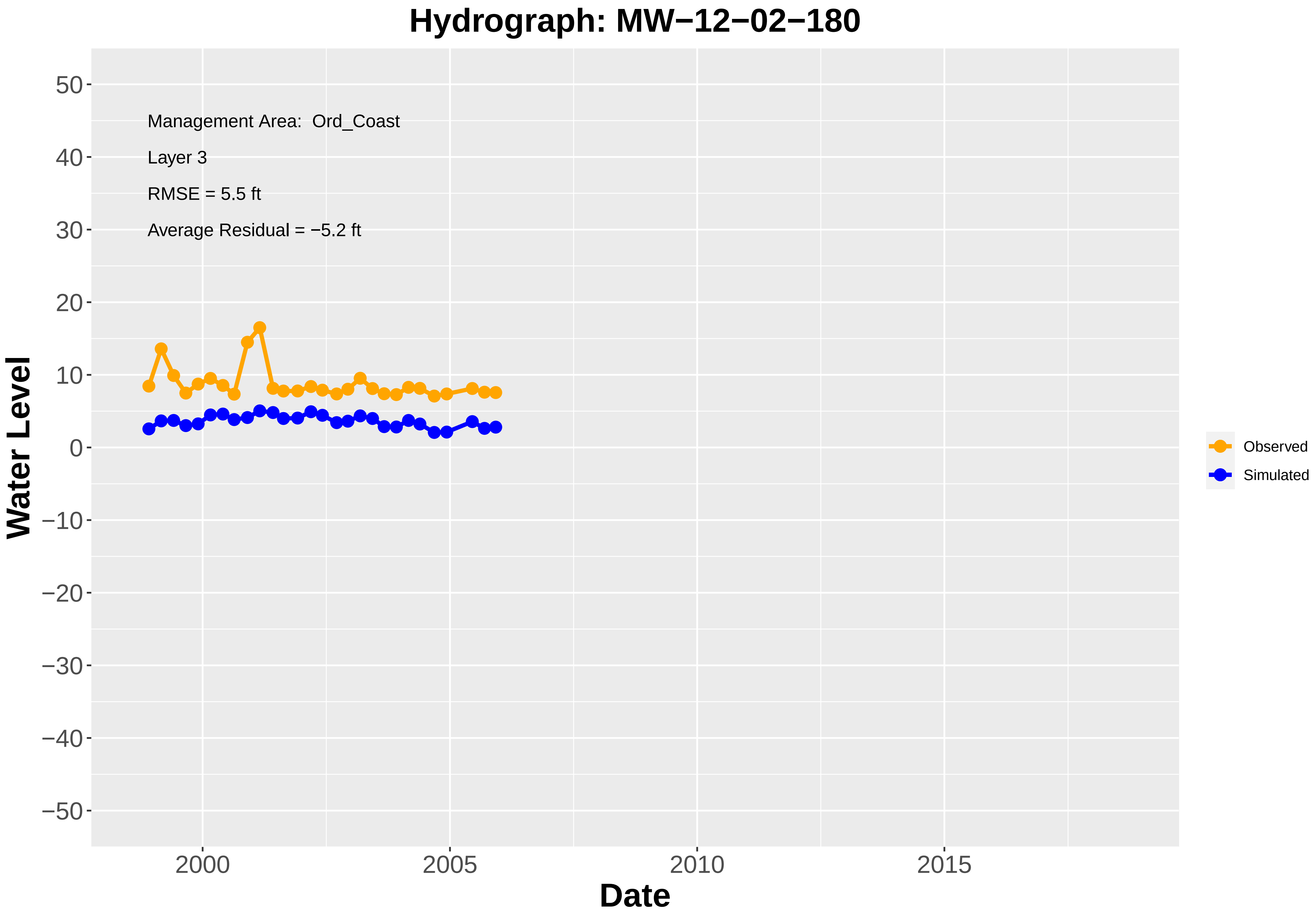
Hydrograph: MW−10−04−180



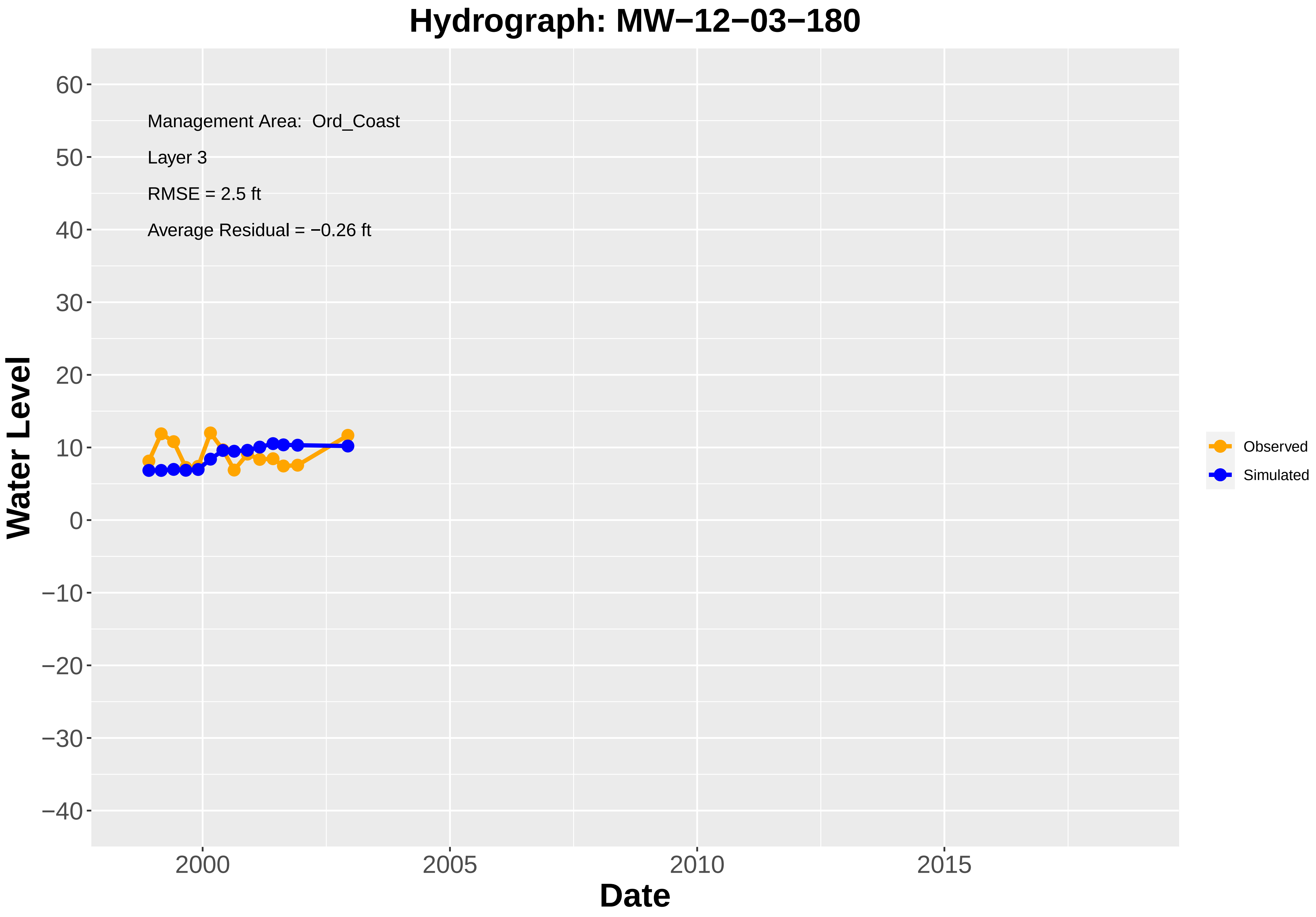

Hydrograph: MW−10−05−180
Management Area: Ord_Seaside
Layer 7
RMSE = 7.5 ft
Average Residual = −7.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−10−06−180
Management Area: Ord_Seaside
Layer 7
RMSE = 6.0 ft
Average Residual = −5.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

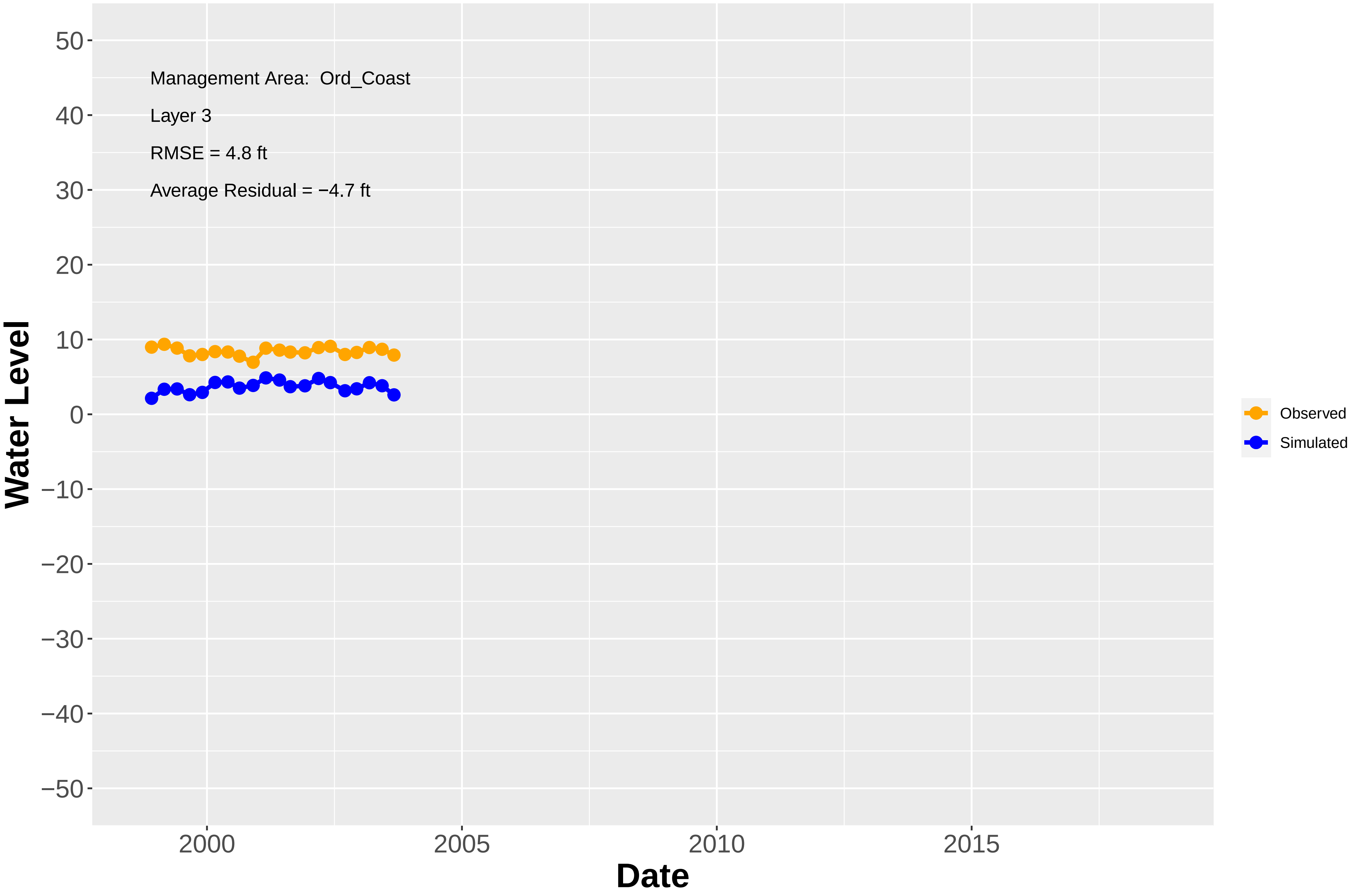
Hydrograph: MW−12−01−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.8 ft
Average Residual = −4.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

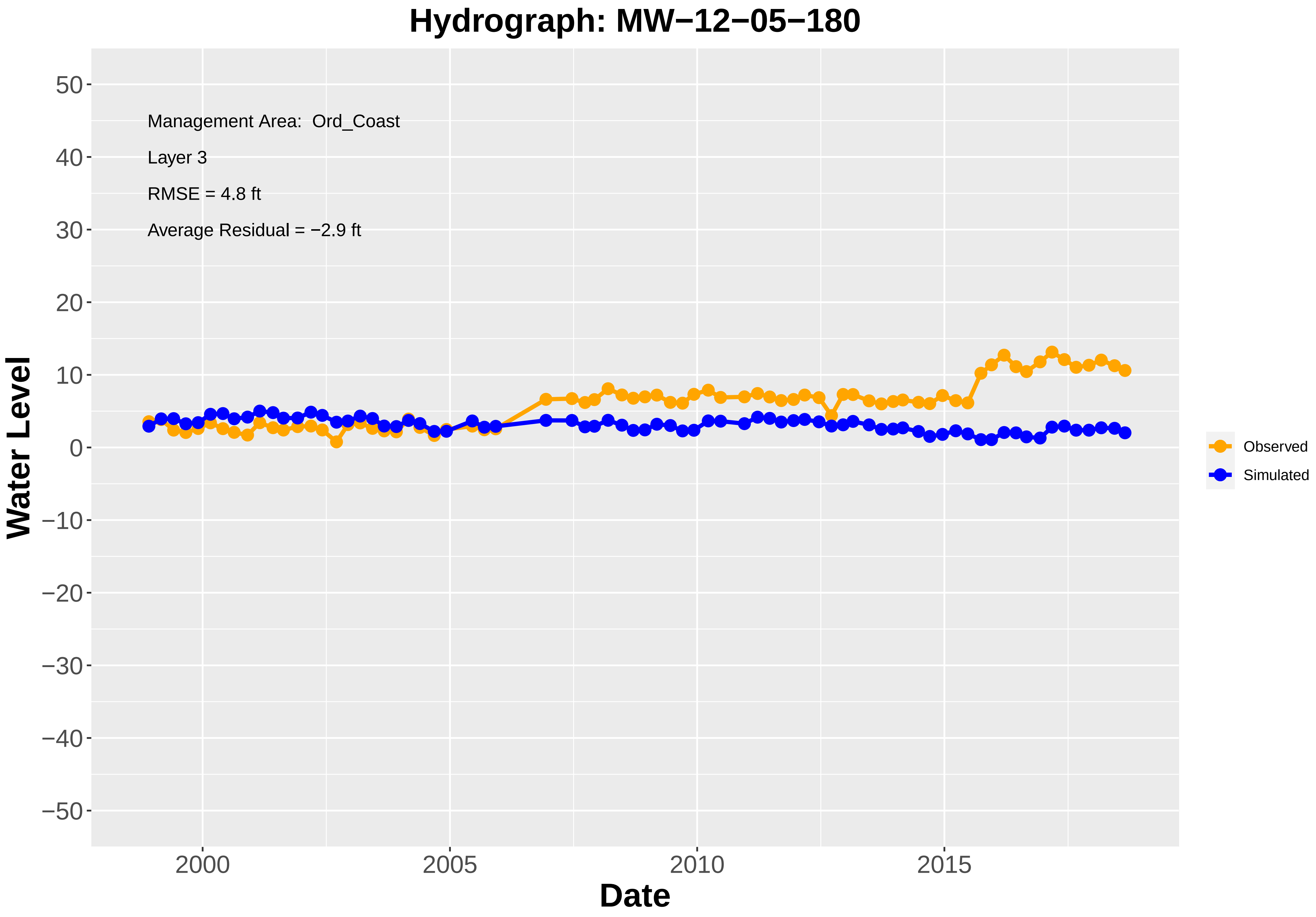


Hydrograph: MW−12−02−180
Management Area: Ord_Coast
Layer 3
RMSE = 5.5 ft
Average Residual = −5.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

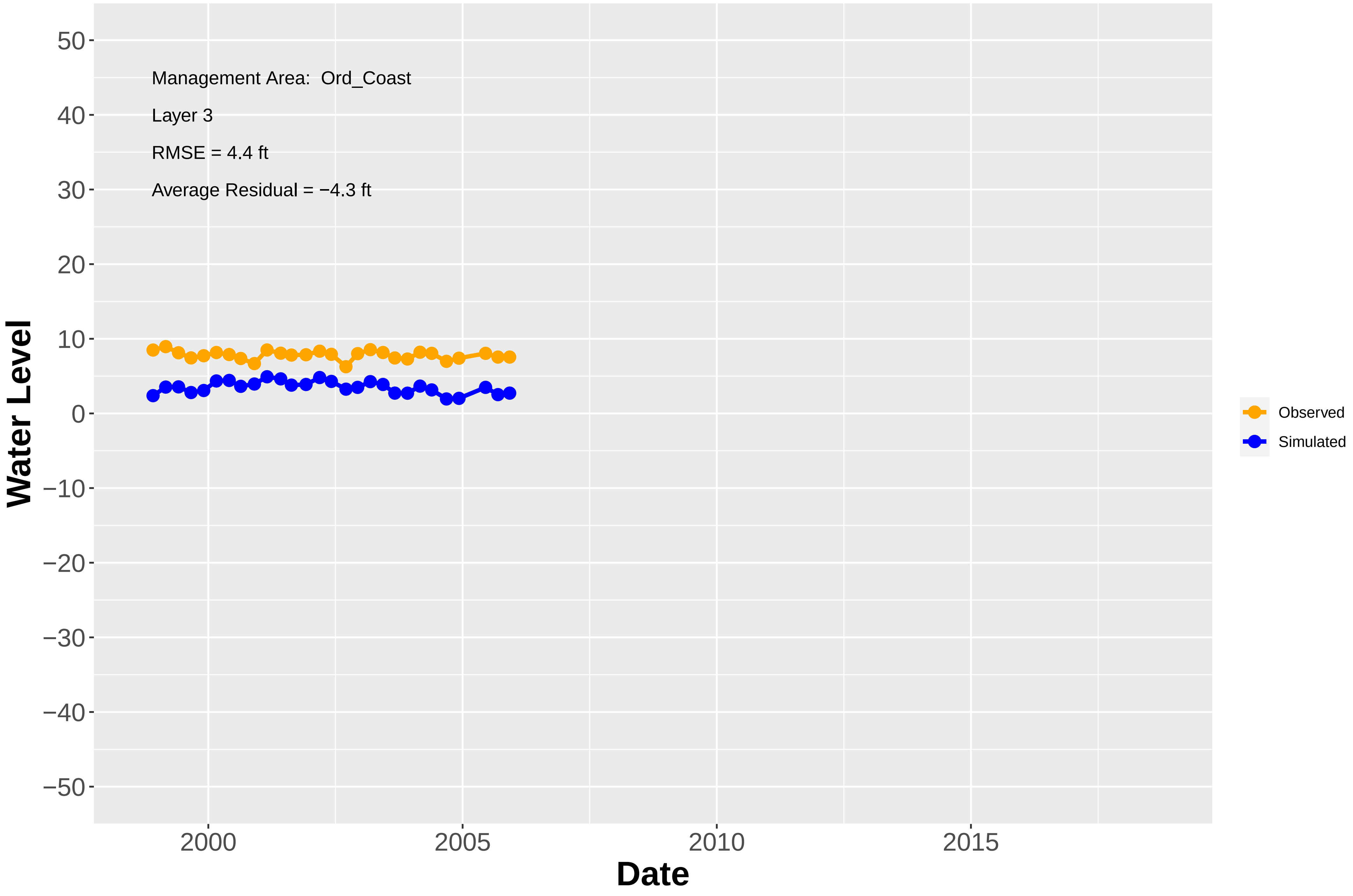

Hydrograph: MW−12−03−180
Management Area: Ord_Coast
Layer 3
RMSE = 2.5 ft
Average Residual = −0.26 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

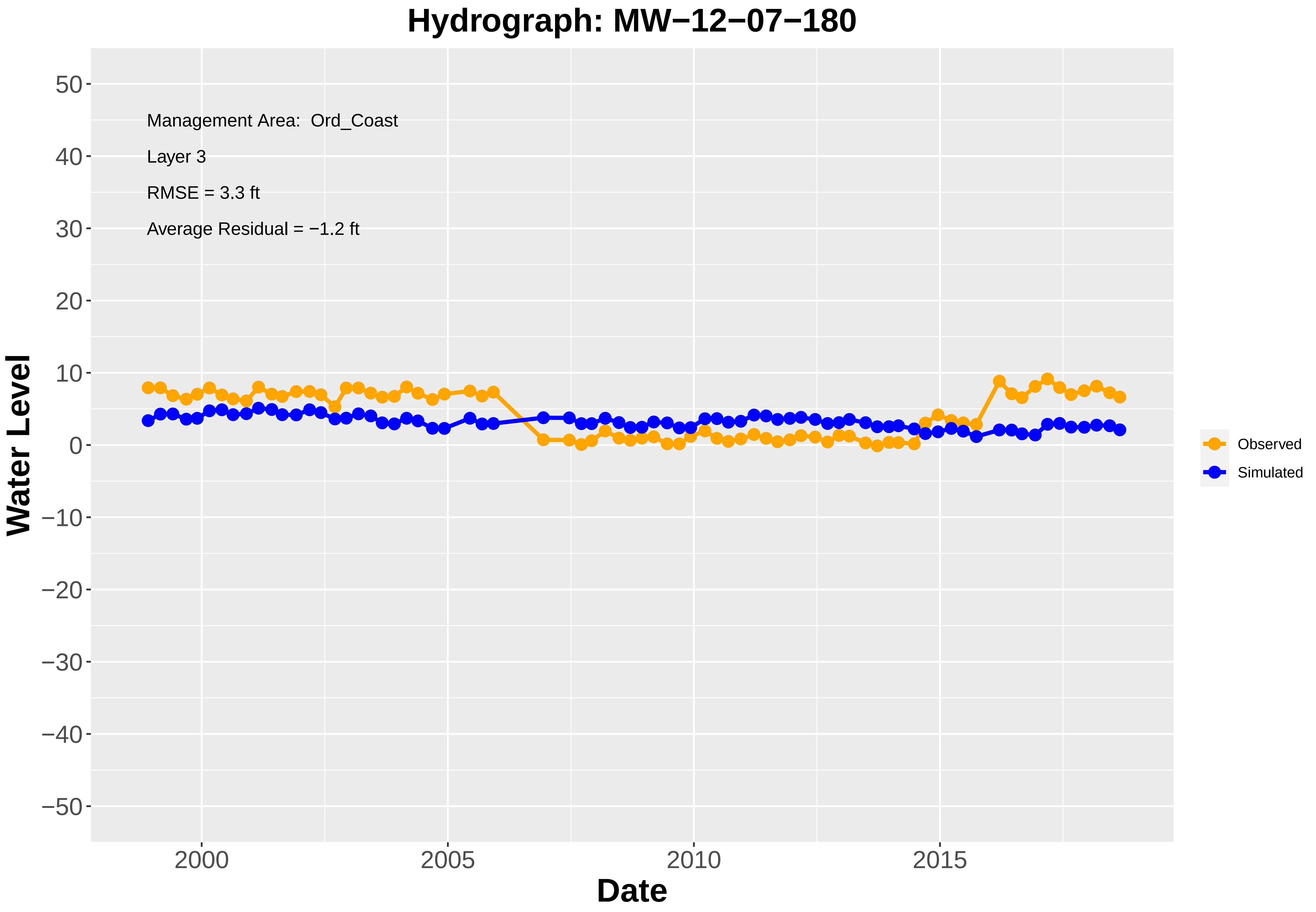
Hydrograph: MW−12−04−180



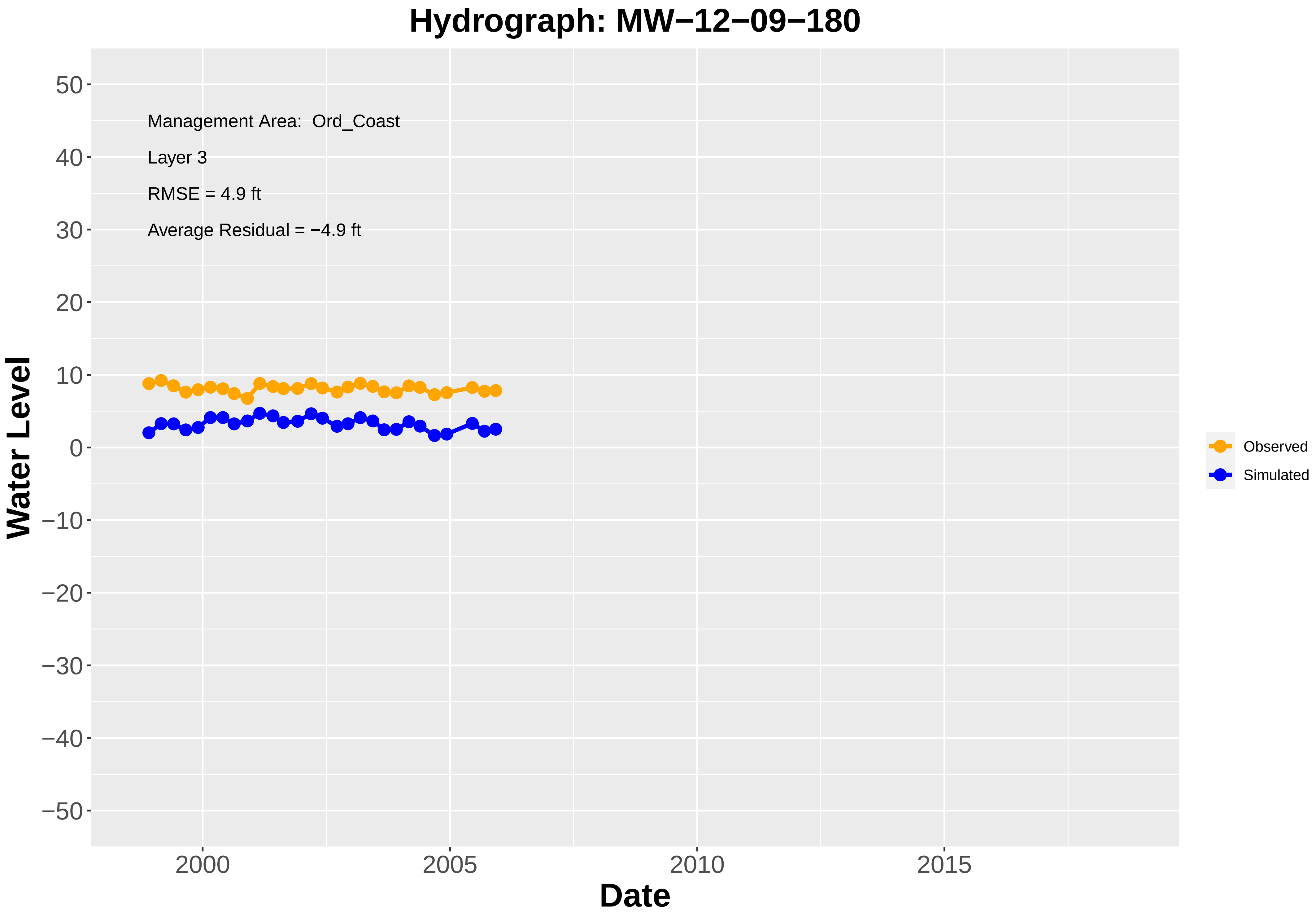

Hydrograph: MW−12−05−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.8 ft
Average Residual = −2.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

Hydrograph: MW−12−06−180

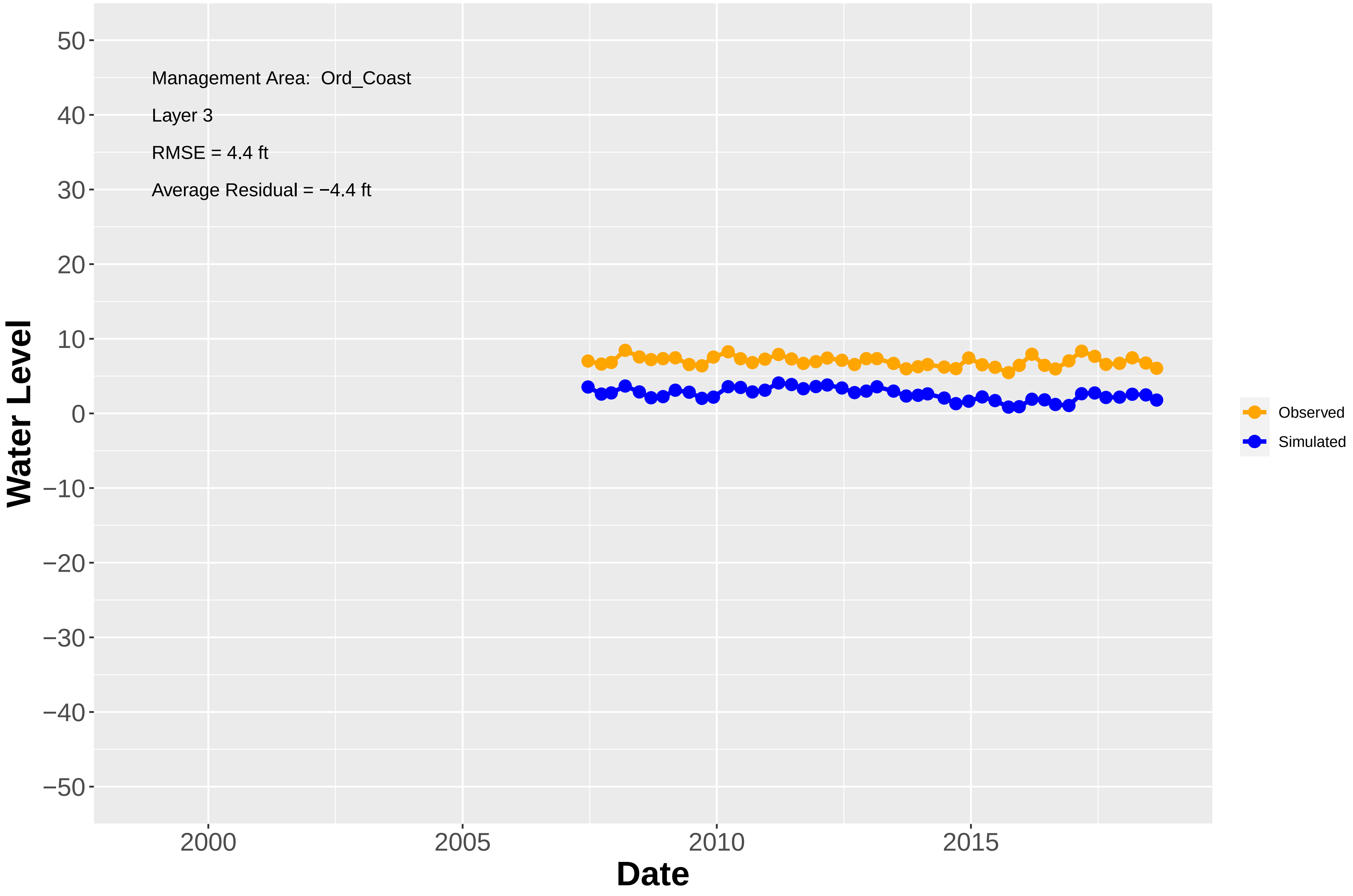


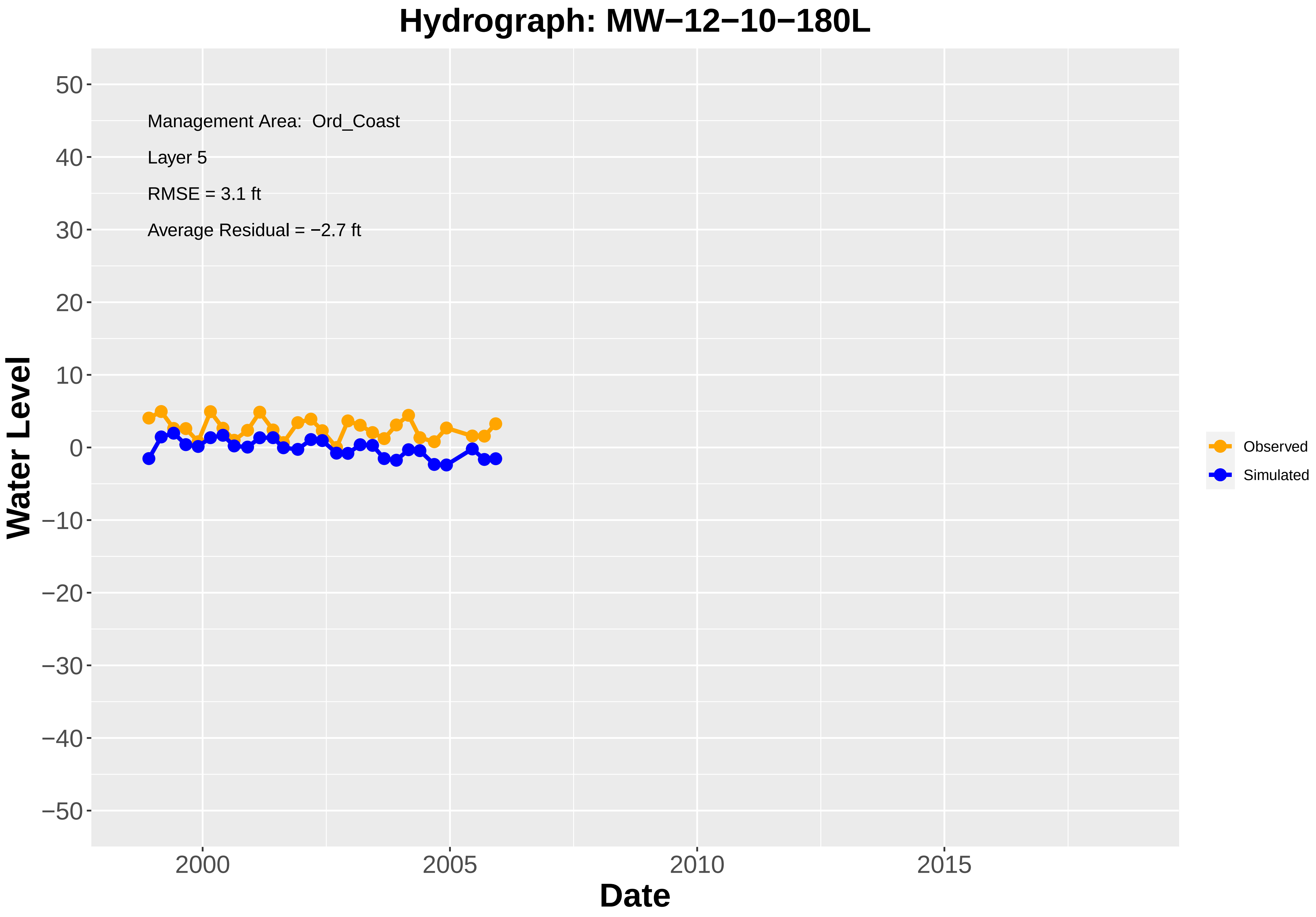

Hydrograph: MW−12−07−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.3 ft
Average Residual = −1.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−12−08−180

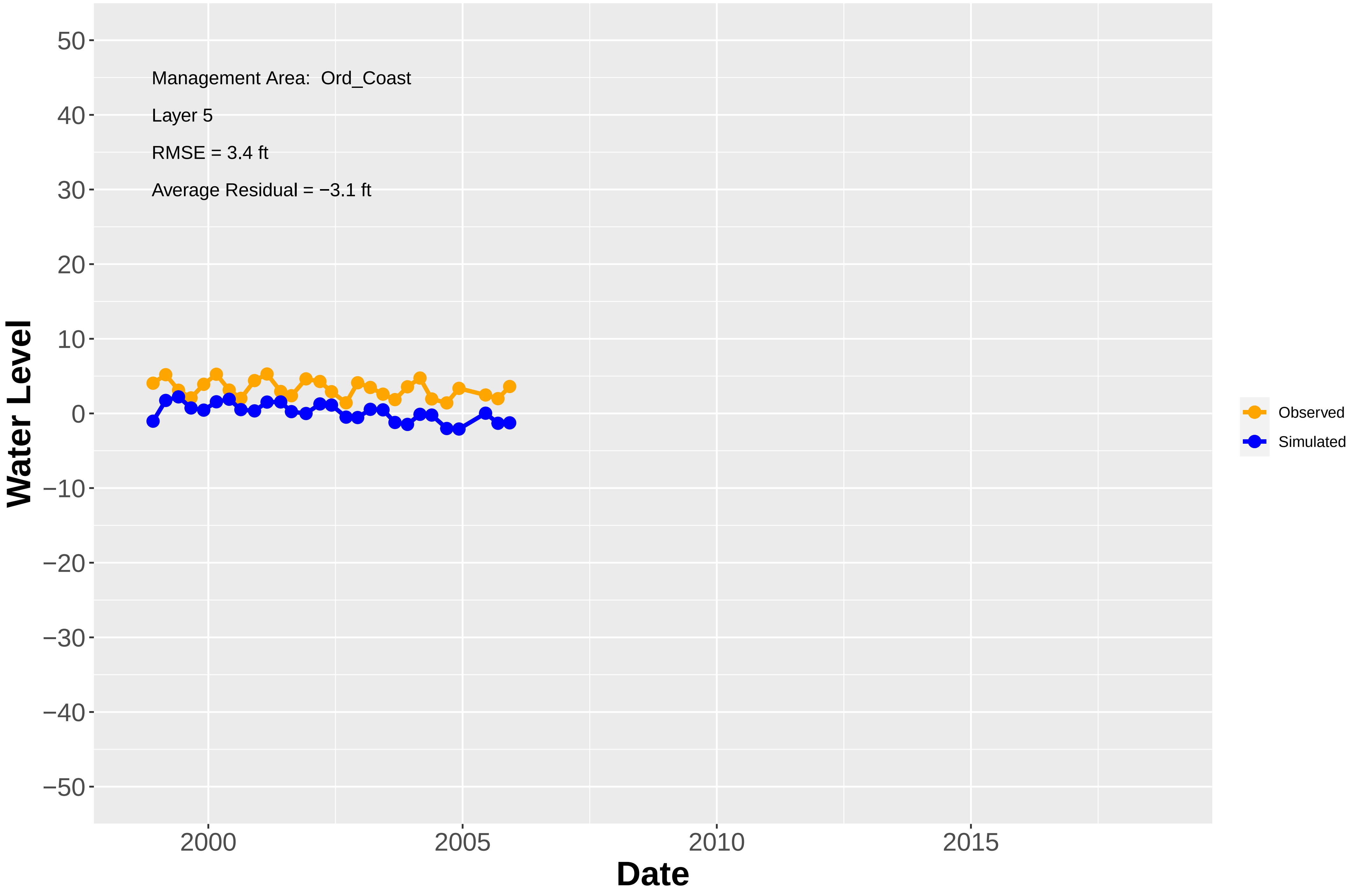

Hydrograph: MW−12−09−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.9 ft
Average Residual = −4.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

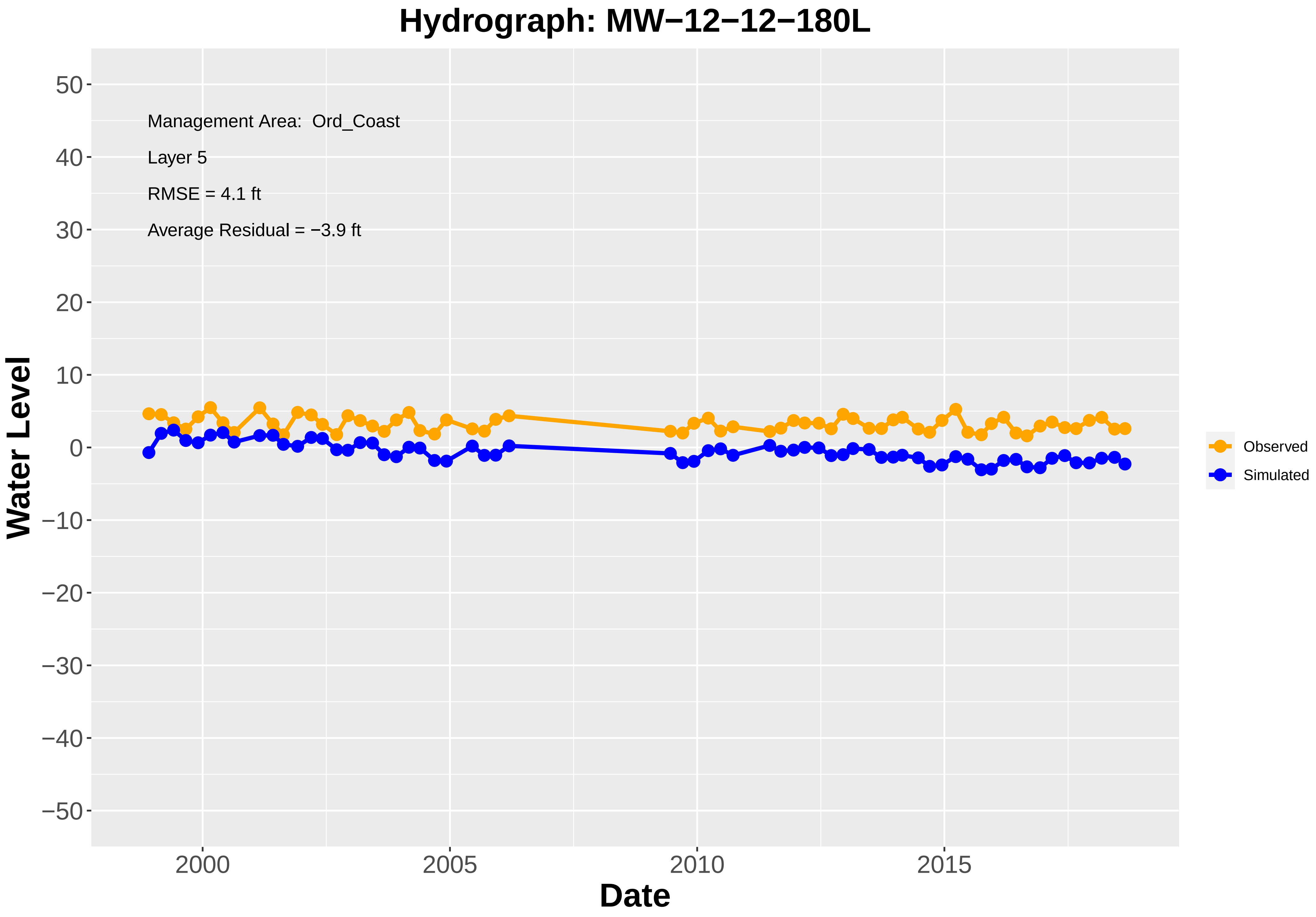
Hydrograph: MW−12−09R−180



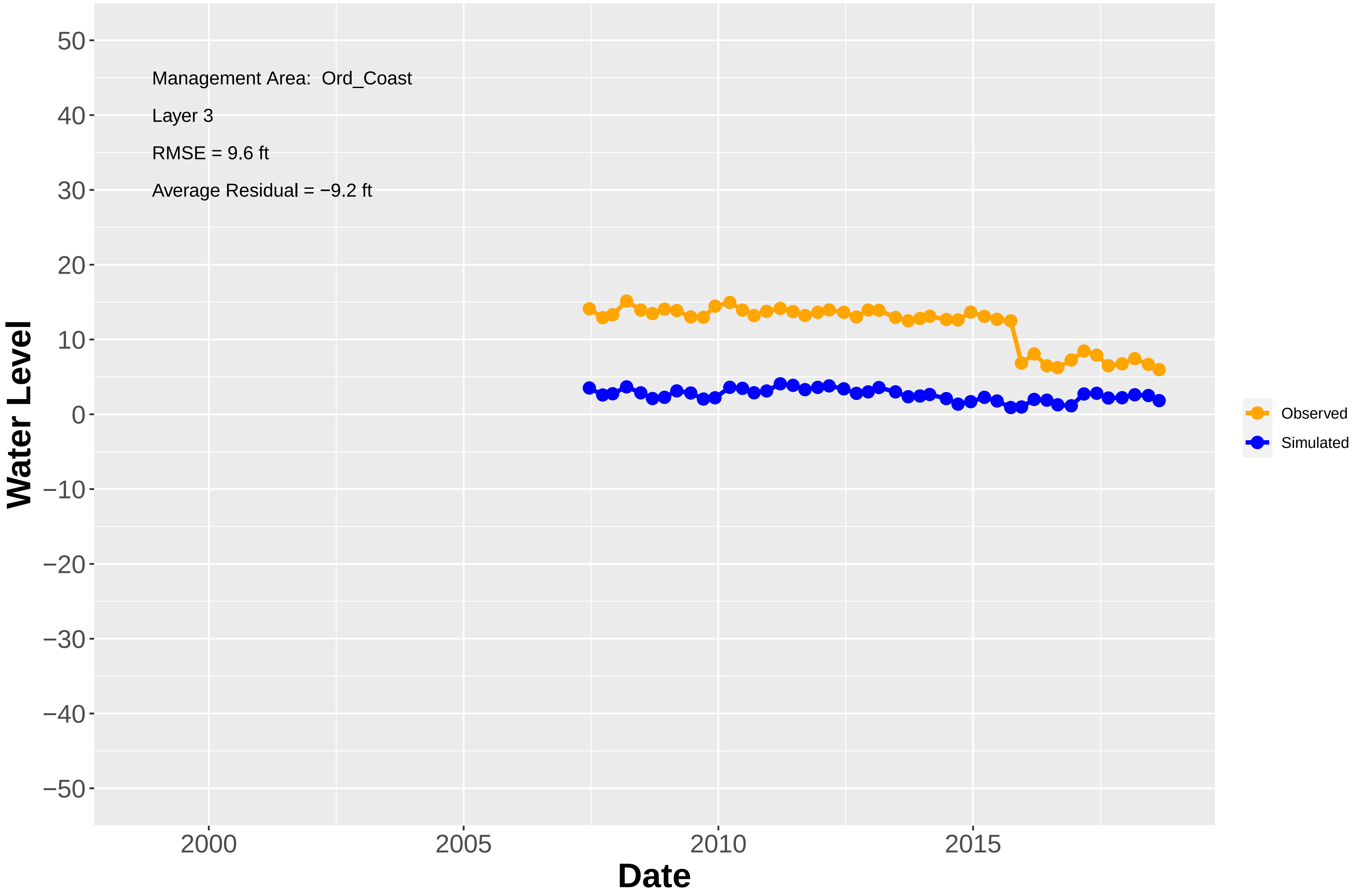

Hydrograph: MW−12−10−180L
Management Area: Ord_Coast
Layer 5
RMSE = 3.1 ft
Average Residual = −2.7 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

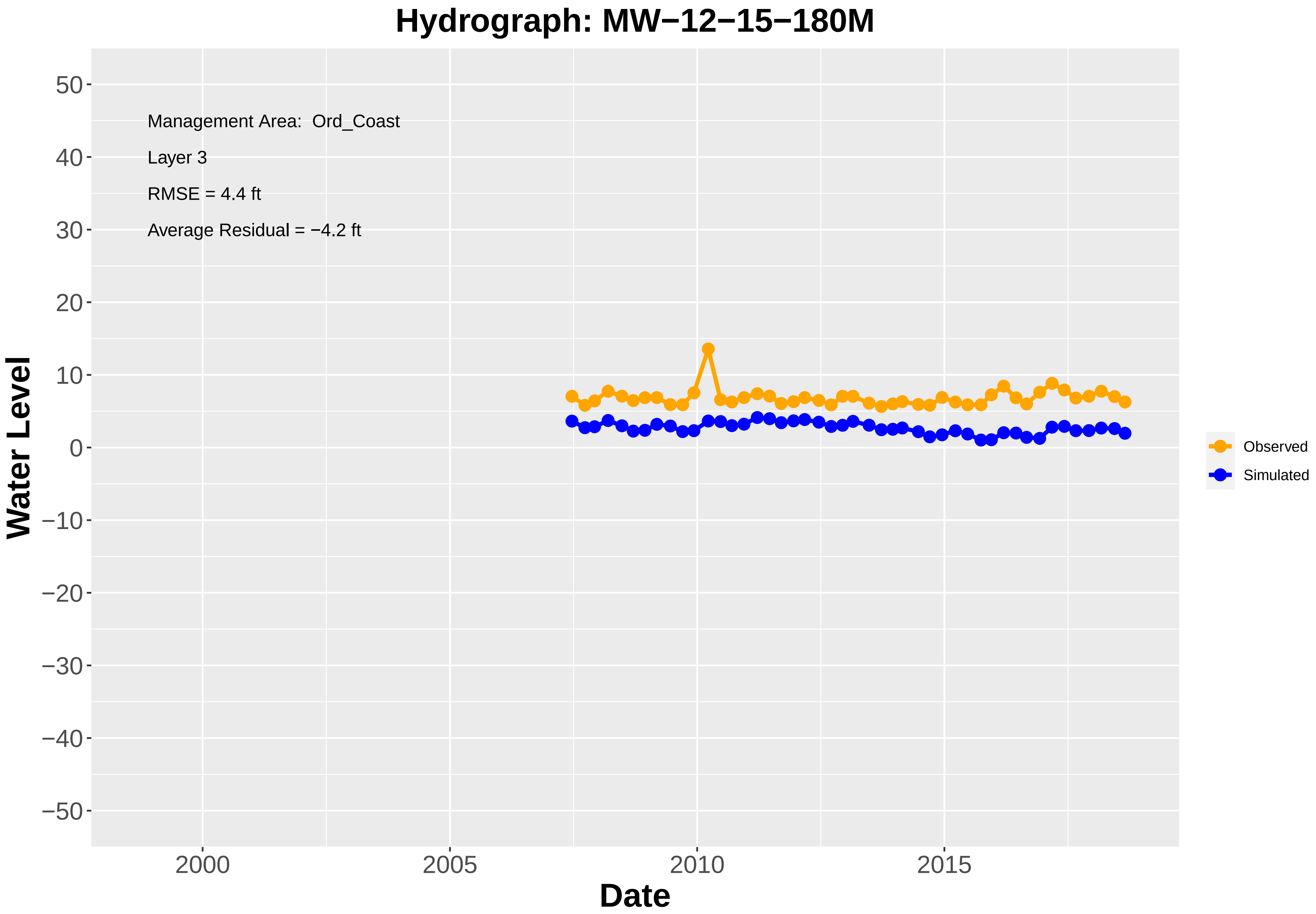
Hydrograph: MW−12−11−180L

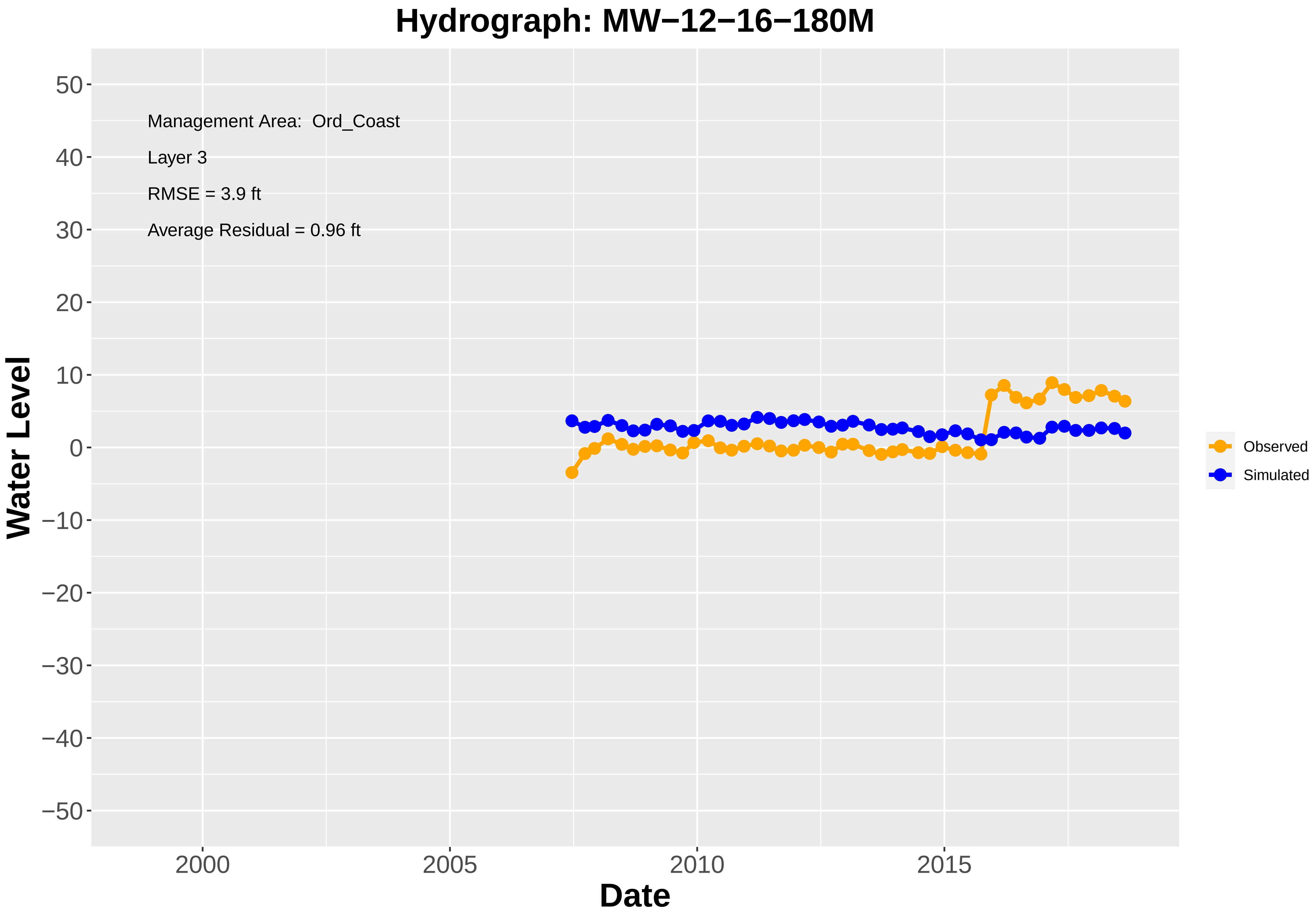


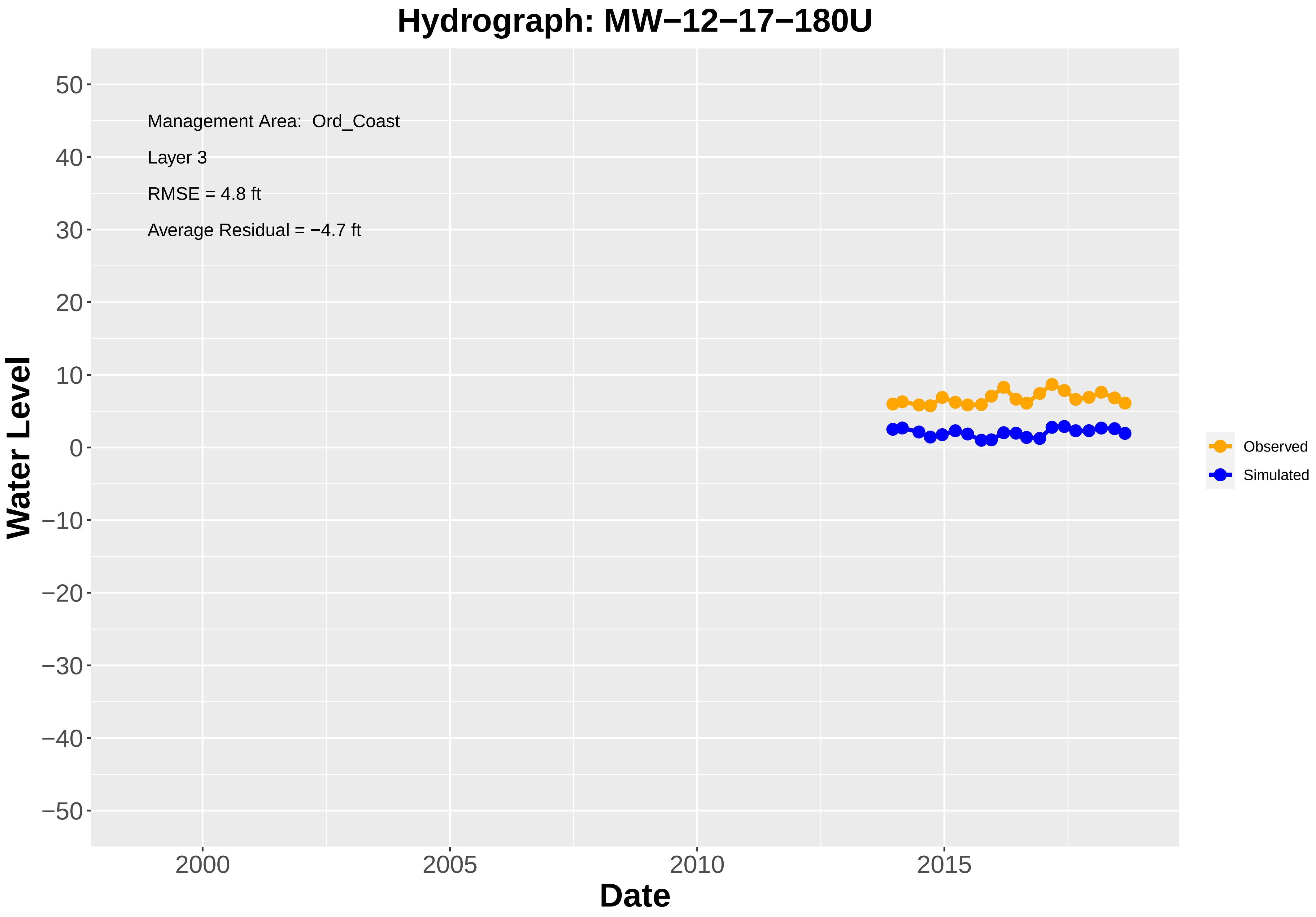

Hydrograph: MW−12−12−180L
Management Area: Ord_Coast
Layer 5
RMSE = 4.1 ft
Average Residual = −3.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

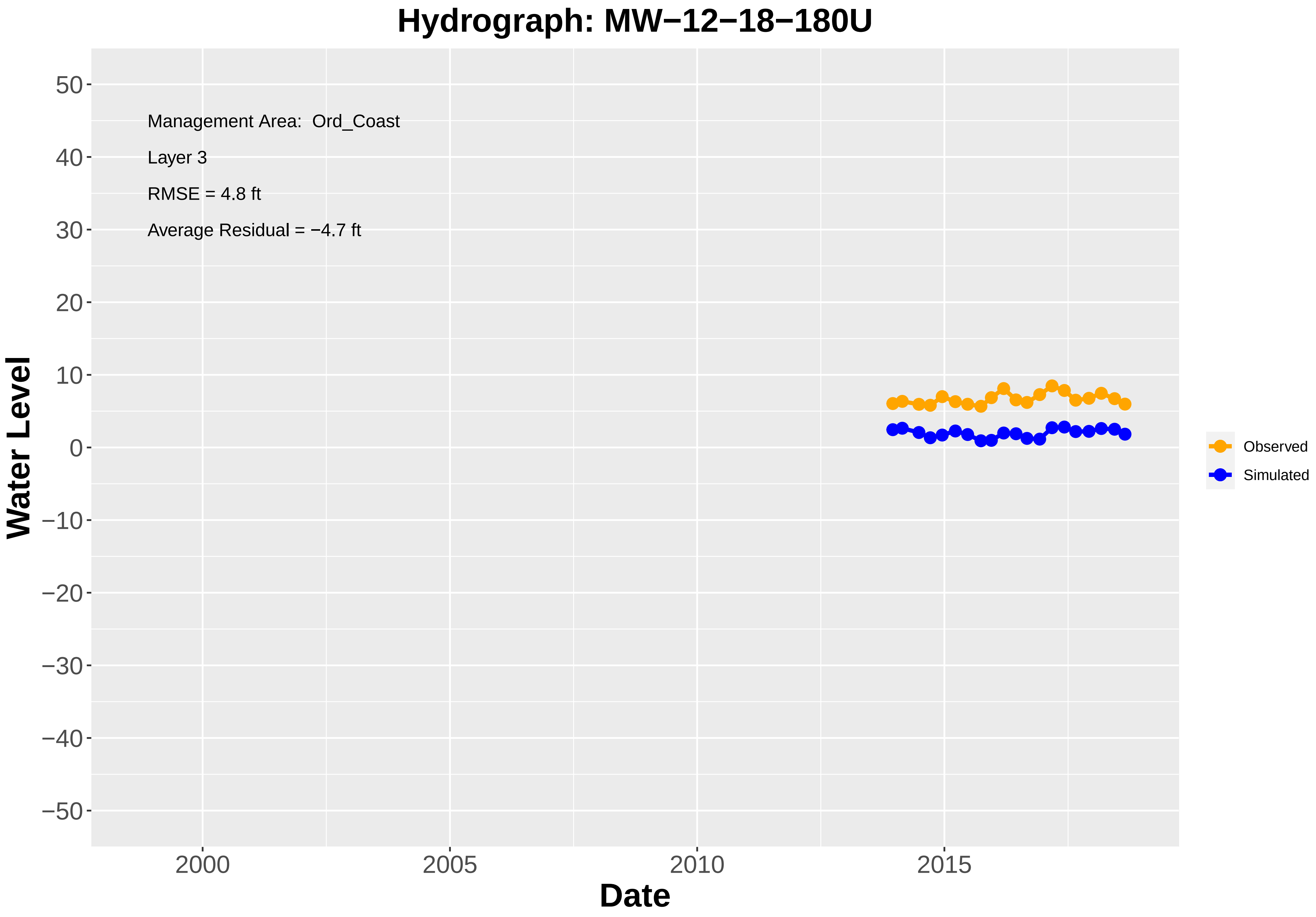
Hydrograph: MW−12−14−180M

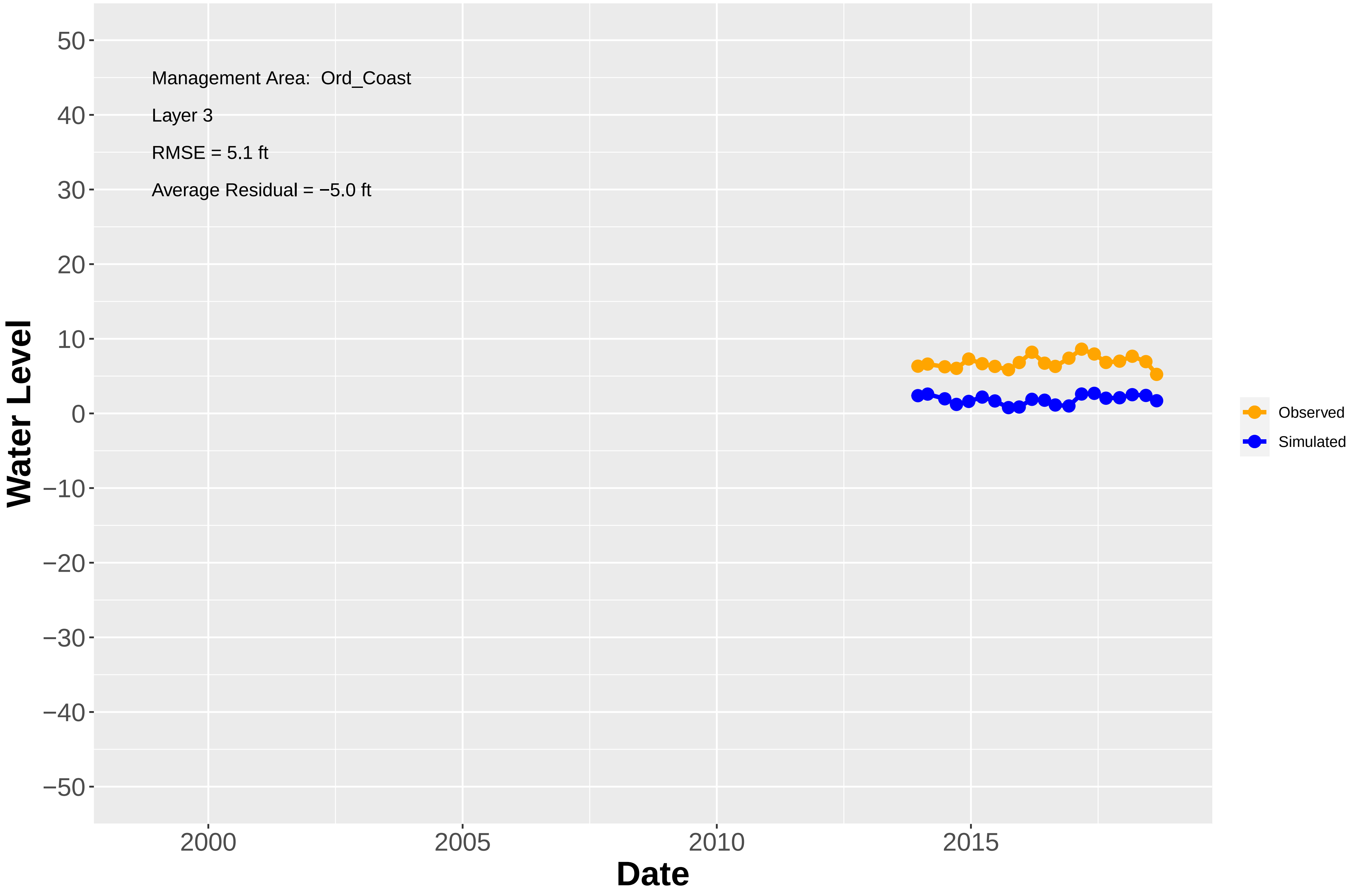



Hydrograph: MW−12−15−180M
Management Area: Ord_Coast
Layer 3
RMSE = 4.4 ft
Average Residual = −4.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

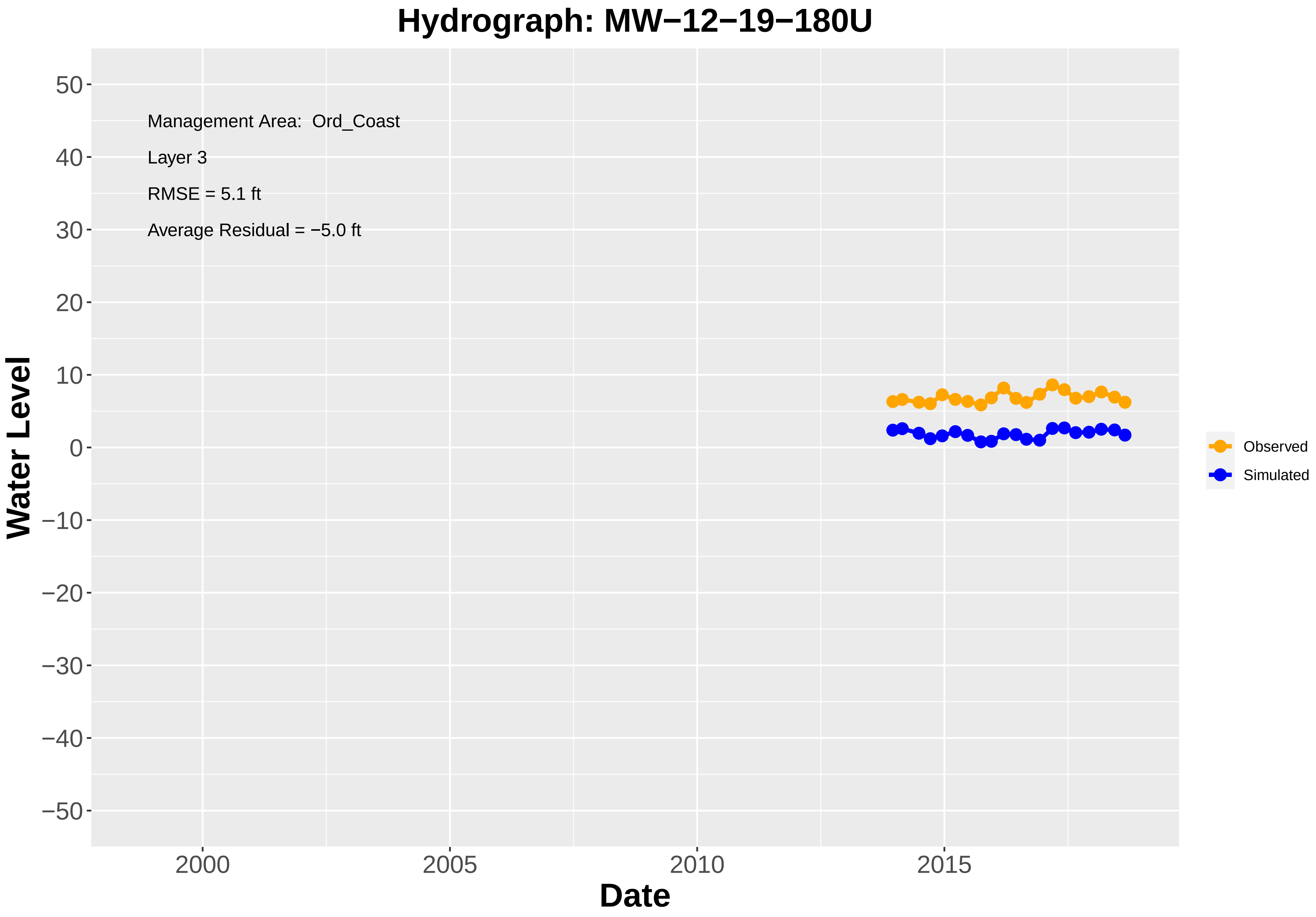

Hydrograph: MW−12−16−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.9 ft
Average Residual = 0.96 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−12−17−180U
Management Area: Ord_Coast
Layer 3
RMSE = 4.8 ft
Average Residual = −4.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

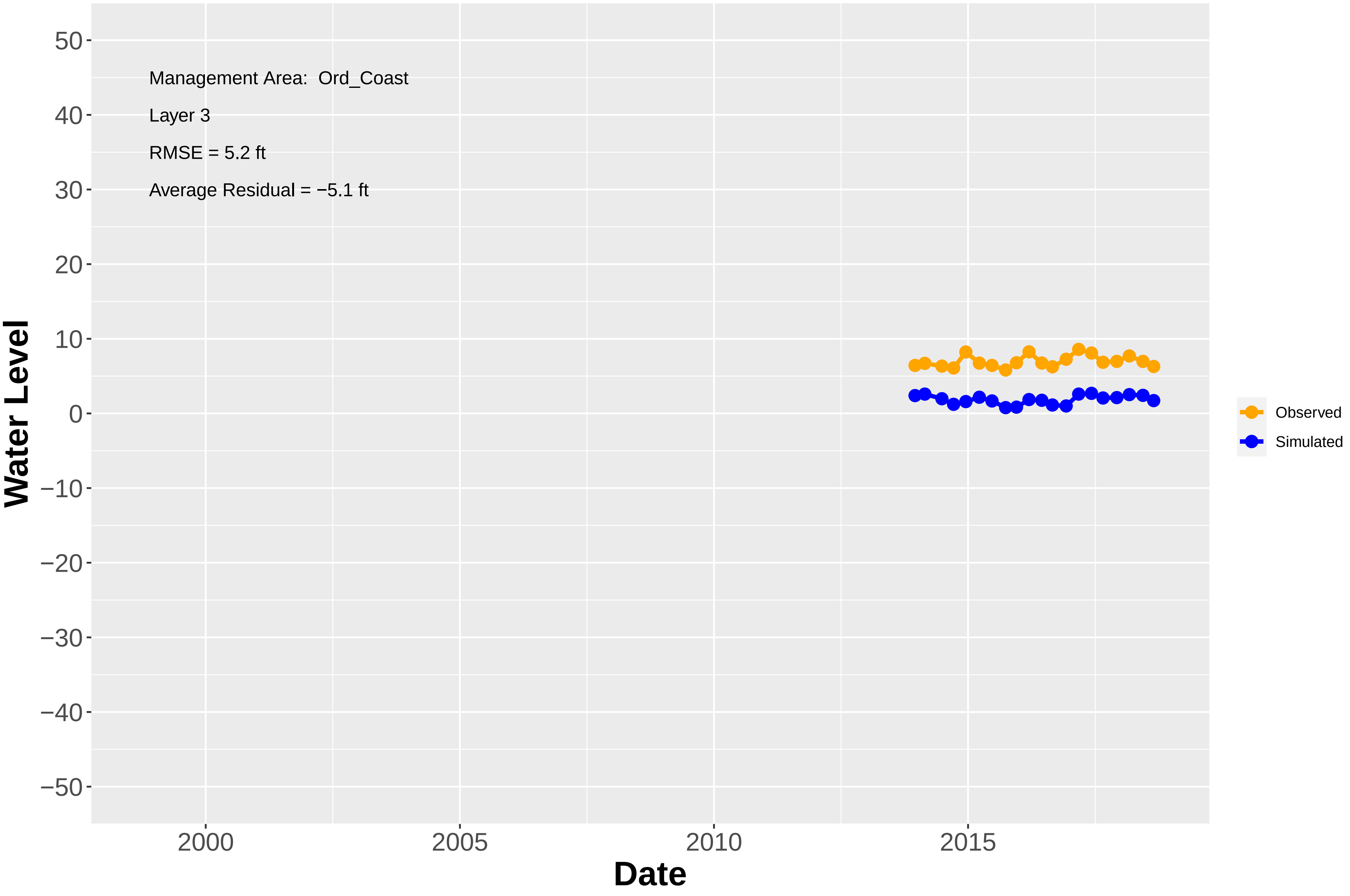

Hydrograph: MW−12−18−180U
Management Area: Ord_Coast
Layer 3
RMSE = 4.8 ft
Average Residual = −4.7 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

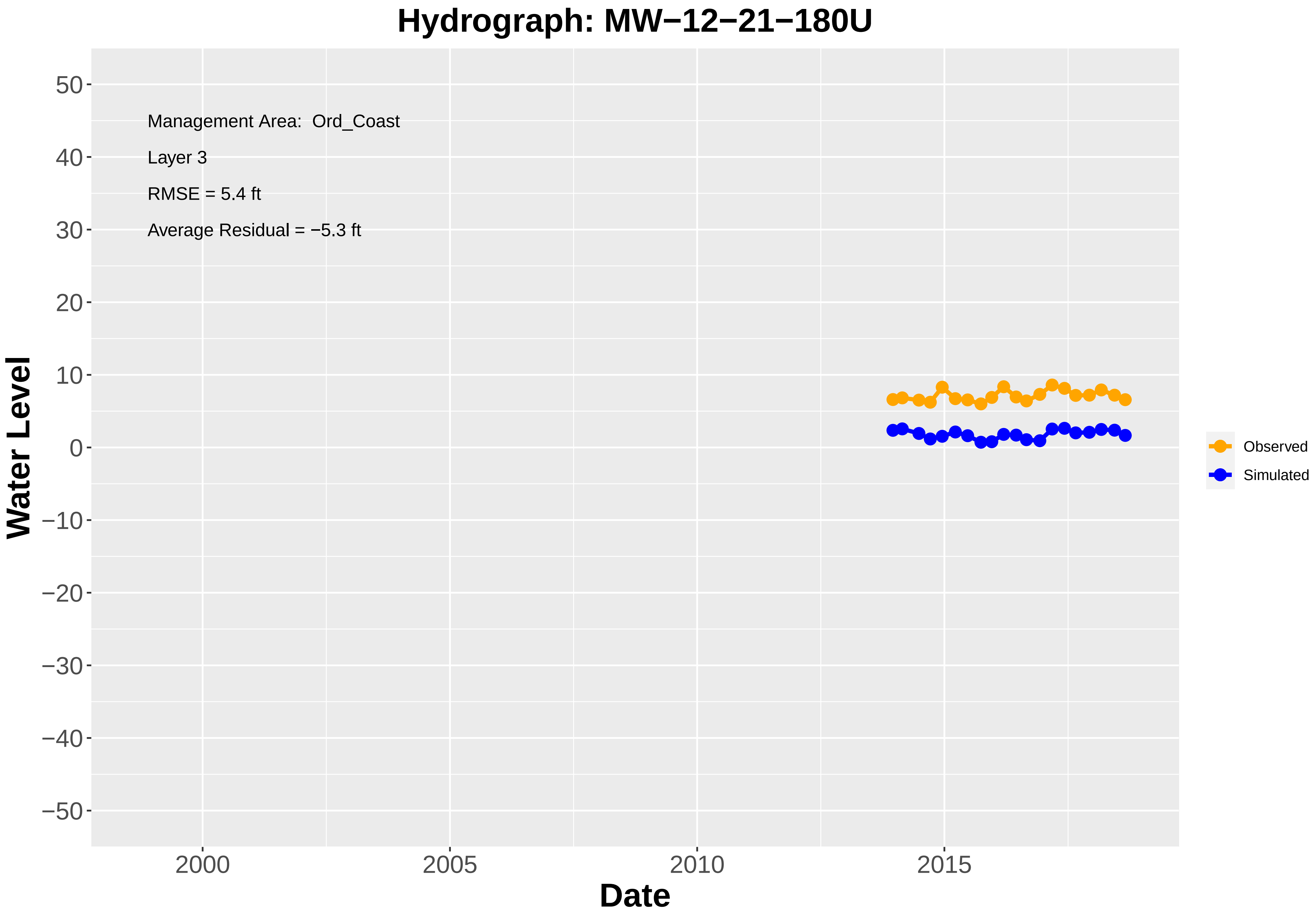


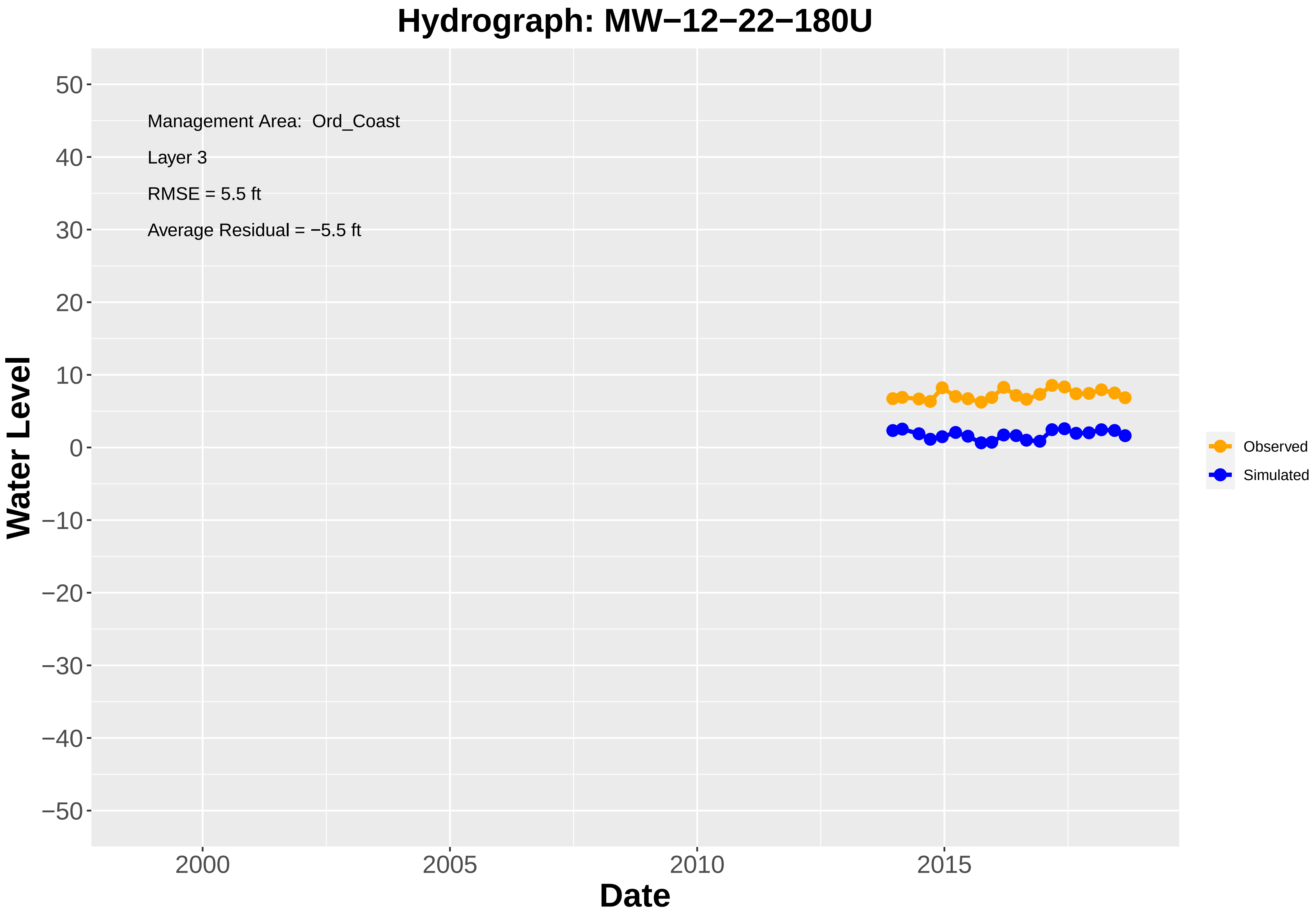
Hydrograph: MW−12−19−180M

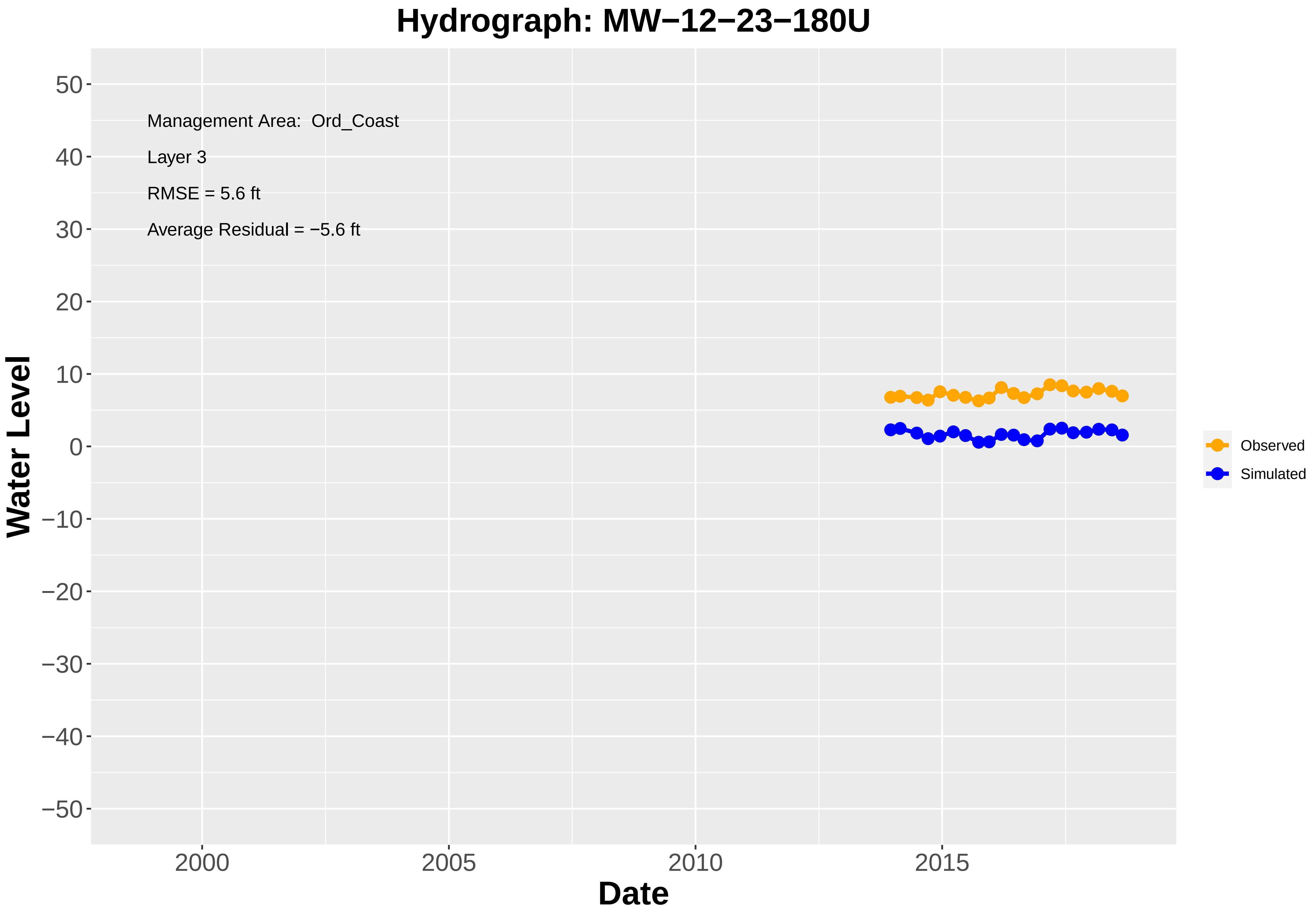

Hydrograph: MW−12−19−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.1 ft
Average Residual = −5.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

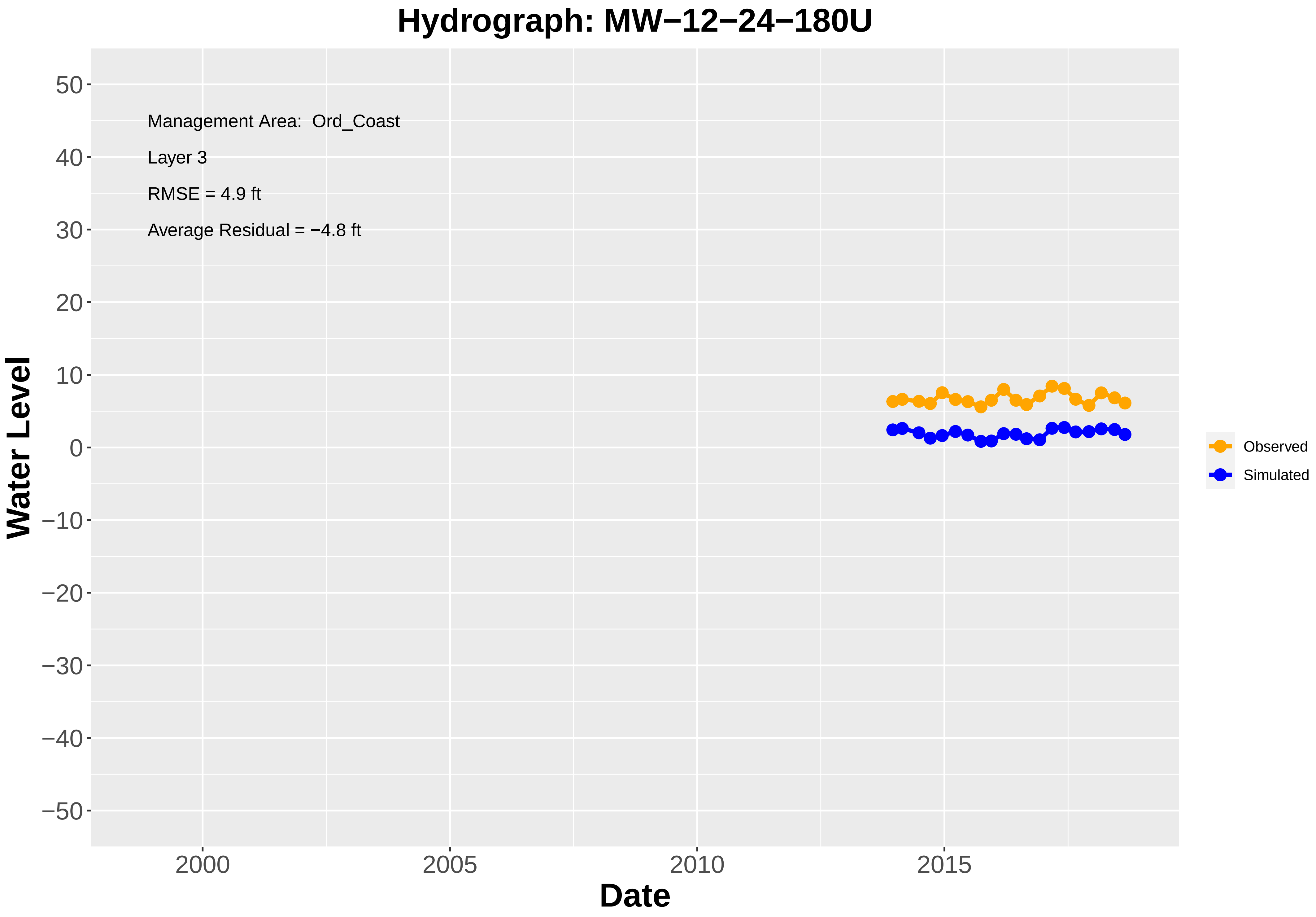
Hydrograph: MW−12−20−180U

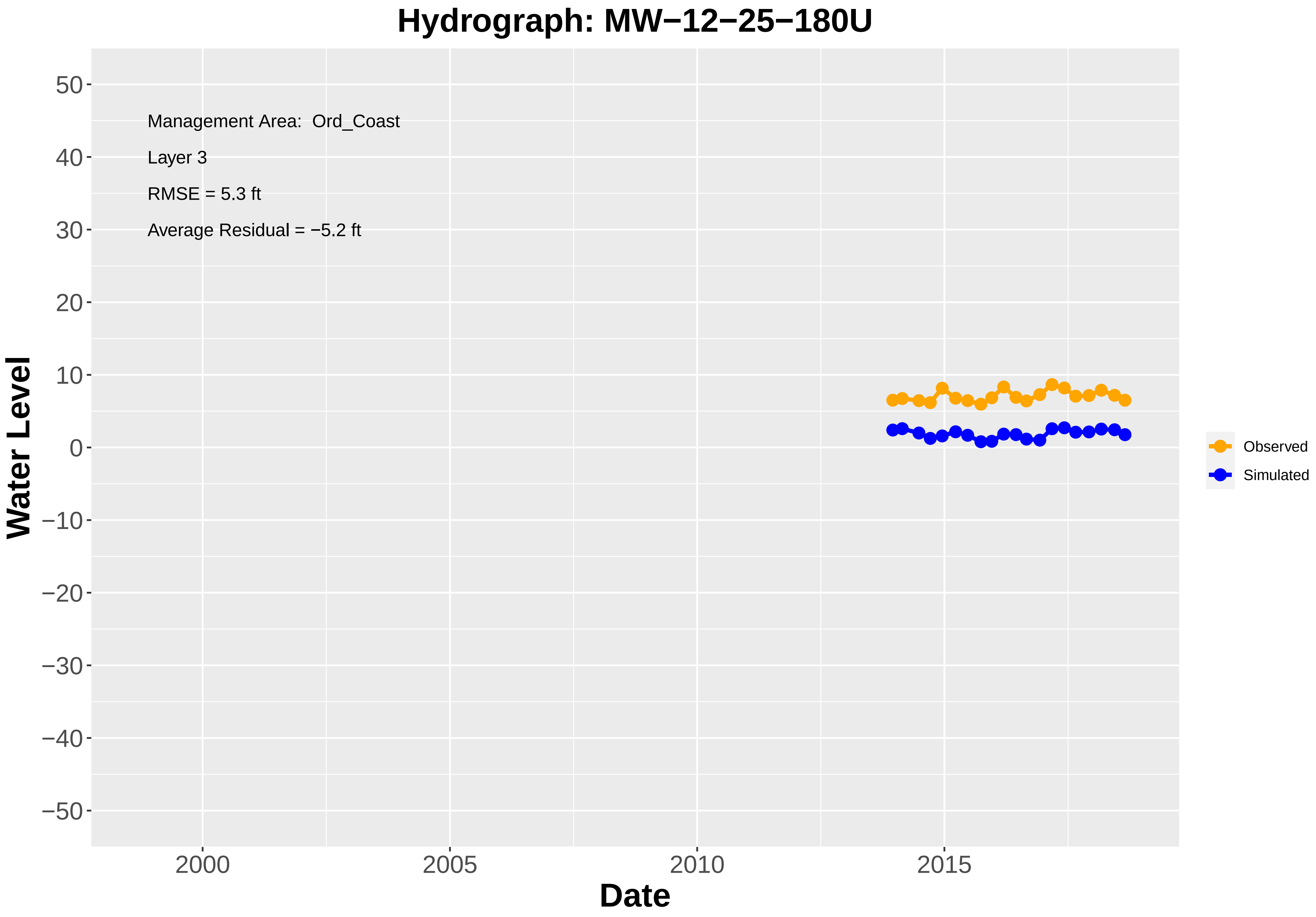


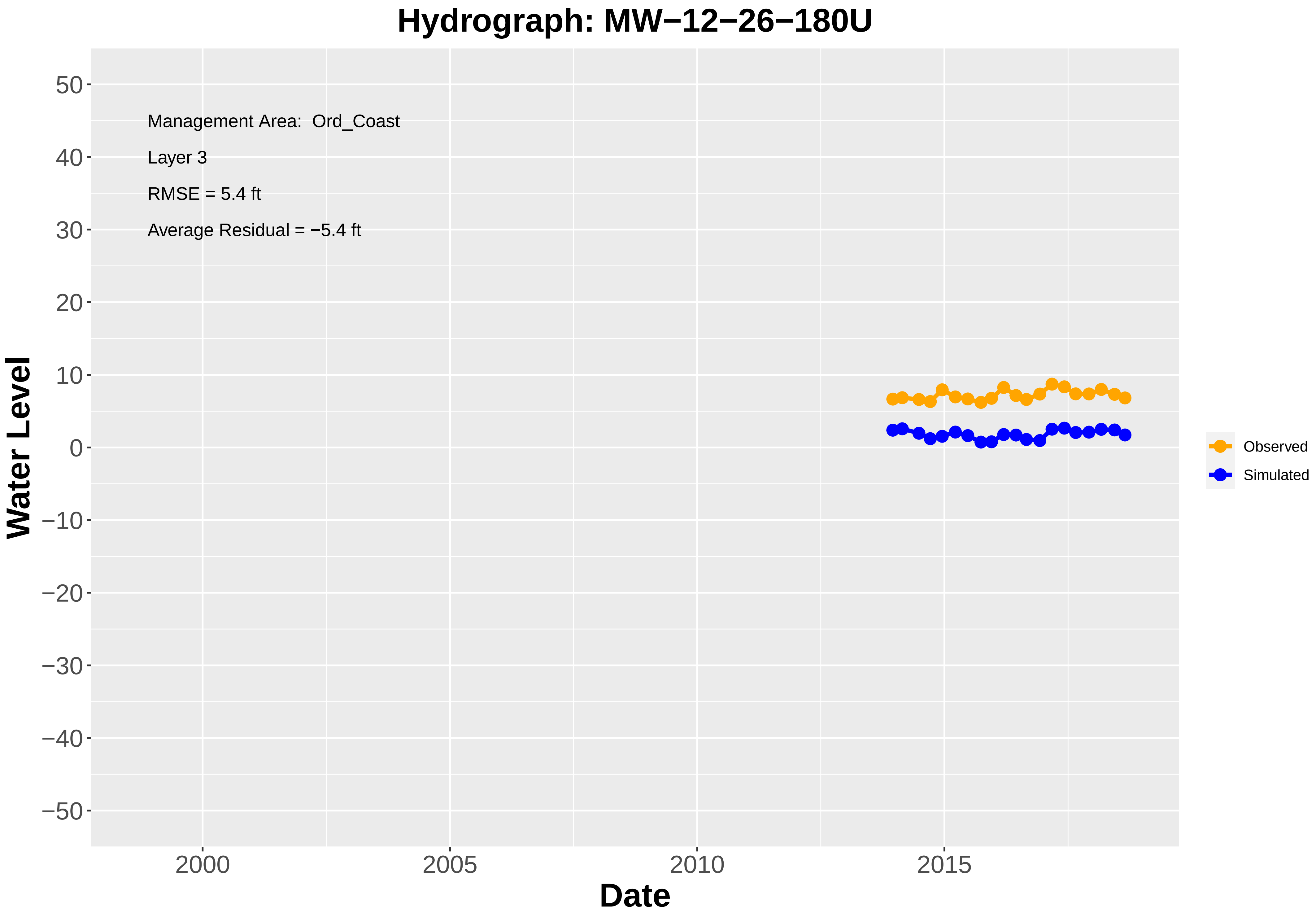

Hydrograph: MW−12−21−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.4 ft
Average Residual = −5.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−12−22−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.5 ft
Average Residual = −5.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

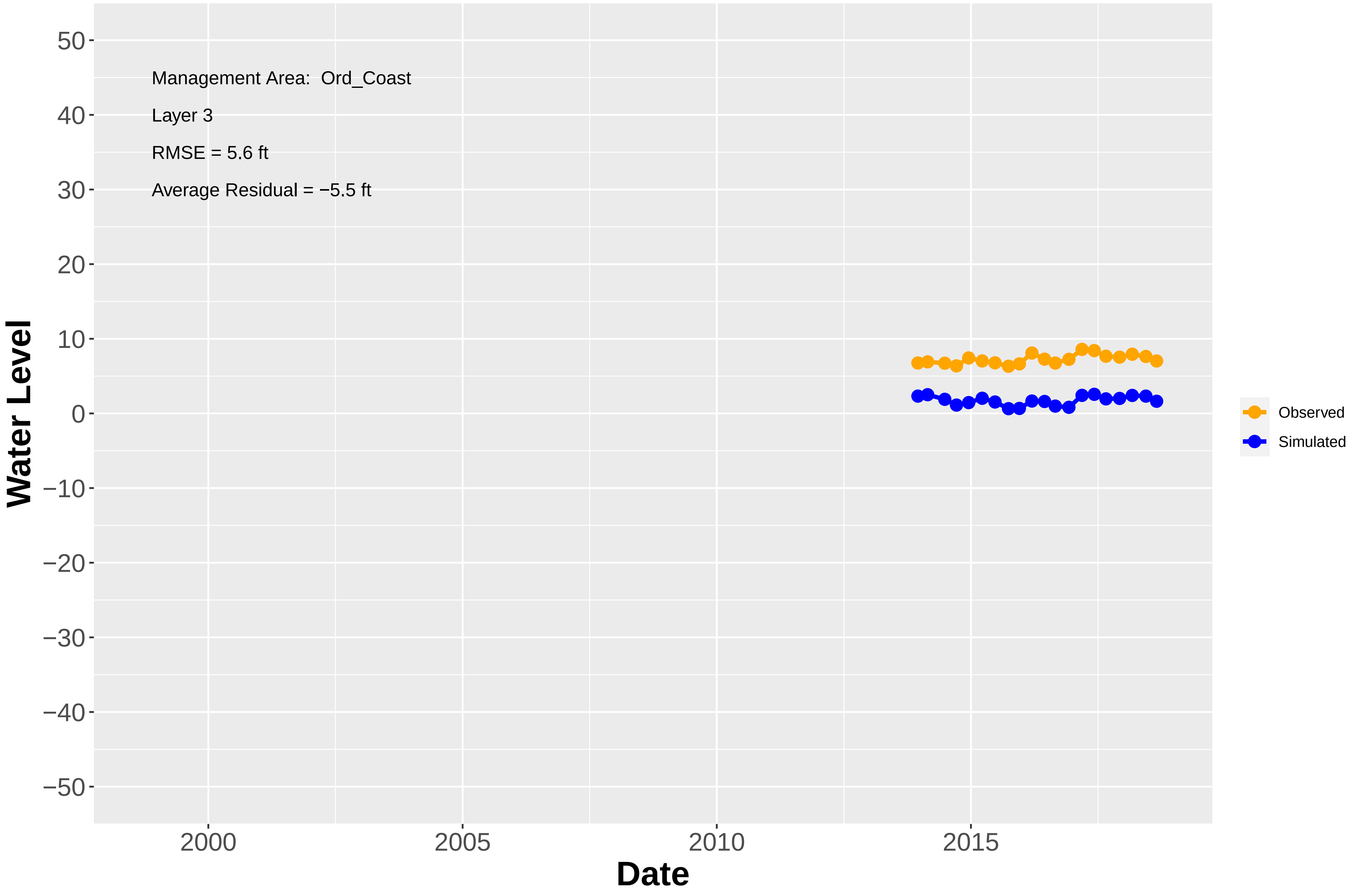

Hydrograph: MW−12−23−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.6 ft
Average Residual = −5.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

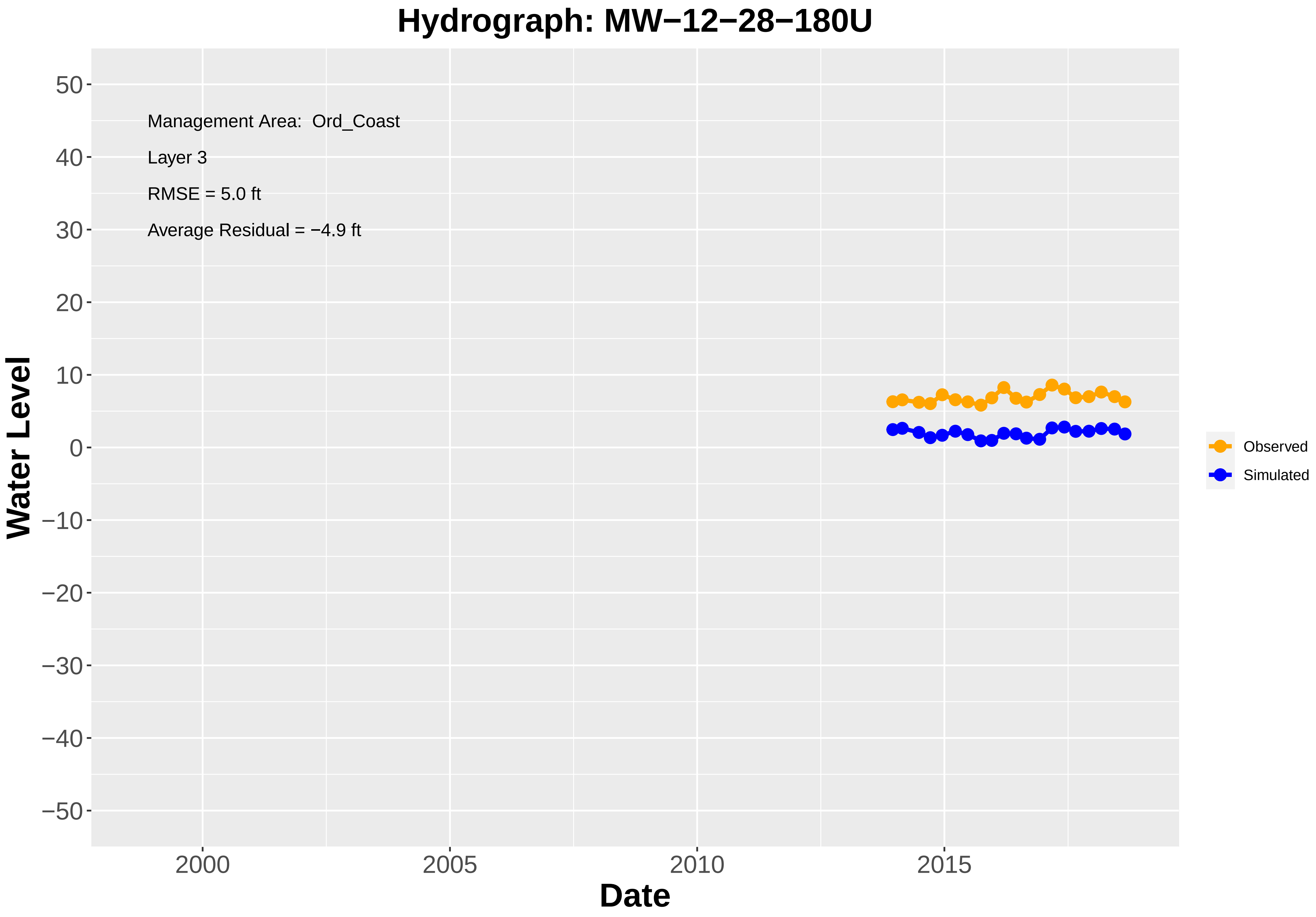

Hydrograph: MW−12−24−180U
Management Area: Ord_Coast
Layer 3
RMSE = 4.9 ft
Average Residual = −4.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−12−25−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.3 ft
Average Residual = −5.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

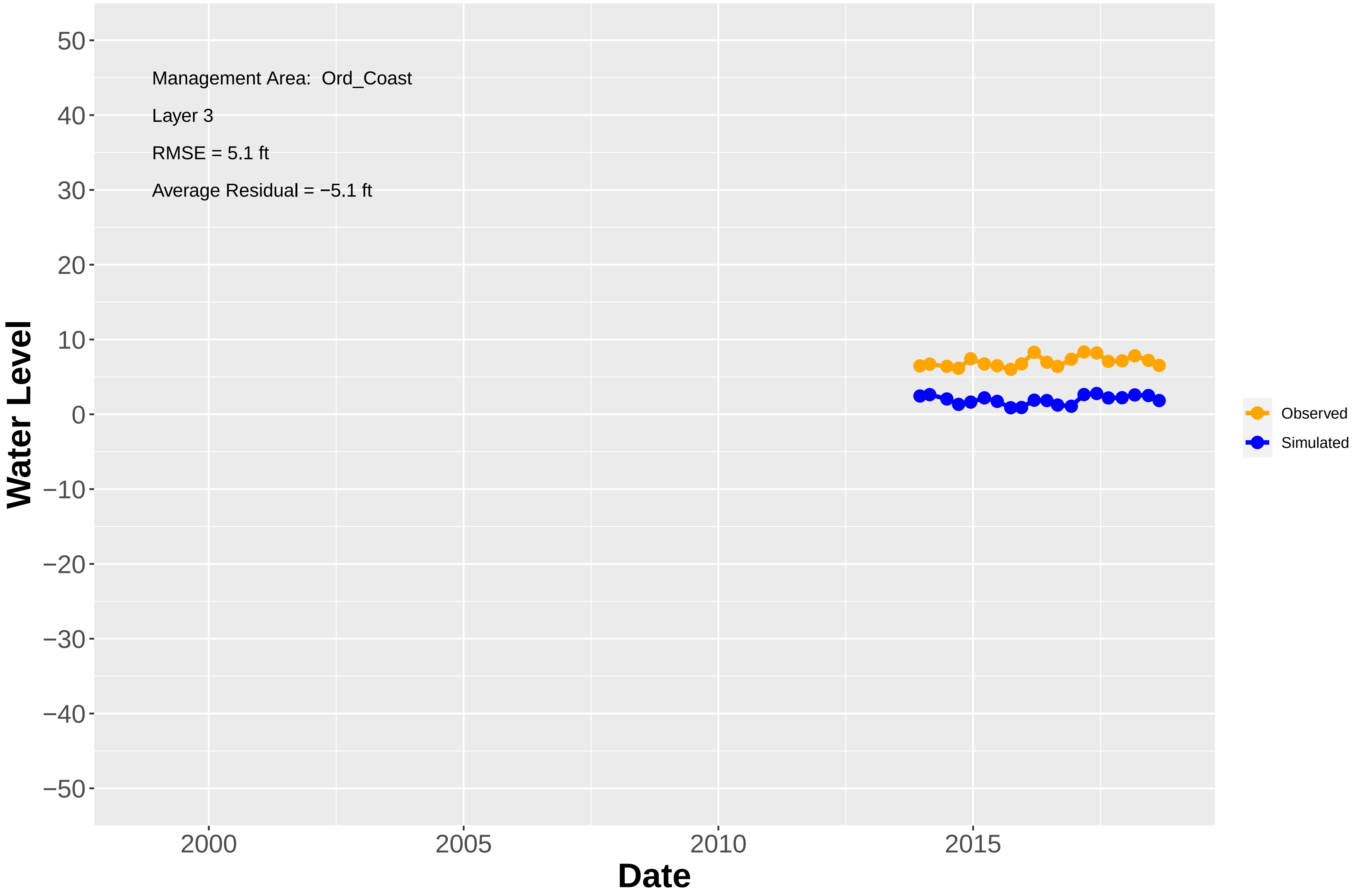

Hydrograph: MW−12−26−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.4 ft
Average Residual = −5.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

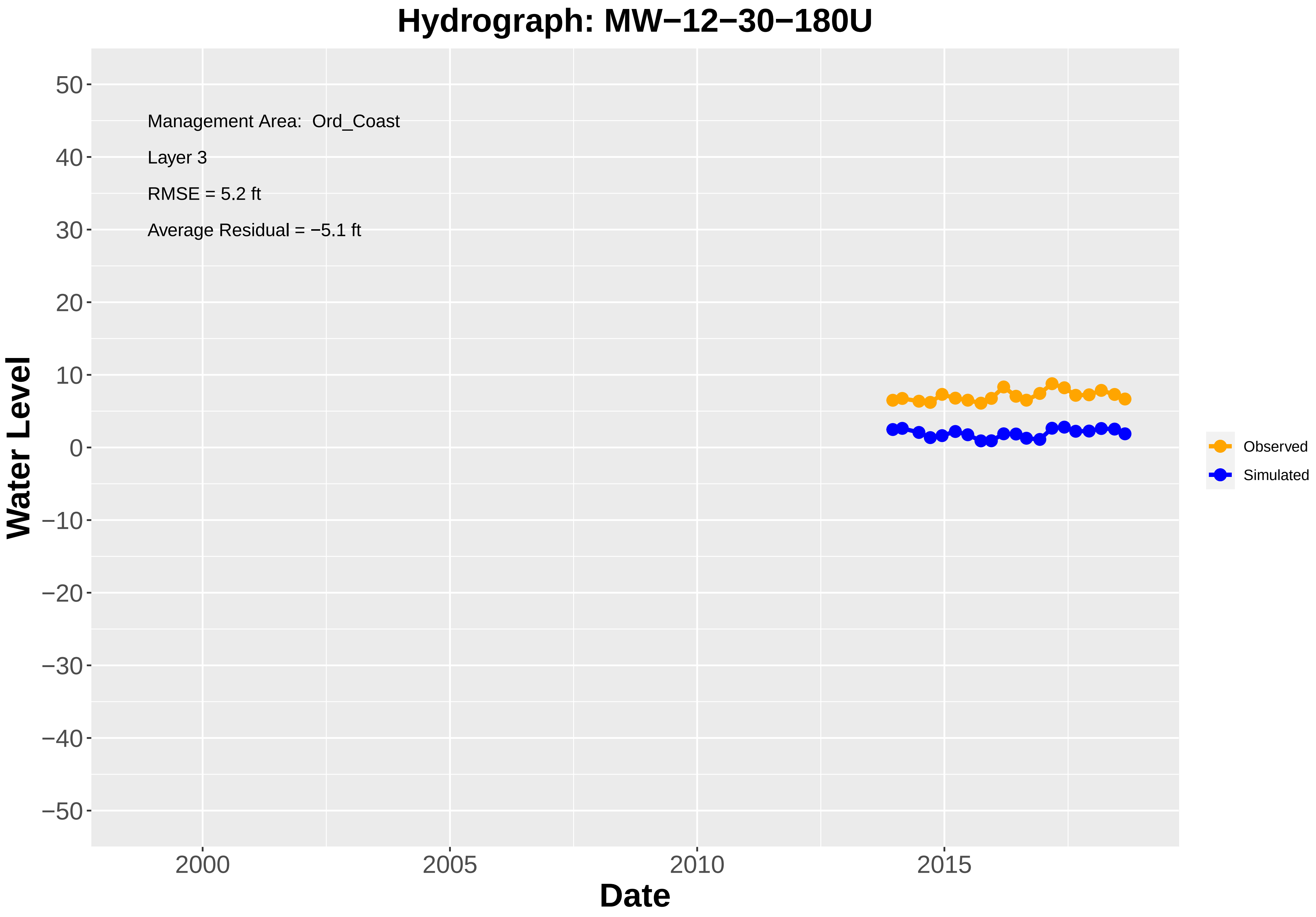
Hydrograph: MW−12−27−180U



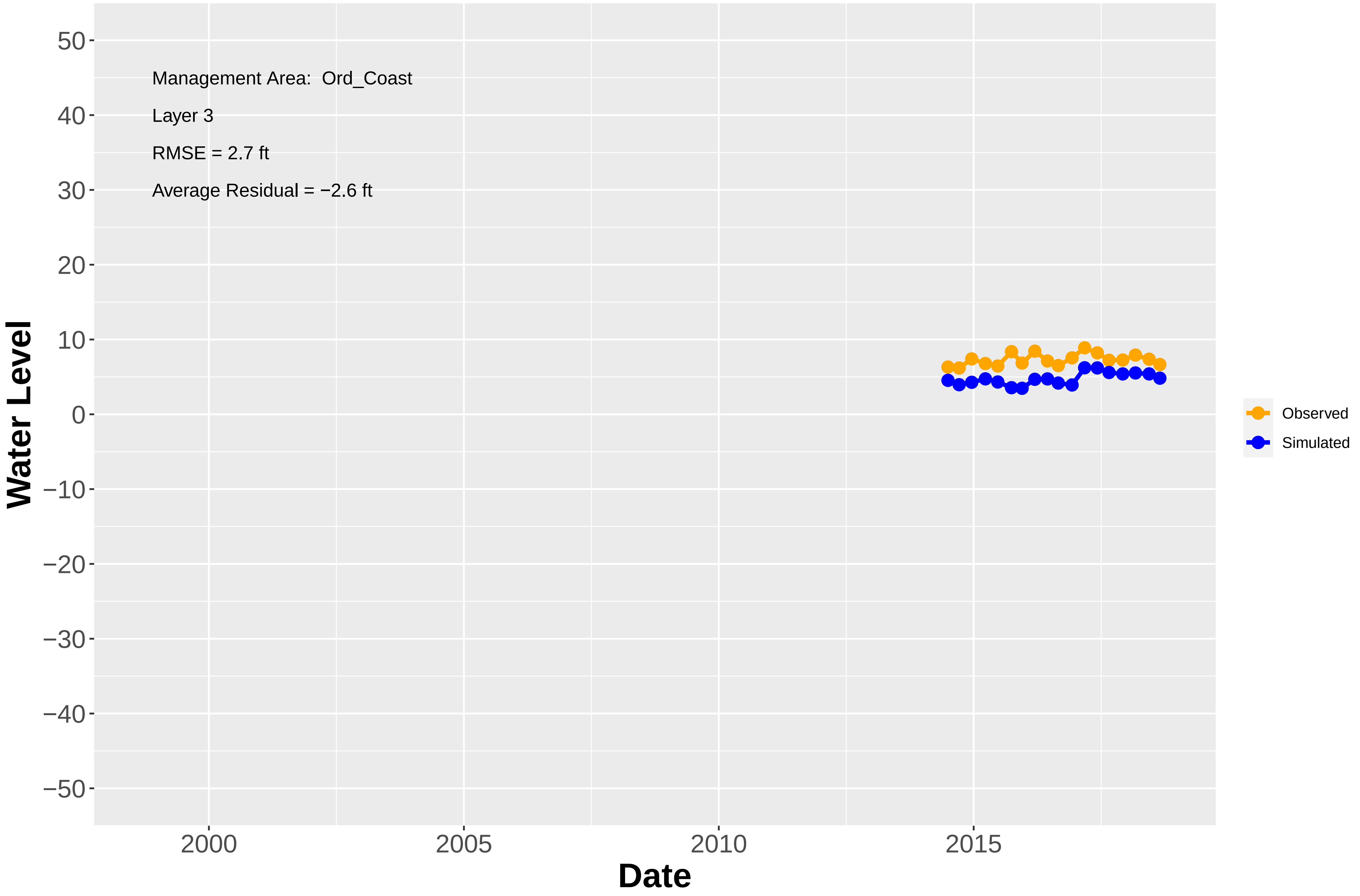

Hydrograph: MW−12−28−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.0 ft
Average Residual = −4.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

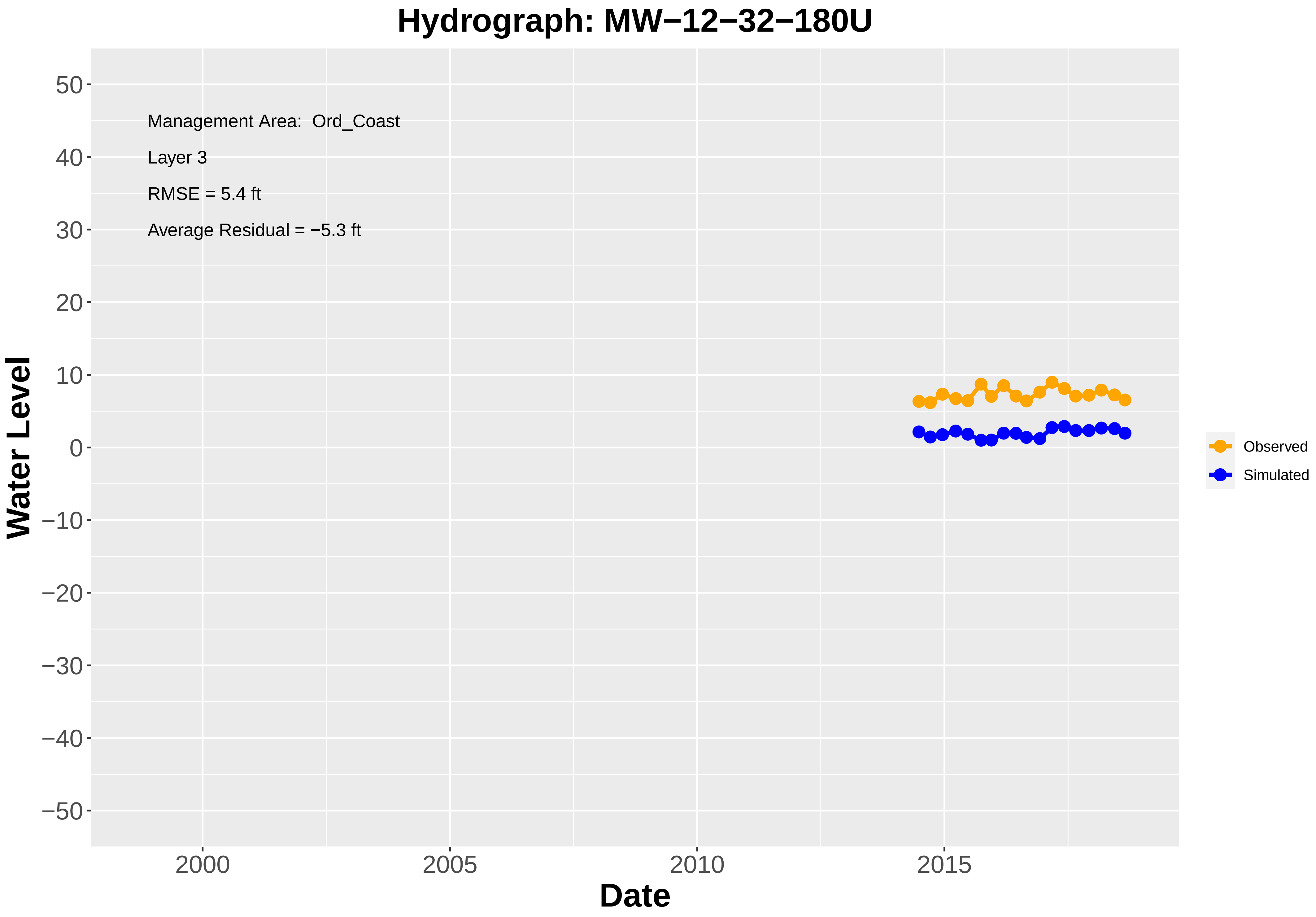
Hydrograph: MW−12−29−180U



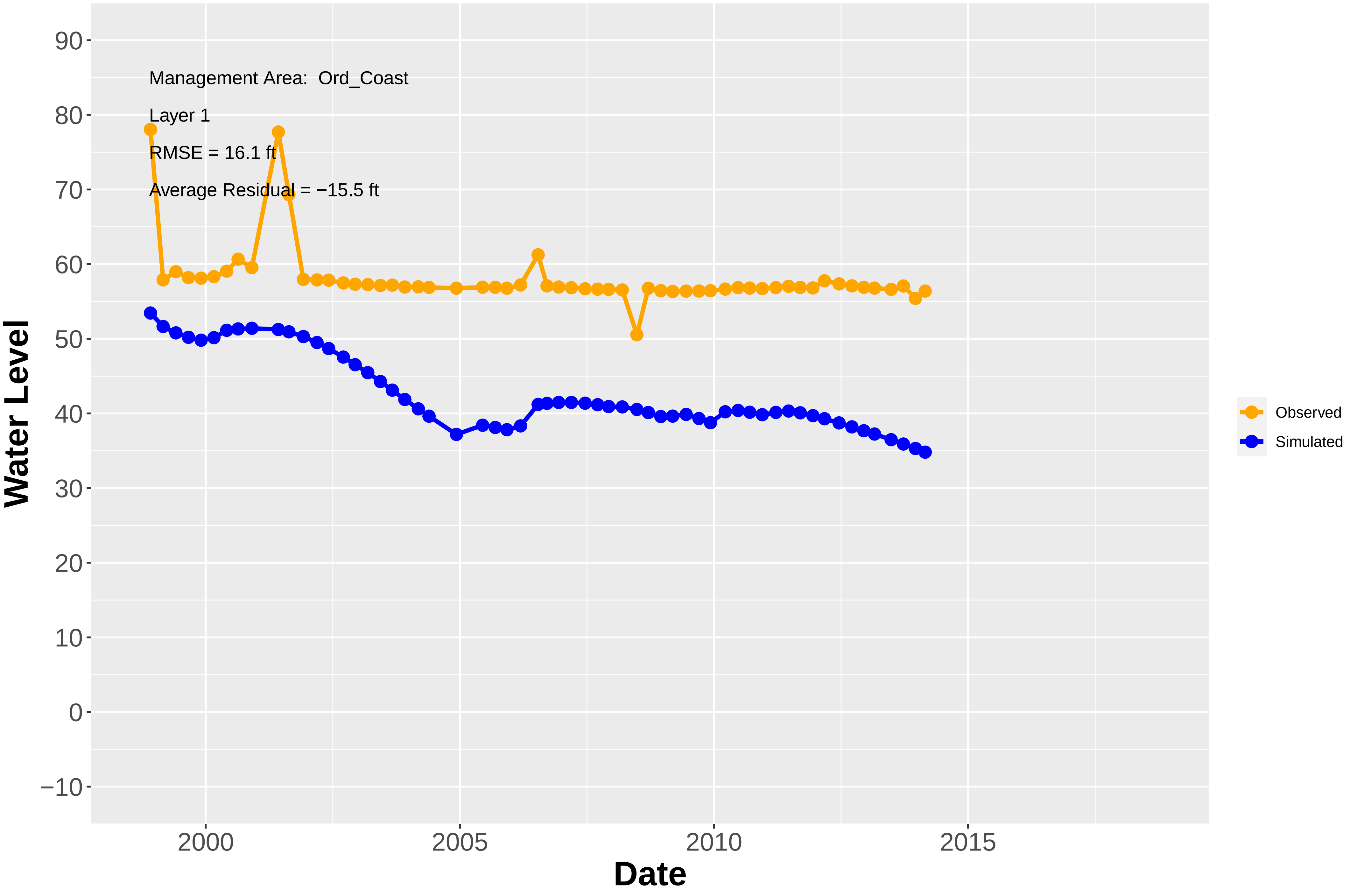

Hydrograph: MW−12−30−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.2 ft
Average Residual = −5.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

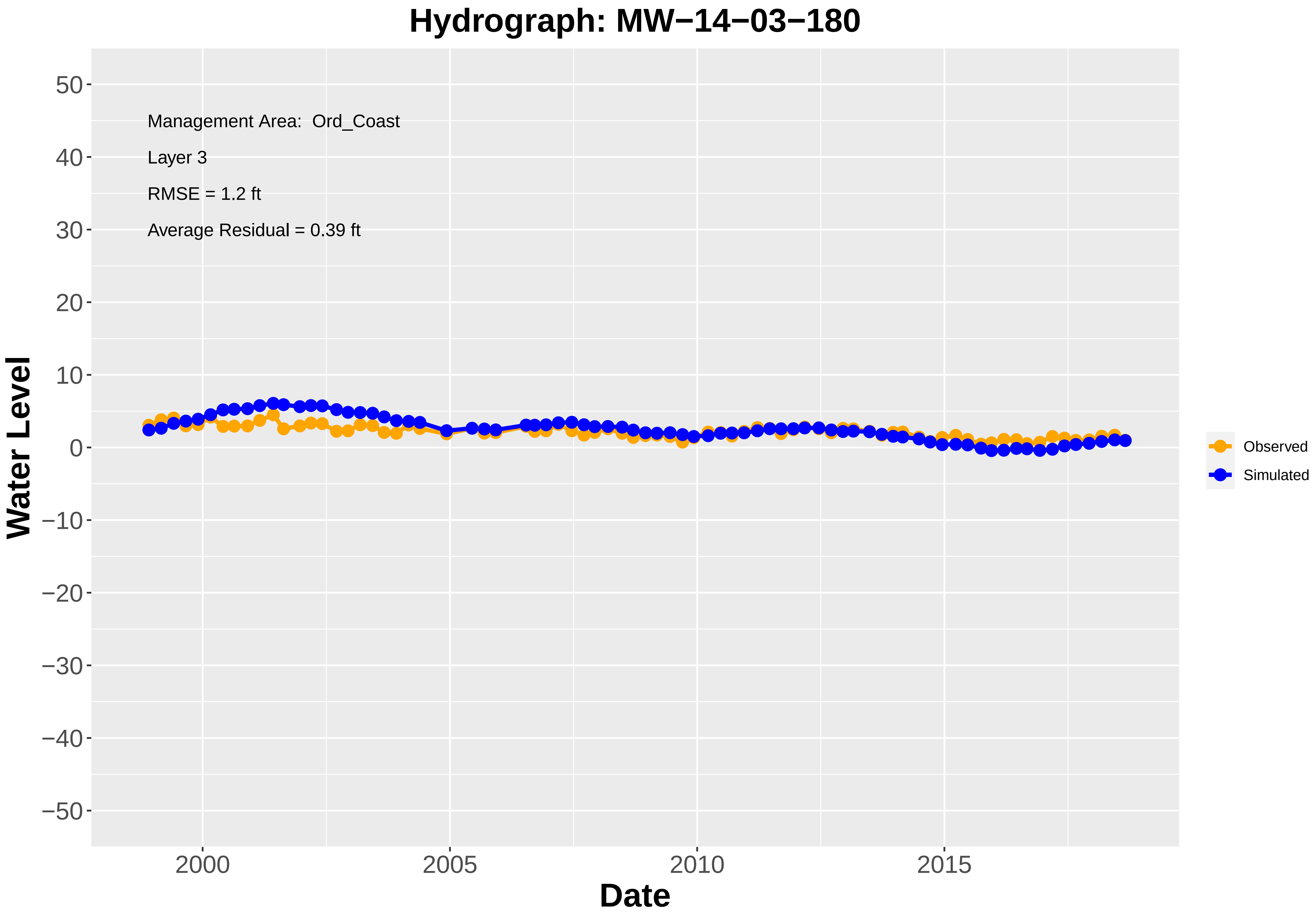
Hydrograph: MW−12−31−180M

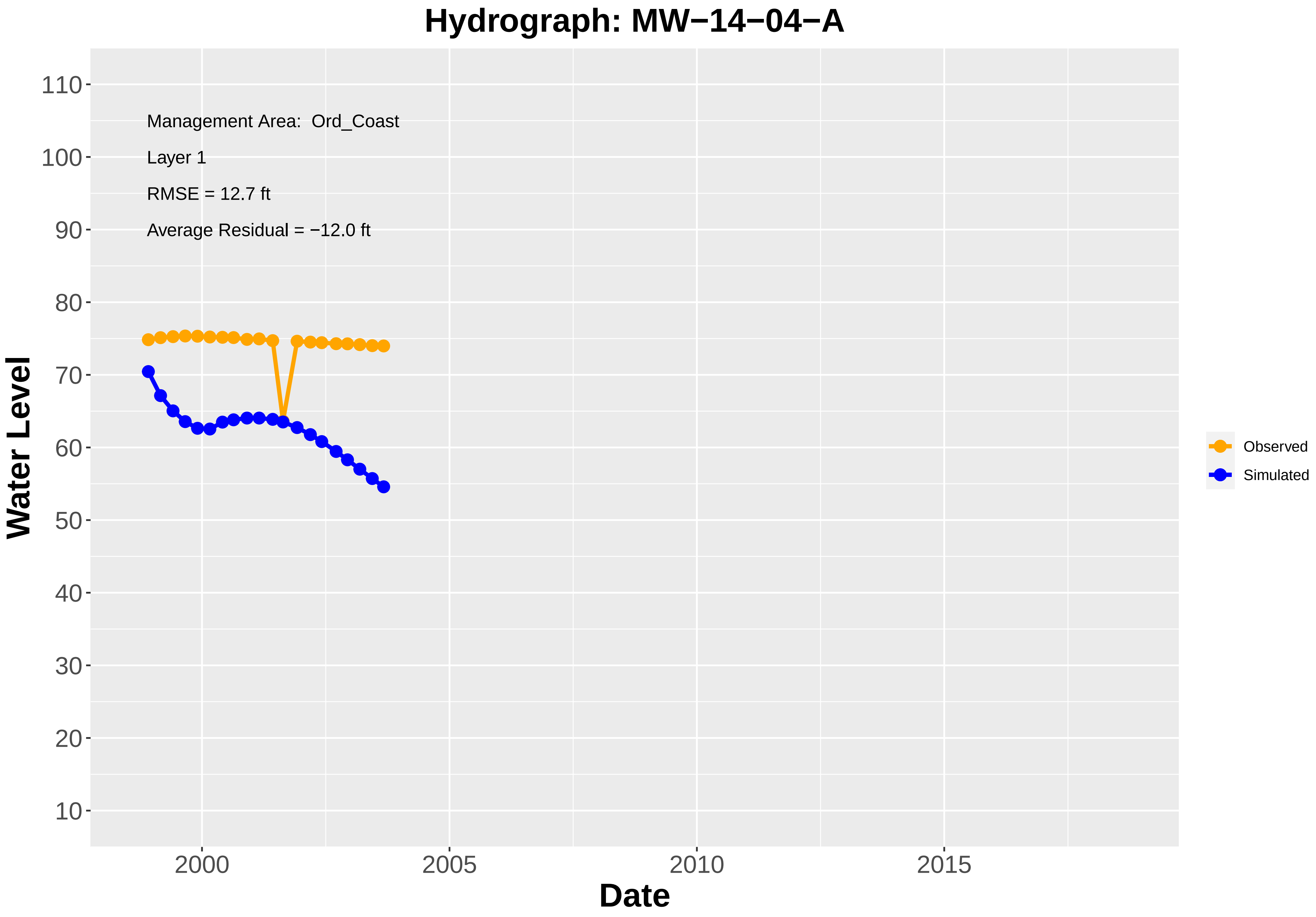


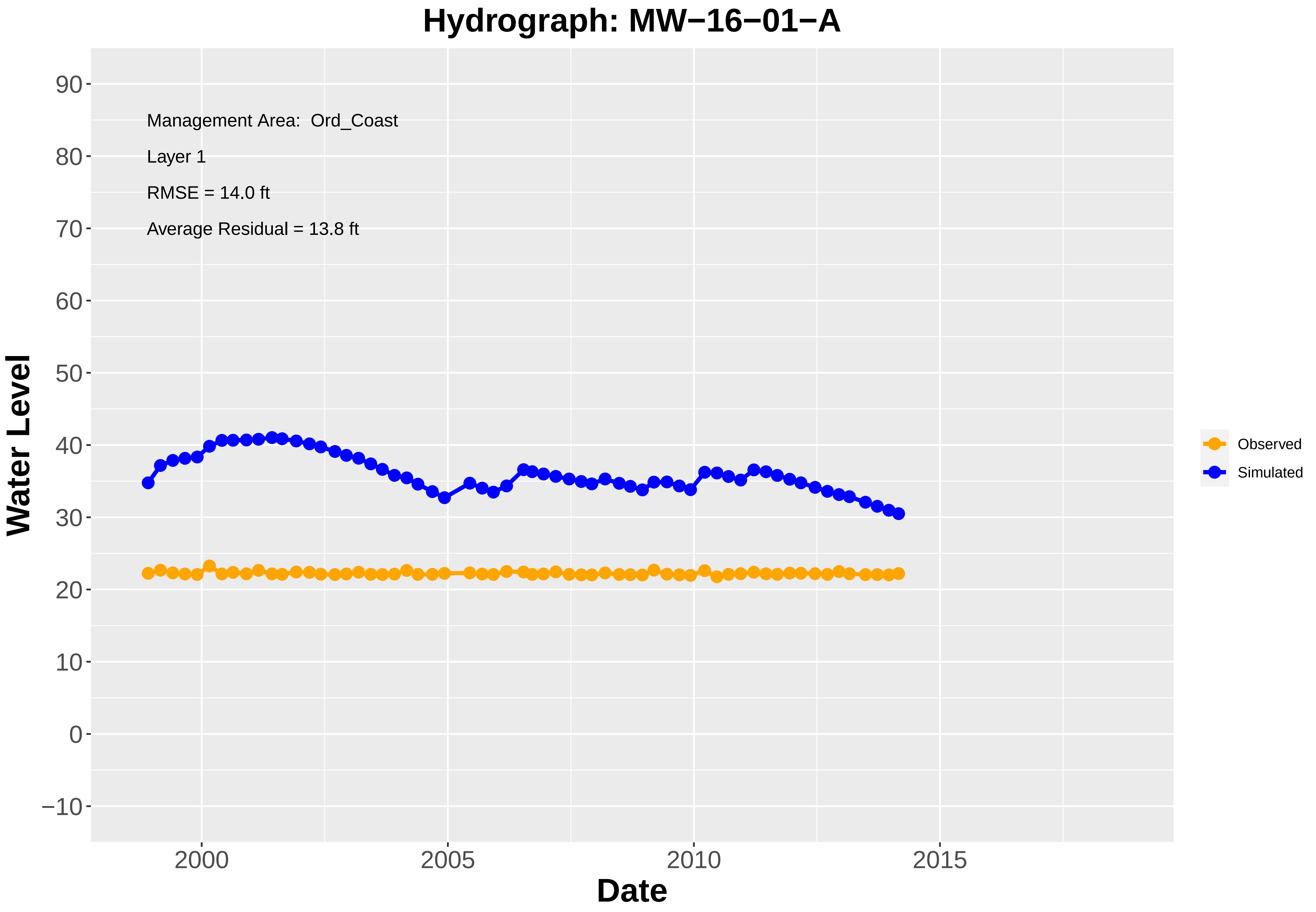

Hydrograph: MW−12−32−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.4 ft
Average Residual = −5.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

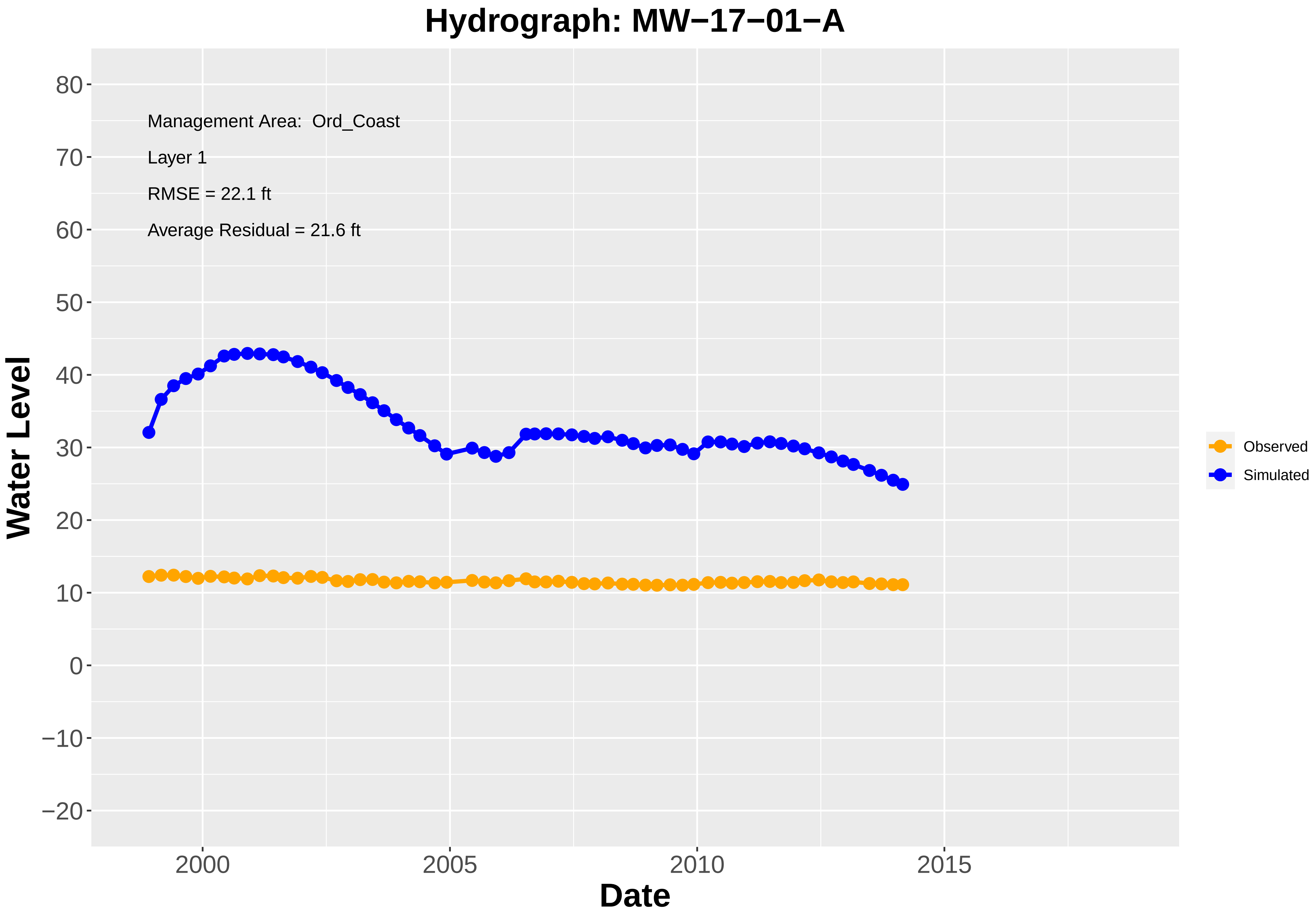
Hydrograph: MW−14−02−A



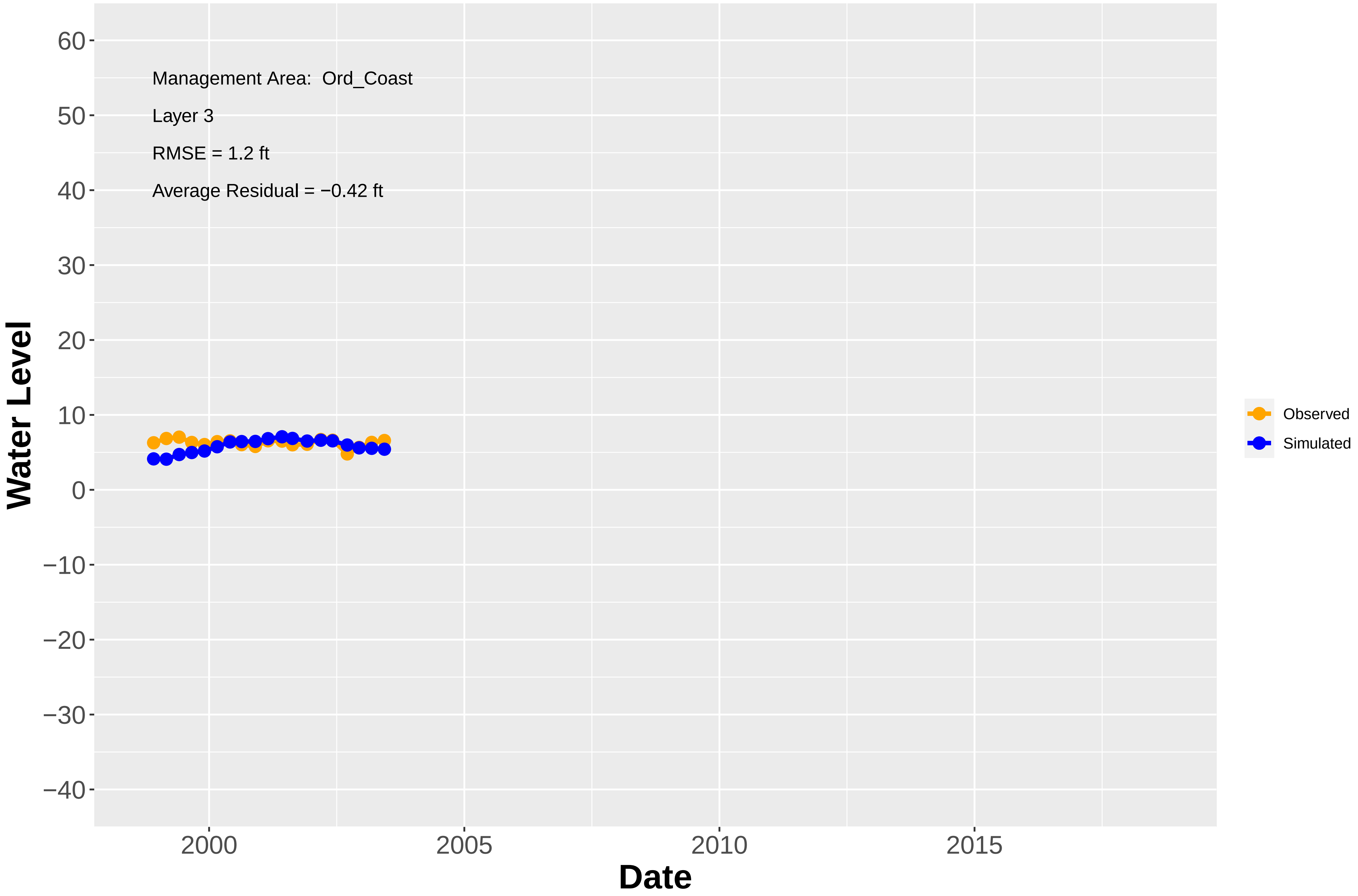

Hydrograph: MW−14−03−180
Management Area: Ord_Coast
Layer 3
RMSE = 1.2 ft
Average Residual = 0.39 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

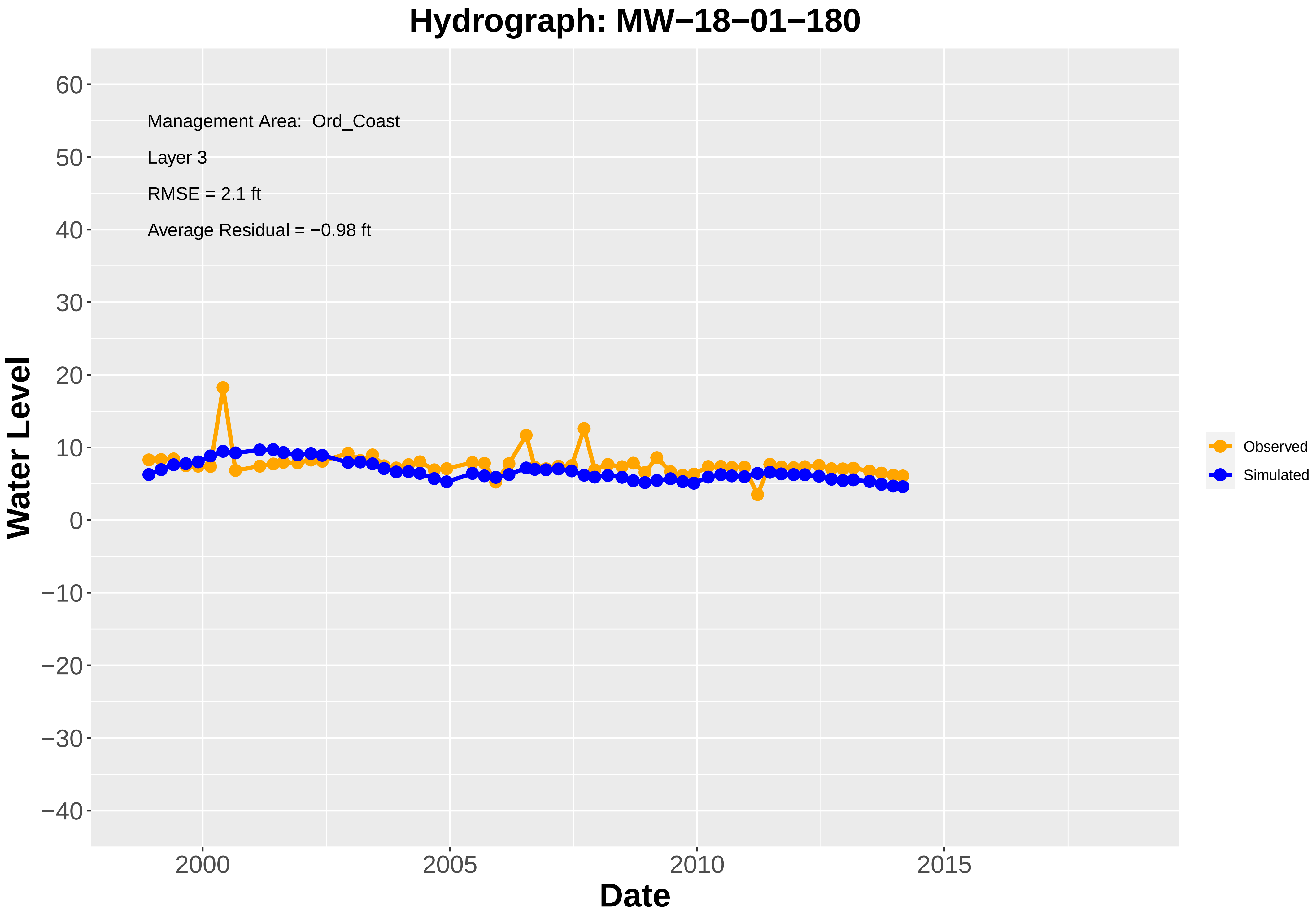

Hydrograph: MW−14−04−A
Management Area: Ord_Coast
Layer 1
RMSE = 12.7 ft
Average Residual = −12.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−16−01−A
Management Area: Ord_Coast
Layer 1
RMSE = 14.0 ft
Average Residual = 13.8 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

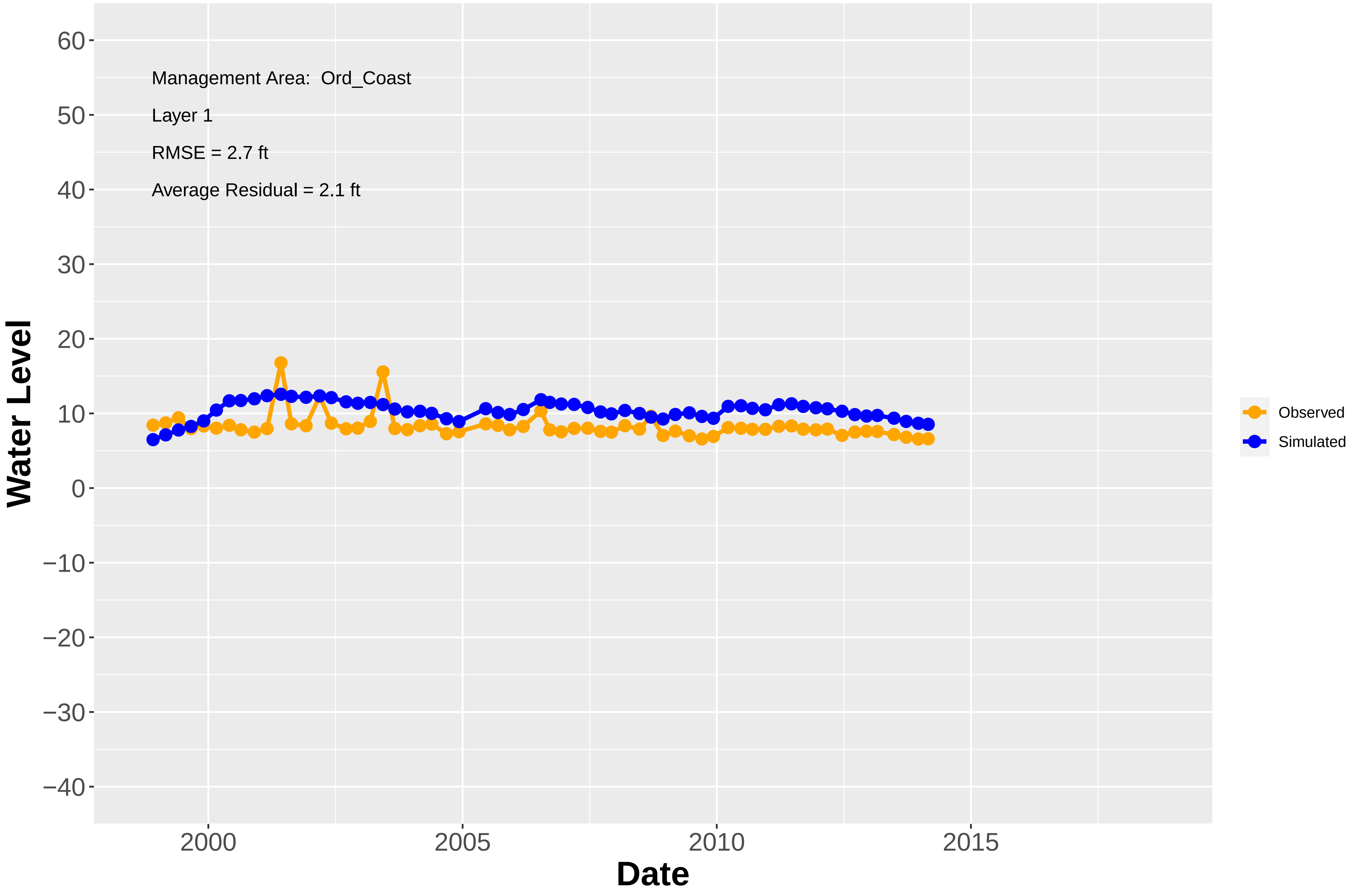

Hydrograph: MW−17−01−A
Management Area: Ord_Coast
Layer 1
RMSE = 22.1 ft
Average Residual = 21.6 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

Hydrograph: MW−17−02−180

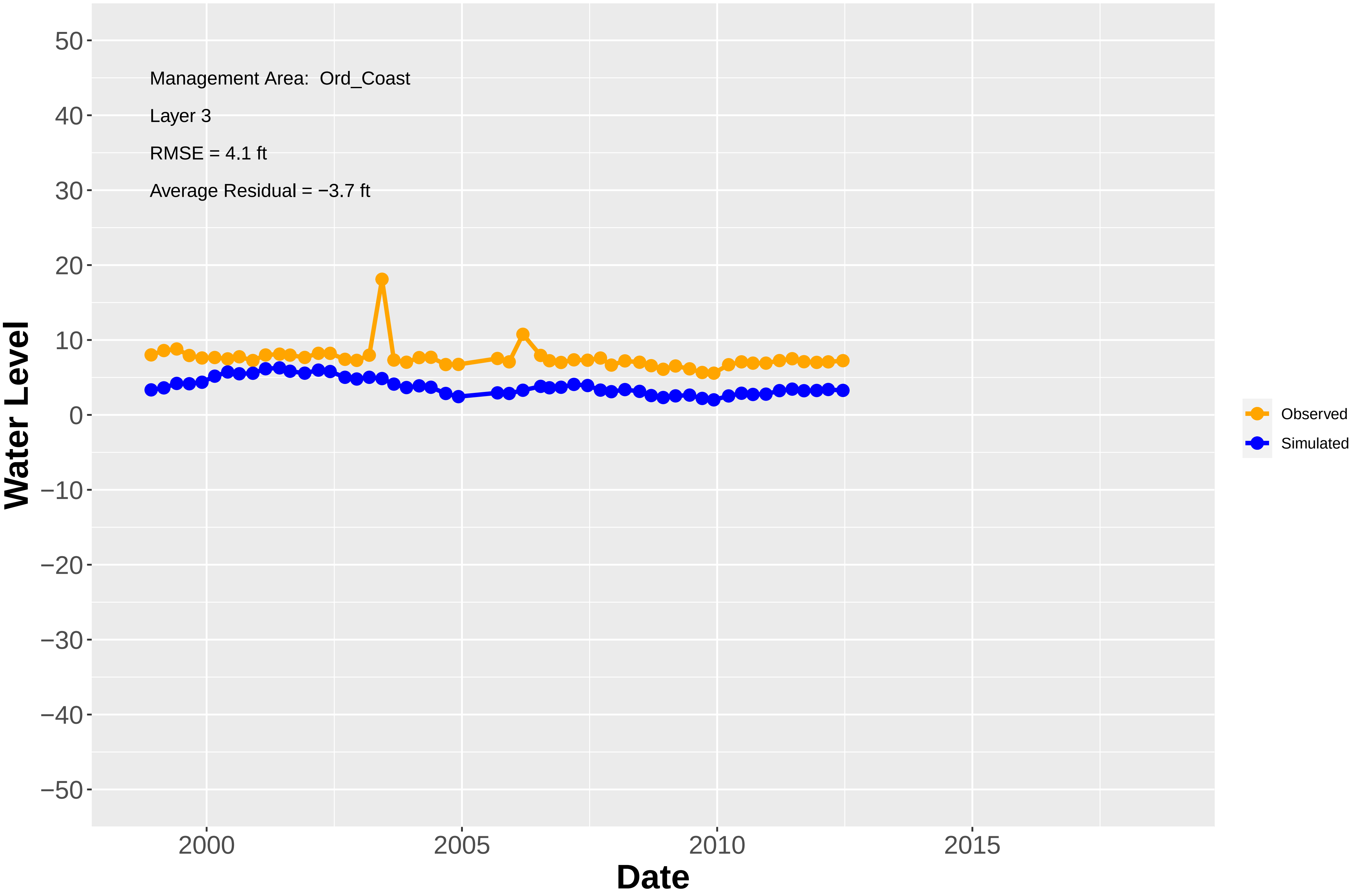


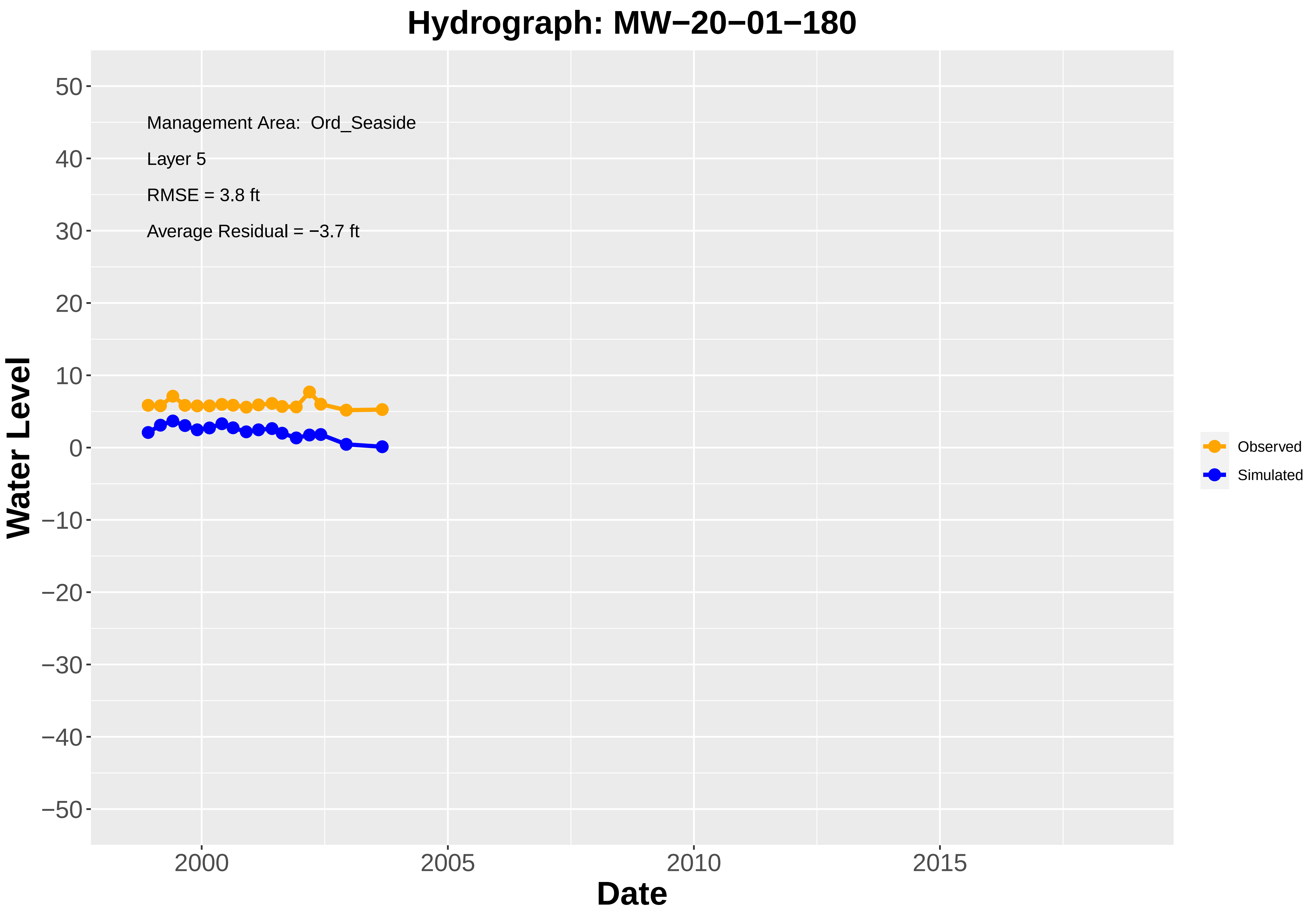

Hydrograph: MW−18−01−180
Management Area: Ord_Coast
Layer 3
RMSE = 2.1 ft
Average Residual = −0.98 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

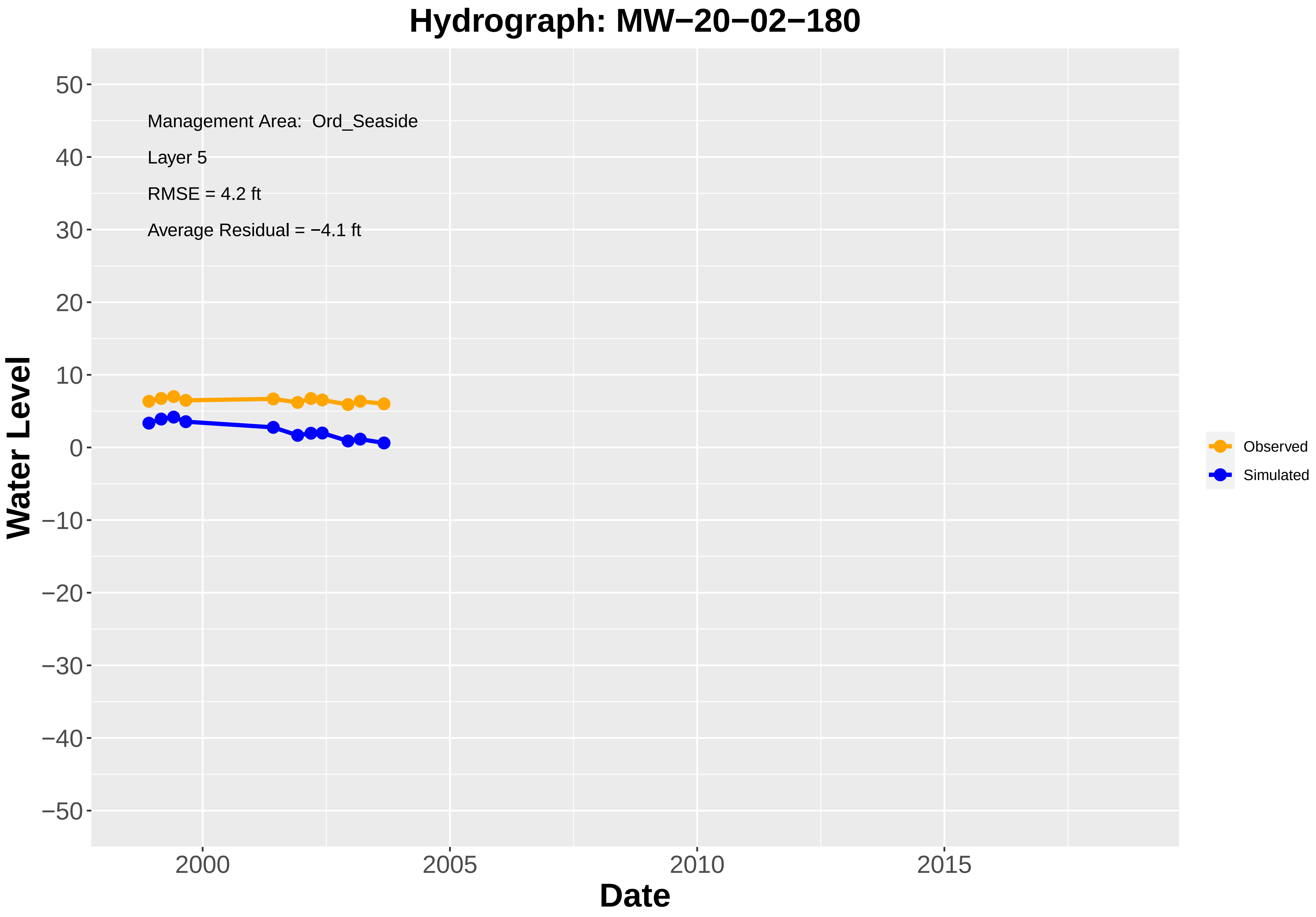
Hydrograph: MW−18−02−180

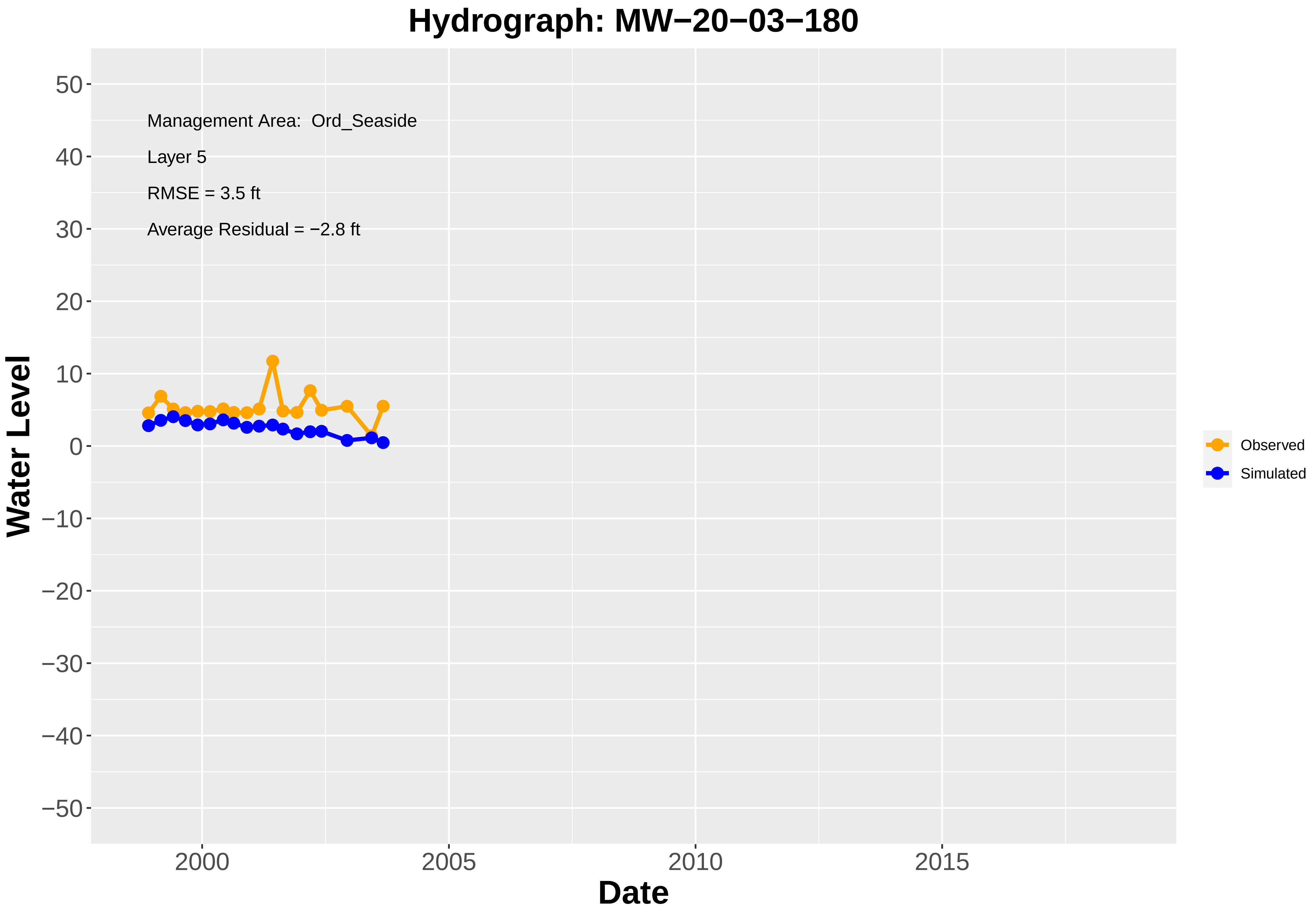


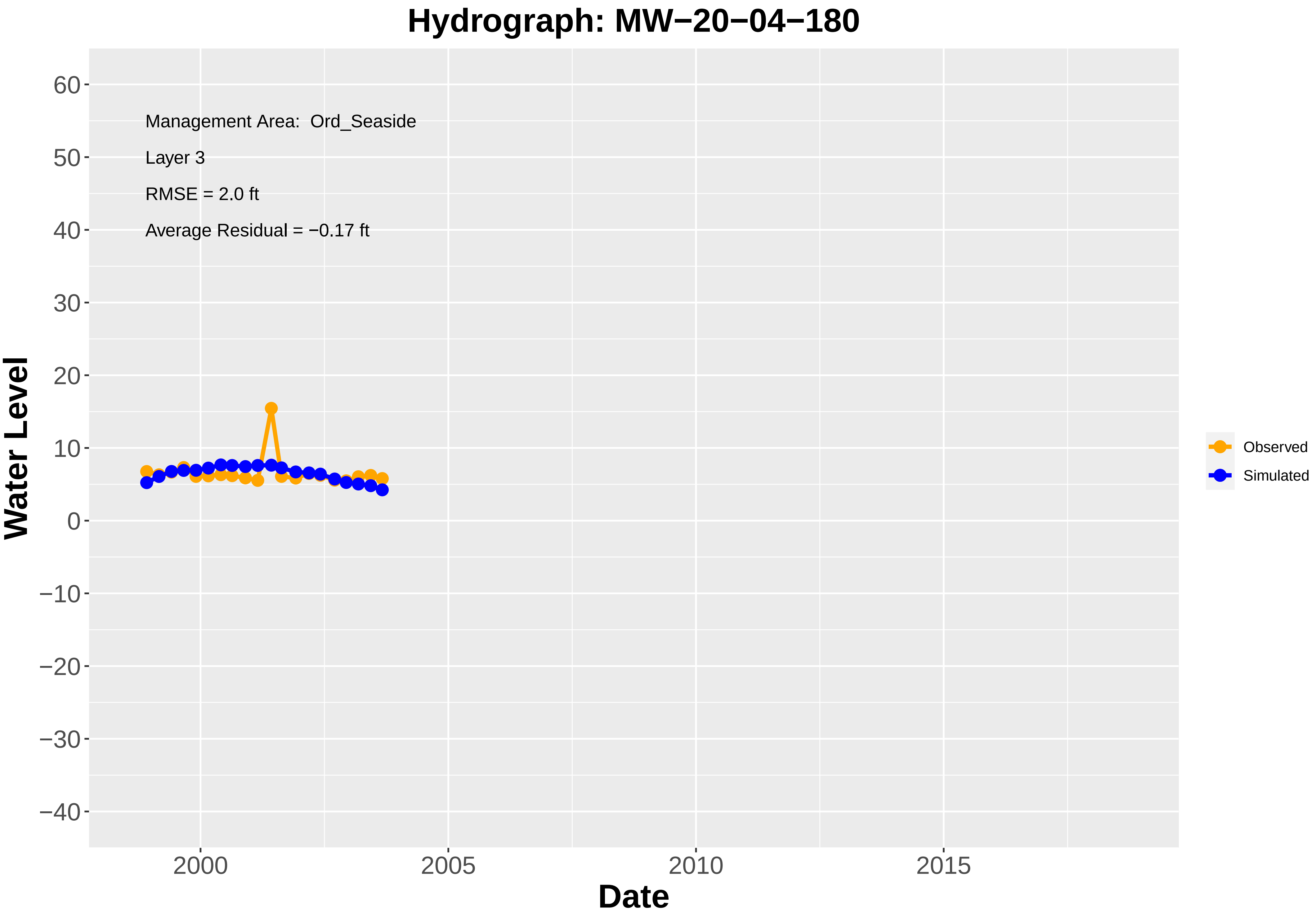
Hydrograph: MW−18−03−180

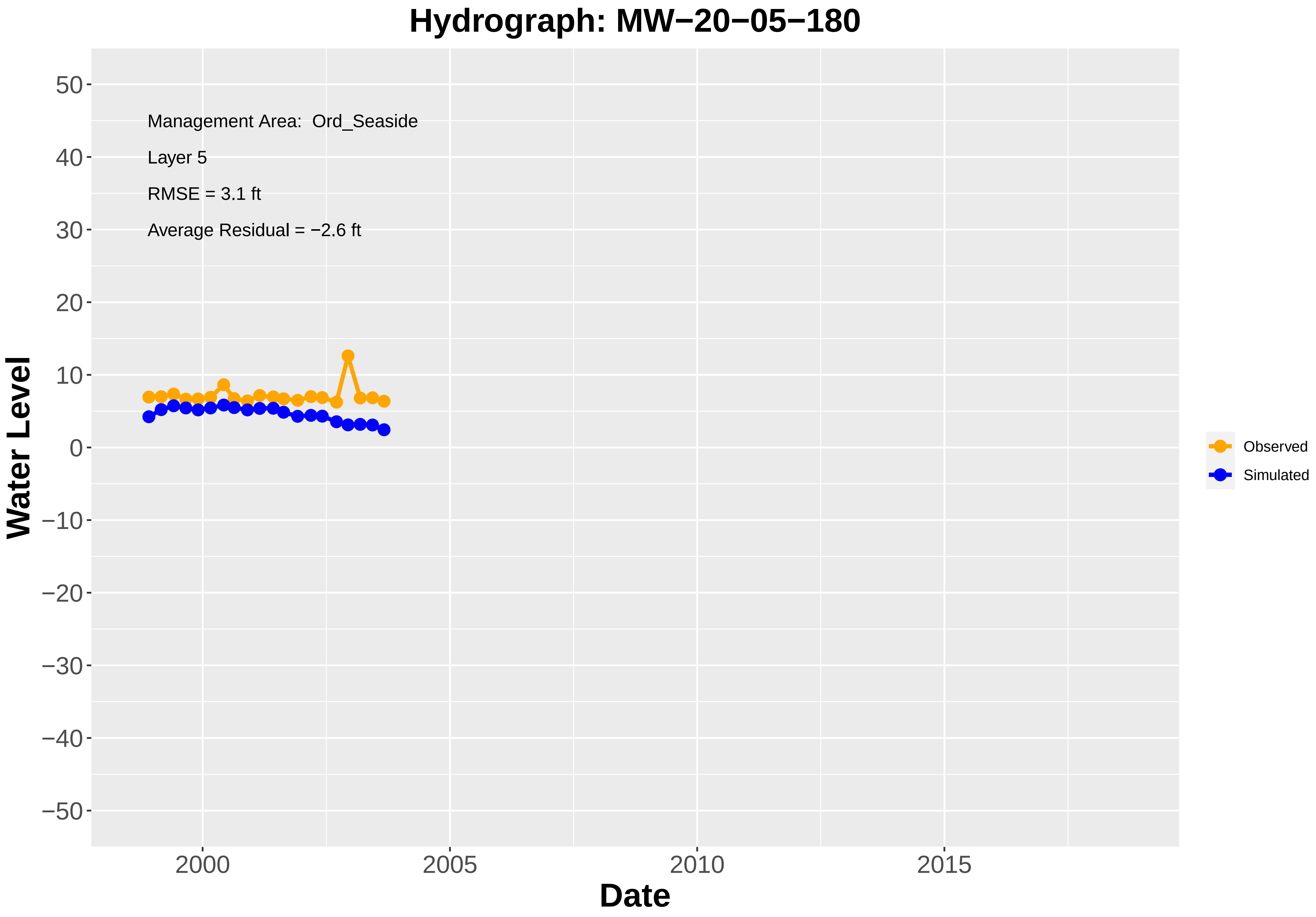


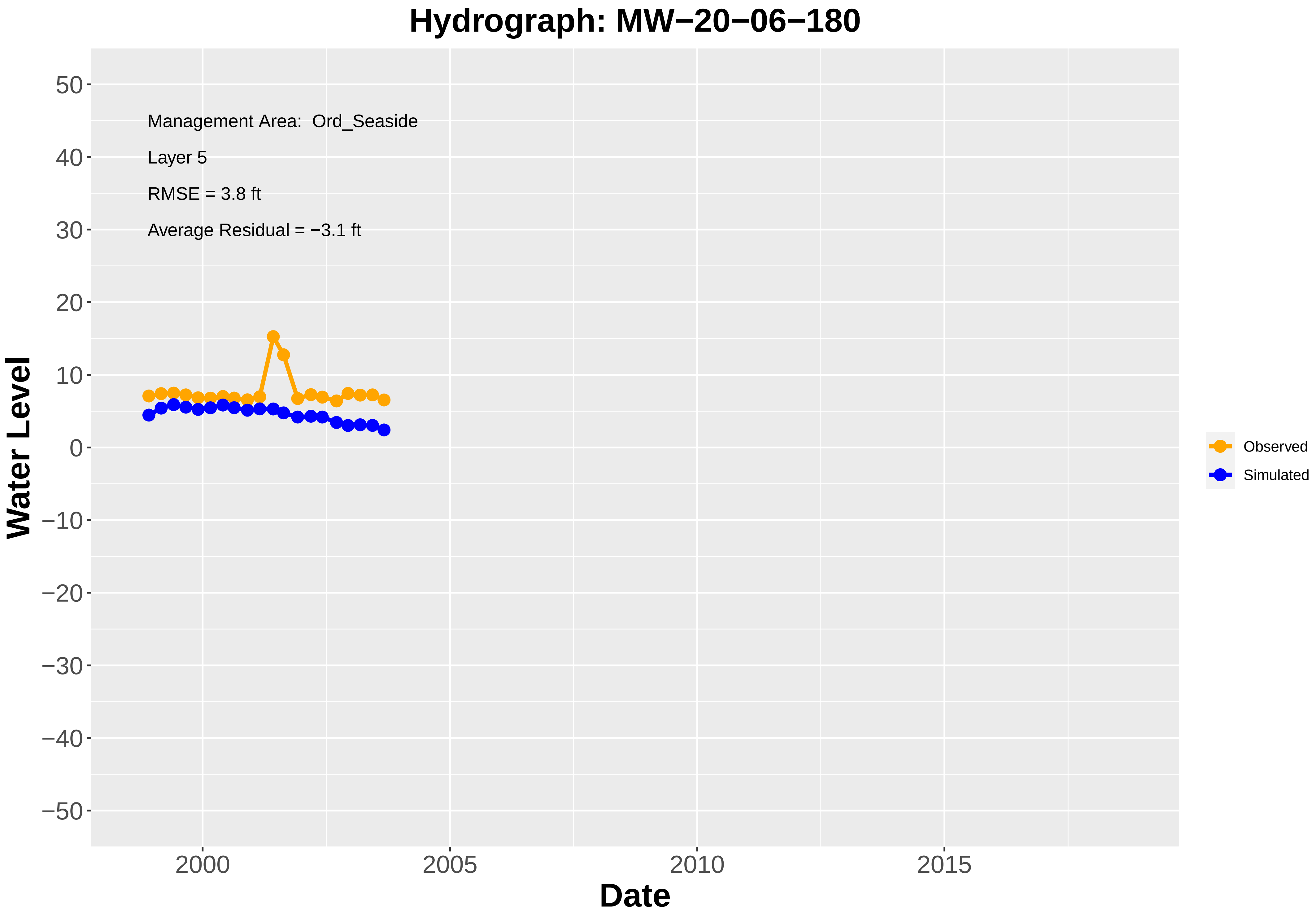

Hydrograph: MW−20−01−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.8 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

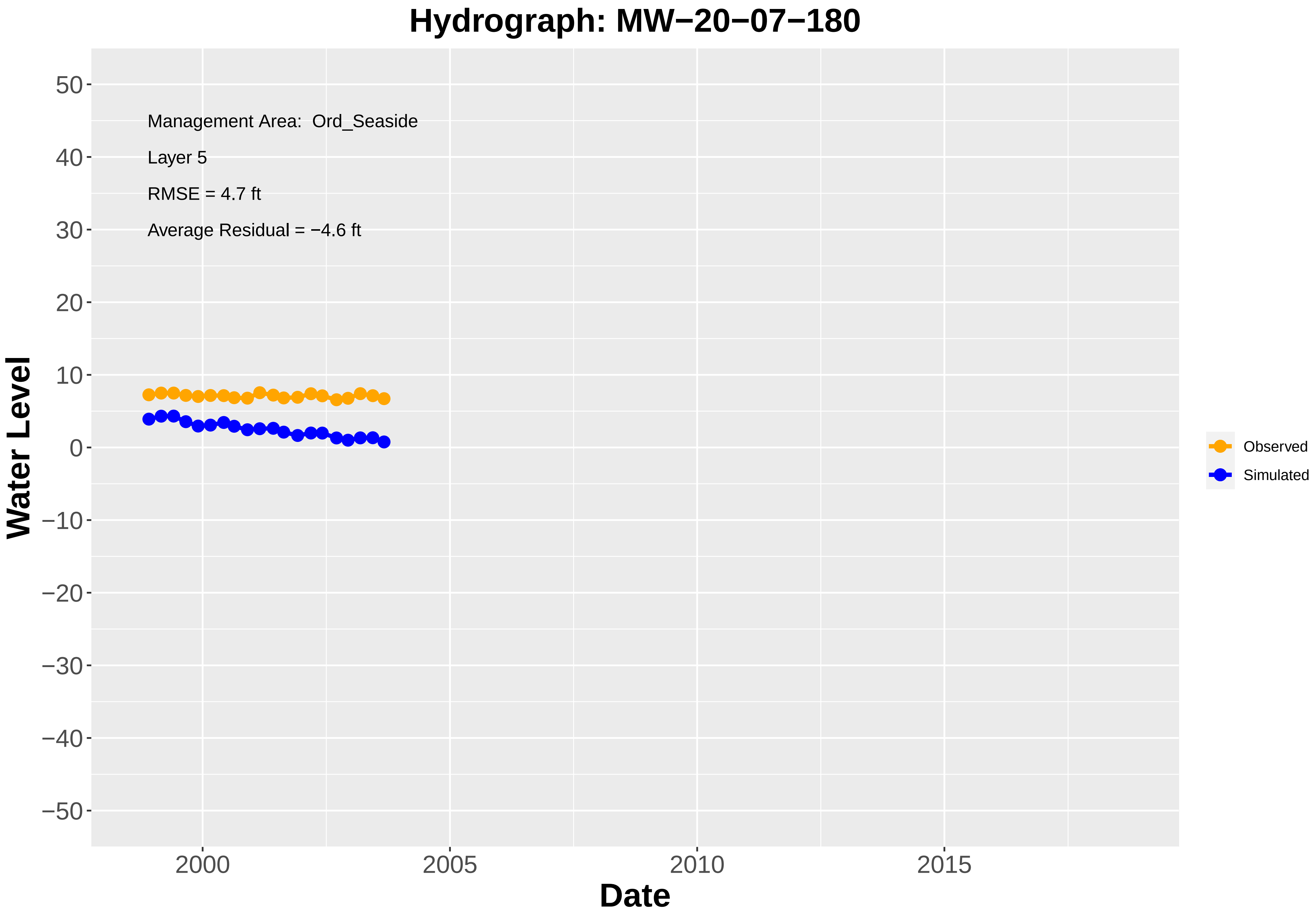

Hydrograph: MW−20−02−180
Management Area: Ord_Seaside
Layer 5
RMSE = 4.2 ft
Average Residual = −4.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−20−03−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.5 ft
Average Residual = −2.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

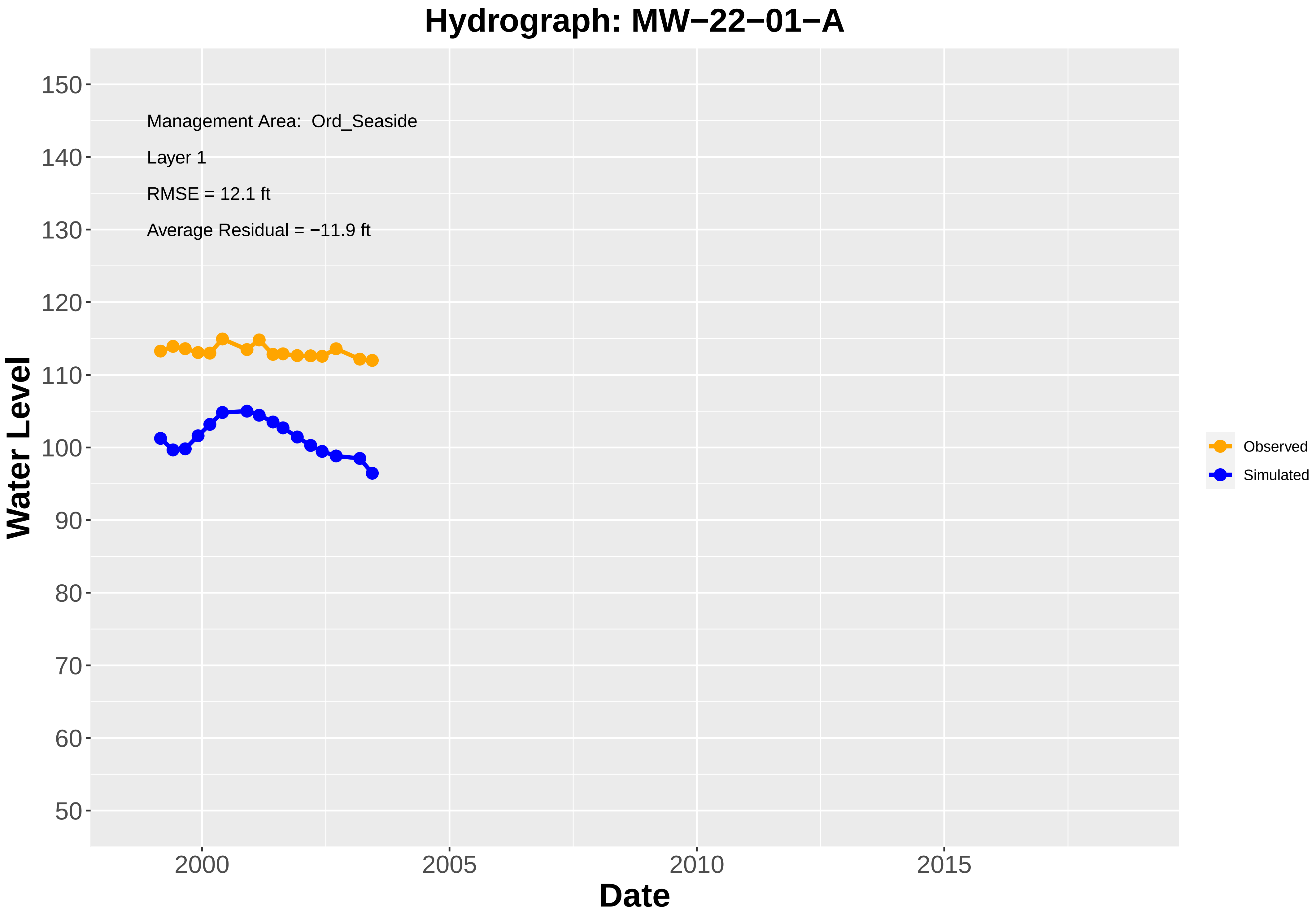

Hydrograph: MW−20−04−180
Management Area: Ord_Seaside
Layer 3
RMSE = 2.0 ft
Average Residual = −0.17 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

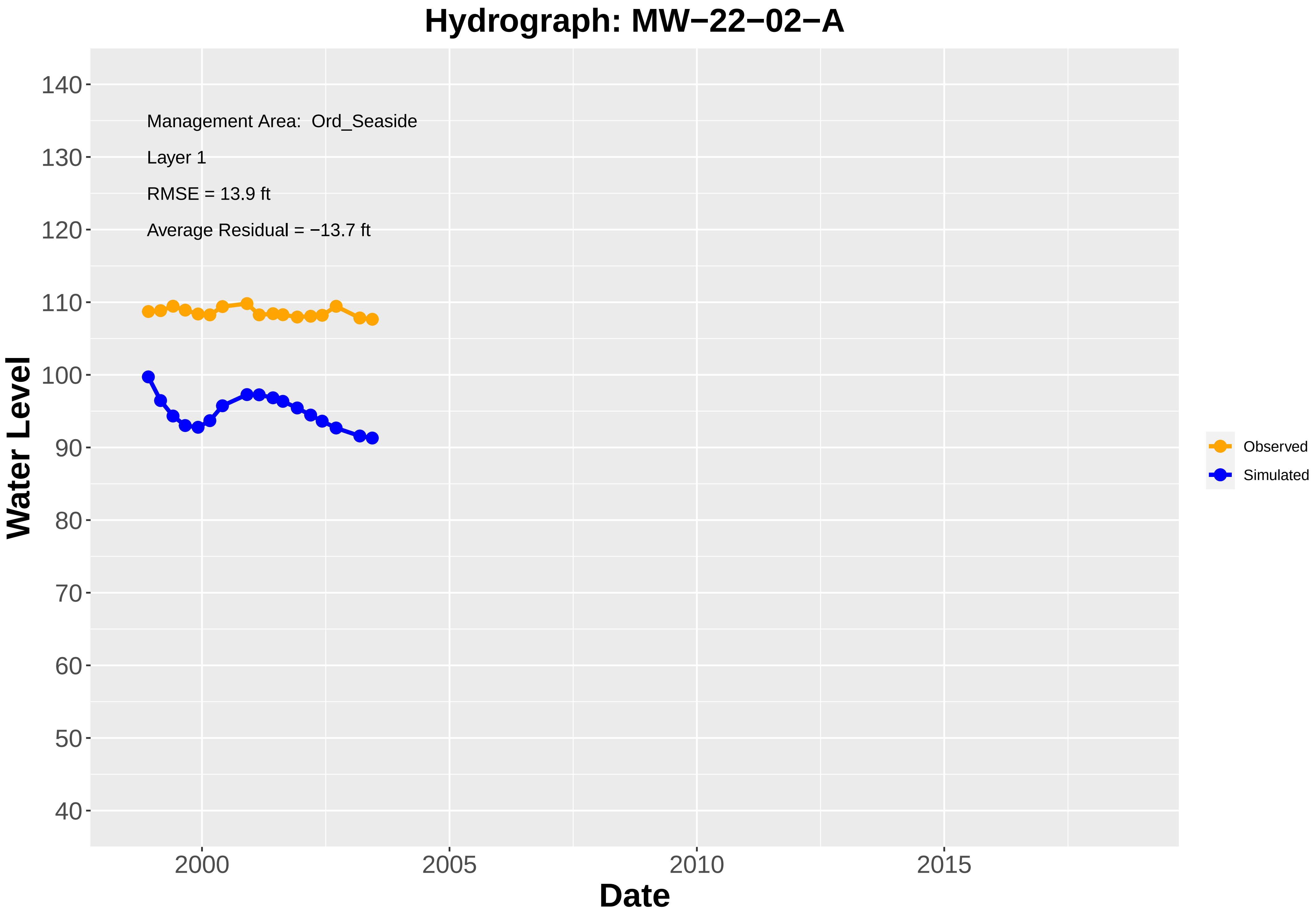

Hydrograph: MW−20−05−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.1 ft
Average Residual = −2.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

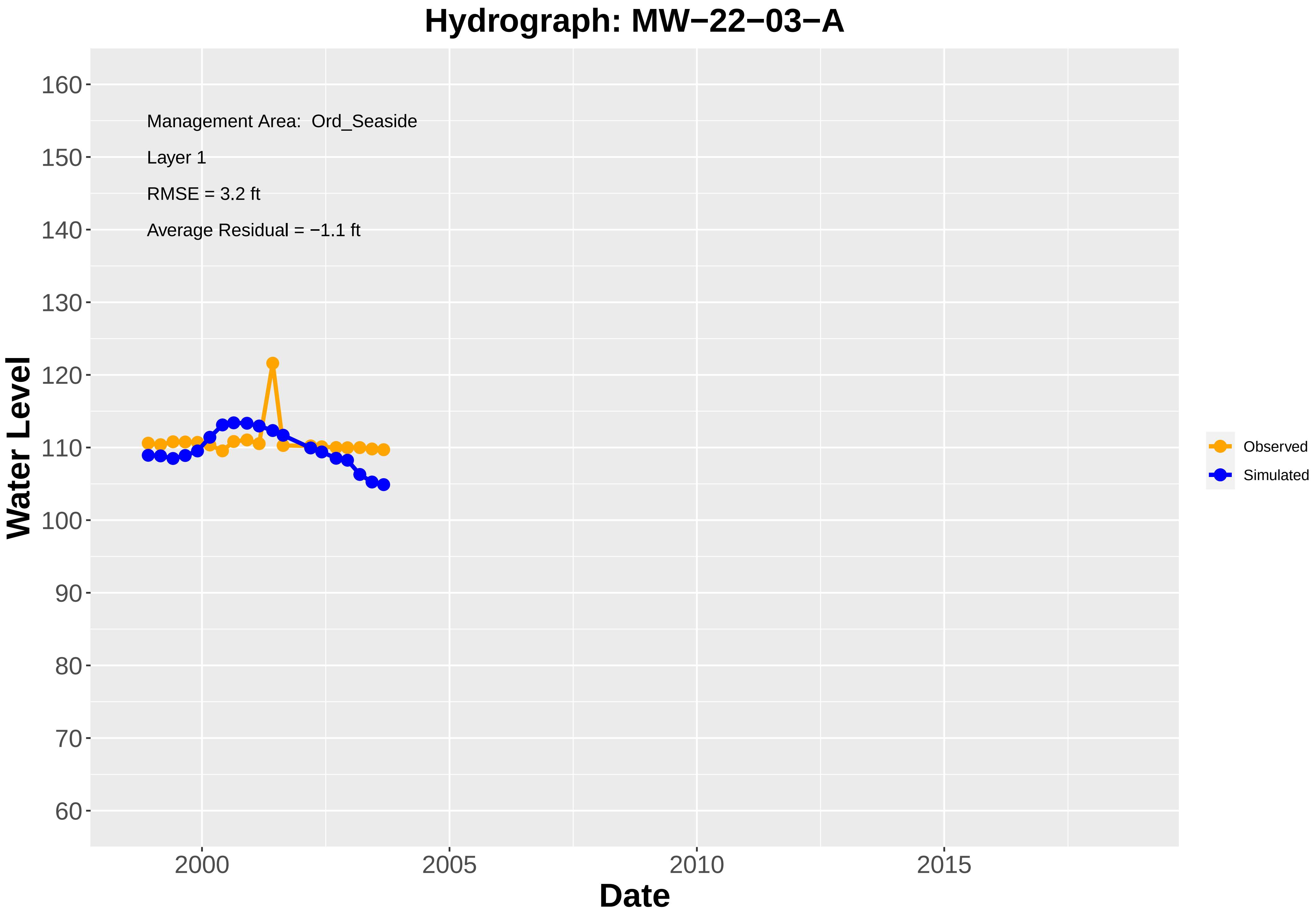

Hydrograph: MW−20−06−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.8 ft
Average Residual = −3.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

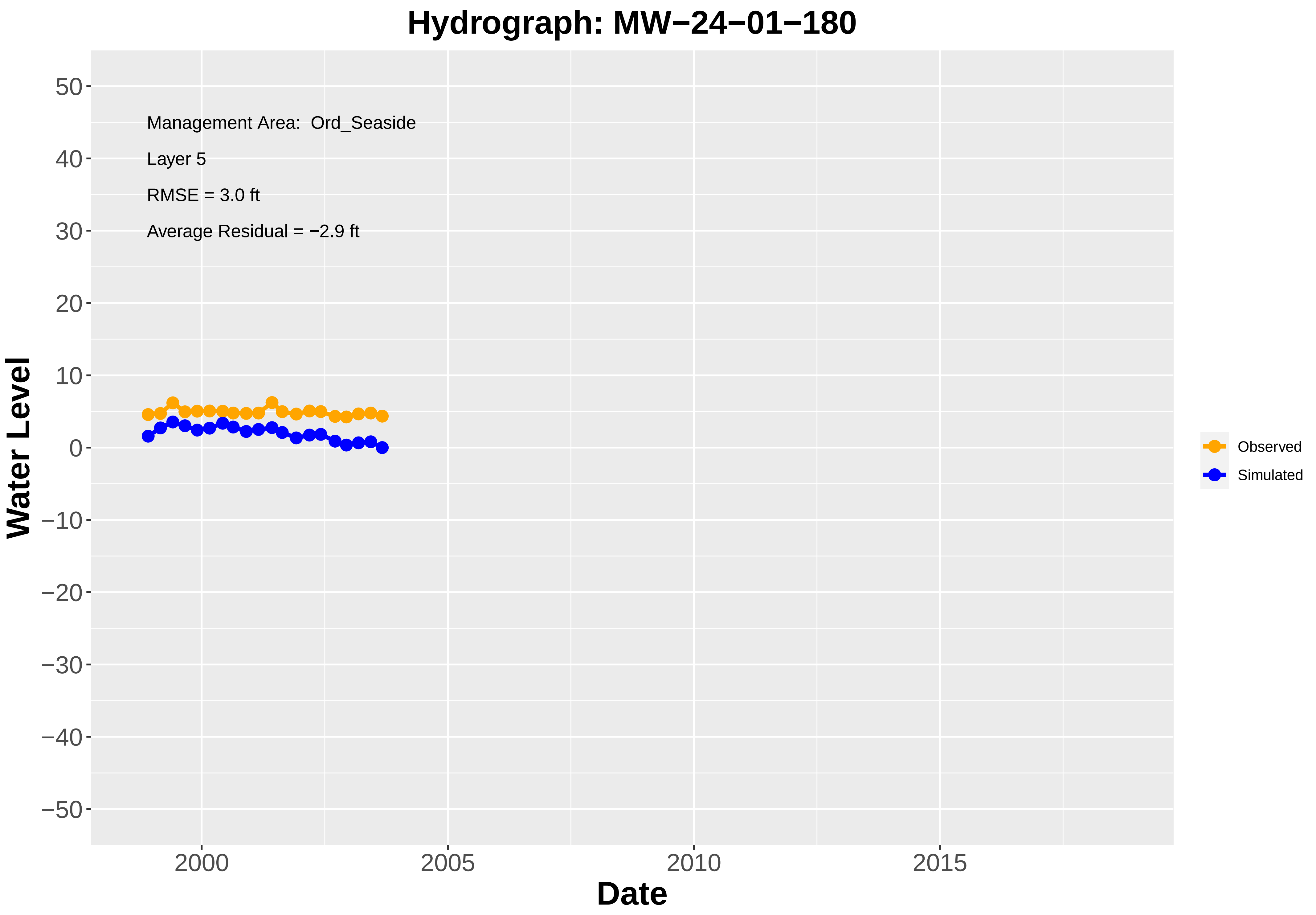


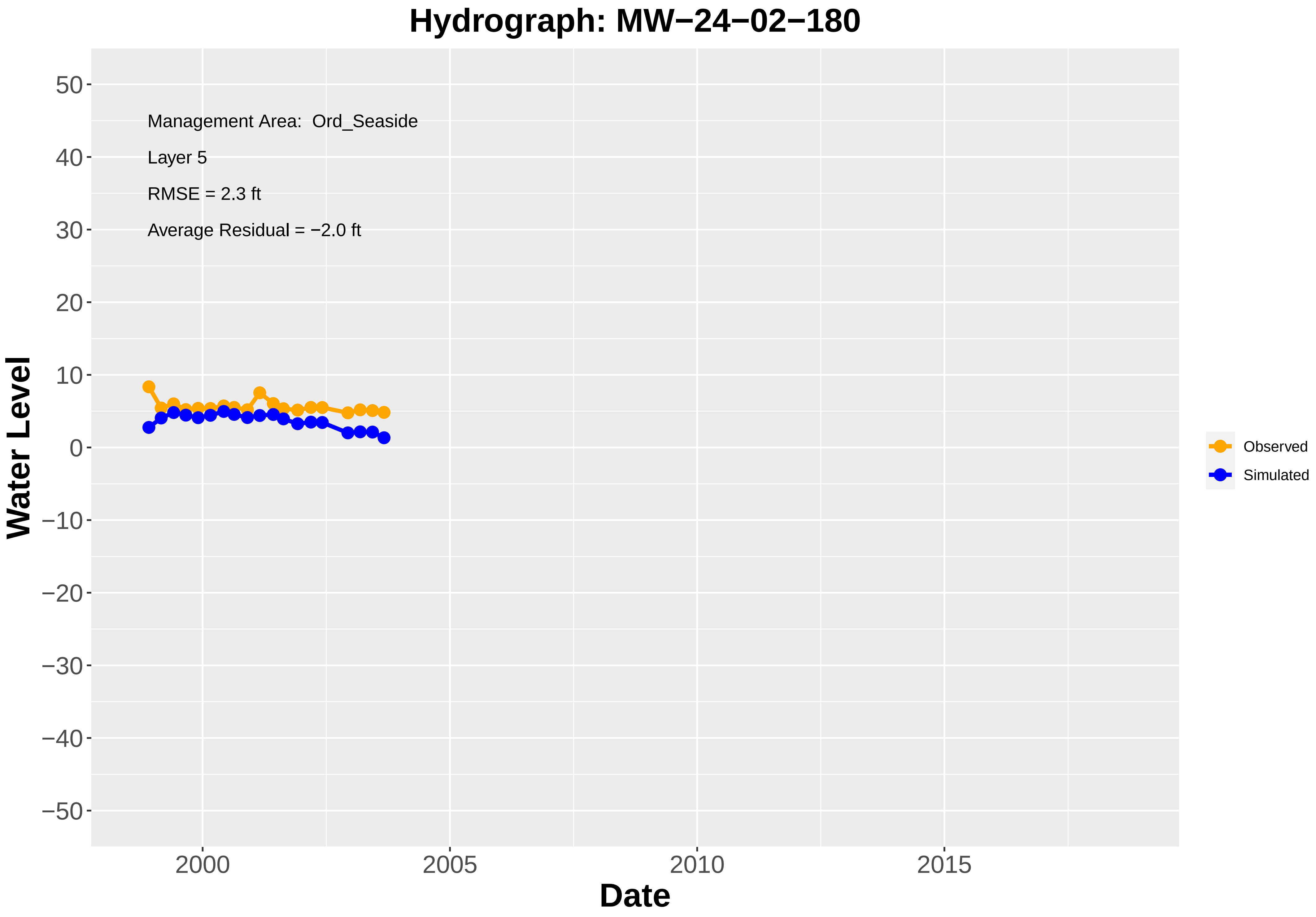
Hydrograph: MW−20−07−180
Management Area: Ord_Seaside
Layer 5
RMSE = 4.7 ft
Average Residual = −4.6 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

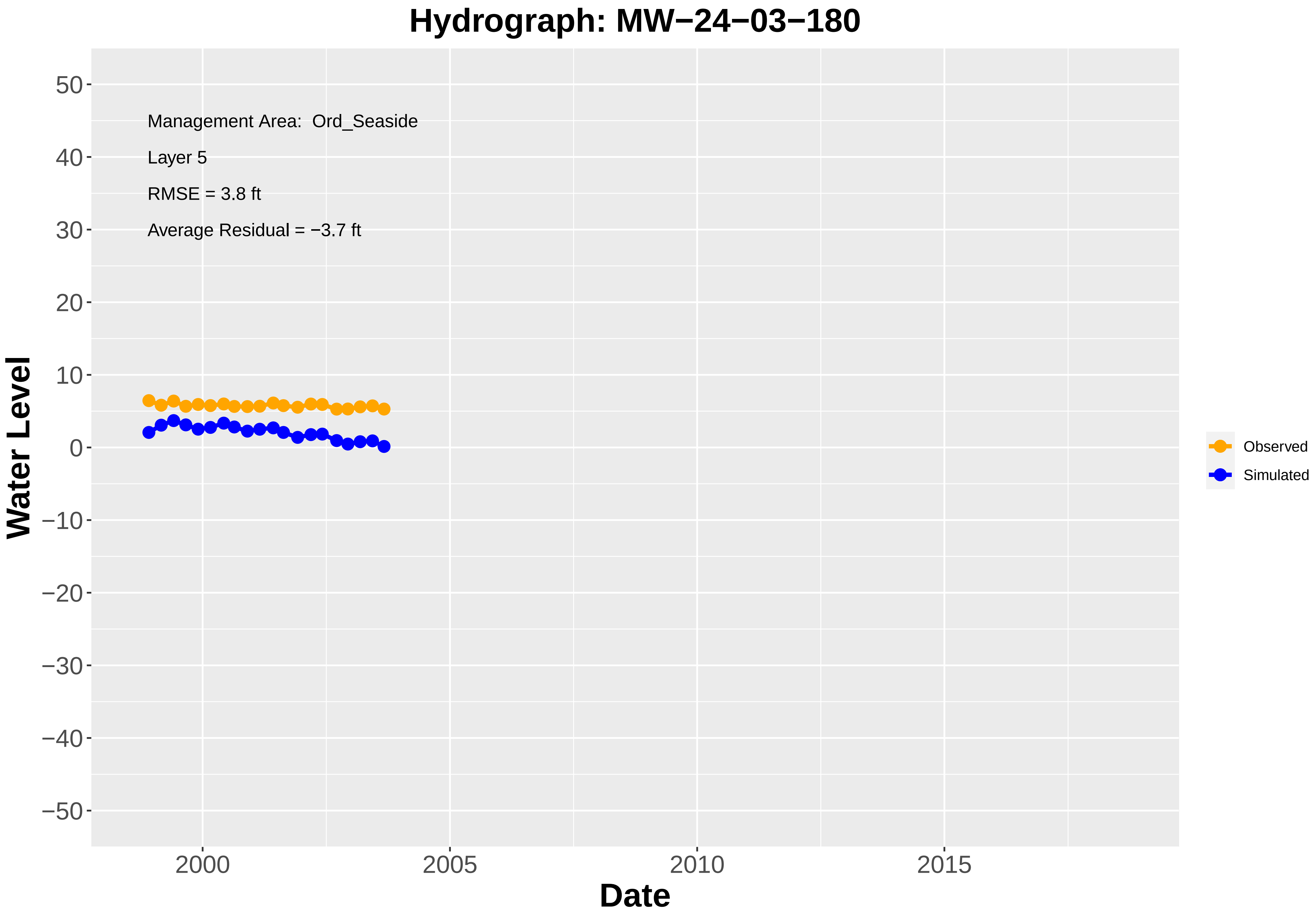

Hydrograph: MW−22−01−A
Management Area: Ord_Seaside
Layer 1
RMSE = 12.1 ft
Average Residual = −11.9 ft
Water Level
150
140
130
120
110
100
90
80
70
60
50
Date
2000
2005
2010
2015
Observed
Simulated

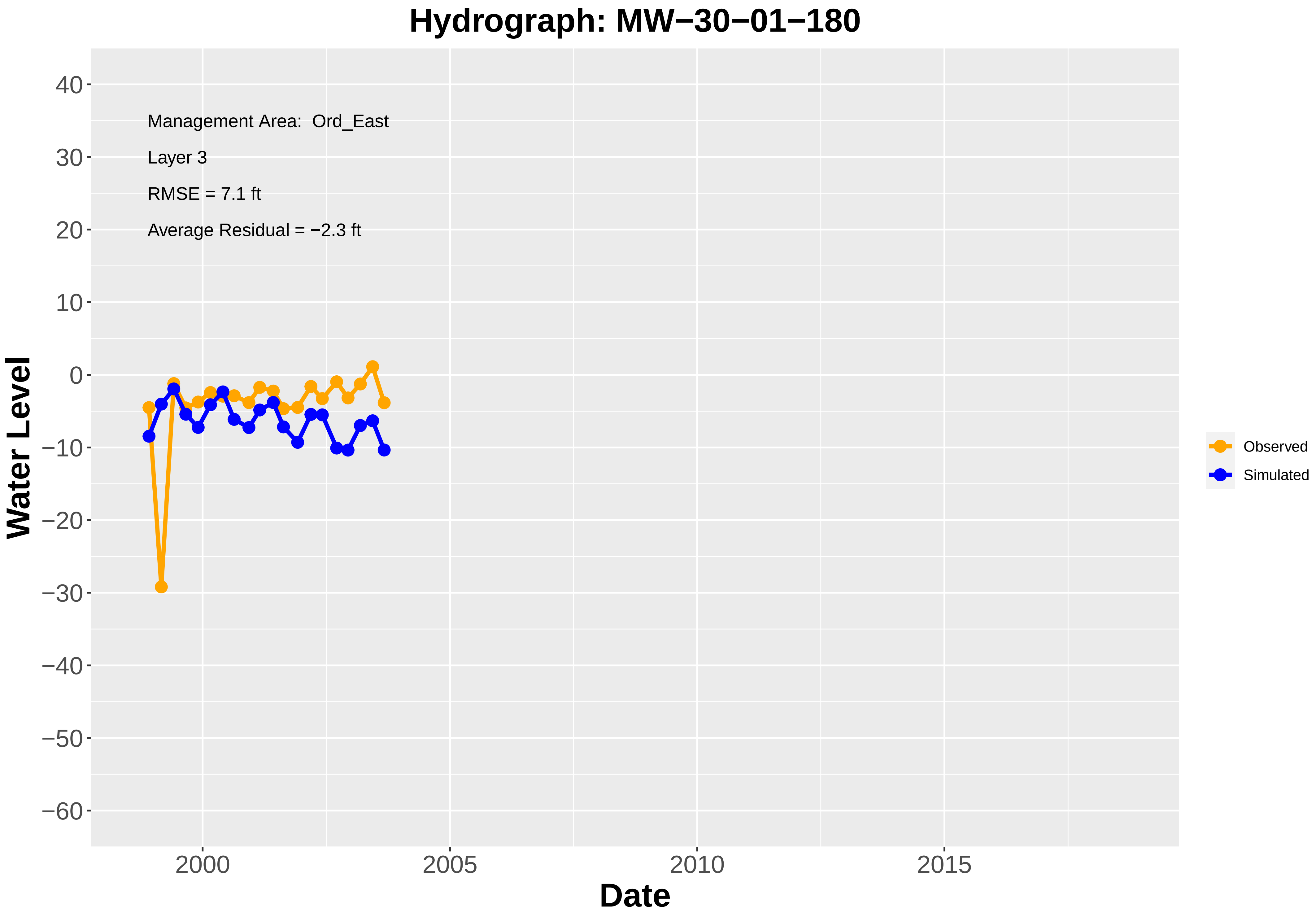

Hydrograph: MW−22−02−A
Management Area: Ord_Seaside
Layer 1
RMSE = 13.9 ft
Average Residual = −13.7 ft
Water Level
140
130
120
110
100
90
80
70
60
50
40
Date
2000
2005
2010
2015
Observed
Simulated

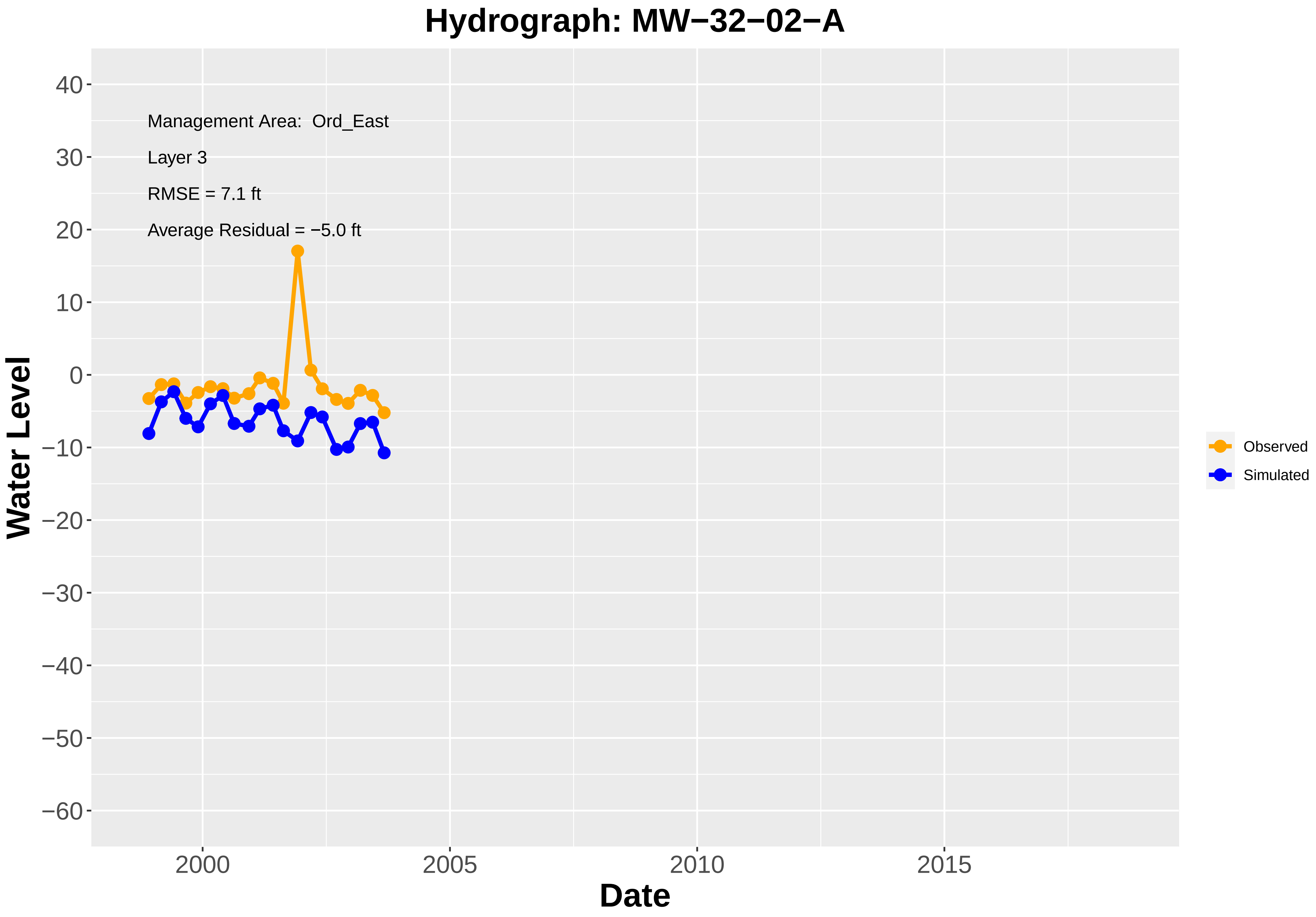

Hydrograph: MW−22−03−A
Management Area: Ord_Seaside
Layer 1
RMSE = 3.2 ft
Average Residual = −1.1 ft
Water Level
160
150
140
130
120
110
100
90
80
70
60
Date
2000
2005
2010
2015
Observed
Simulated

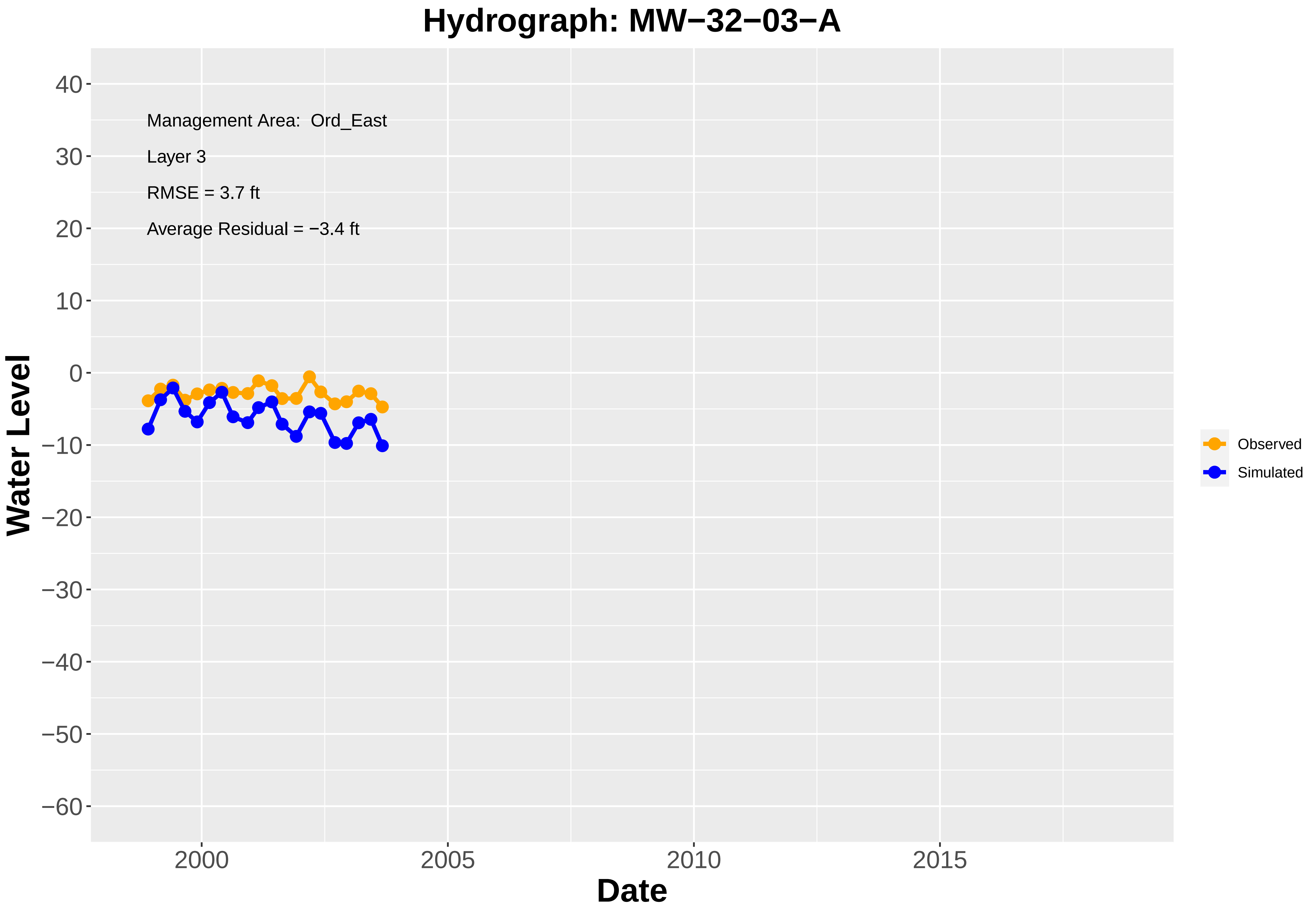

Hydrograph: MW−24−01−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.0 ft
Average Residual = −2.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−24−02−180
Management Area: Ord_Seaside
Layer 5
RMSE = 2.3 ft
Average Residual = −2.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

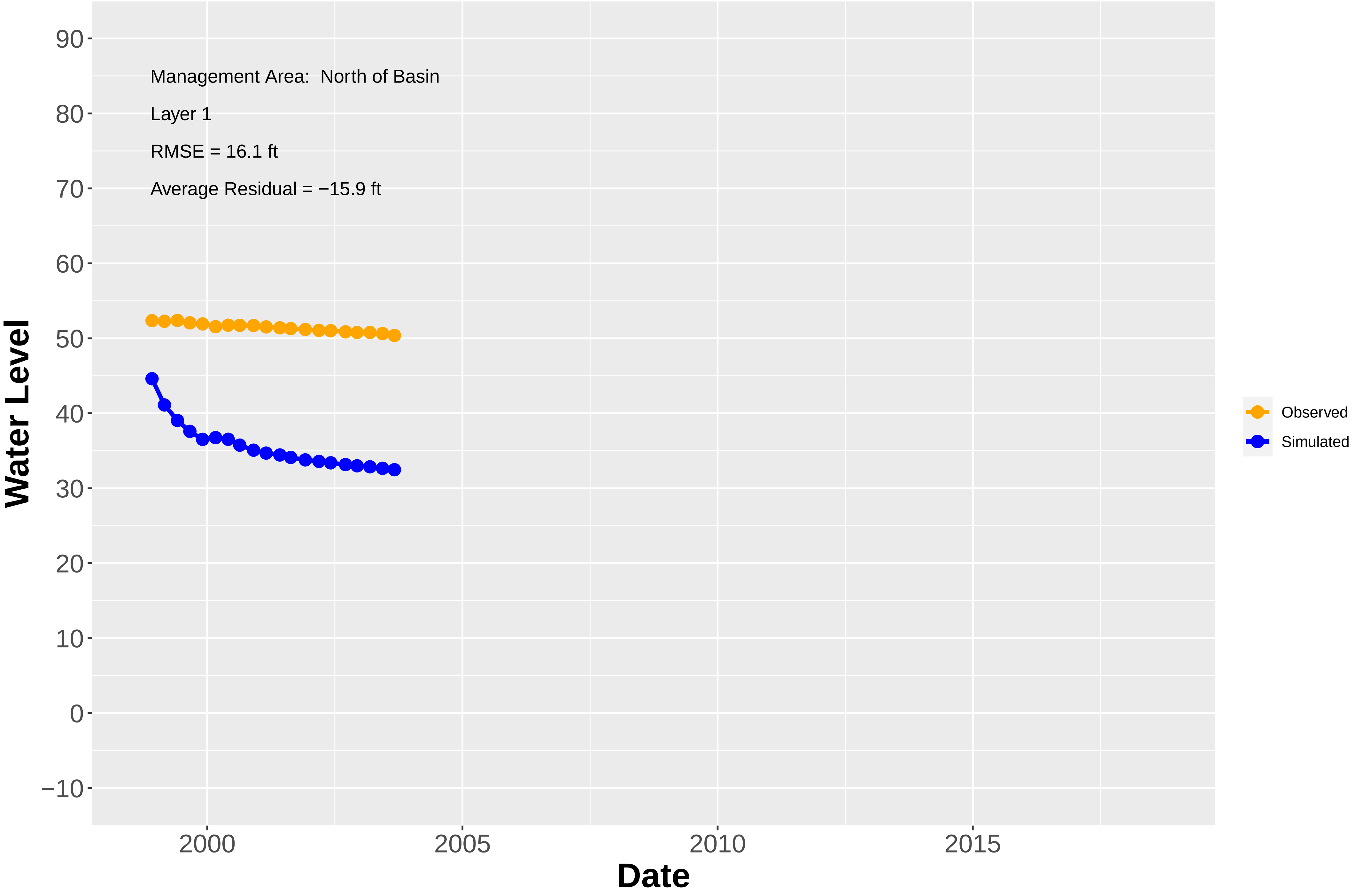

Hydrograph: MW−24−03−180
Management Area: Ord_Seaside
Layer 5
RMSE = 3.8 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

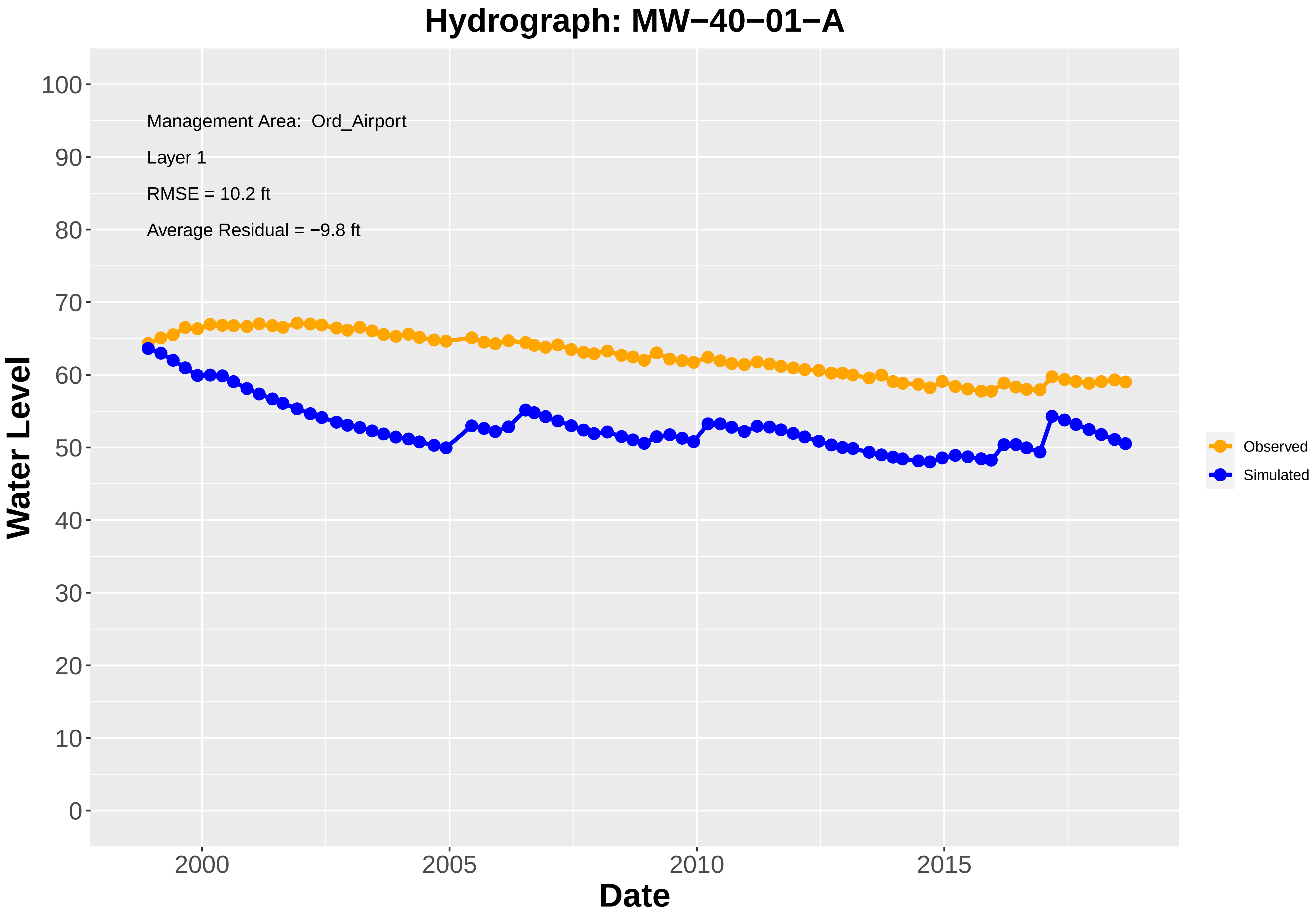

Hydrograph: MW−30−01−180
Management Area: Ord_East
Layer 3
RMSE = 7.1 ft
Average Residual = −2.3 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

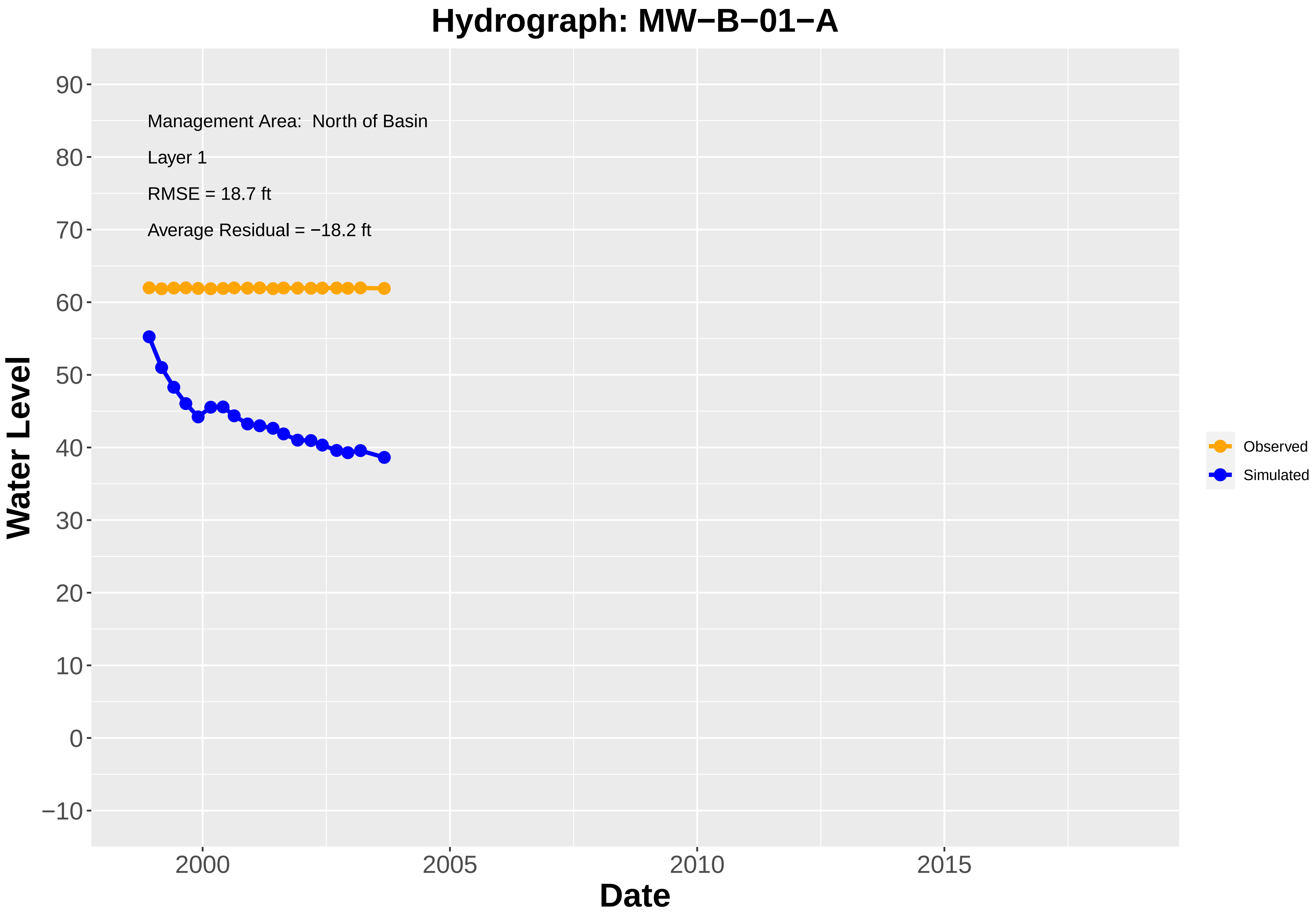

Hydrograph: MW−32−02−A
Management Area: Ord_East
Layer 3
RMSE = 7.1 ft
Average Residual = −5.0 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−32−03−A
Management Area: Ord_East
Layer 3
RMSE = 3.7 ft
Average Residual = −3.4 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

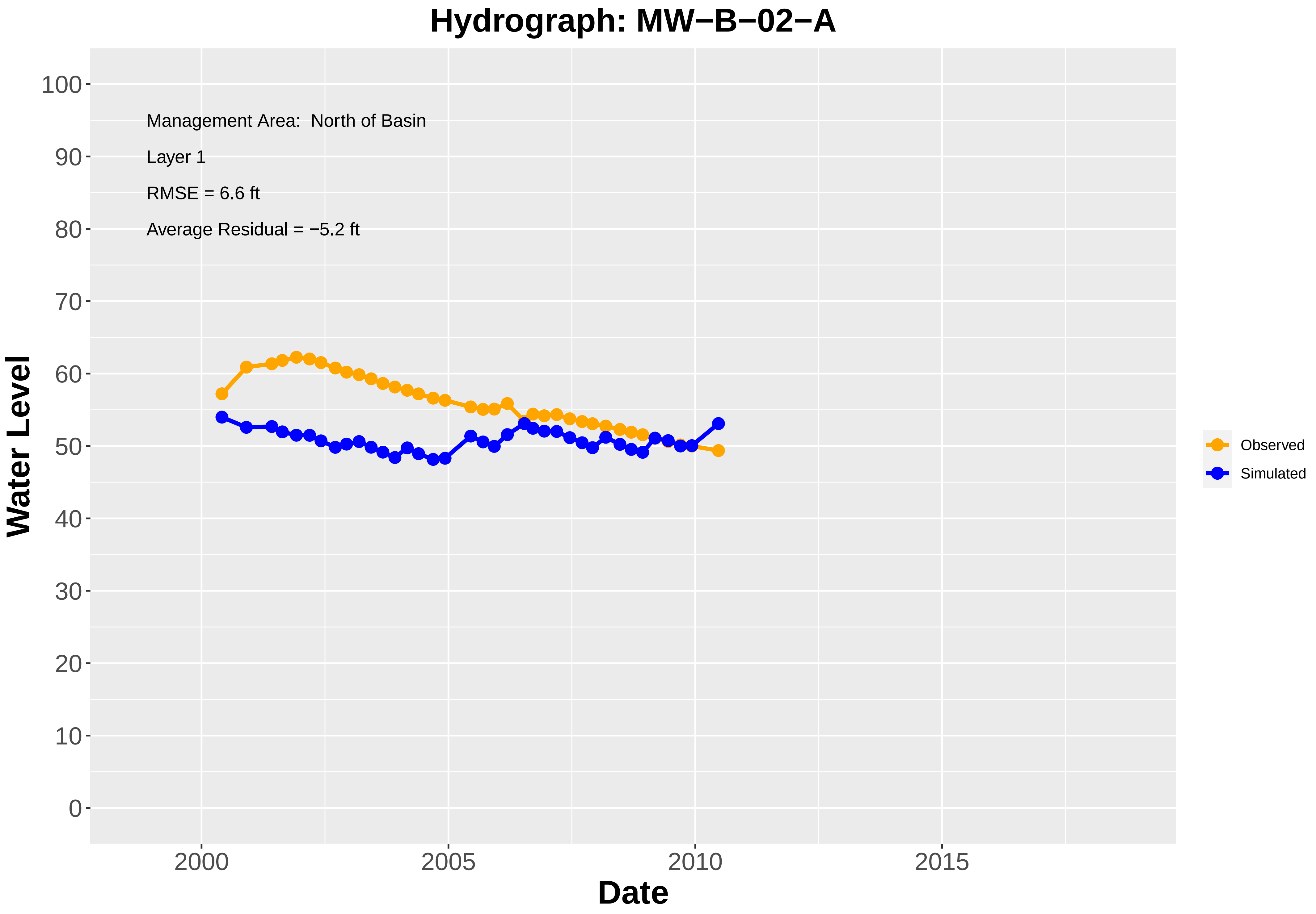
Hydrograph: MW−36−01−A

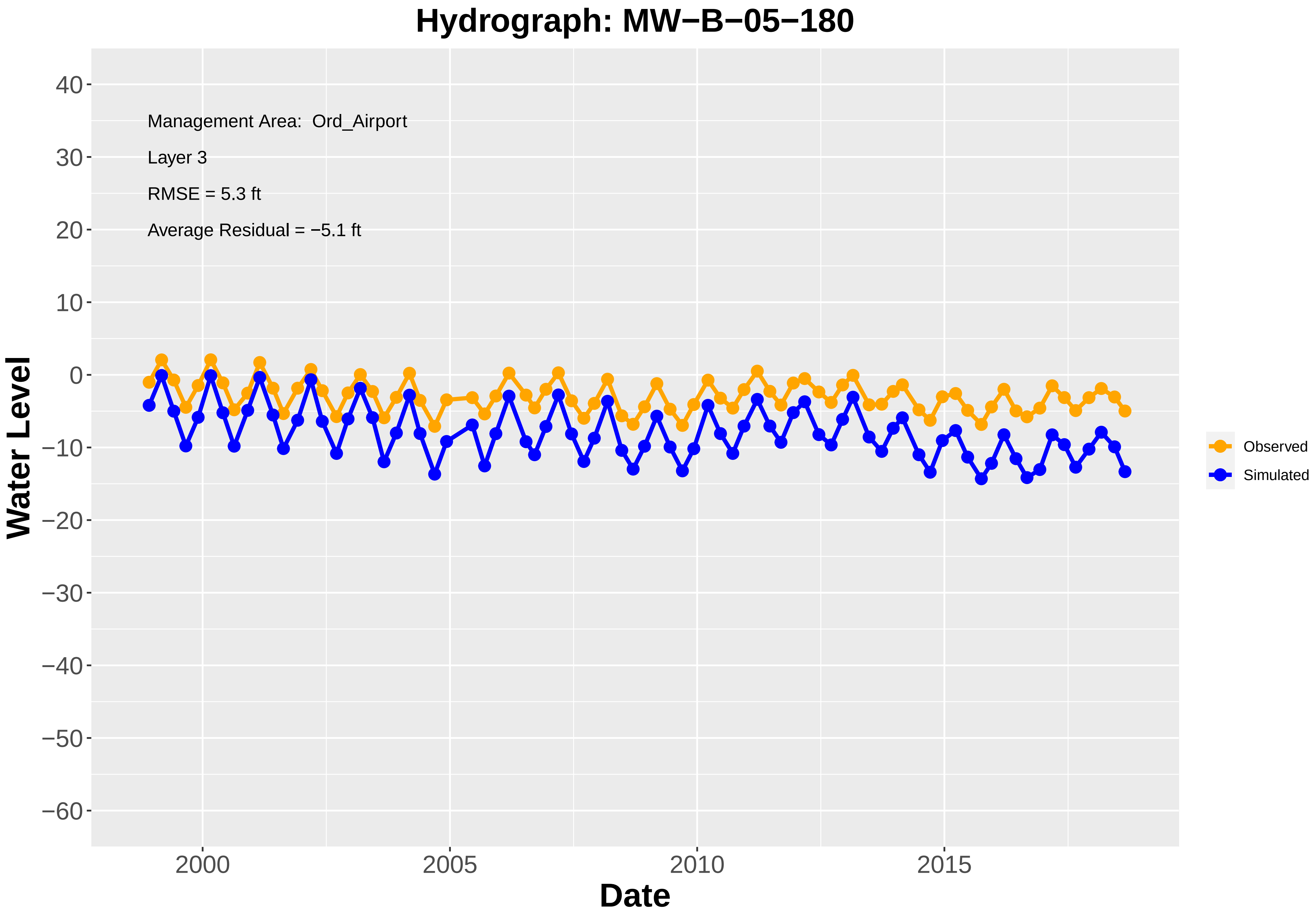


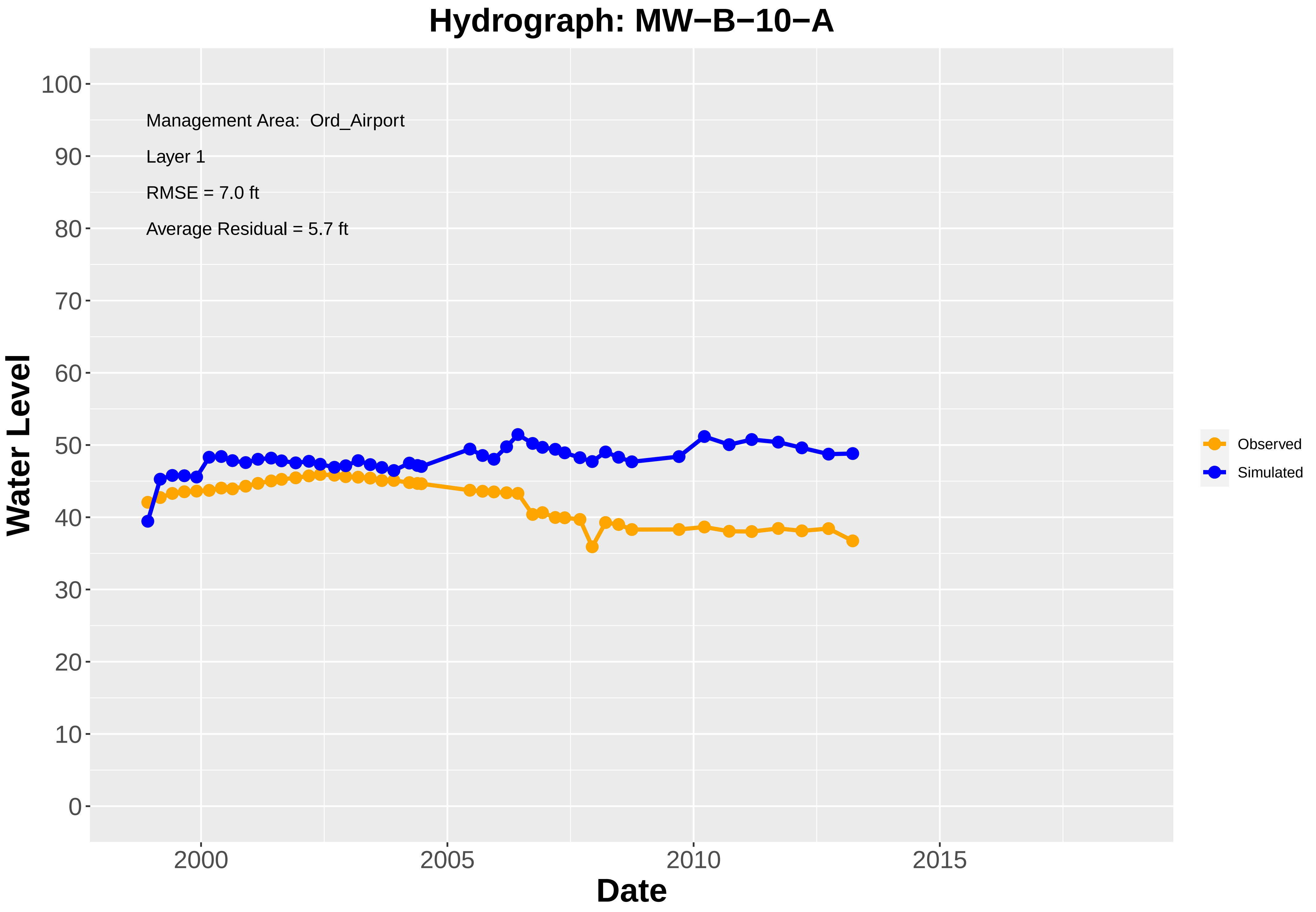

Hydrograph: MW−40−01−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.2 ft
Average Residual = −9.8 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

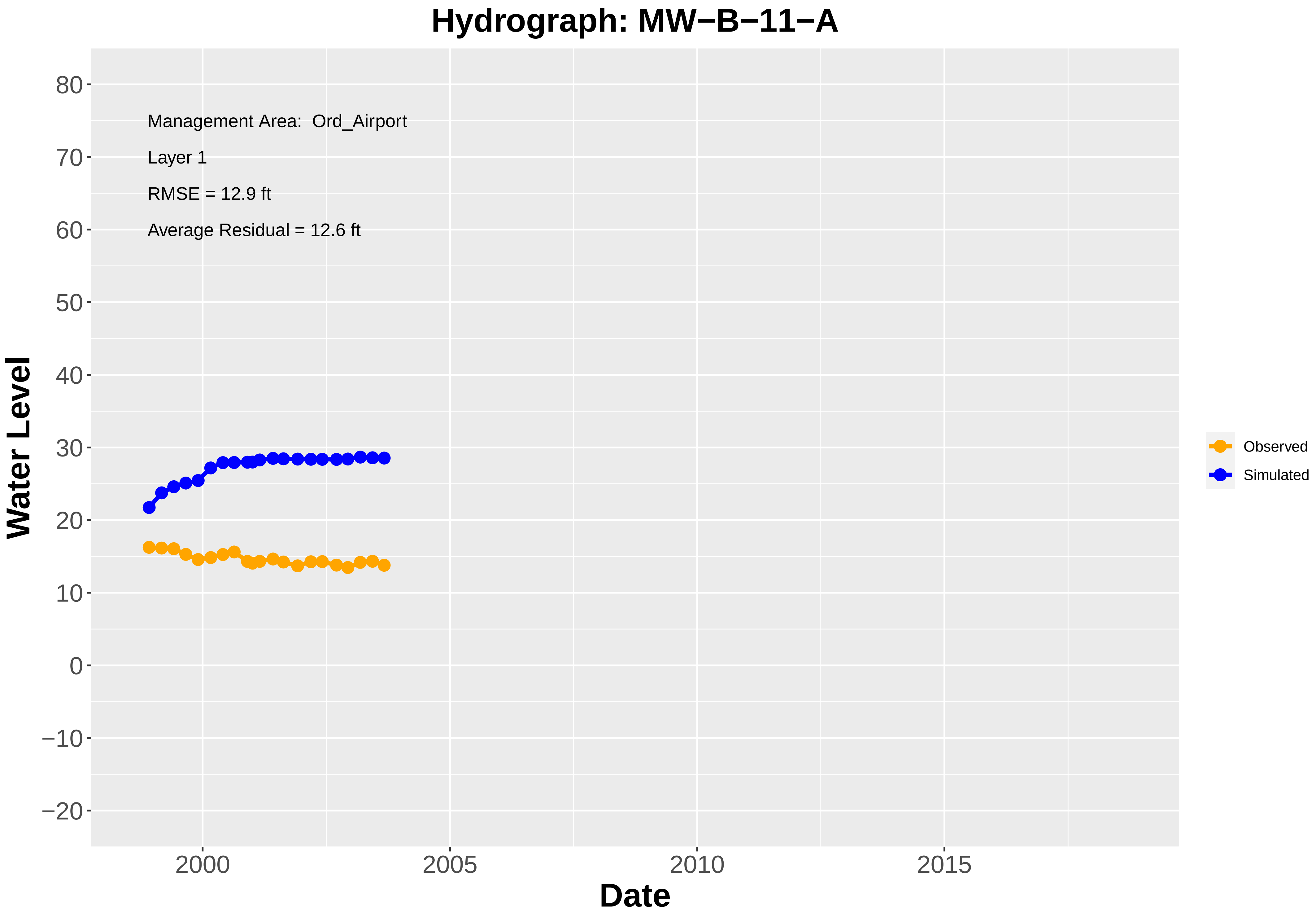


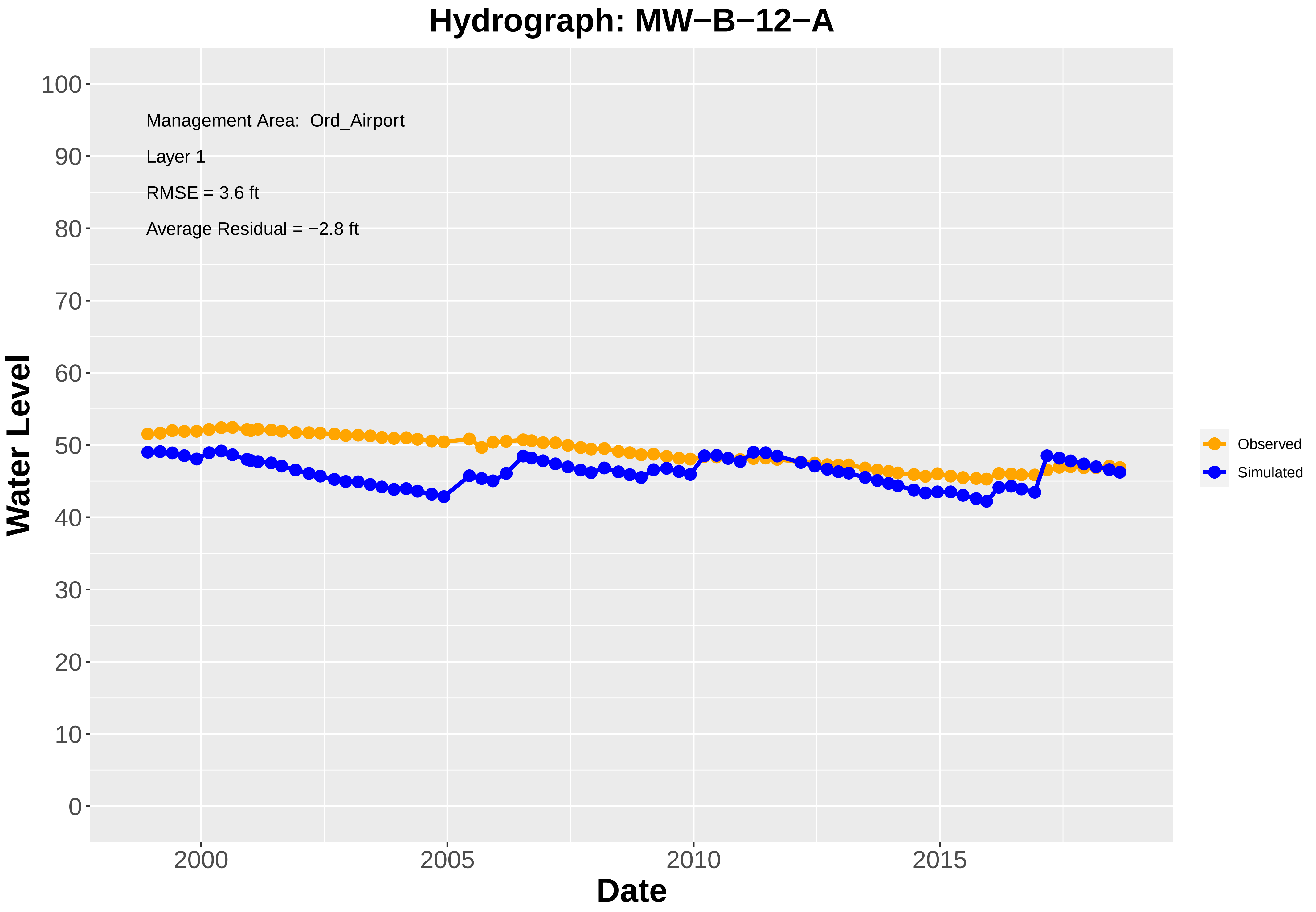
Hydrograph: MW−B−01−A
Management Area: North of Basin
Layer 1
RMSE = 18.7 ft
Average Residual = −18.2 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

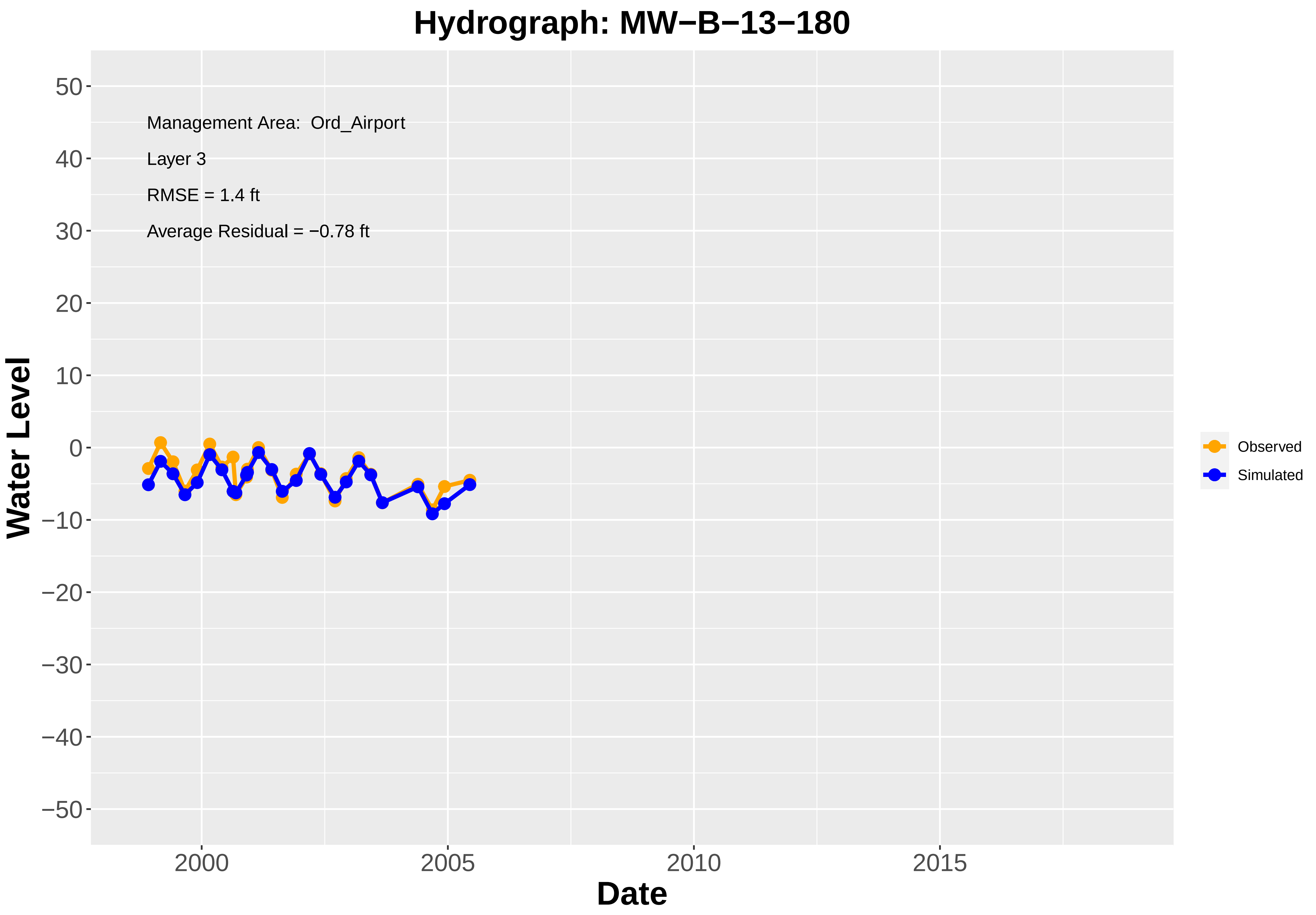

Hydrograph: MW−B−02−A
Management Area: North of Basin
Layer 1
RMSE = 6.6 ft
Average Residual = −5.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

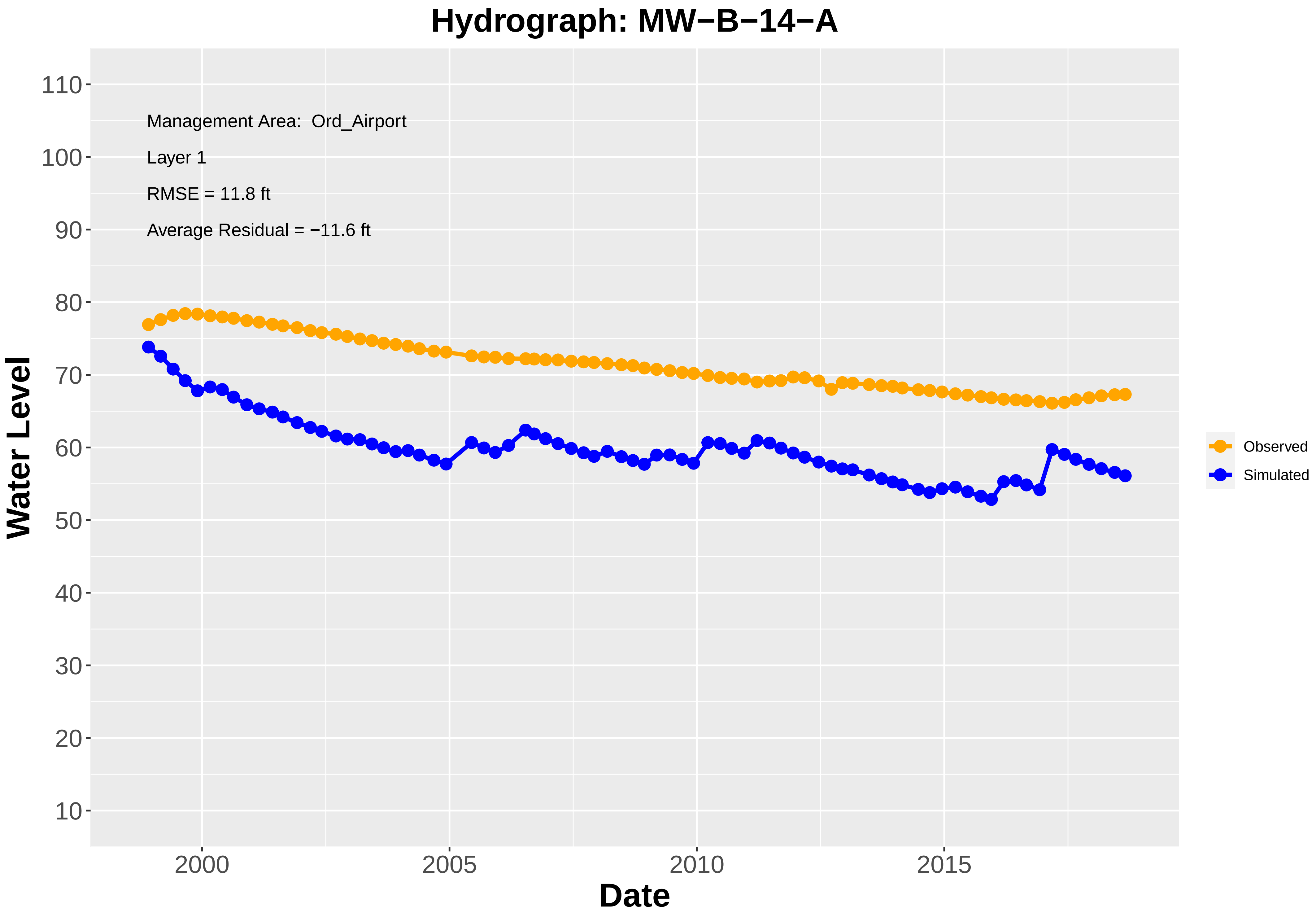

Hydrograph: MW−B−05−180
Management Area: Ord_Airport
Layer 3
RMSE = 5.3 ft
Average Residual = −5.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

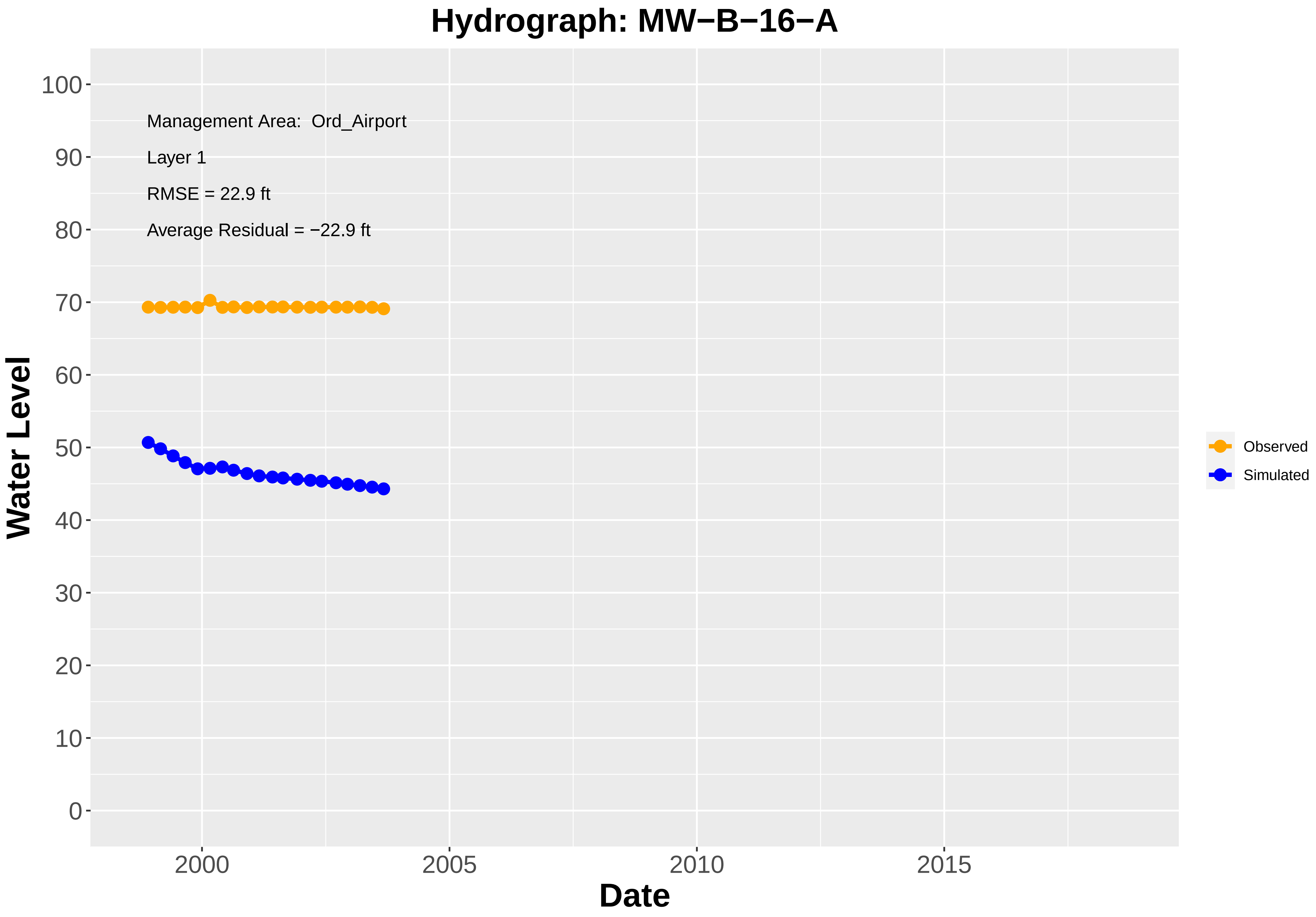

Hydrograph: MW−B−10−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.0 ft
Average Residual = 5.7 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

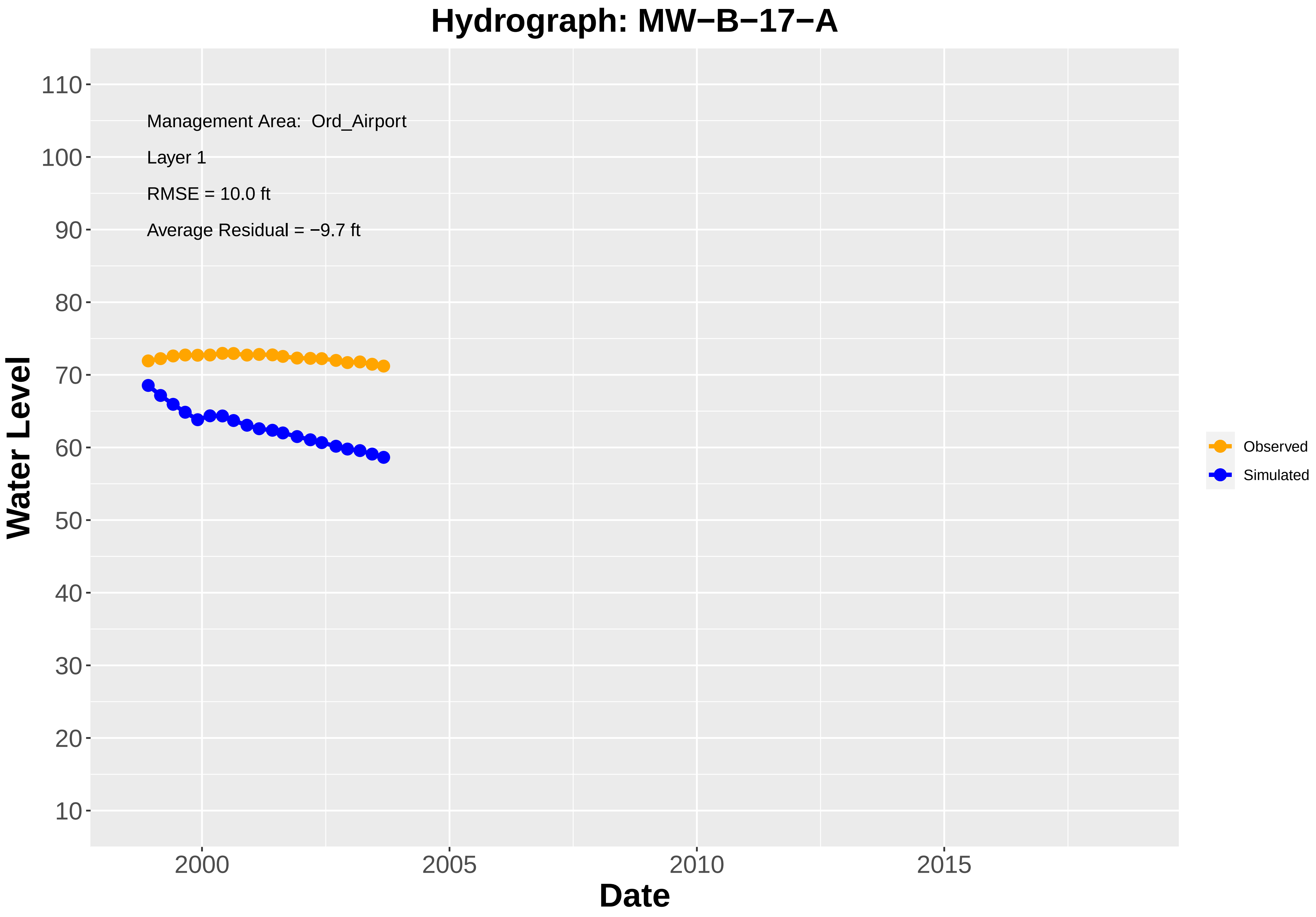

Hydrograph: MW−B−11−A
Management Area: Ord_Airport
Layer 1
RMSE = 12.9 ft
Average Residual = 12.6 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−B−12−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.6 ft
Average Residual = −2.8 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

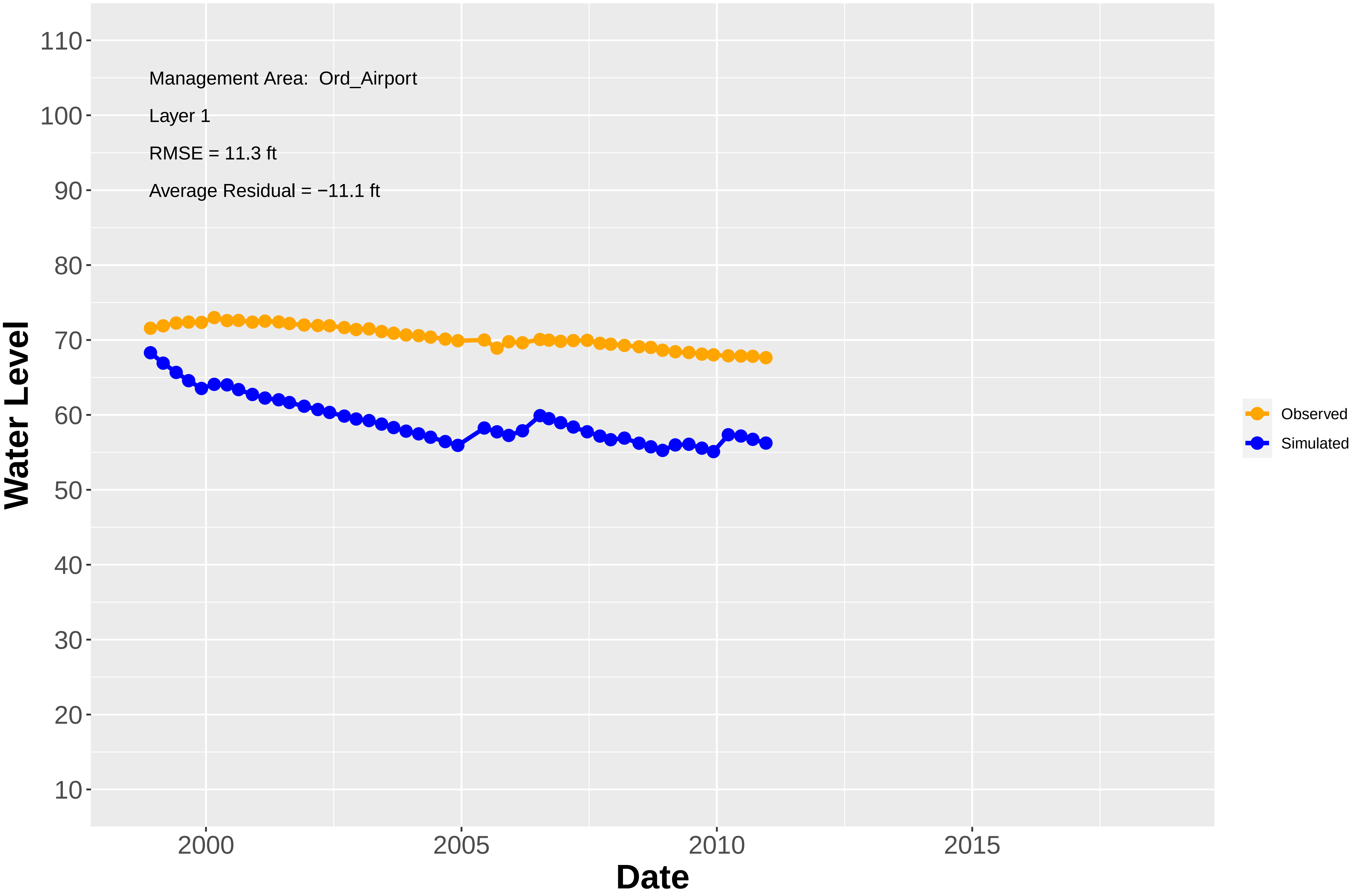

Hydrograph: MW−B−13−180
Management Area: Ord_Airport
Layer 3
RMSE = 1.4 ft
Average Residual = −0.78 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

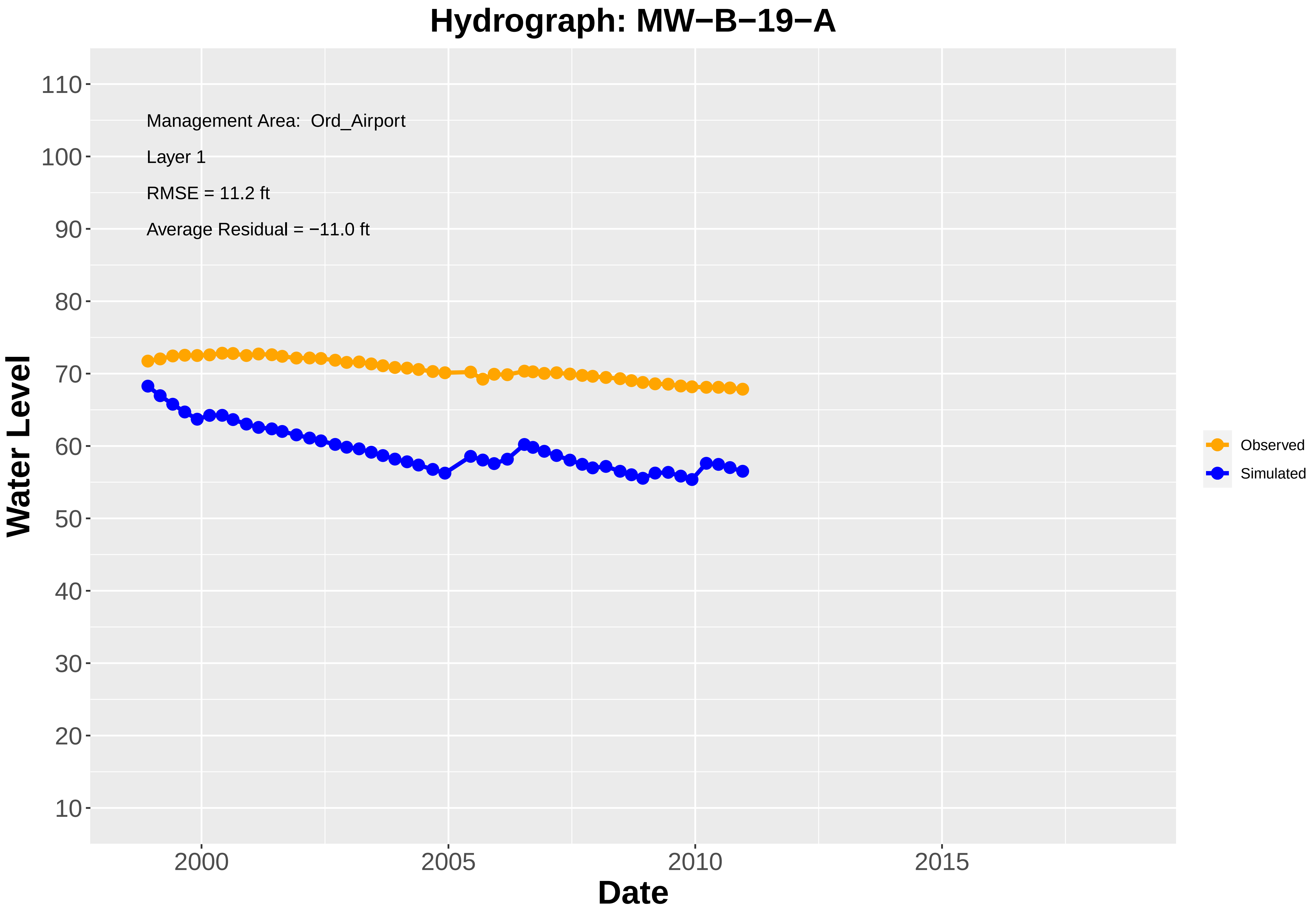

Hydrograph: MW−B−14−A
Management Area: Ord_Airport
Layer 1
RMSE = 11.8 ft
Average Residual = −11.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−B−16−A
Management Area: Ord_Airport
Layer 1
RMSE = 22.9 ft
Average Residual = −22.9 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

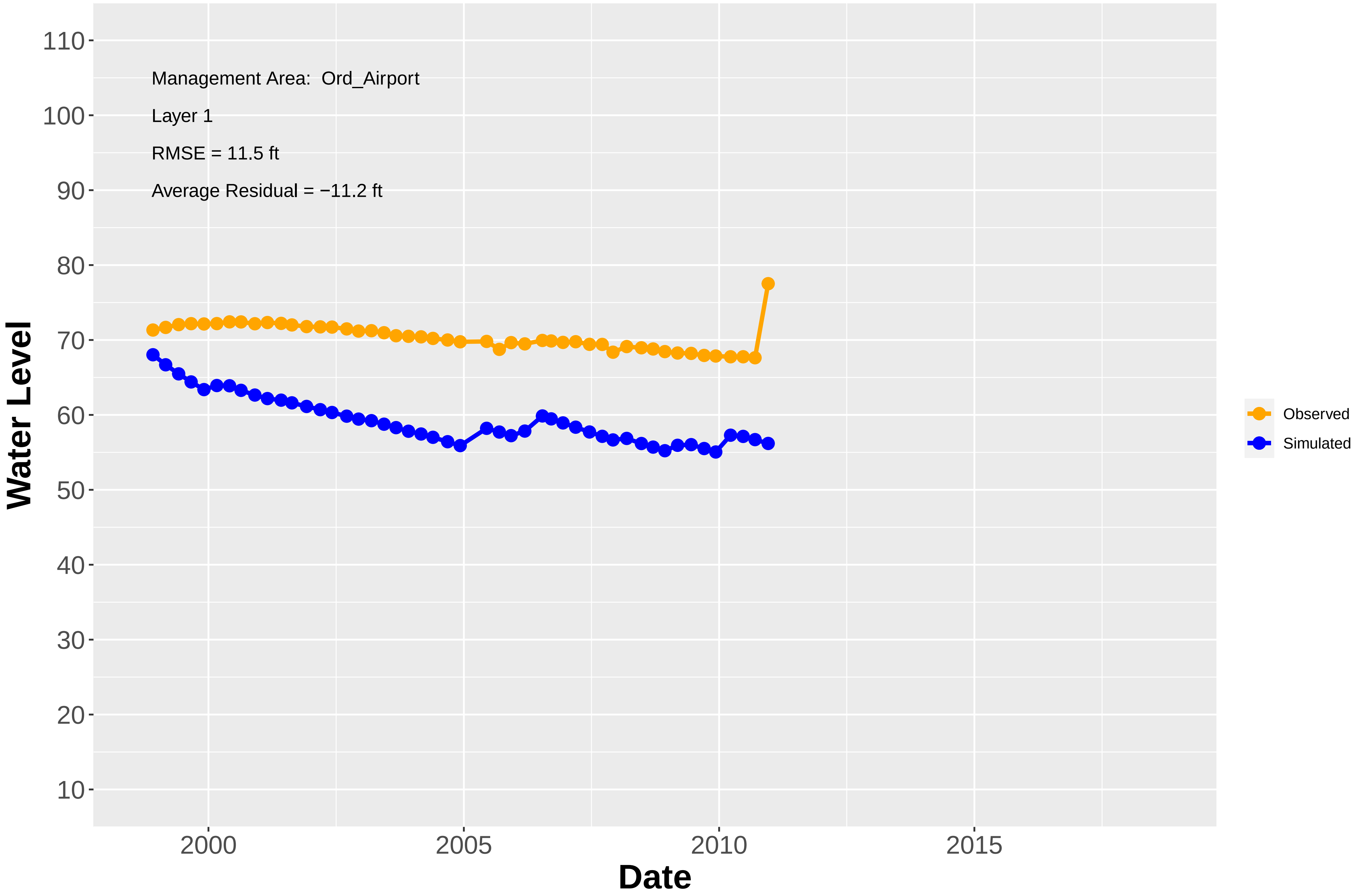

Hydrograph: MW−B−17−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.0 ft
Average Residual = −9.7 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

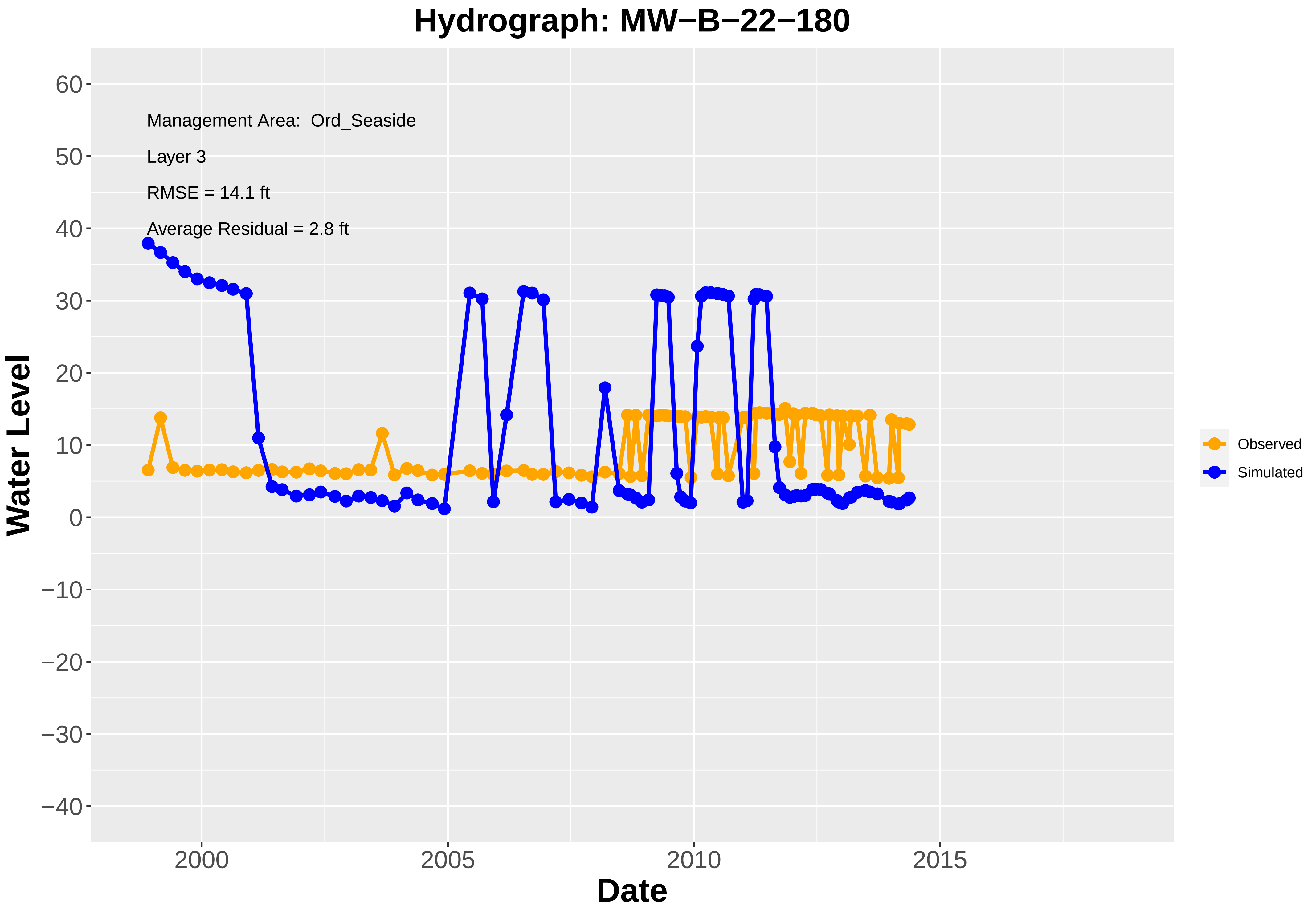
Hydrograph: MW−B−18−A

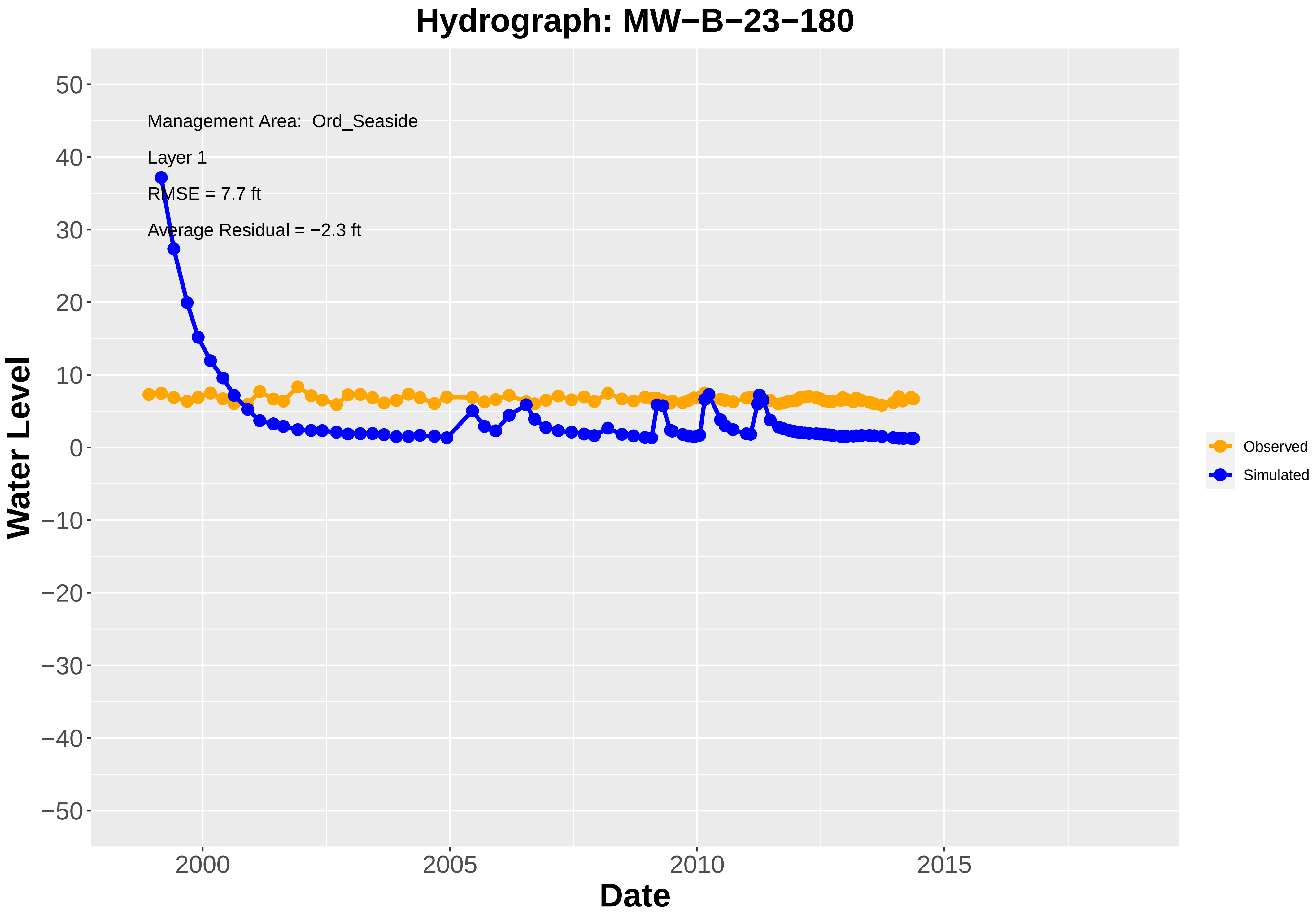


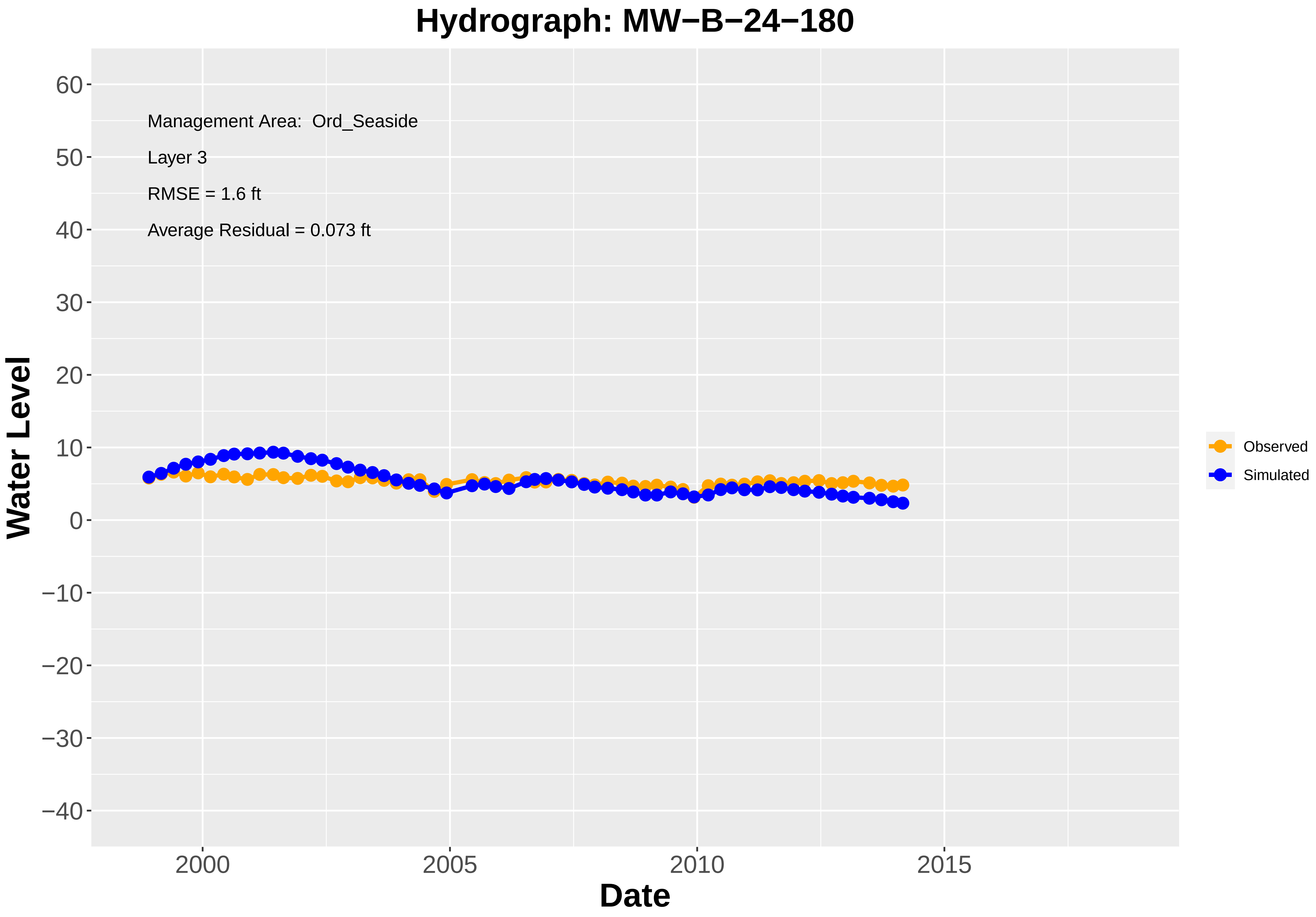

Hydrograph: MW−B−19−A
Management Area: Ord_Airport
Layer 1
RMSE = 11.2 ft
Average Residual = −11.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

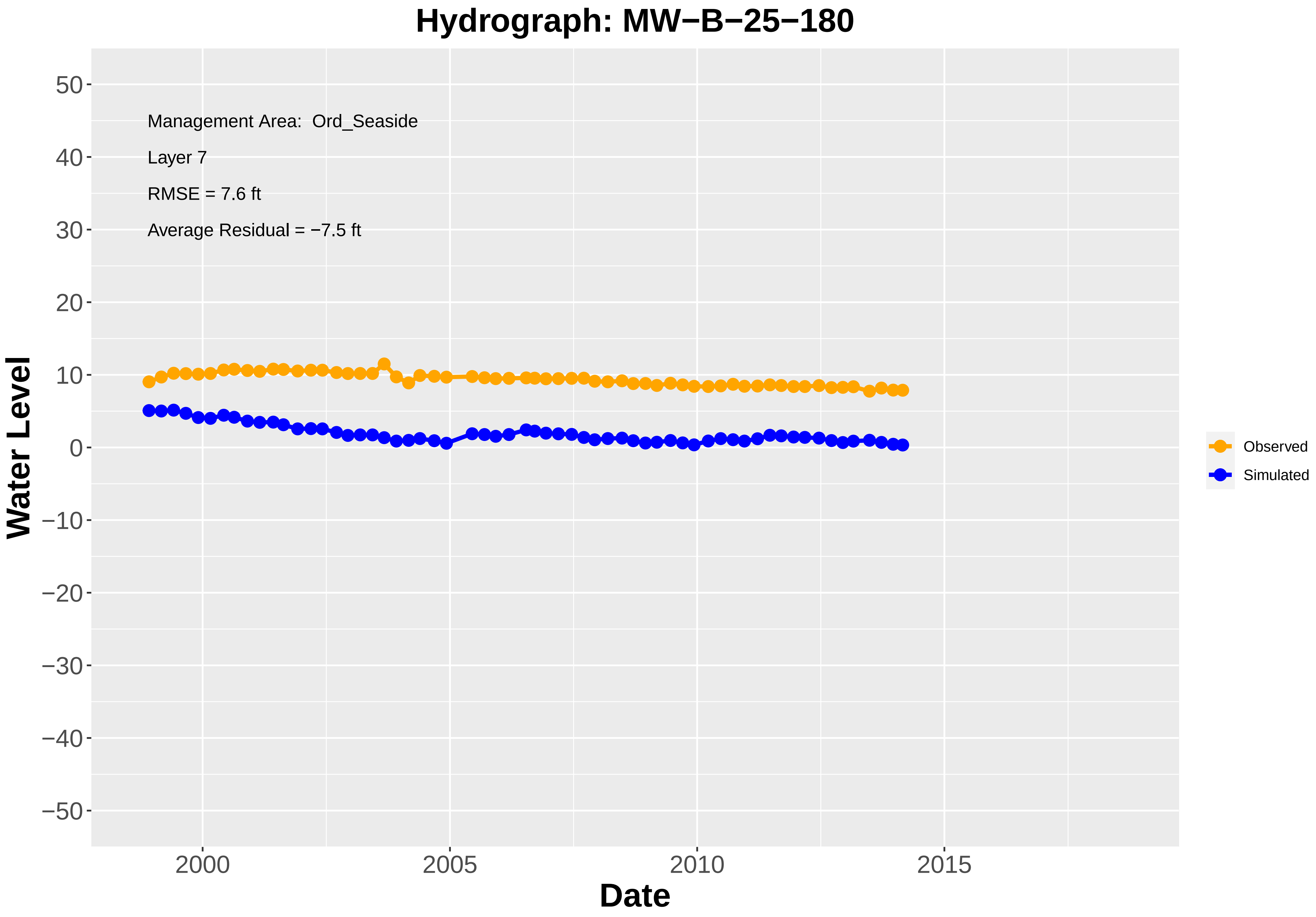
Hydrograph: MW−B−20−A

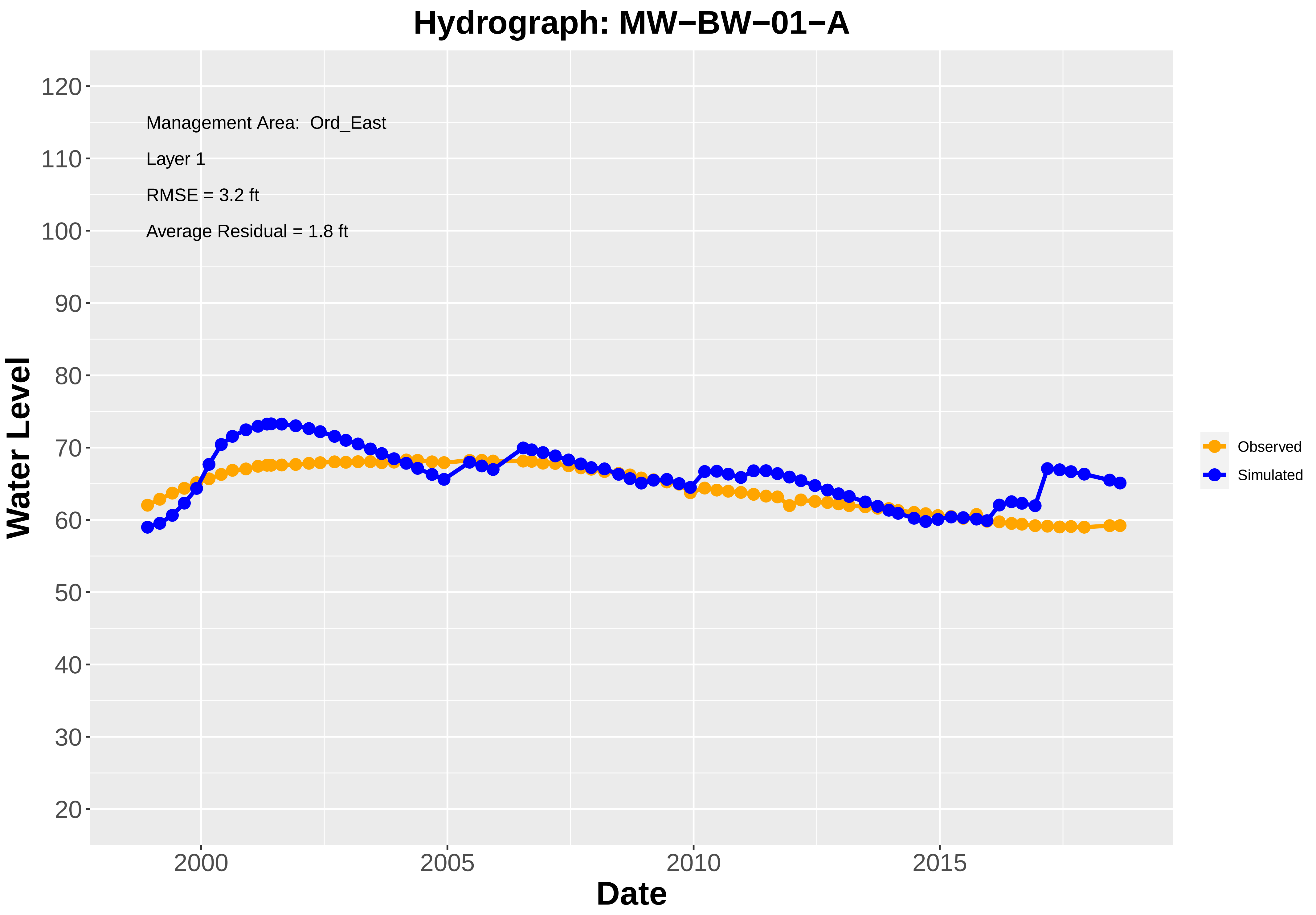


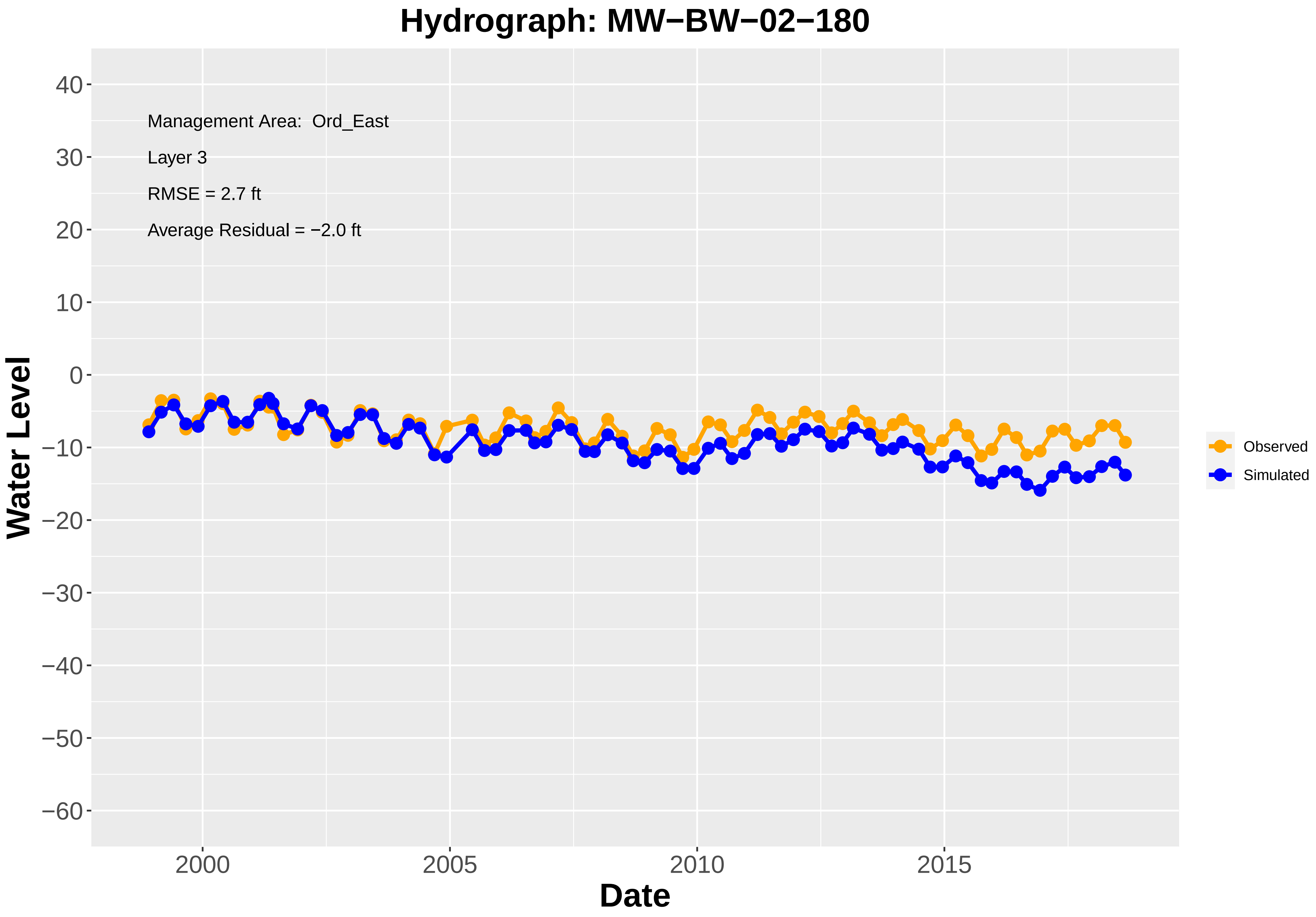

Hydrograph: MW−B−22−180
Management Area: Ord_Seaside
Layer 3
RMSE = 14.1 ft
Average Residual = 2.8 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

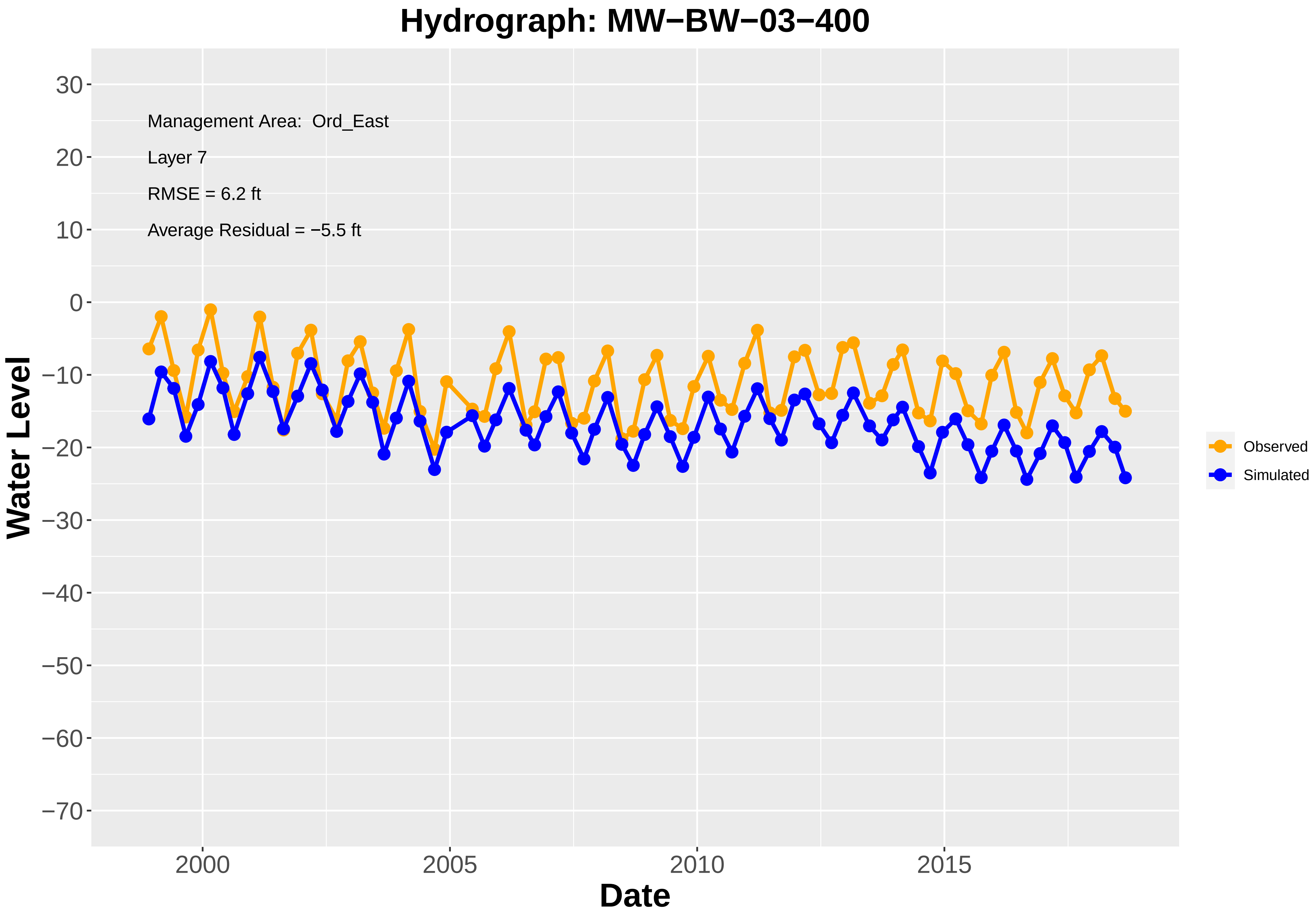

Hydrograph: MW−B−23−180
Management Area: Ord_Seaside
Layer 1
RMSE = 7.7 ft
Average Residual = −2.3 ft
50
40
30
20
10
0
−10
−20
−30
−40
−50
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

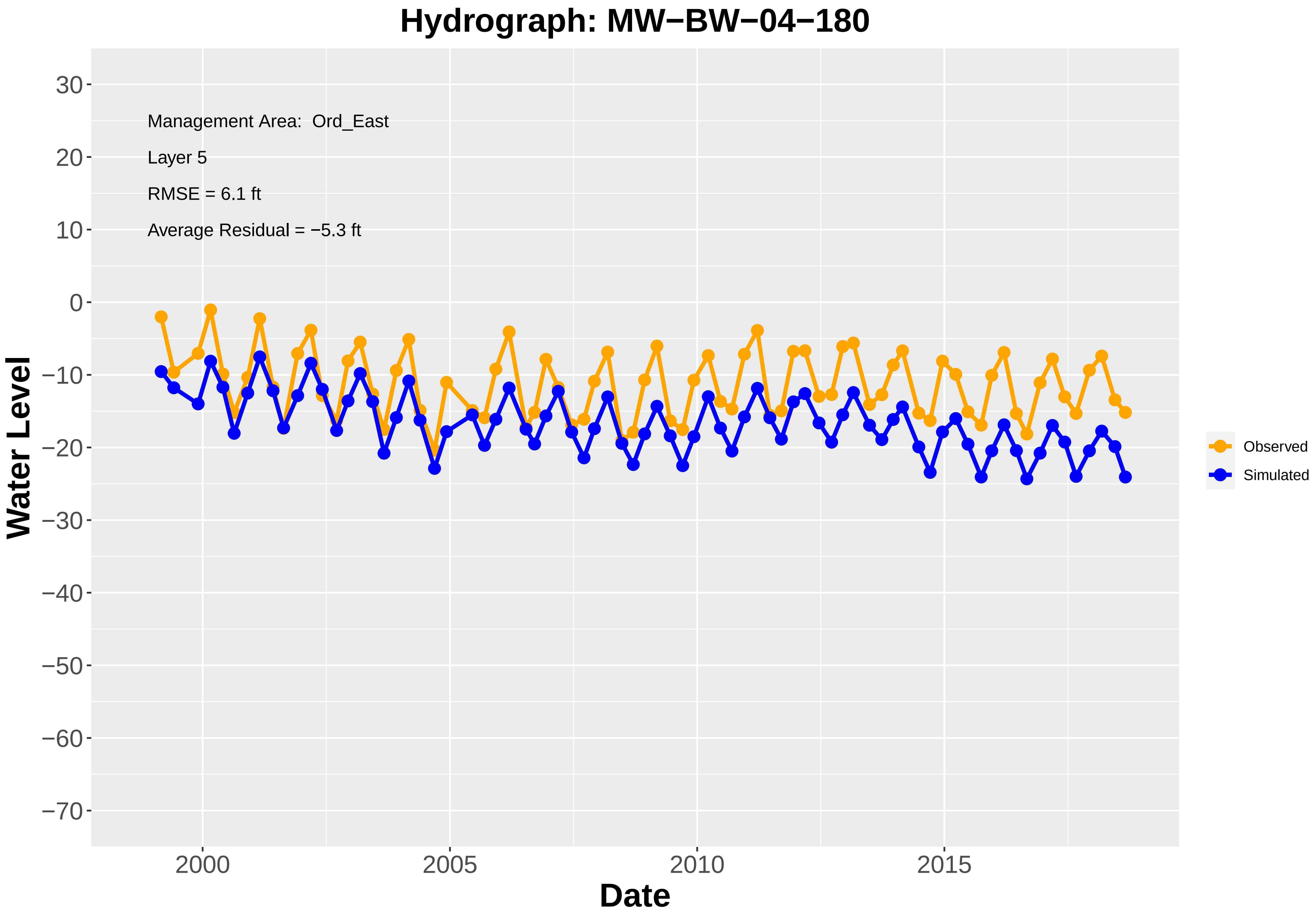

Hydrograph: MW−B−24−180
Management Area: Ord_Seaside
Layer 3
RMSE = 1.6 ft
Average Residual = 0.073 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−B−25−180
Management Area: Ord_Seaside
Layer 7
RMSE = 7.6 ft
Average Residual = −7.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

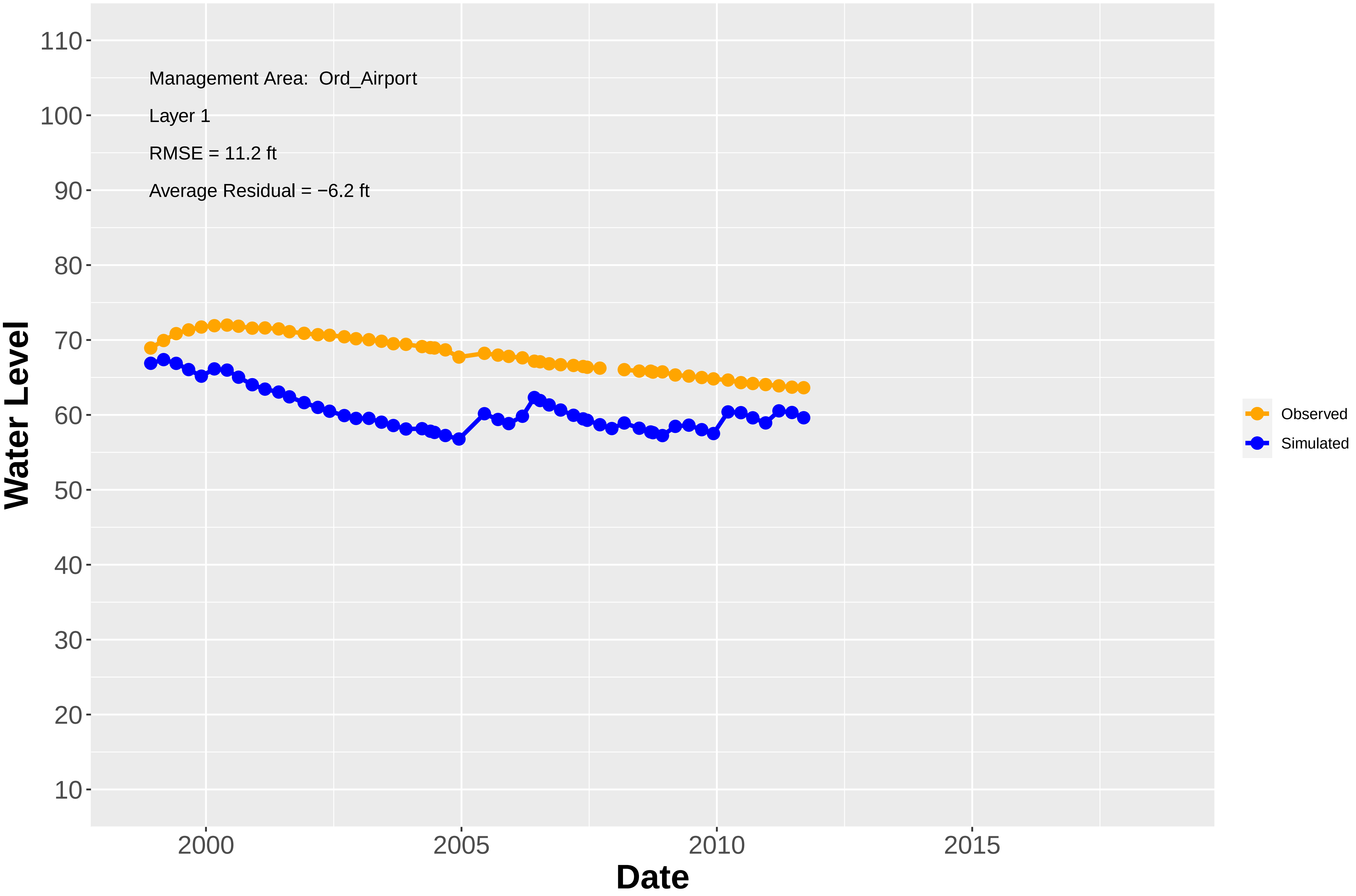

Hydrograph: MW−BW−01−A
Management Area: Ord_East
Layer 1
RMSE = 3.2 ft
Average Residual = 1.8 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−02−180
Management Area: Ord_East
Layer 3
RMSE = 2.7 ft
Average Residual = −2.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

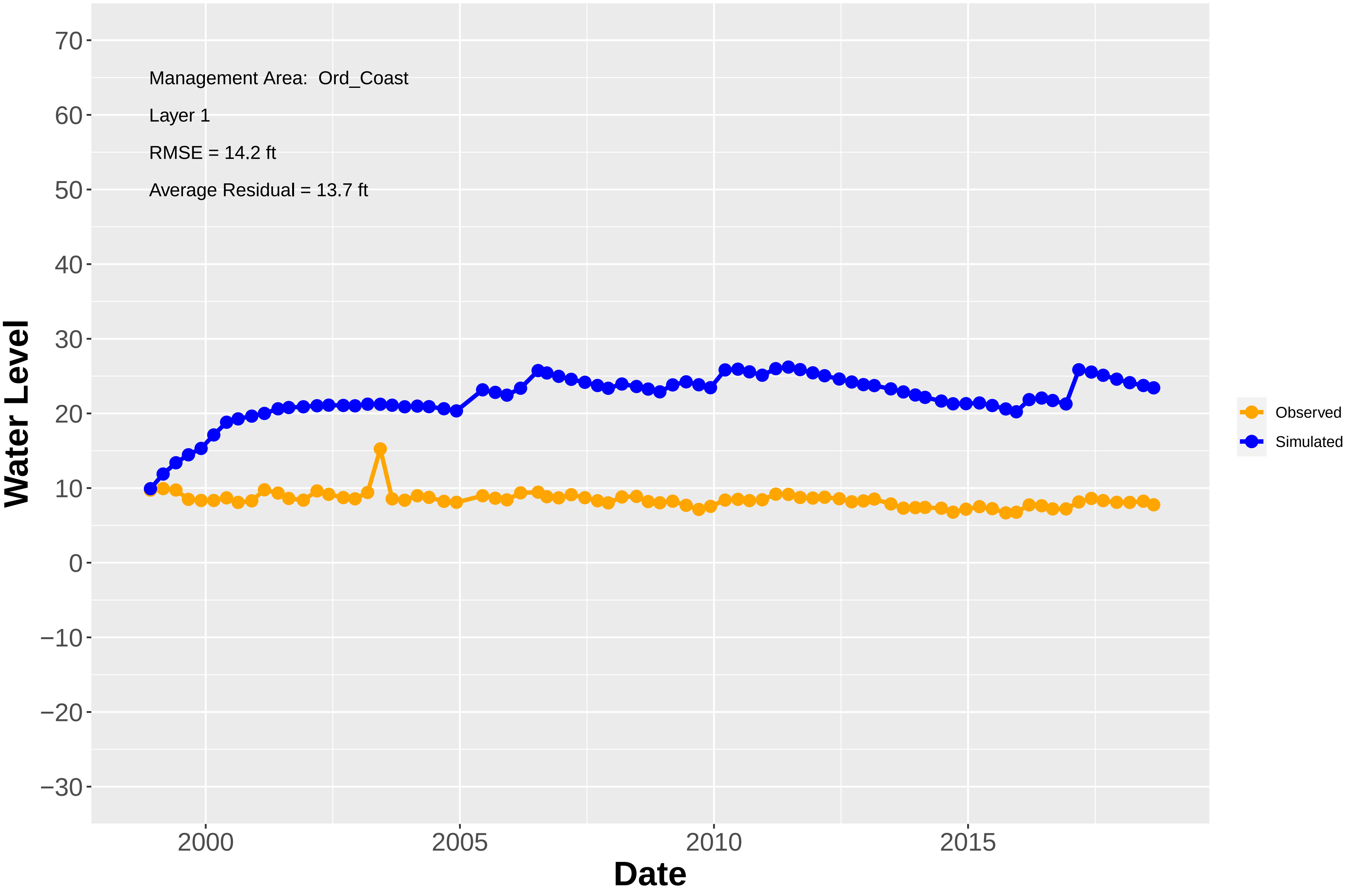

Hydrograph: MW−BW−03−400
Management Area: Ord_East
Layer 7
RMSE = 6.2 ft
Average Residual = −5.5 ft
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

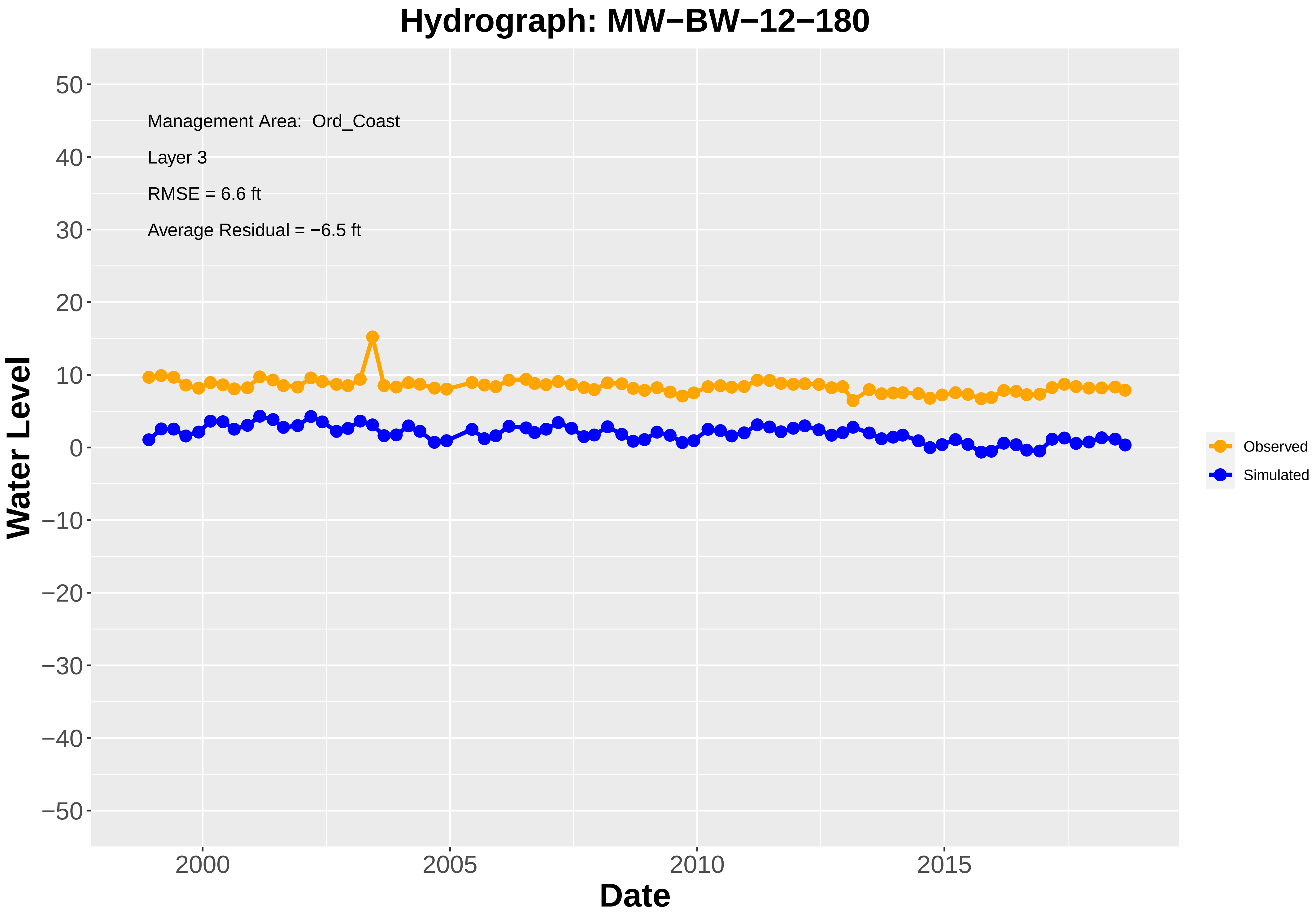

Hydrograph: MW−BW−04−180
Management Area: Ord_East
Layer 5
RMSE = 6.1 ft
Average Residual = −5.3 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

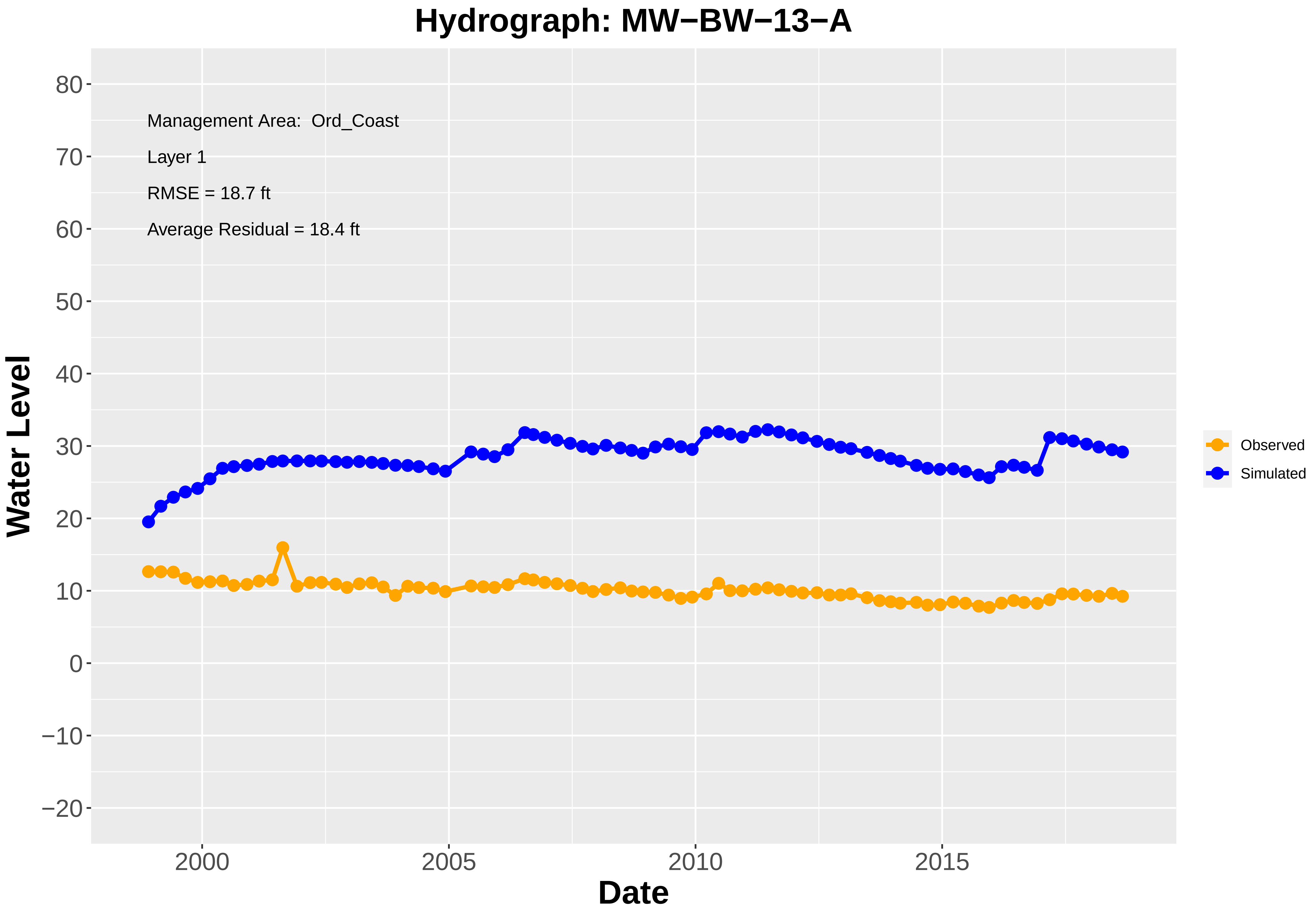
Hydrograph: MW−BW−10−A

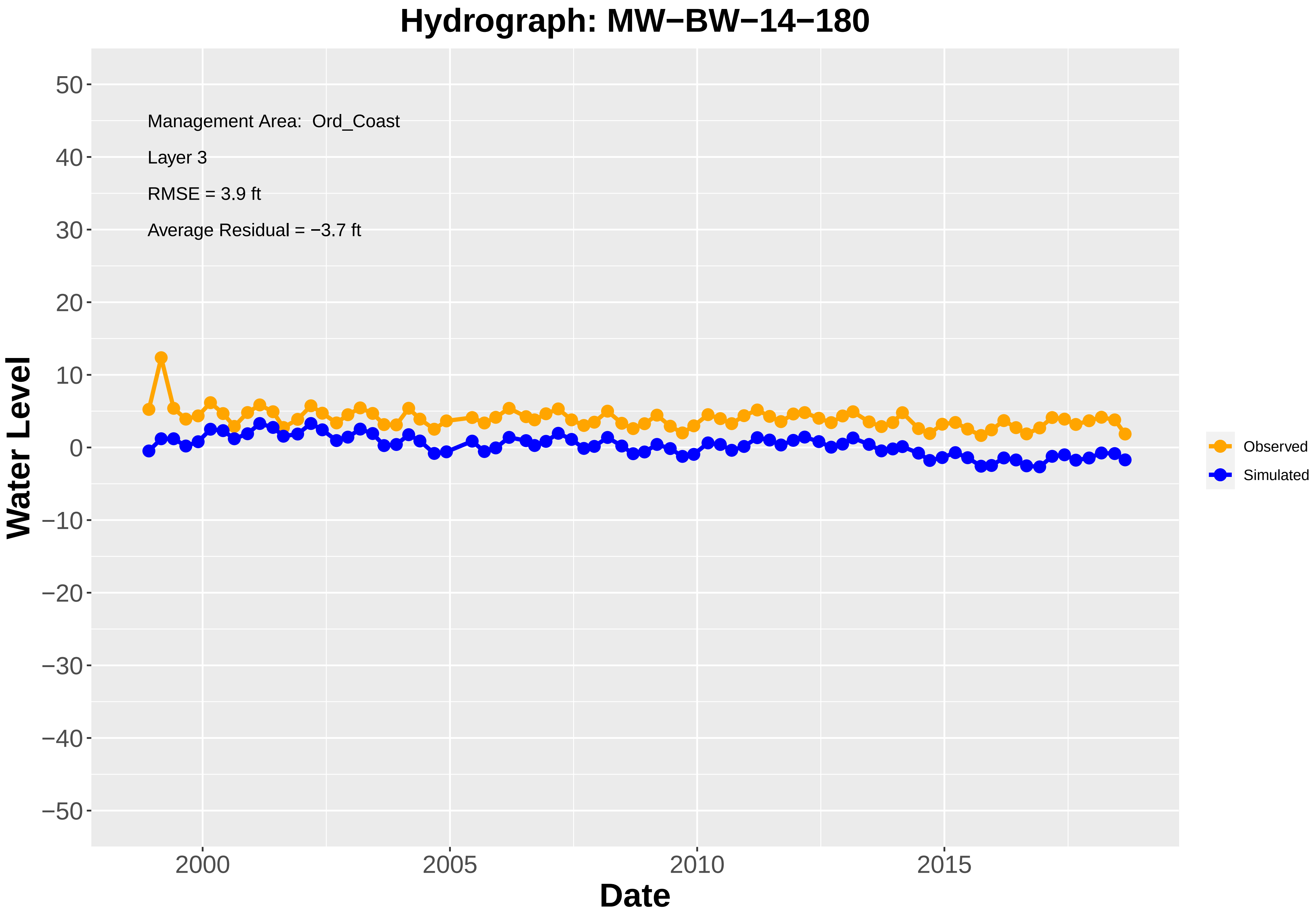


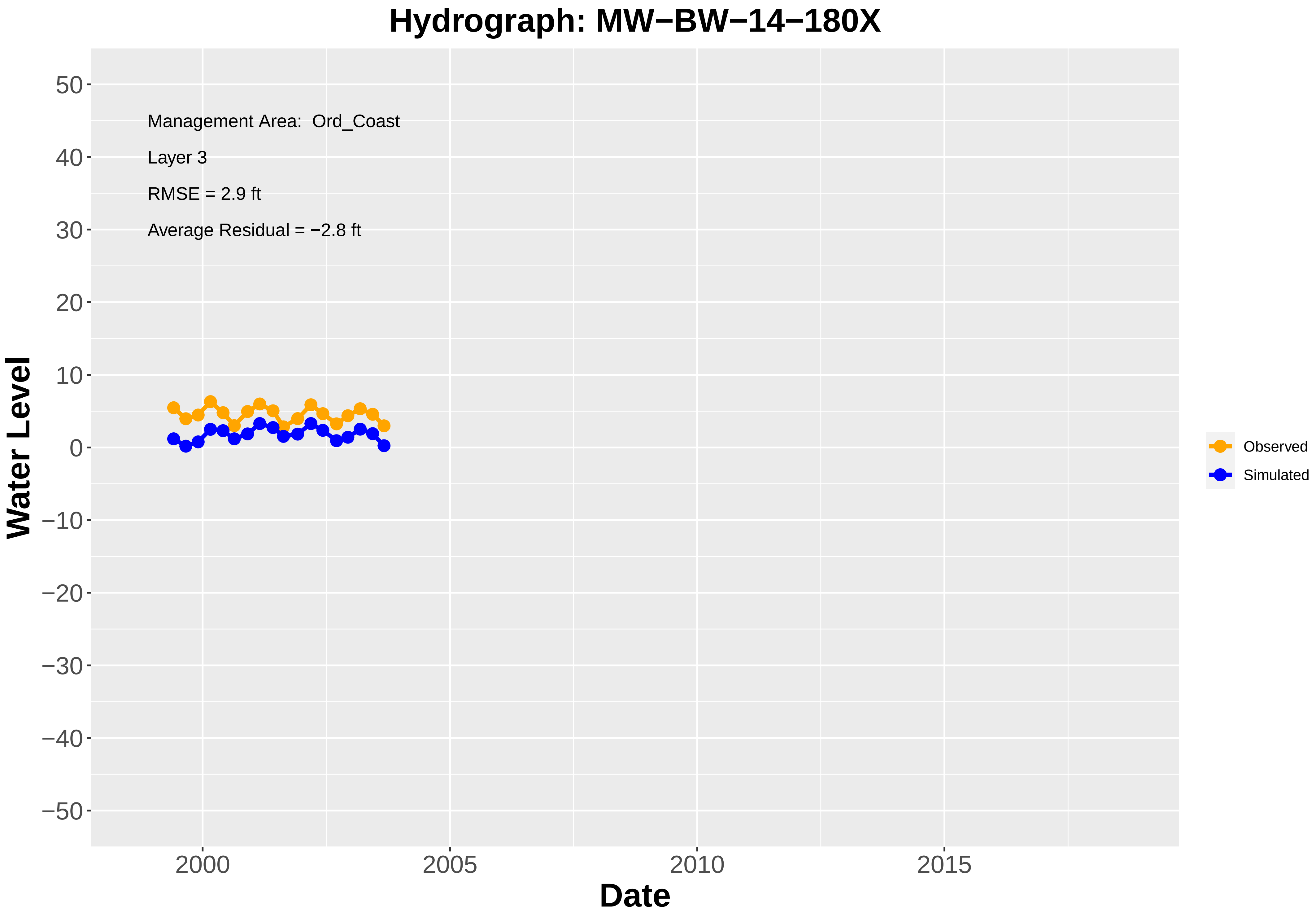
Hydrograph: MW−BW−11−A



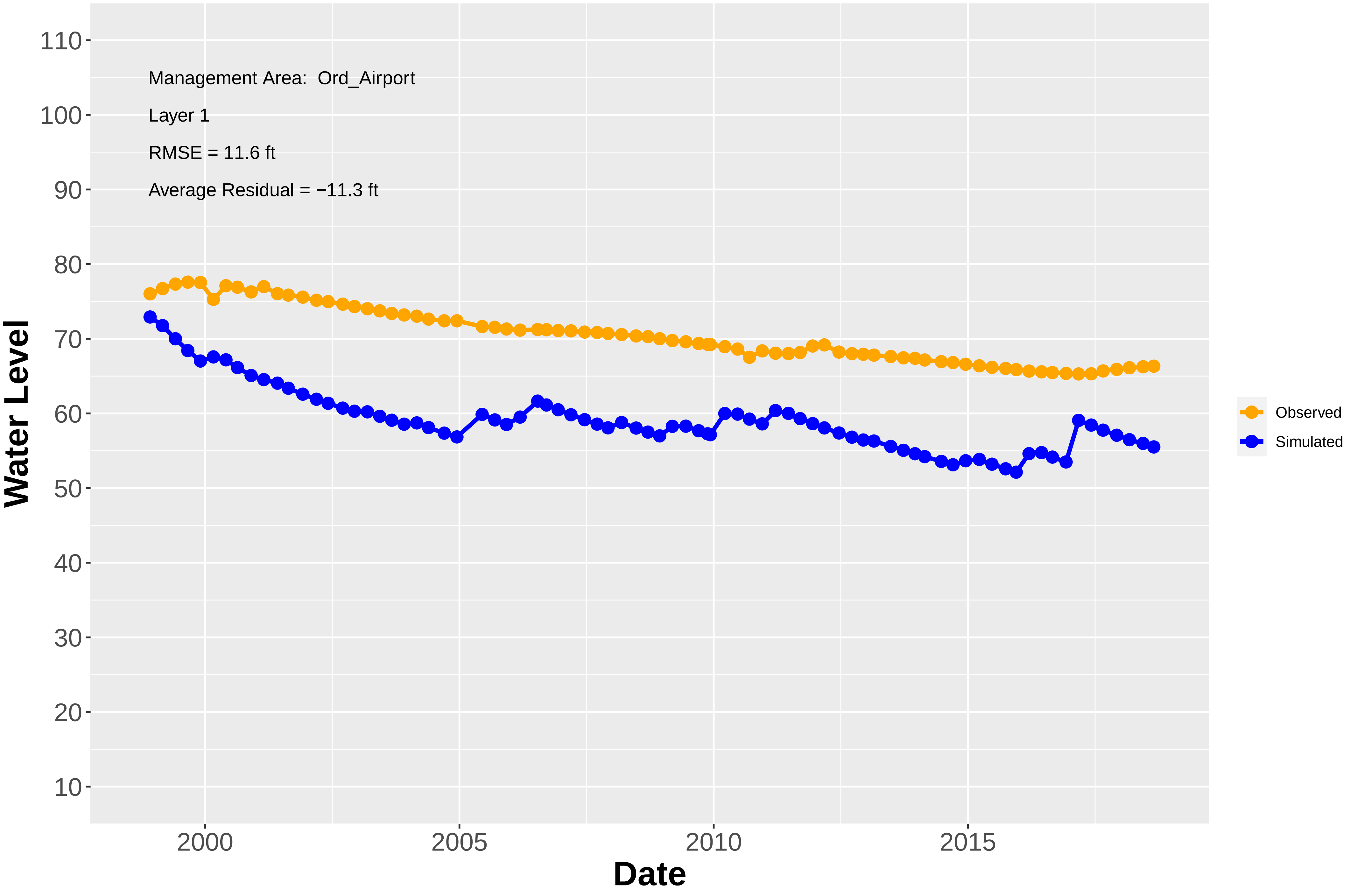

Hydrograph: MW−BW−12−180
Management Area: Ord_Coast
Layer 3
RMSE = 6.6 ft
Average Residual = −6.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

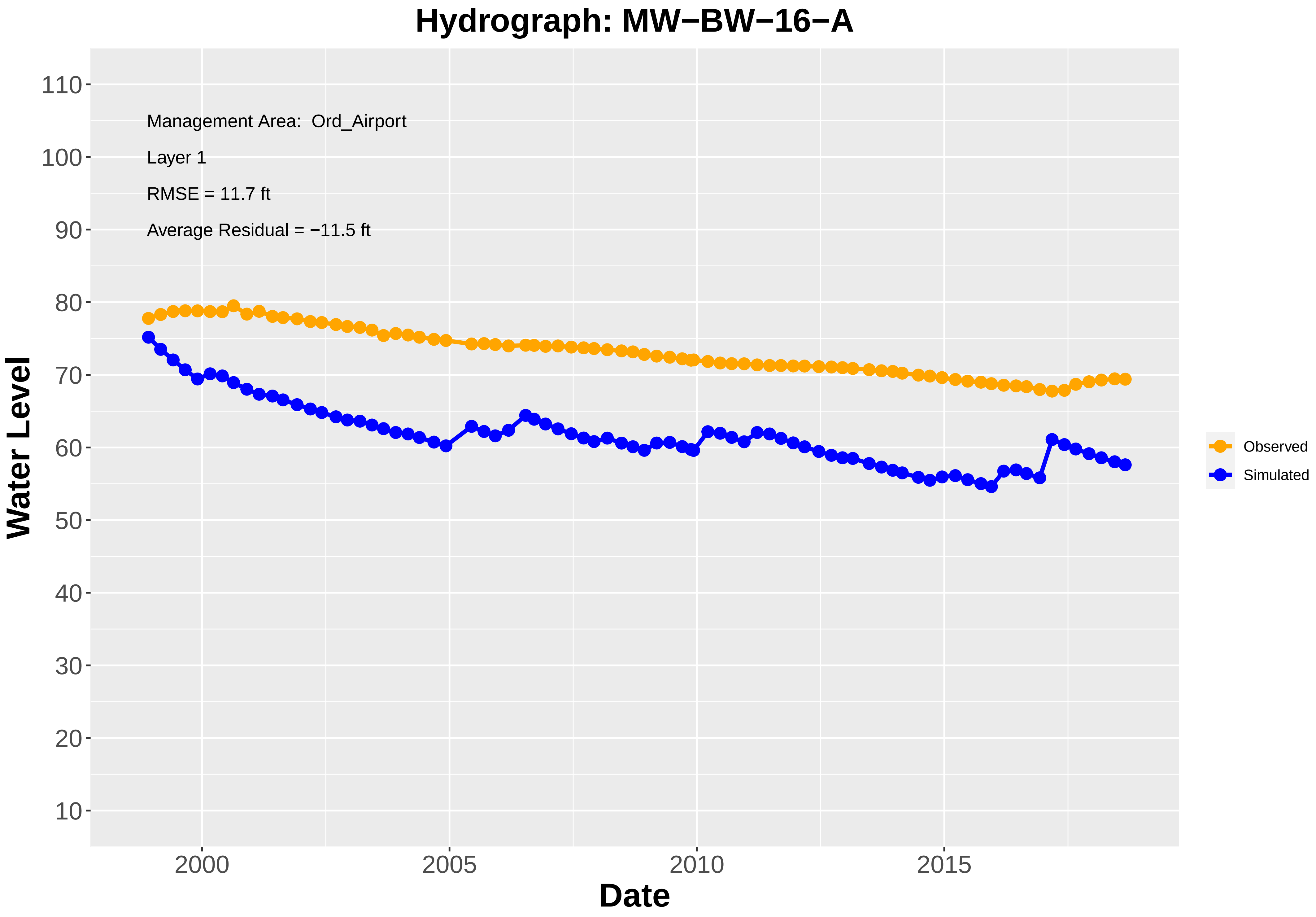

Hydrograph: MW−BW−13−A
Management Area: Ord_Coast
Layer 1
RMSE = 18.7 ft
Average Residual = 18.4 ft
Water Level
Date
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−14−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.9 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

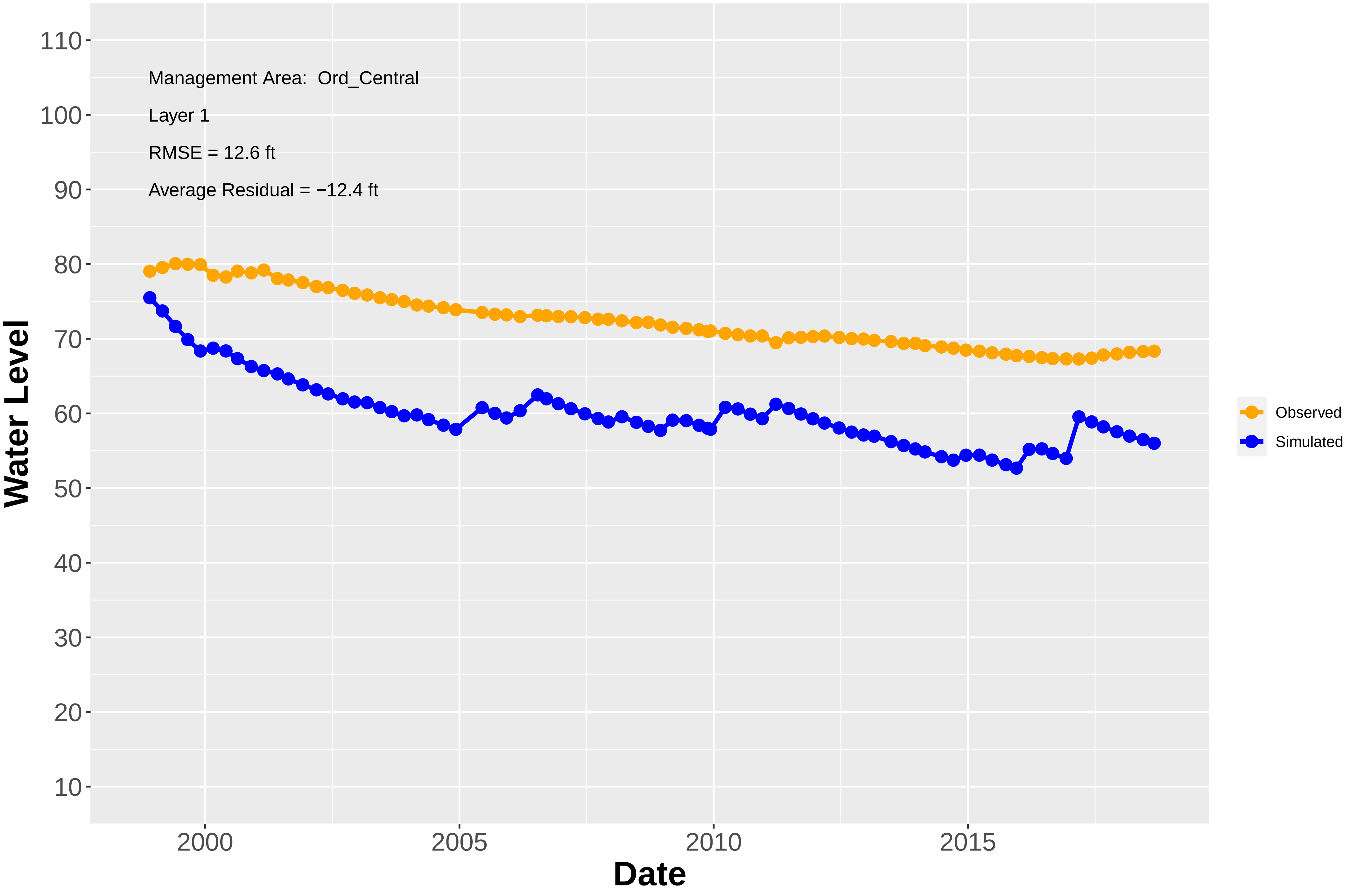

Hydrograph: MW−BW−14−180X
Management Area: Ord_Coast
Layer 3
RMSE = 2.9 ft
Average Residual = −2.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

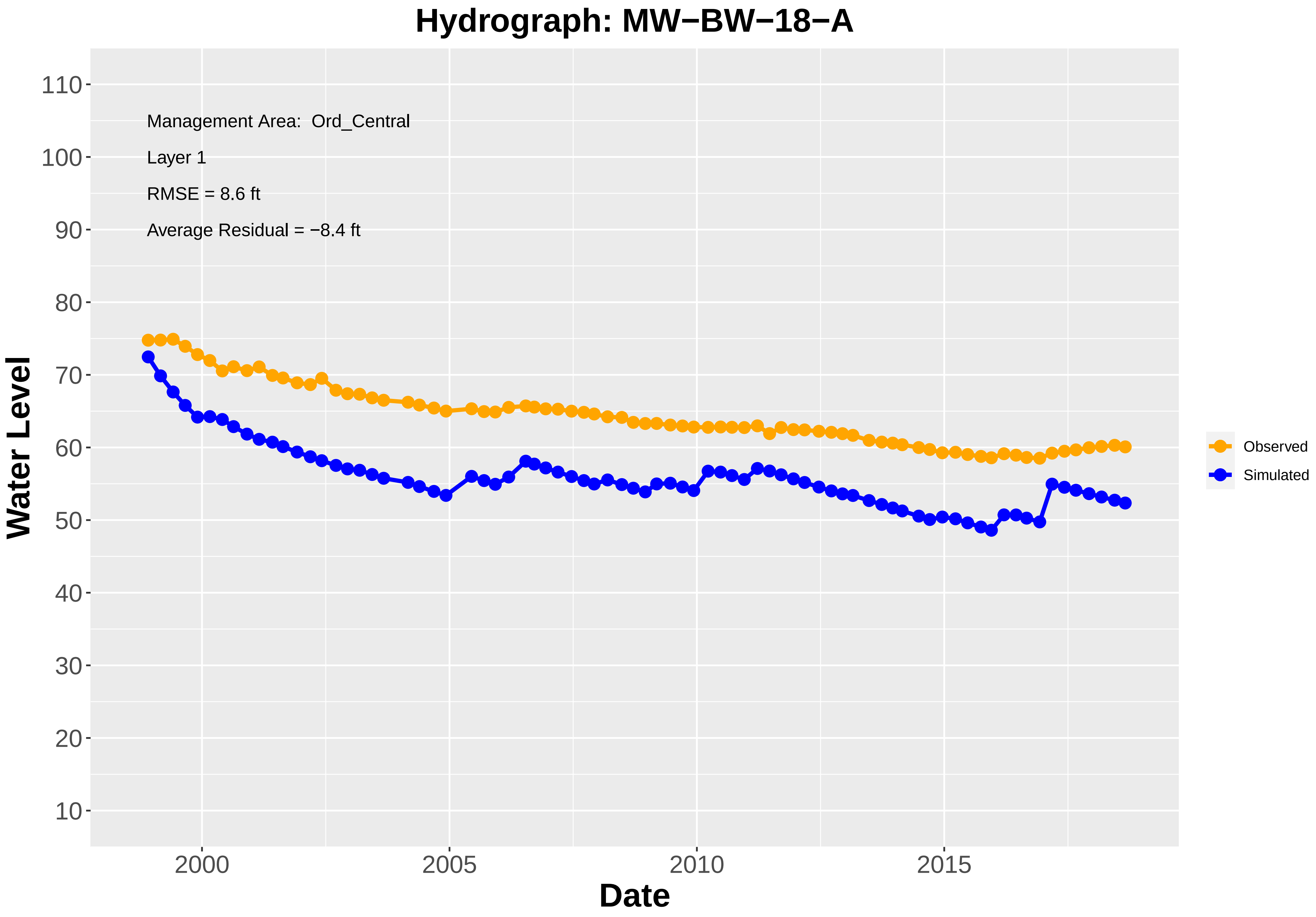
Hydrograph: MW−BW−15−A

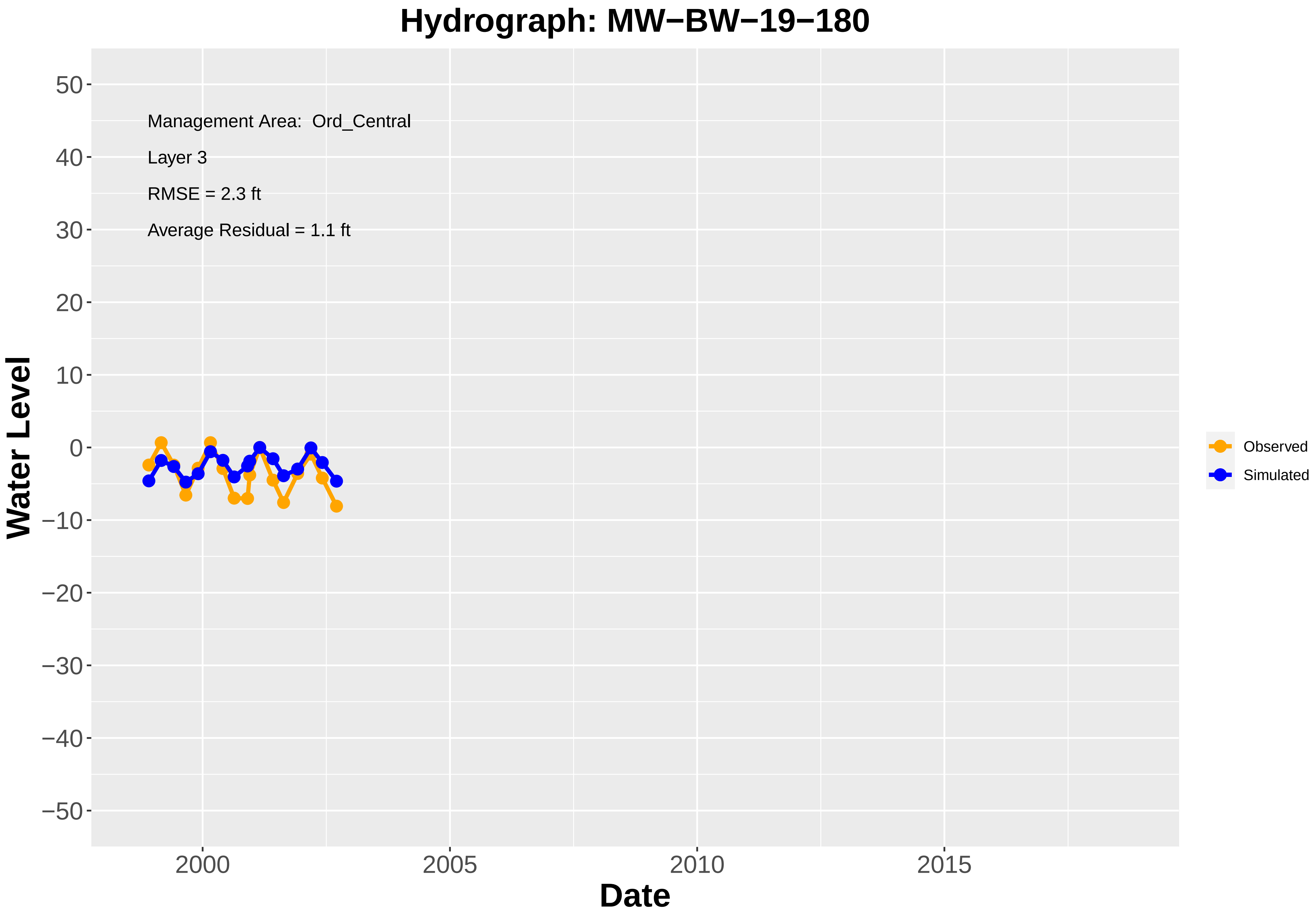


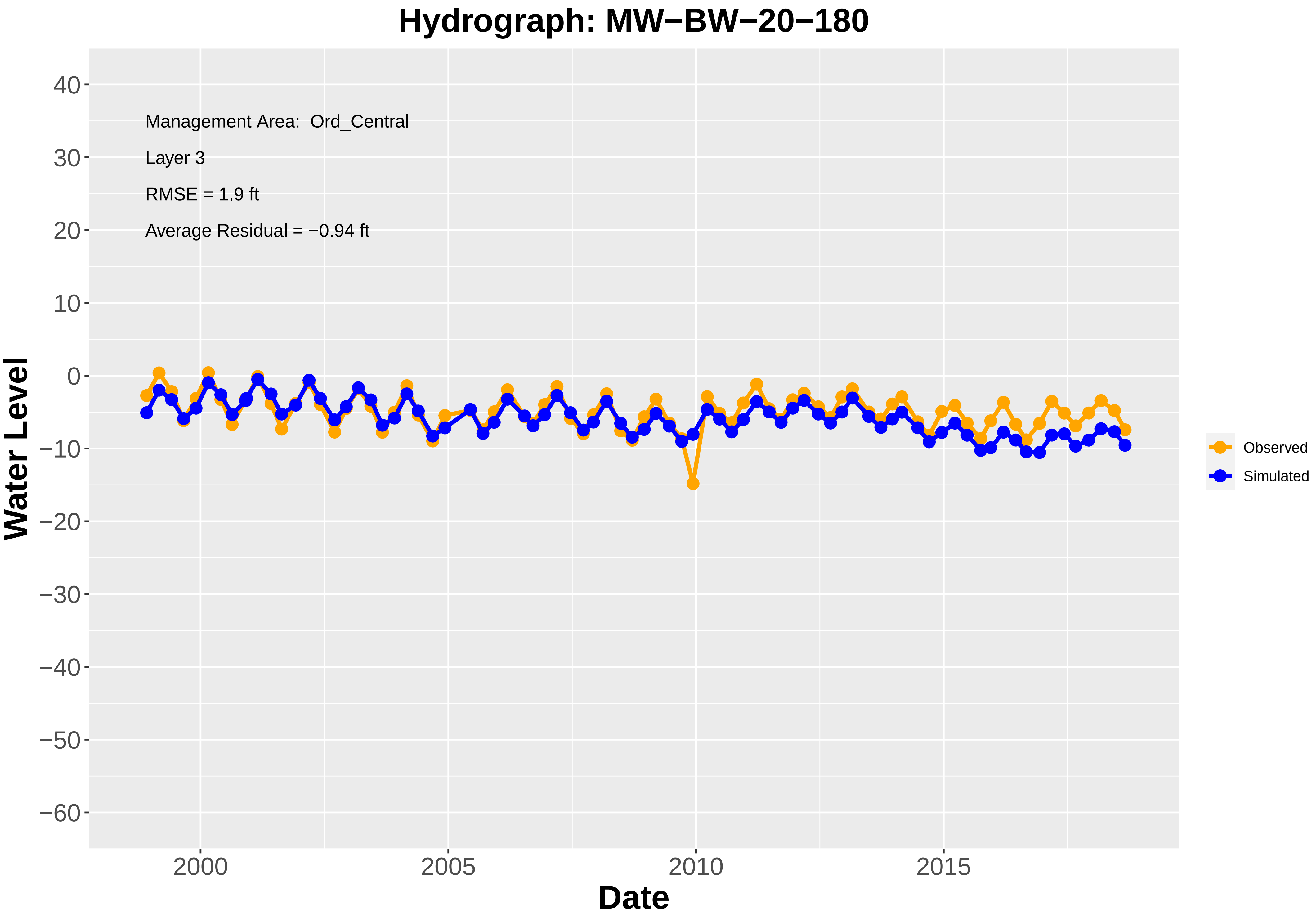

Hydrograph: MW−BW−16−A
Management Area: Ord_Airport
Layer 1
RMSE = 11.7 ft
Average Residual = −11.5 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

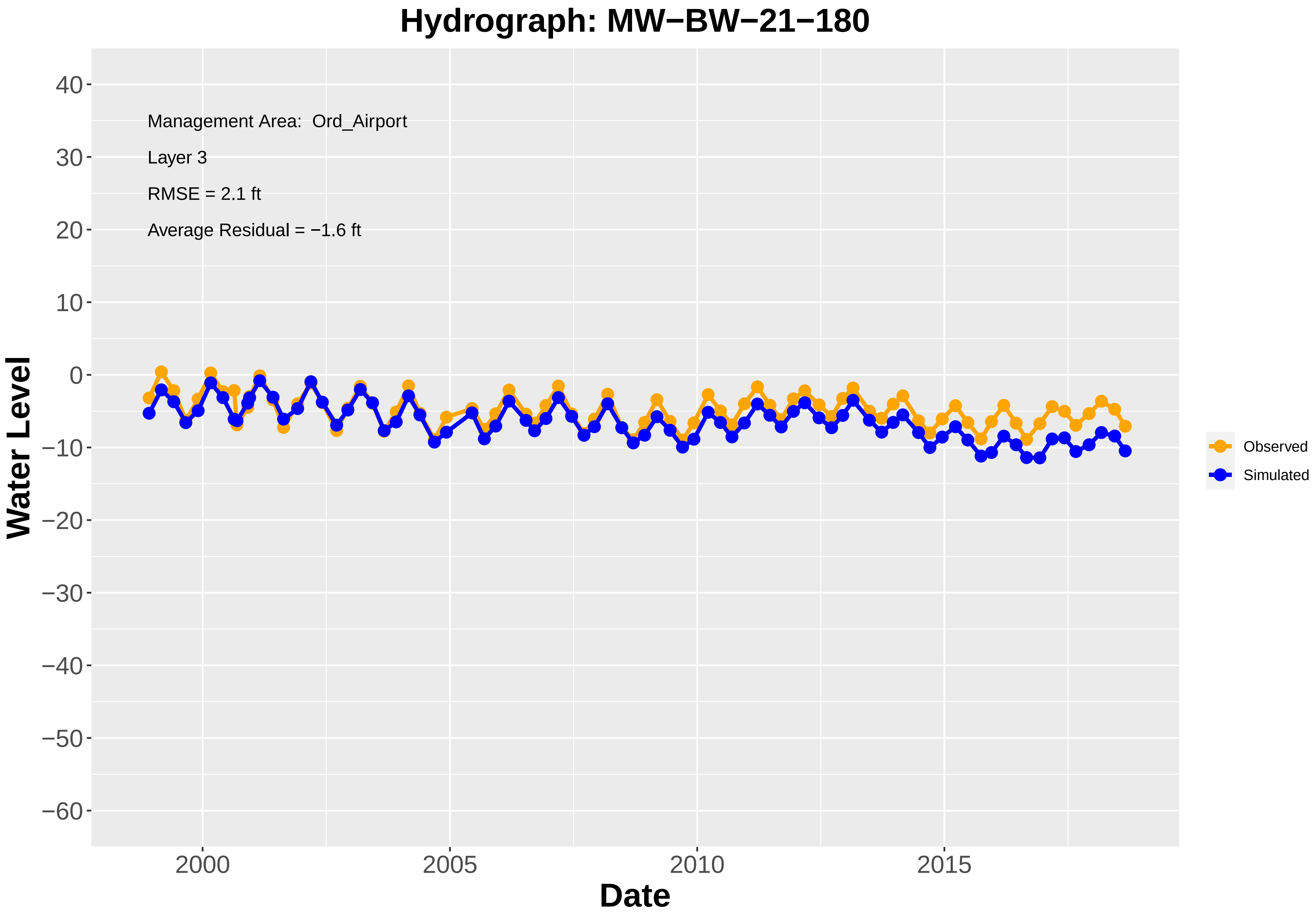
Hydrograph: MW−BW−17−A

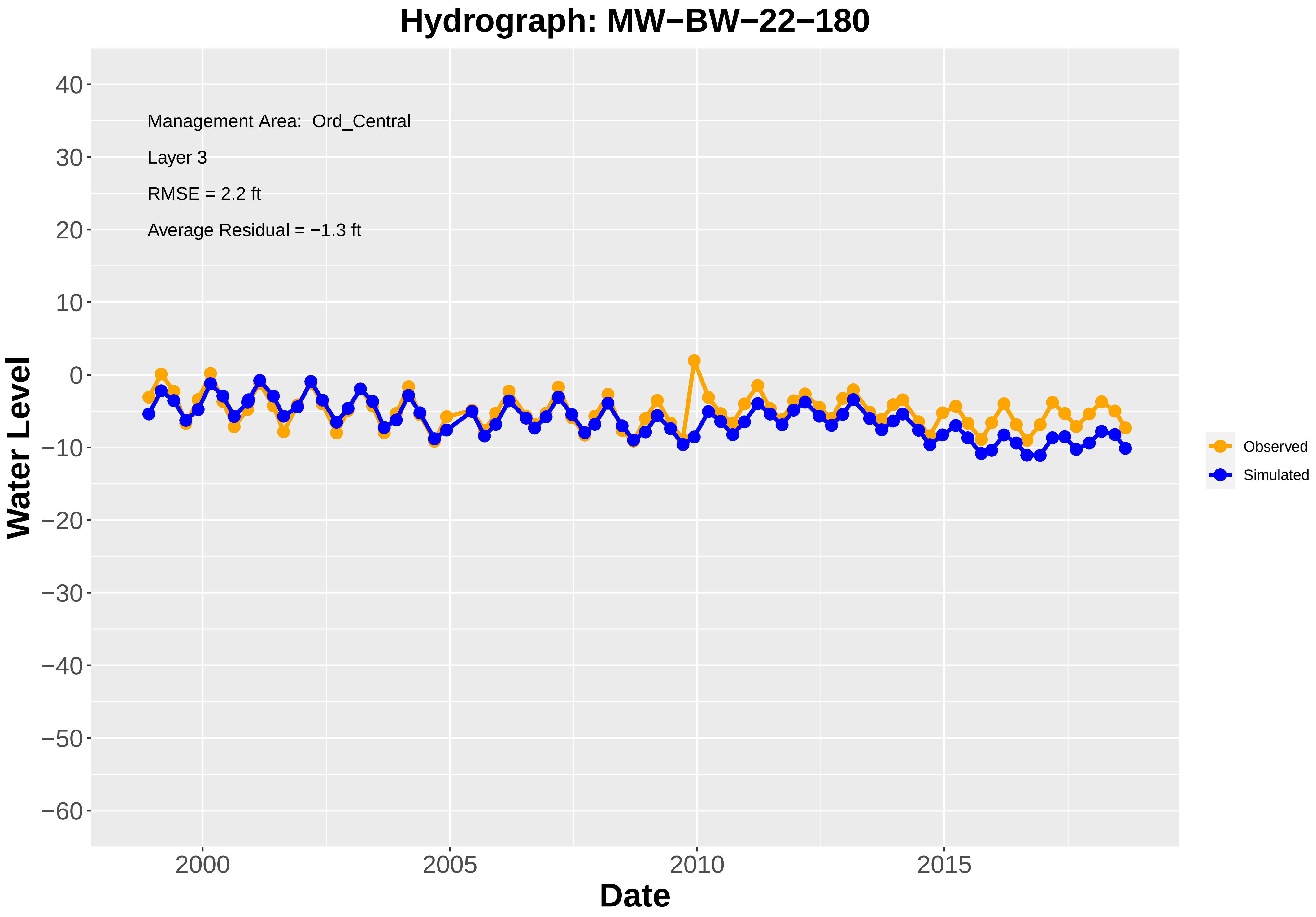


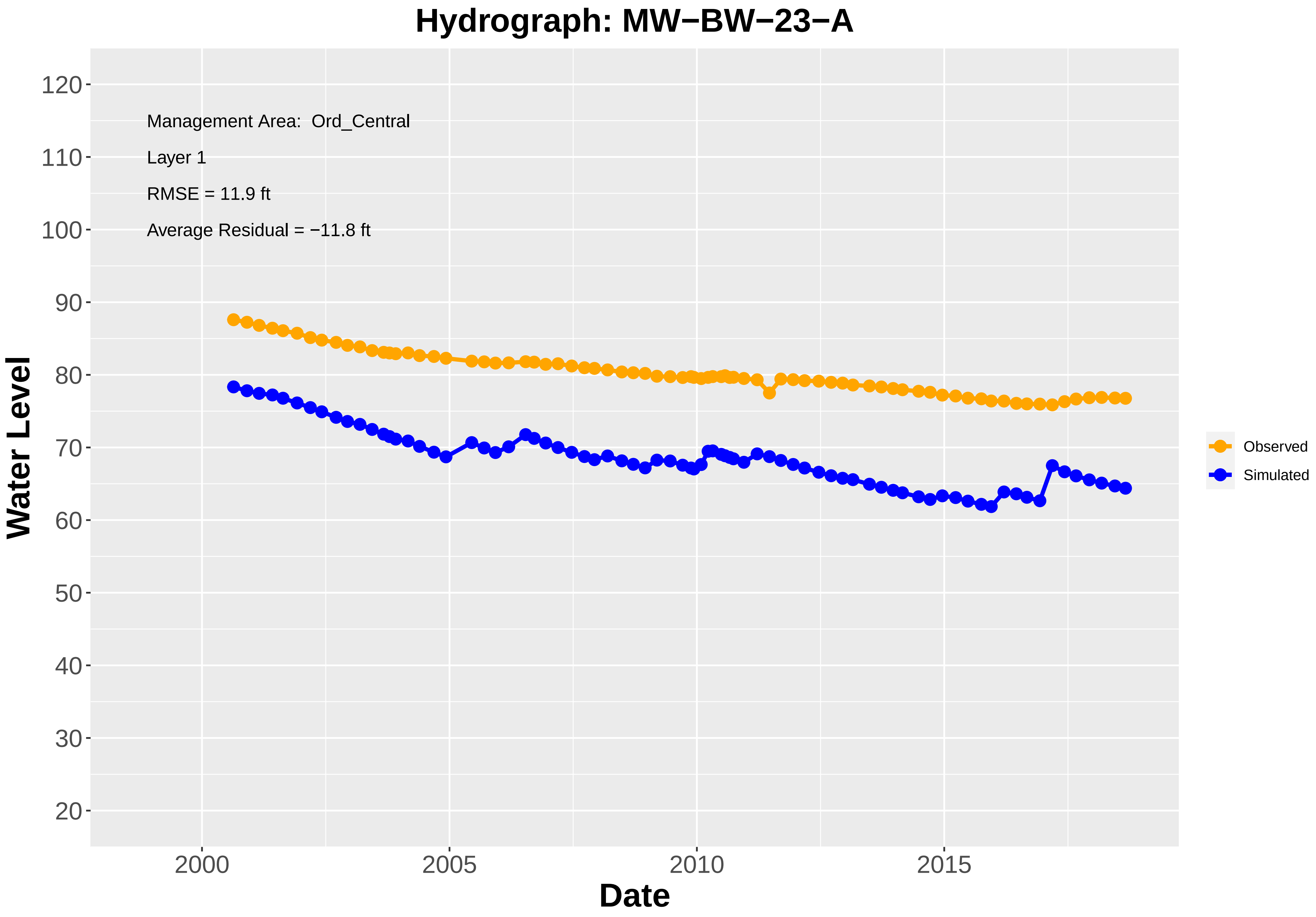

Hydrograph: MW−BW−18−A
Management Area: Ord_Central
Layer 1
RMSE = 8.6 ft
Average Residual = −8.4 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

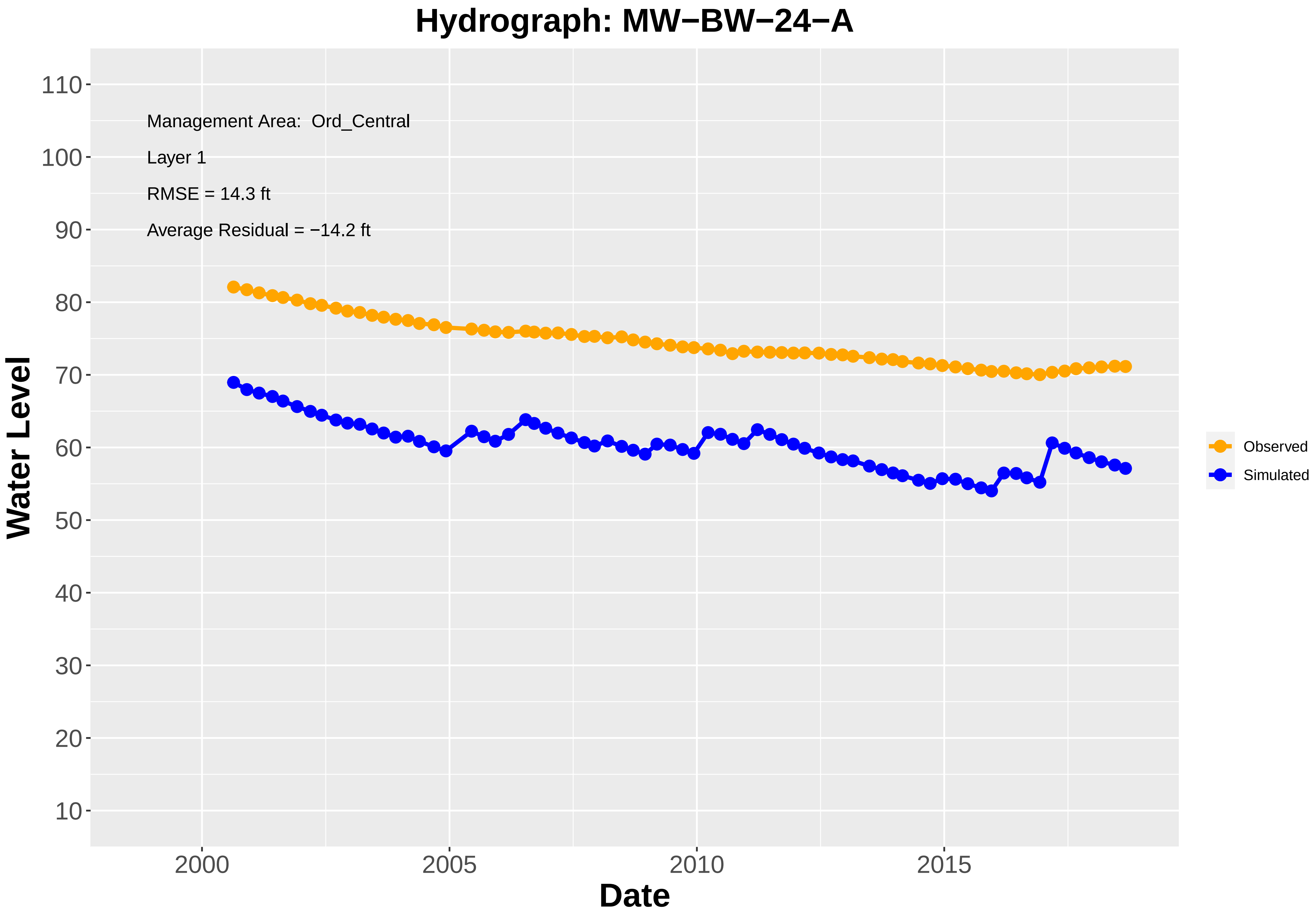

Hydrograph: MW−BW−19−180
Management Area: Ord_Central
Layer 3
RMSE = 2.3 ft
Average Residual = 1.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

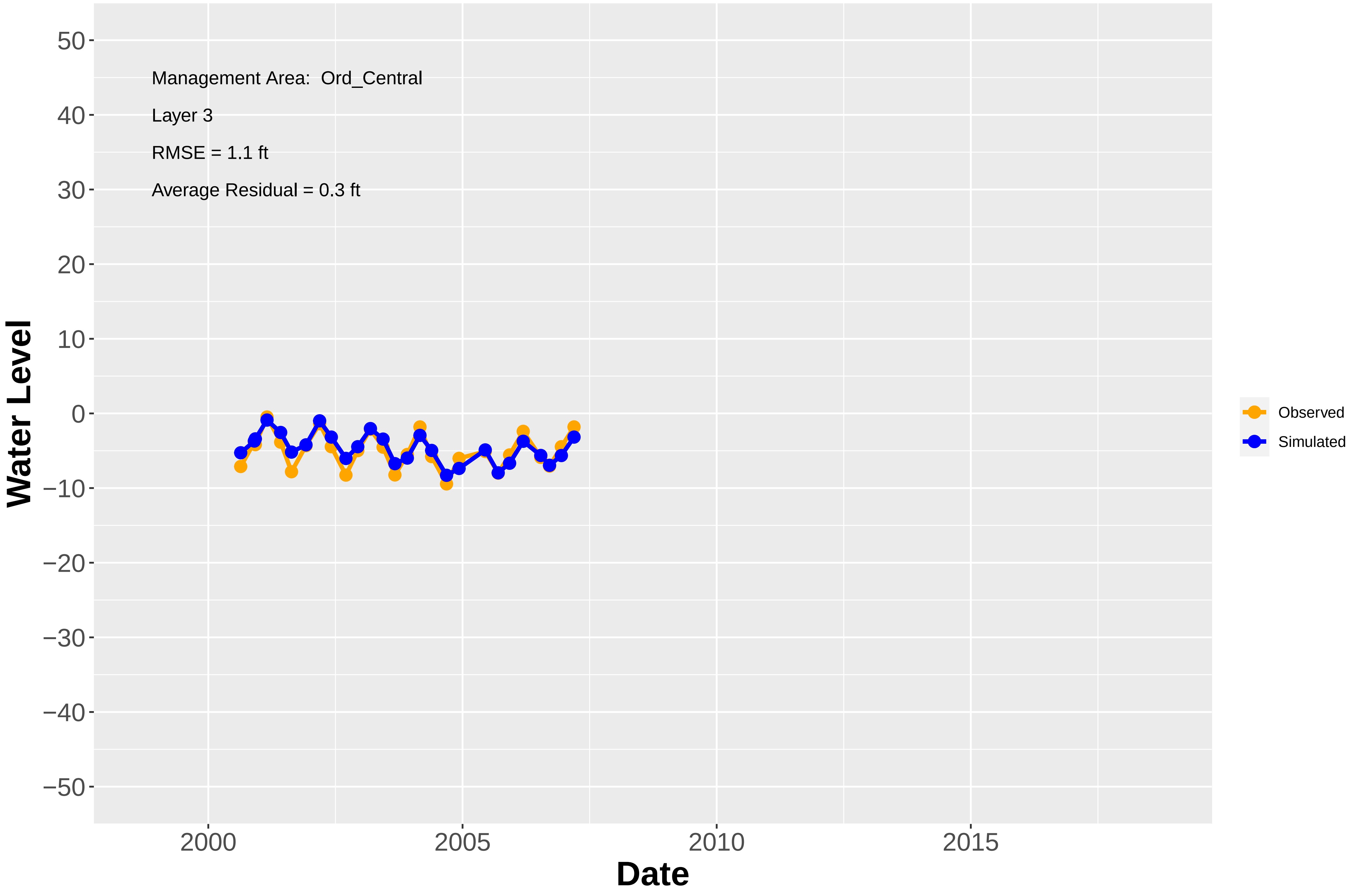

Hydrograph: MW−BW−20−180
Management Area: Ord_Central
Layer 3
RMSE = 1.9 ft
Average Residual = −0.94 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−21−180
Management Area: Ord_Airport
Layer 3
RMSE = 2.1 ft
Average Residual = −1.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

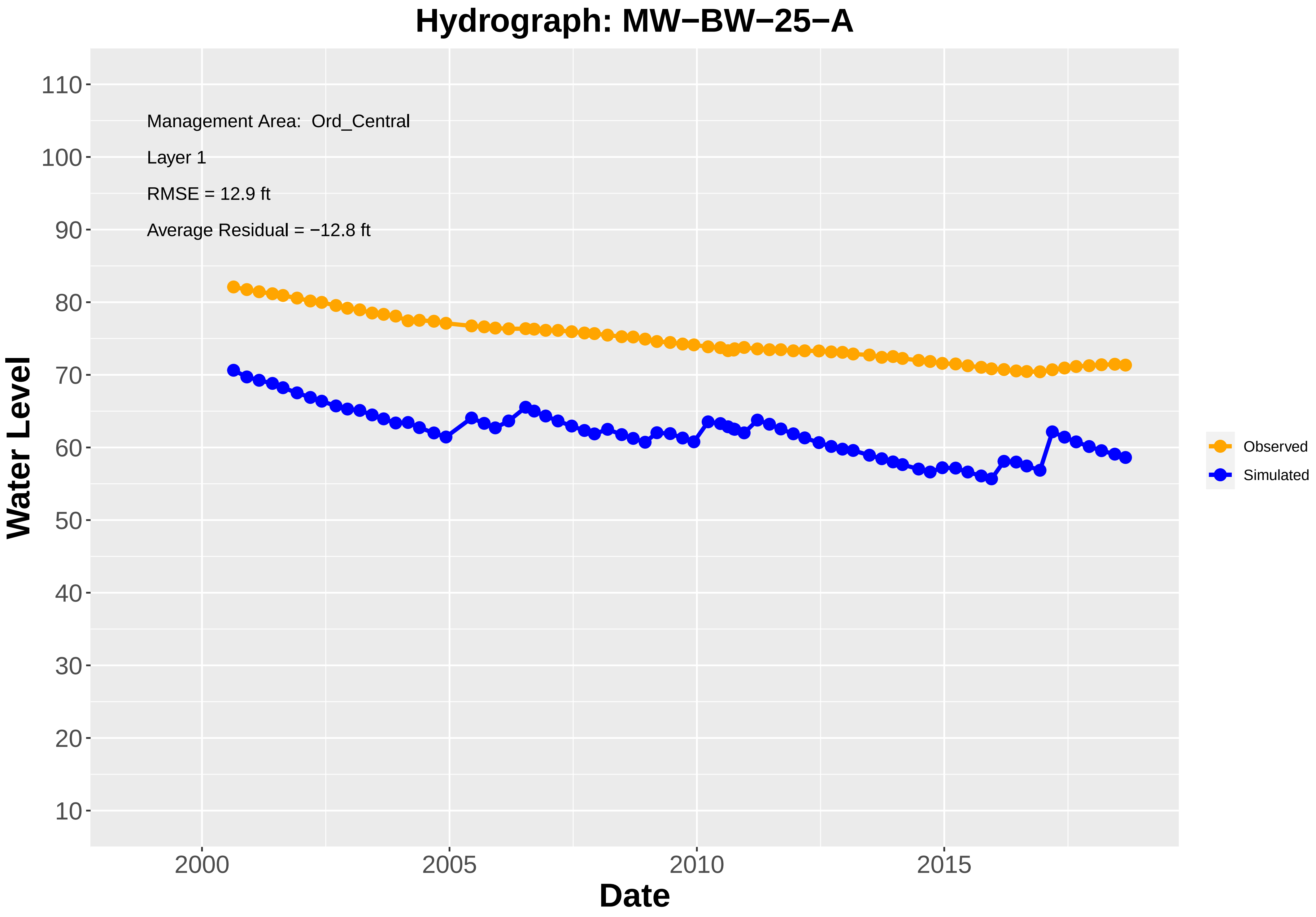

Hydrograph: MW−BW−22−180
Management Area: Ord_Central
Layer 3
RMSE = 2.2 ft
Average Residual = −1.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−23−A
Management Area: Ord_Central
Layer 1
RMSE = 11.9 ft
Average Residual = −11.8 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated

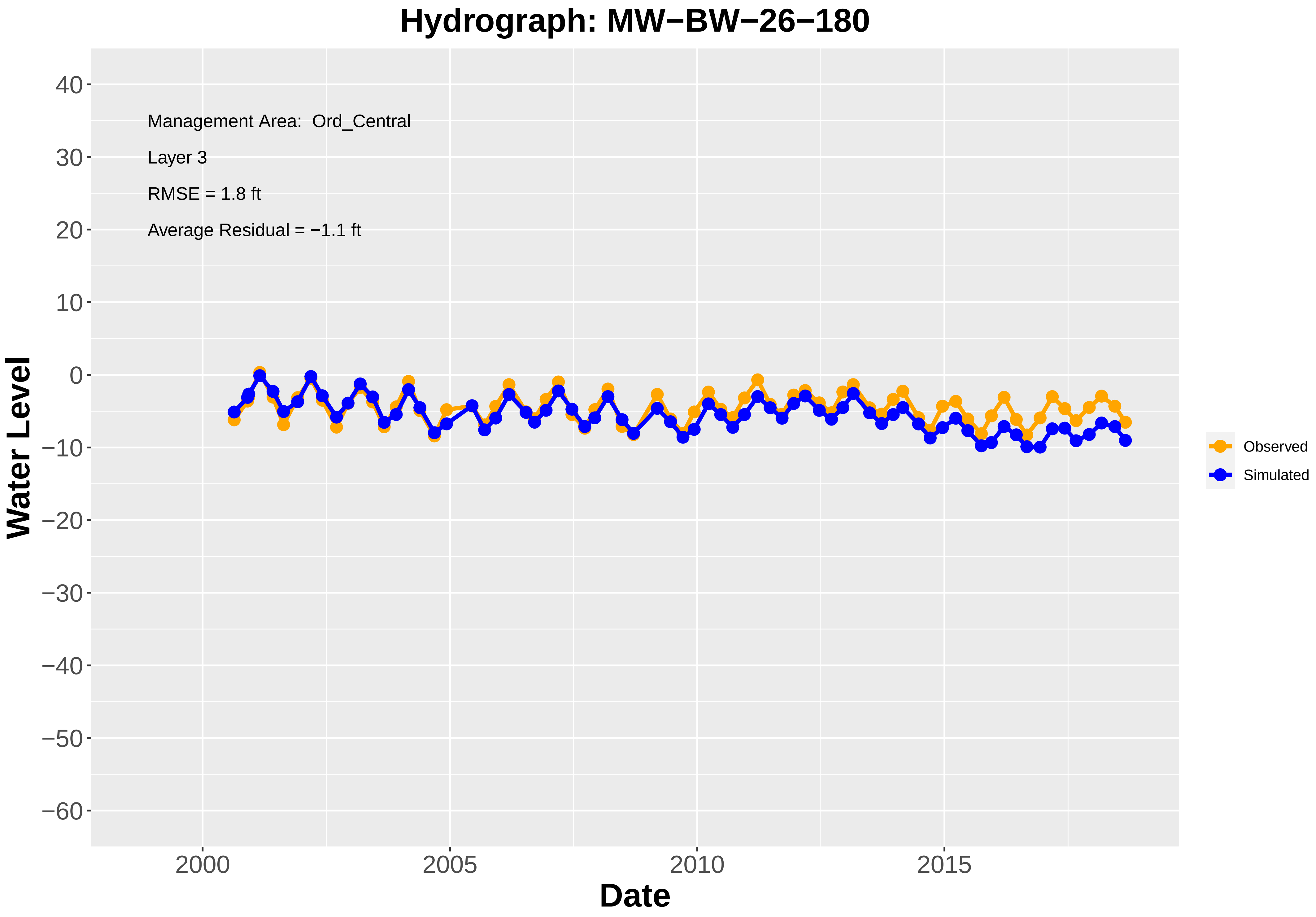

Hydrograph: MW−BW−24−A
Management Area: Ord_Central
Layer 1
RMSE = 14.3 ft
Average Residual = −14.2 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

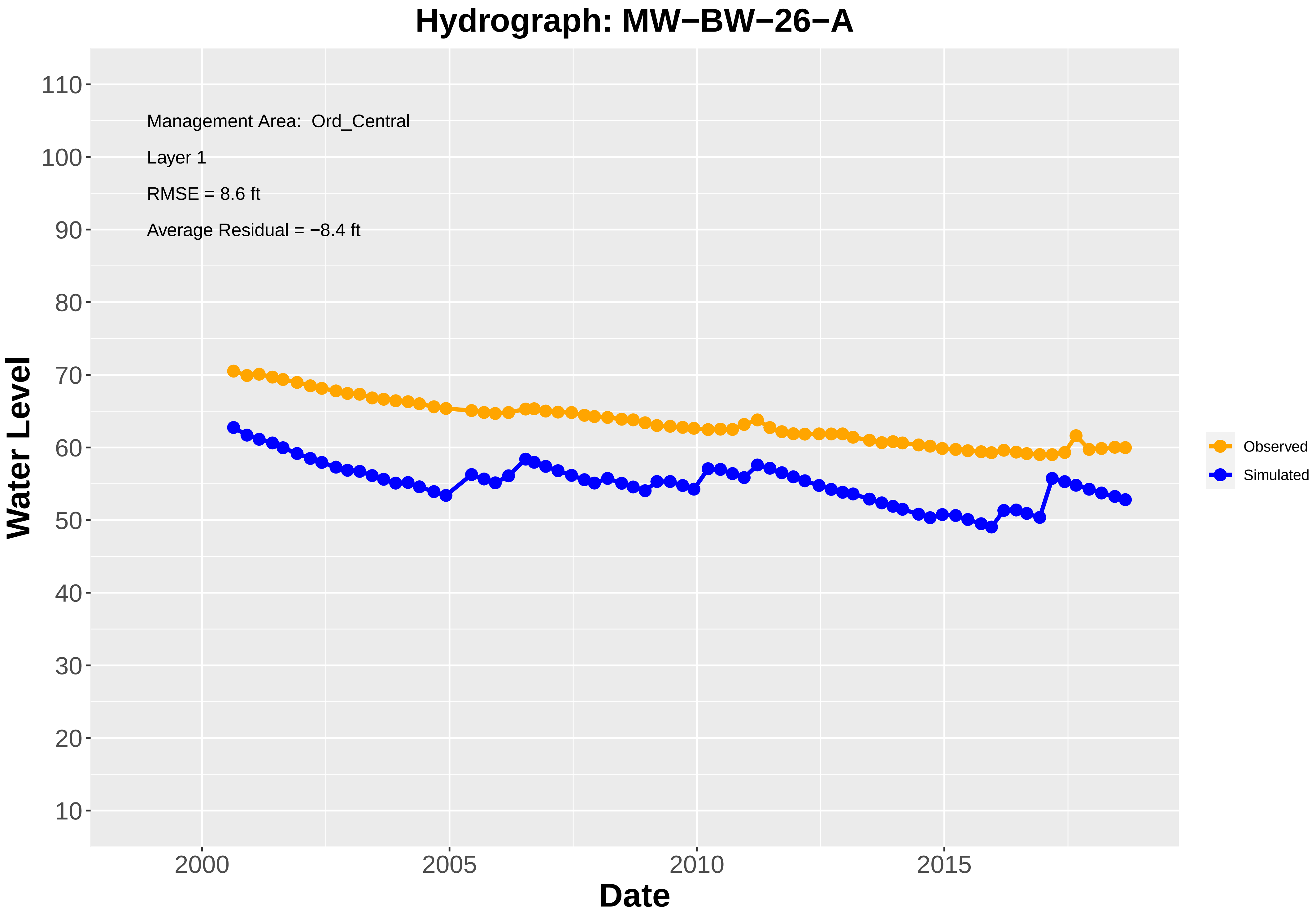


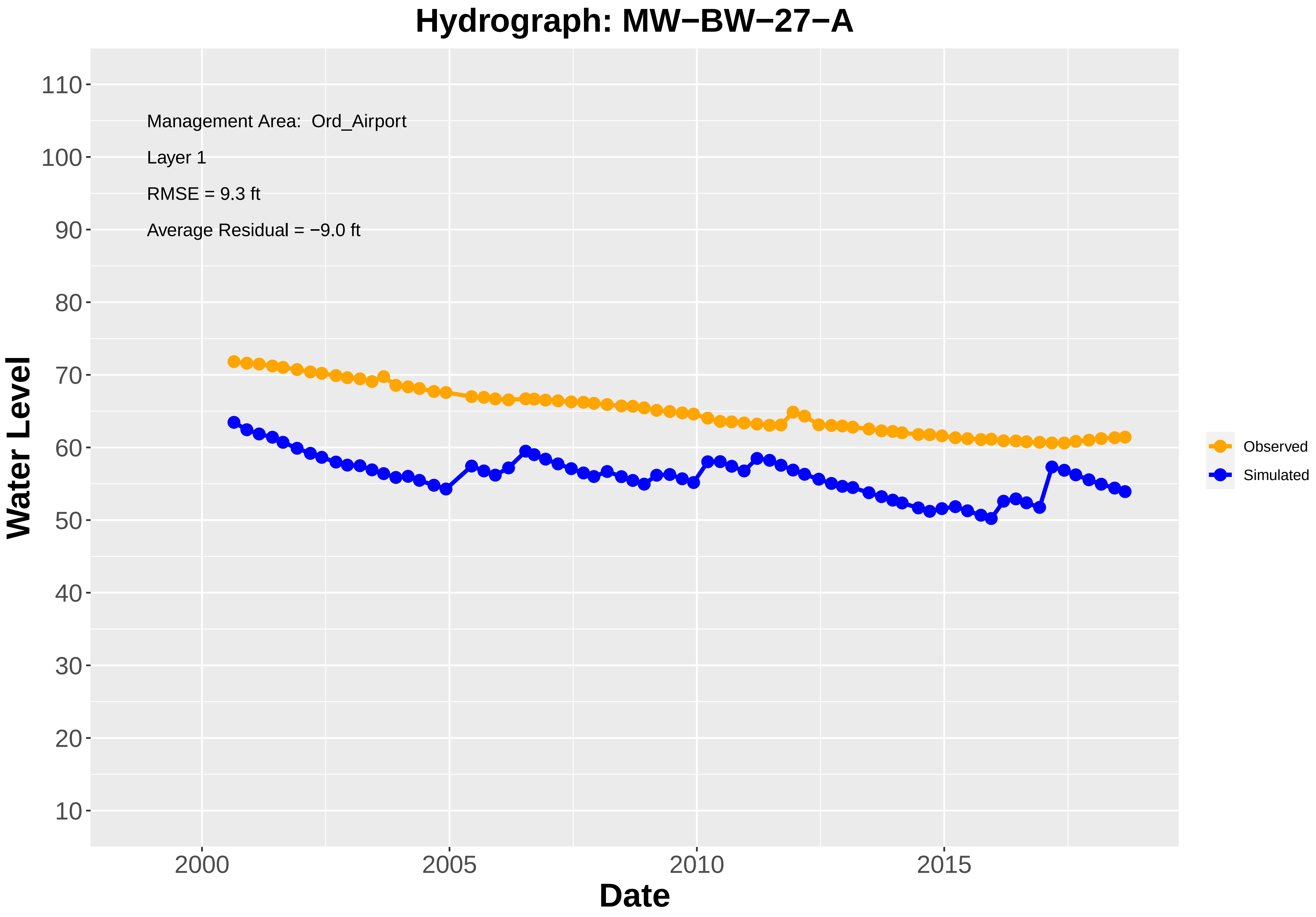
Hydrograph: MW−BW−25−180

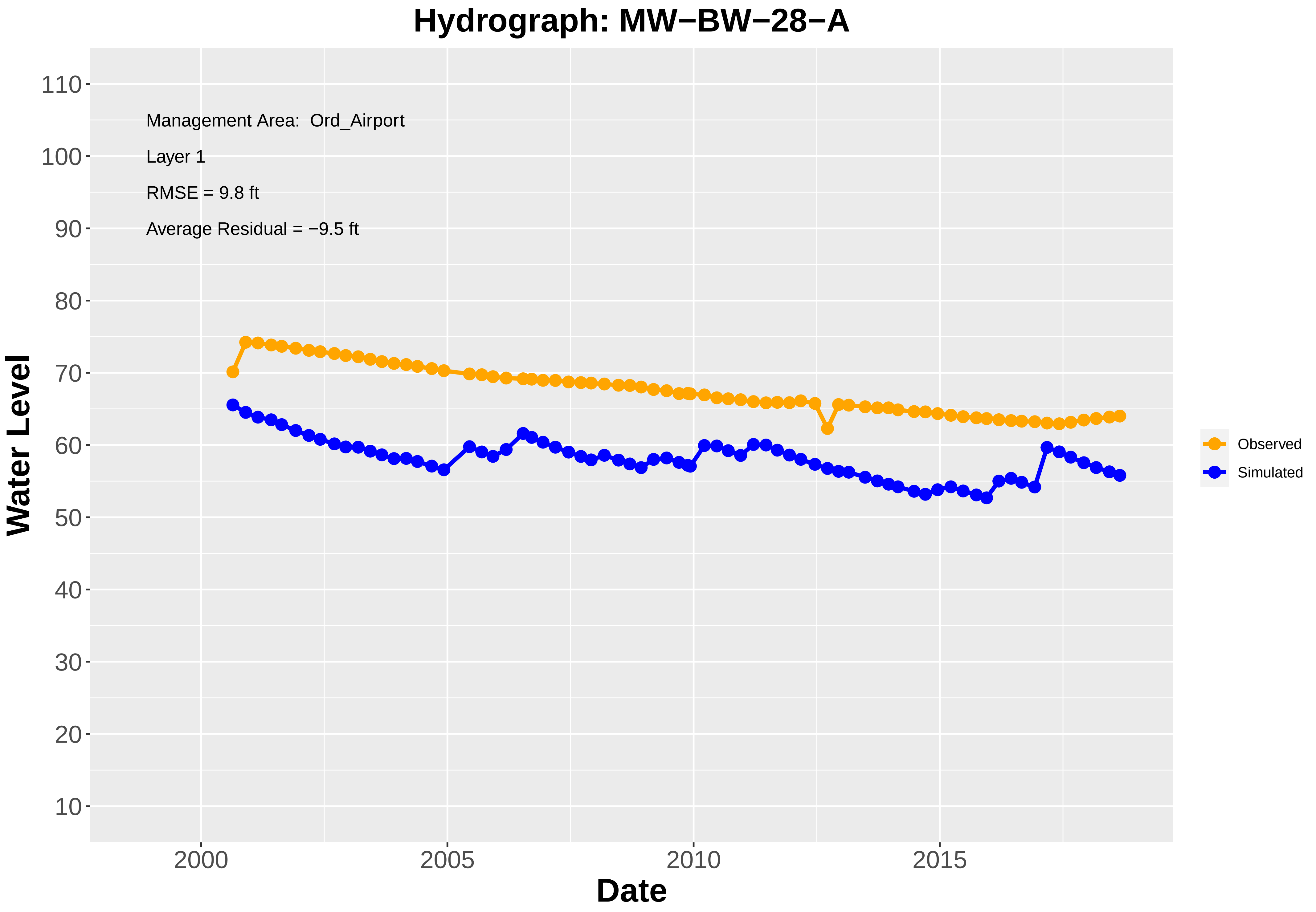


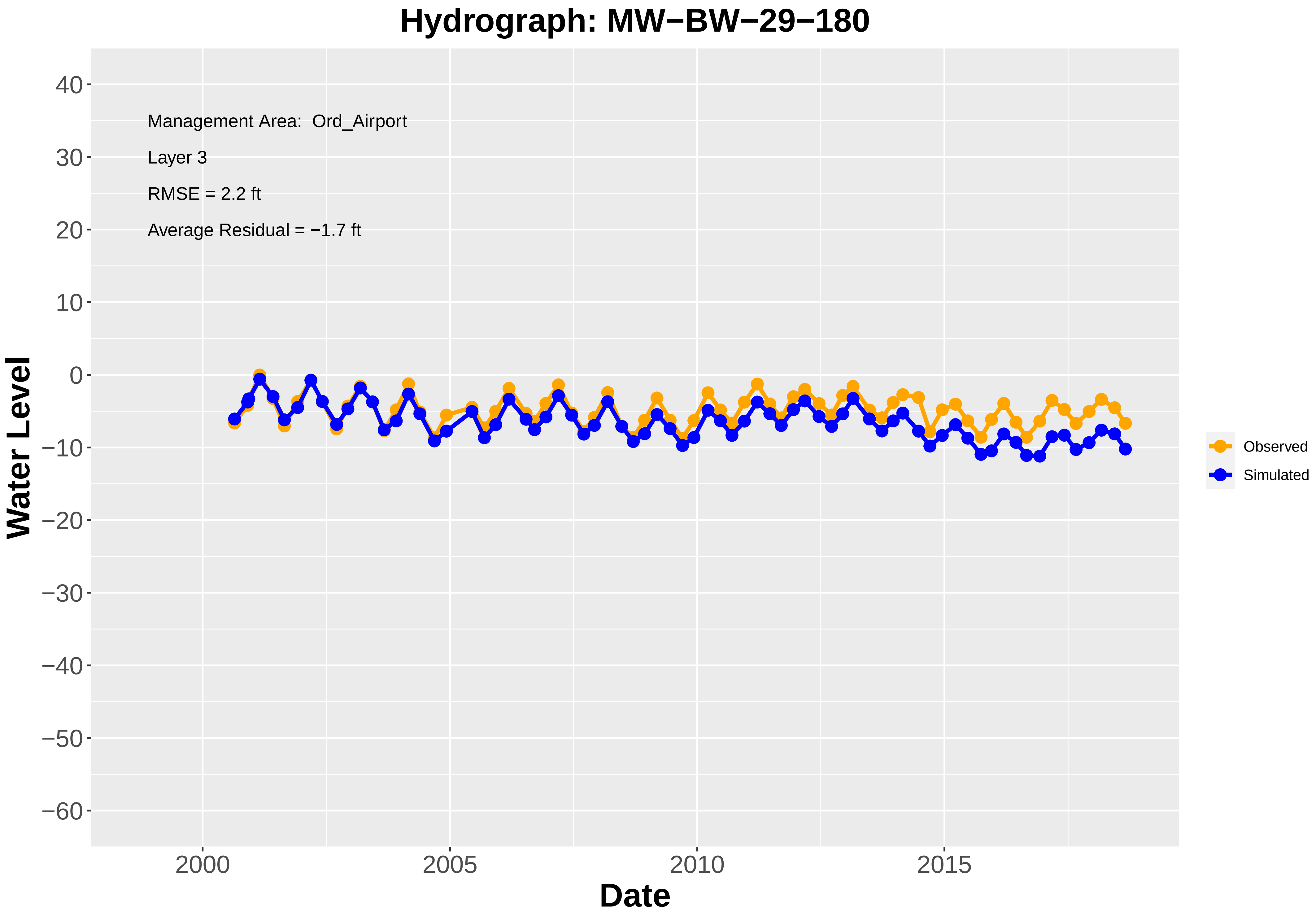
Hydrograph: MW−BW−25−A
Management Area: Ord_Central
Layer 1
RMSE = 12.9 ft
Average Residual = −12.8 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

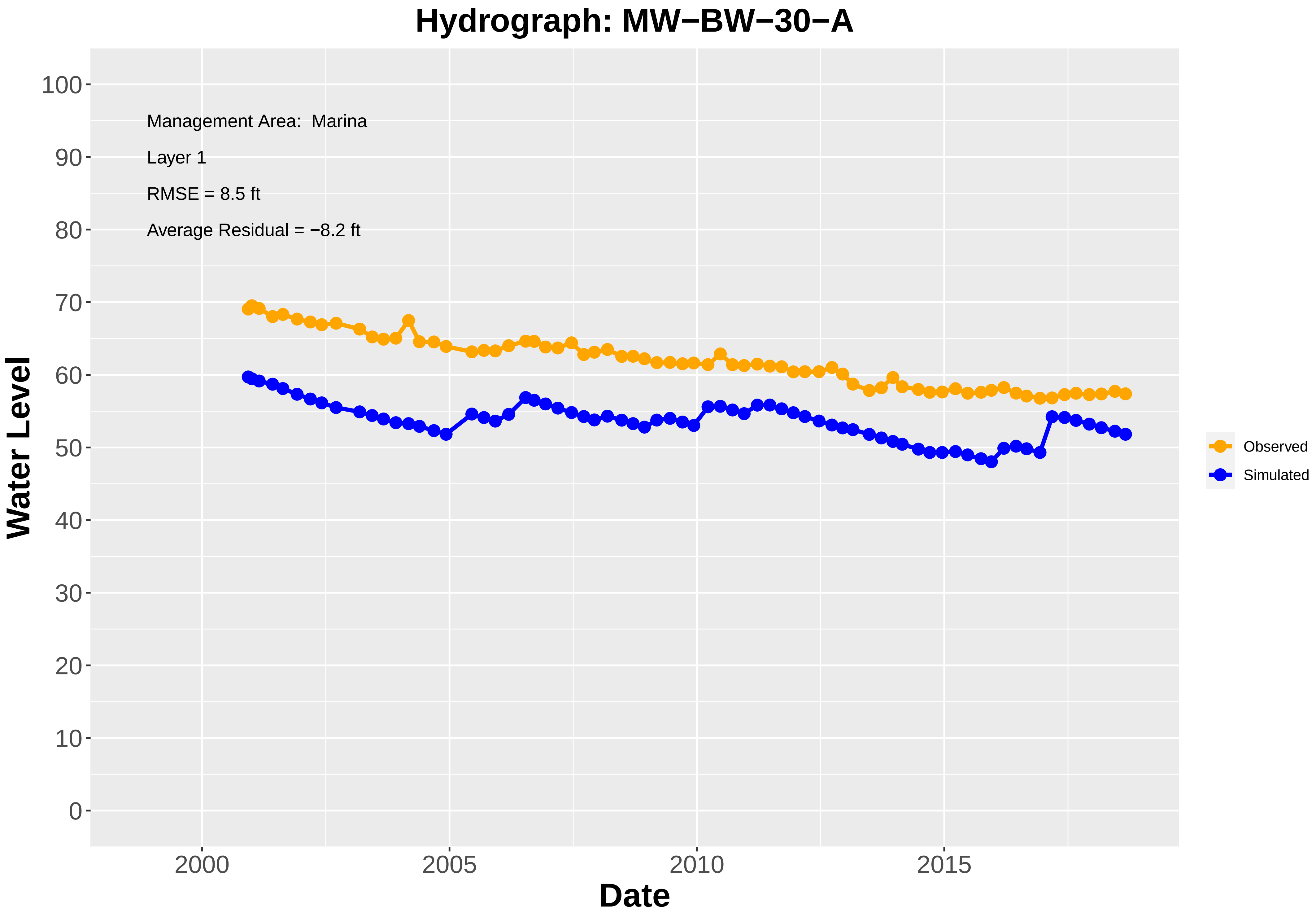

Hydrograph: MW−BW−26−180
Management Area: Ord_Central
Layer 3
RMSE = 1.8 ft
Average Residual = −1.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

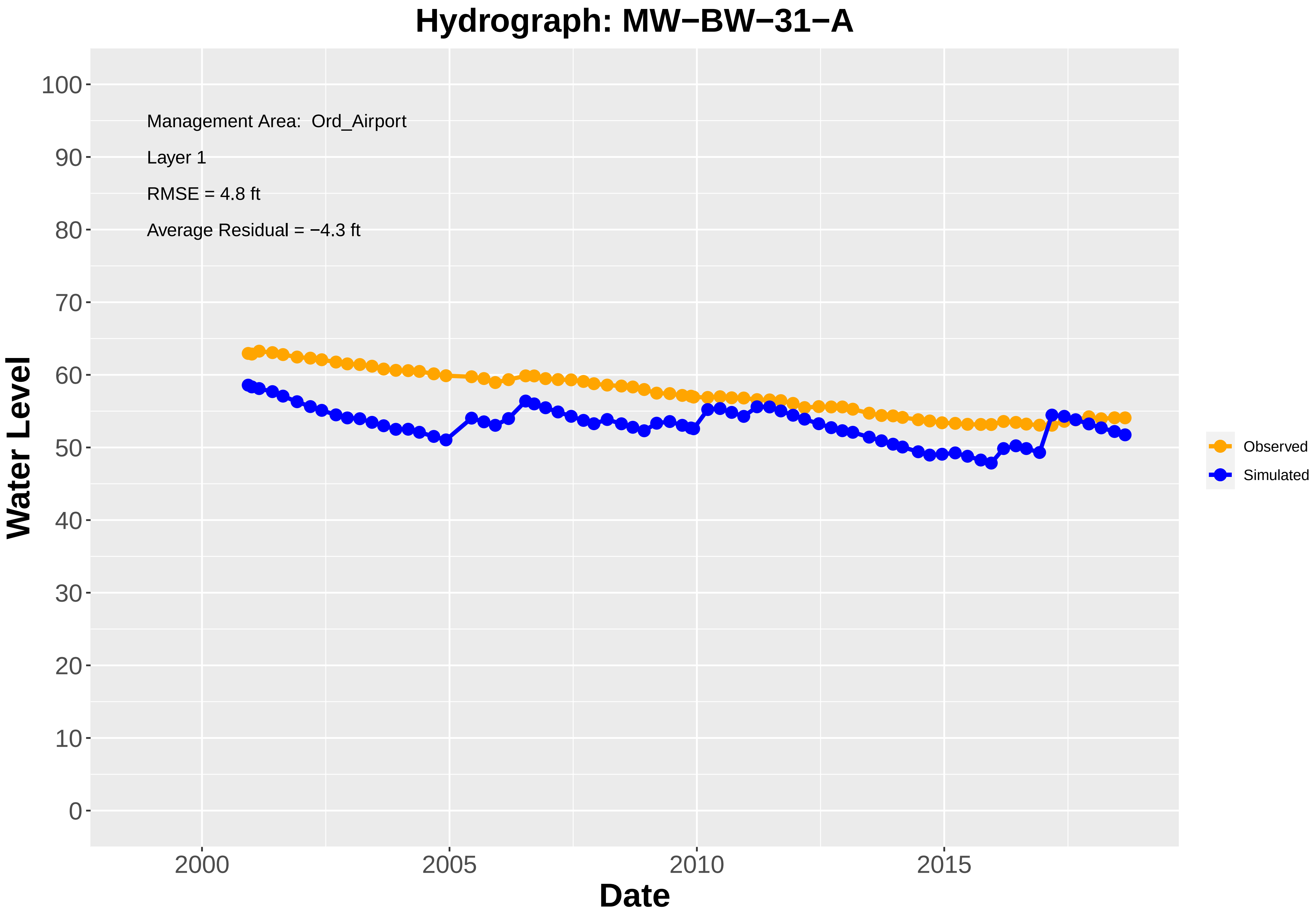

Hydrograph: MW−BW−26−A
Management Area: Ord_Central
Layer 1
RMSE = 8.6 ft
Average Residual = −8.4 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

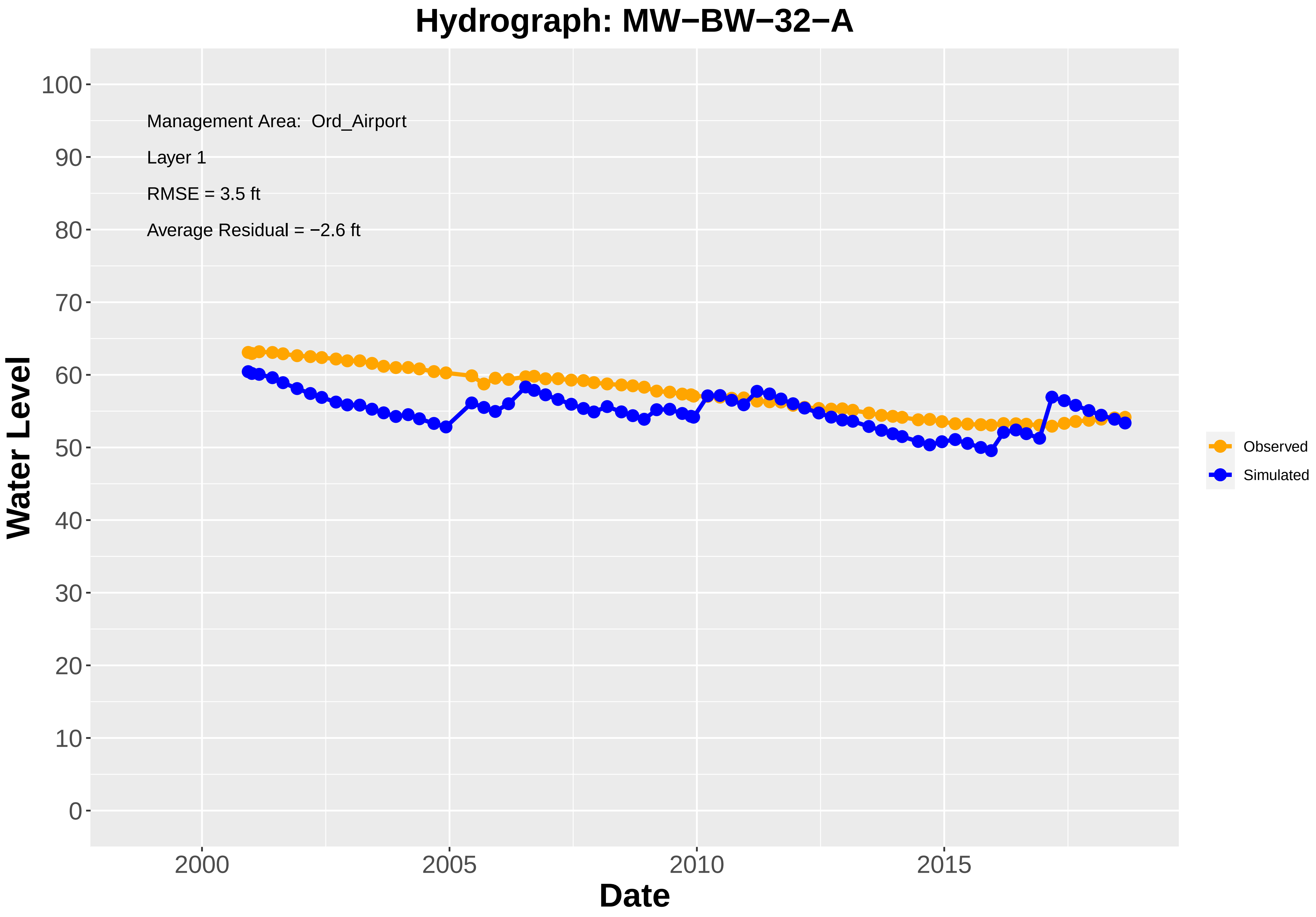

Hydrograph: MW−BW−27−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.3 ft
Average Residual = −9.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

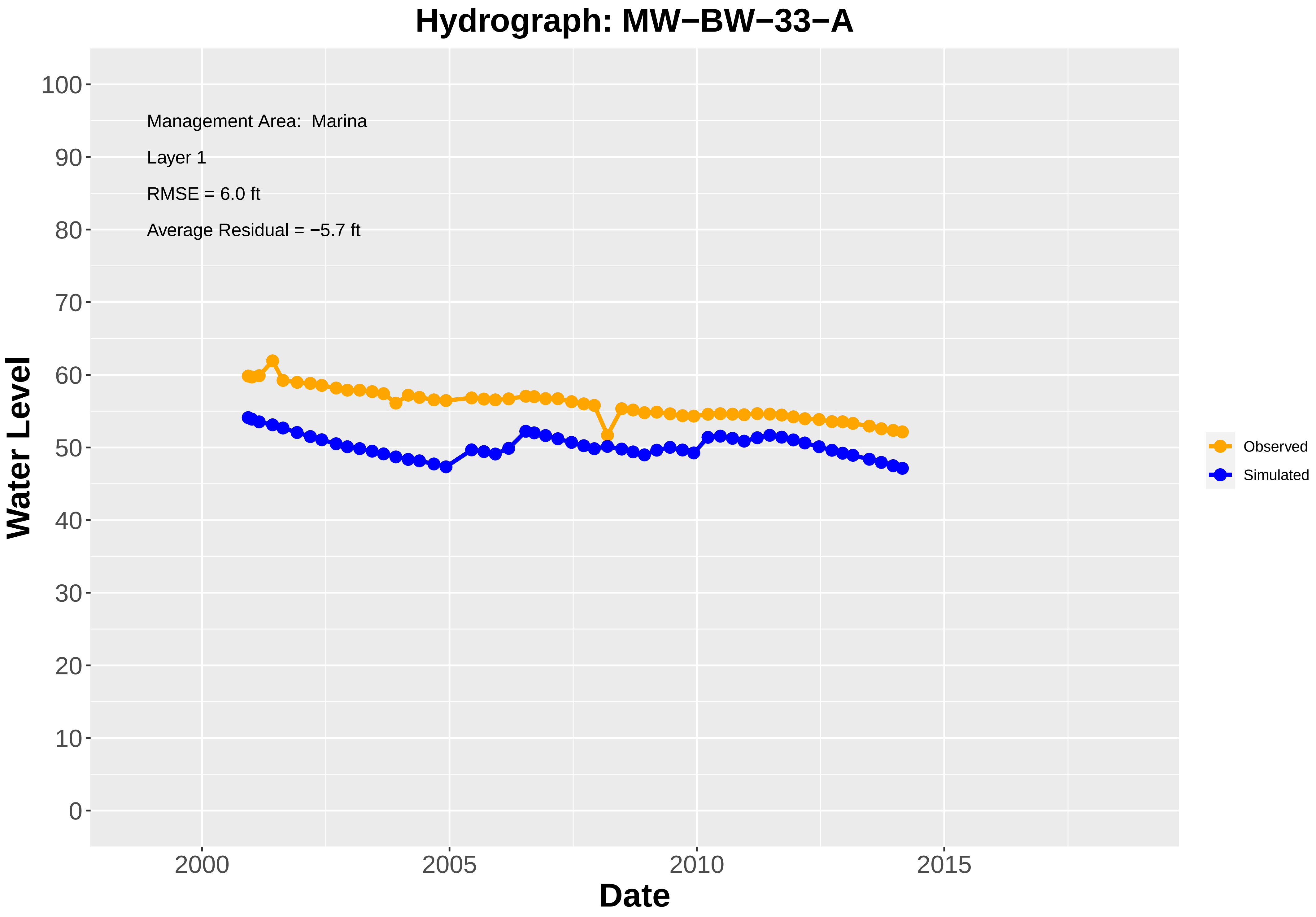

Hydrograph: MW−BW−28−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.8 ft
Average Residual = −9.5 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

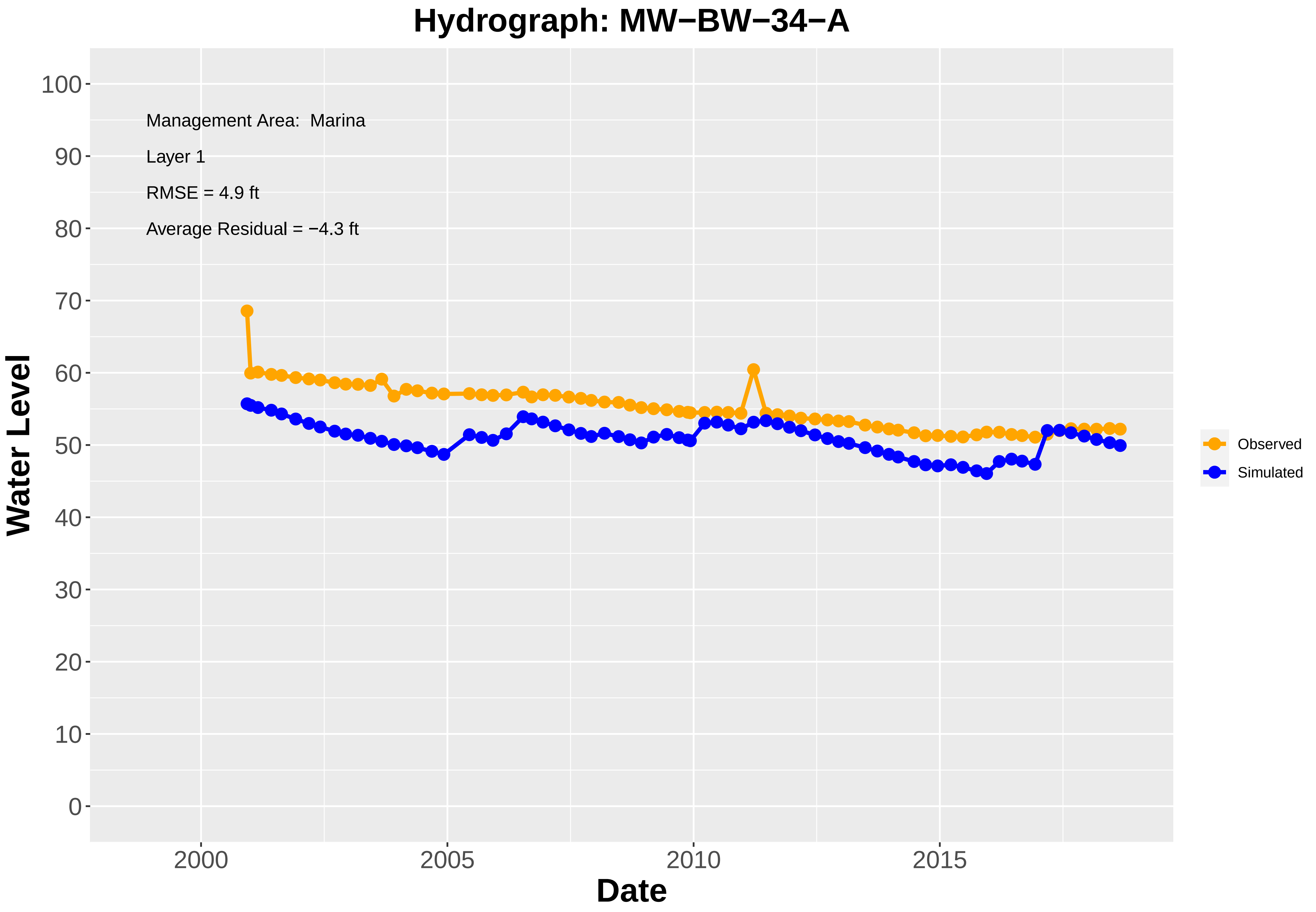

Hydrograph: MW−BW−29−180
Management Area: Ord_Airport
Layer 3
RMSE = 2.2 ft
Average Residual = −1.7 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

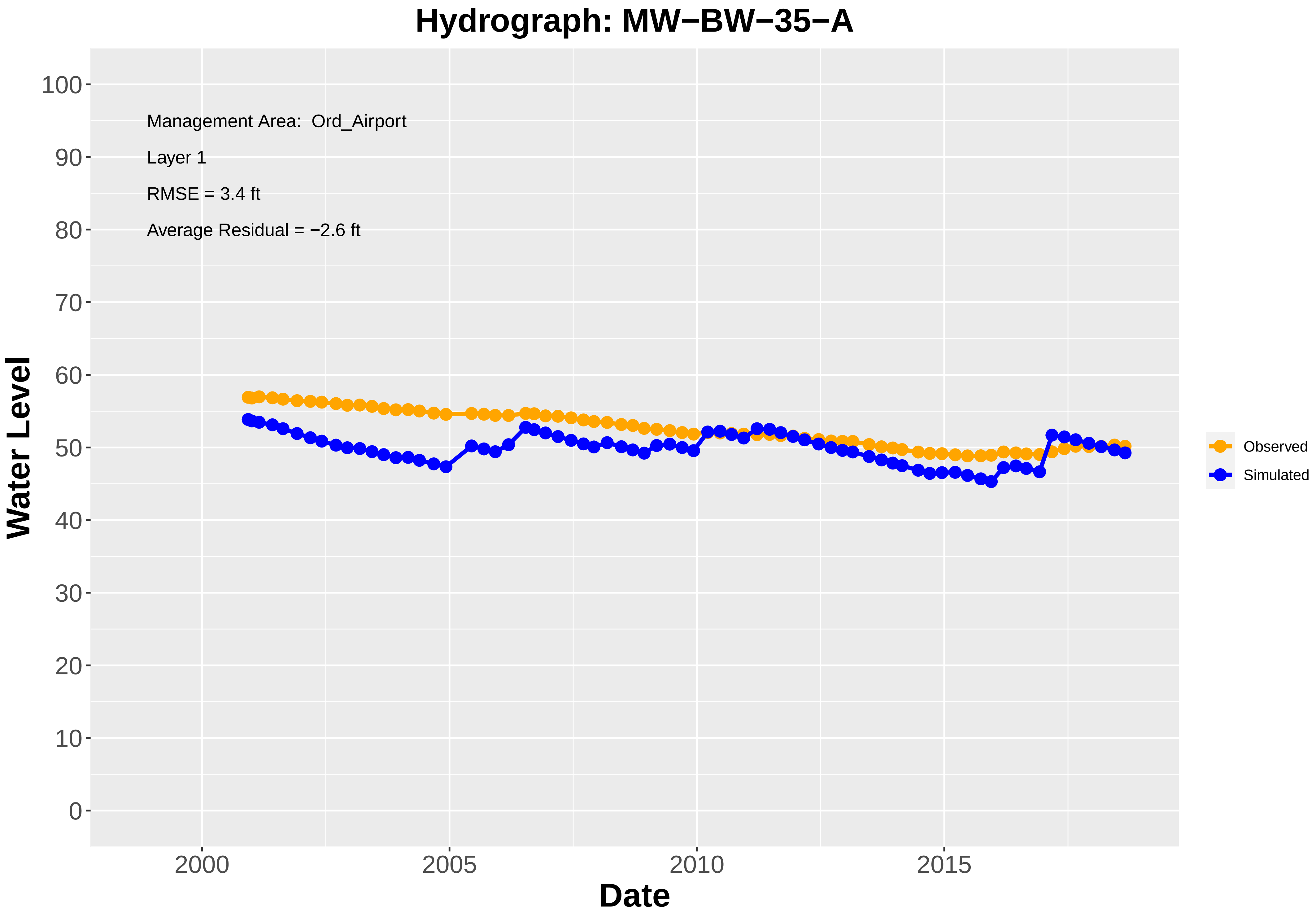

Hydrograph: MW−BW−30−A
Management Area: Marina
Layer 1
RMSE = 8.5 ft
Average Residual = −8.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−31−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.8 ft
Average Residual = −4.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

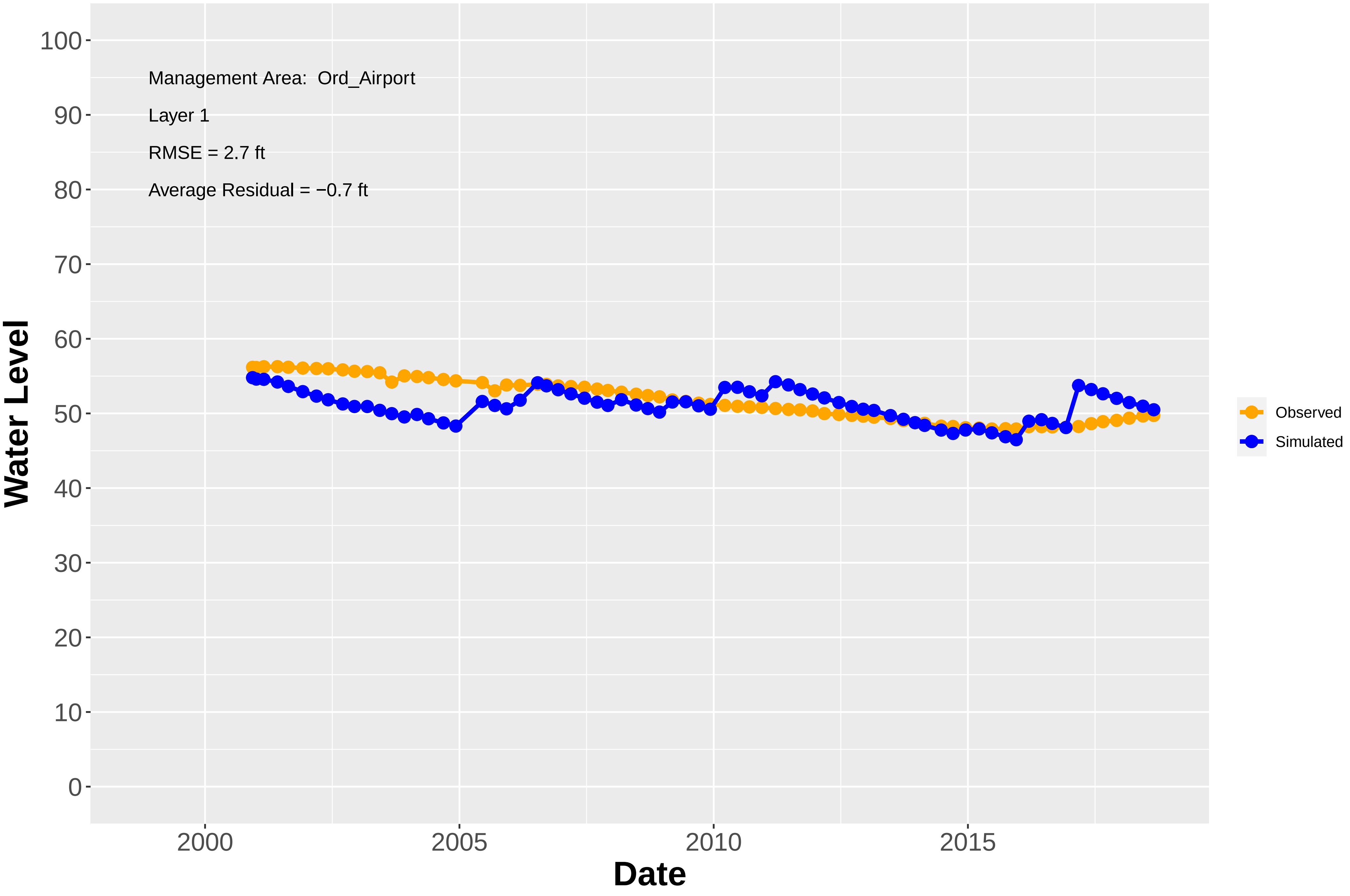

Hydrograph: MW−BW−32−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.5 ft
Average Residual = −2.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

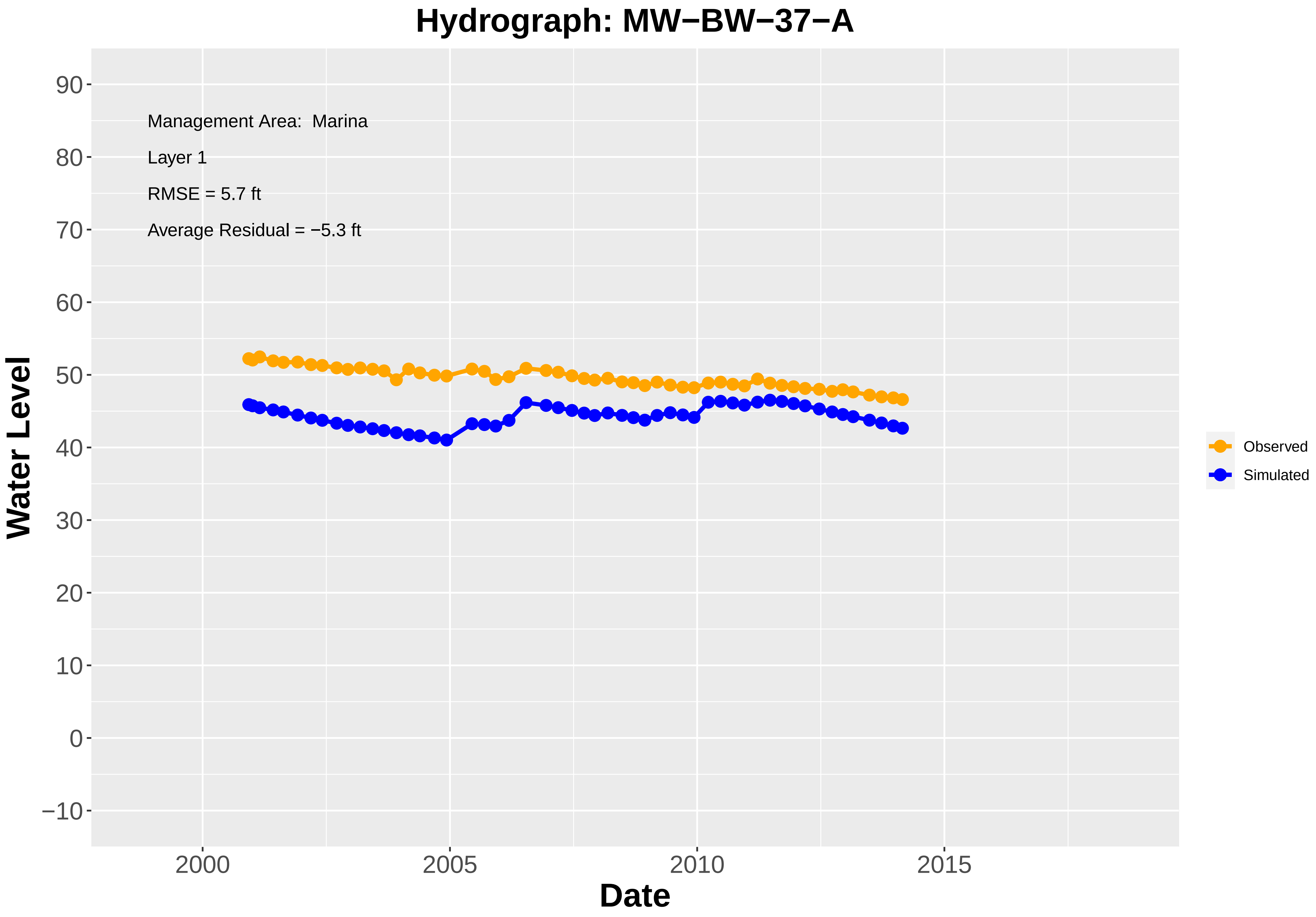

Hydrograph: MW−BW−33−A
Management Area: Marina
Layer 1
RMSE = 6.0 ft
Average Residual = −5.7 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

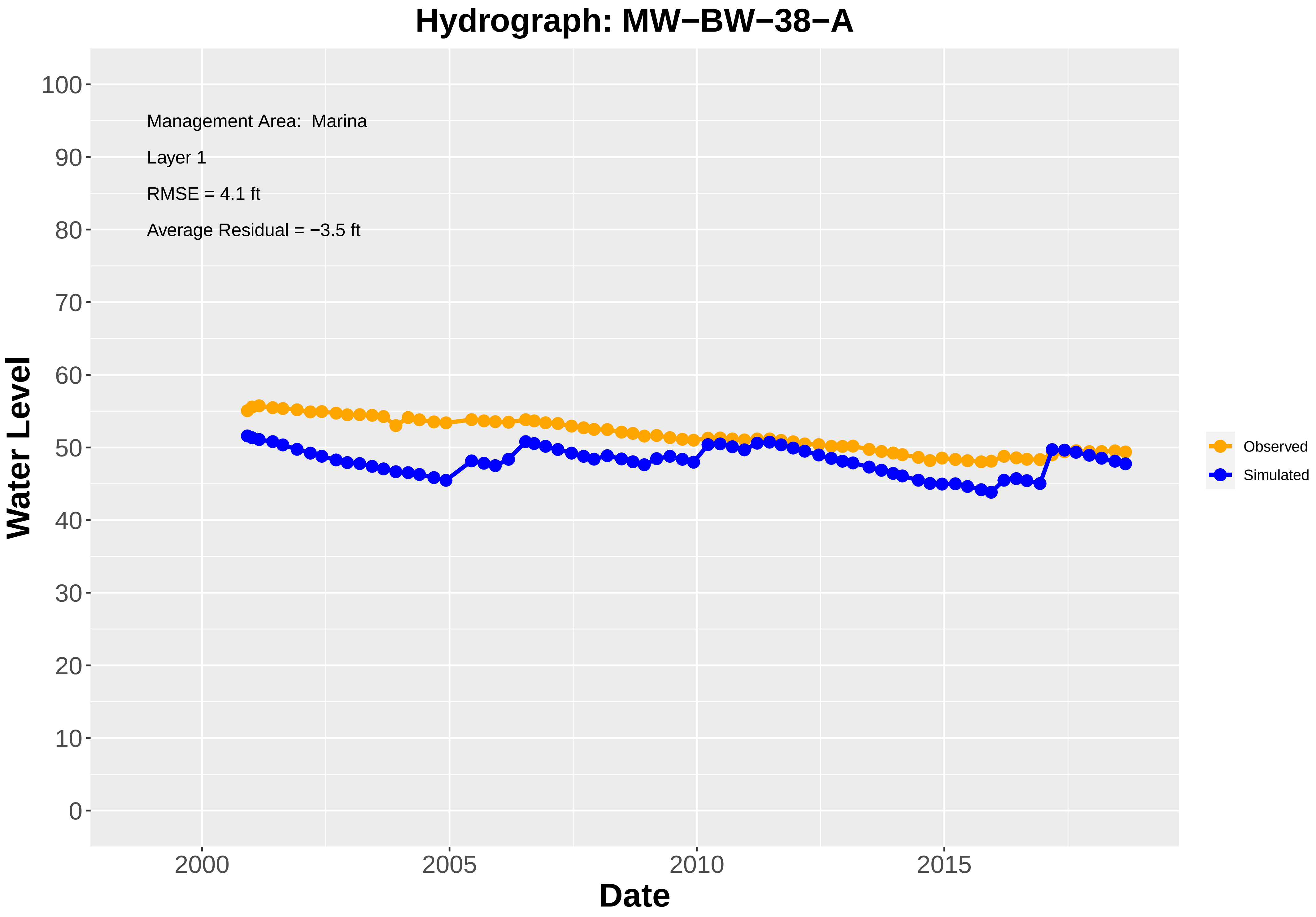
Hydrograph: MW−BW−34−A
Management Area: Marina
Layer 1
RMSE = 4.9 ft
Average Residual = −4.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−BW−35−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.4 ft
Average Residual = −2.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

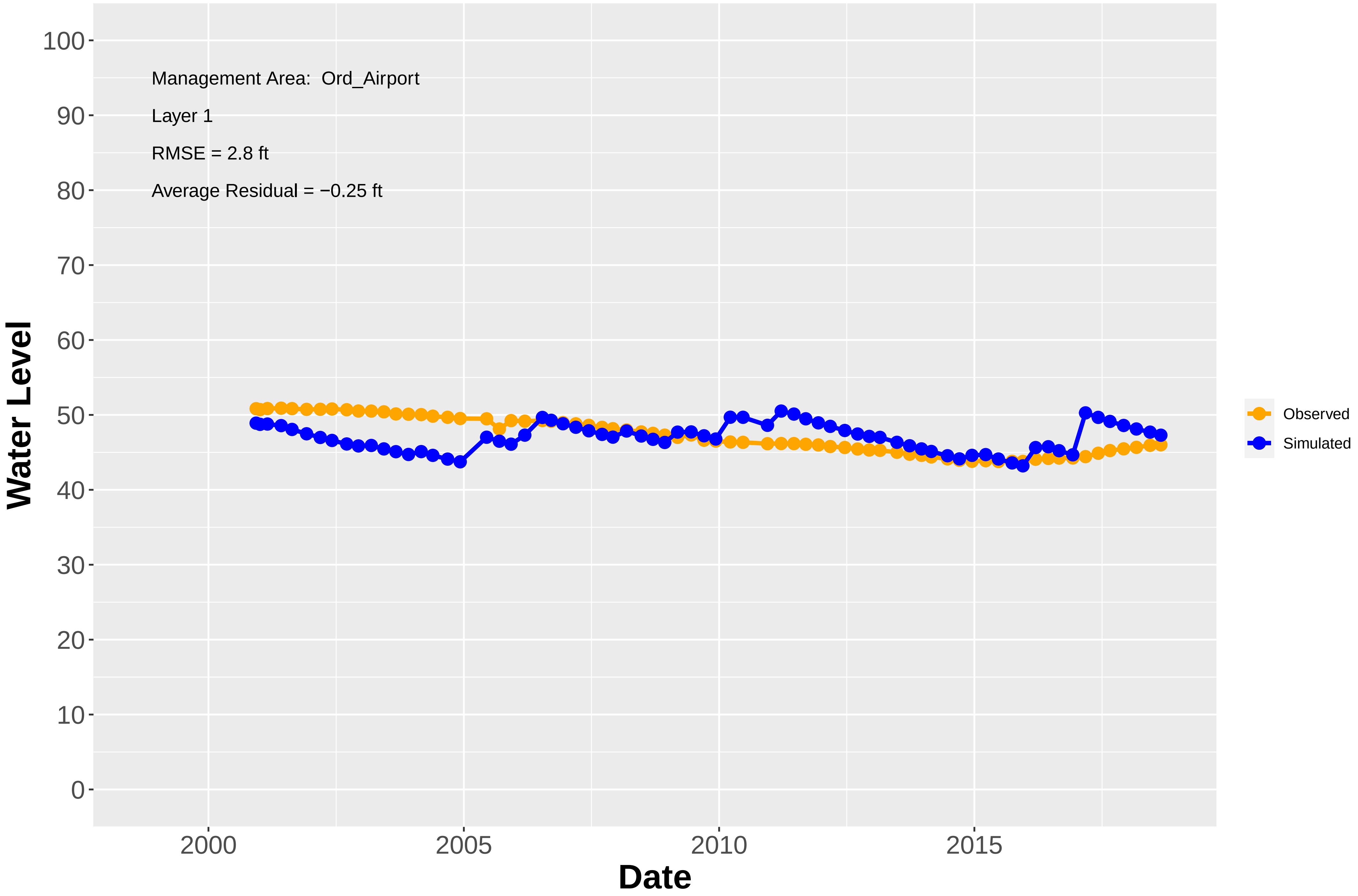
Hydrograph: MW−BW−36−A

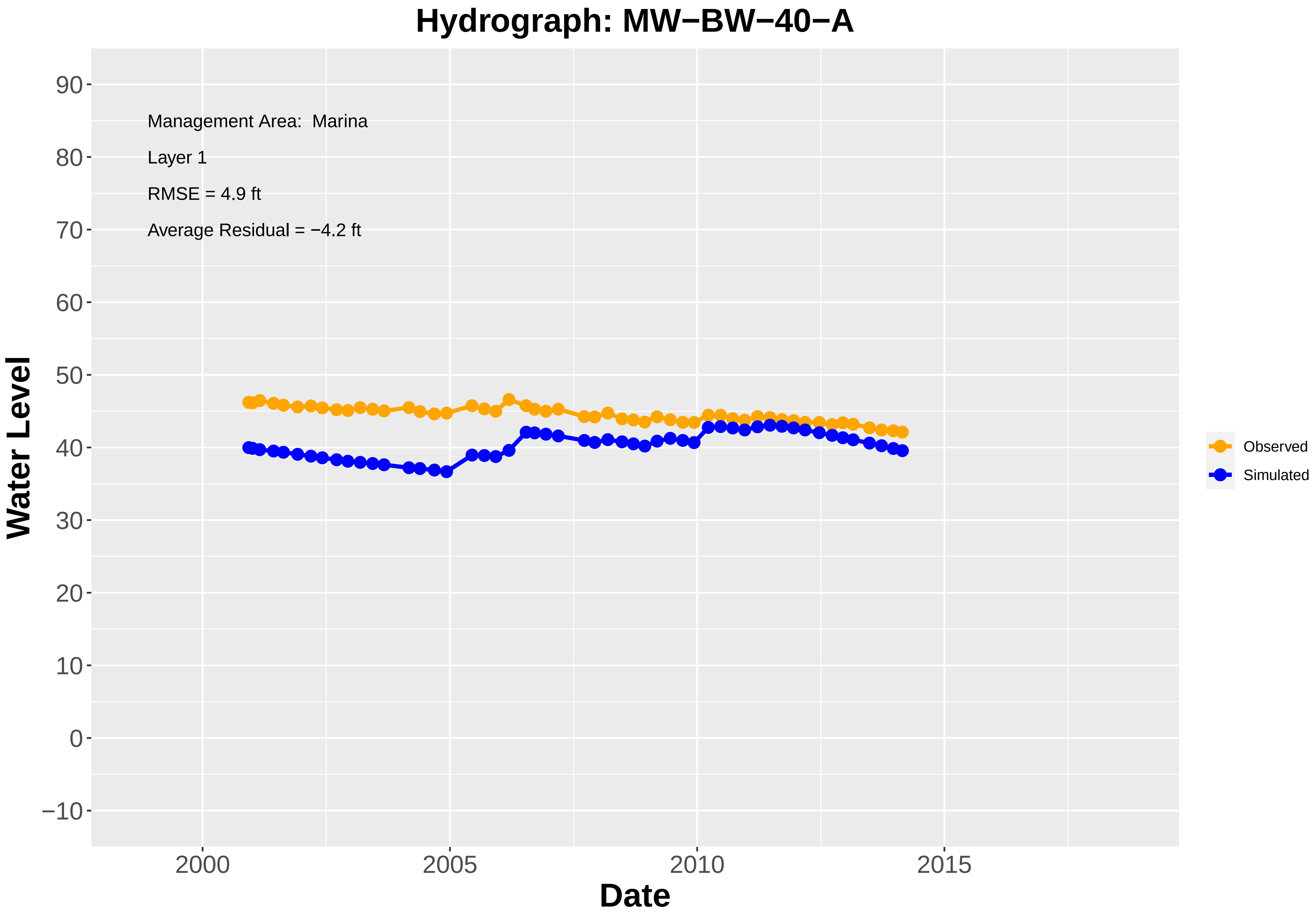


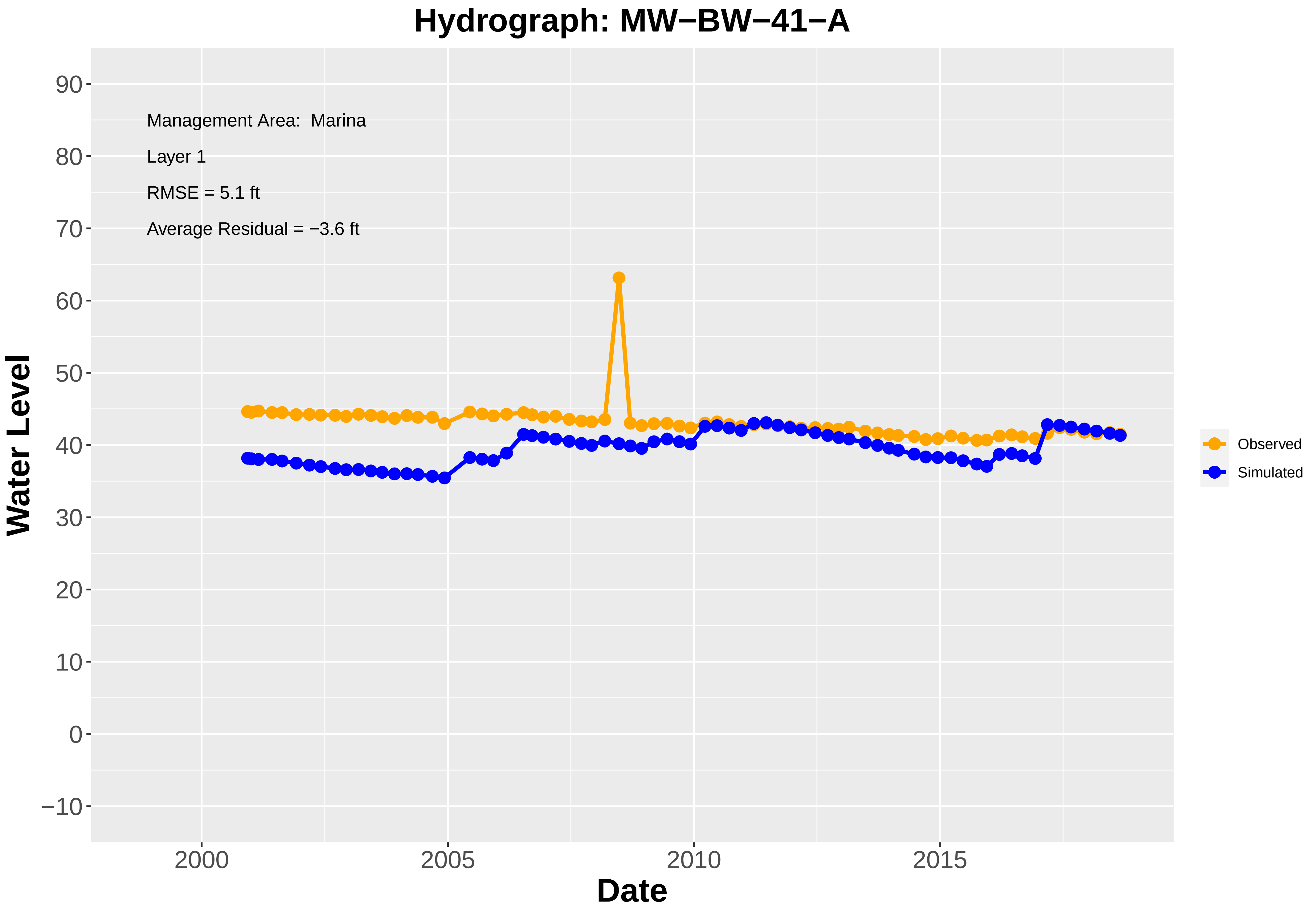

Hydrograph: MW−BW−37−A
Management Area: Marina
Layer 1
RMSE = 5.7 ft
Average Residual = −5.3 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

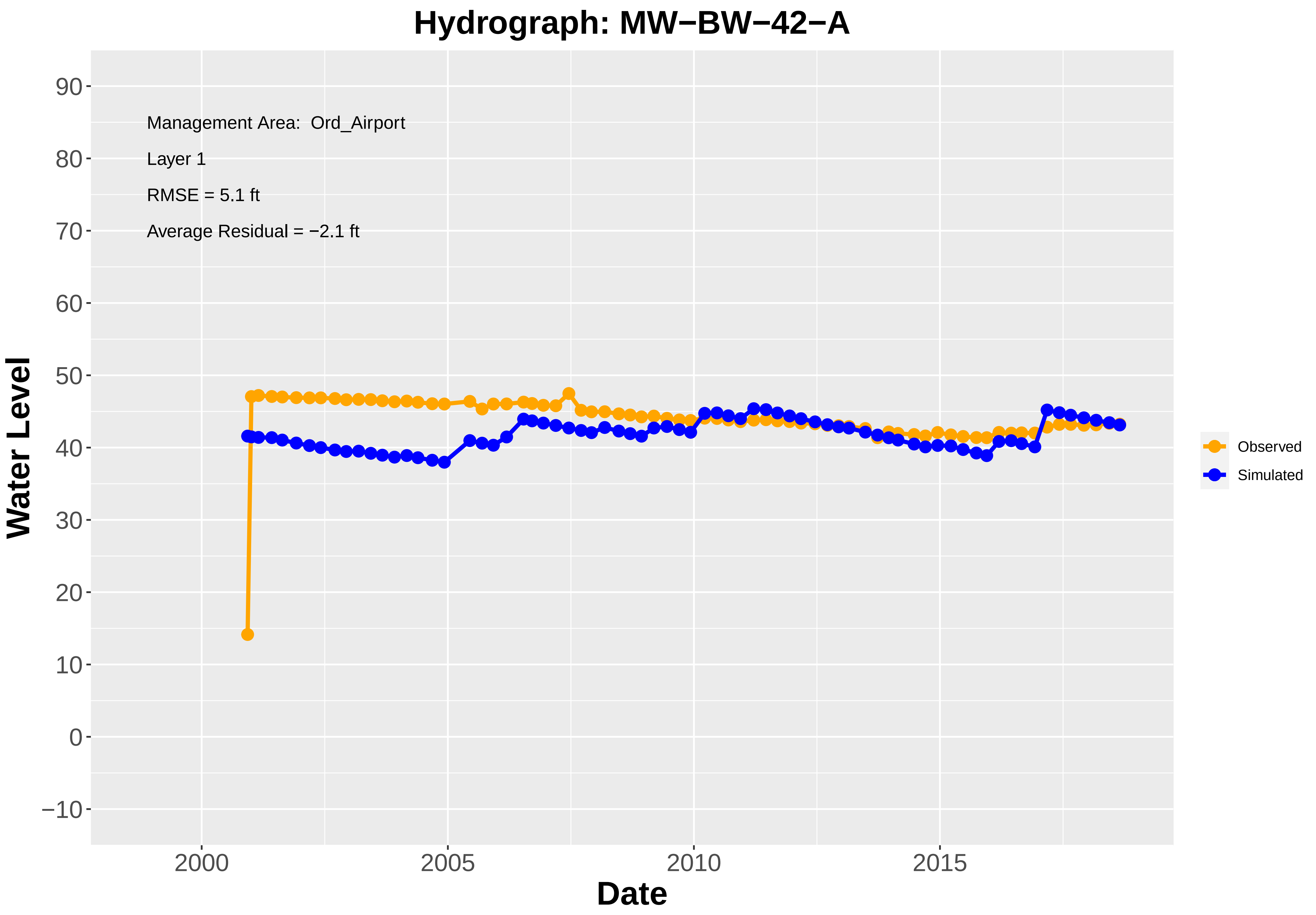

Hydrograph: MW−BW−38−A
Management Area: Marina
Layer 1
RMSE = 4.1 ft
Average Residual = −3.5 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

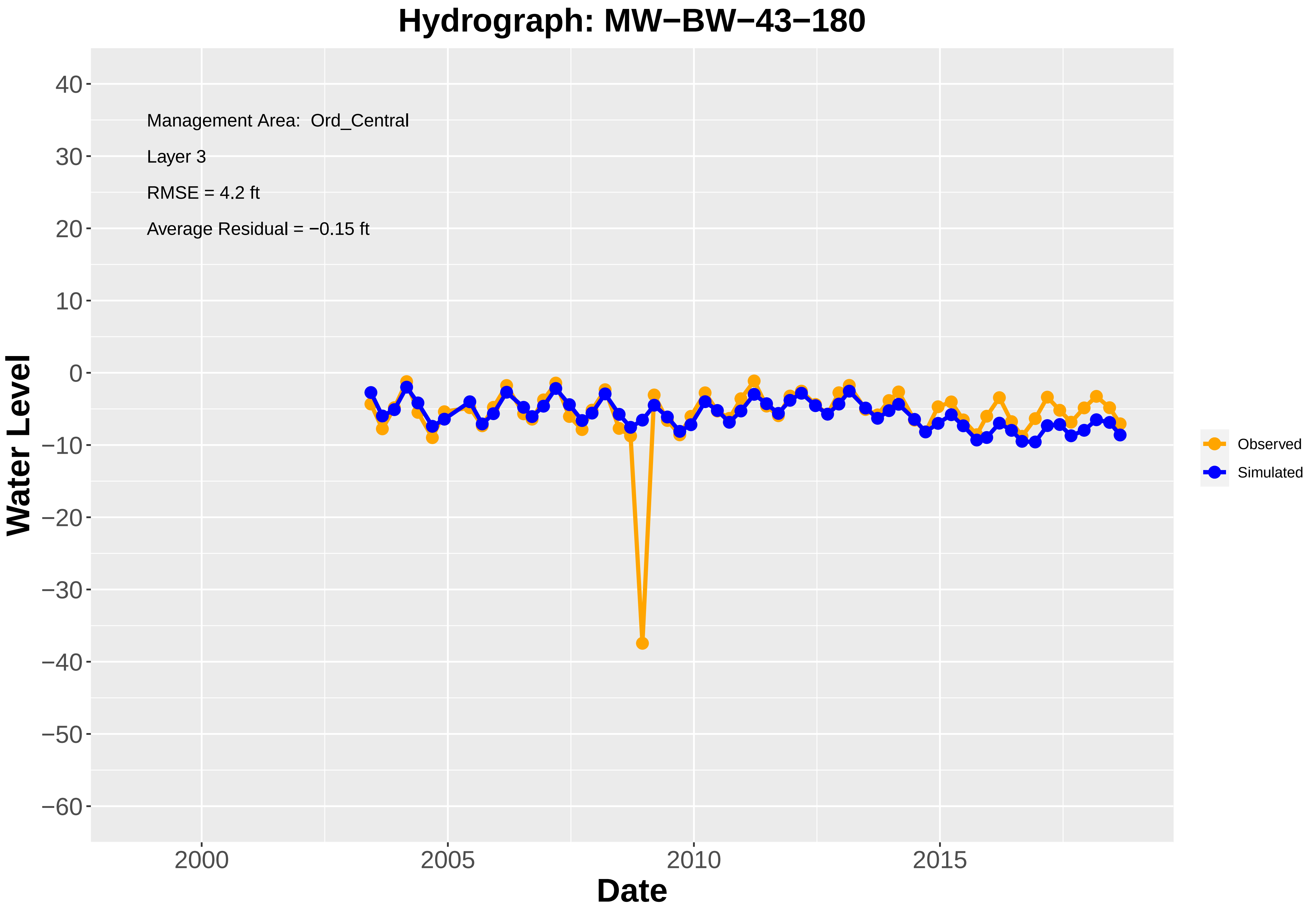
Hydrograph: MW−BW−39−A

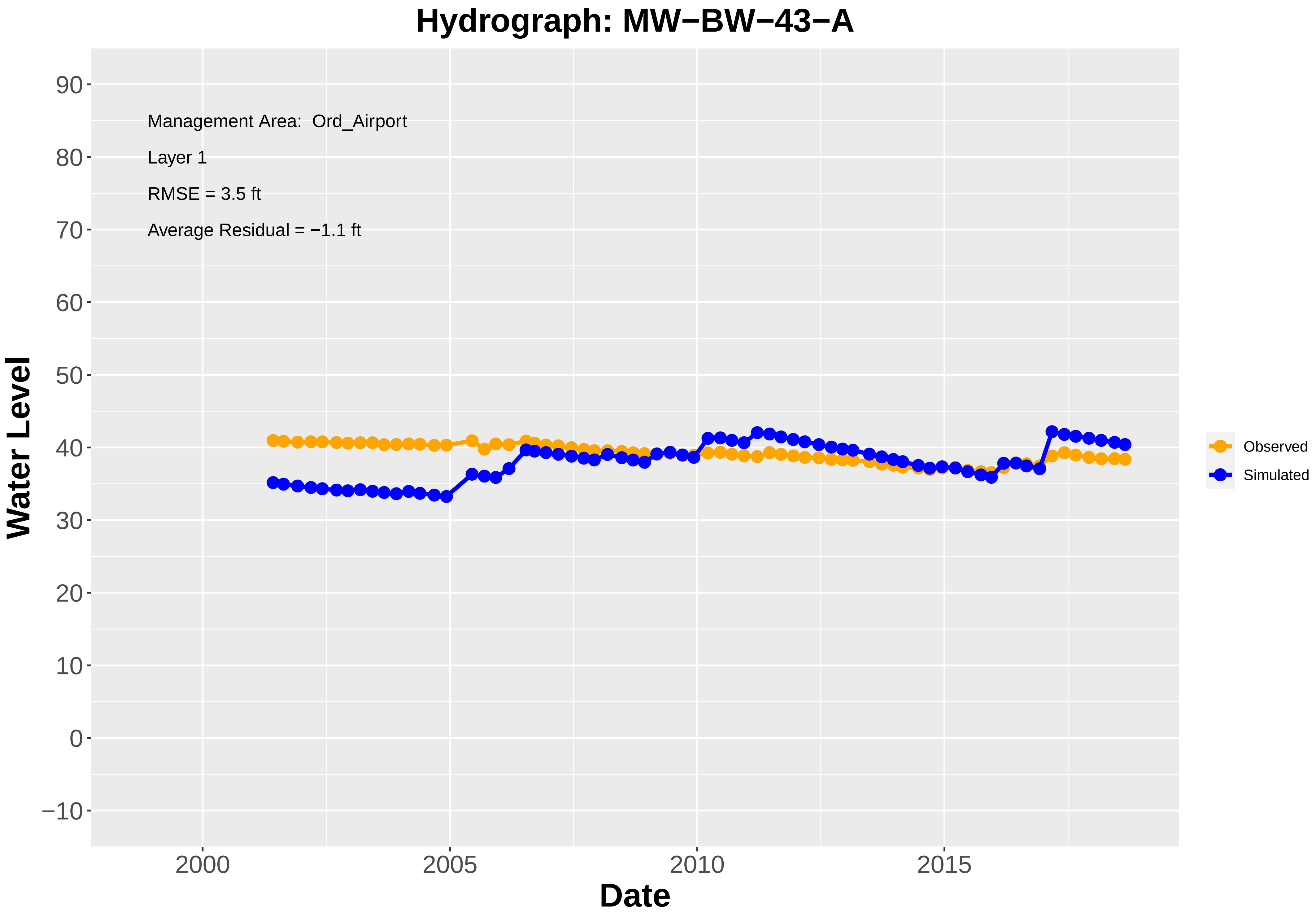


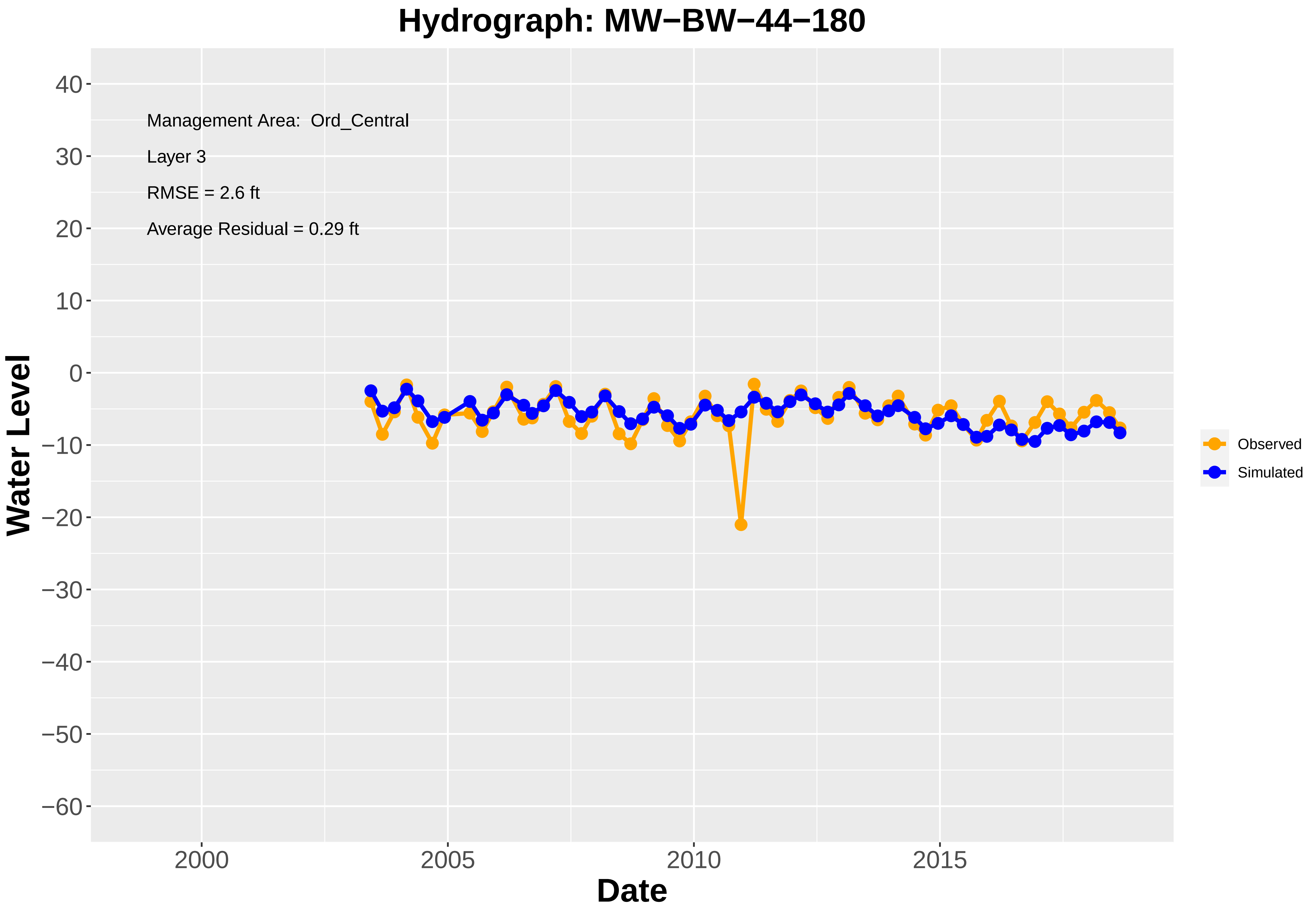

Hydrograph: MW−BW−40−A
Management Area: Marina
Layer 1
RMSE = 4.9 ft
Average Residual = −4.2 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

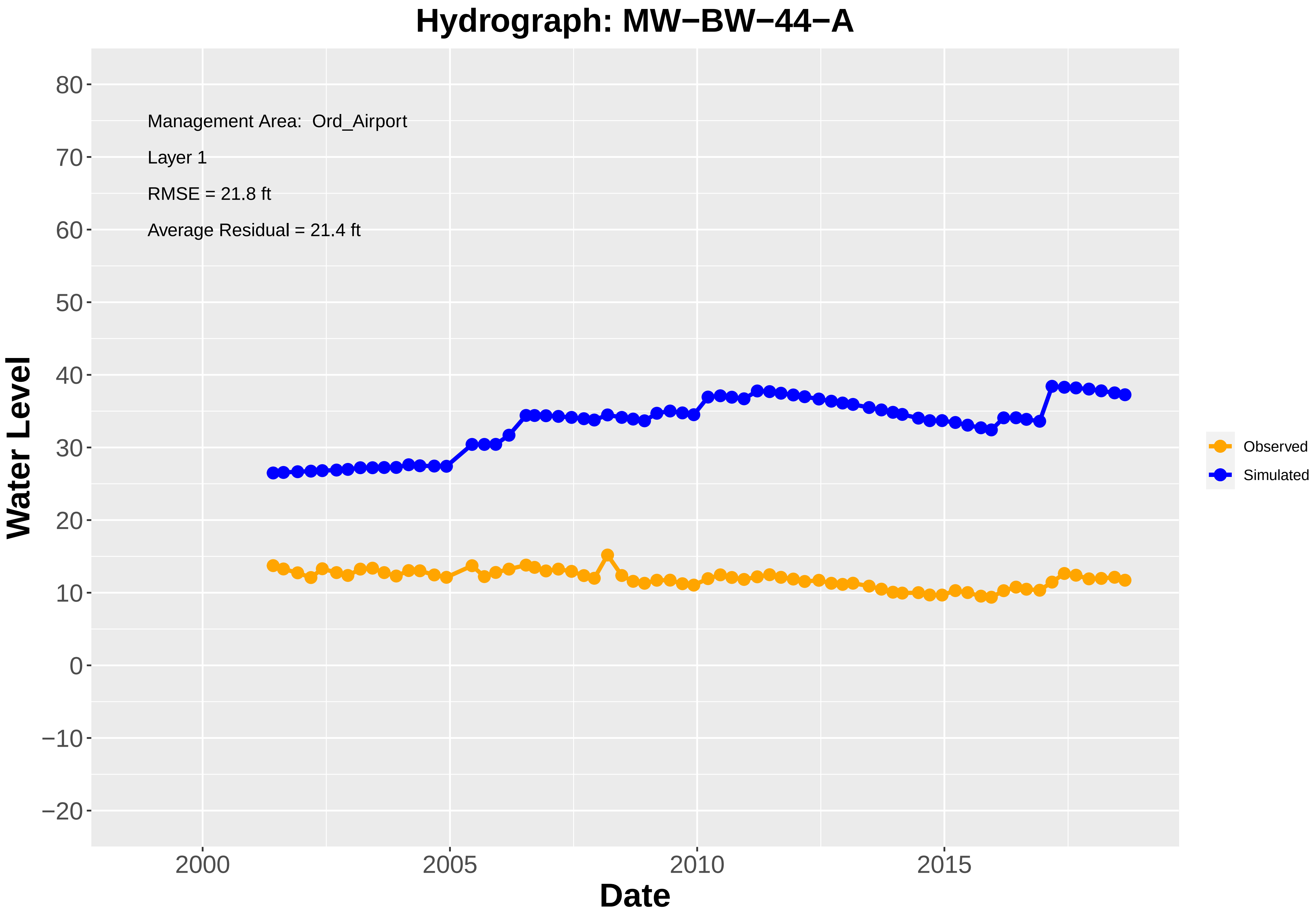

Hydrograph: MW−BW−41−A
Management Area: Marina
Layer 1
RMSE = 5.1 ft
Average Residual = −3.6 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

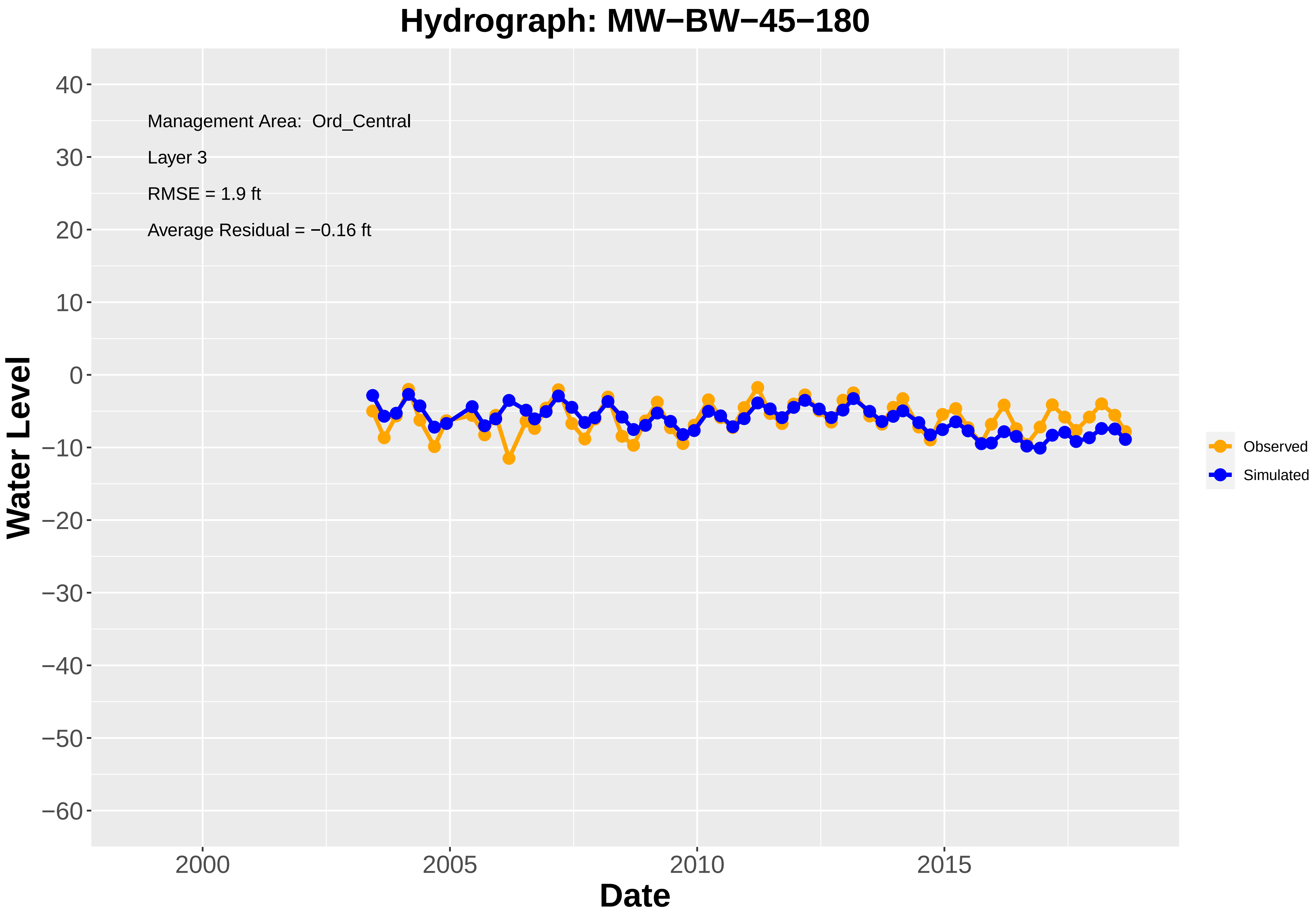

Hydrograph: MW−BW−42−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.1 ft
Average Residual = −2.1 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−BW−43−180
Management Area: Ord_Central
Layer 3
RMSE = 4.2 ft
Average Residual = −0.15 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

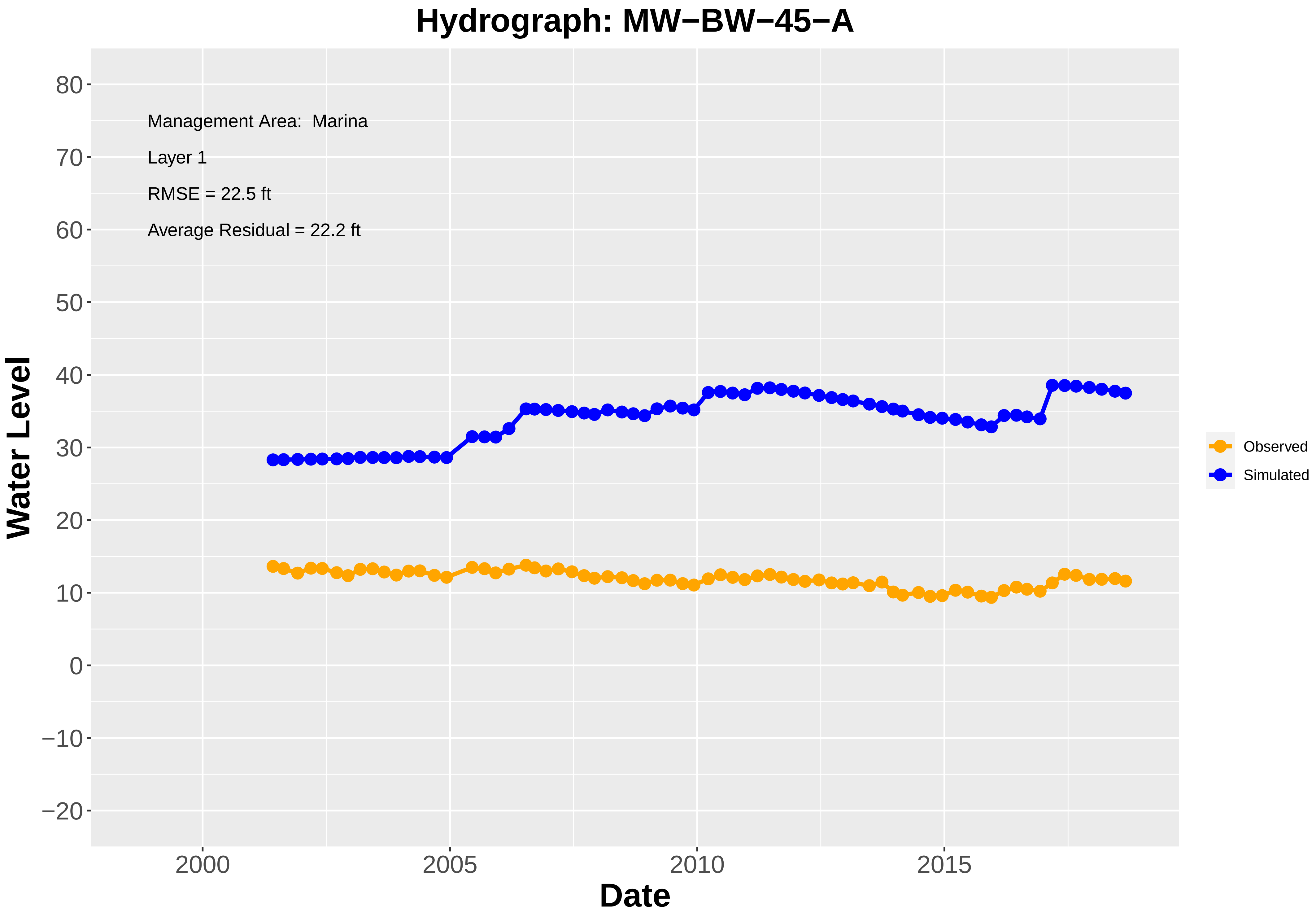

Hydrograph: MW−BW−43−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.5 ft
Average Residual = −1.1 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

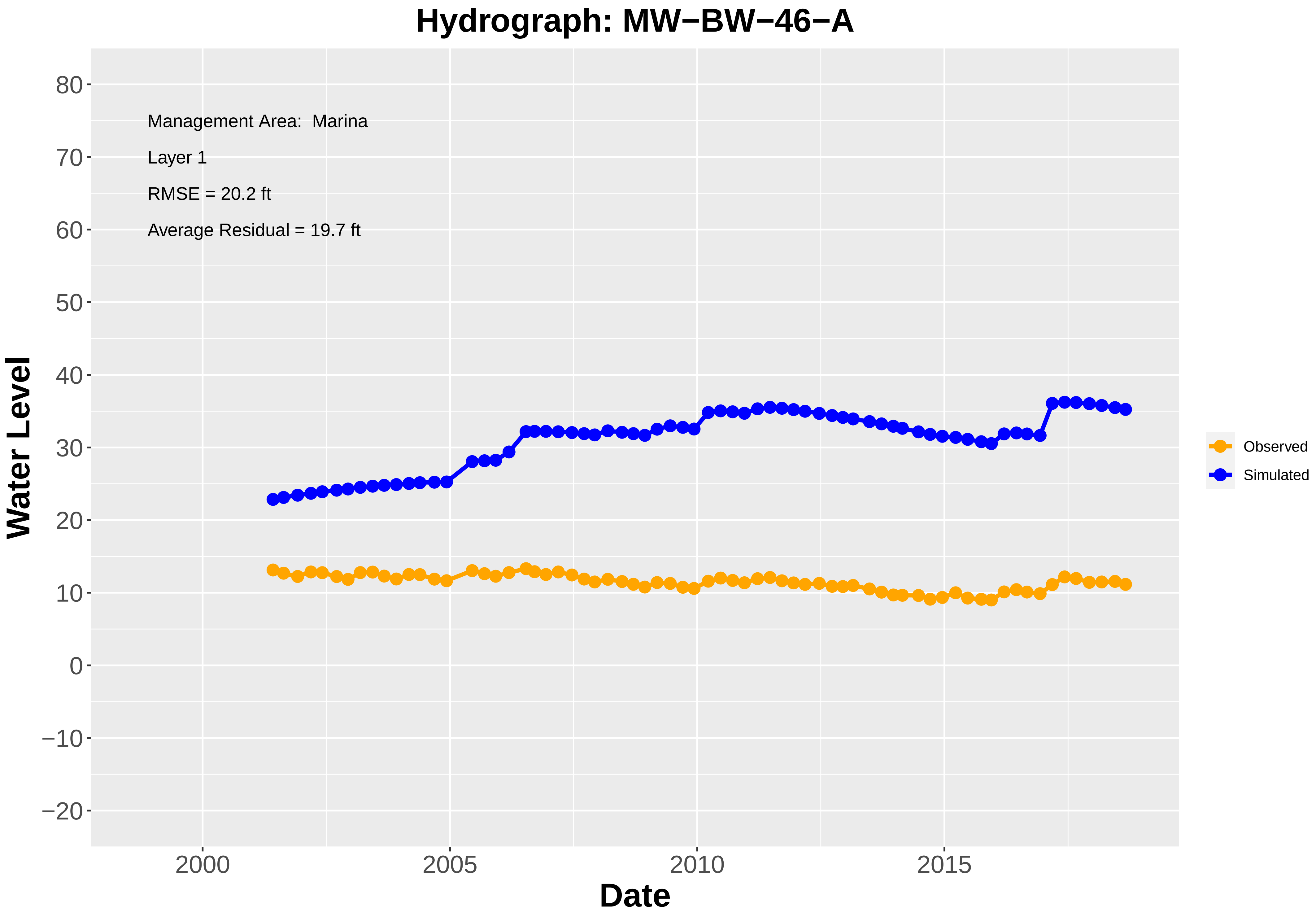

Hydrograph: MW−BW−44−180
Management Area: Ord_Central
Layer 3
RMSE = 2.6 ft
Average Residual = 0.29 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

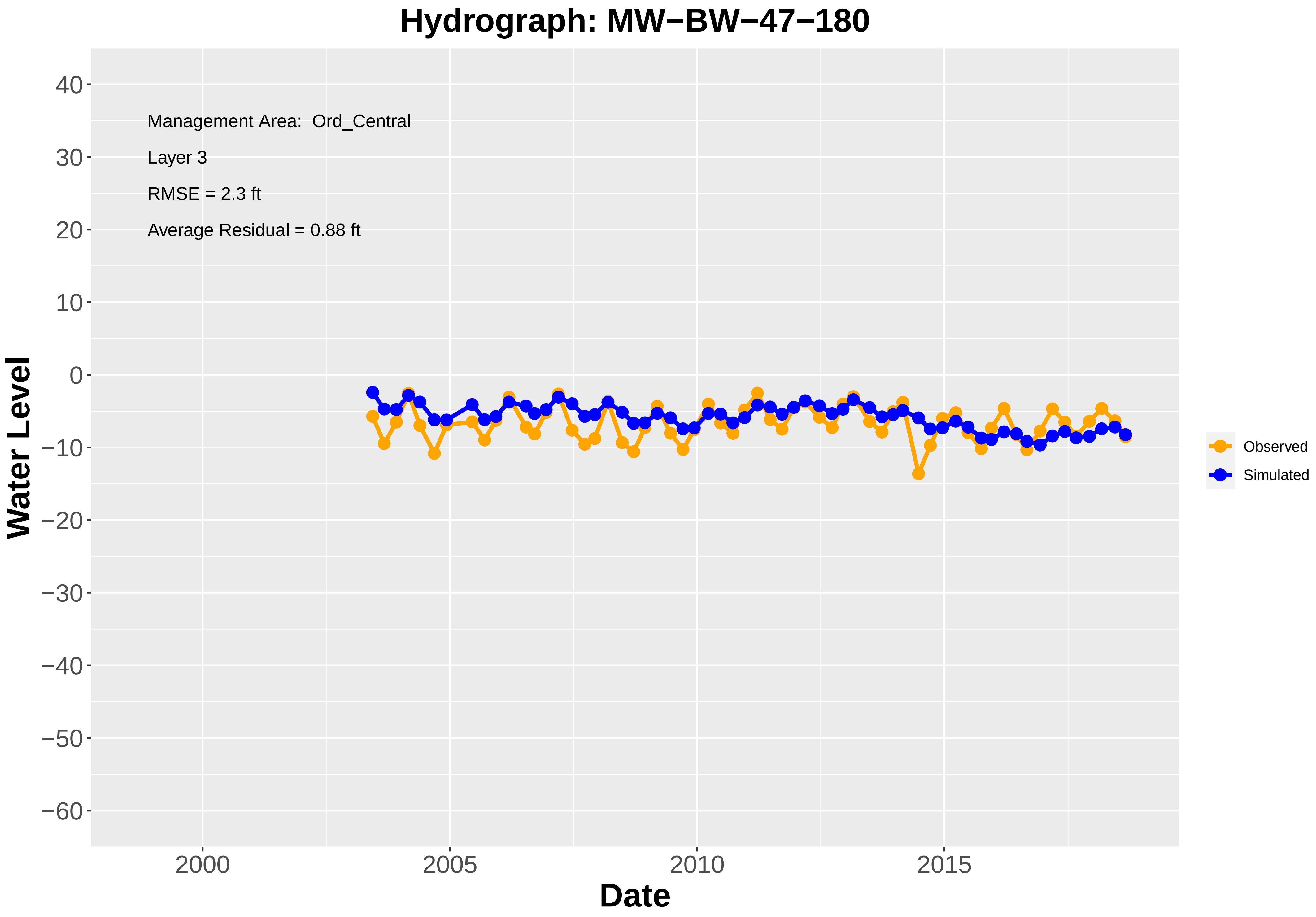

Hydrograph: MW−BW−44−A
Management Area: Ord_Airport
Layer 1
RMSE = 21.8 ft
Average Residual = 21.4 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated



Hydrograph: MW−BW−45−180
Management Area: Ord_Central
Layer 3
RMSE = 1.9 ft
Average Residual = −0.16 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

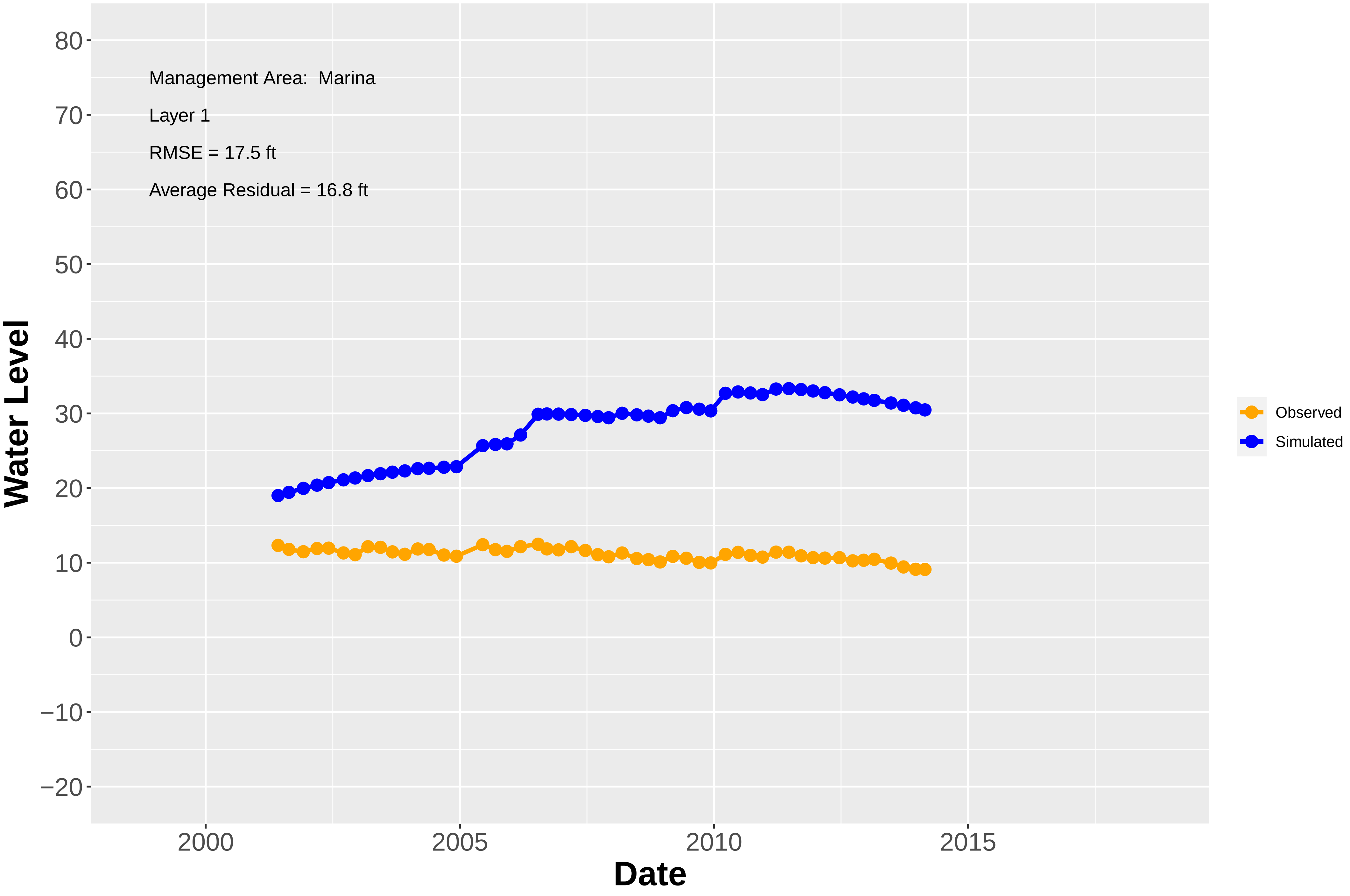

Hydrograph: MW−BW−45−A
Management Area: Marina
Layer 1
RMSE = 22.5 ft
Average Residual = 22.2 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated

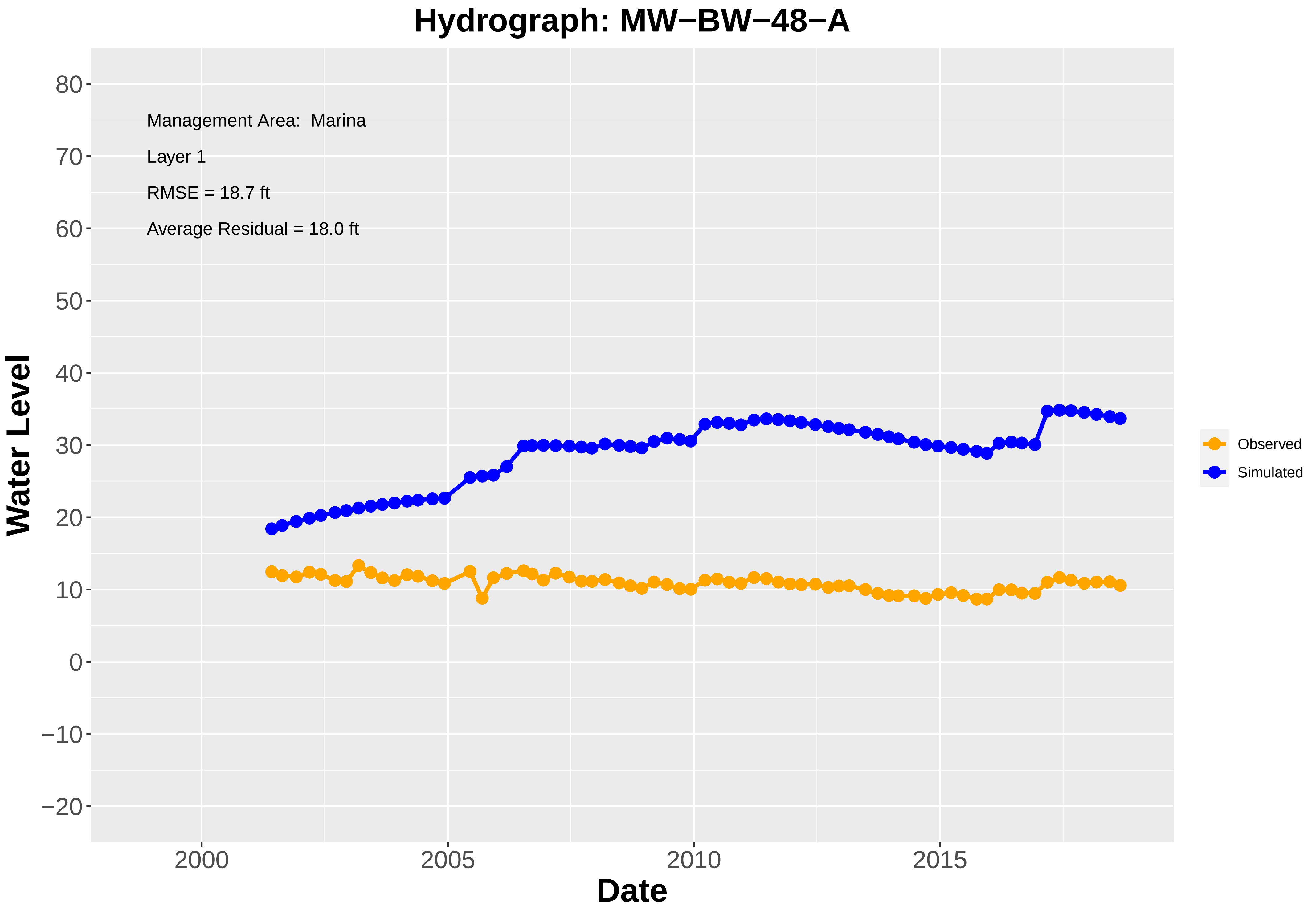

Hydrograph: MW−BW−46−A
Management Area: Marina
Layer 1
RMSE = 20.2 ft
Average Residual = 19.7 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated

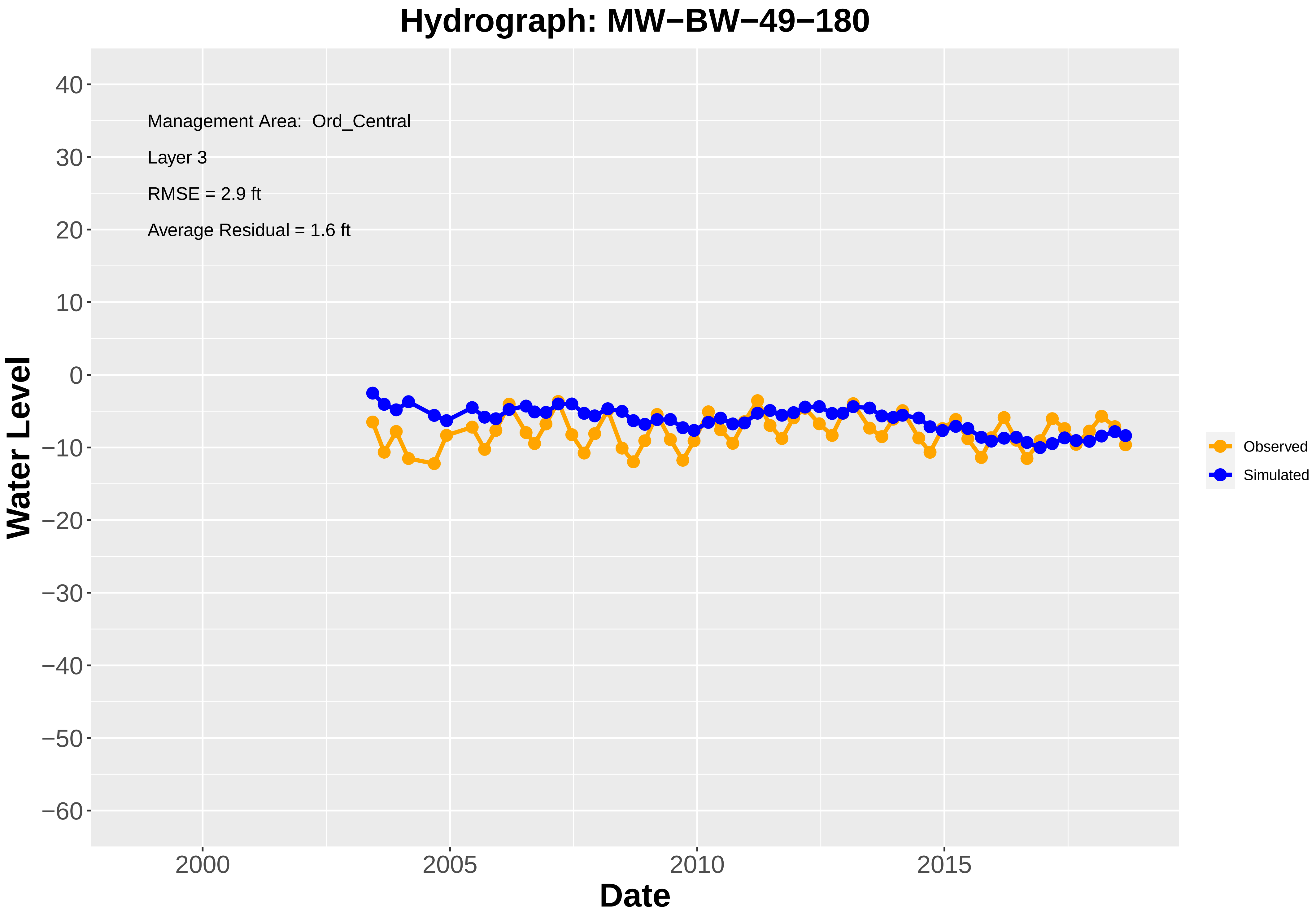


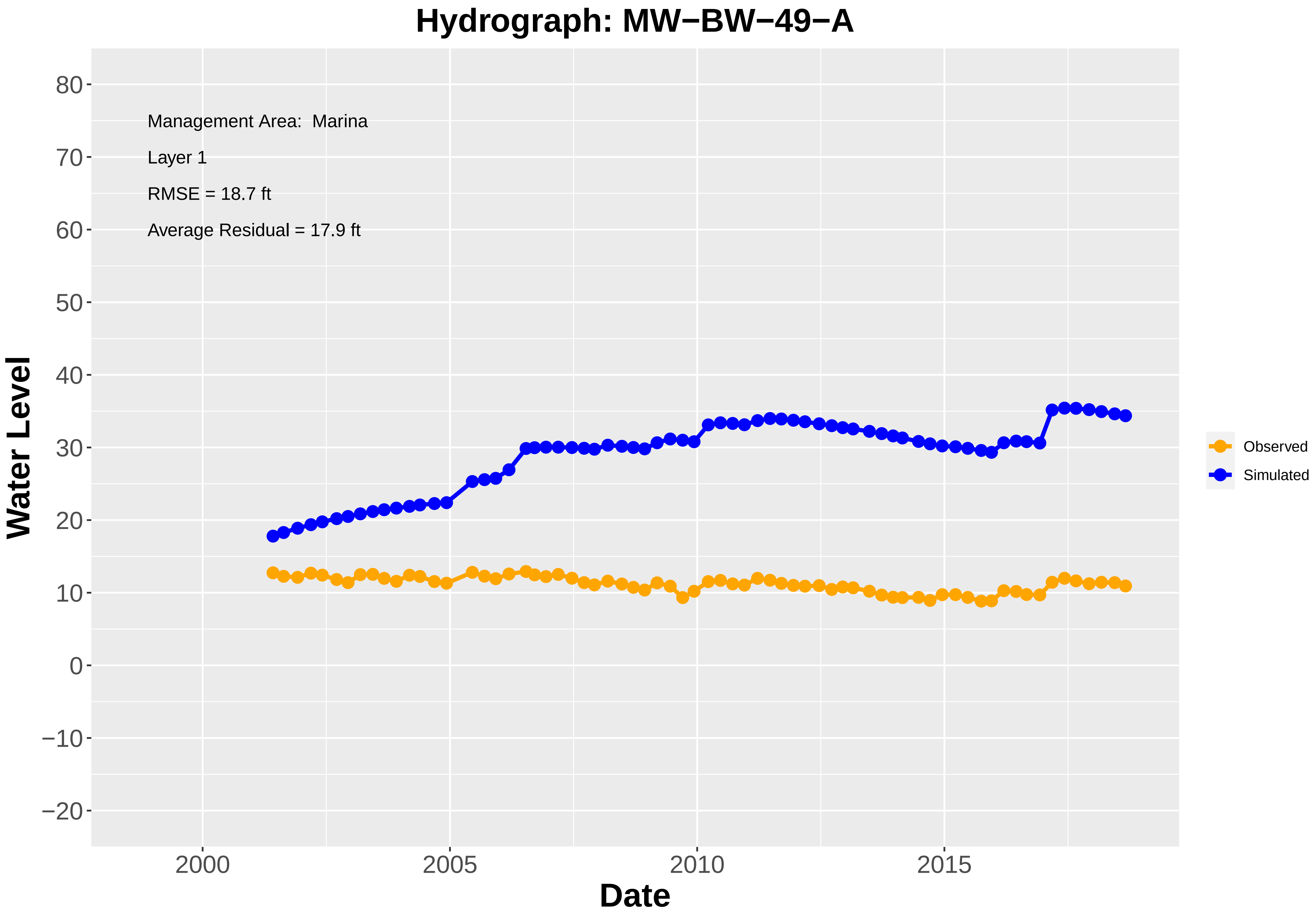
Hydrograph: MW−BW−47−180
Management Area: Ord_Central
Layer 3
RMSE = 2.3 ft
Average Residual = 0.88 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

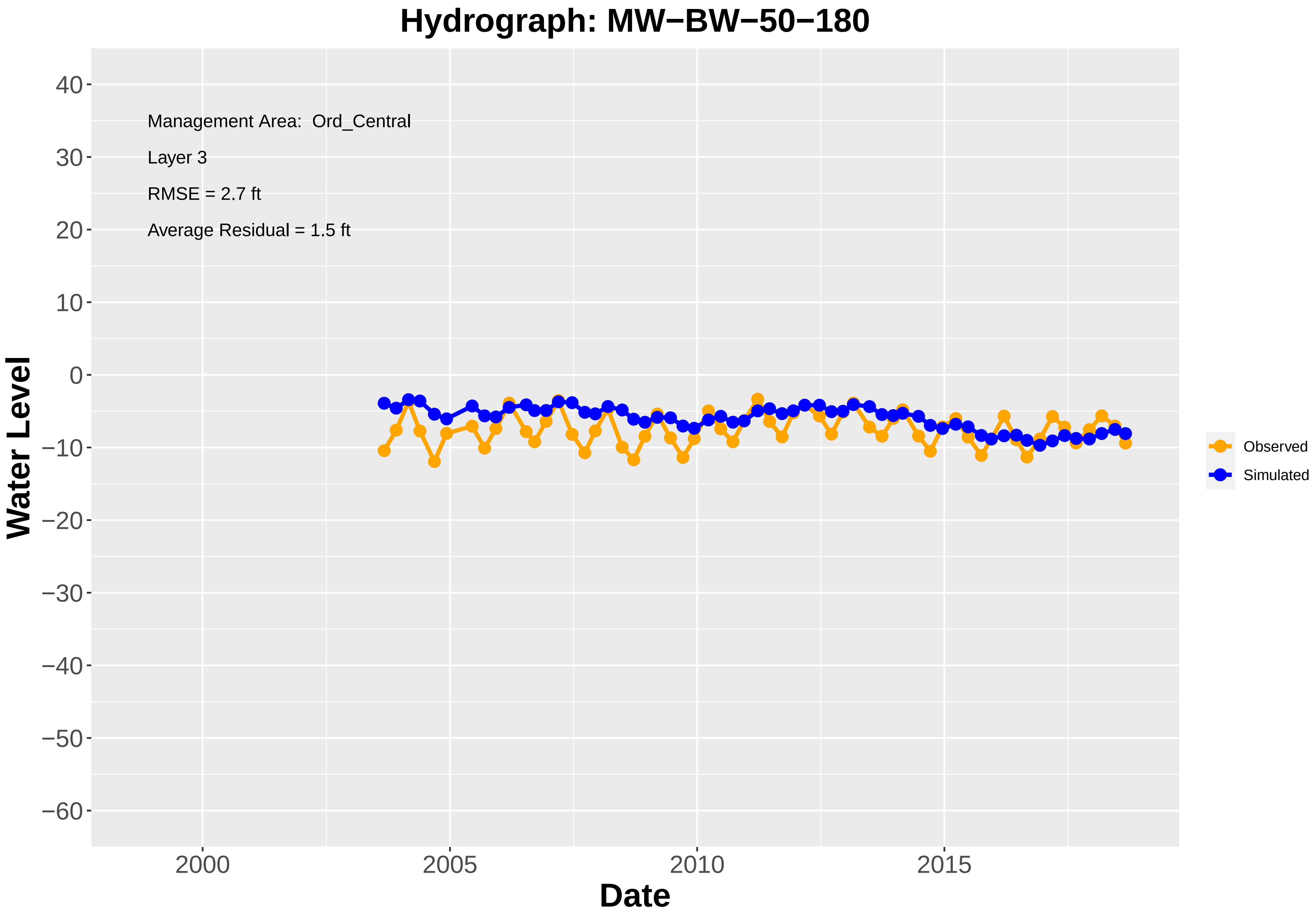
Hydrograph: MW−BW−47−A

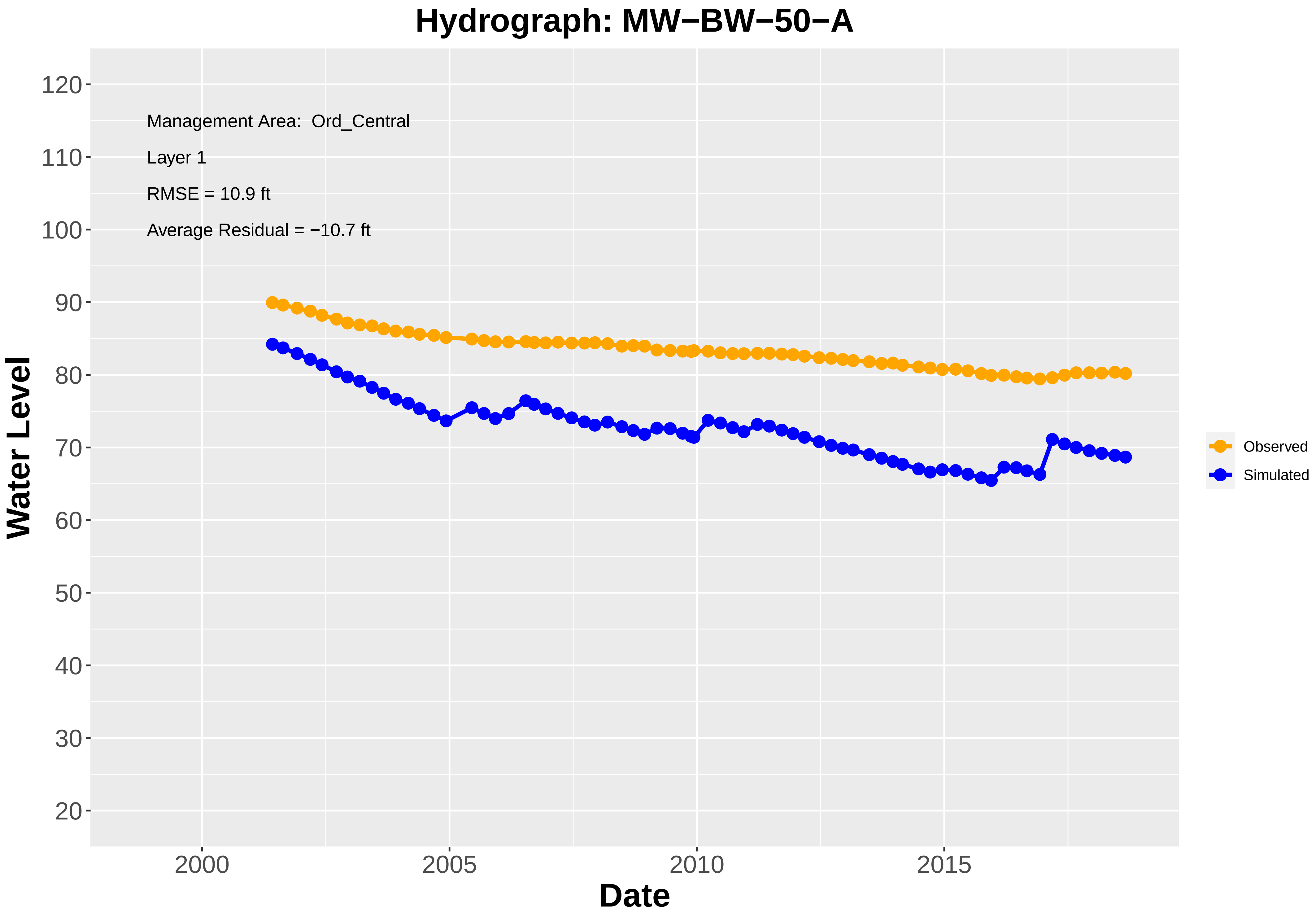


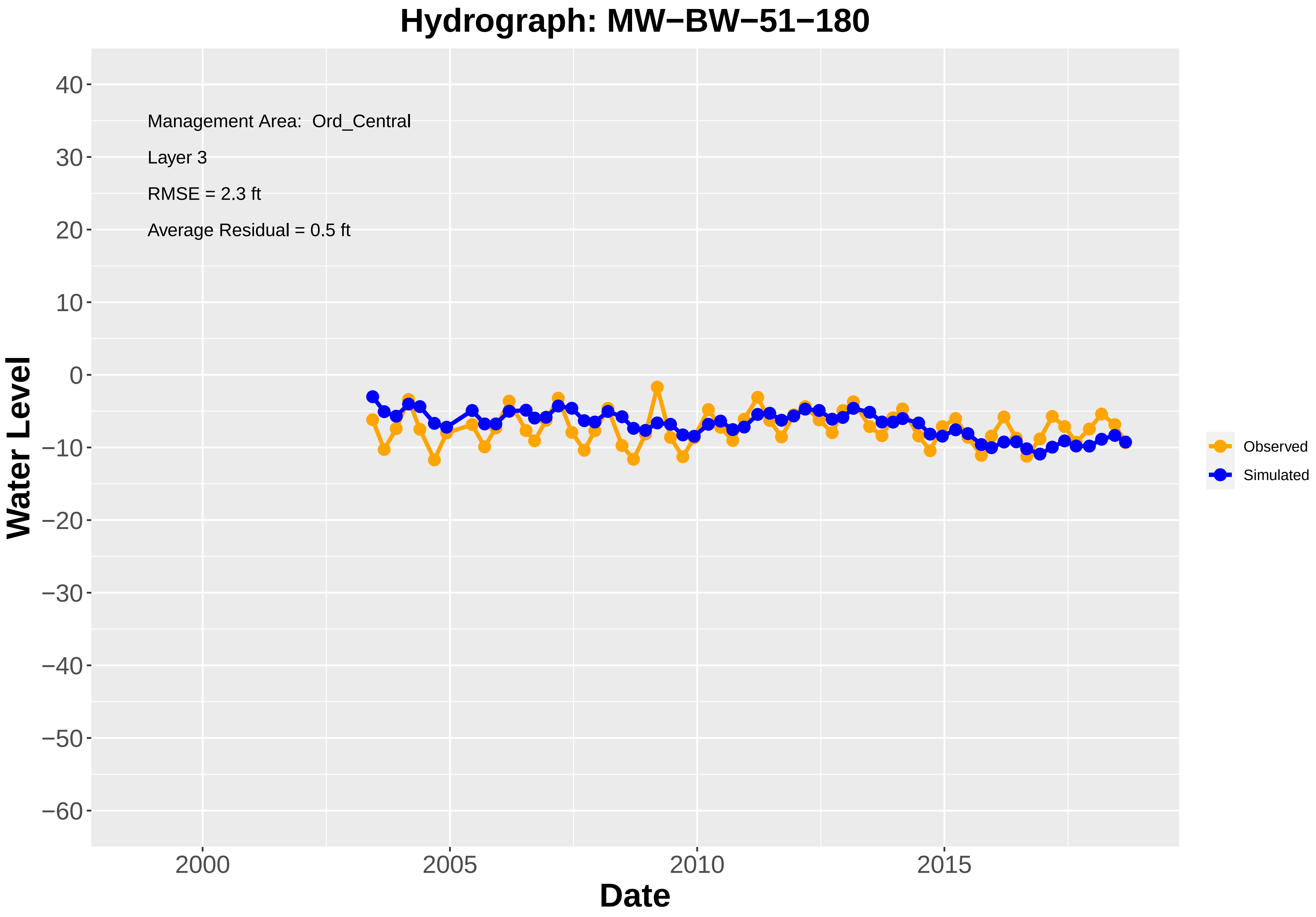

Hydrograph: MW−BW−48−A
Management Area: Marina
Layer 1
RMSE = 18.7 ft
Average Residual = 18.0 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−49−180
Management Area: Ord_Central
Layer 3
RMSE = 2.9 ft
Average Residual = 1.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

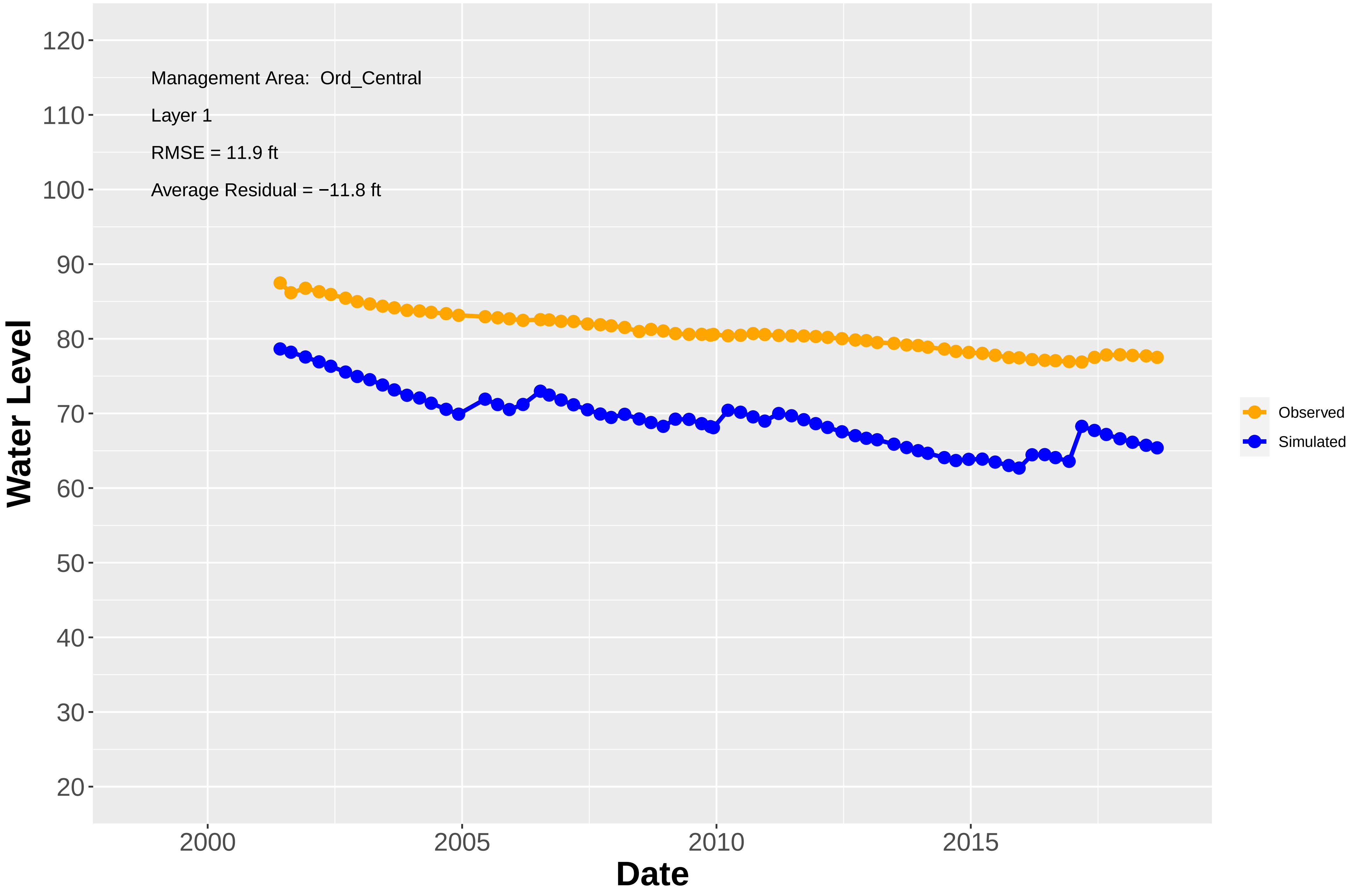

Hydrograph: MW−BW−49−A
Management Area: Marina
Layer 1
RMSE = 18.7 ft
Average Residual = 17.9 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated

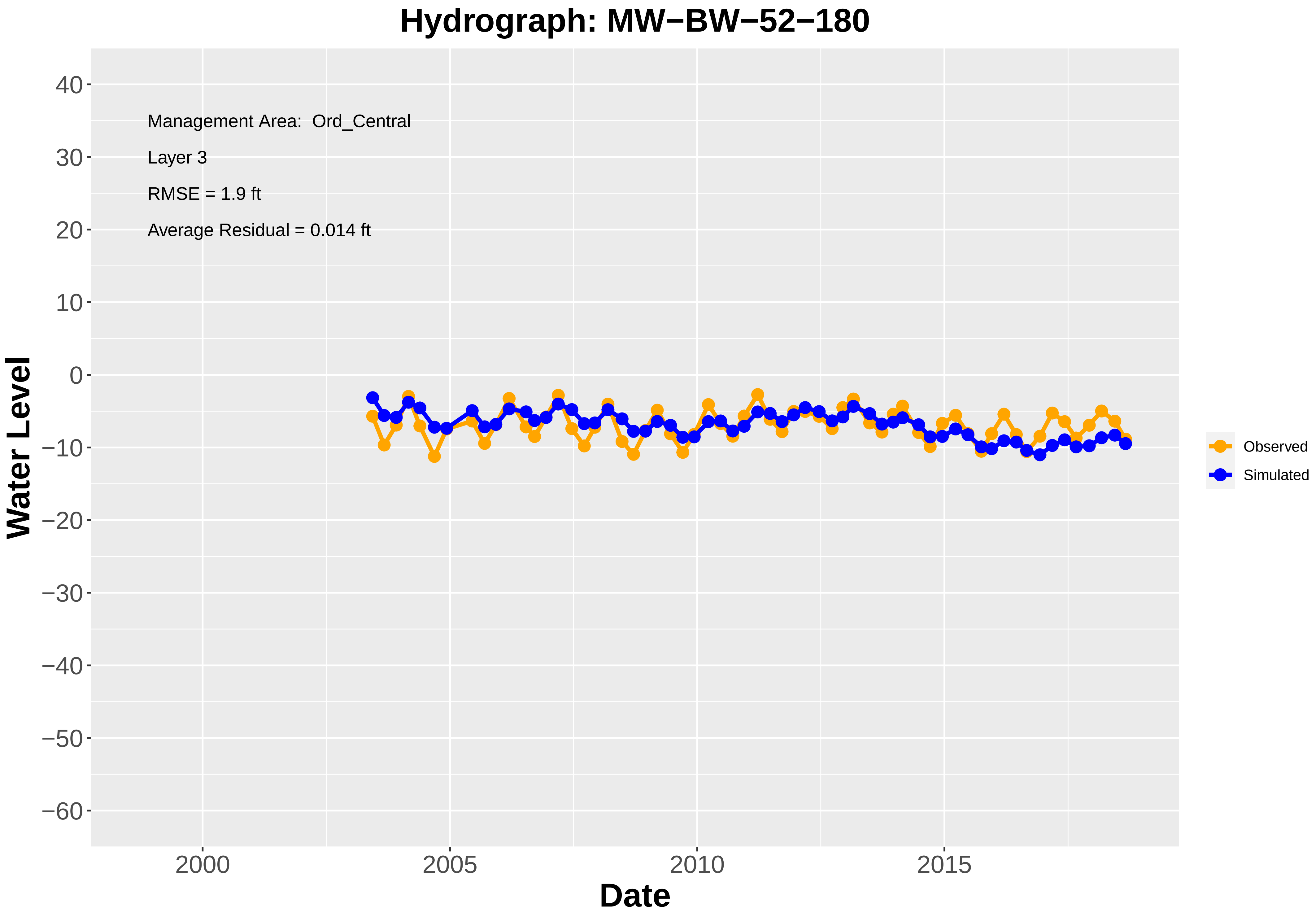

Hydrograph: MW−BW−50−180
Management Area: Ord_Central
Layer 3
RMSE = 2.7 ft
Average Residual = 1.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

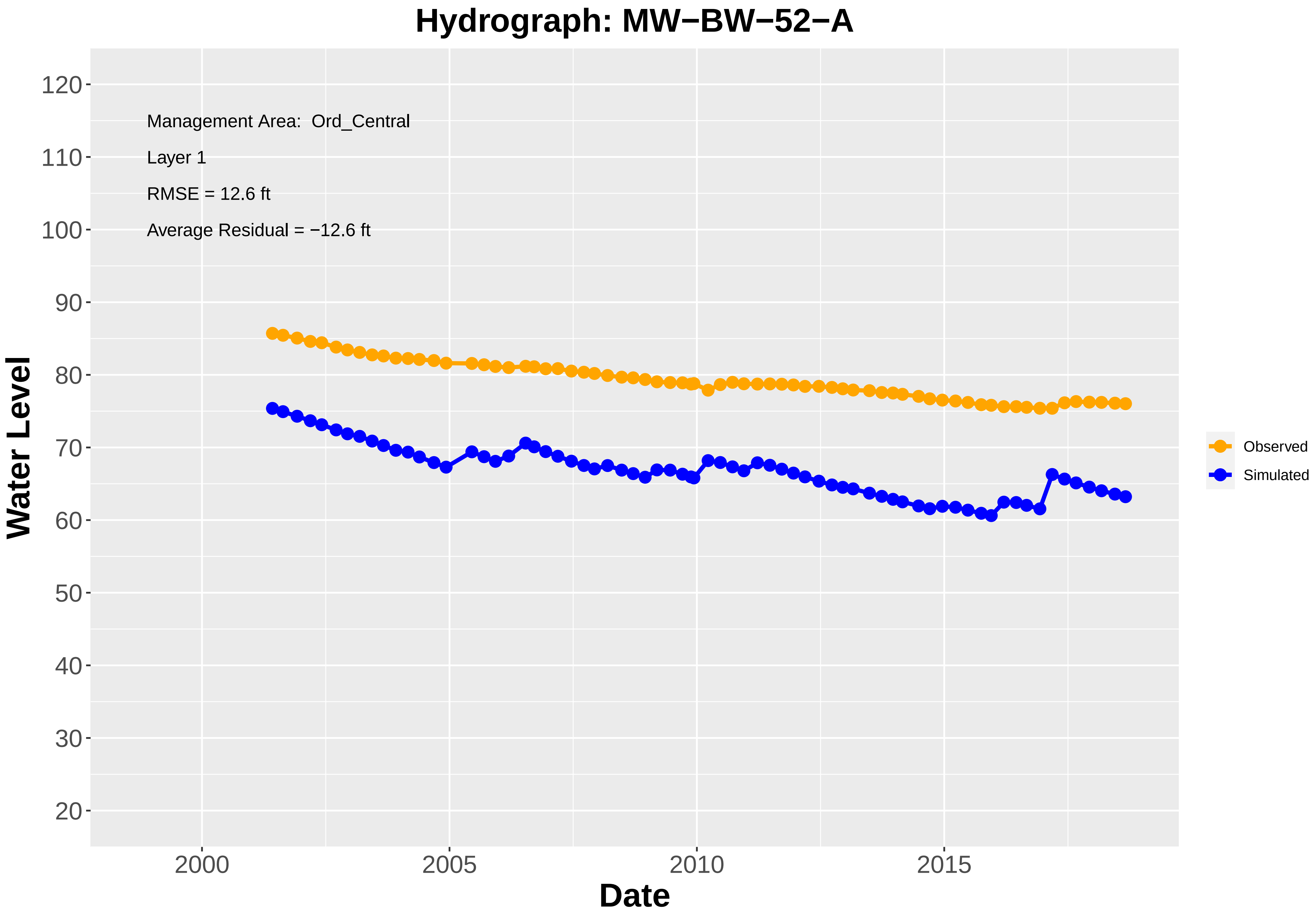

Hydrograph: MW−BW−50−A
Management Area: Ord_Central
Layer 1
RMSE = 10.9 ft
Average Residual = −10.7 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated

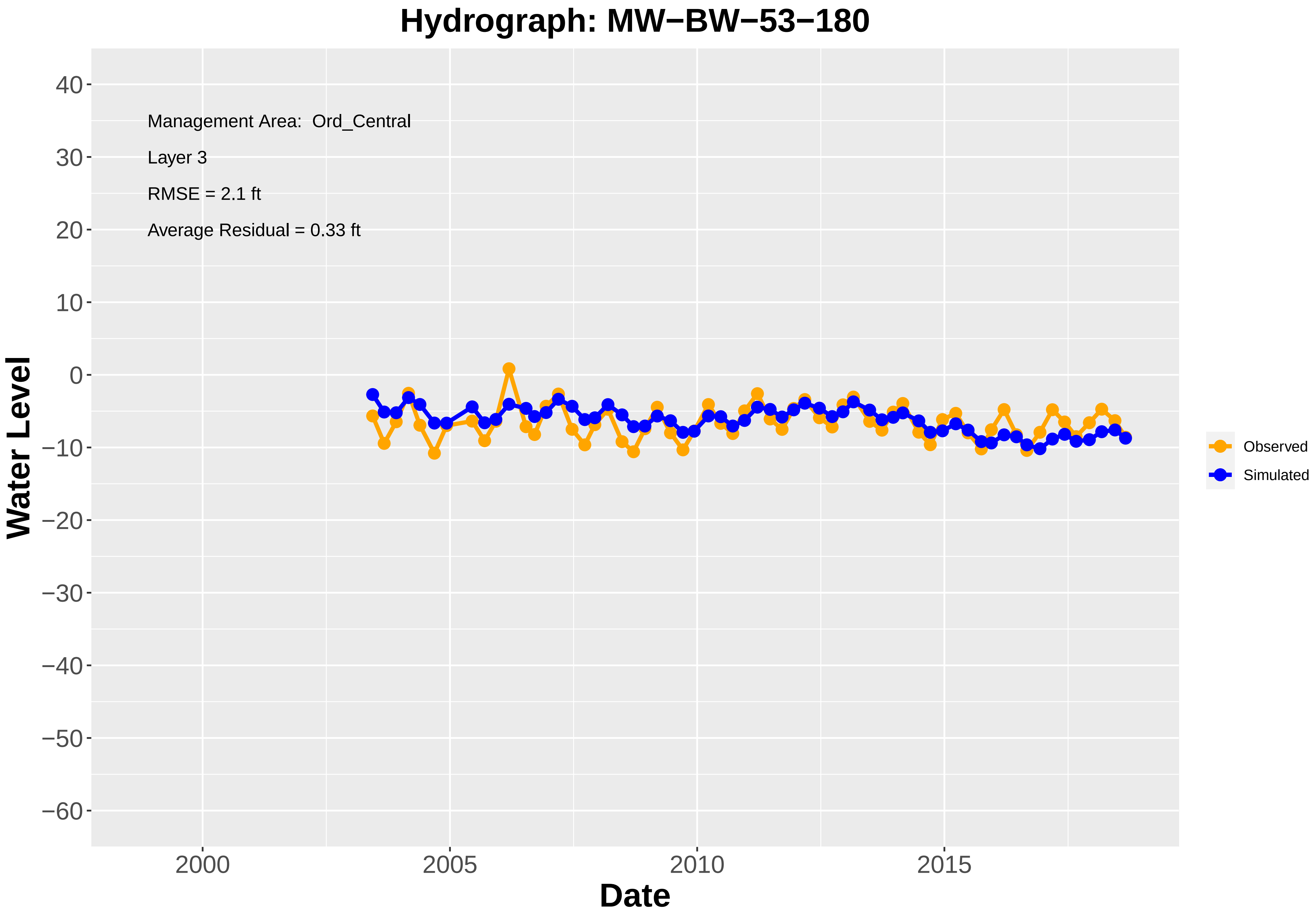

Hydrograph: MW−BW−51−180
Management Area: Ord_Central
Layer 3
RMSE = 2.3 ft
Average Residual = 0.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

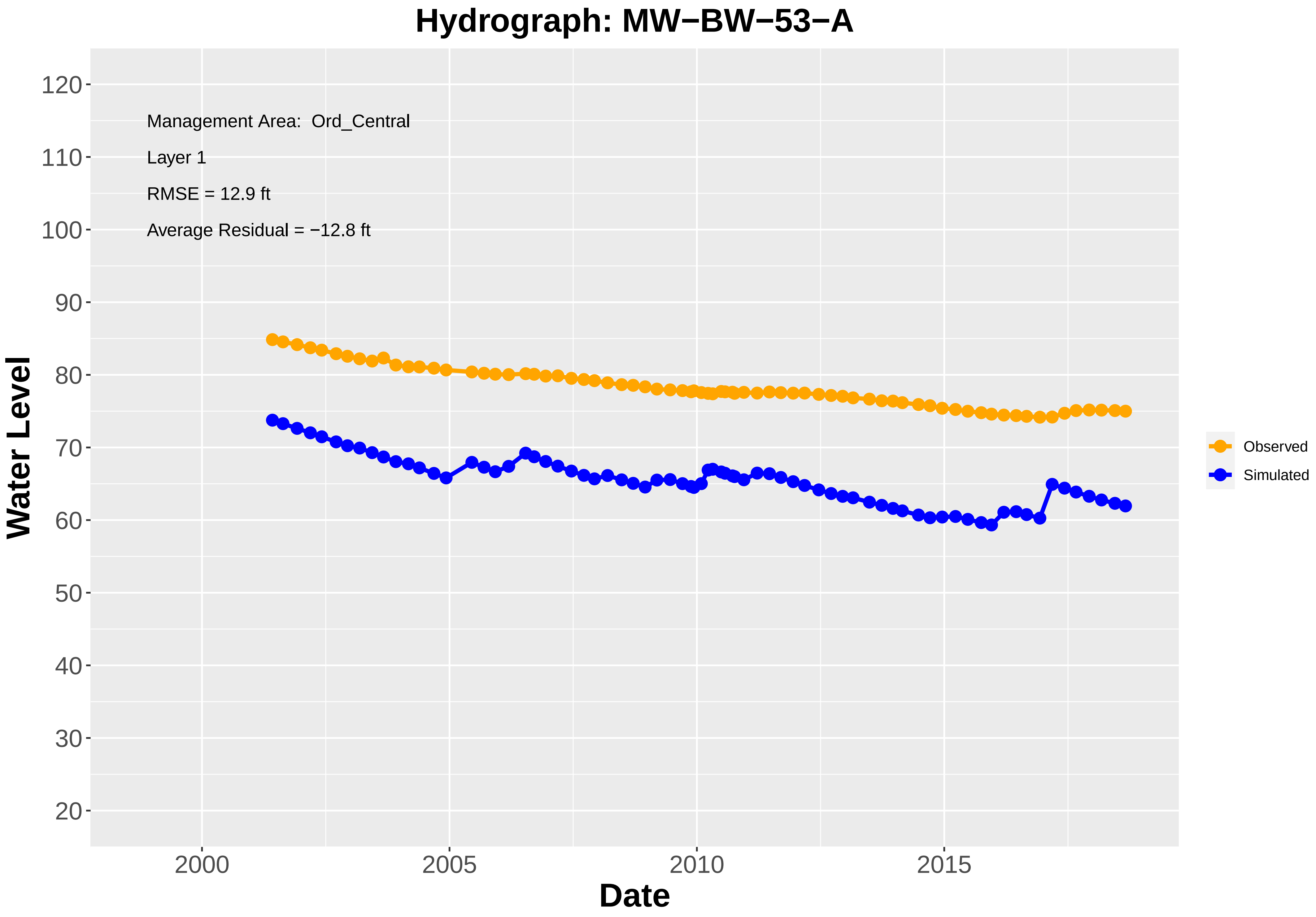
Hydrograph: MW−BW−51−A

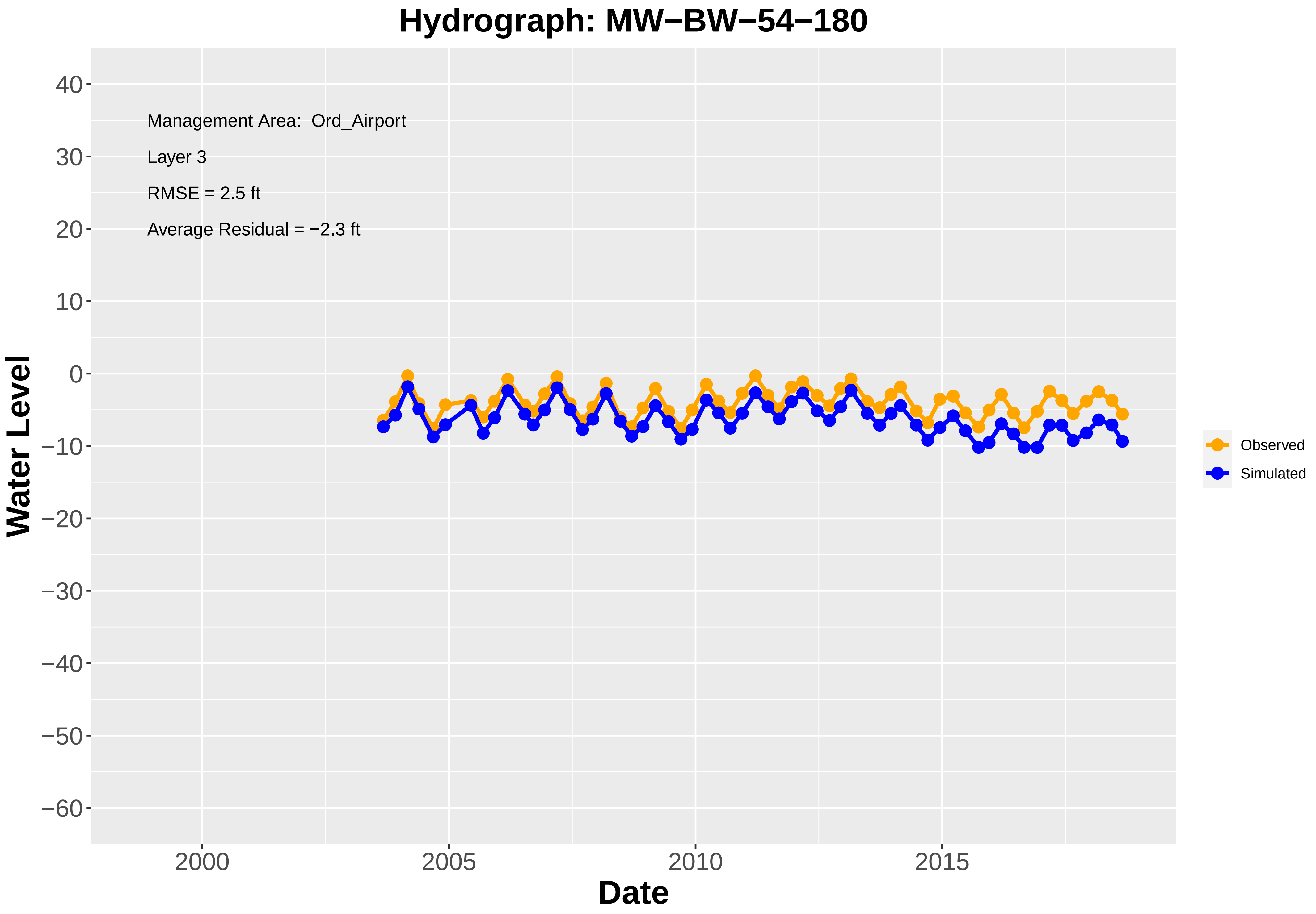


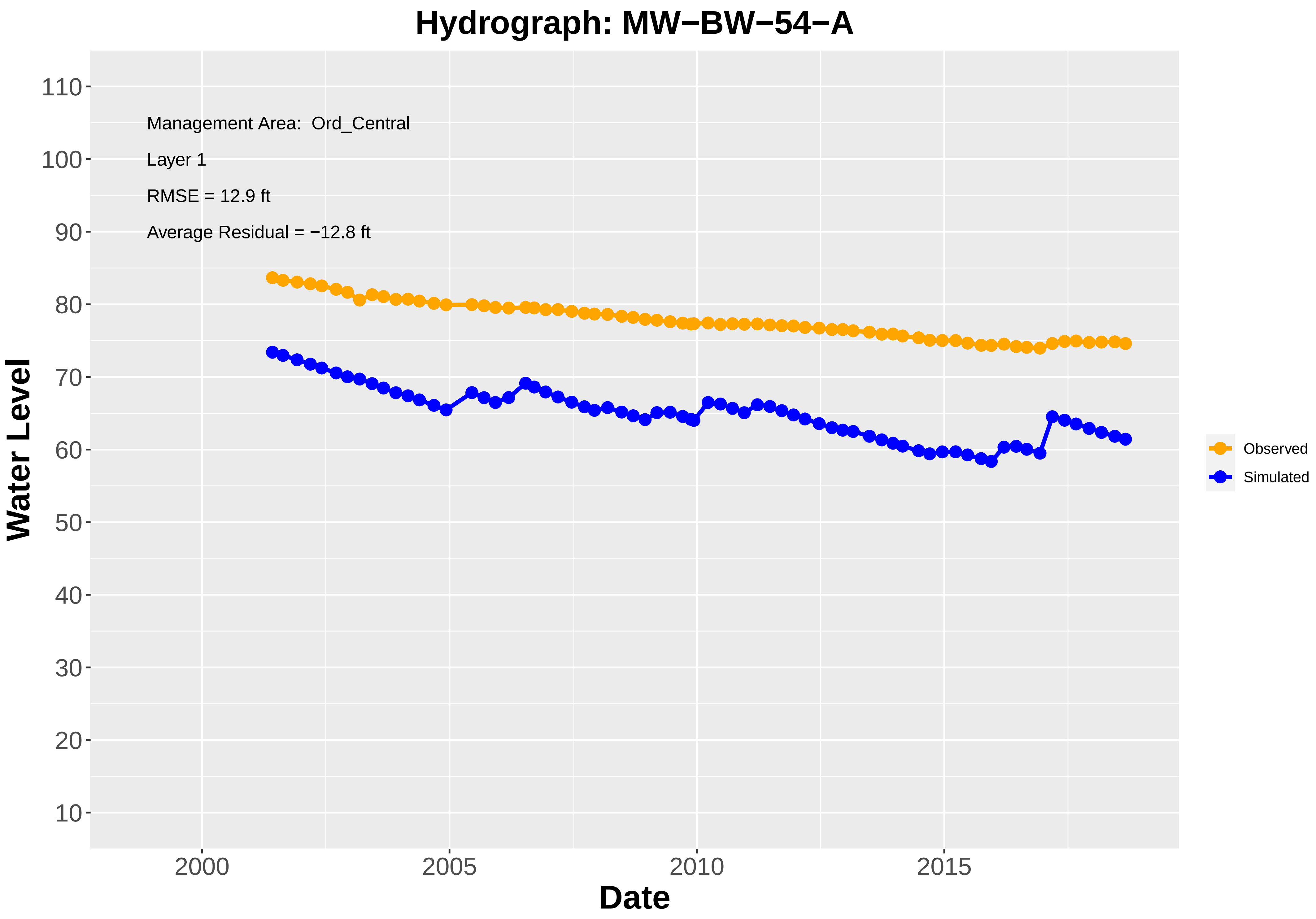

Hydrograph: MW−BW−52−180
Management Area: Ord_Central
Layer 3
RMSE = 1.9 ft
Average Residual = 0.014 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

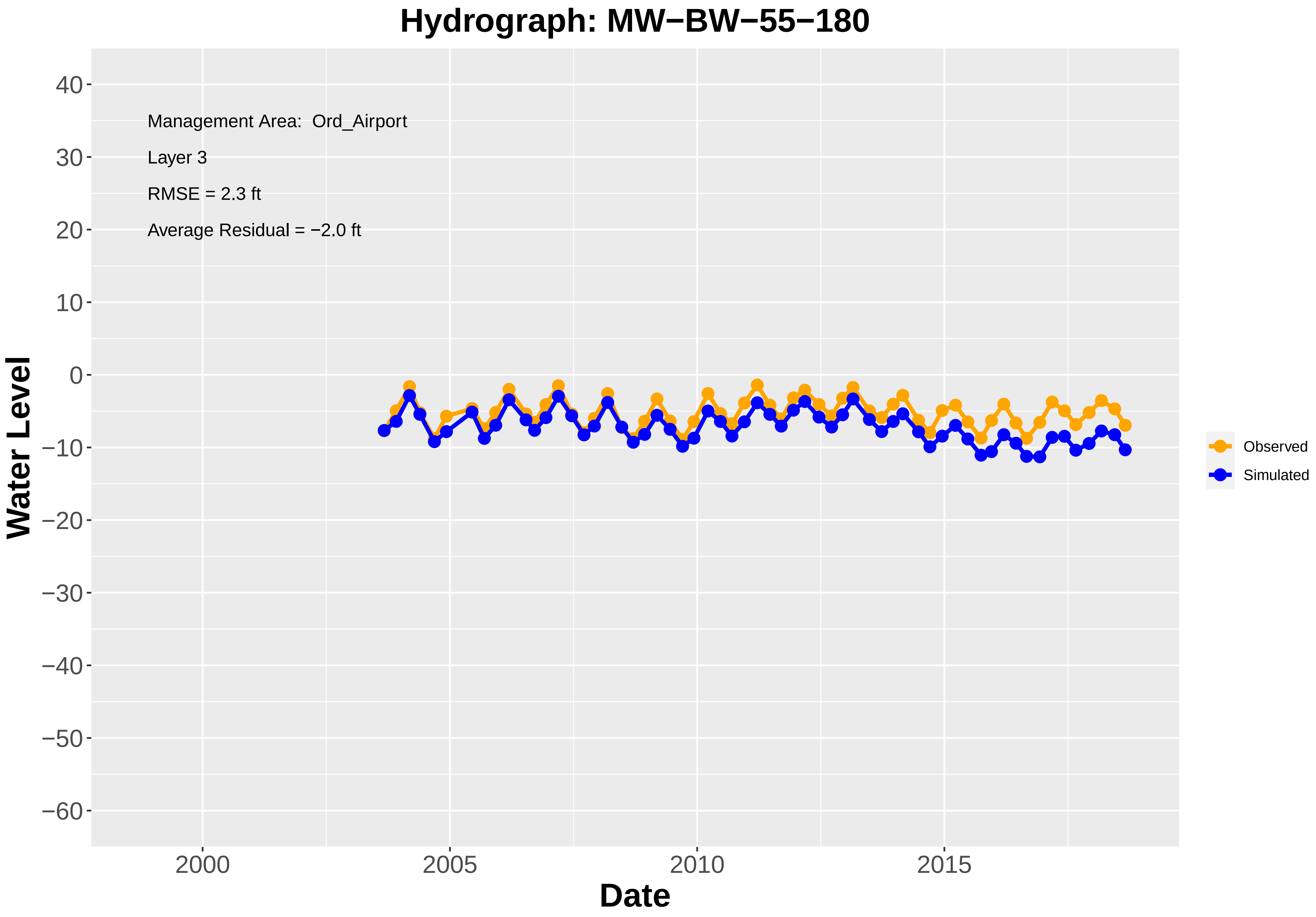

Hydrograph: MW−BW−52−A
Management Area: Ord_Central
Layer 1
RMSE = 12.6 ft
Average Residual = −12.6 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated

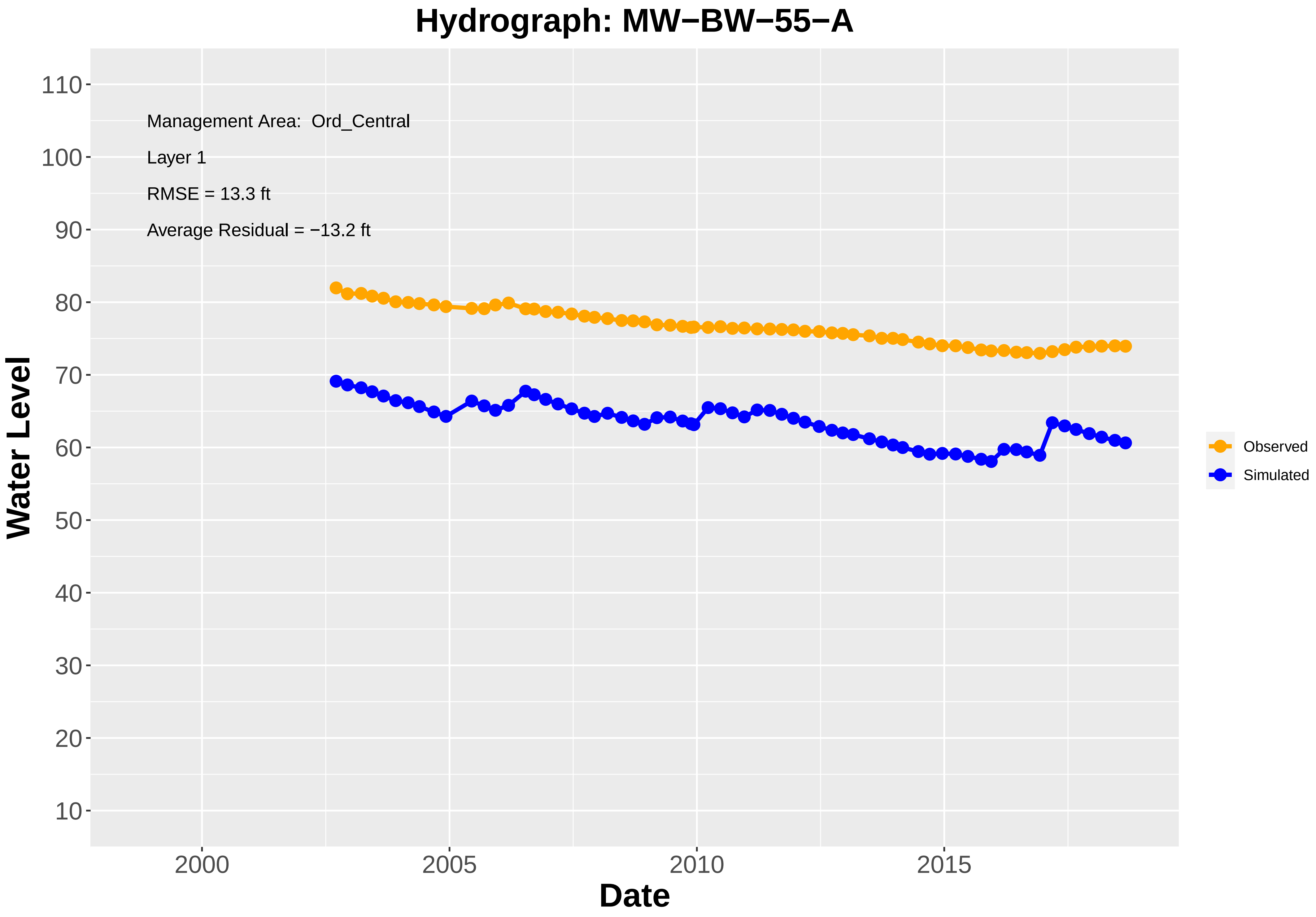

Hydrograph: MW−BW−53−180
Management Area: Ord_Central
Layer 3
RMSE = 2.1 ft
Average Residual = 0.33 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

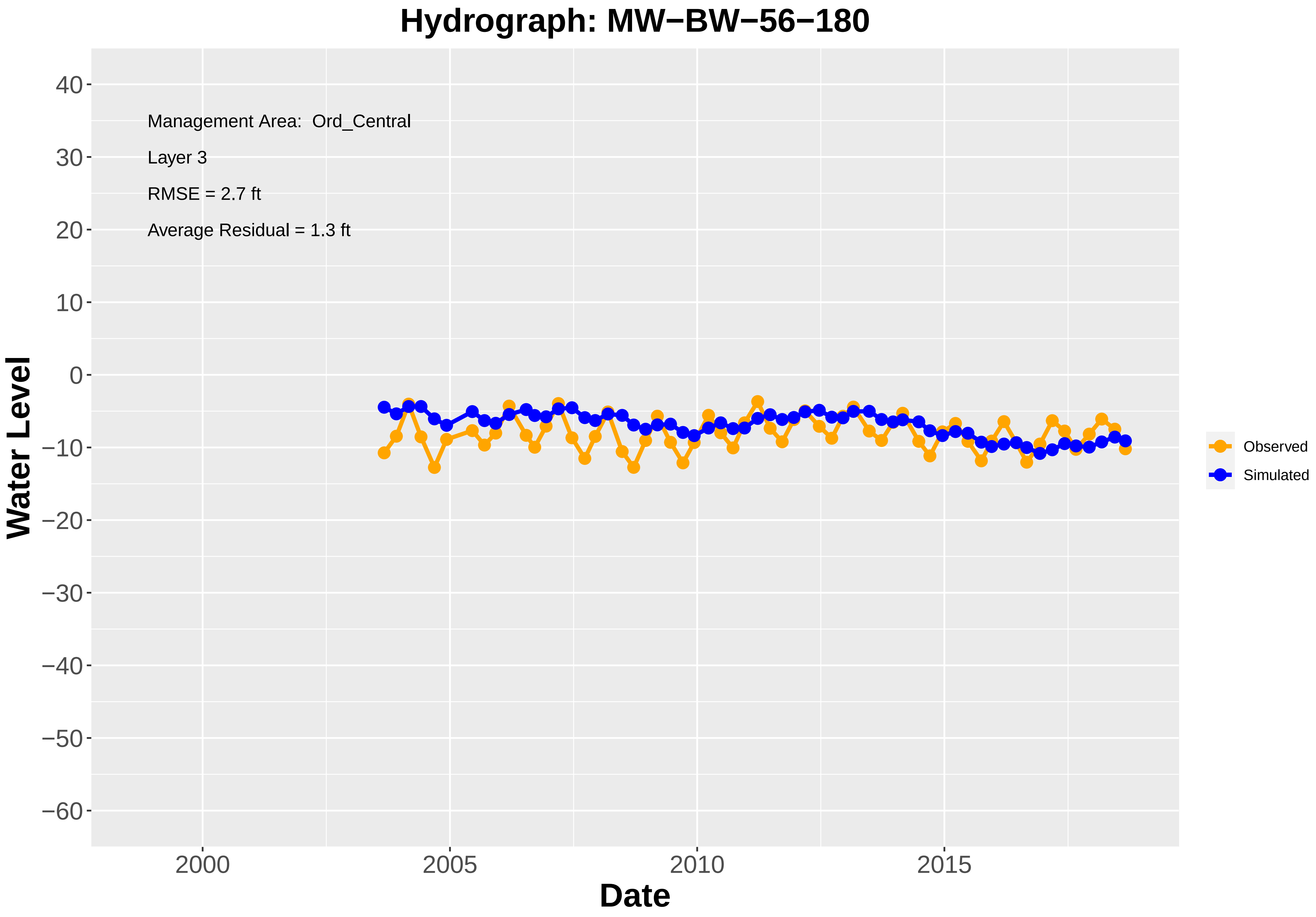

Hydrograph: MW−BW−53−A
Management Area: Ord_Central
Layer 1
RMSE = 12.9 ft
Average Residual = −12.8 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated

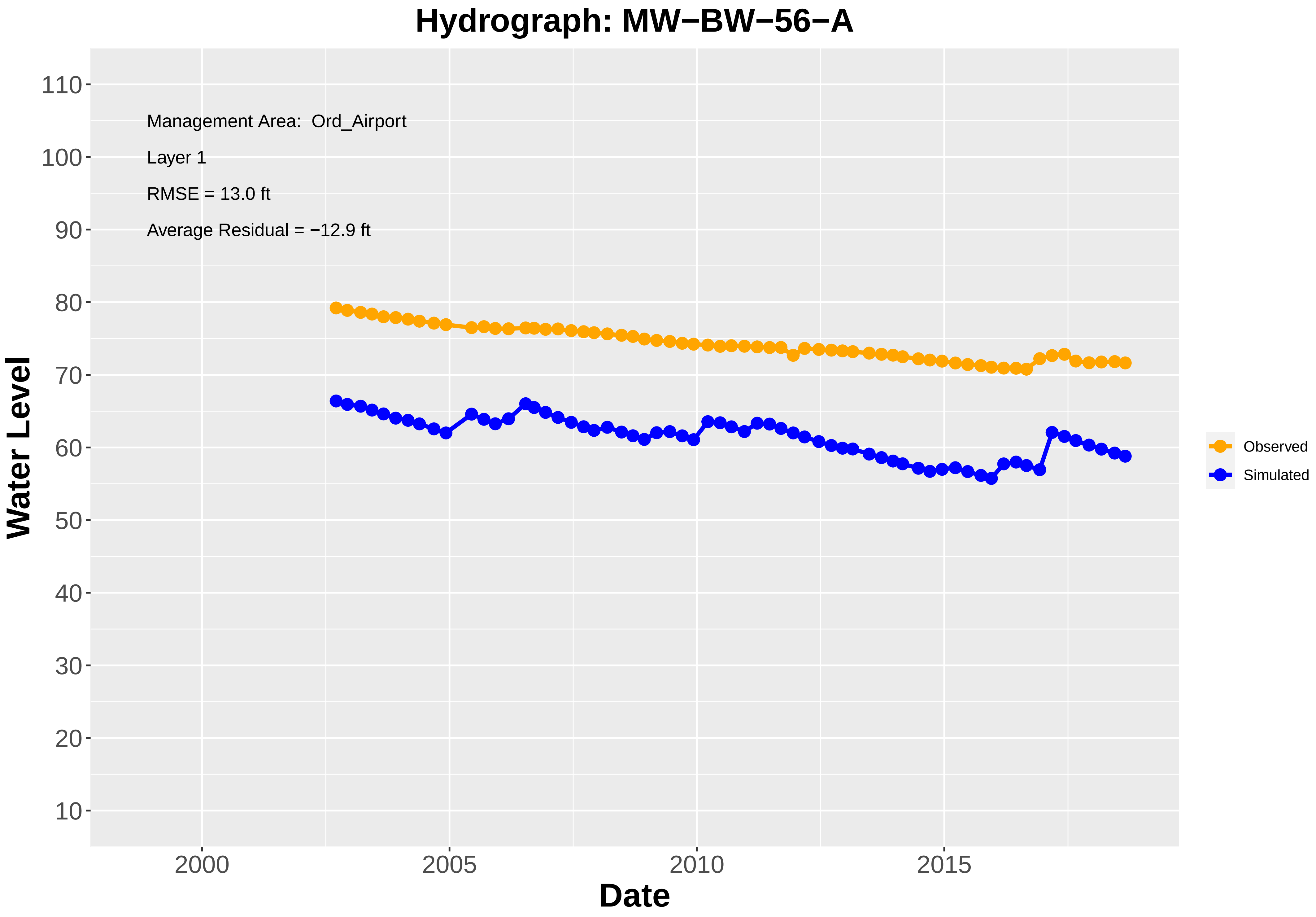

Hydrograph: MW−BW−54−180
Management Area: Ord_Airport
Layer 3
RMSE = 2.5 ft
Average Residual = −2.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

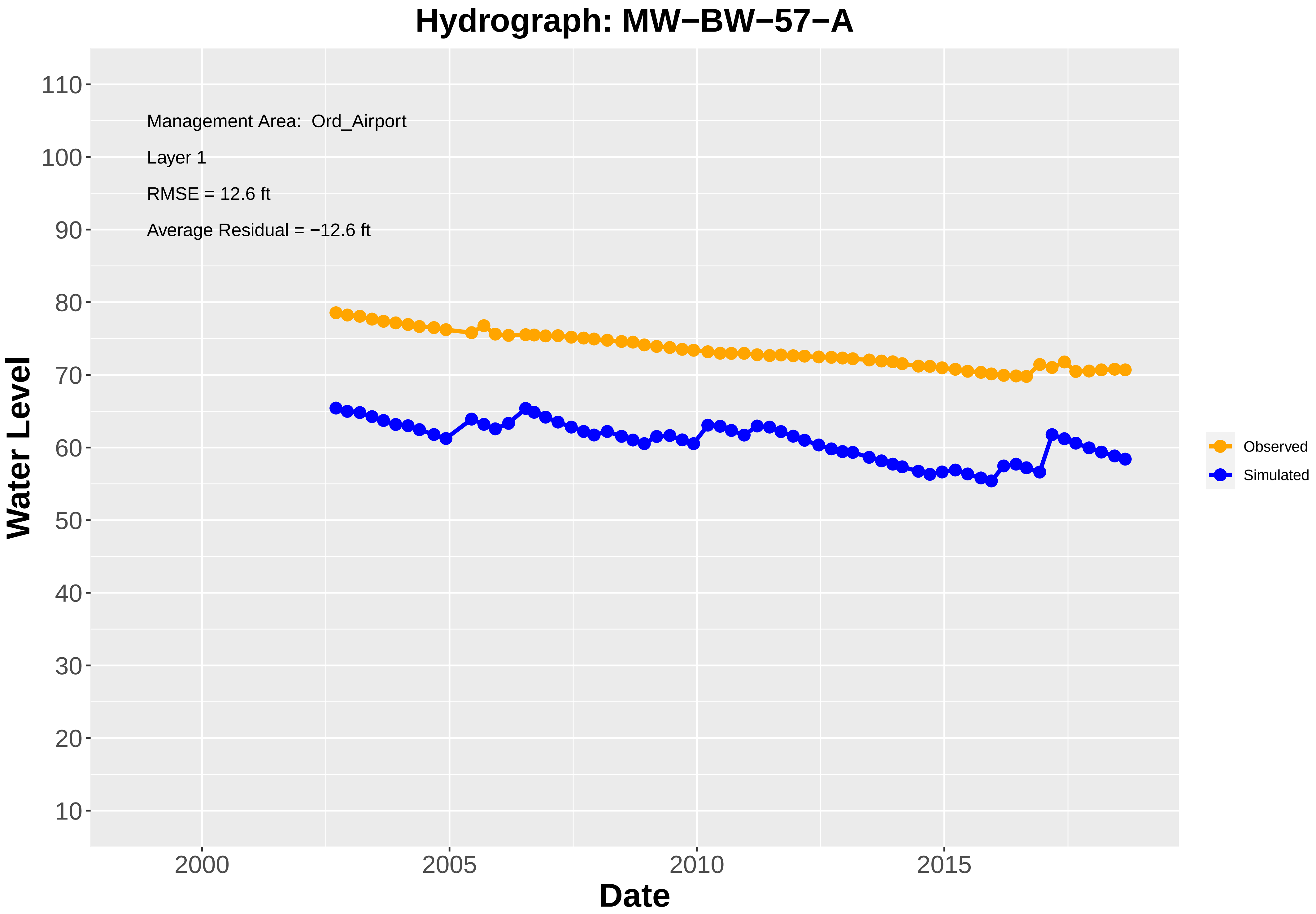

Hydrograph: MW−BW−54−A
Management Area: Ord_Central
Layer 1
RMSE = 12.9 ft
Average Residual = −12.8 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

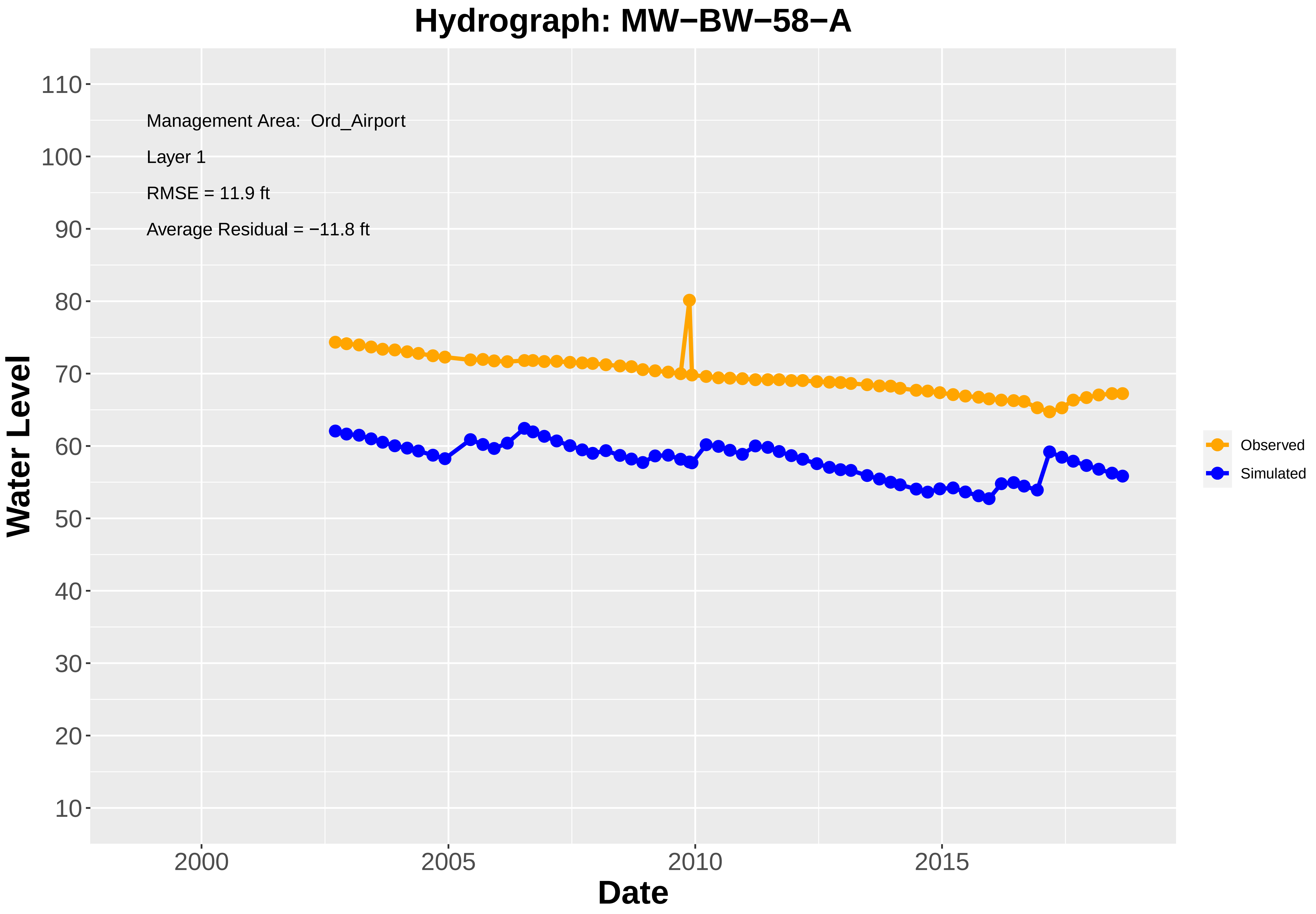

Hydrograph: MW−BW−55−180
Management Area: Ord_Airport
Layer 3
RMSE = 2.3 ft
Average Residual = −2.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

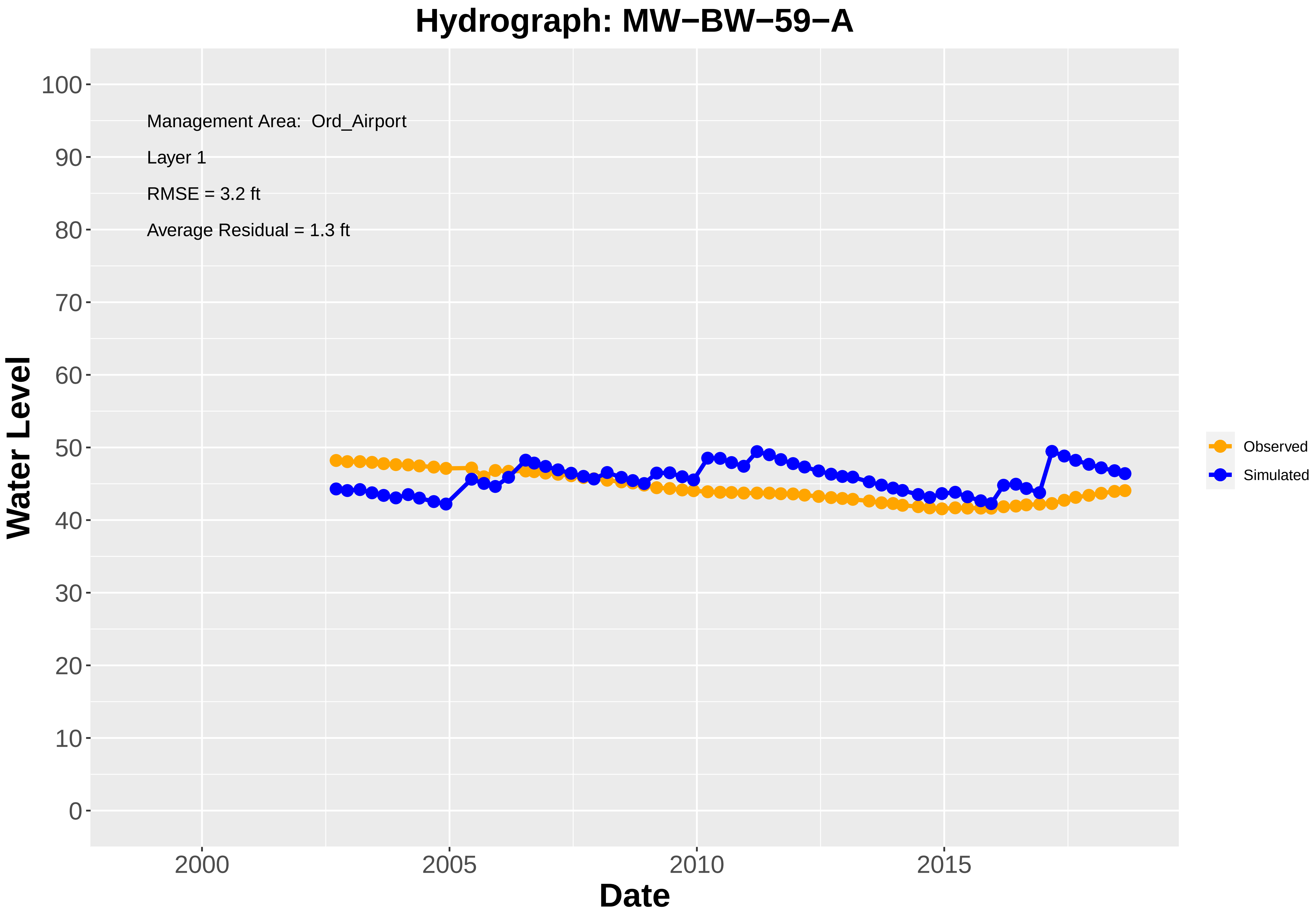

Hydrograph: MW−BW−55−A
Management Area: Ord_Central
Layer 1
RMSE = 13.3 ft
Average Residual = −13.2 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

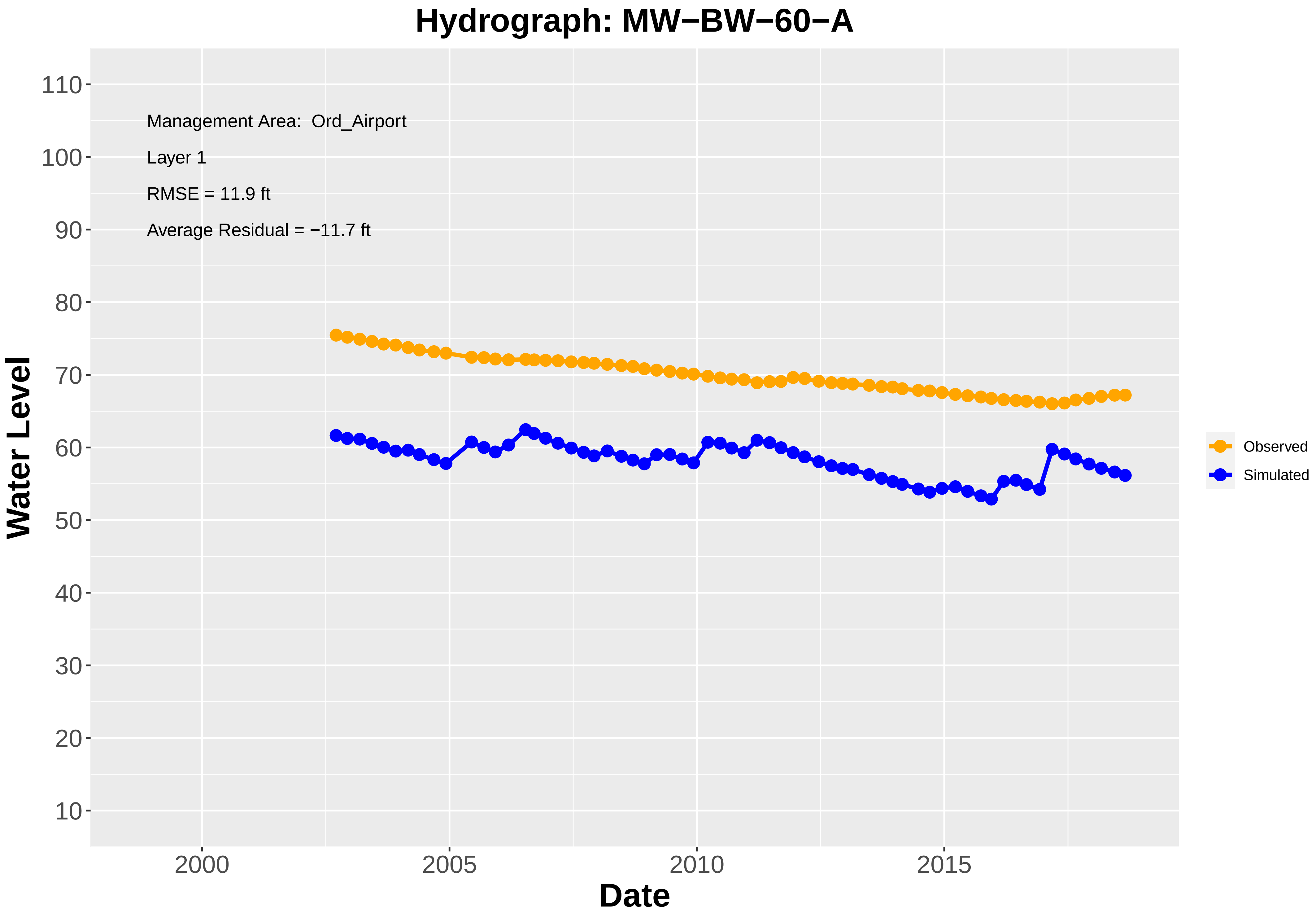

Hydrograph: MW−BW−56−180
Management Area: Ord_Central
Layer 3
RMSE = 2.7 ft
Average Residual = 1.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

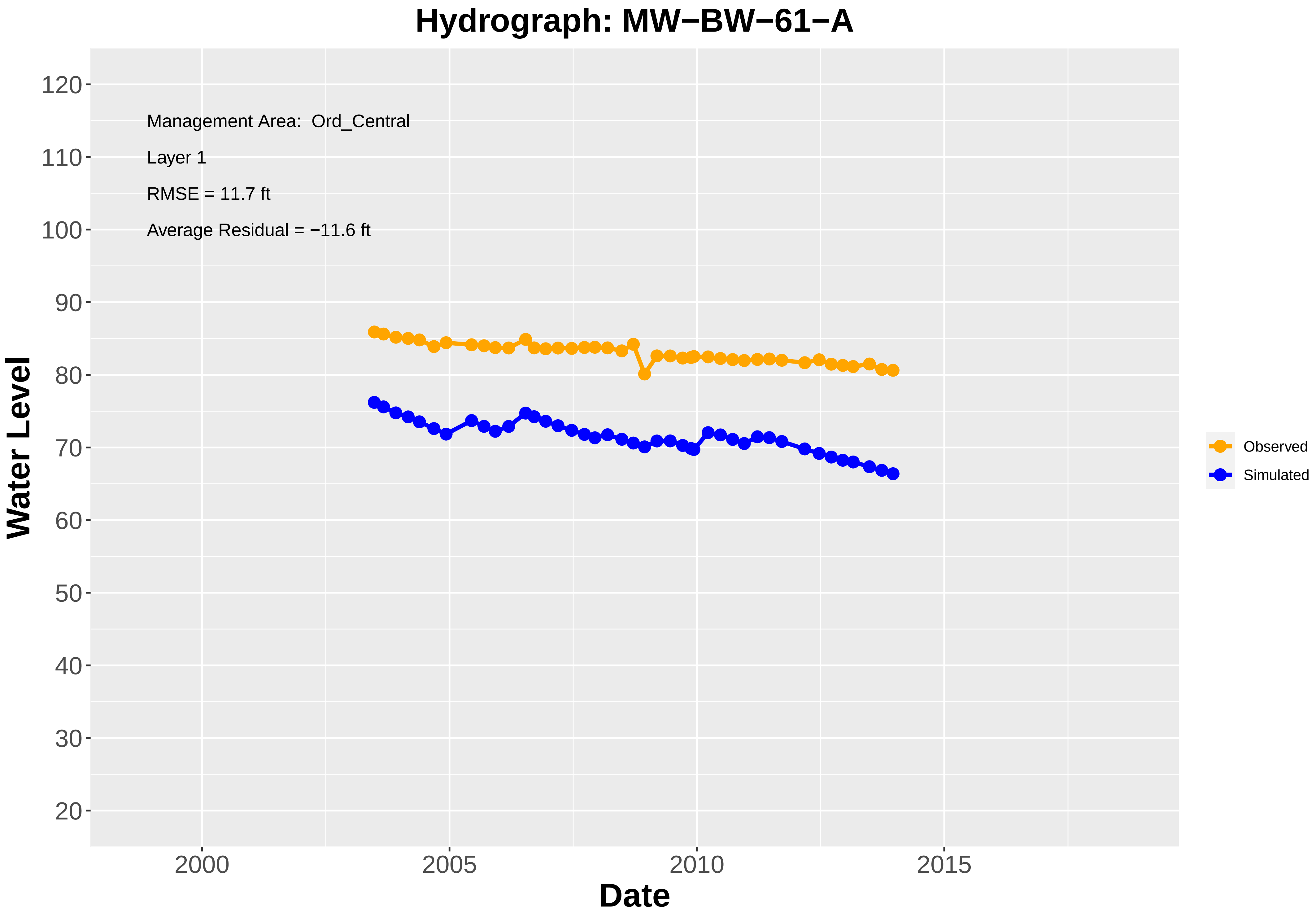

Hydrograph: MW−BW−56−A
Management Area: Ord_Airport
Layer 1
RMSE = 13.0 ft
Average Residual = −12.9 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

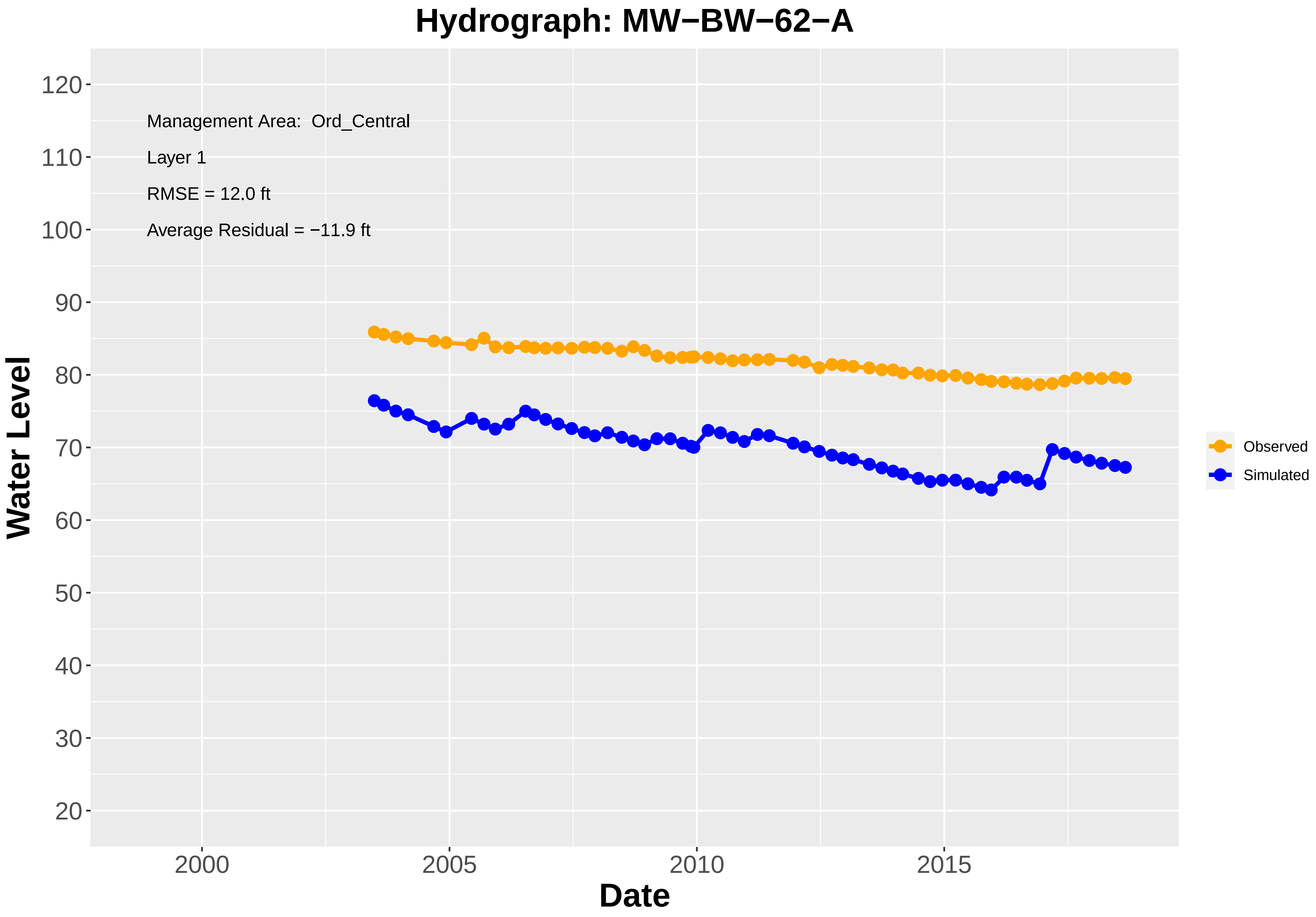

Hydrograph: MW−BW−57−A
Management Area: Ord_Airport
Layer 1
RMSE = 12.6 ft
Average Residual = −12.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−58−A
Management Area: Ord_Airport
Layer 1
RMSE = 11.9 ft
Average Residual = −11.8 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

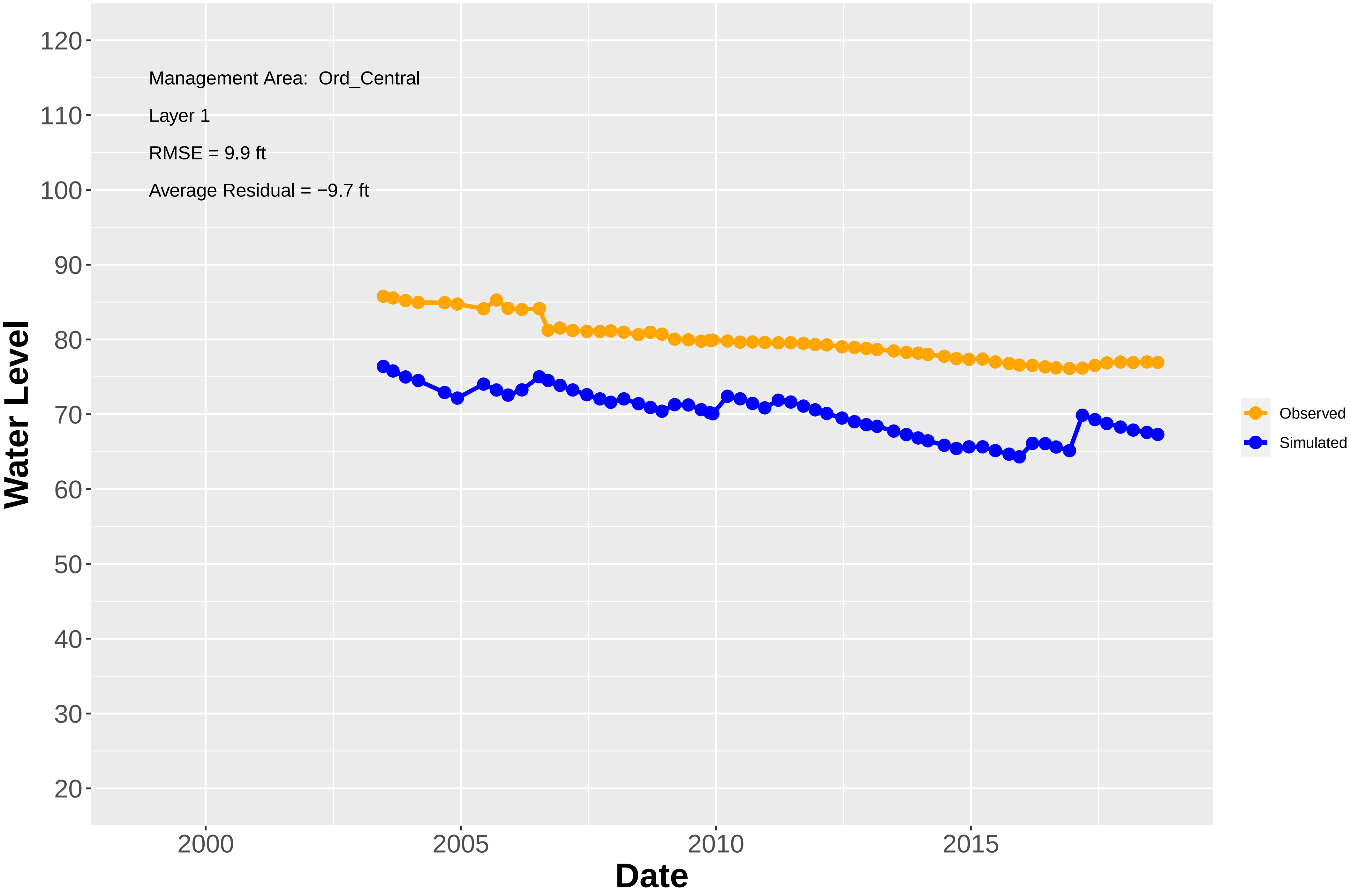

Hydrograph: MW−BW−59−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.2 ft
Average Residual = 1.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

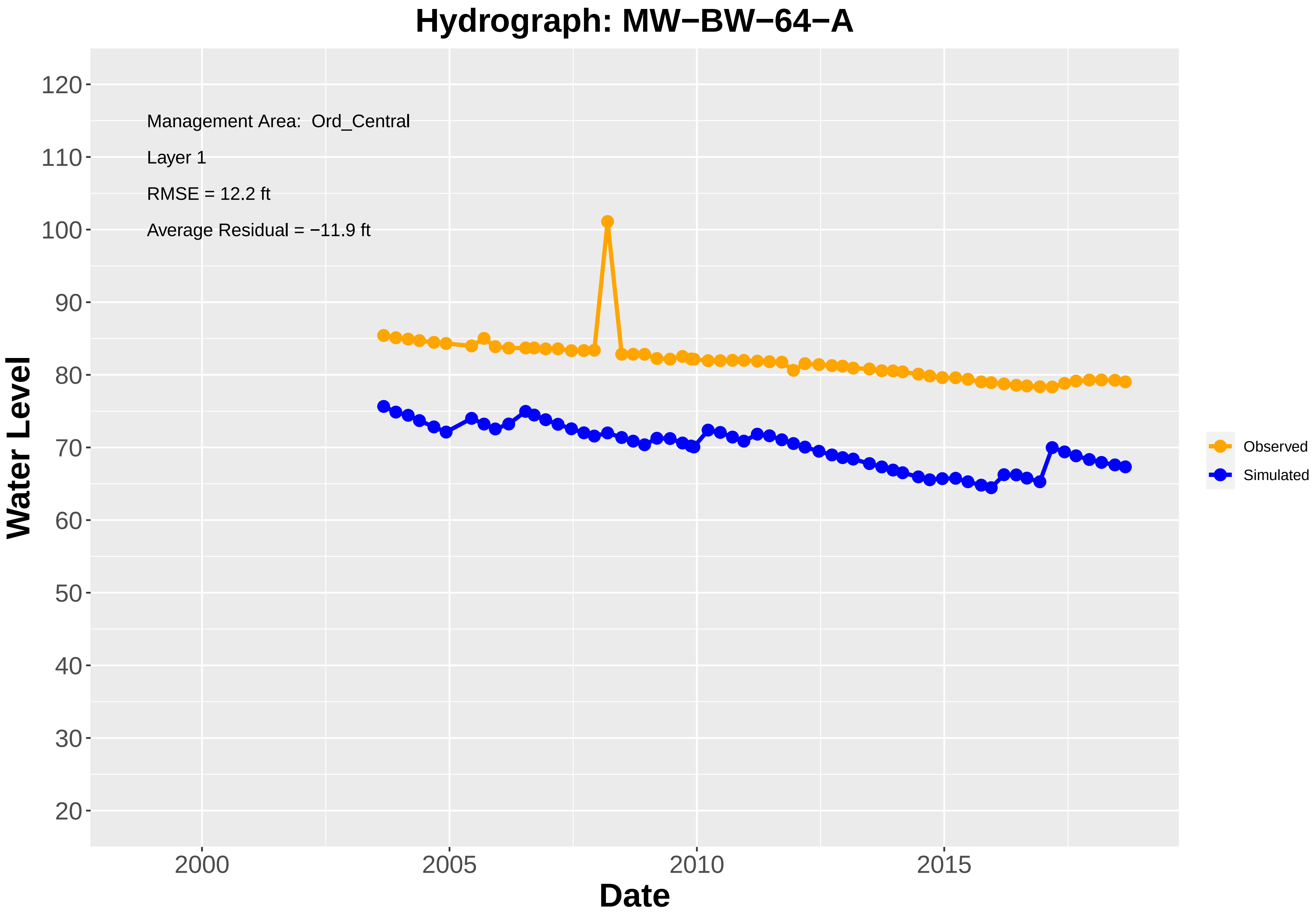

Hydrograph: MW−BW−60−A
Management Area: Ord_Airport
Layer 1
RMSE = 11.9 ft
Average Residual = −11.7 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

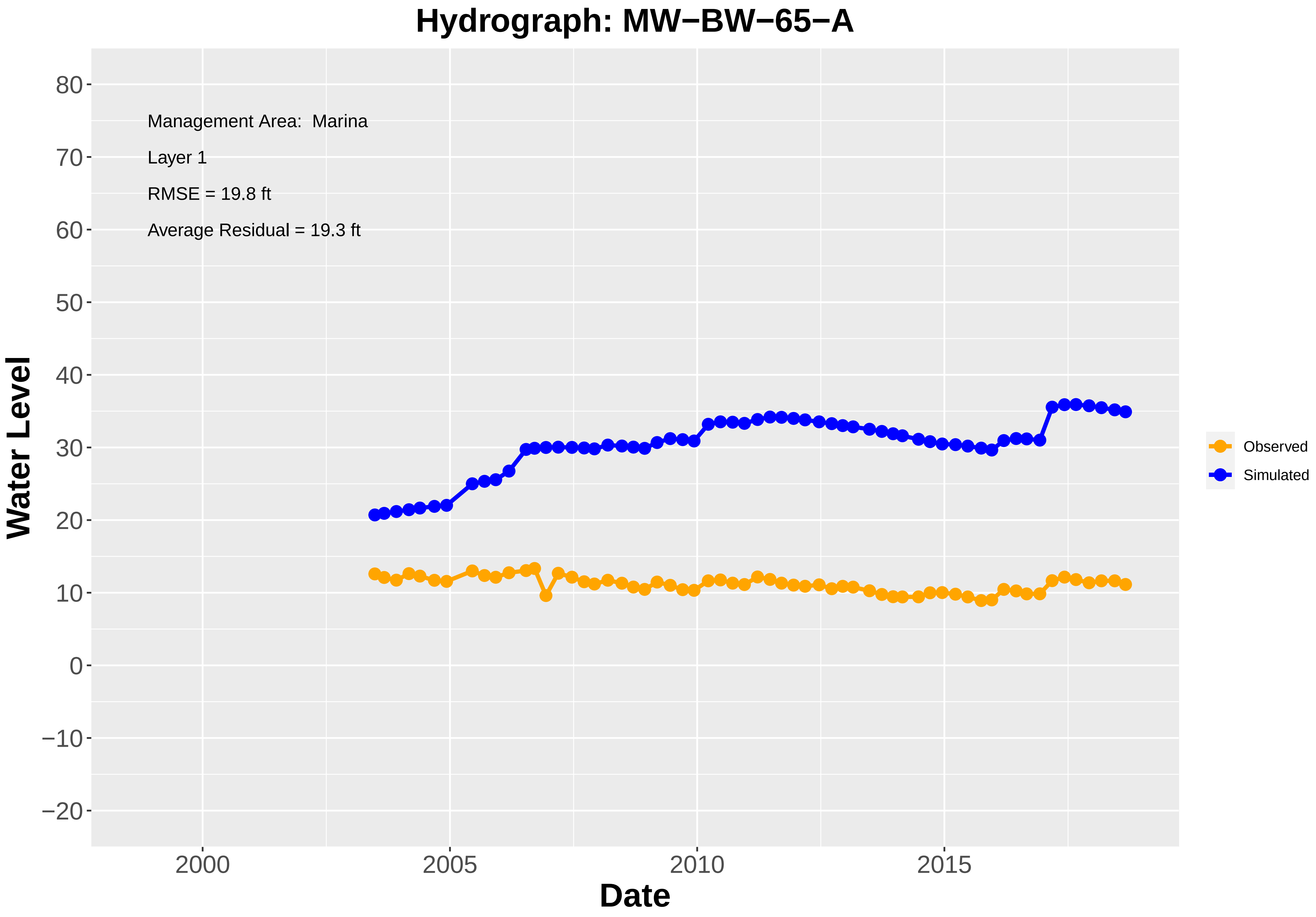

Hydrograph: MW−BW−61−A
Management Area: Ord_Central
Layer 1
RMSE = 11.7 ft
Average Residual = −11.6 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated

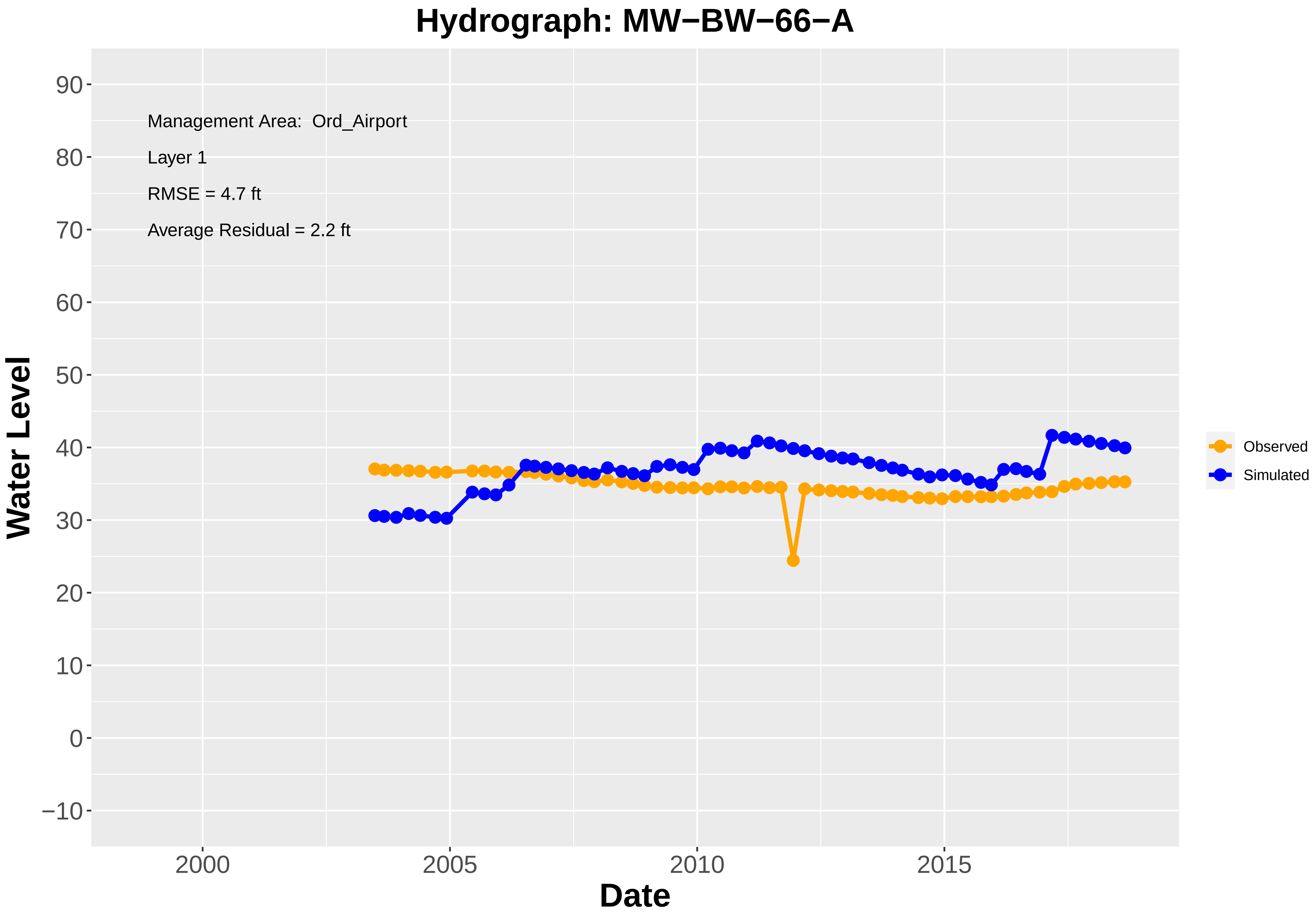

Hydrograph: MW−BW−62−A
Management Area: Ord_Central
Layer 1
RMSE = 12.0 ft
Average Residual = −11.9 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−BW−63−A

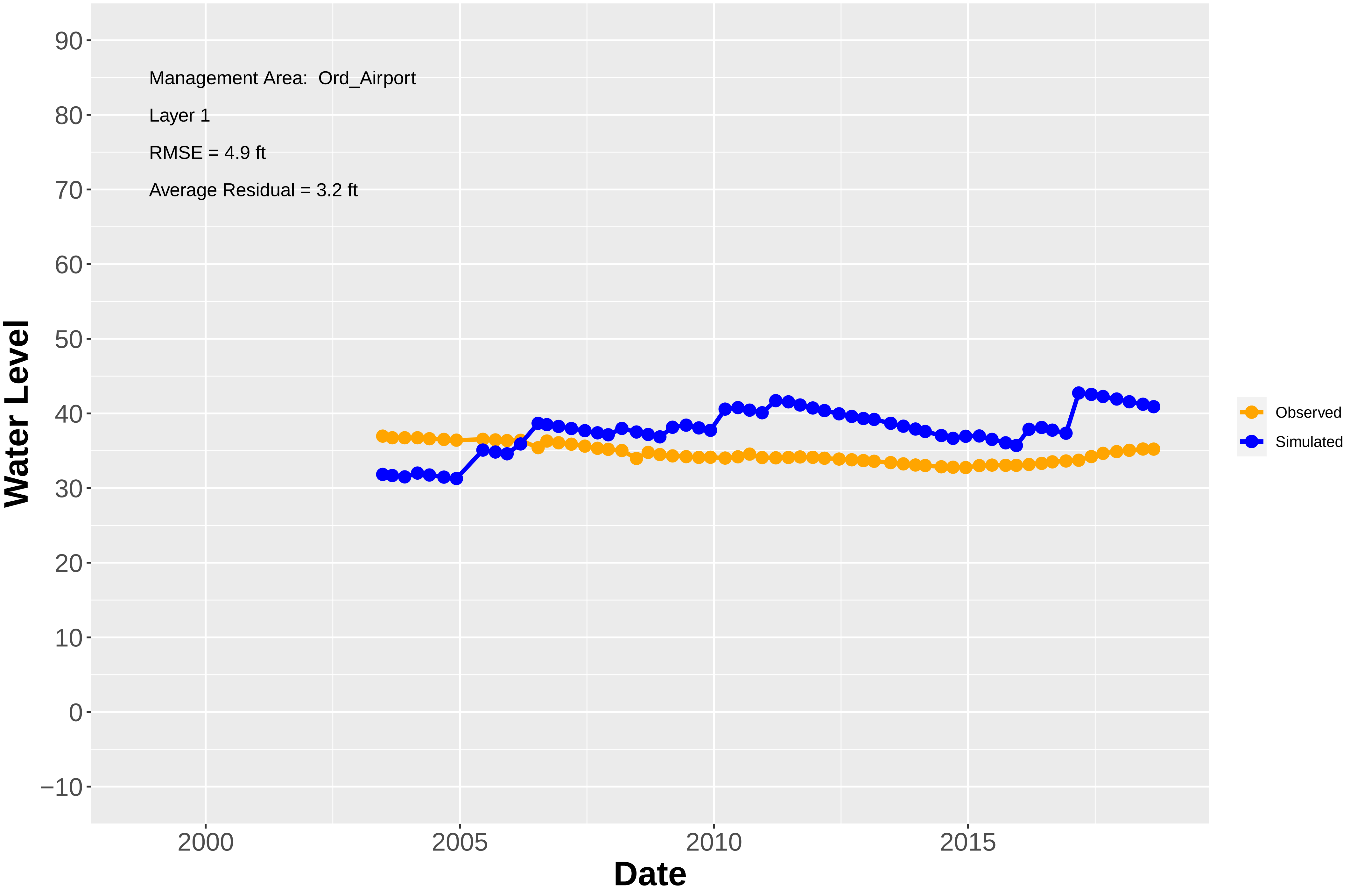


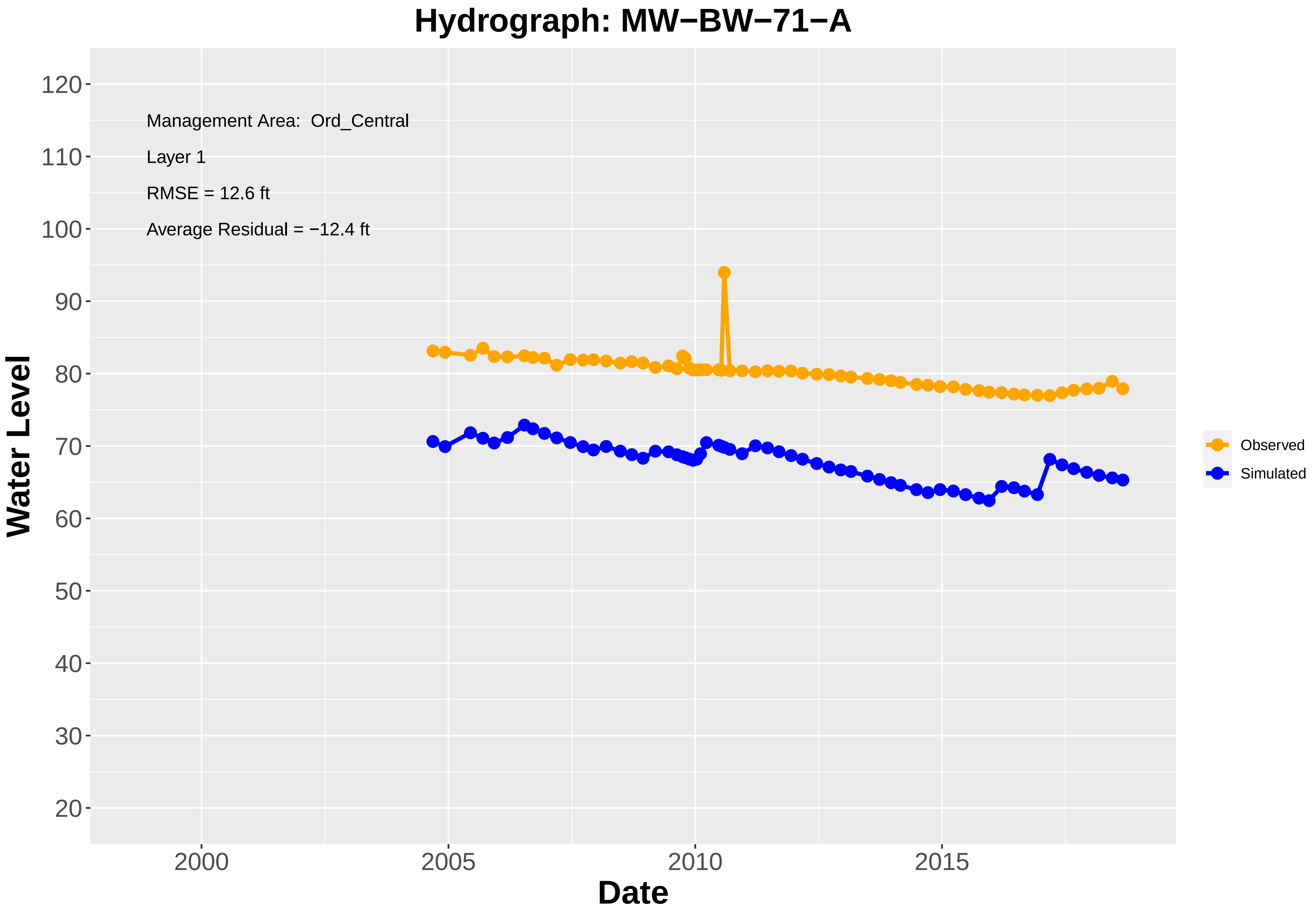

Hydrograph: MW−BW−64−A
Management Area: Ord_Central
Layer 1
RMSE = 12.2 ft
Average Residual = −11.9 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

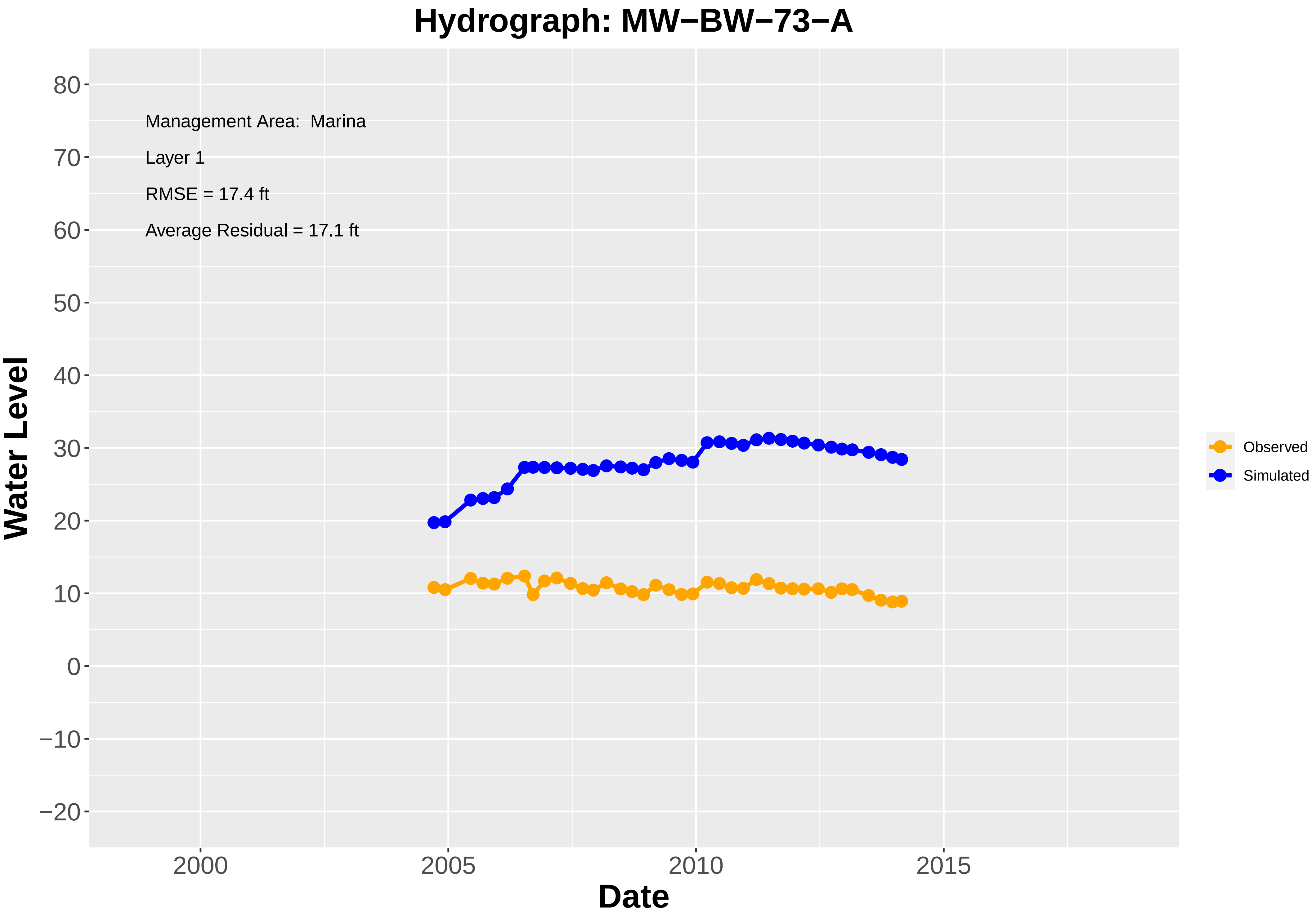

Hydrograph: MW−BW−65−A
Management Area: Marina
Layer 1
RMSE = 19.8 ft
Average Residual = 19.3 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated

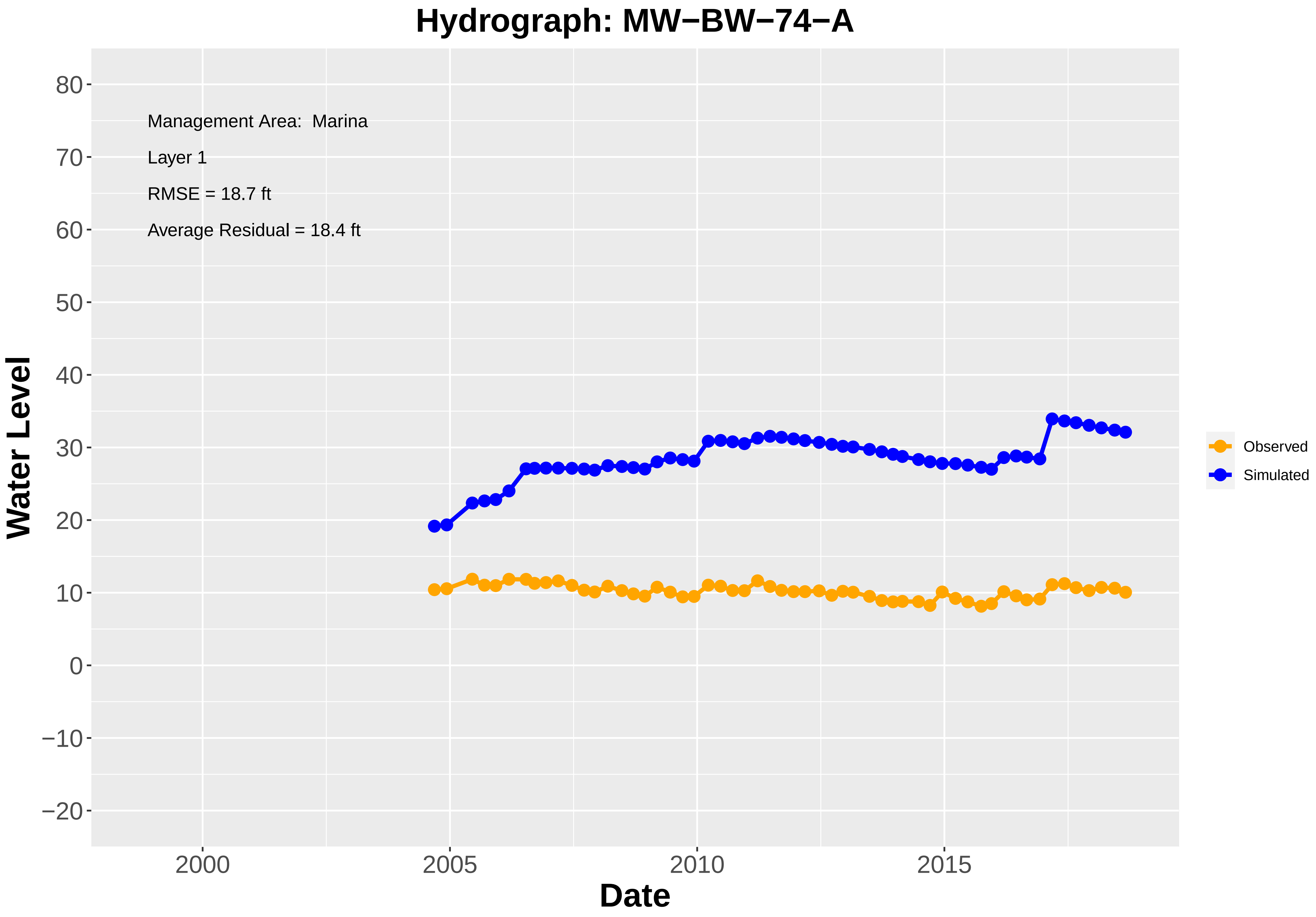

Hydrograph: MW−BW−66−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.7 ft
Average Residual = 2.2 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

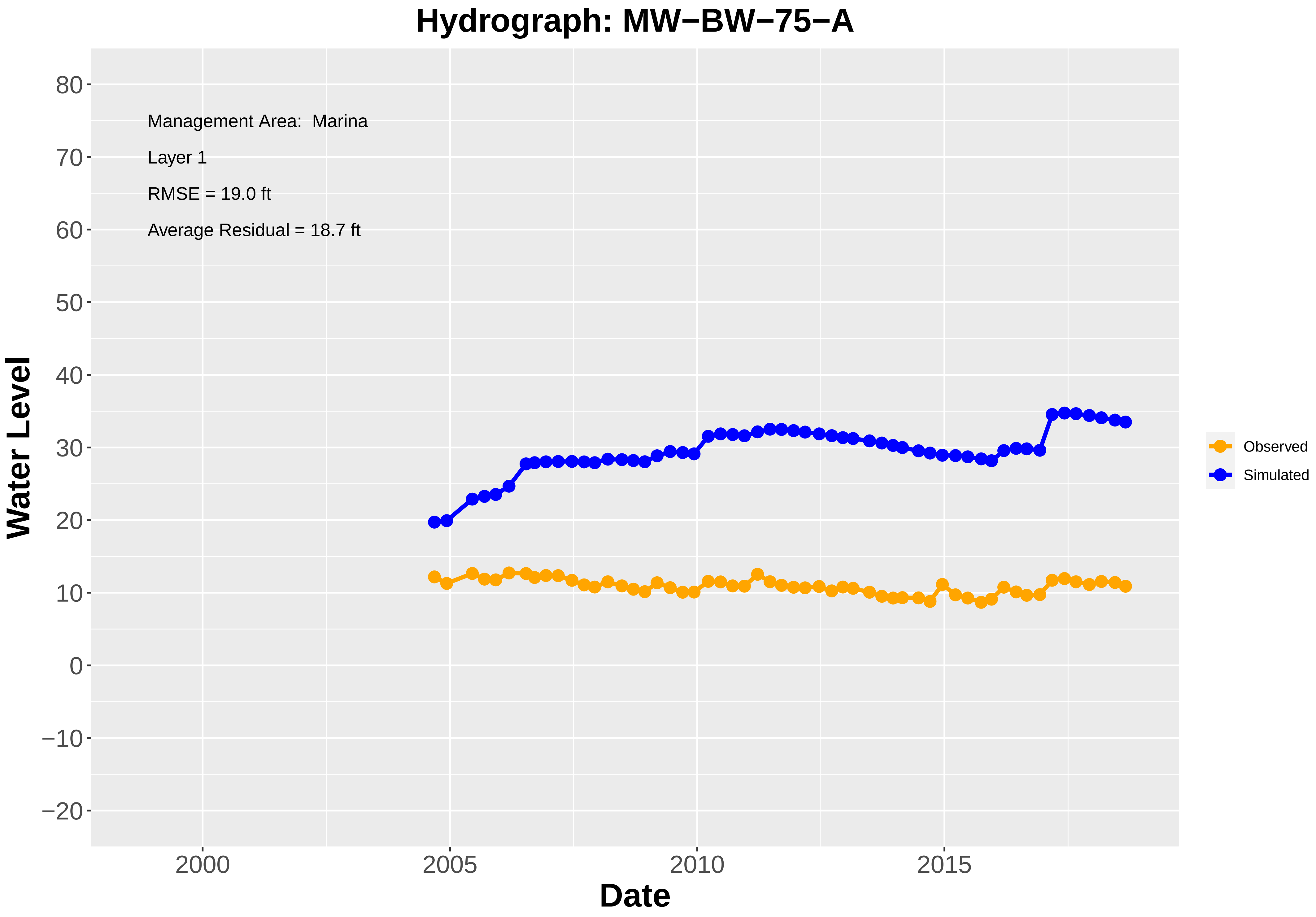
Hydrograph: MW−BW−67−A

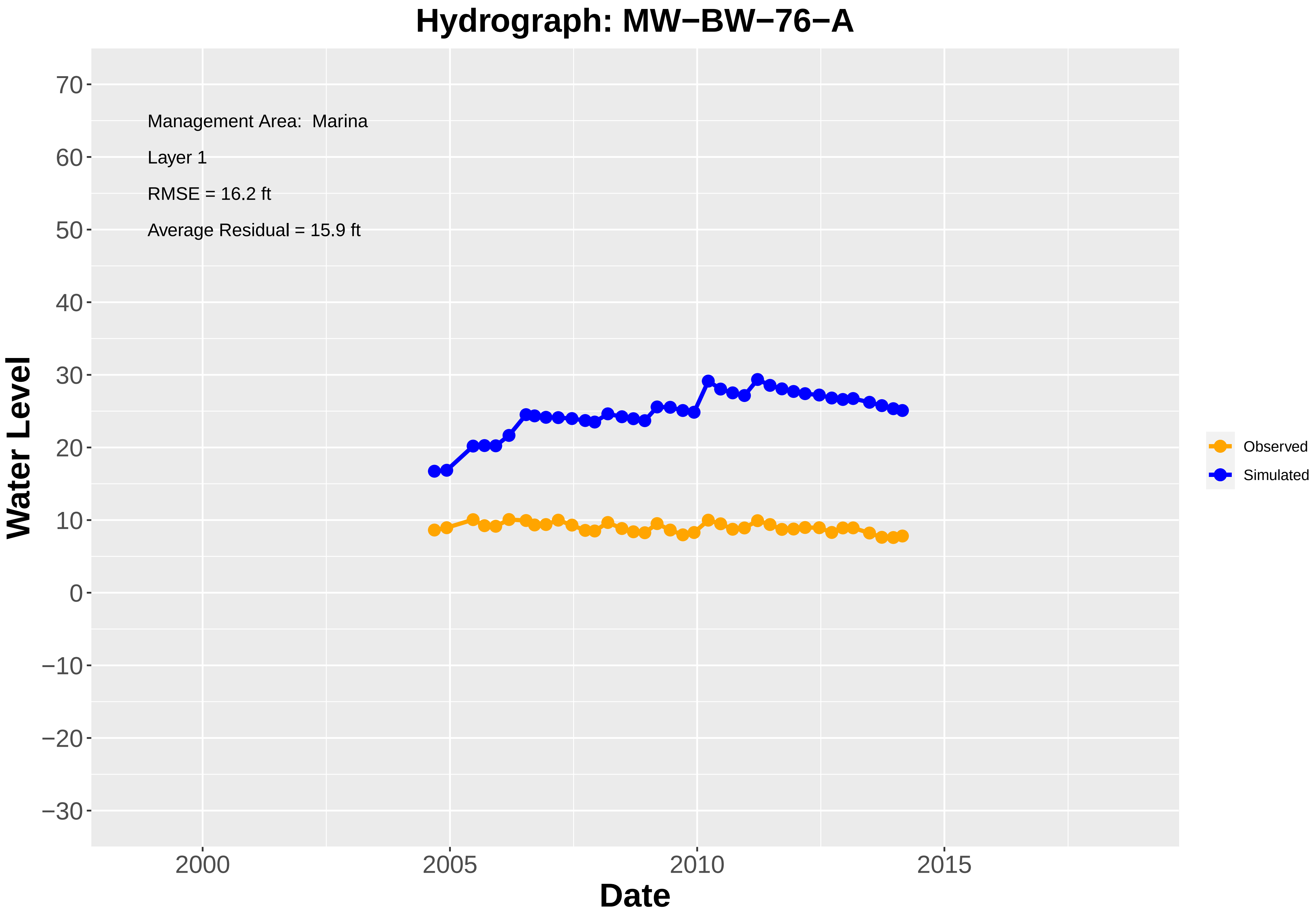



Hydrograph: MW−BW−71−A
Management Area: Ord_Central
Layer 1
RMSE = 12.6 ft
Average Residual = −12.4 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

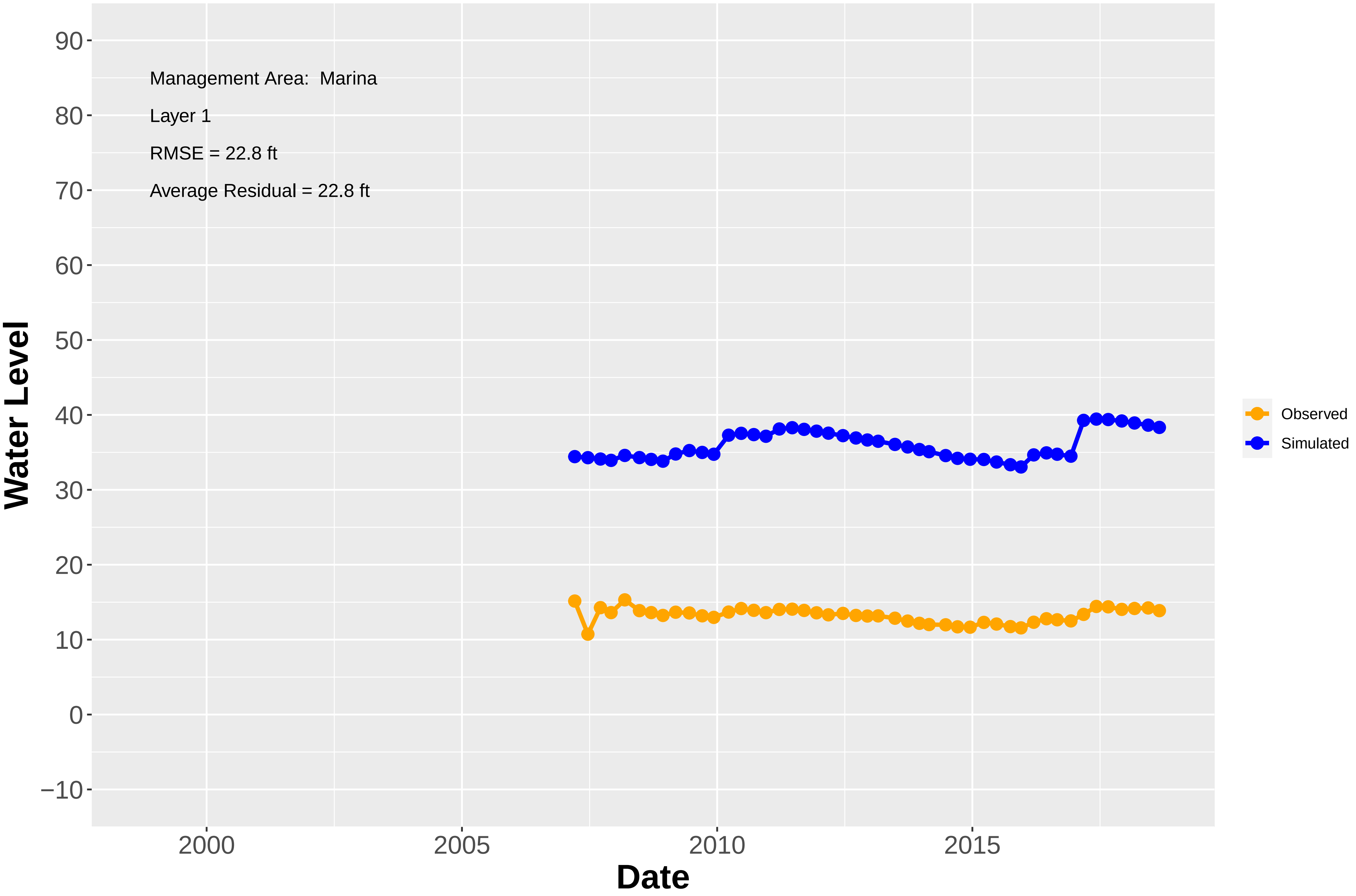

Hydrograph: MW−BW−73−A
Management Area: Marina
Layer 1
RMSE = 17.4 ft
Average Residual = 17.1 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

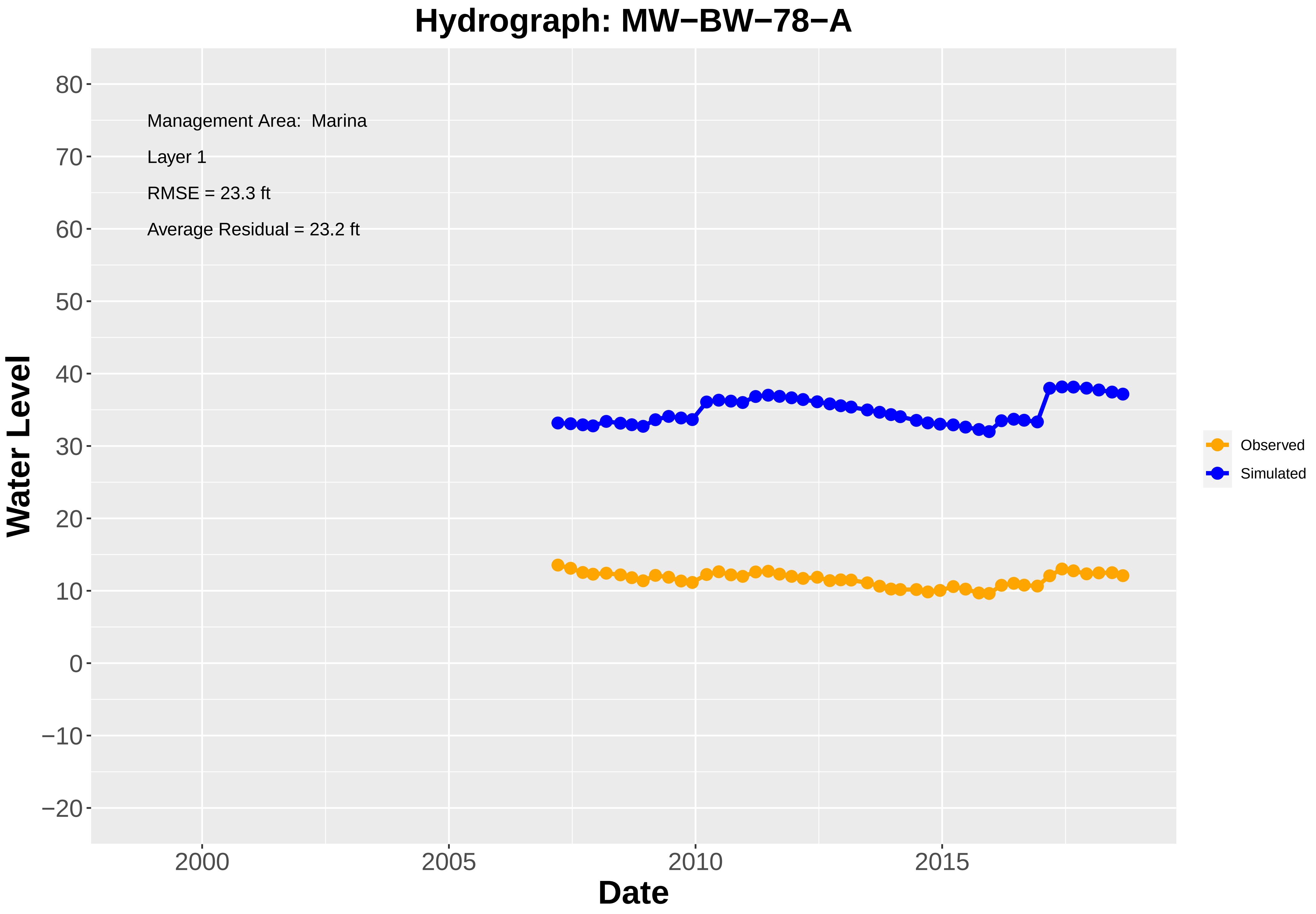

Hydrograph: MW−BW−74−A
Management Area: Marina
Layer 1
RMSE = 18.7 ft
Average Residual = 18.4 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

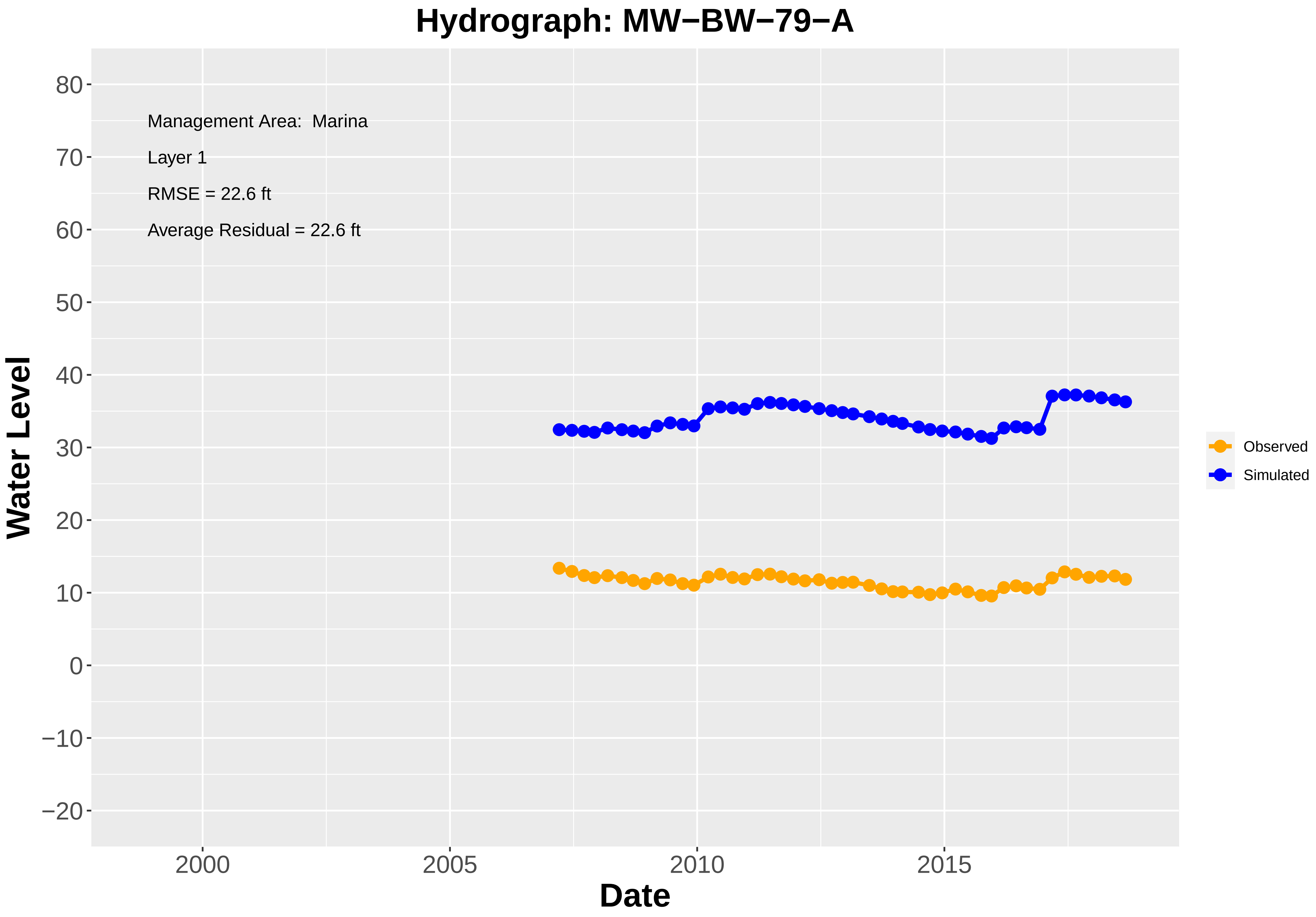

Hydrograph: MW−BW−75−A
Management Area: Marina
Layer 1
RMSE = 19.0 ft
Average Residual = 18.7 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

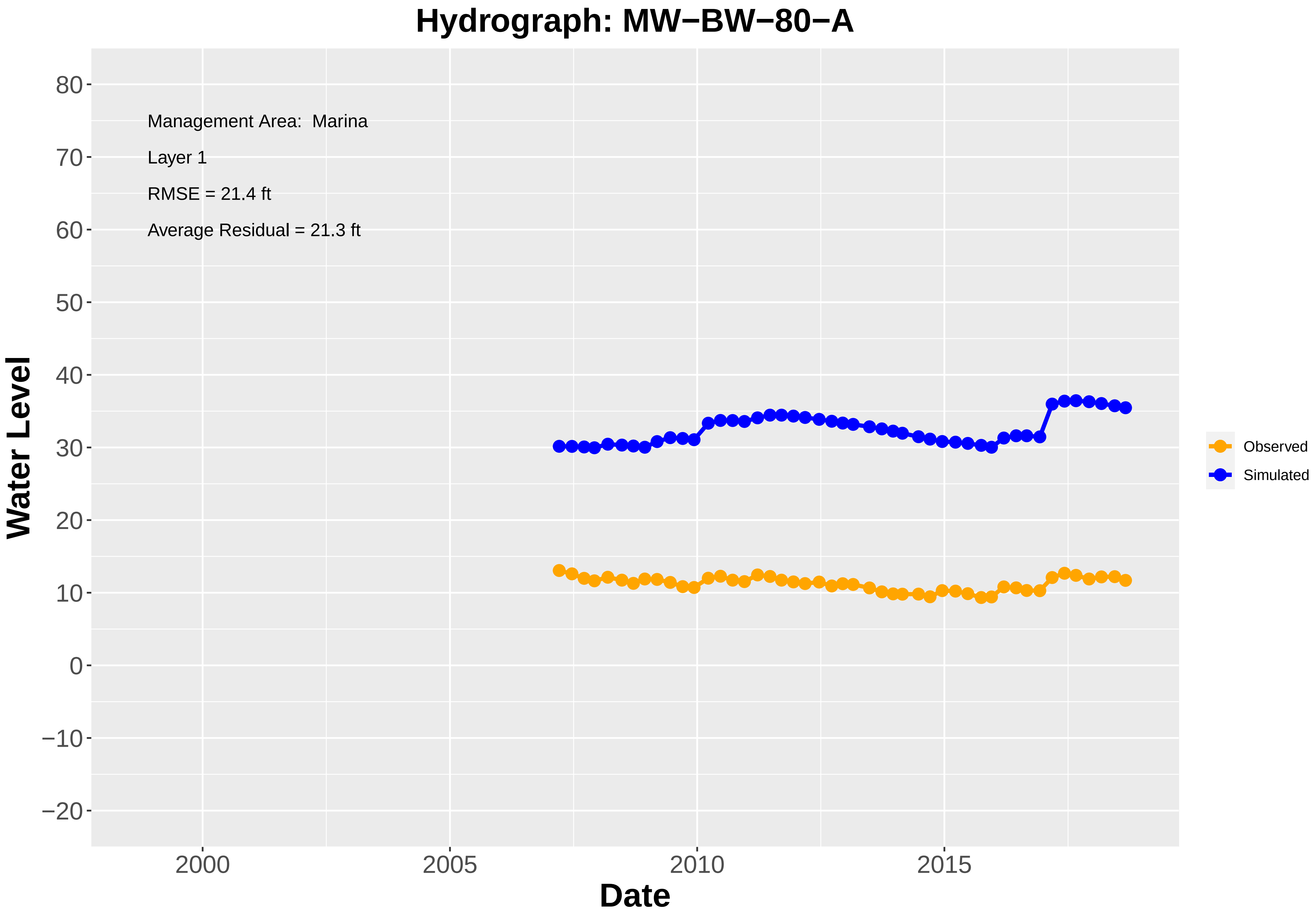

Hydrograph: MW−BW−76−A
Management Area: Marina
Layer 1
RMSE = 16.2 ft
Average Residual = 15.9 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−BW−77−A

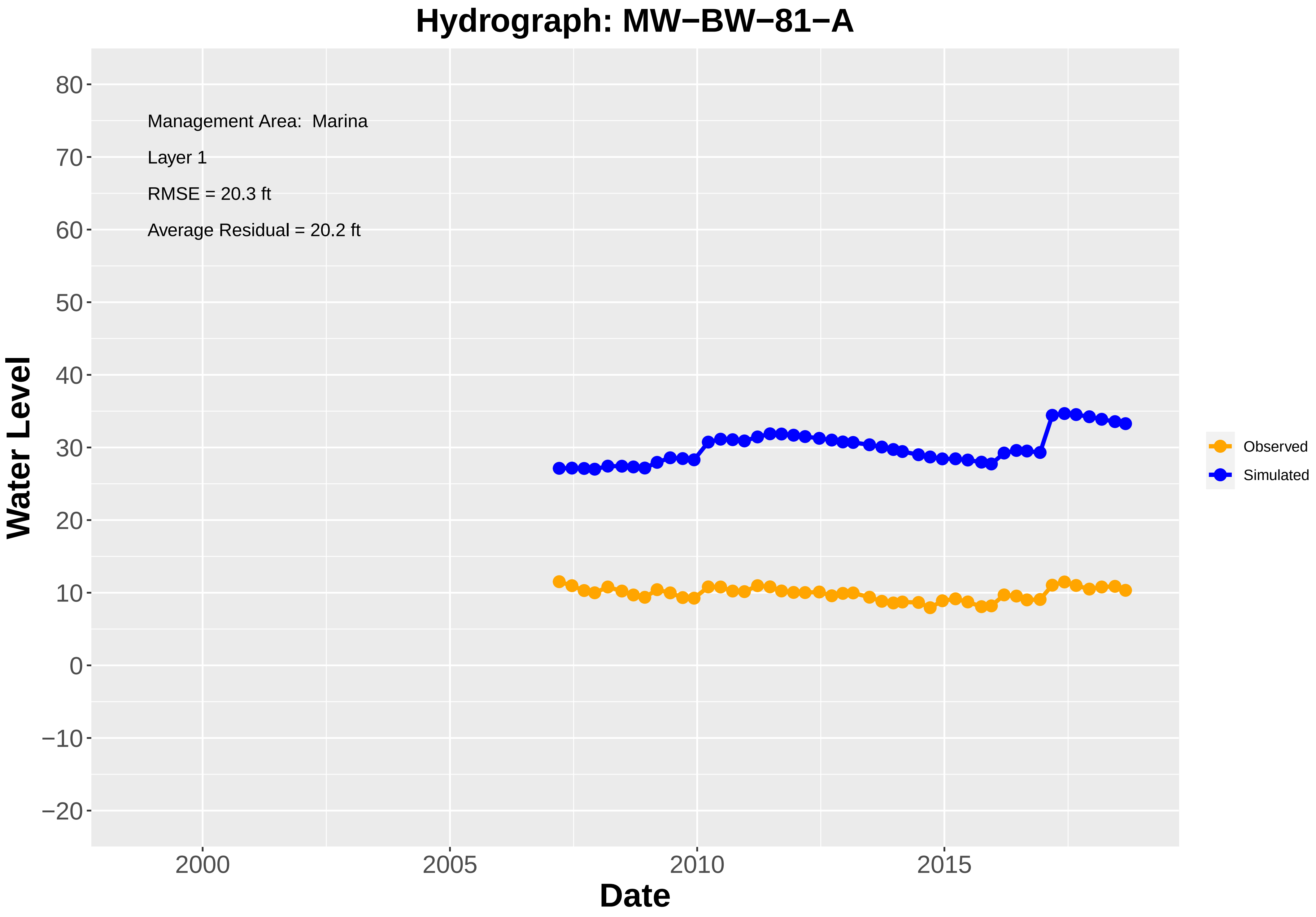


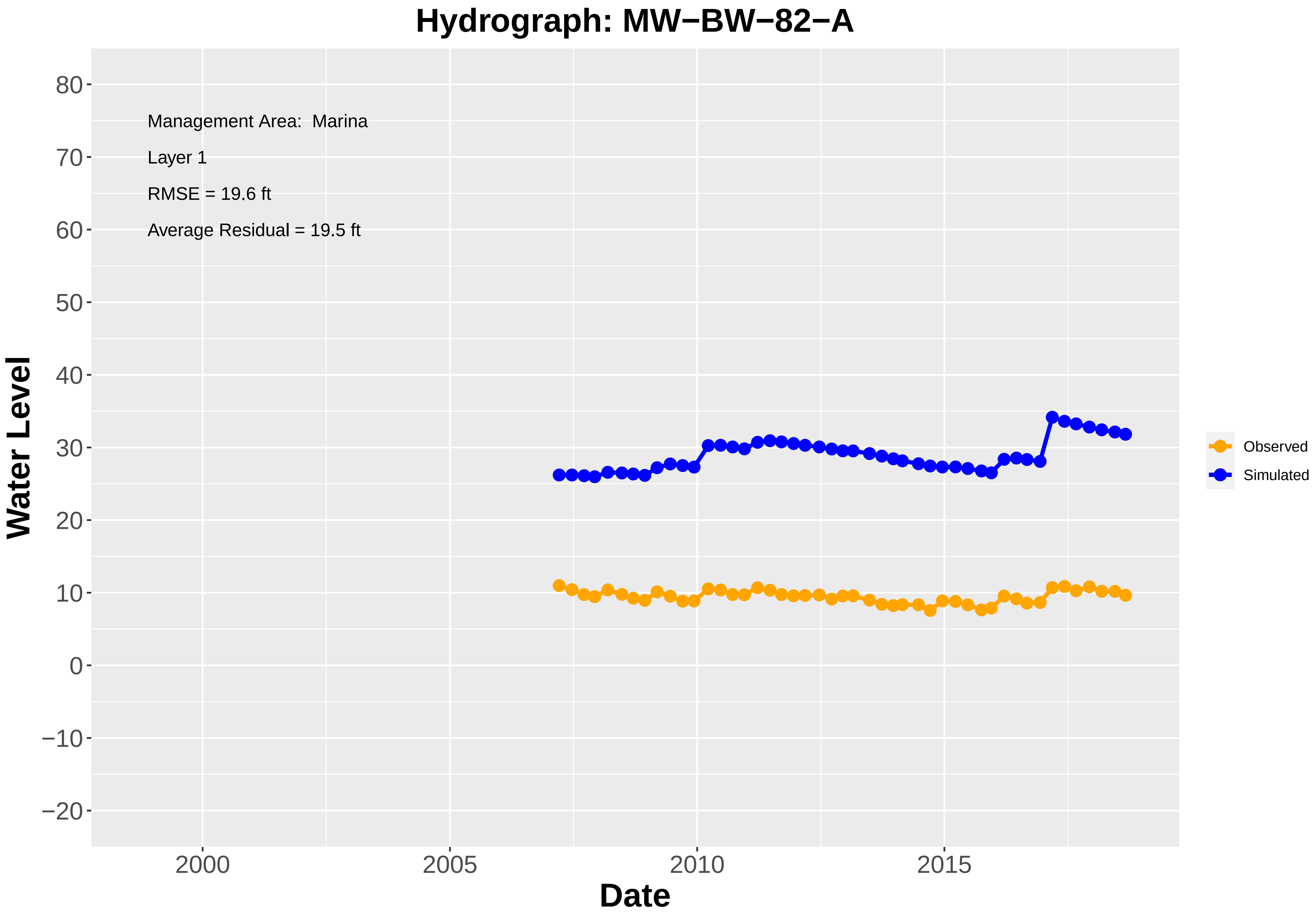

Hydrograph: MW−BW−78−A
Management Area: Marina
Layer 1
RMSE = 23.3 ft
Average Residual = 23.2 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

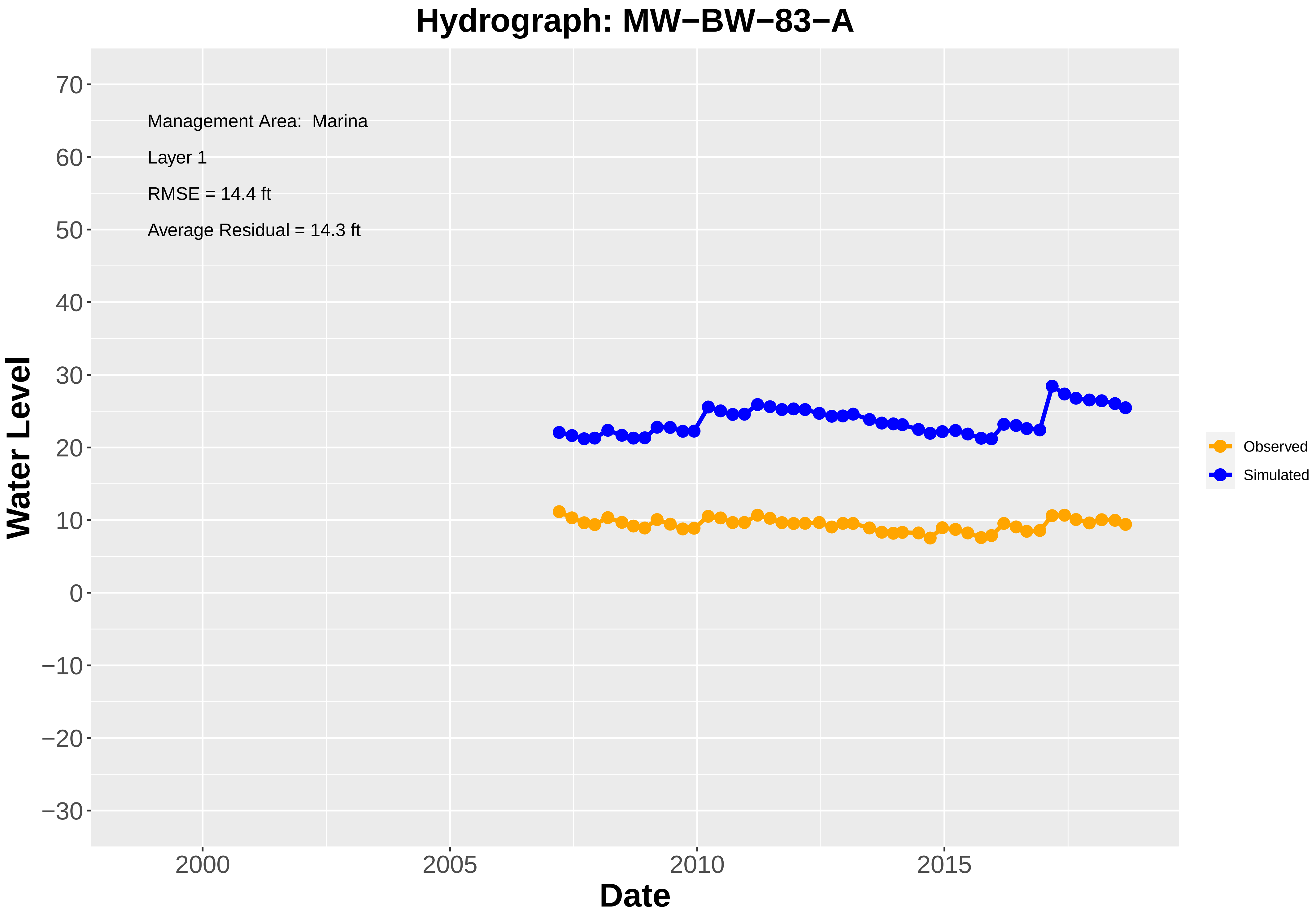

Hydrograph: MW−BW−79−A
Management Area: Marina
Layer 1
RMSE = 22.6 ft
Average Residual = 22.6 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated



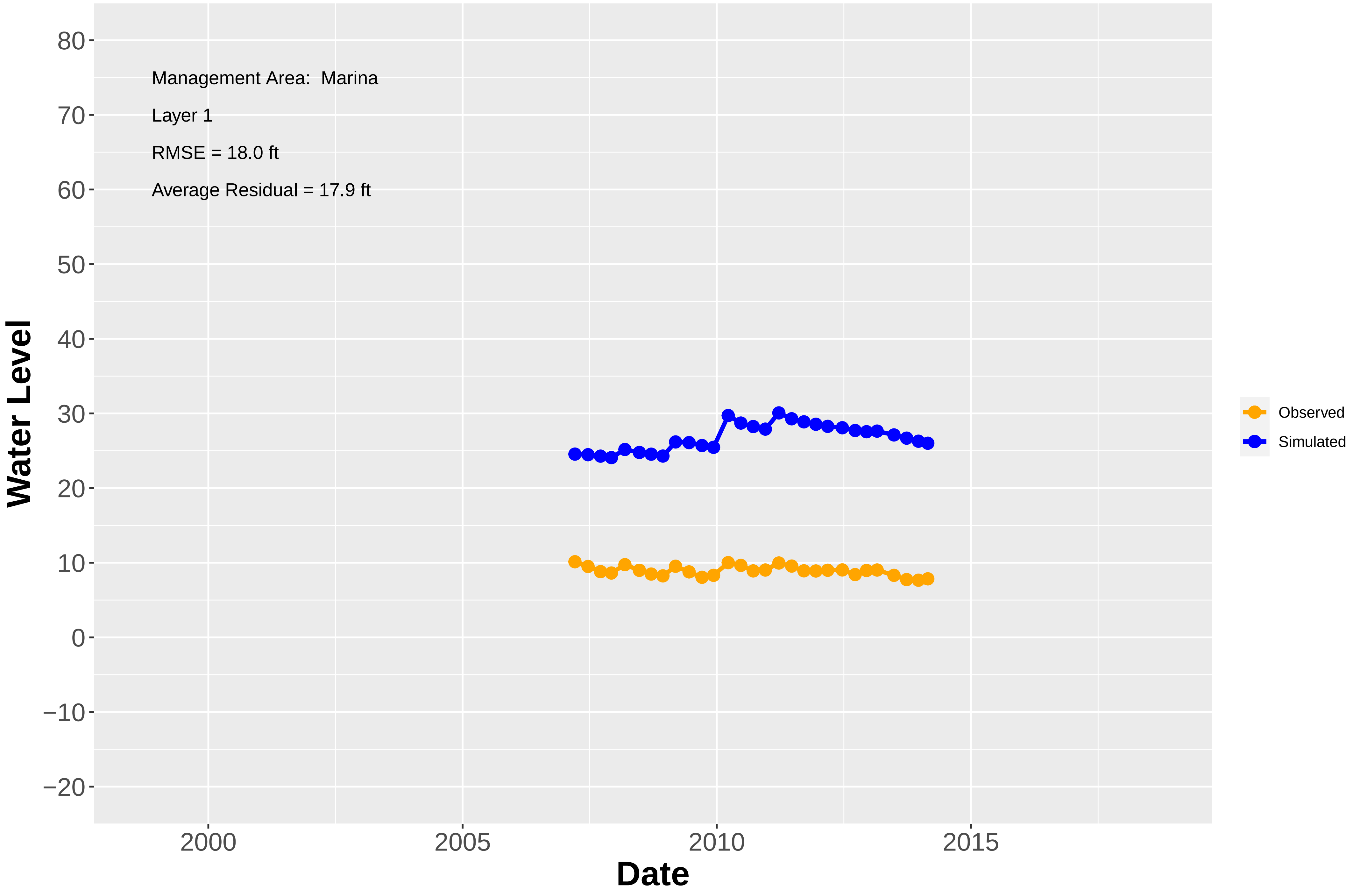
Hydrograph: MW−BW−80−A
Management Area: Marina
Layer 1
RMSE = 21.4 ft
Average Residual = 21.3 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated

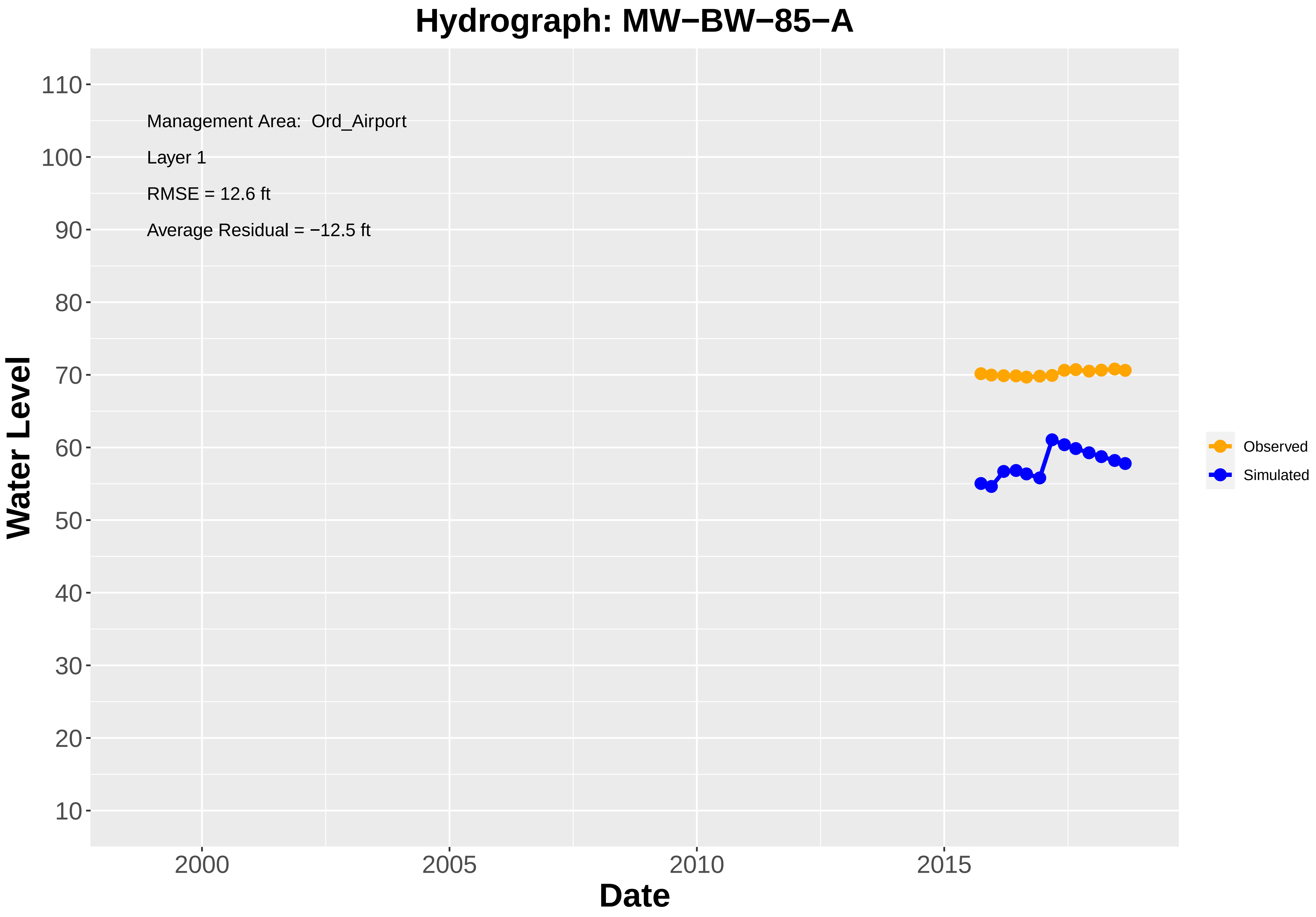

Hydrograph: MW−BW−81−A
Management Area: Marina
Layer 1
RMSE = 20.3 ft
Average Residual = 20.2 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−BW−82−A
Management Area: Marina
Layer 1
RMSE = 19.6 ft
Average Residual = 19.5 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

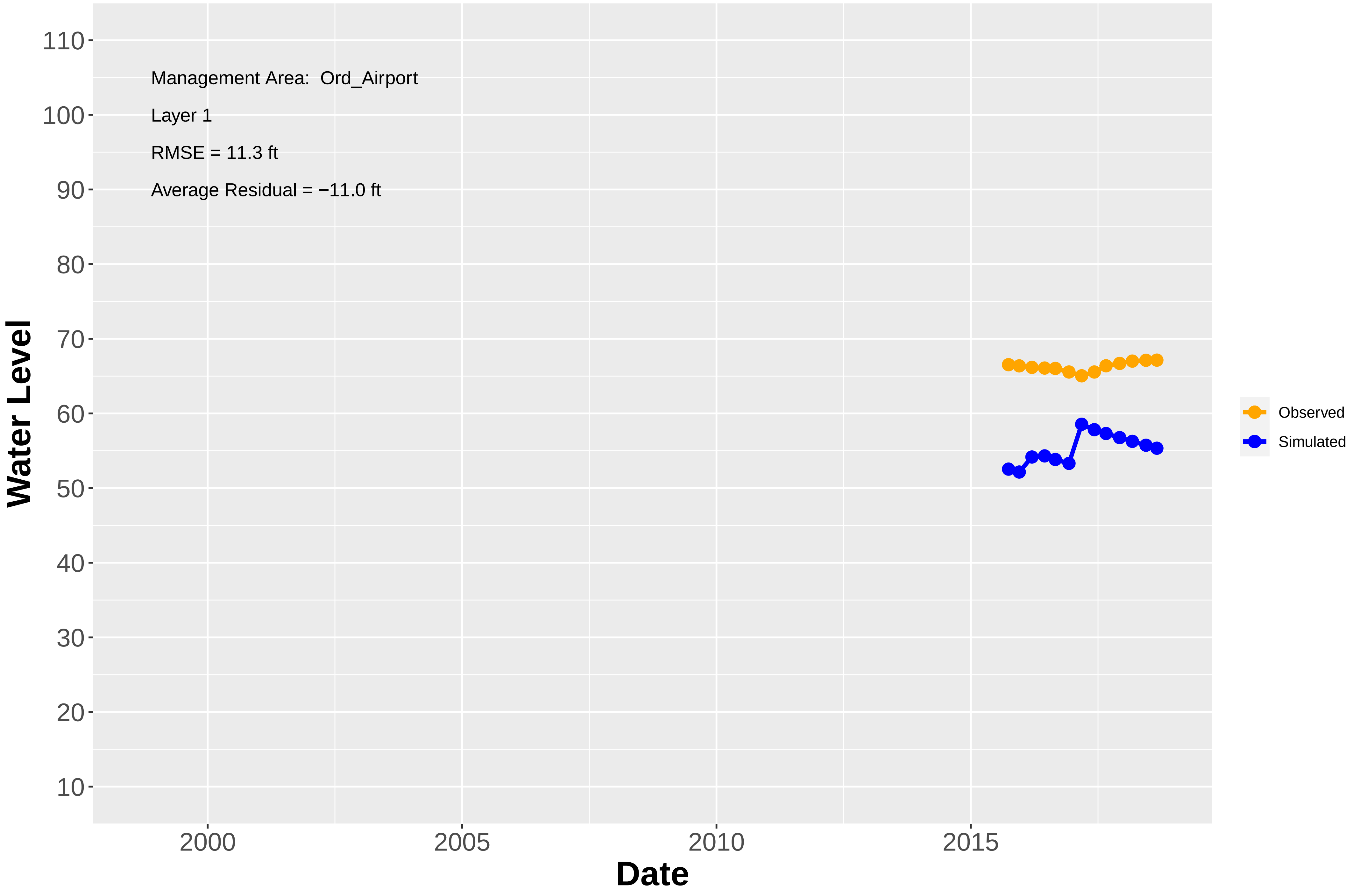

Hydrograph: MW−BW−83−A
Management Area: Marina
Layer 1
RMSE = 14.4 ft
Average Residual = 14.3 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
2000
2005
2010
2015
Date
Observed
Simulated

Hydrograph: MW−BW−84−A

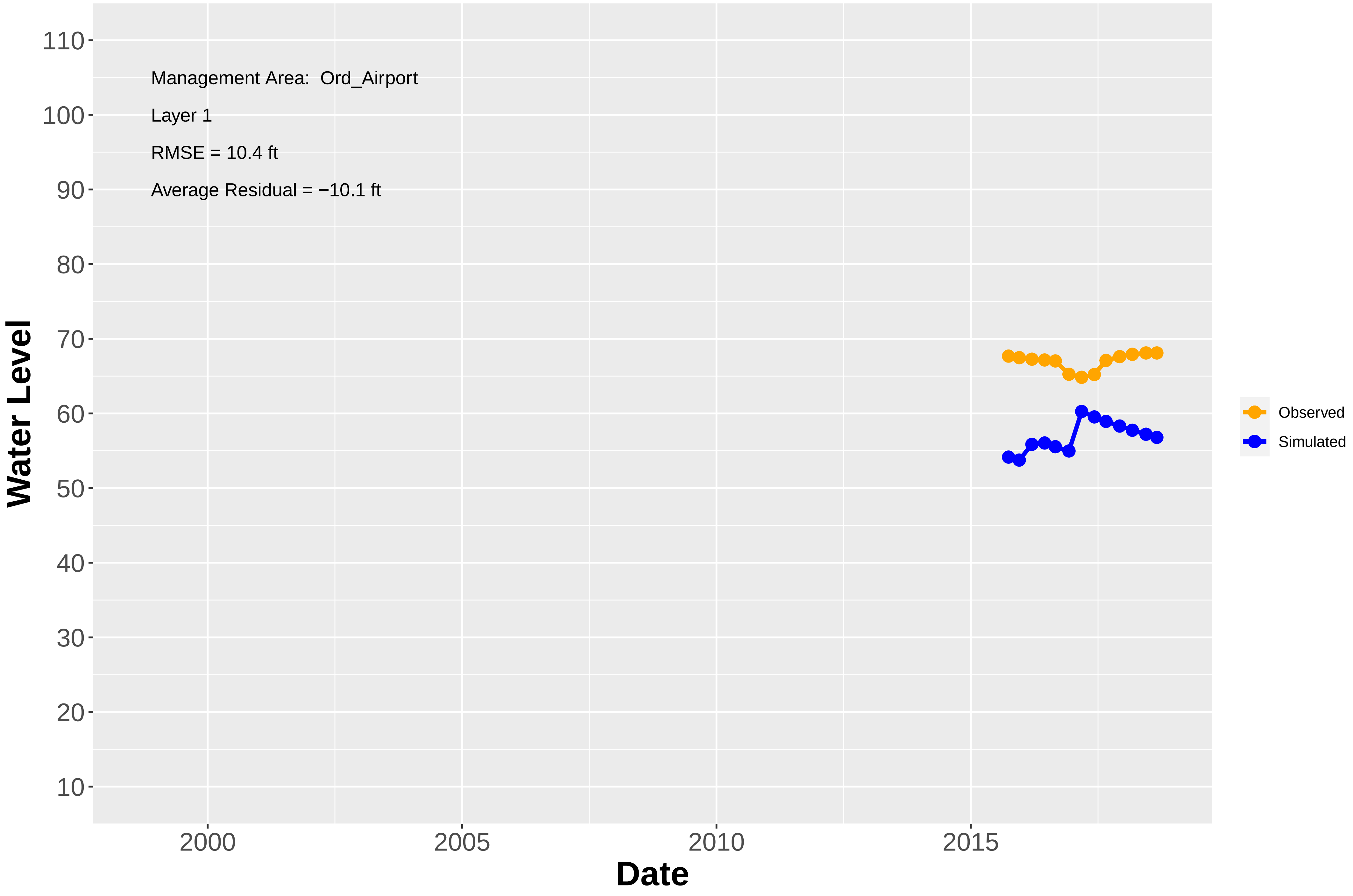


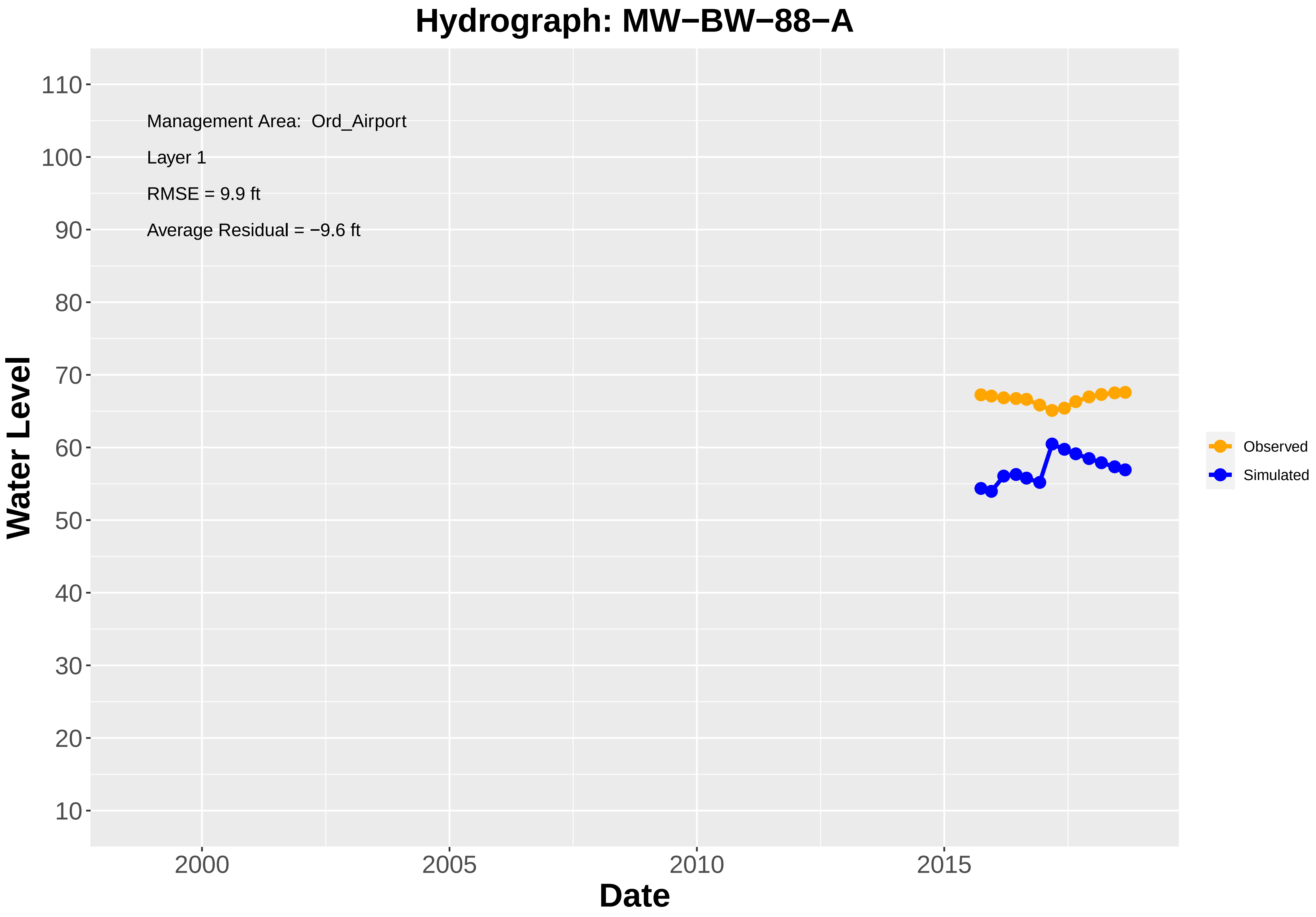

Hydrograph: MW−BW−85−A
Management Area: Ord_Airport
Layer 1
RMSE = 12.6 ft
Average Residual = −12.5 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

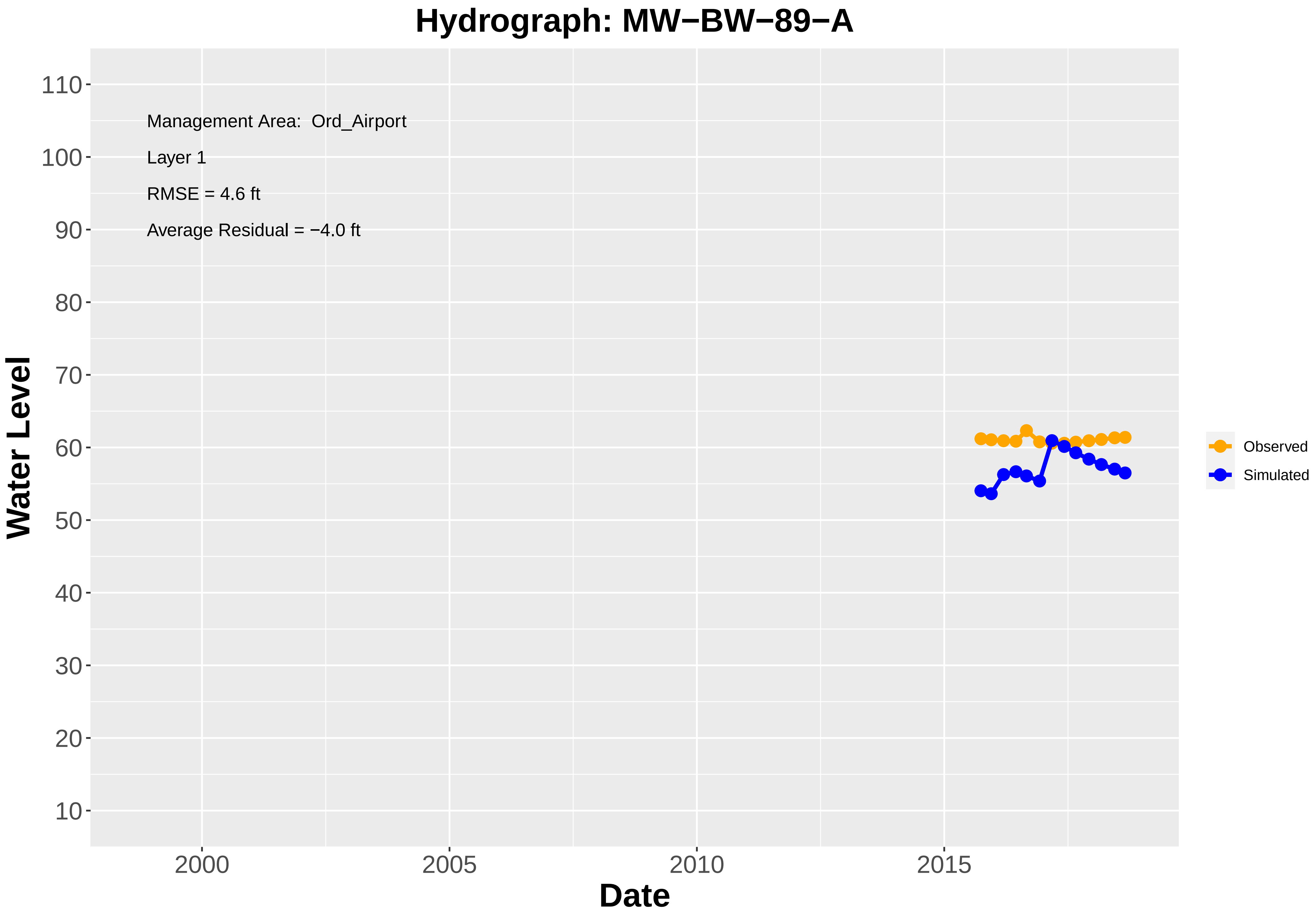
Hydrograph: MW−BW−86−A

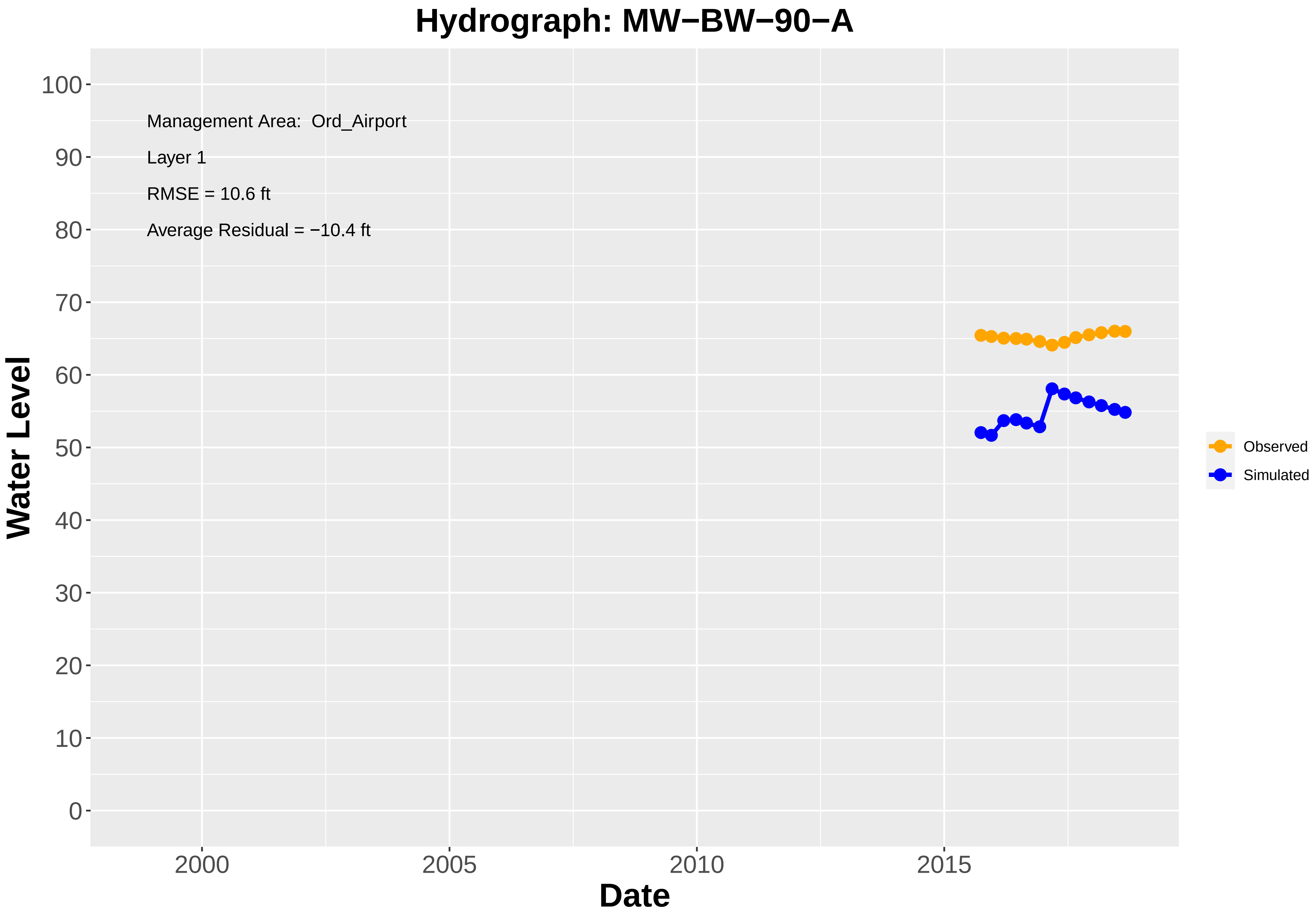


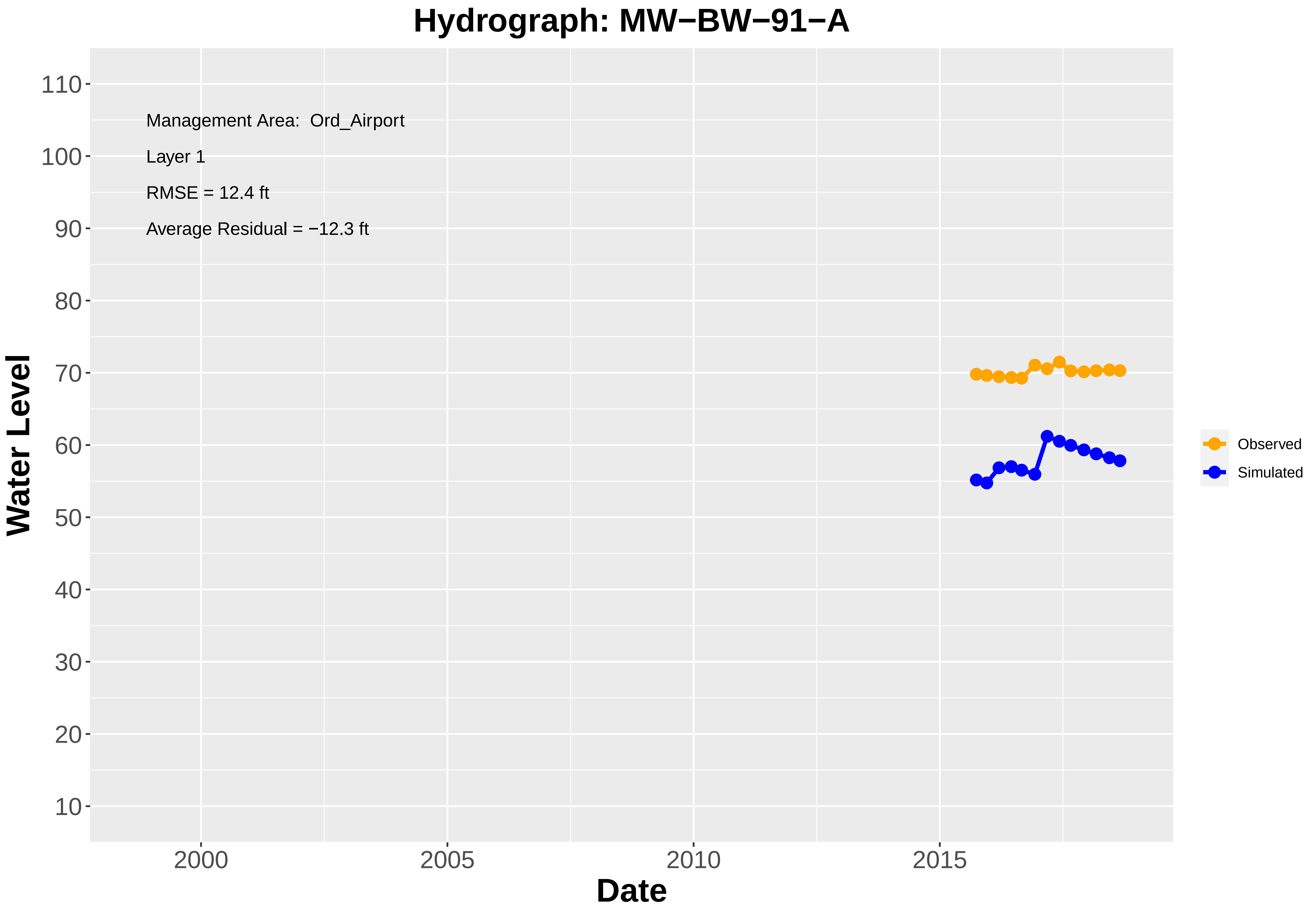
Hydrograph: MW−BW−87−A

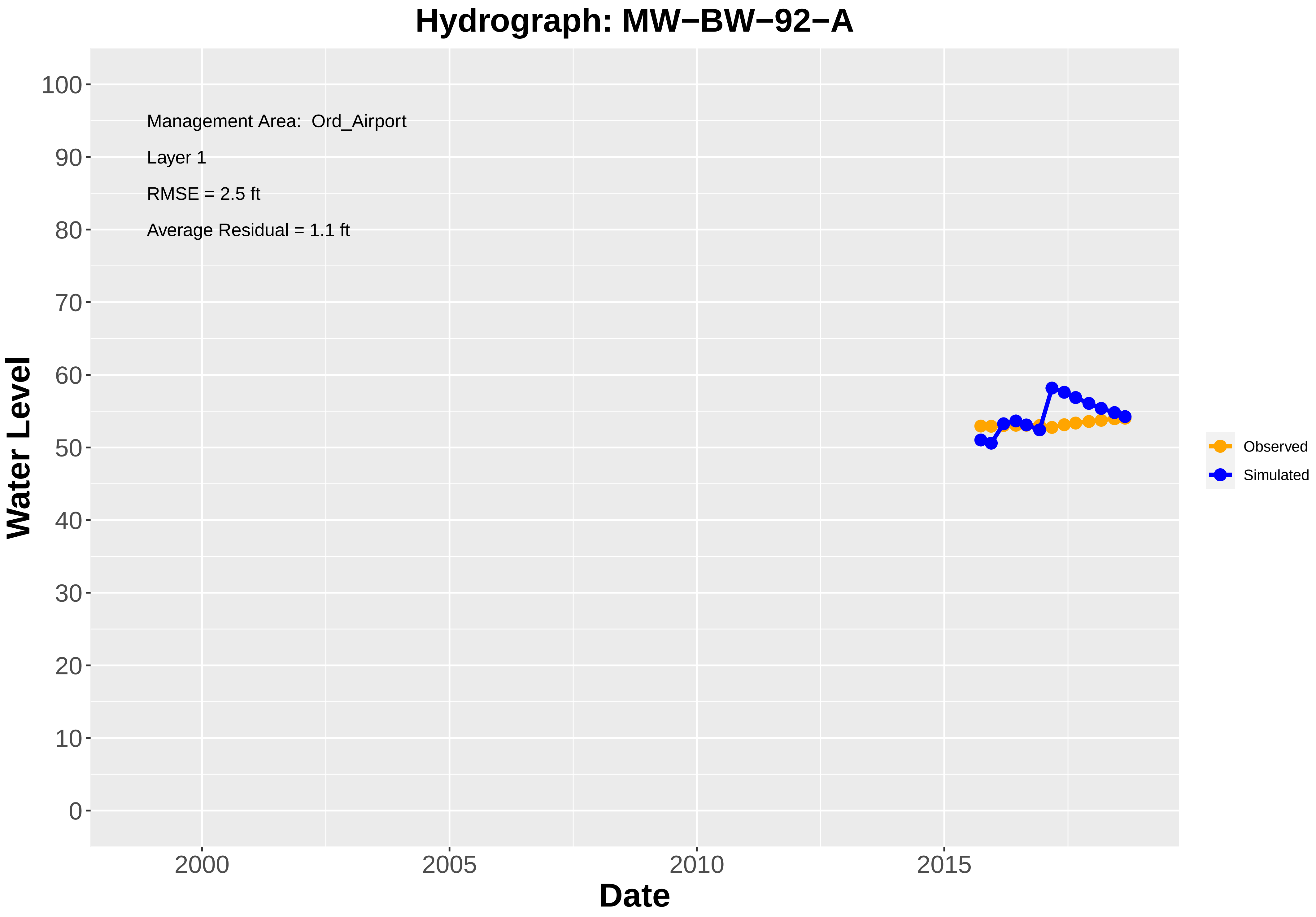


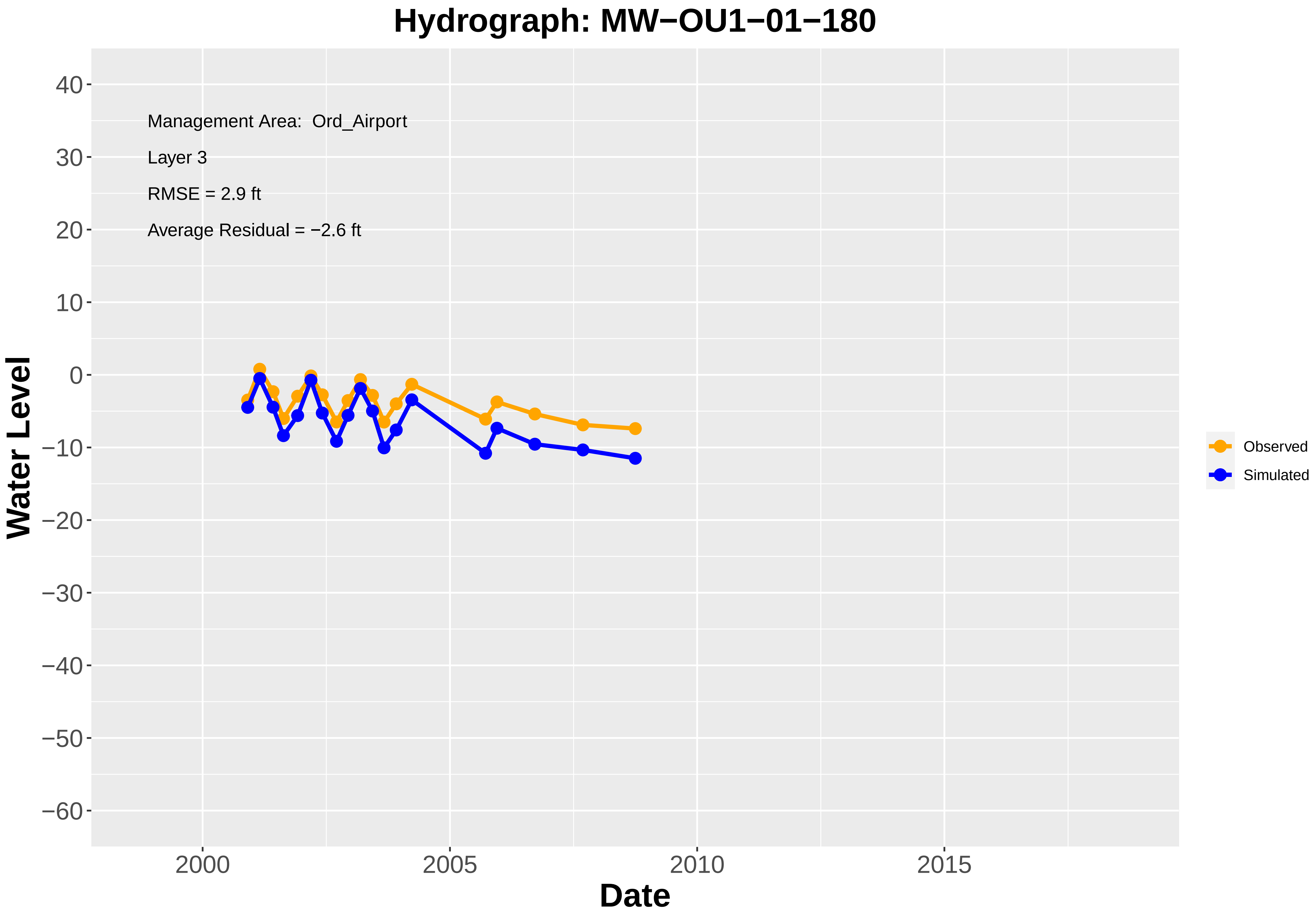

Hydrograph: MW−BW−88−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.9 ft
Average Residual = −9.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

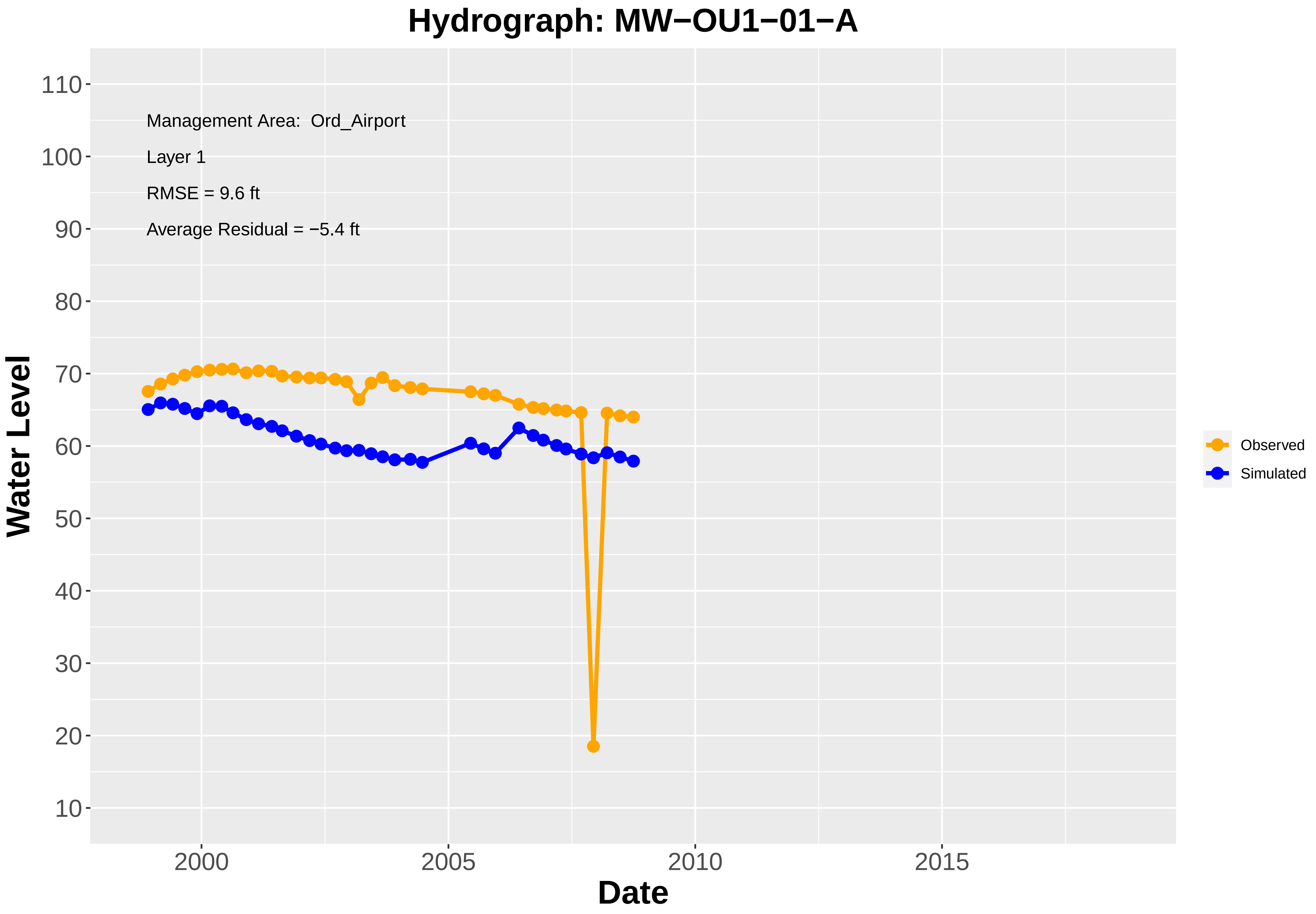

Hydrograph: MW−BW−89−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.6 ft
Average Residual = −4.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

Hydrograph: MW−BW−90−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.6 ft
Average Residual = −10.4 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

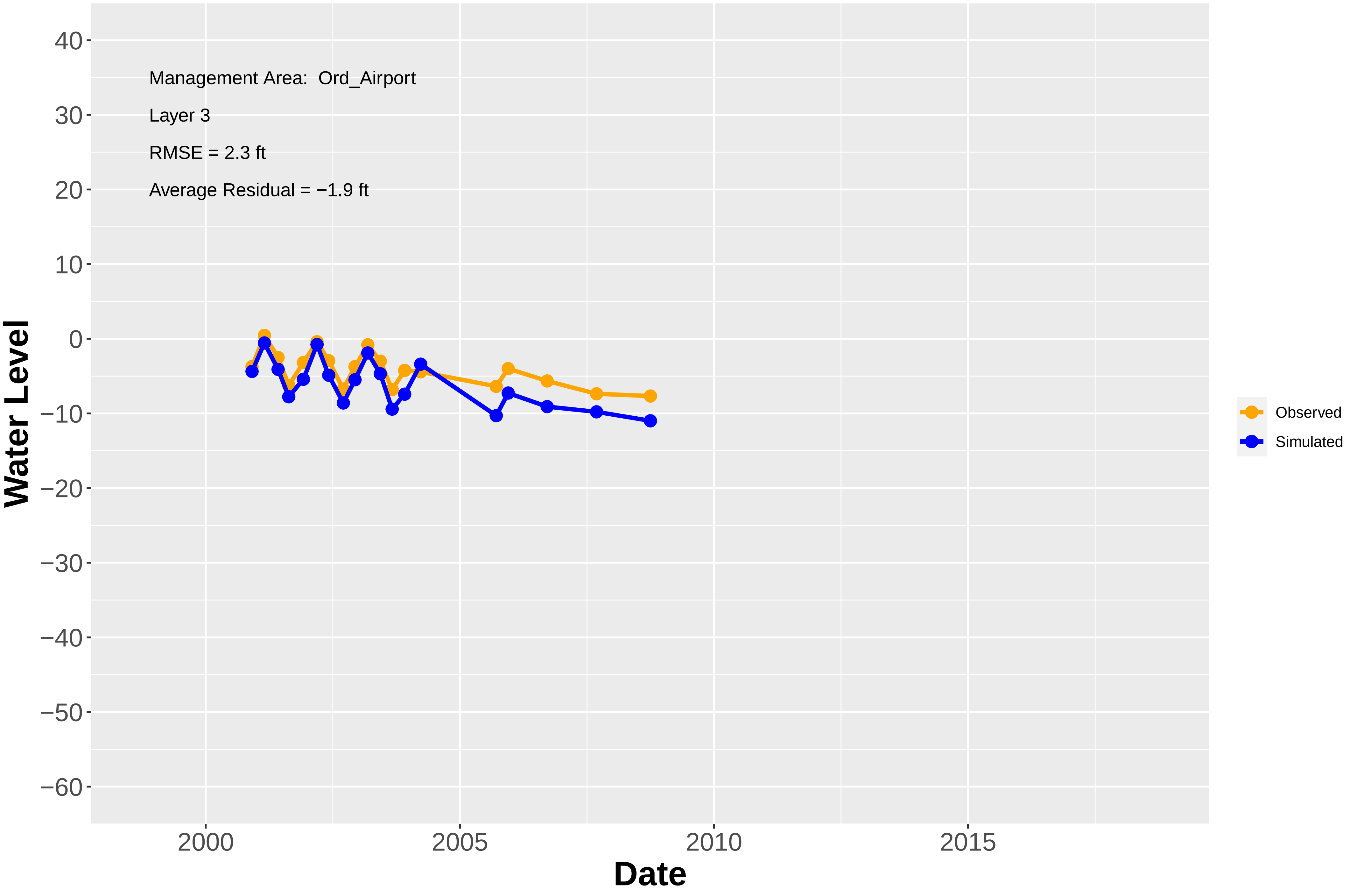

Hydrograph: MW−BW−91−A
Management Area: Ord_Airport
Layer 1
RMSE = 12.4 ft
Average Residual = −12.3 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

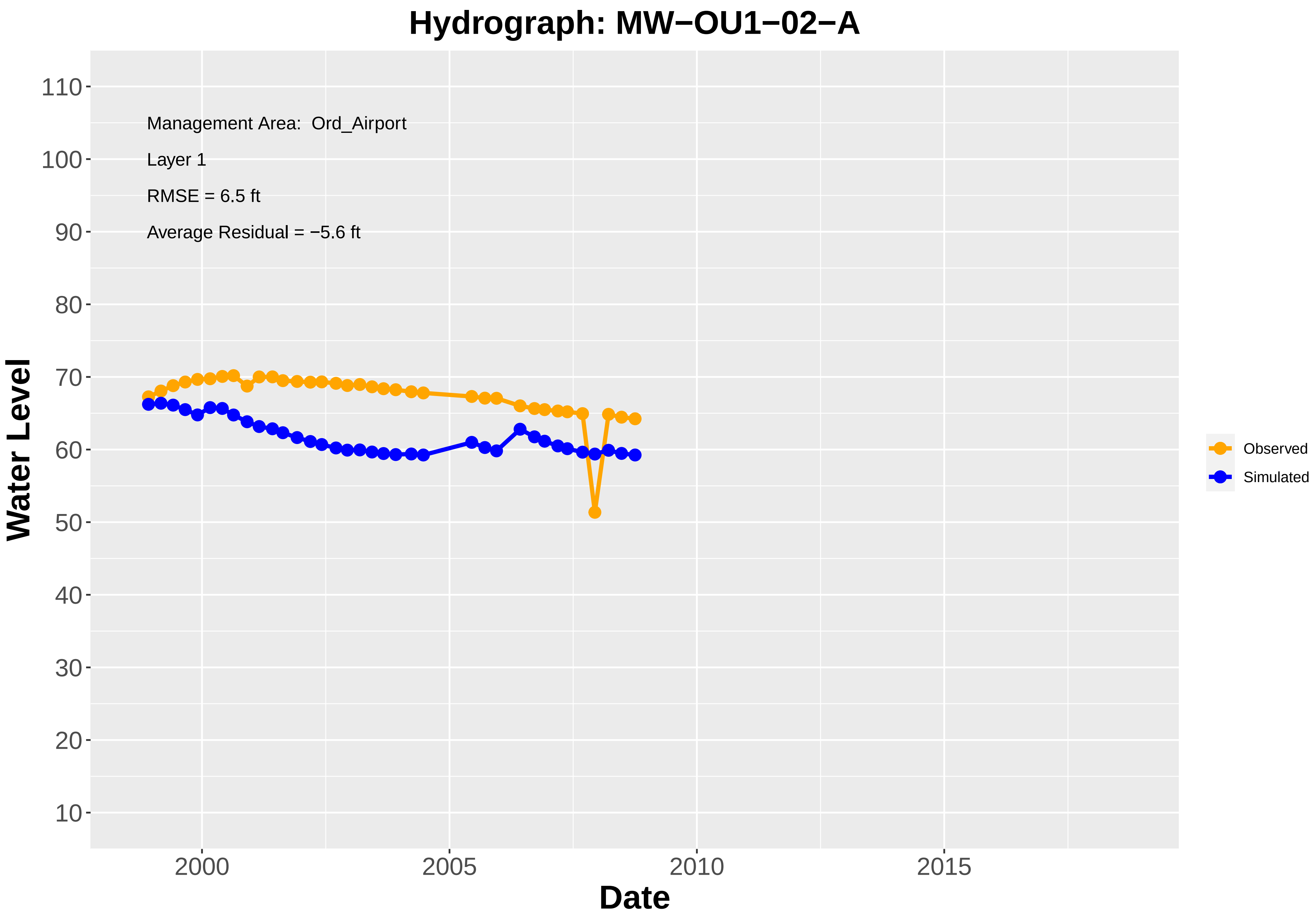

Hydrograph: MW−BW−92−A
Management Area: Ord_Airport
Layer 1
RMSE = 2.5 ft
Average Residual = 1.1 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

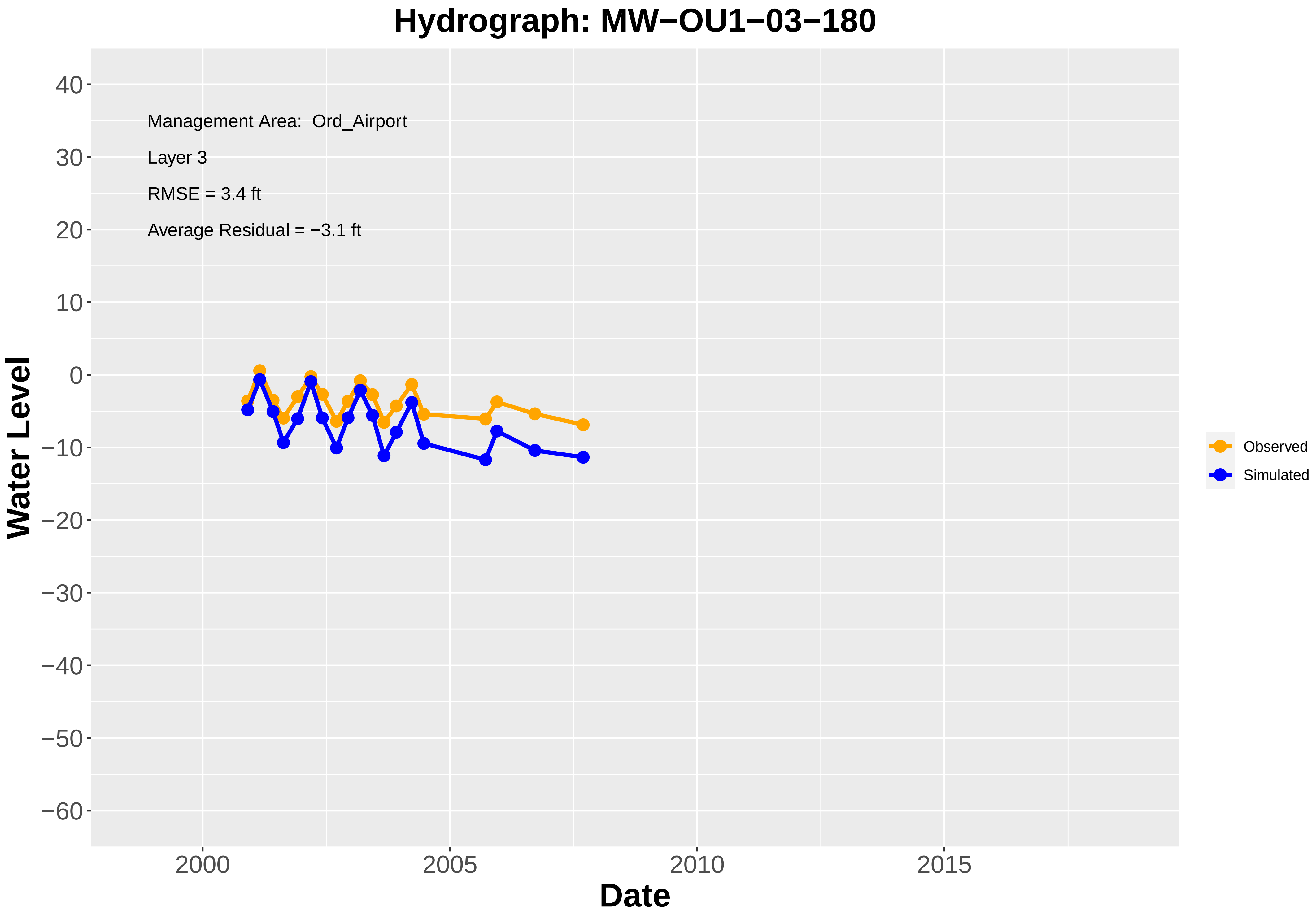

Hydrograph: MW−OU1−01−180
Management Area: Ord_Airport
Layer 3
RMSE = 2.9 ft
Average Residual = −2.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

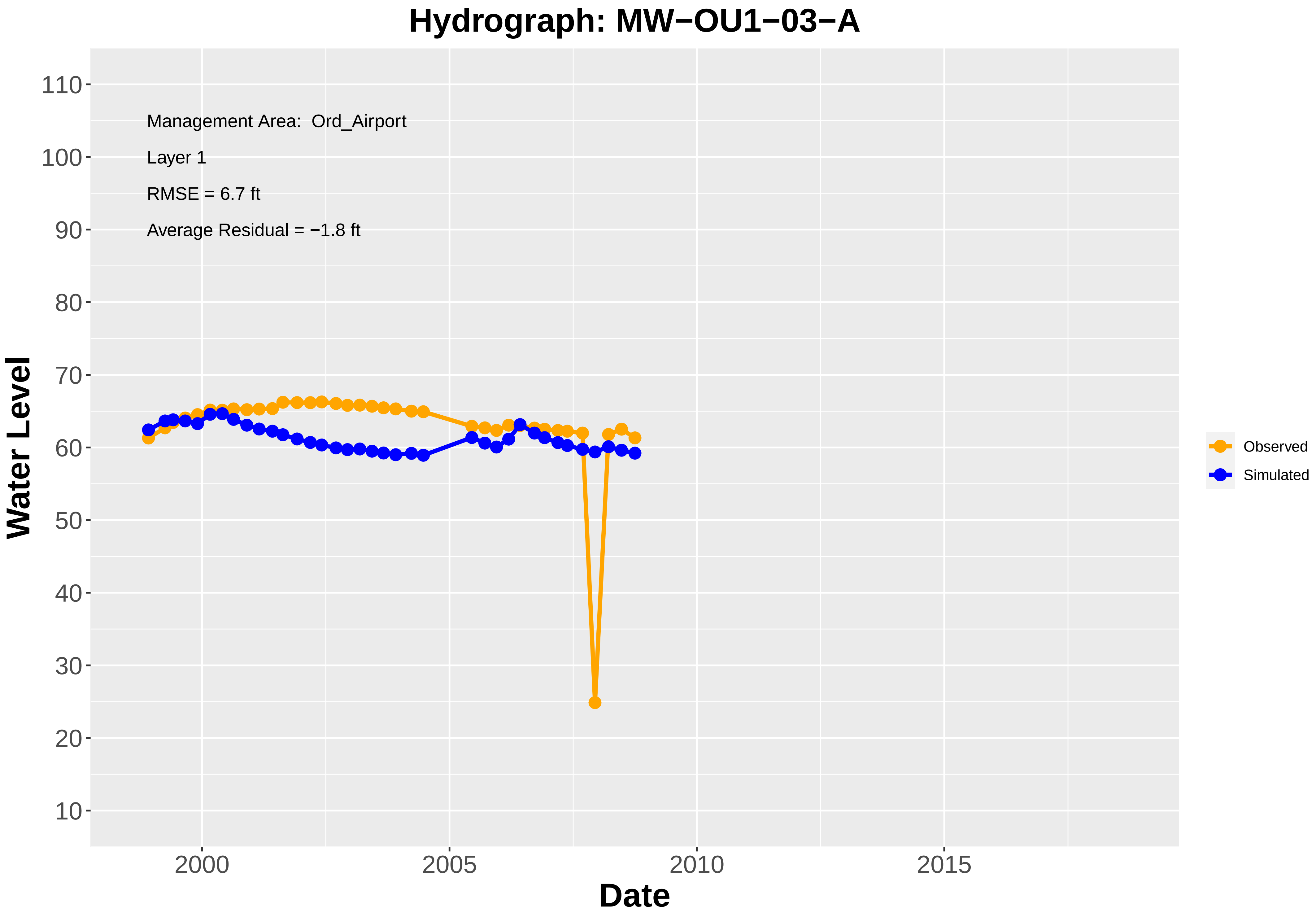

Hydrograph: MW−OU1−01−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.6 ft
Average Residual = −5.4 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

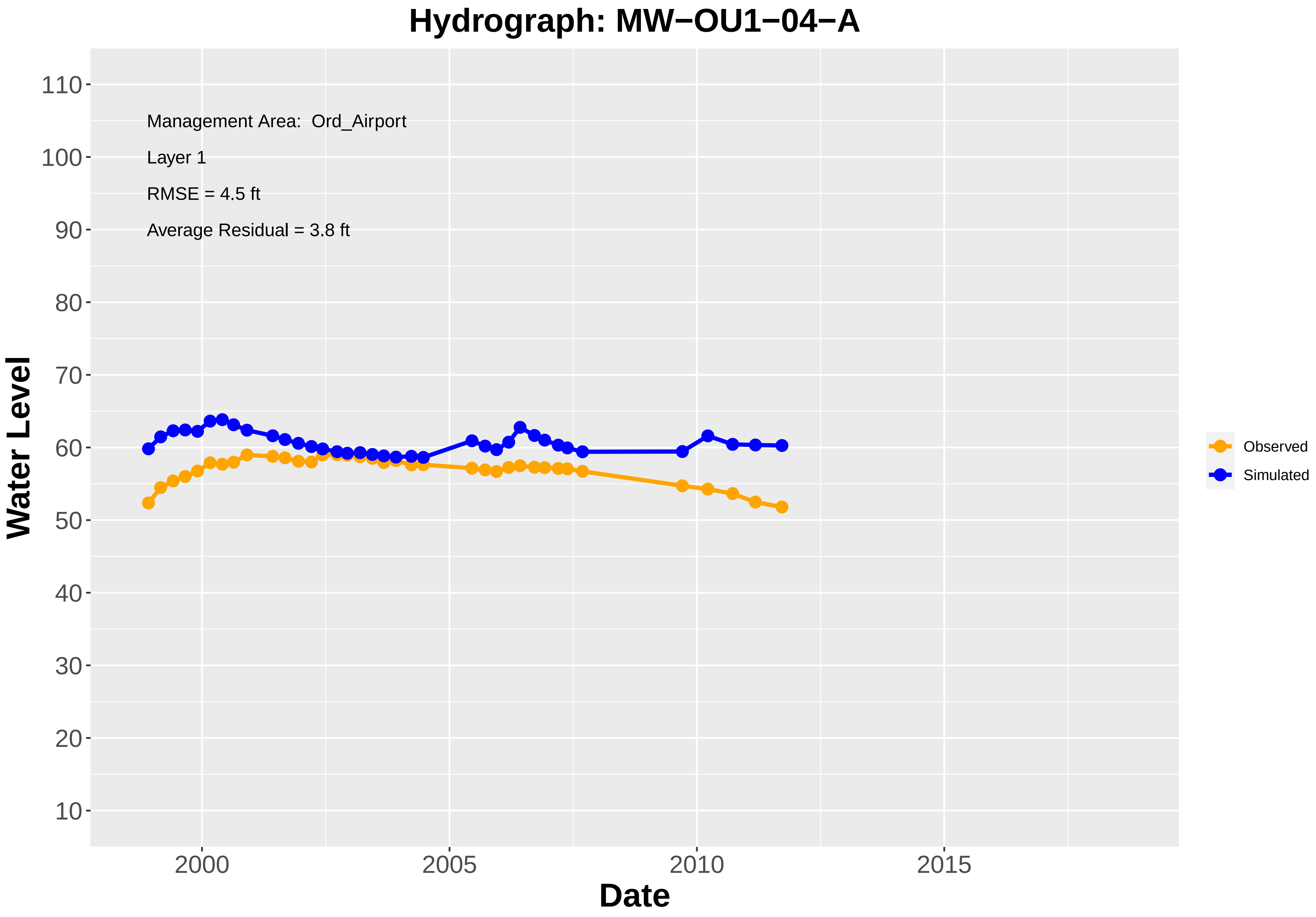
Hydrograph: MW−OU1−02−180

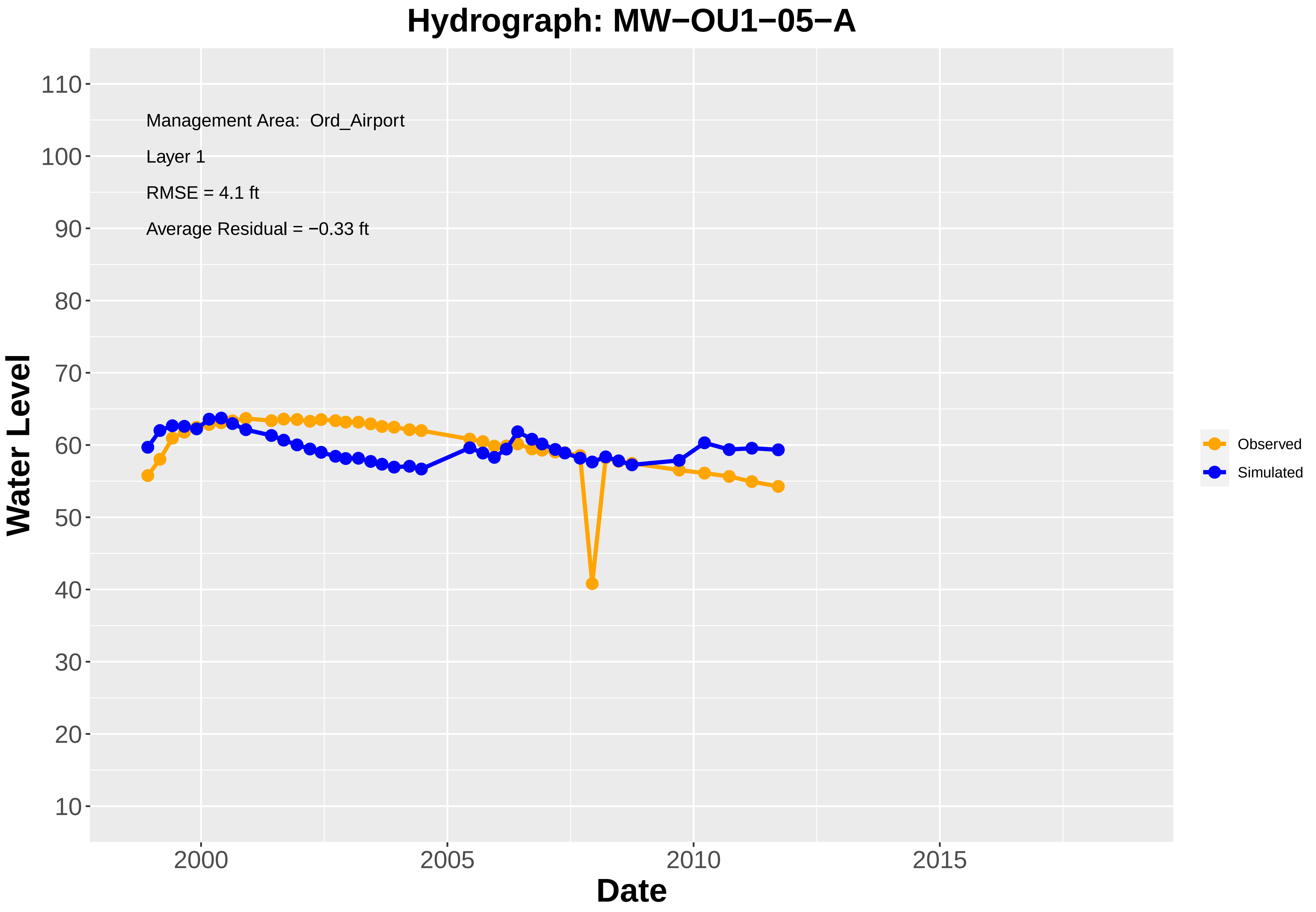


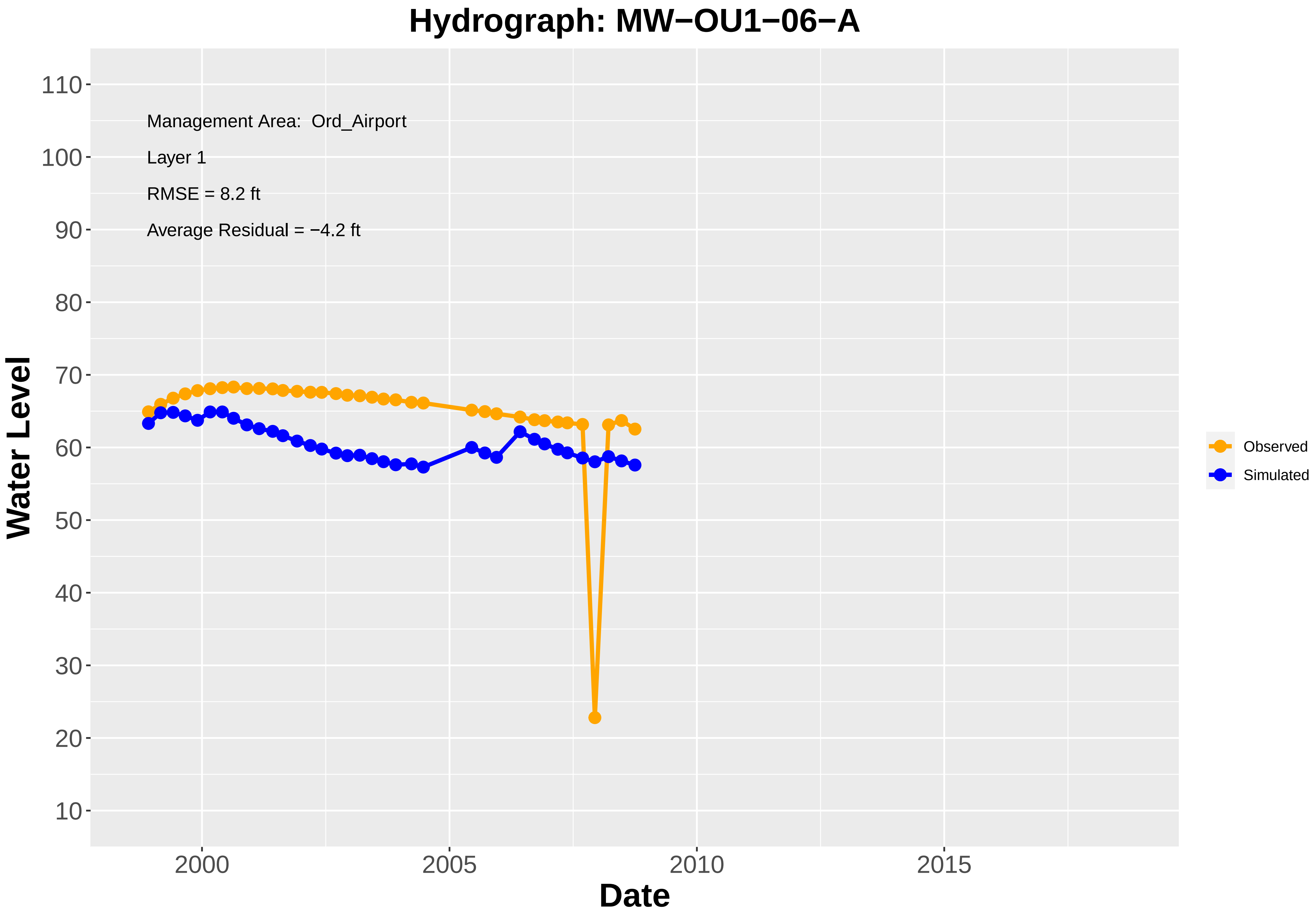

Hydrograph: MW−OU1−02−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.5 ft
Average Residual = −5.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

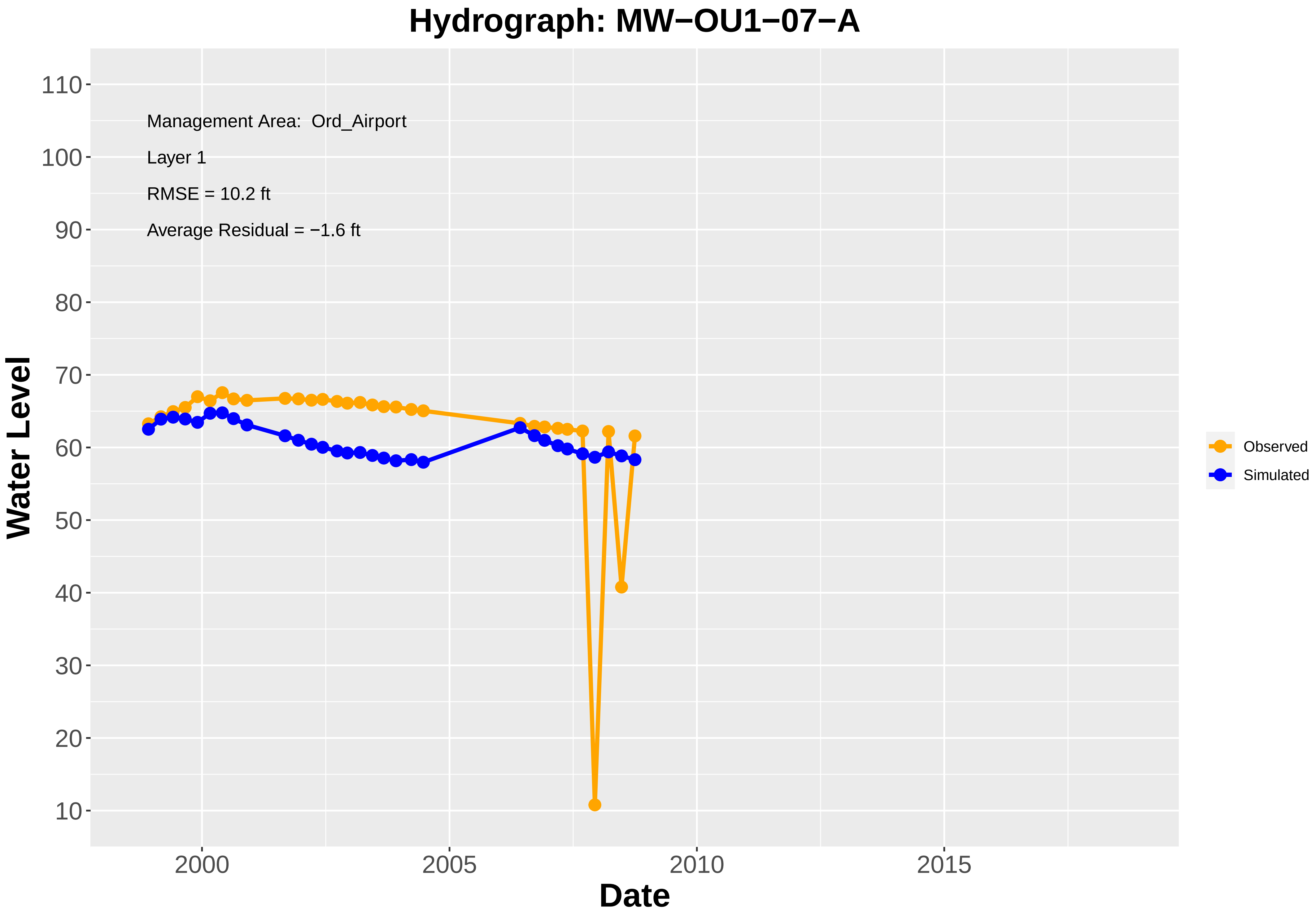

Hydrograph: MW−OU1−03−180
Management Area: Ord_Airport
Layer 3
RMSE = 3.4 ft
Average Residual = −3.1 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

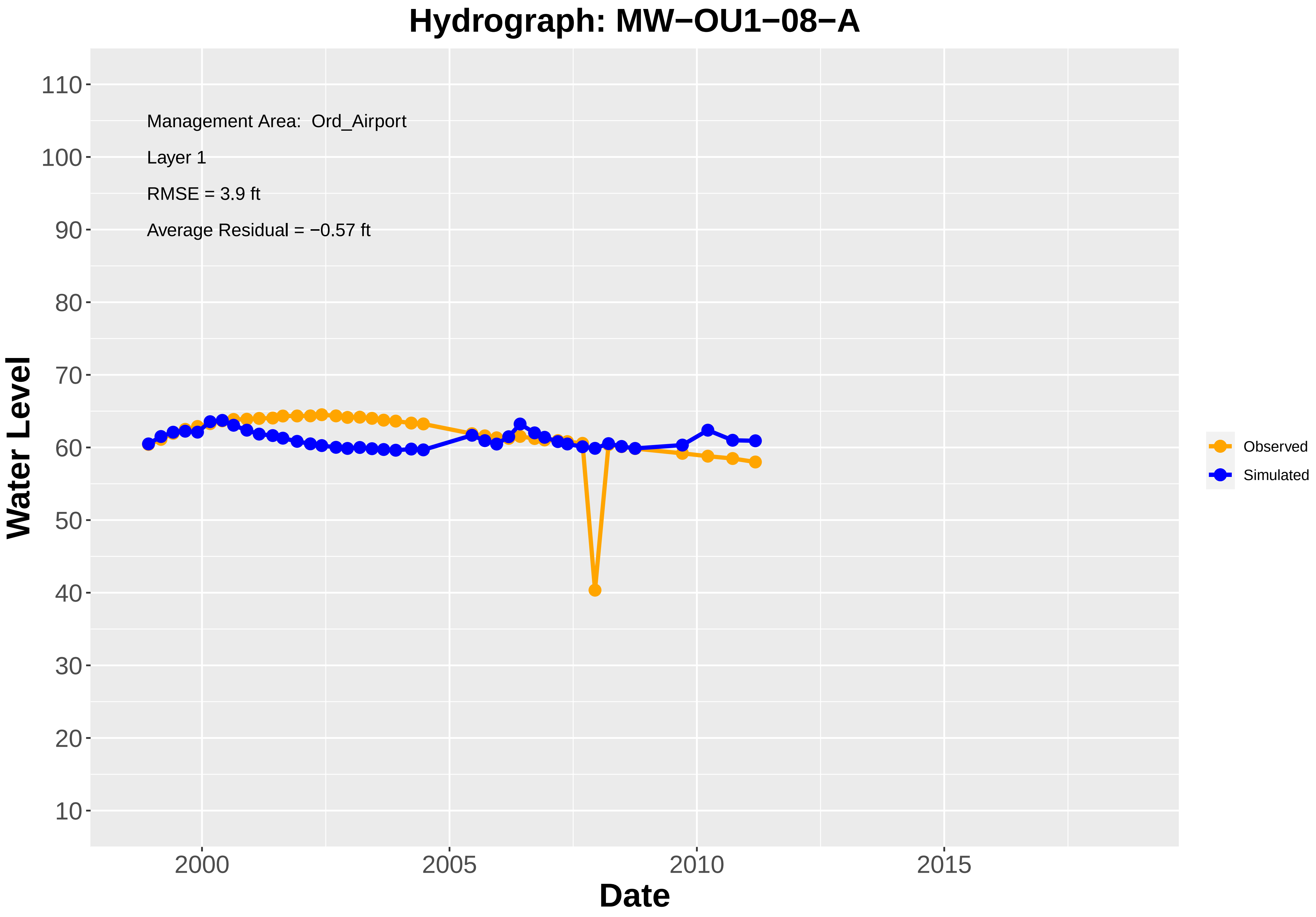

Hydrograph: MW−OU1−03−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.7 ft
Average Residual = −1.8 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−04−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.5 ft
Average Residual = 3.8 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

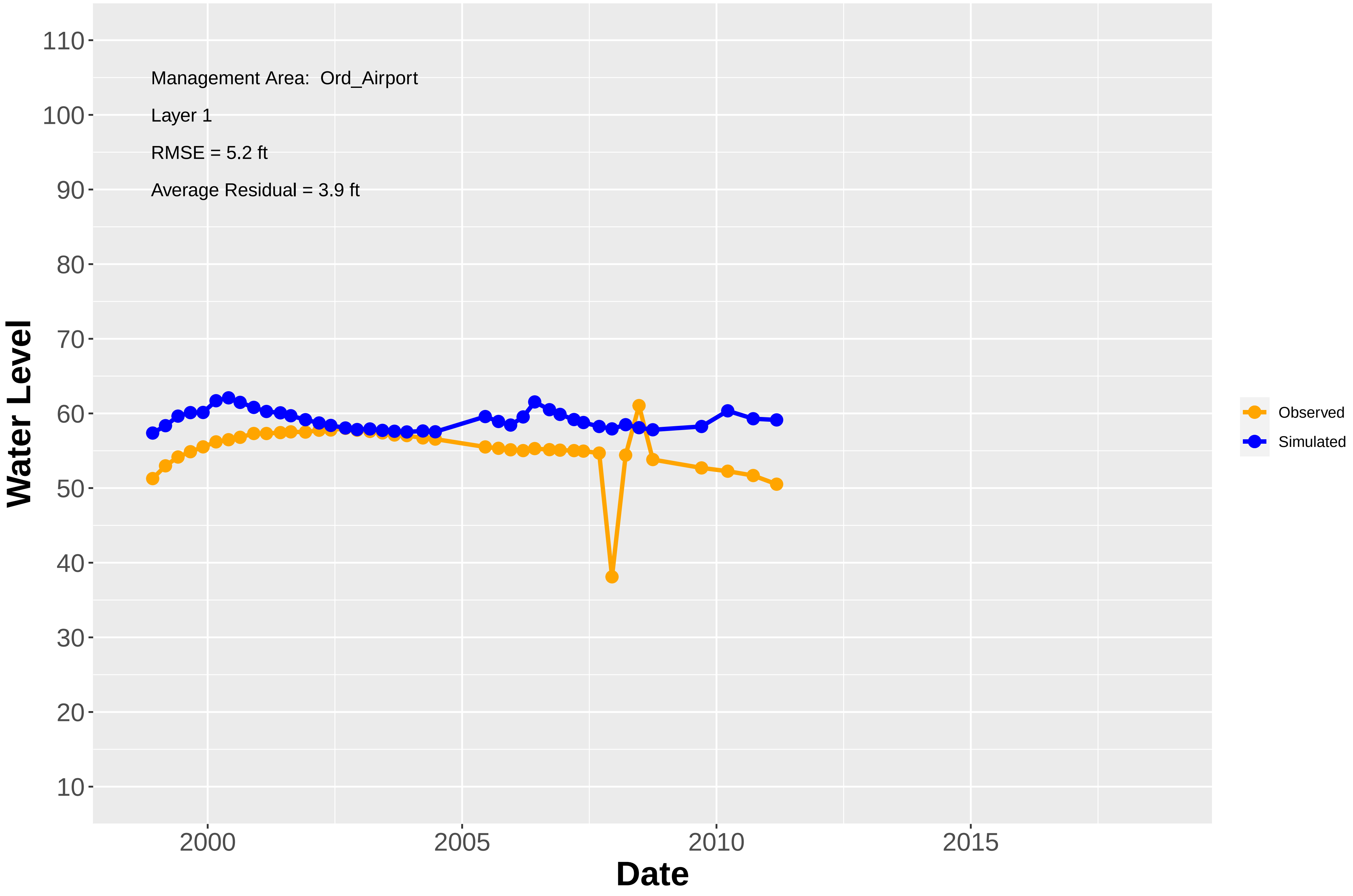

Hydrograph: MW−OU1−05−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.1 ft
Average Residual = −0.33 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

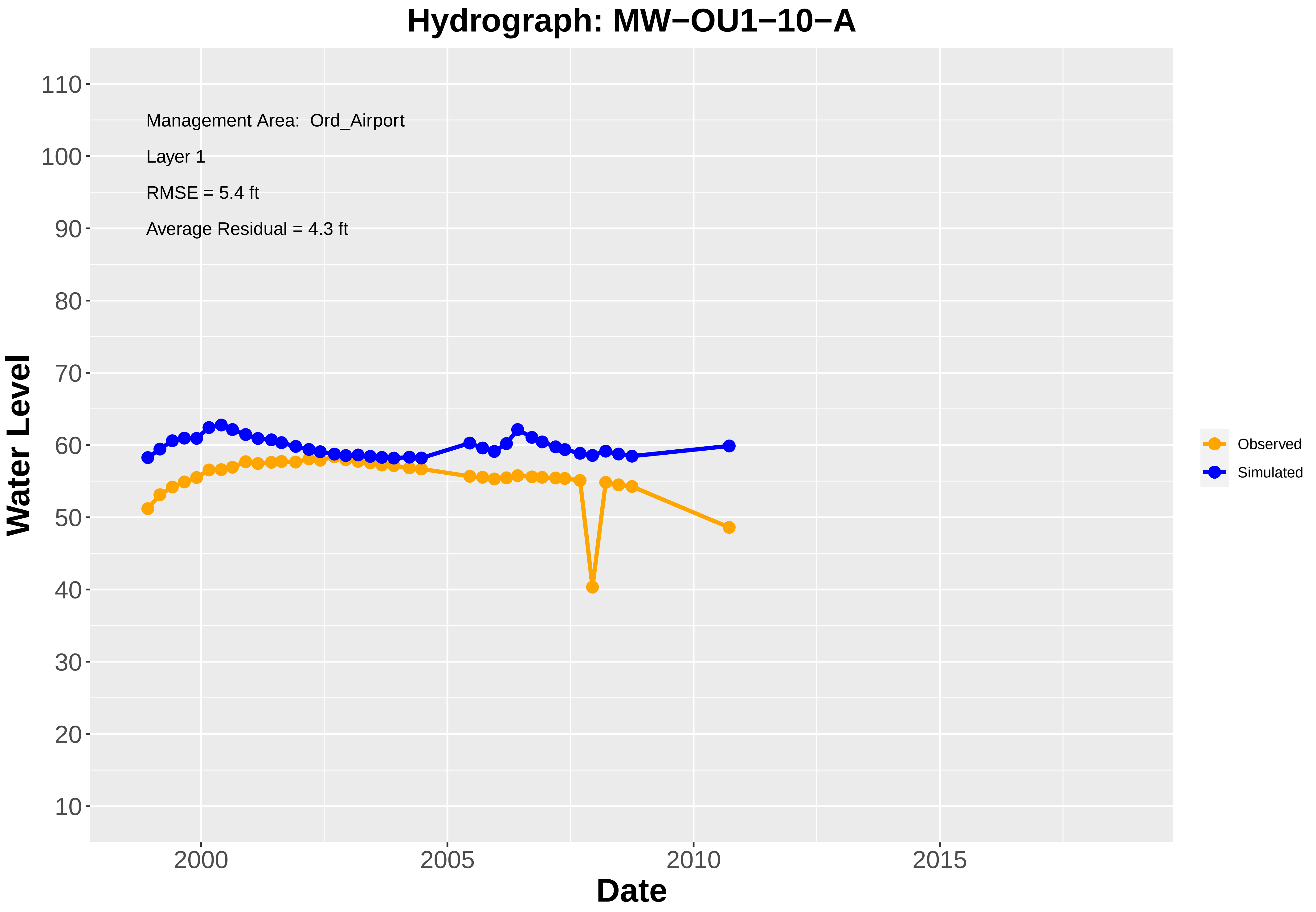

Hydrograph: MW−OU1−06−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.2 ft
Average Residual = −4.2 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

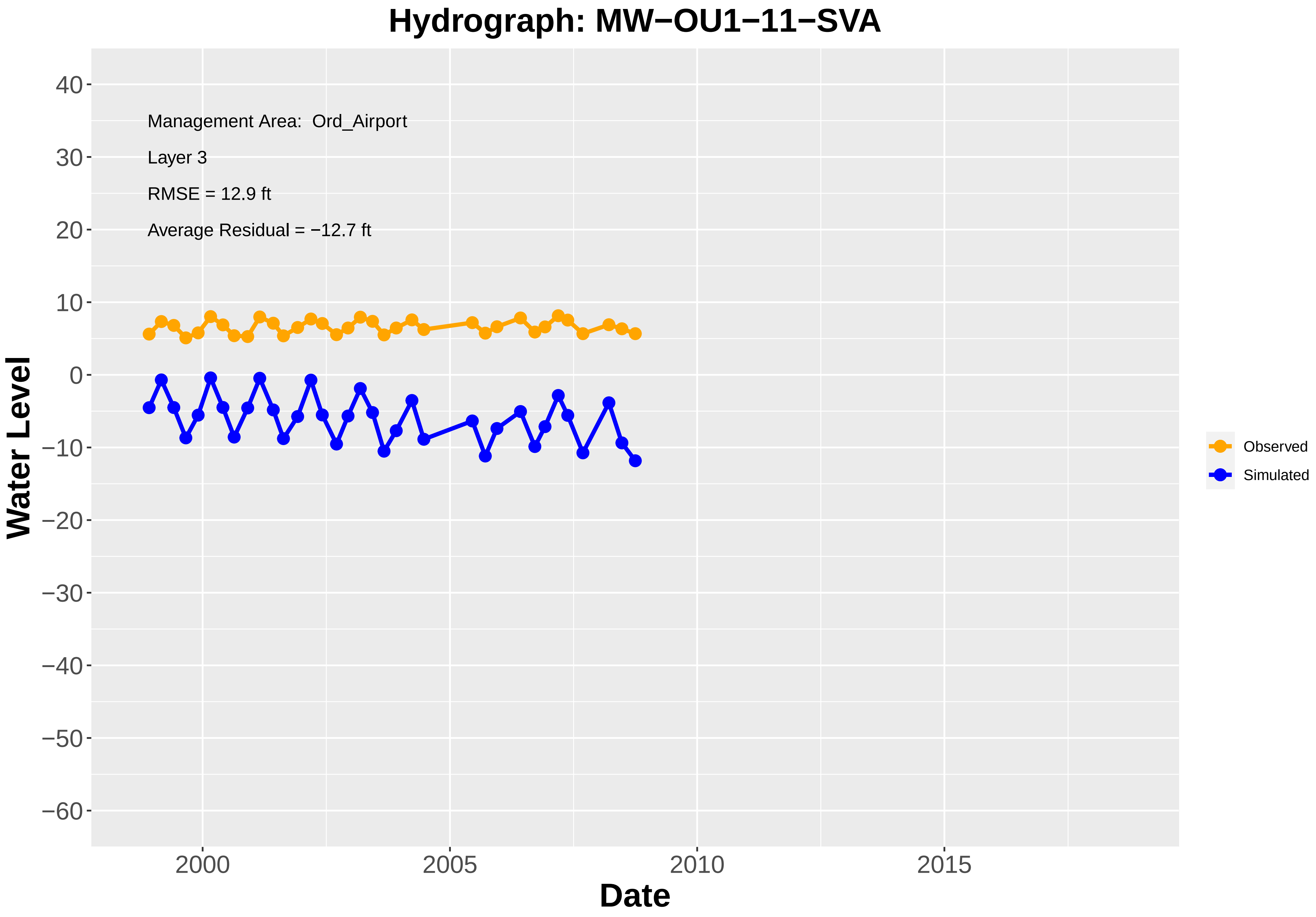

Hydrograph: MW−OU1−07−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.2 ft
Average Residual = −1.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

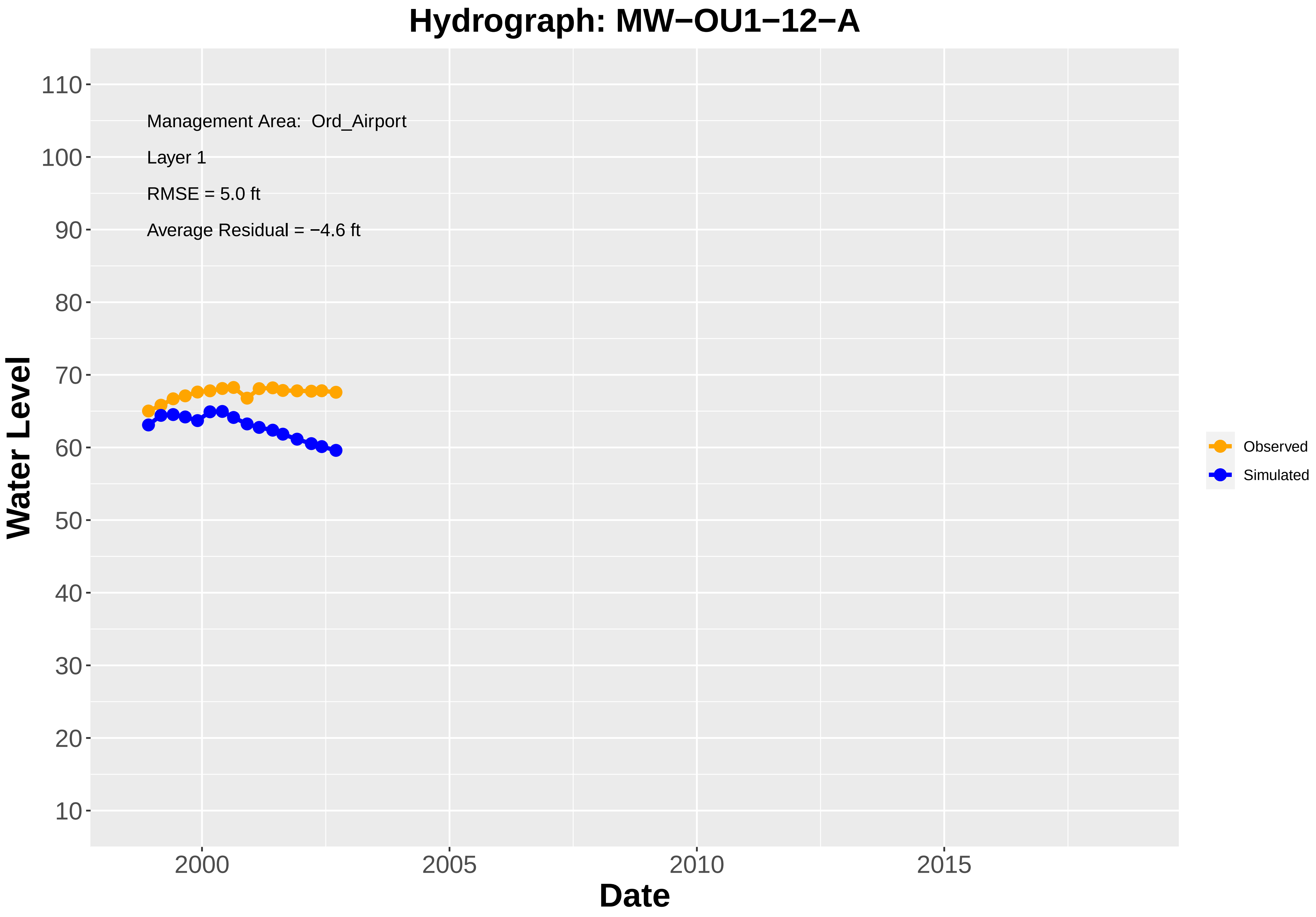

Hydrograph: MW−OU1−08−A
Management Area: Ord_Airport
Layer 1
RMSE = 3.9 ft
Average Residual = −0.57 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−OU1−09−A

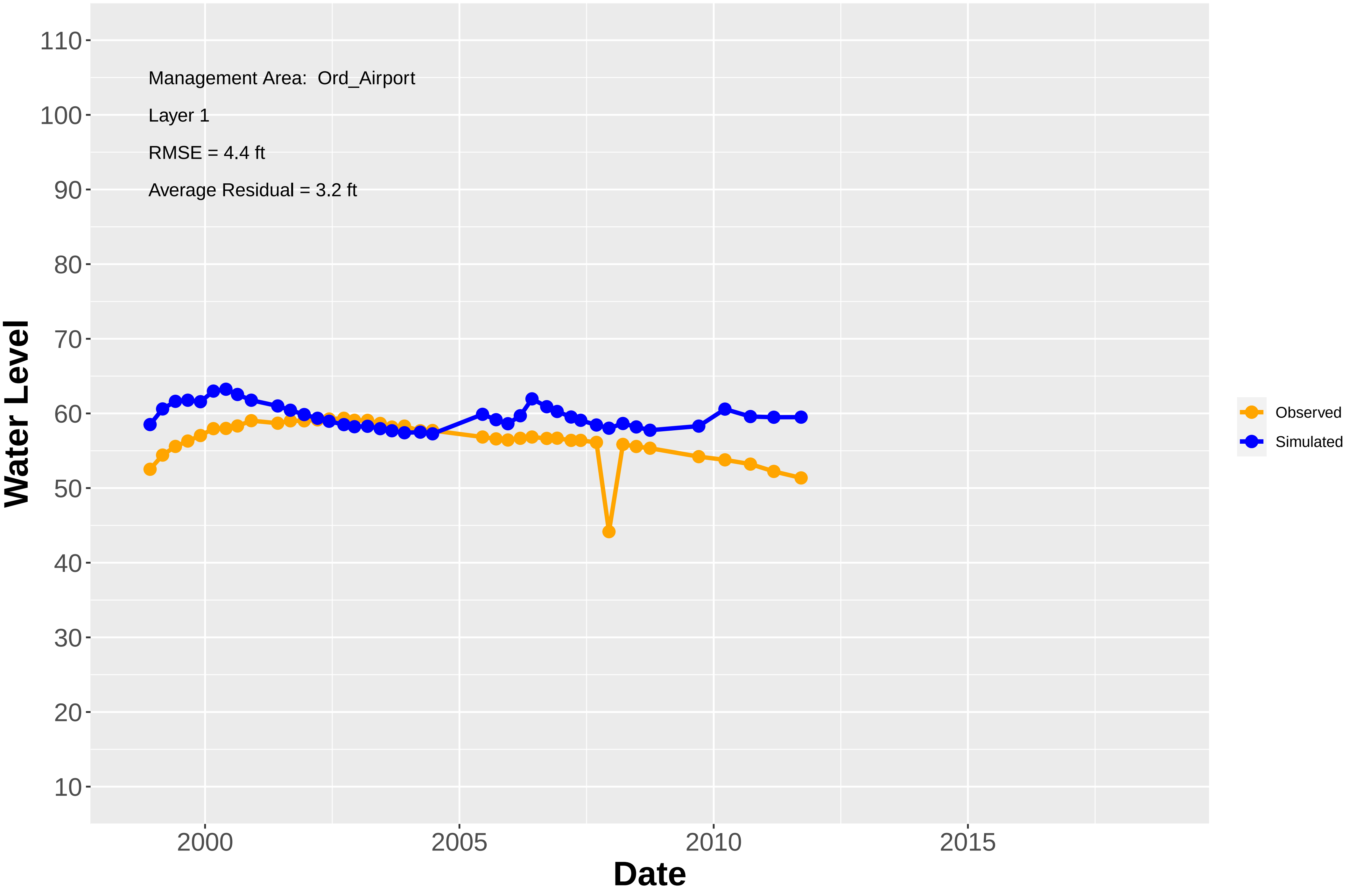



Hydrograph: MW−OU1−10−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.4 ft
Average Residual = 4.3 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

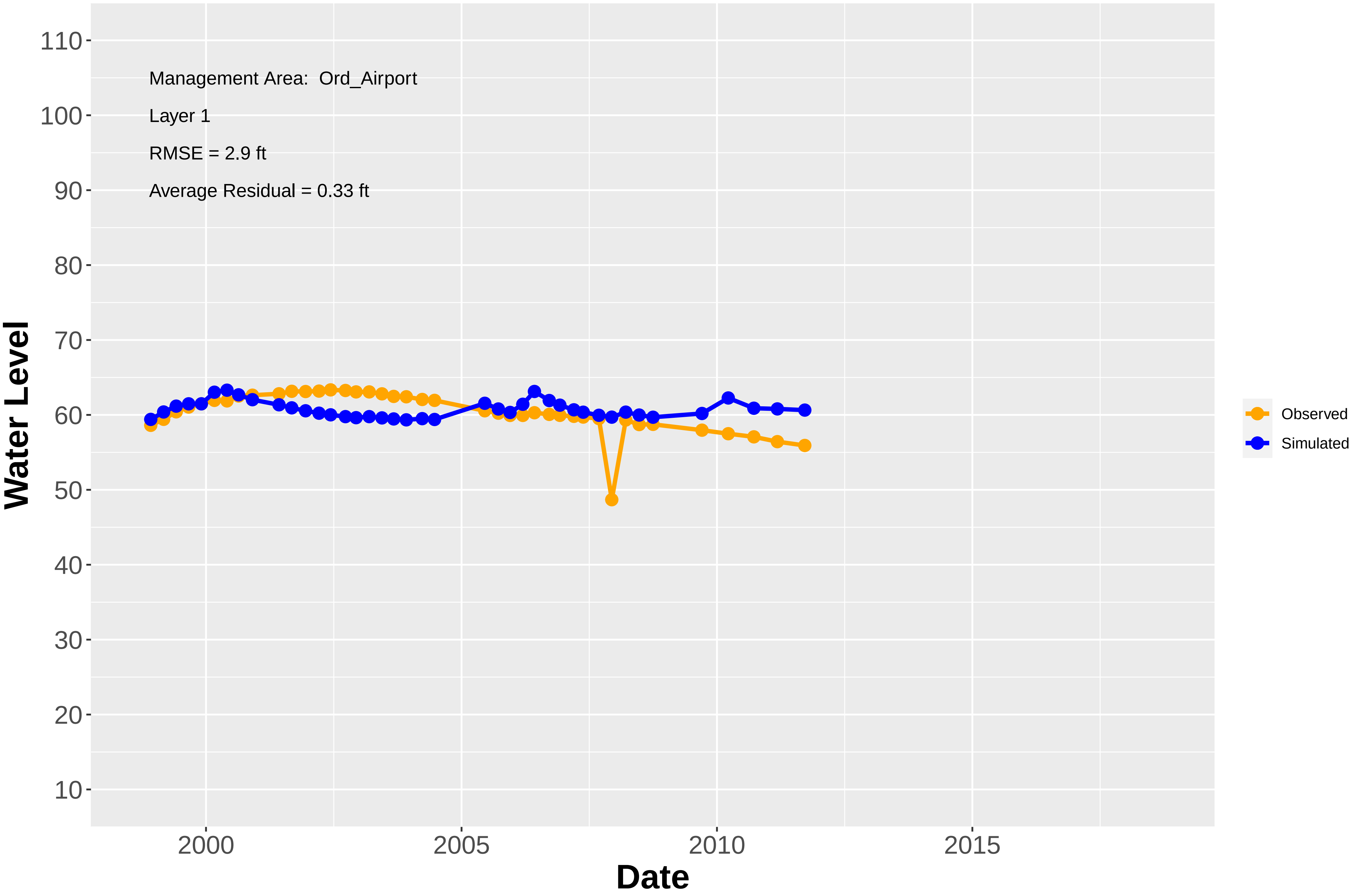

Hydrograph: MW−OU1−11−SVA
Management Area: Ord_Airport
Layer 3
RMSE = 12.9 ft
Average Residual = −12.7 ft
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−12−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.0 ft
Average Residual = −4.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

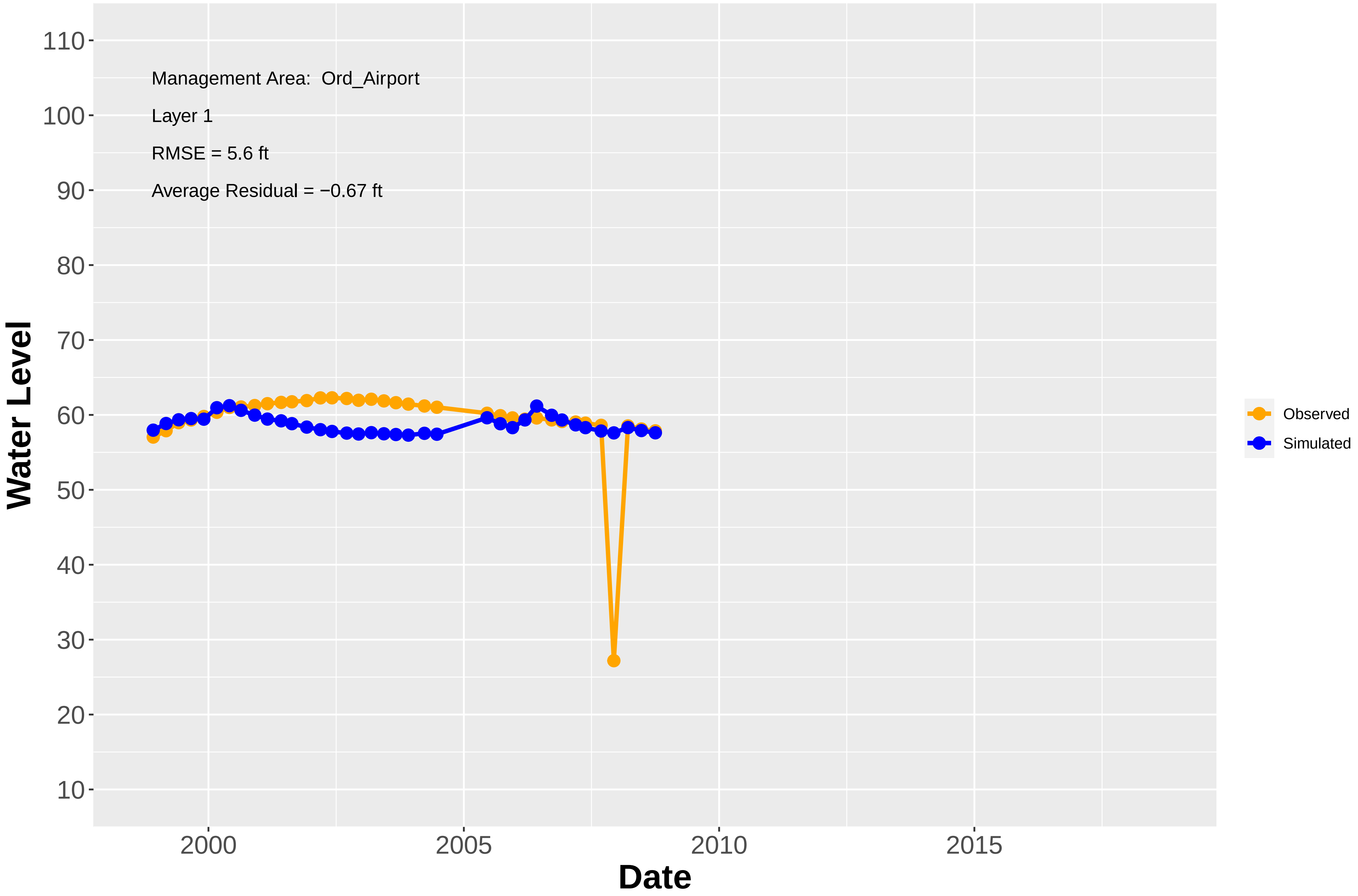
Hydrograph: MW−OU1−19−A

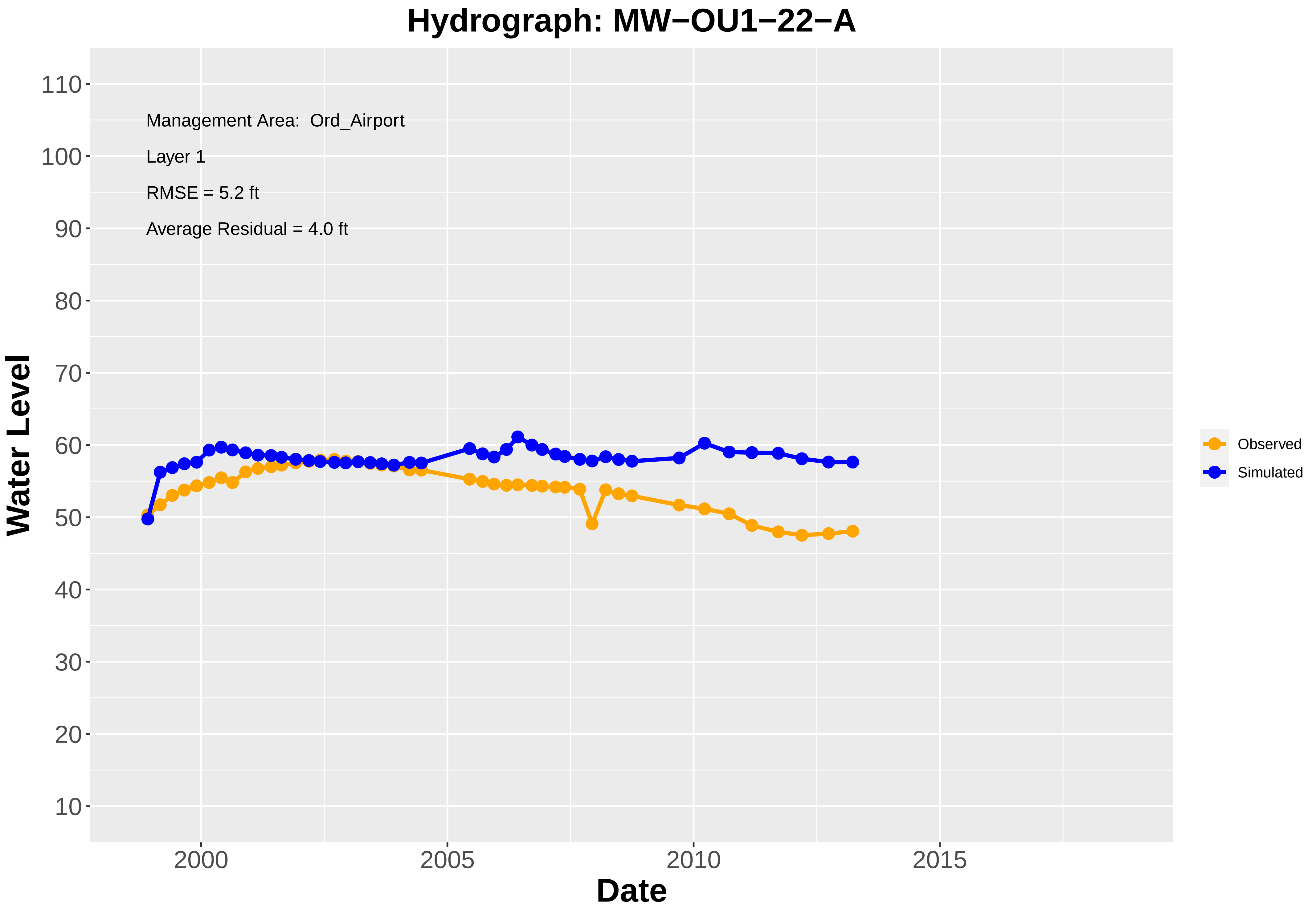


Hydrograph: MW−OU1−20−A

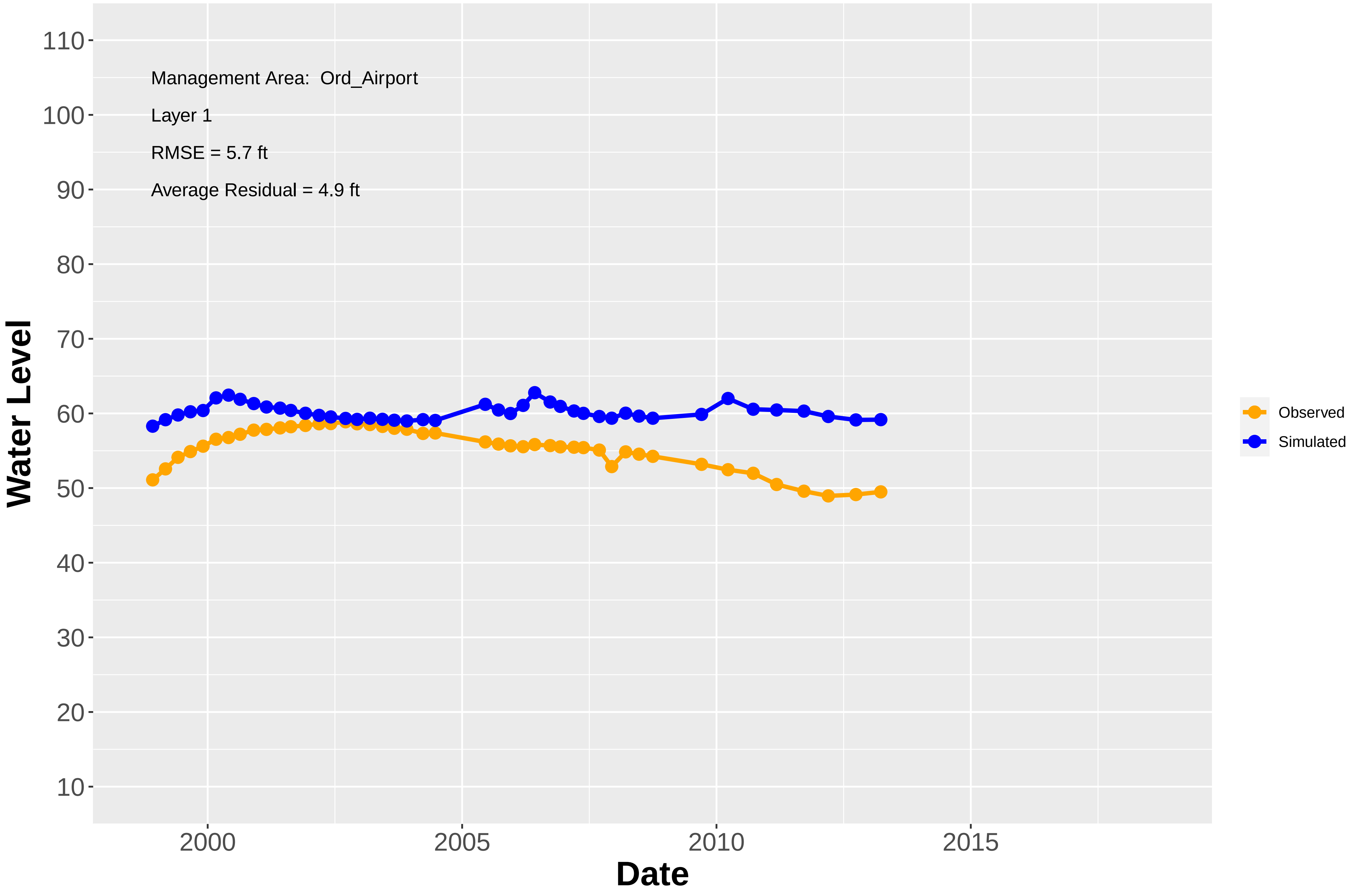


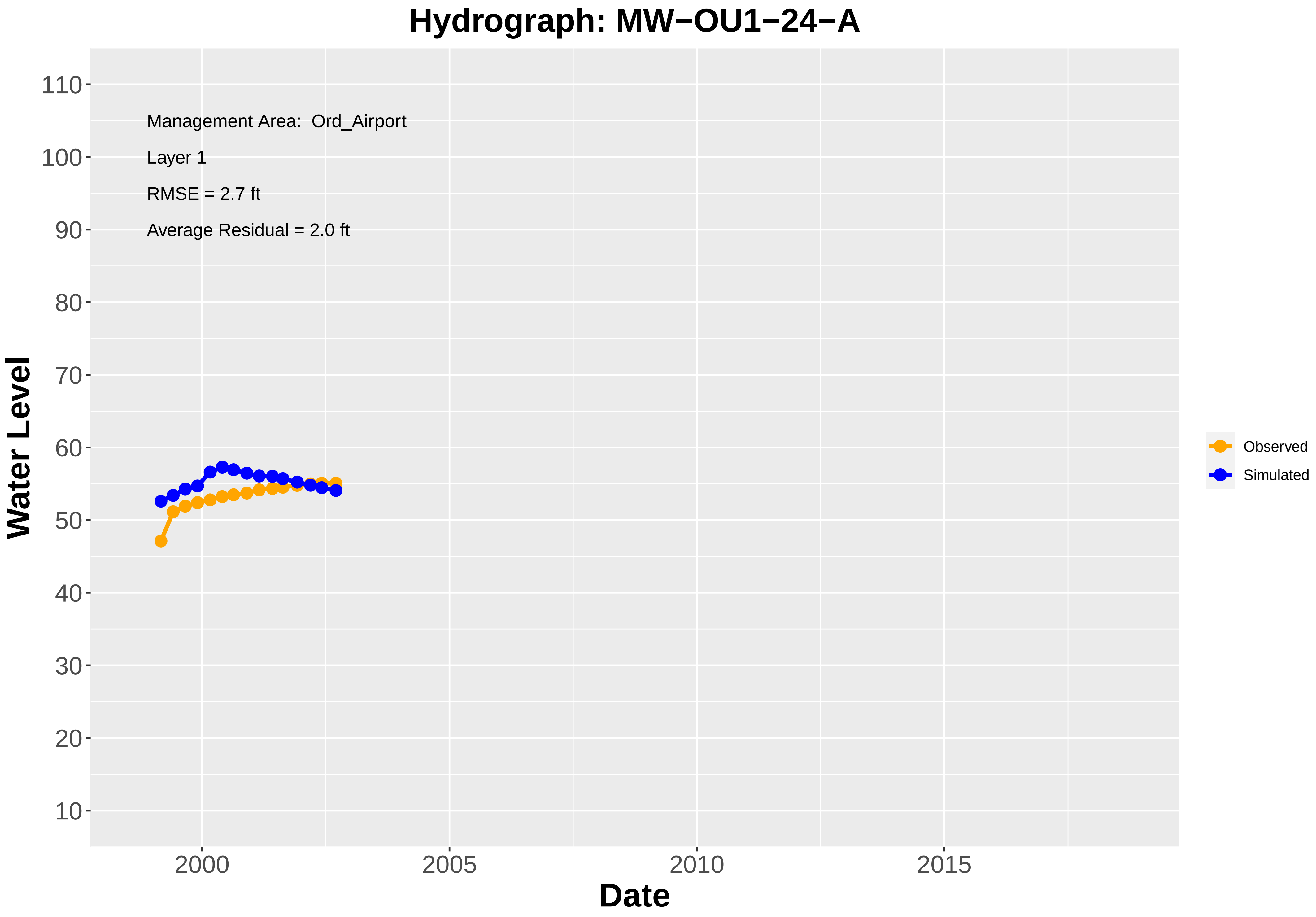
Hydrograph: MW−OU1−21−A

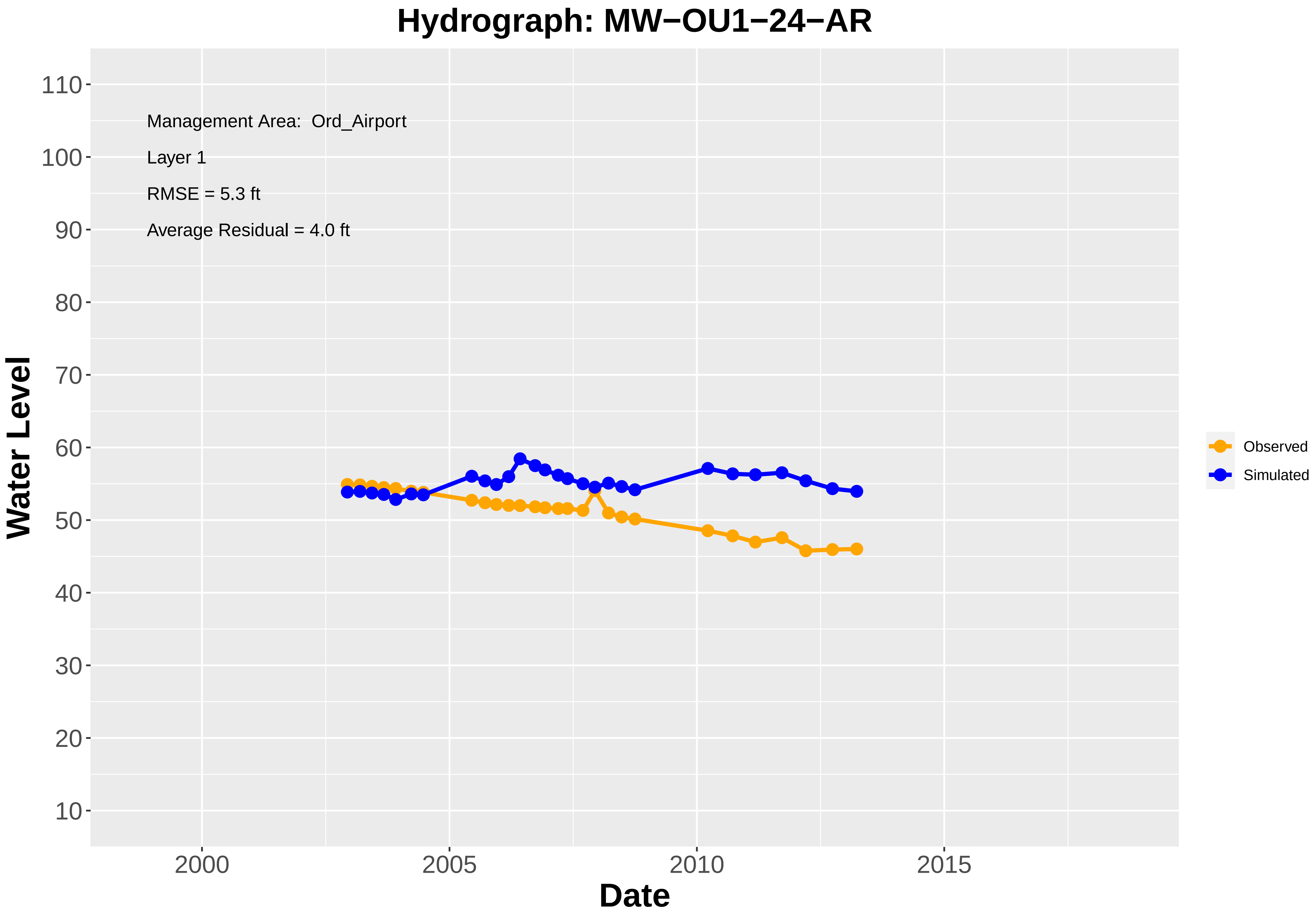


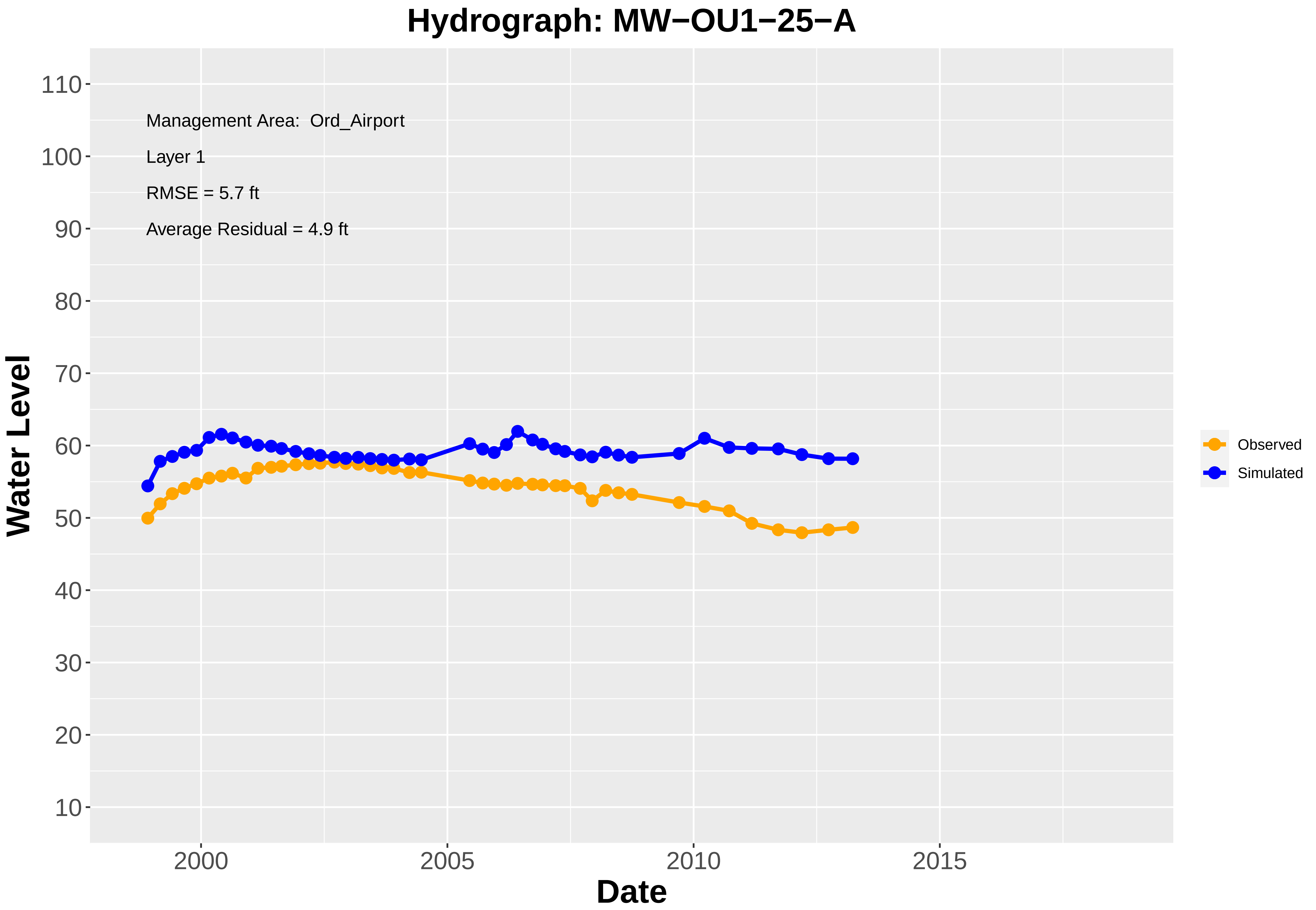

Hydrograph: MW−OU1−22−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.2 ft
Average Residual = 4.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

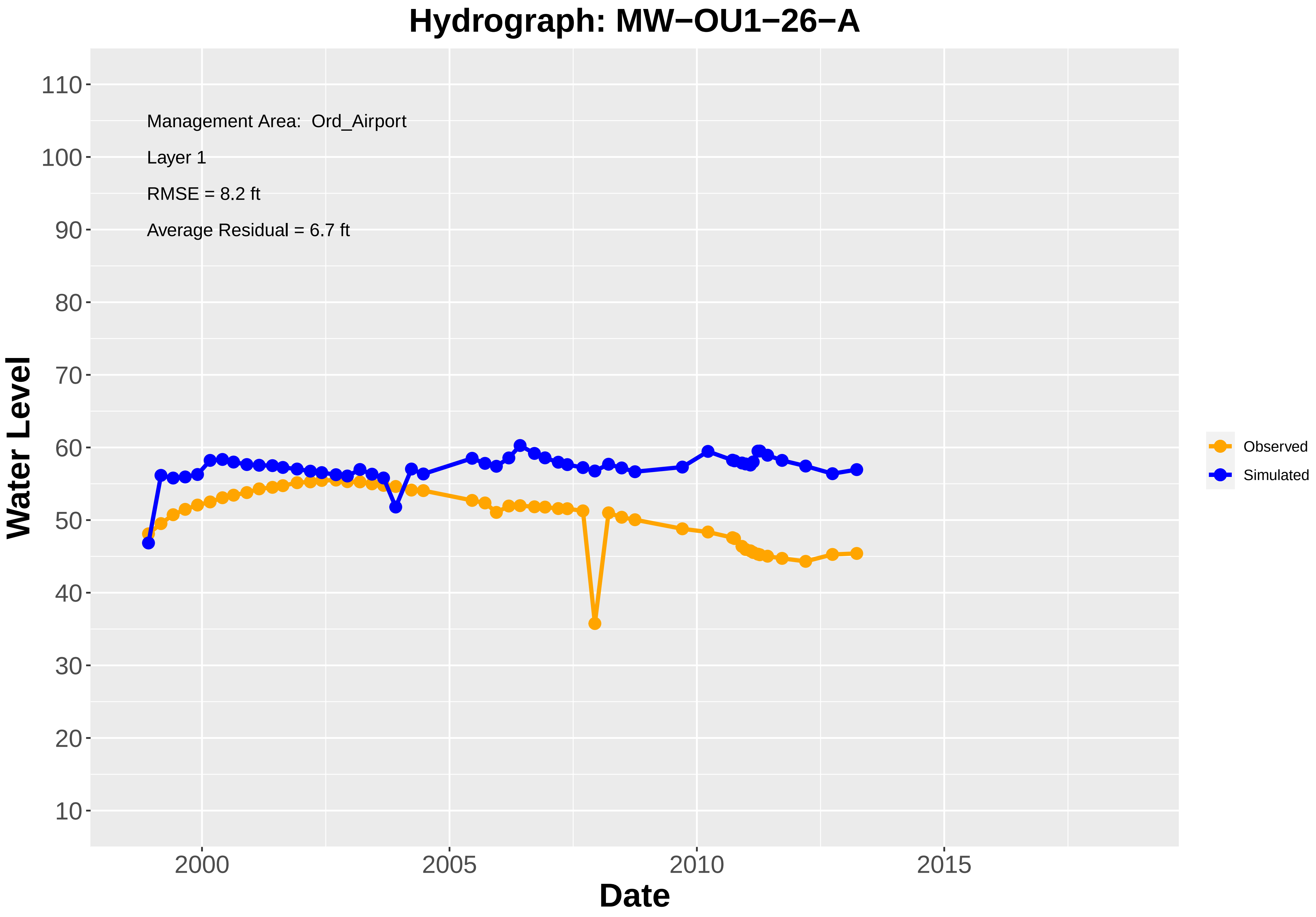
Hydrograph: MW−OU1−23−A

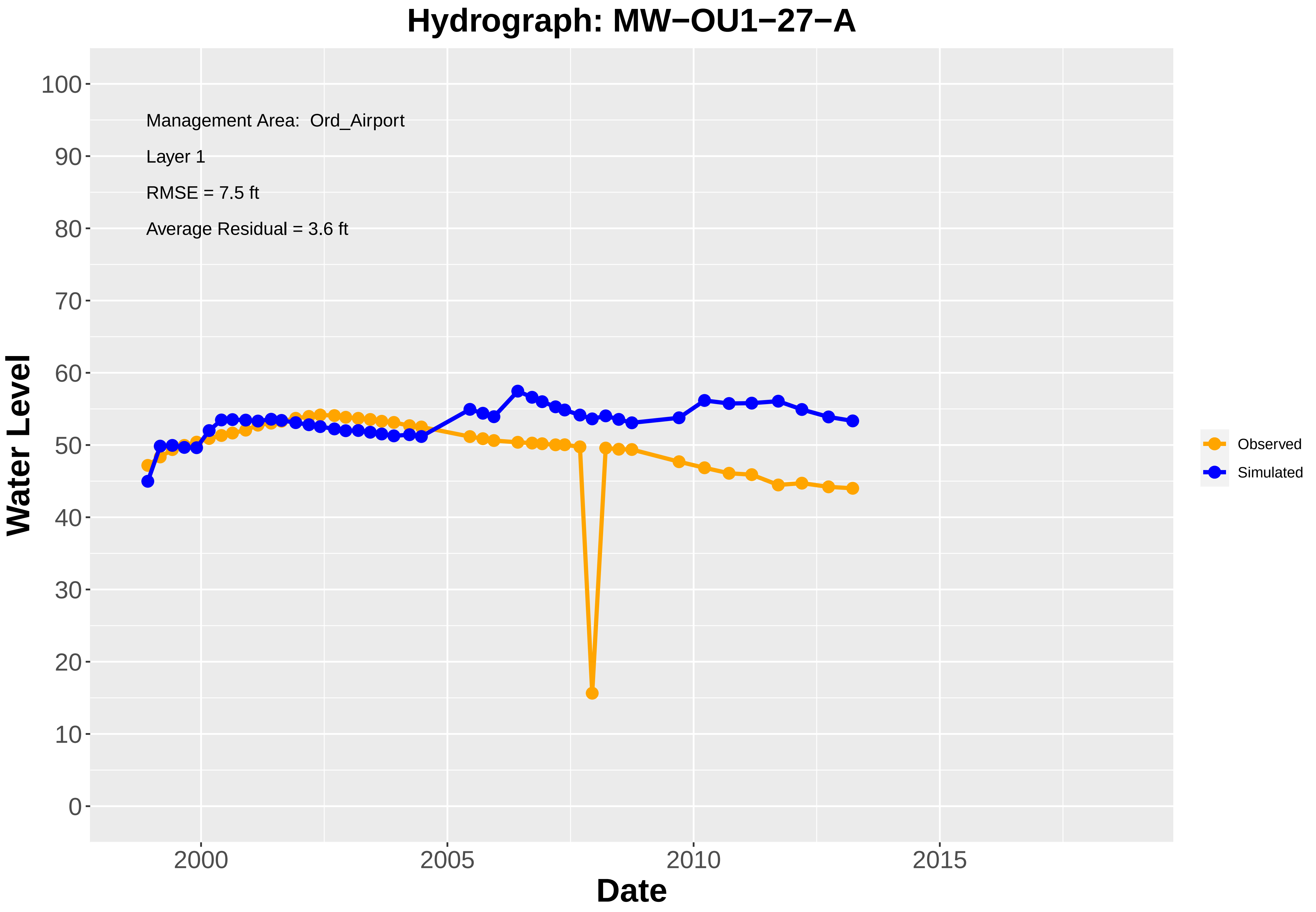


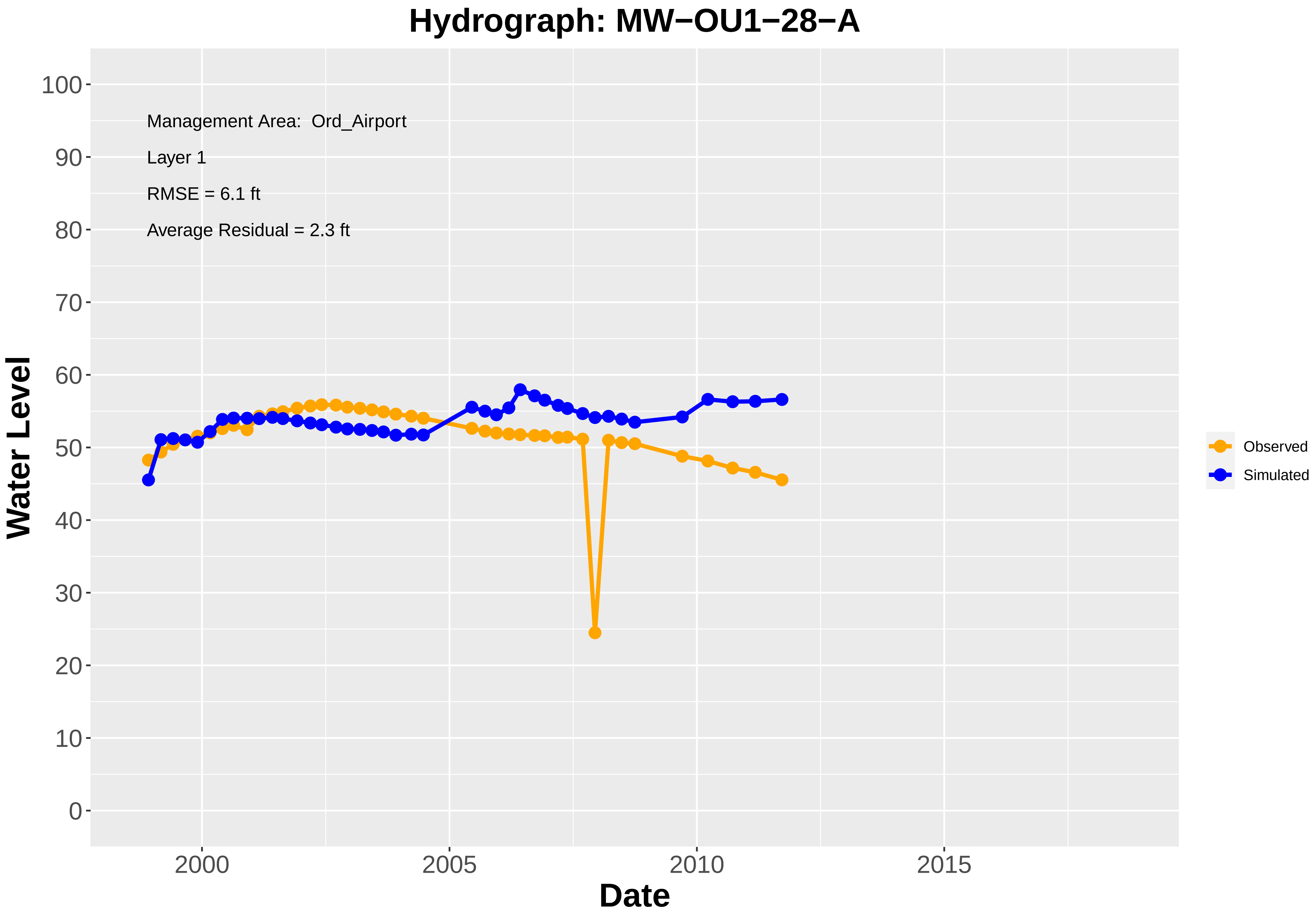

Hydrograph: MW−OU1−24−A
Management Area: Ord_Airport
Layer 1
RMSE = 2.7 ft
Average Residual = 2.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

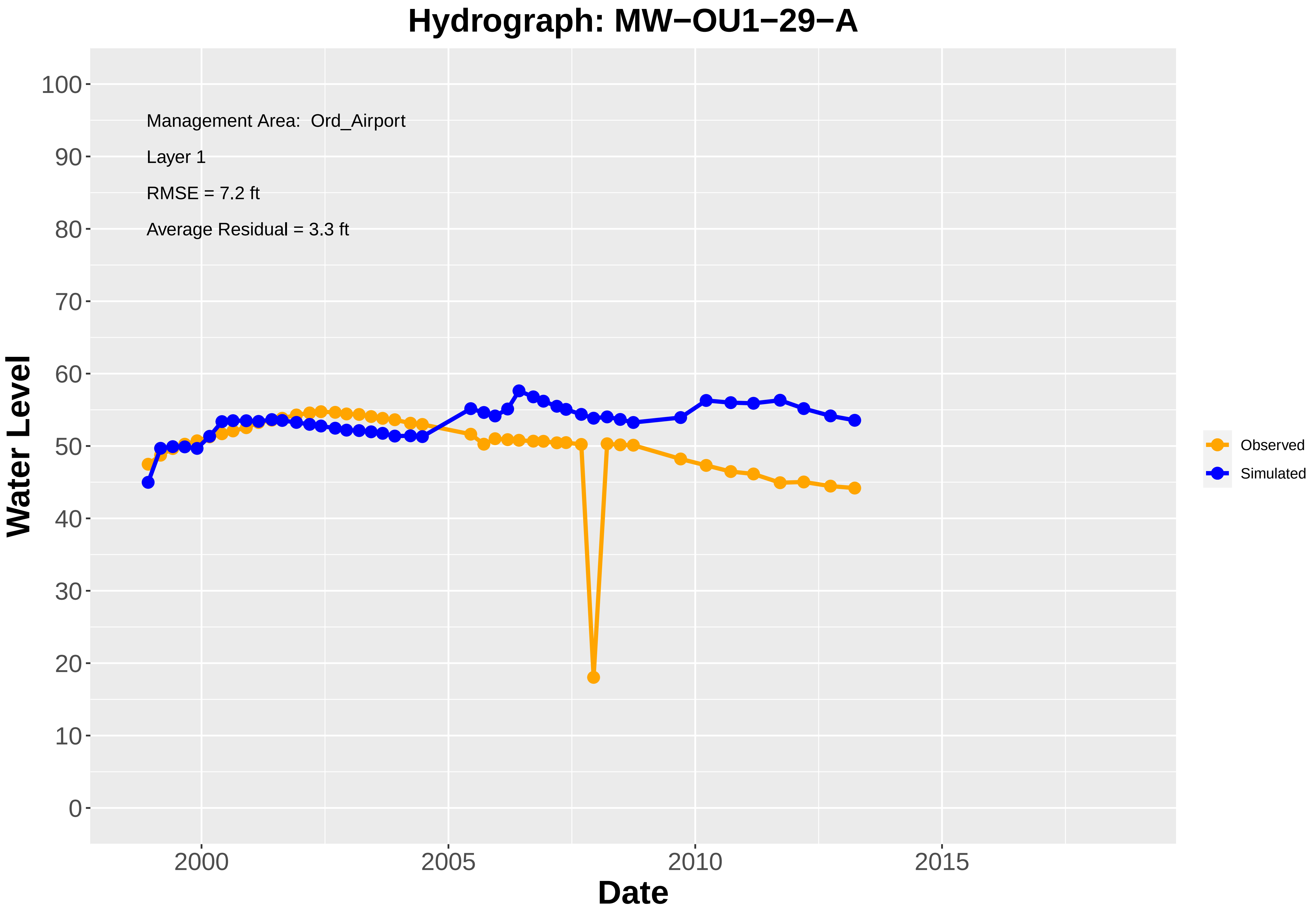

Hydrograph: MW−OU1−24−AR
Management Area: Ord_Airport
Layer 1
RMSE = 5.3 ft
Average Residual = 4.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

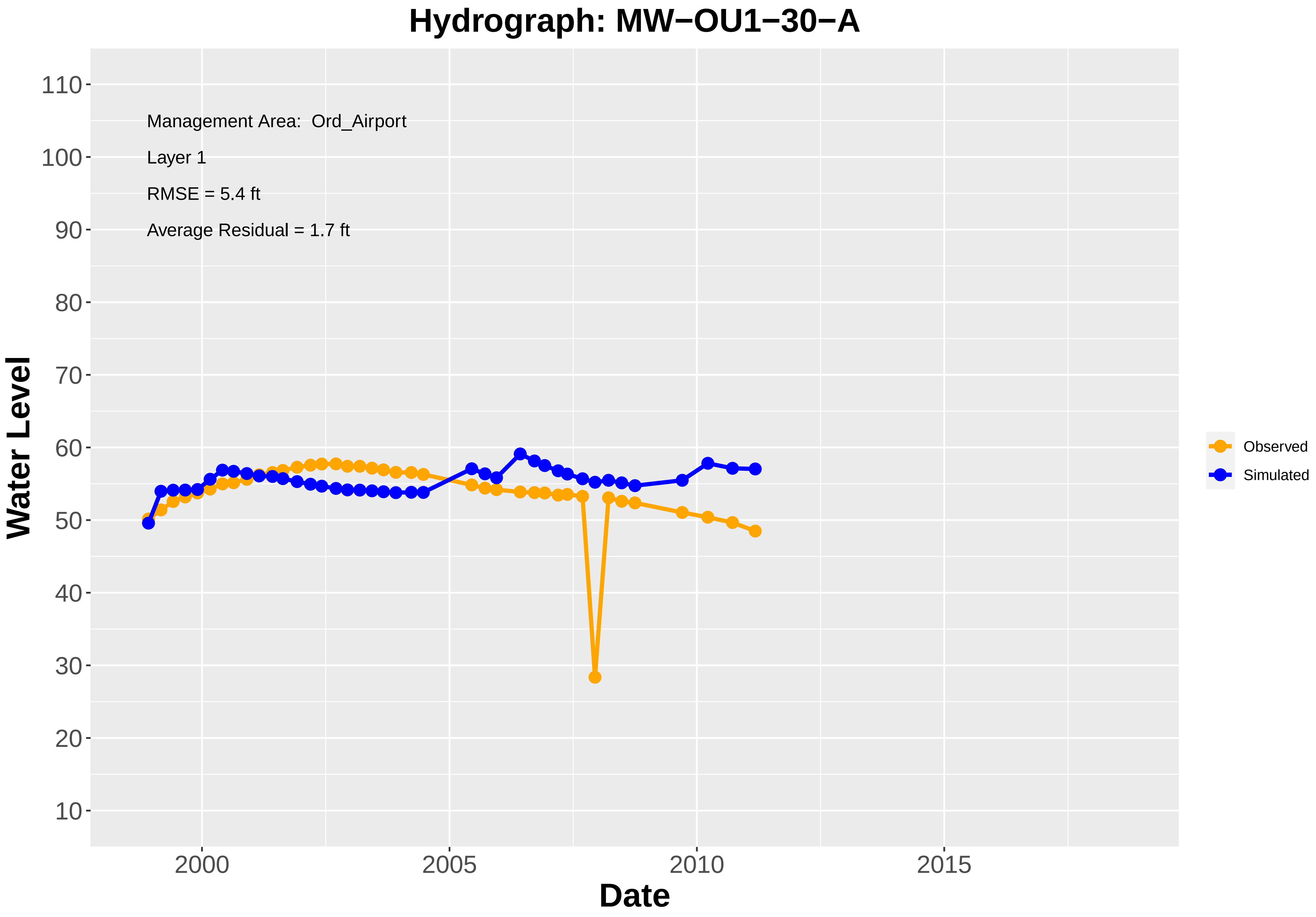

Hydrograph: MW−OU1−25−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.7 ft
Average Residual = 4.9 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

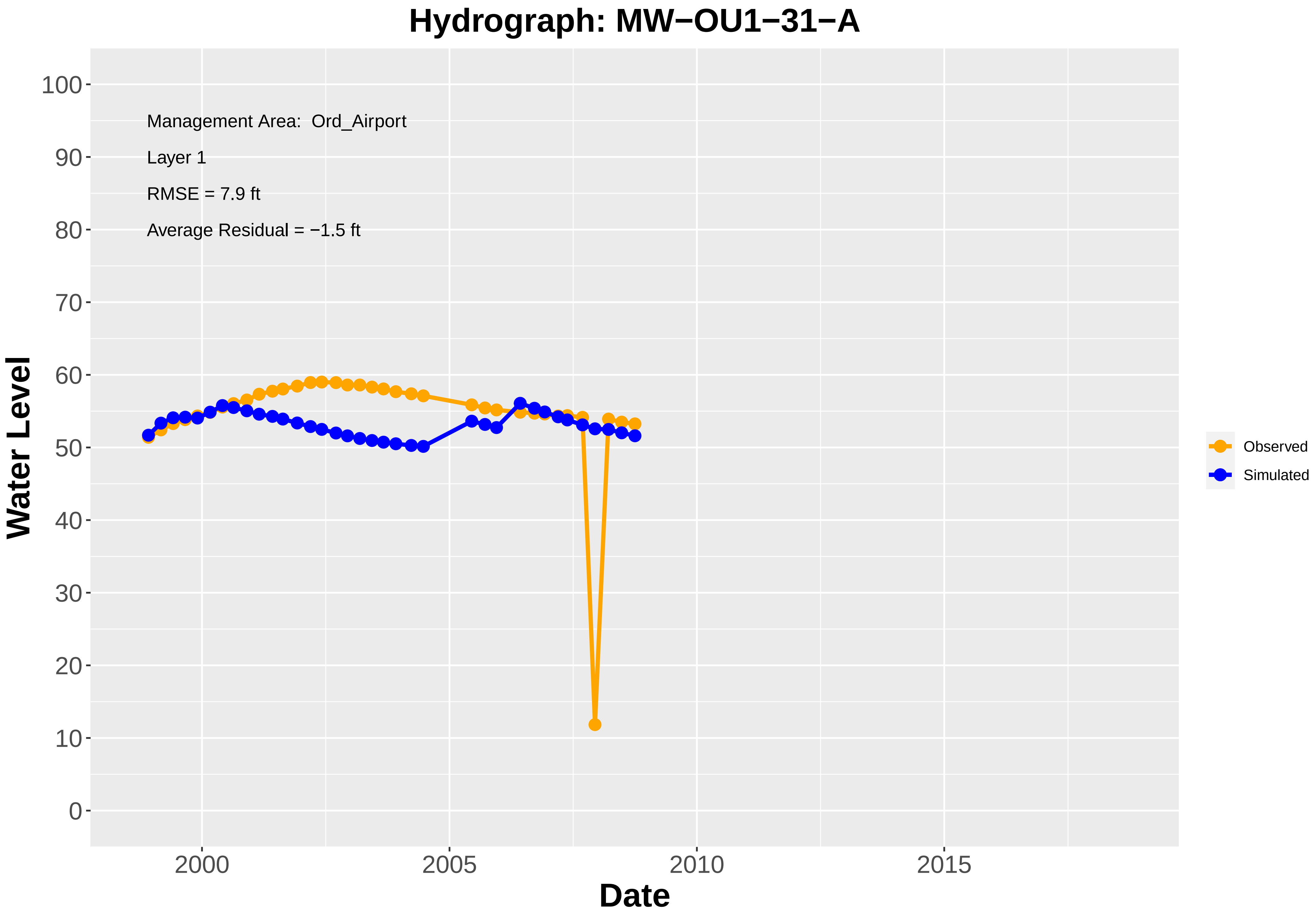

Hydrograph: MW−OU1−26−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.2 ft
Average Residual = 6.7 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

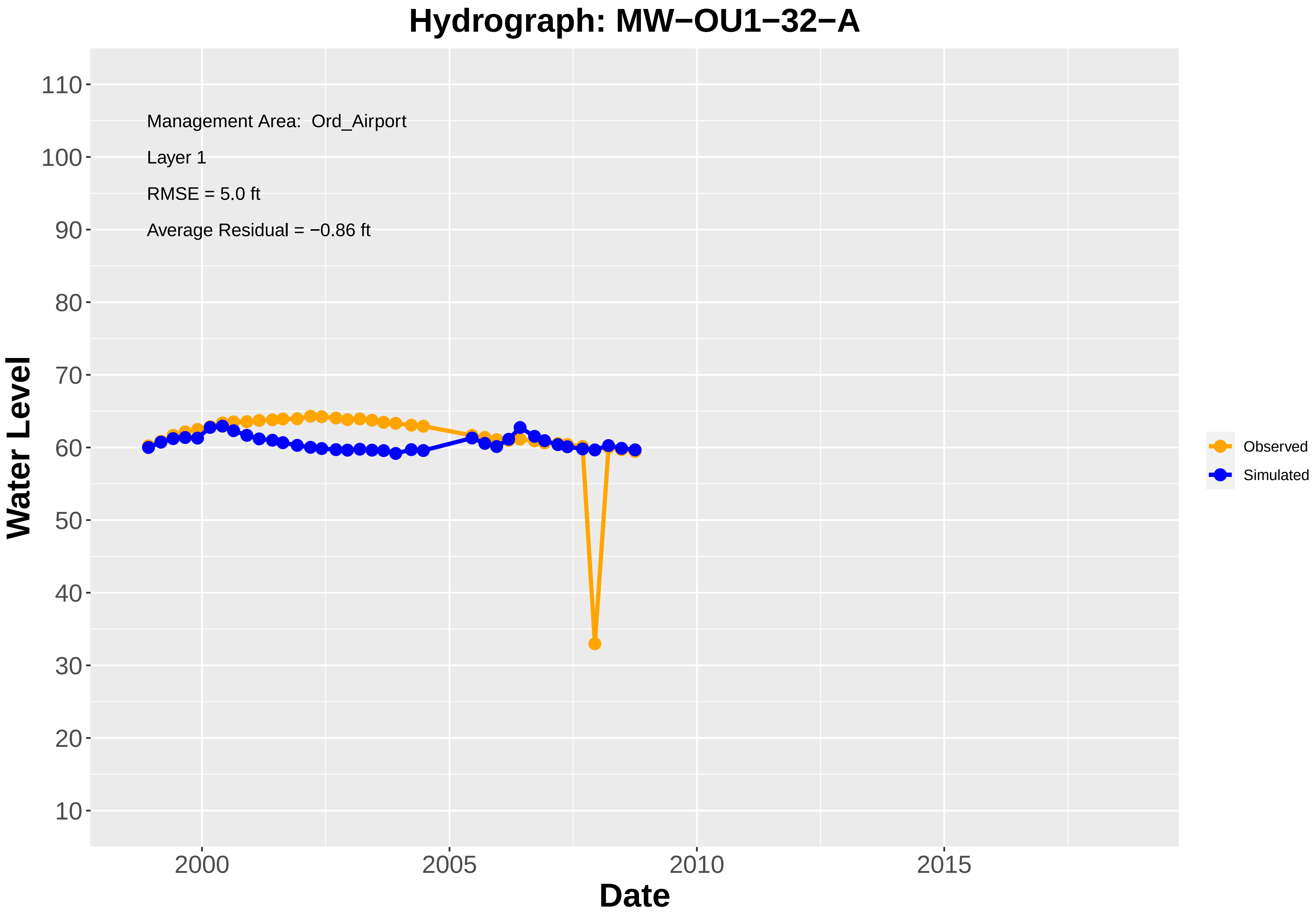

Hydrograph: MW−OU1−27−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.5 ft
Average Residual = 3.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

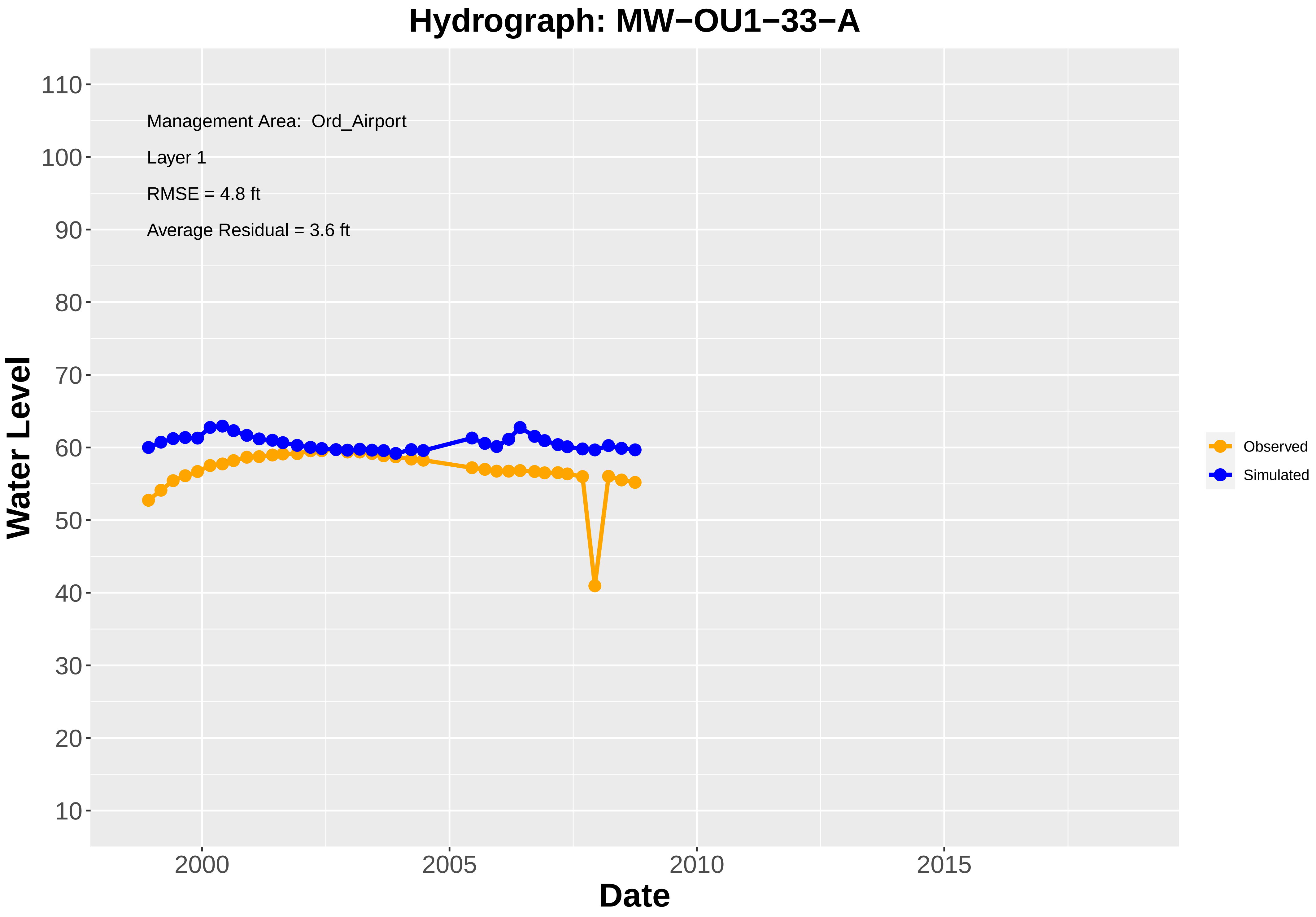

Hydrograph: MW−OU1−28−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.1 ft
Average Residual = 2.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

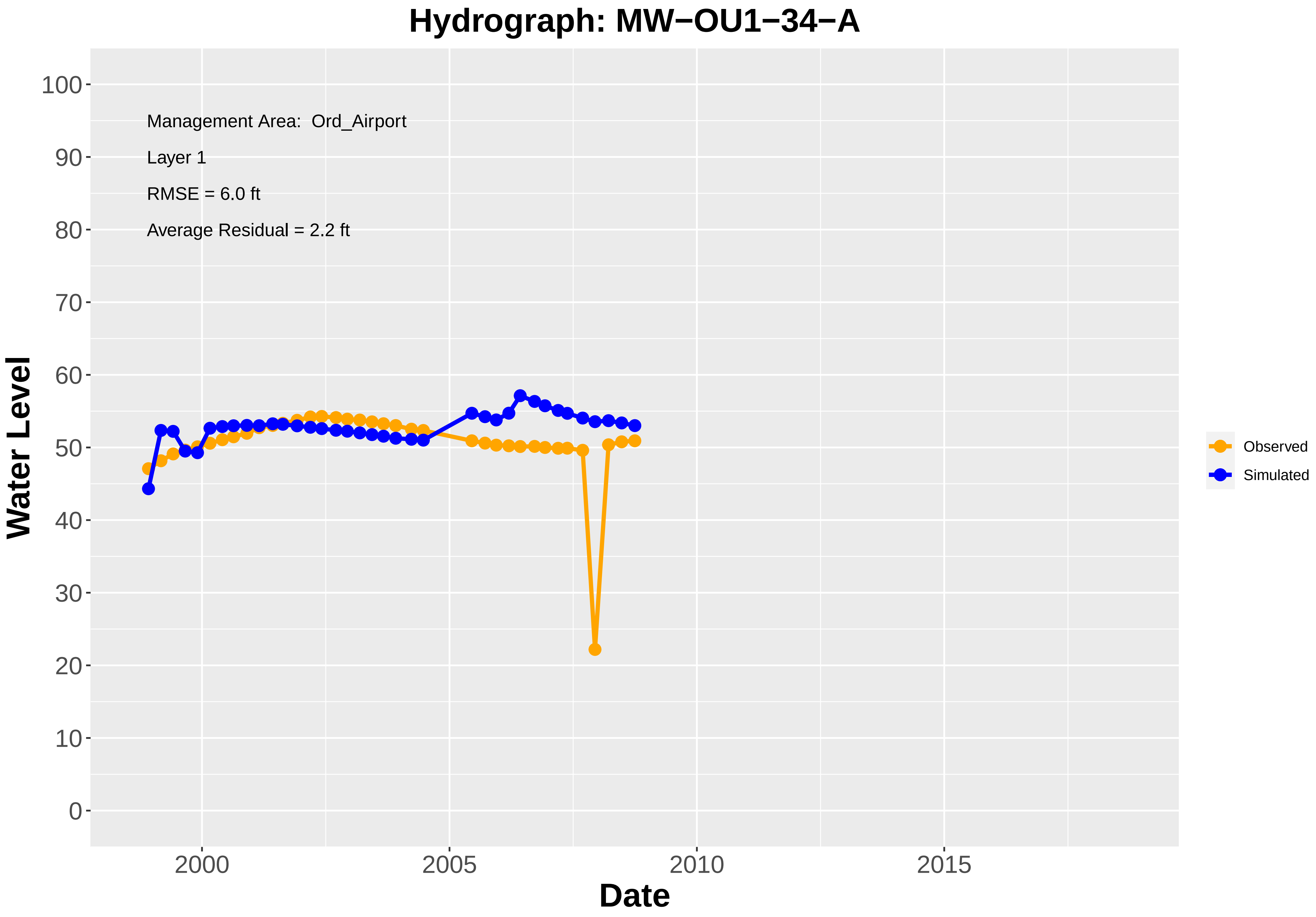

Hydrograph: MW−OU1−29−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.2 ft
Average Residual = 3.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU1−30−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.4 ft
Average Residual = 1.7 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

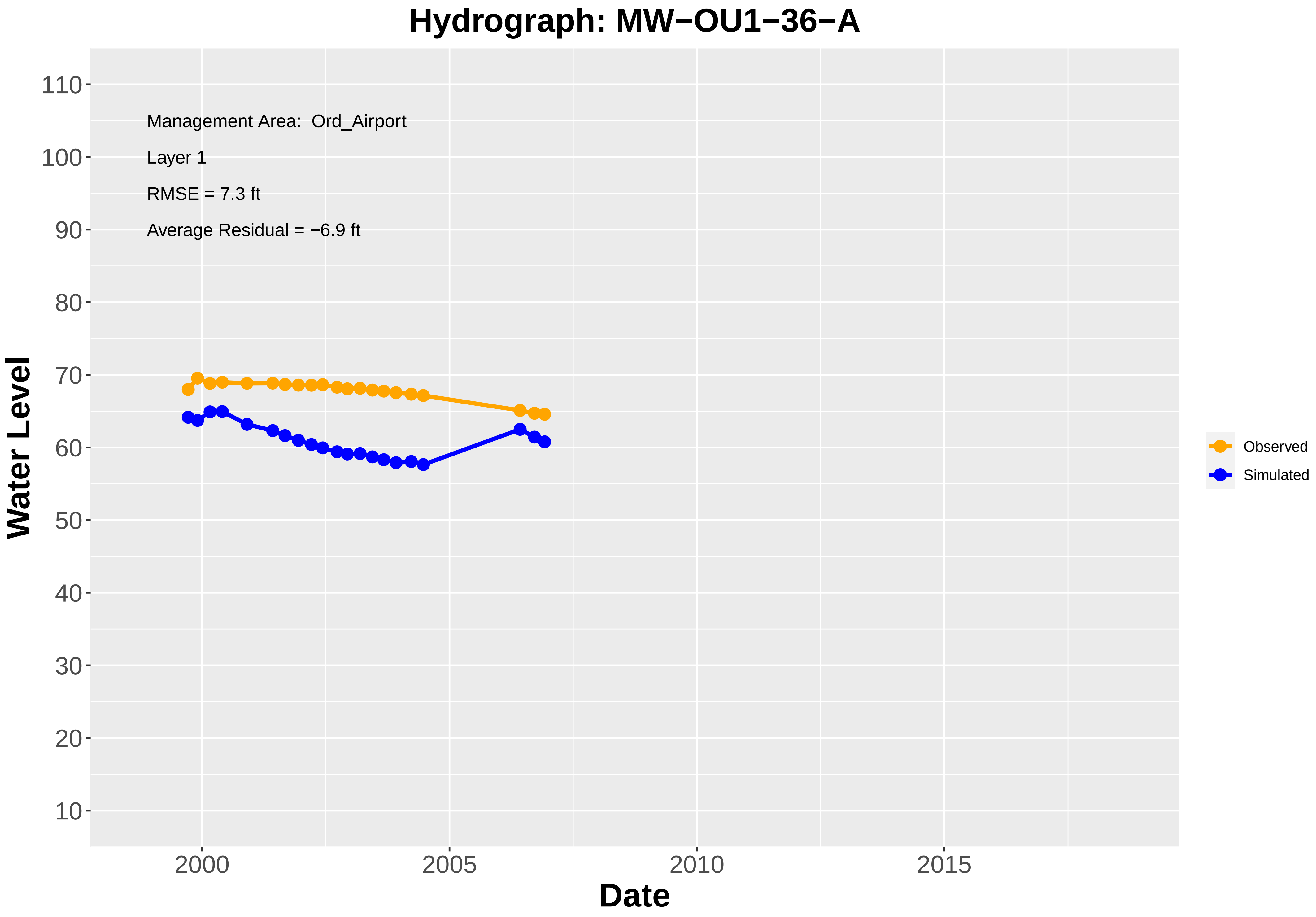

Hydrograph: MW−OU1−31−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.9 ft
Average Residual = −1.5 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

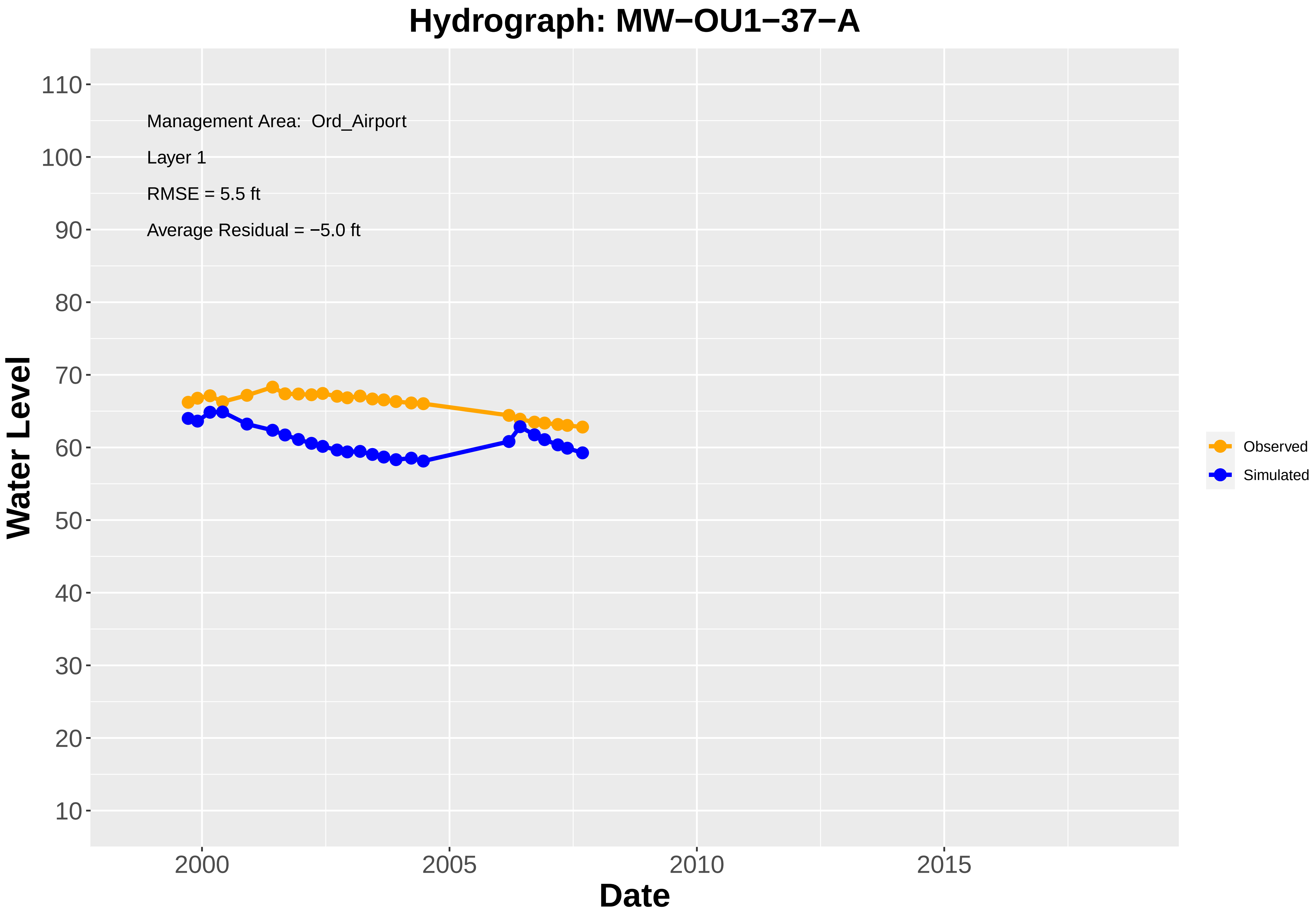

Hydrograph: MW−OU1−32−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.0 ft
Average Residual = −0.86 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

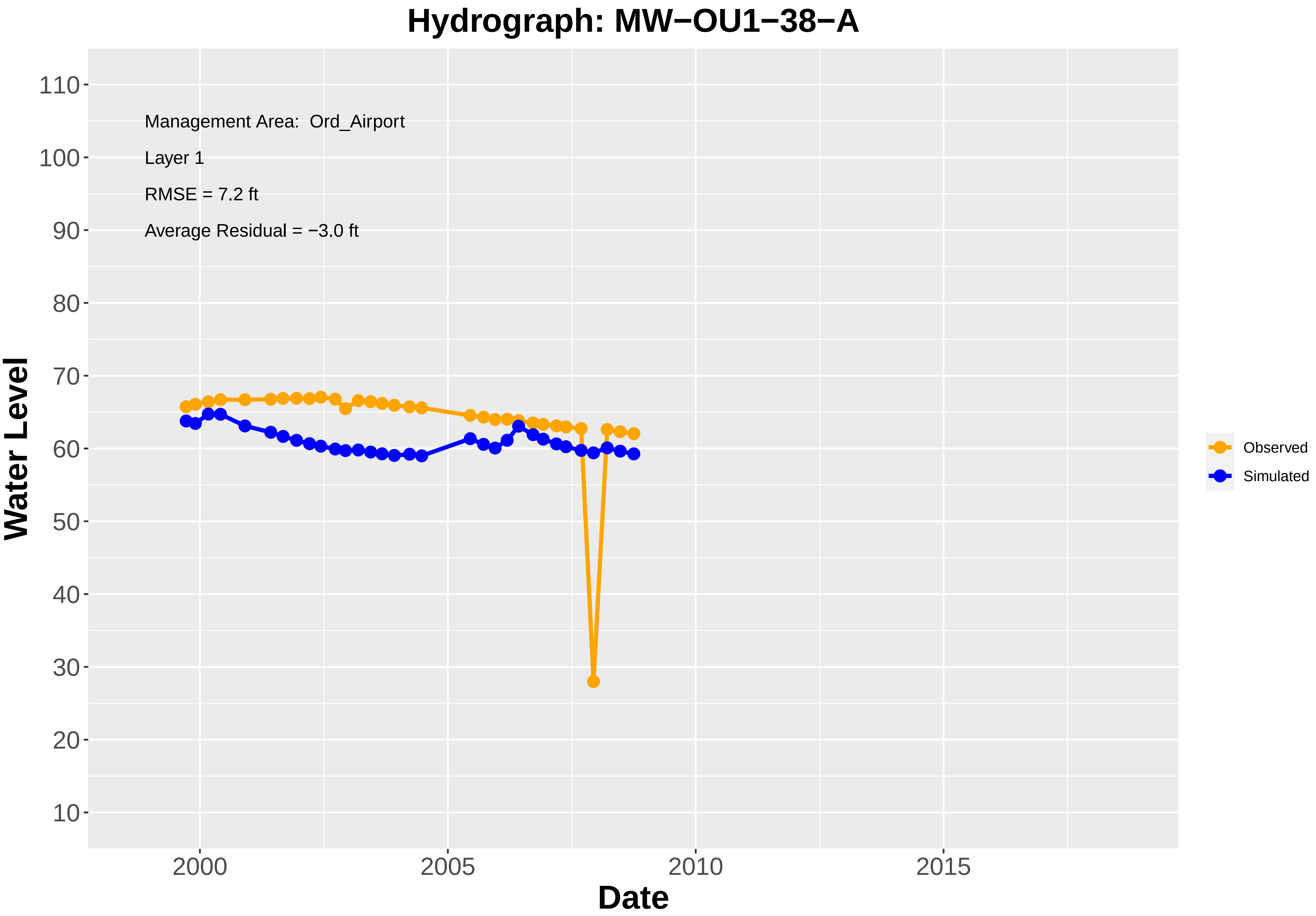

Hydrograph: MW−OU1−33−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.8 ft
Average Residual = 3.6 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated



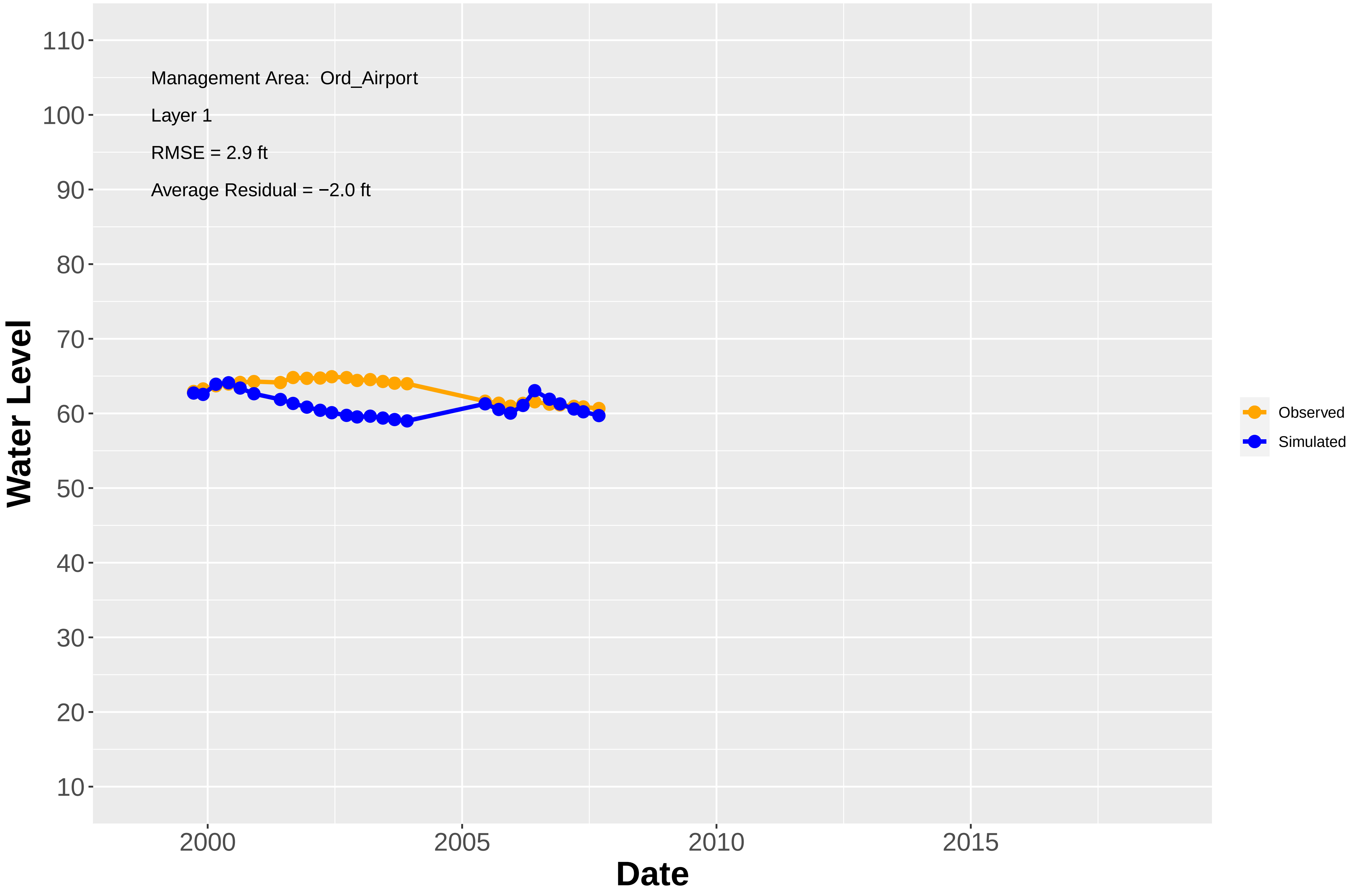
Hydrograph: MW−OU1−34−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.0 ft
Average Residual = 2.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

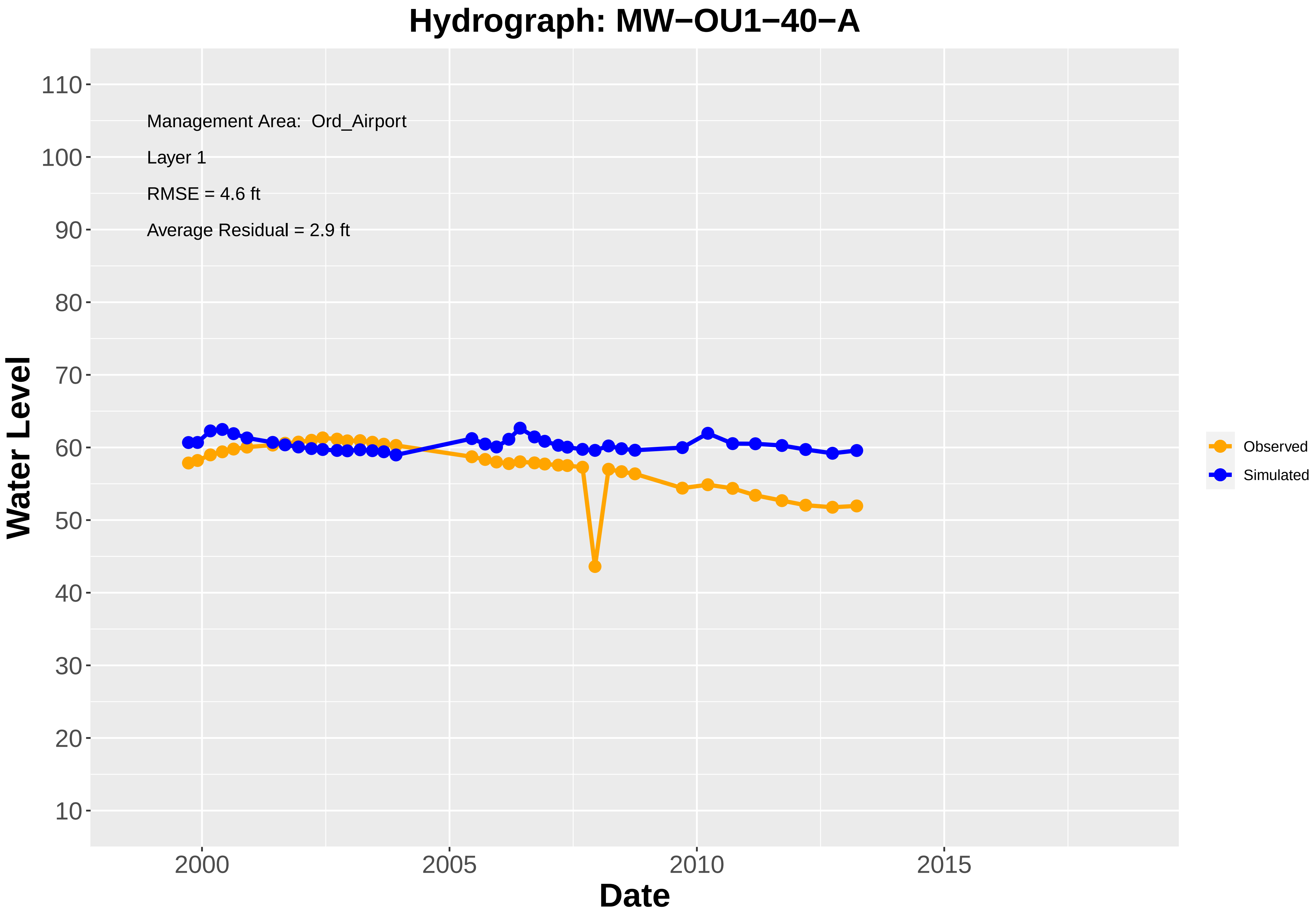

Hydrograph: MW−OU1−36−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.3 ft
Average Residual = −6.9 ft
110
100
90
80
70
60
50
40
30
20
10
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−37−A
Management Area: Ord_Airport
Layer 1
RMSE = 5.5 ft
Average Residual = −5.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

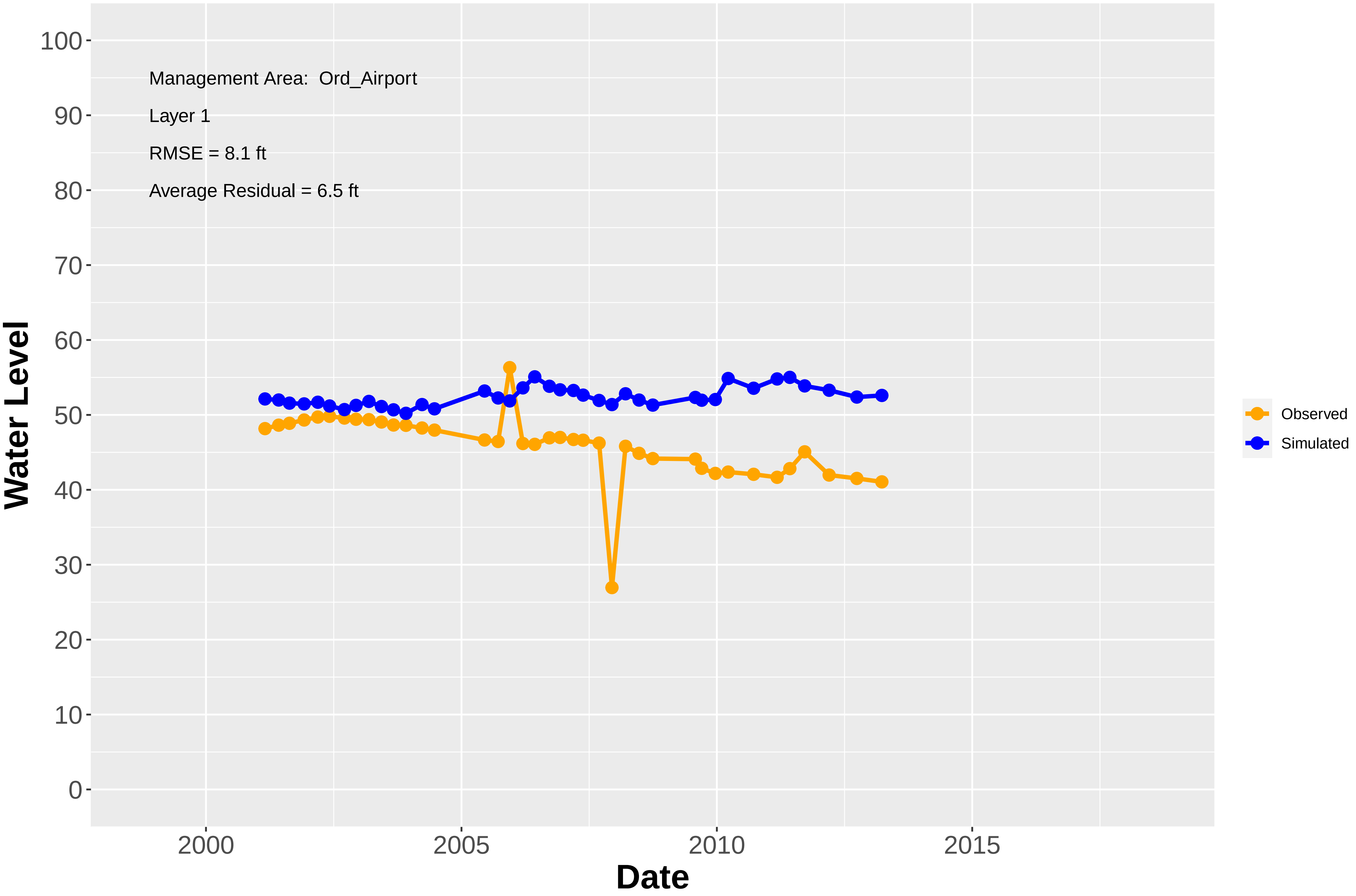

Hydrograph: MW−OU1−38−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.2 ft
Average Residual = −3.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

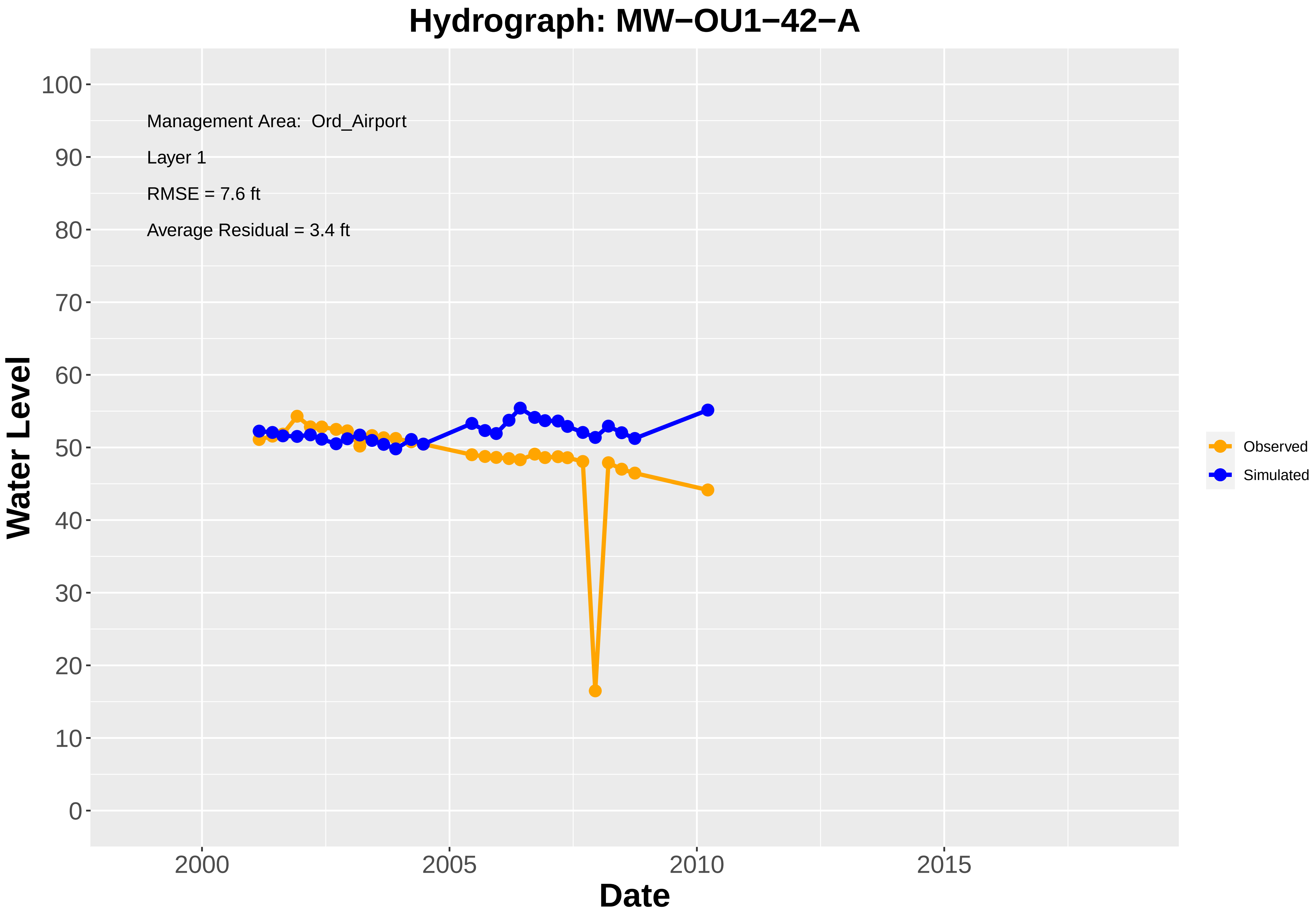
Hydrograph: MW−OU1−39−A

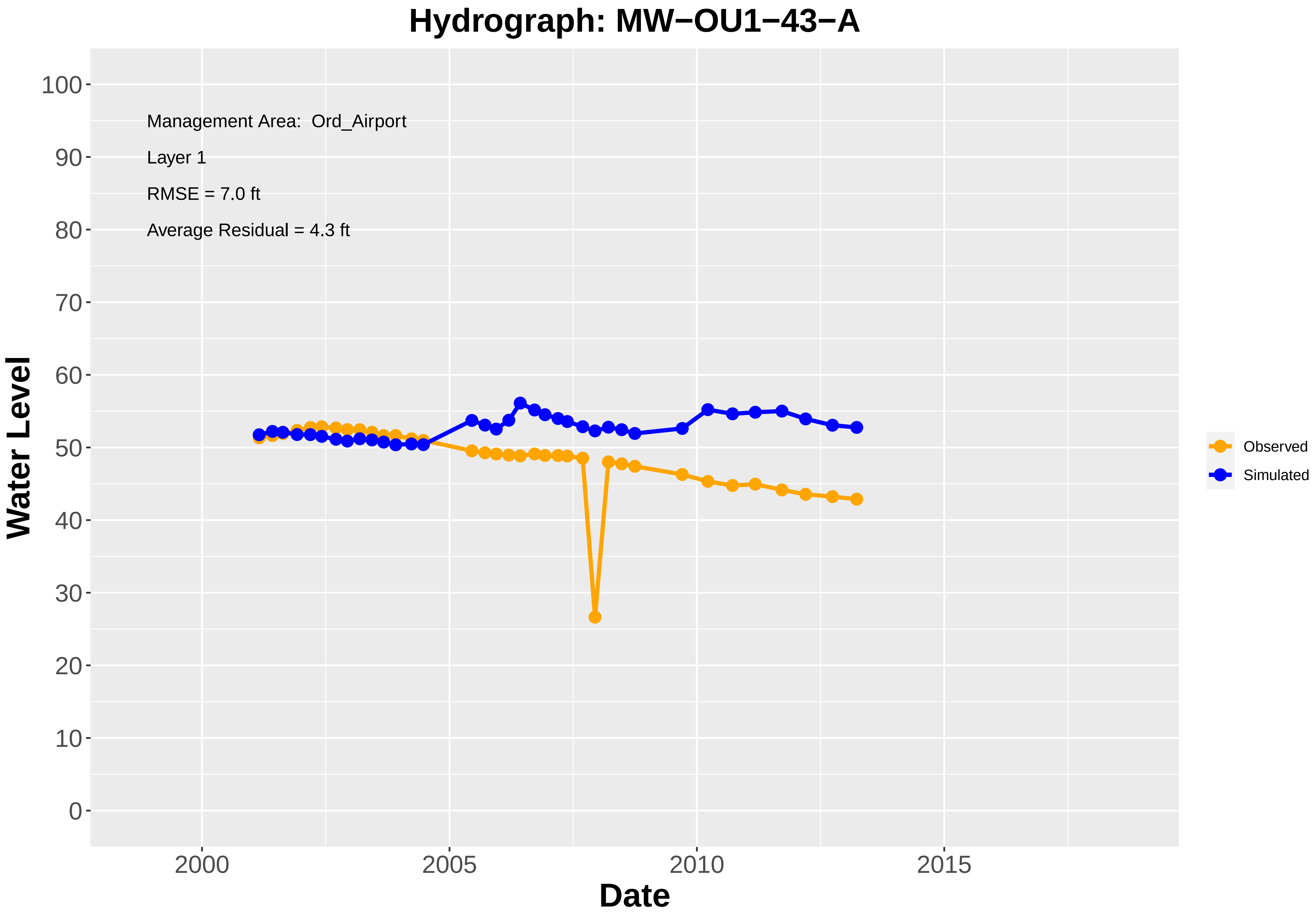


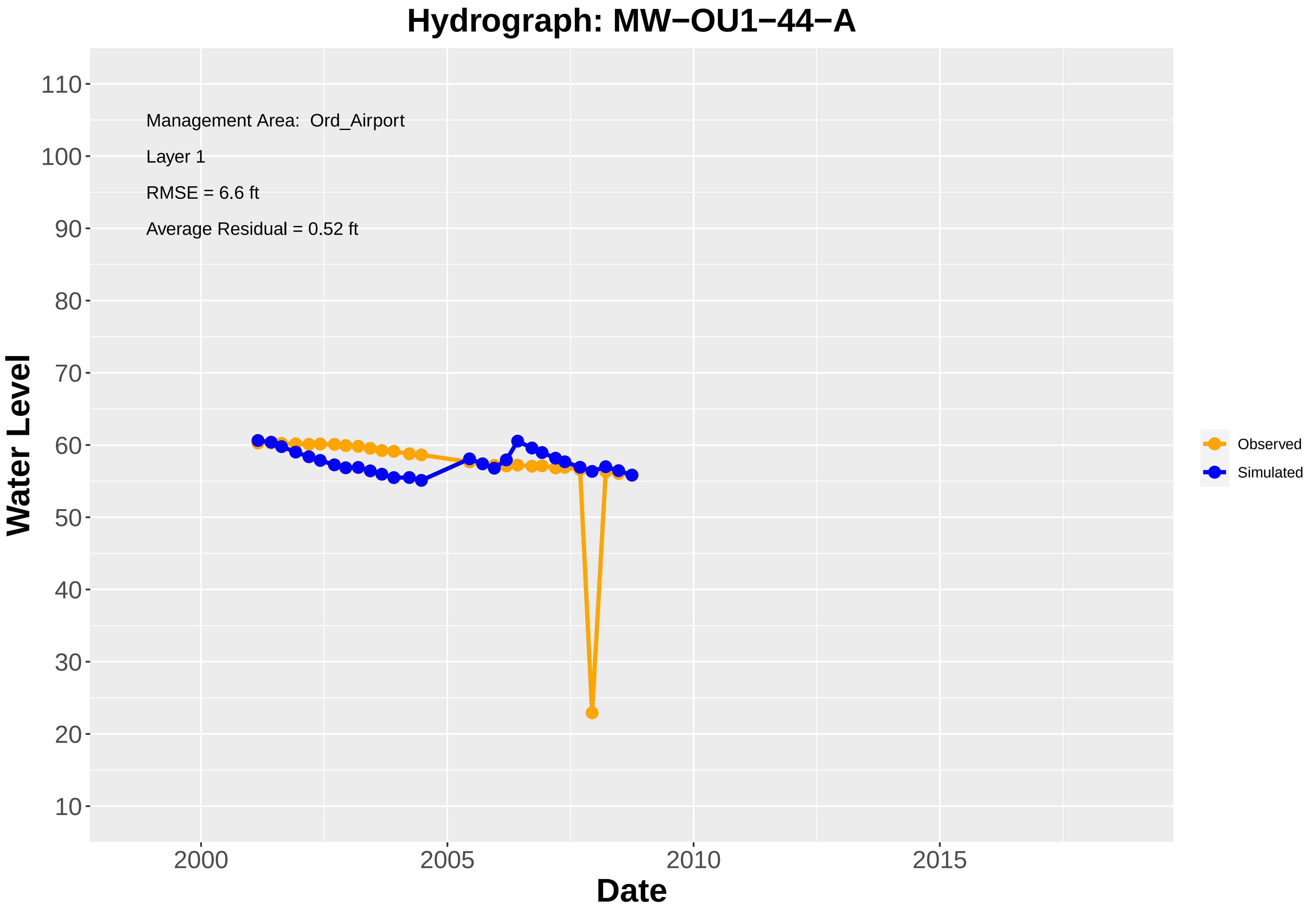

Hydrograph: MW−OU1−40−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.6 ft
Average Residual = 2.9 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

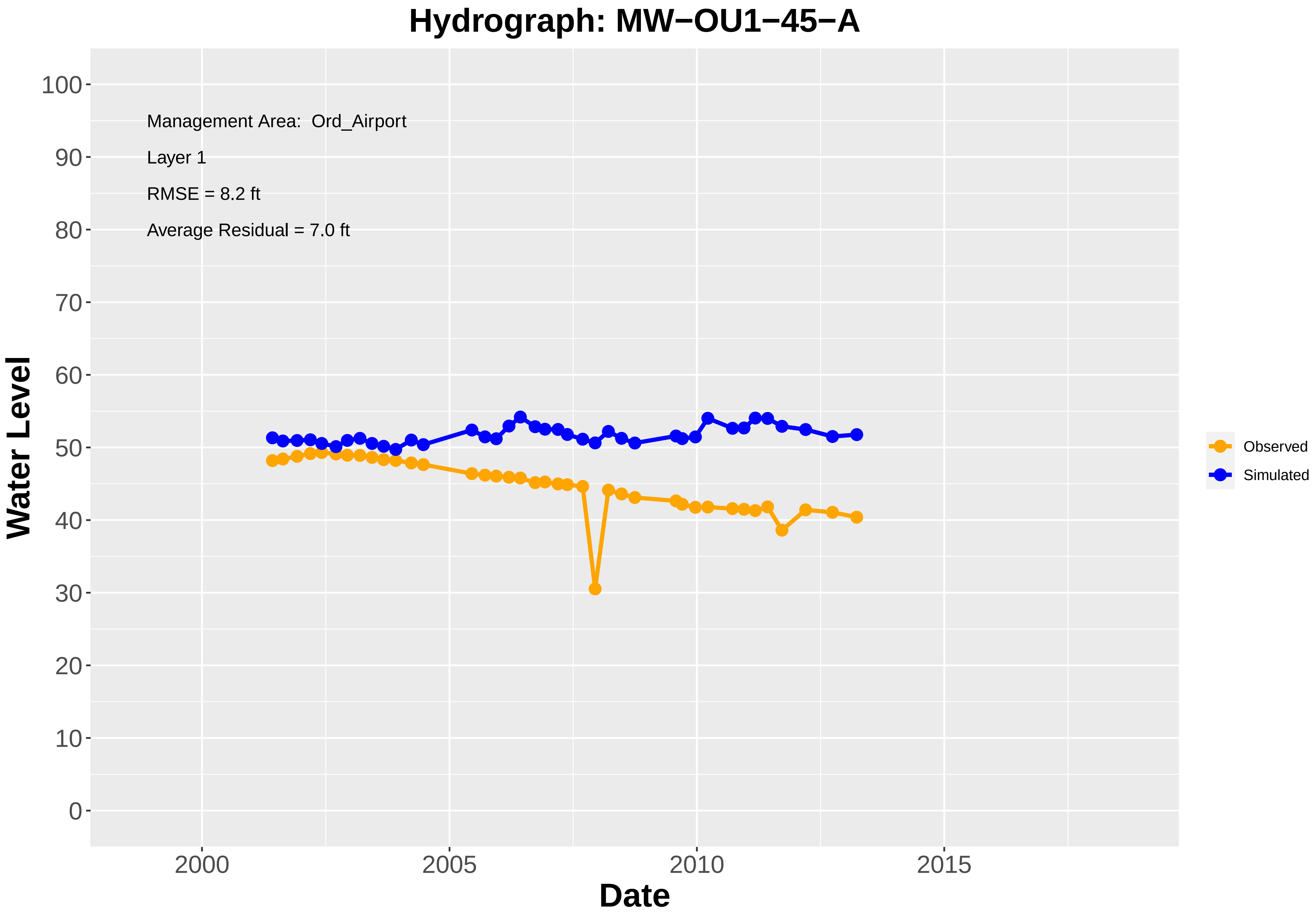
Hydrograph: MW−OU1−41−A

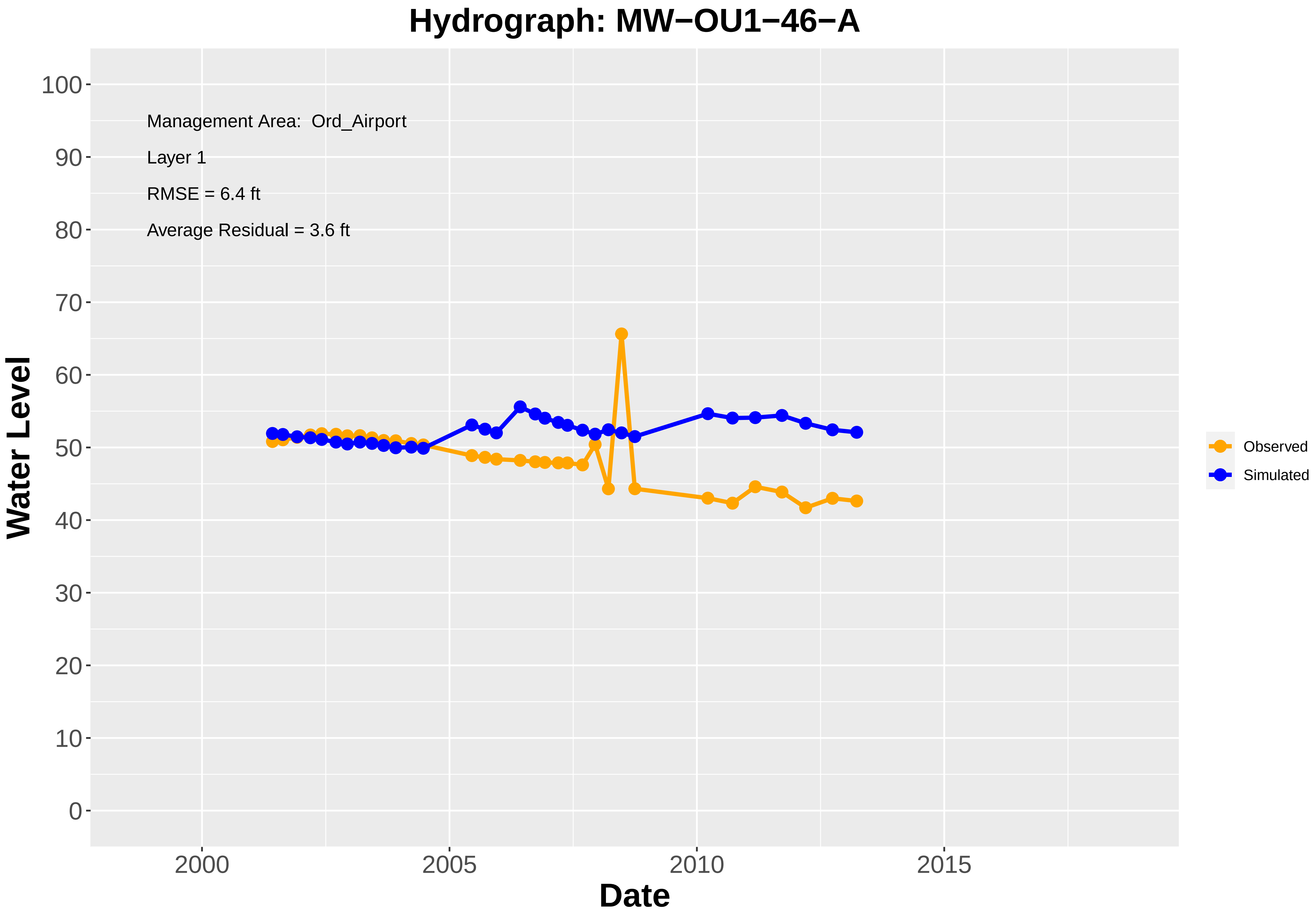


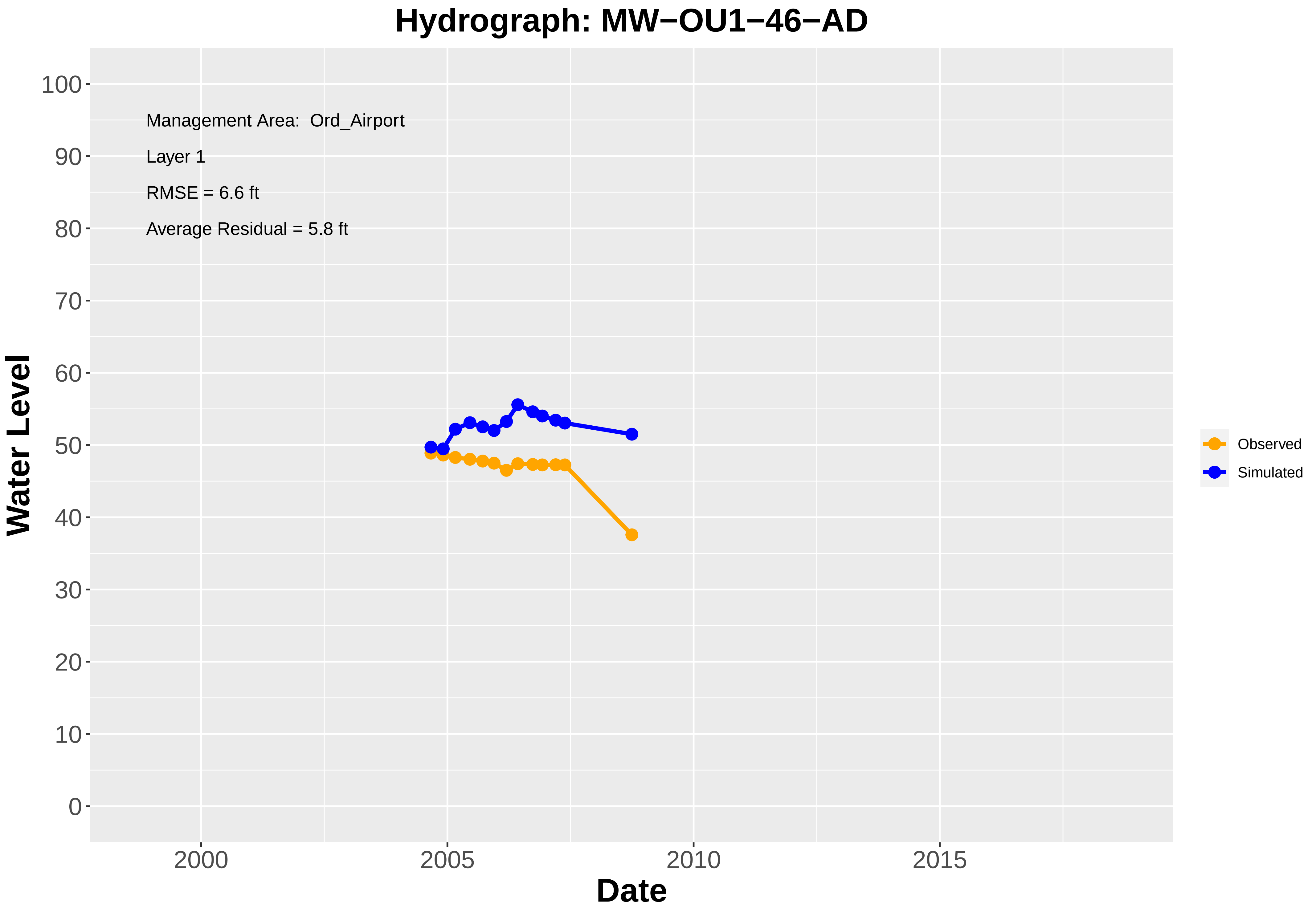

Hydrograph: MW−OU1−42−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.6 ft
Average Residual = 3.4 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

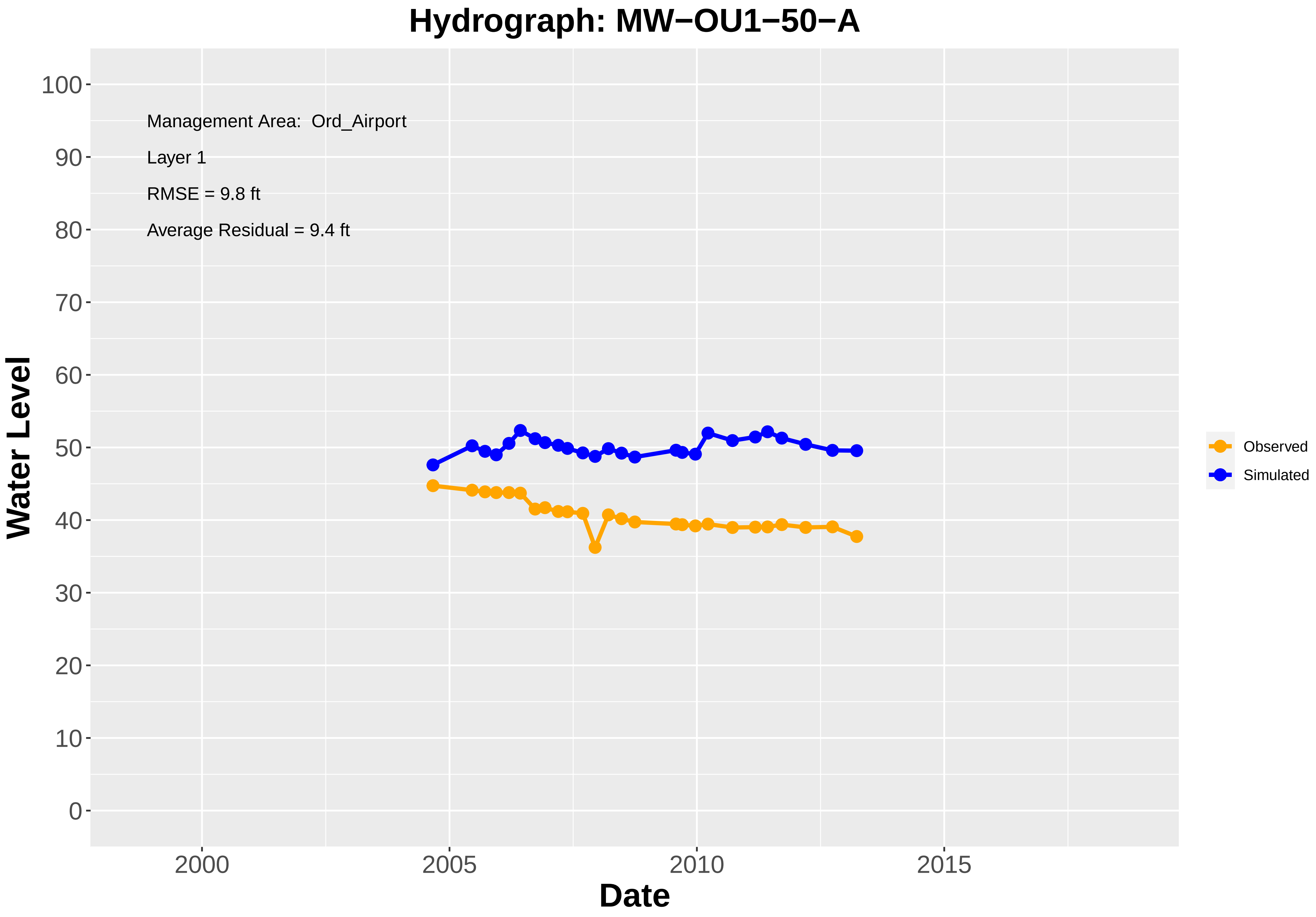

Hydrograph: MW−OU1−43−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.0 ft
Average Residual = 4.3 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

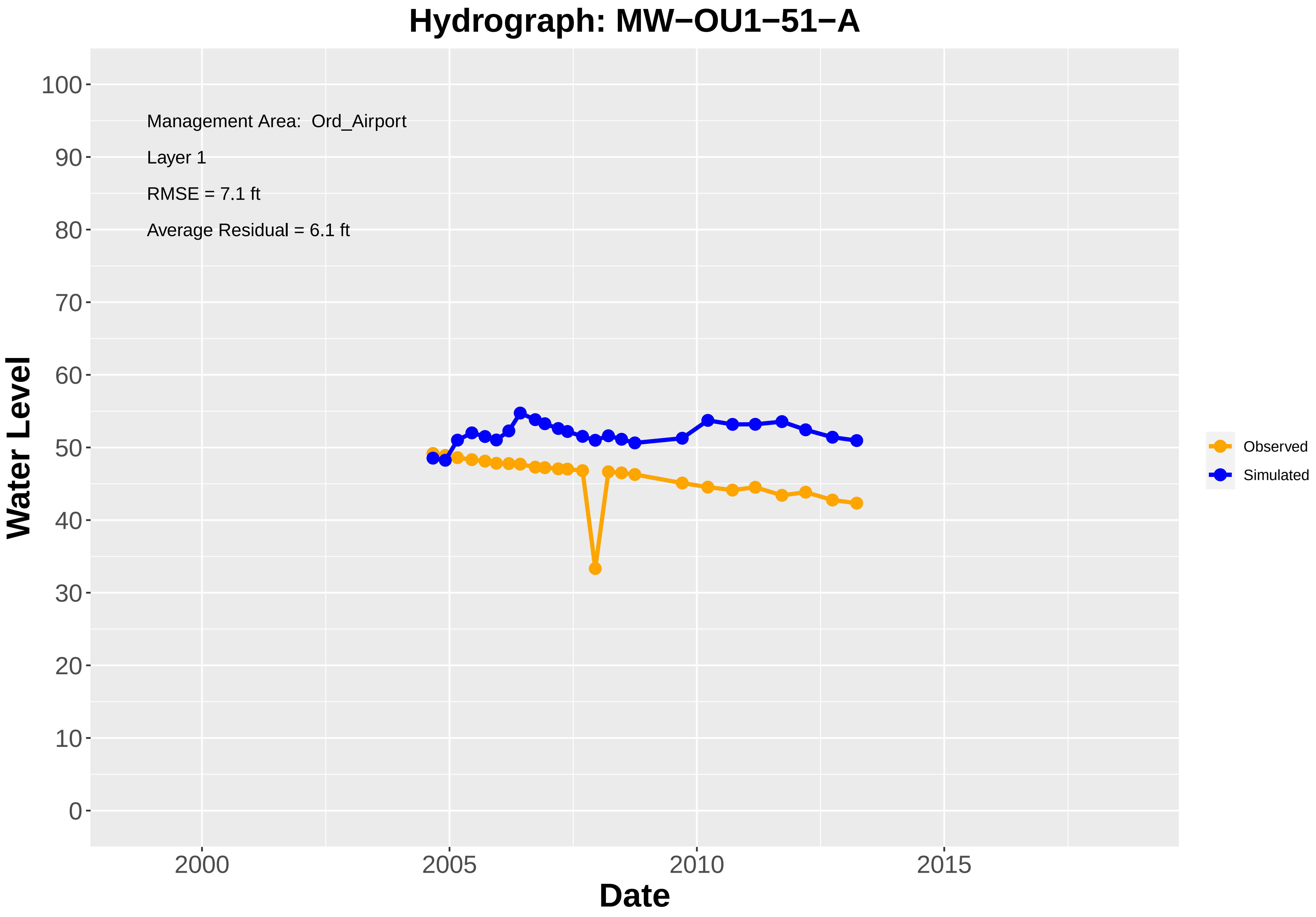

Hydrograph: MW−OU1−44−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.6 ft
Average Residual = 0.52 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

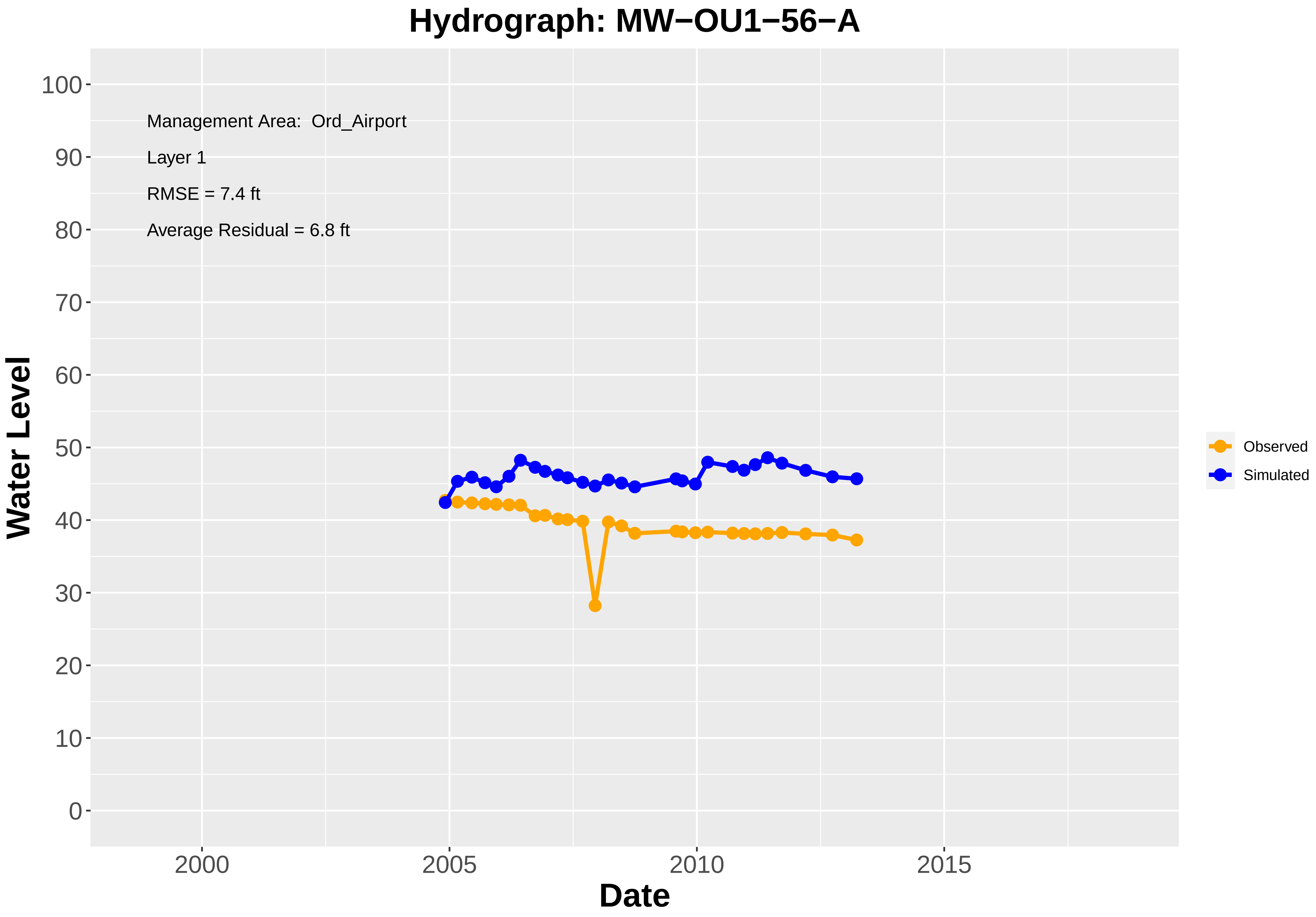

Hydrograph: MW−OU1−45−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.2 ft
Average Residual = 7.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU1−46−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.4 ft
Average Residual = 3.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

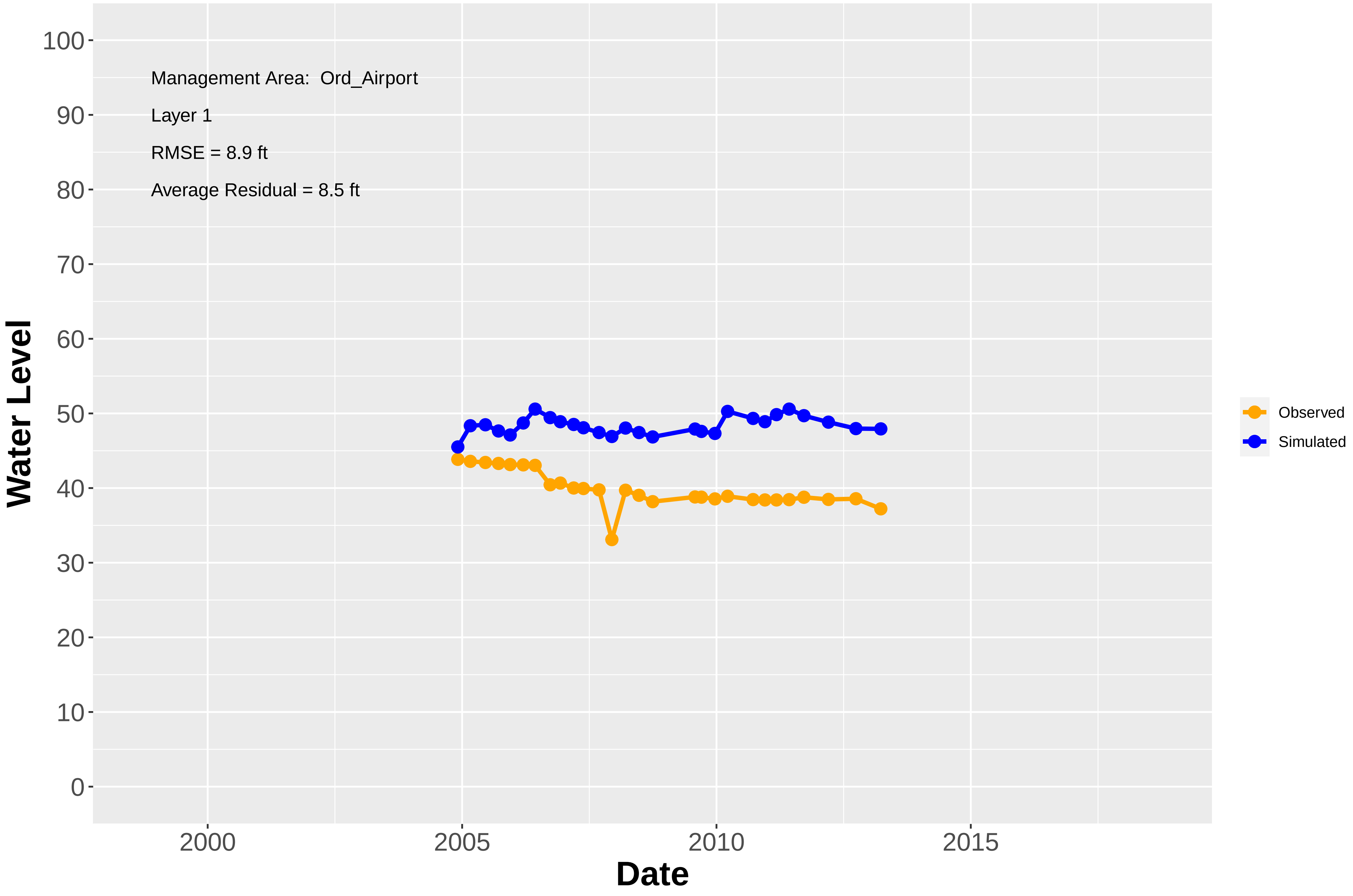

Hydrograph: MW−OU1−46−AD
Management Area: Ord_Airport
Layer 1
RMSE = 6.6 ft
Average Residual = 5.8 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

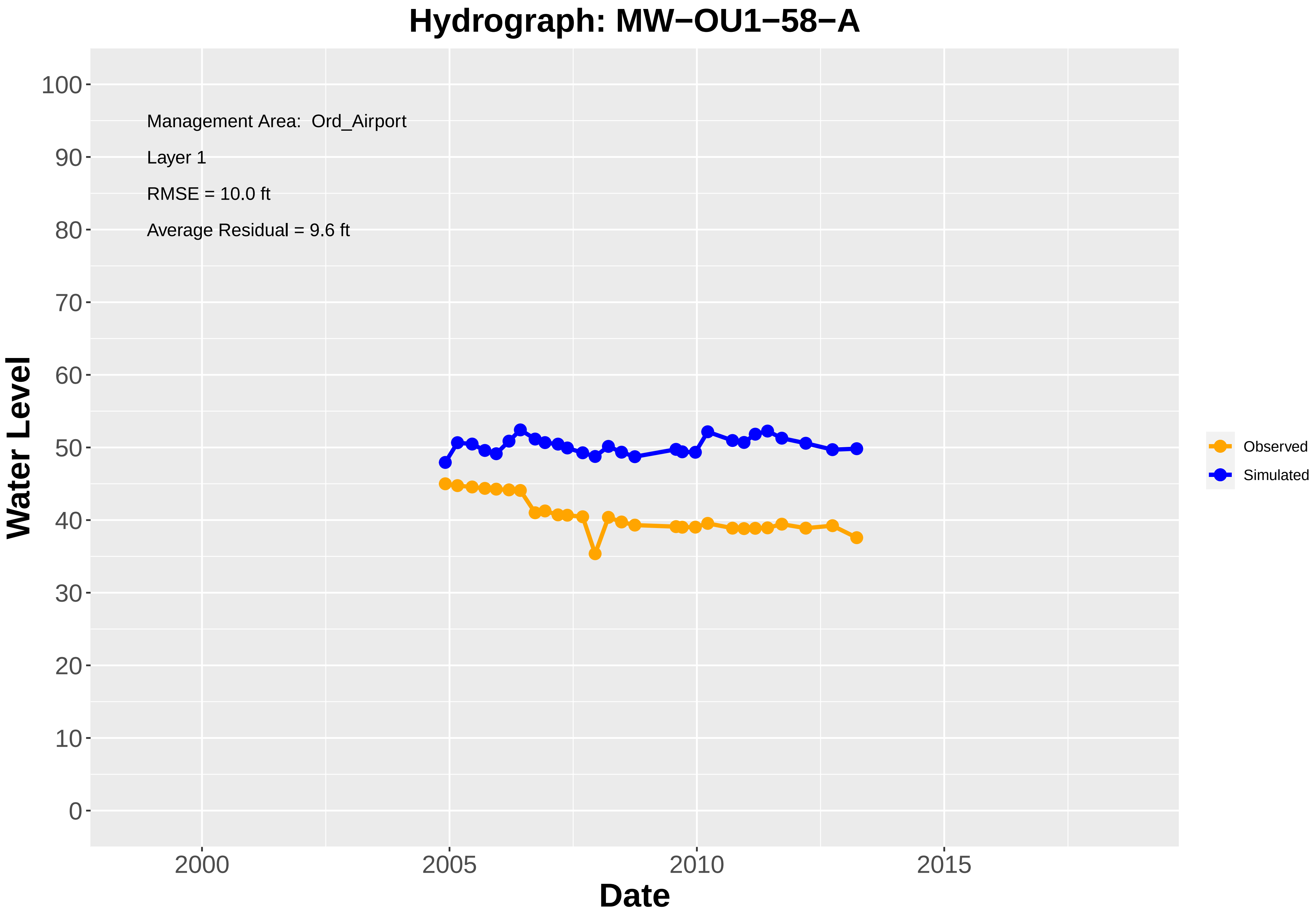

Hydrograph: MW−OU1−50−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.8 ft
Average Residual = 9.4 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

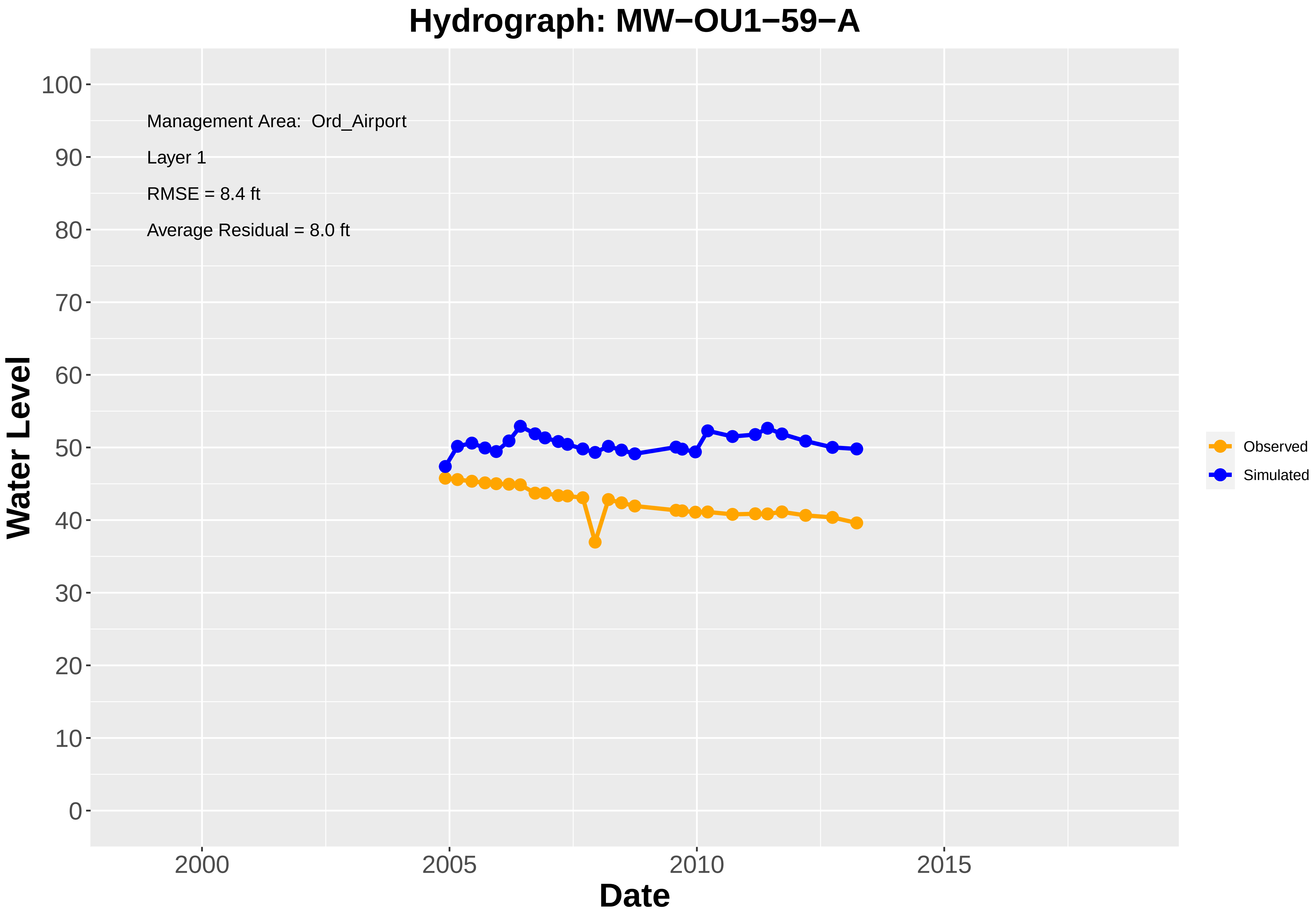

Hydrograph: MW−OU1−51−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.1 ft
Average Residual = 6.1 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

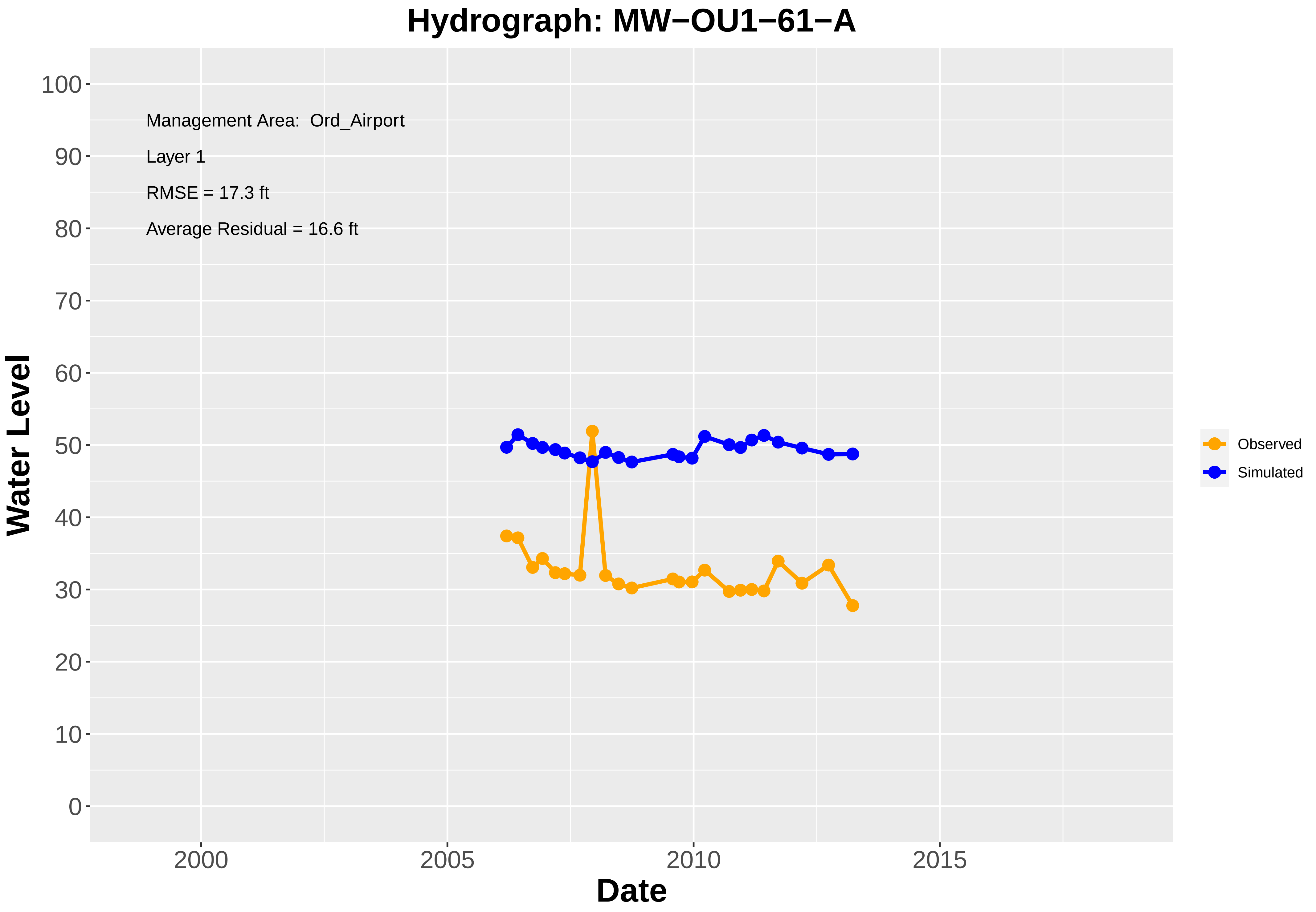

Hydrograph: MW−OU1−56−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.4 ft
Average Residual = 6.8 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

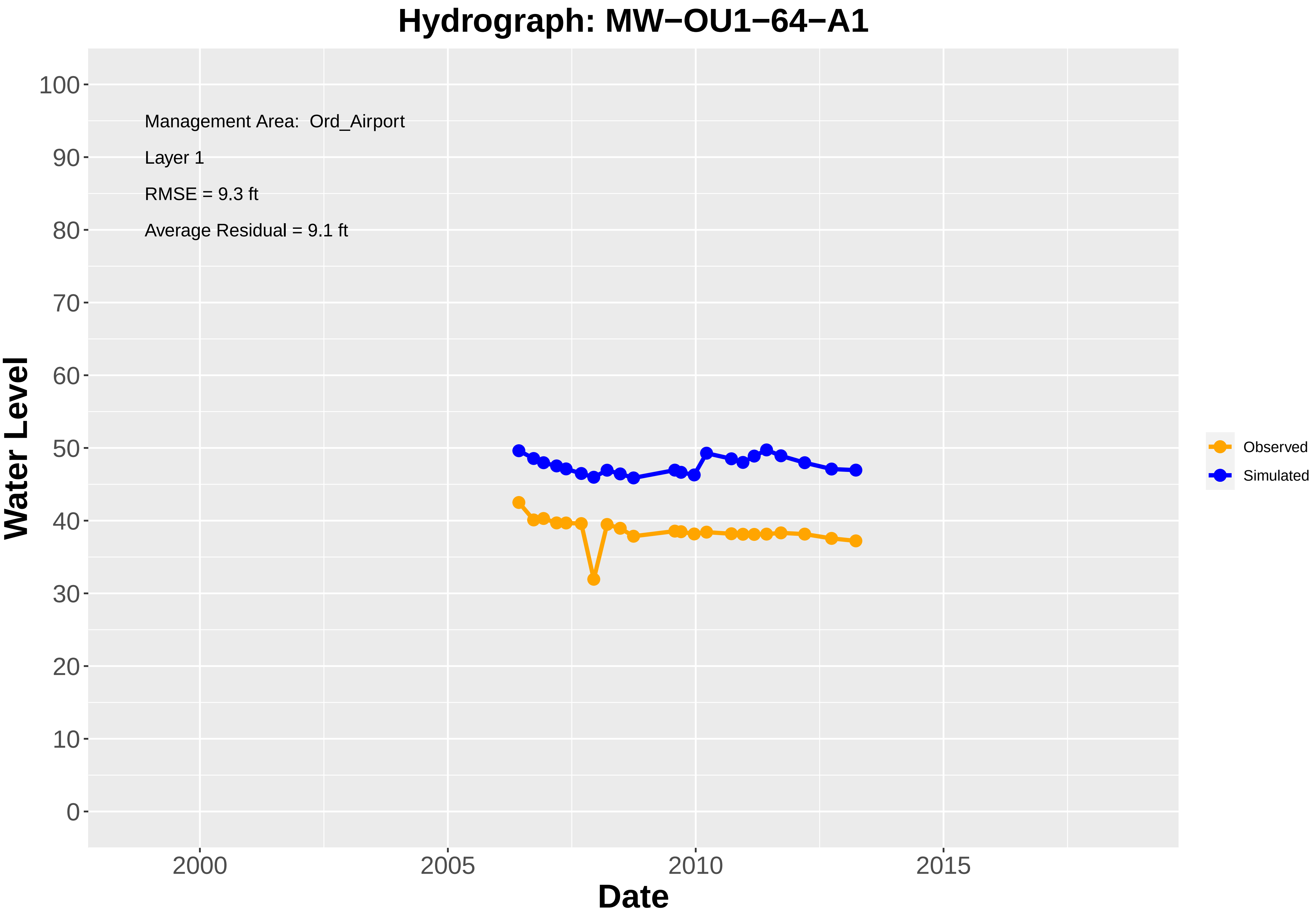
Hydrograph: MW−OU1−57−A

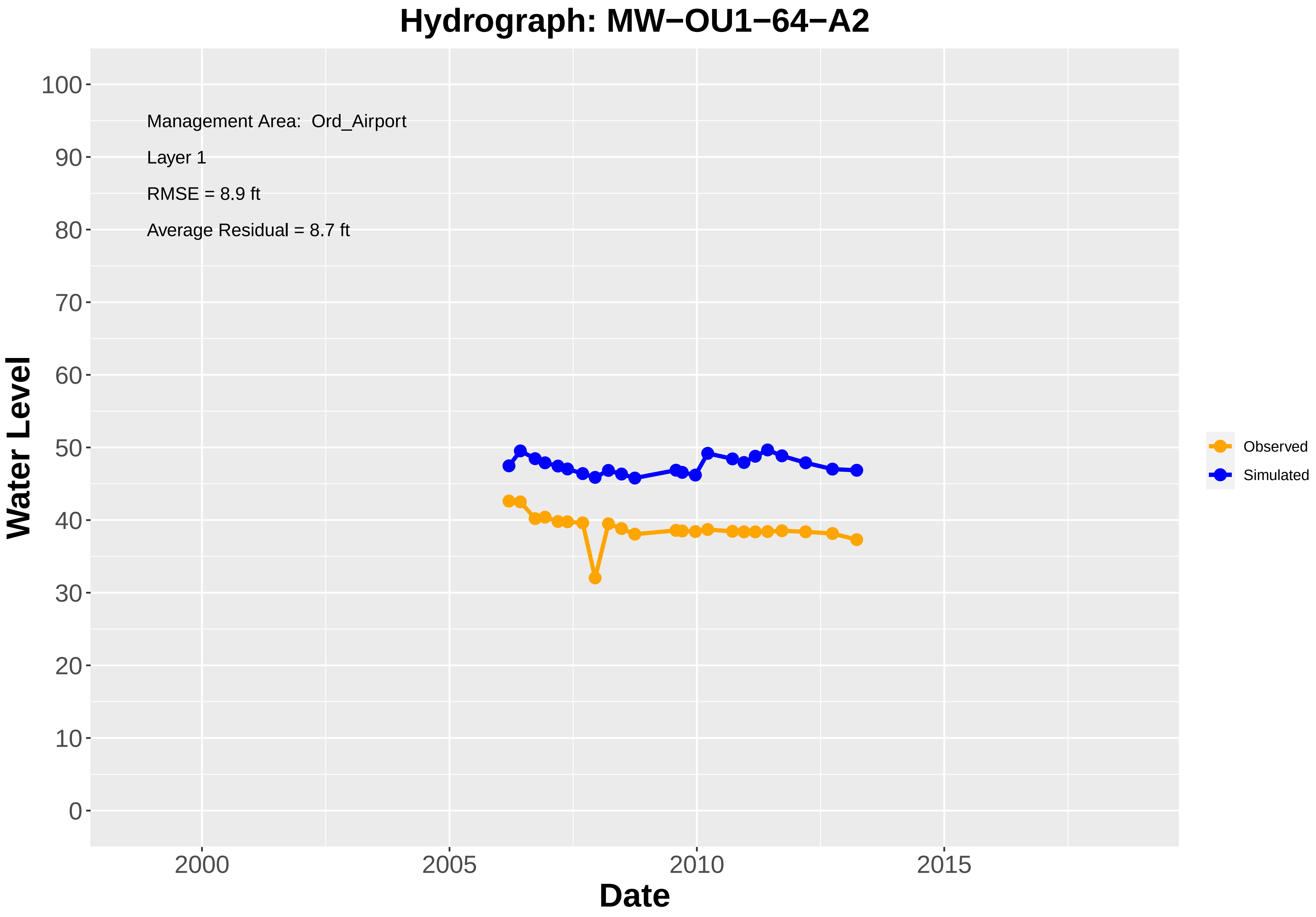


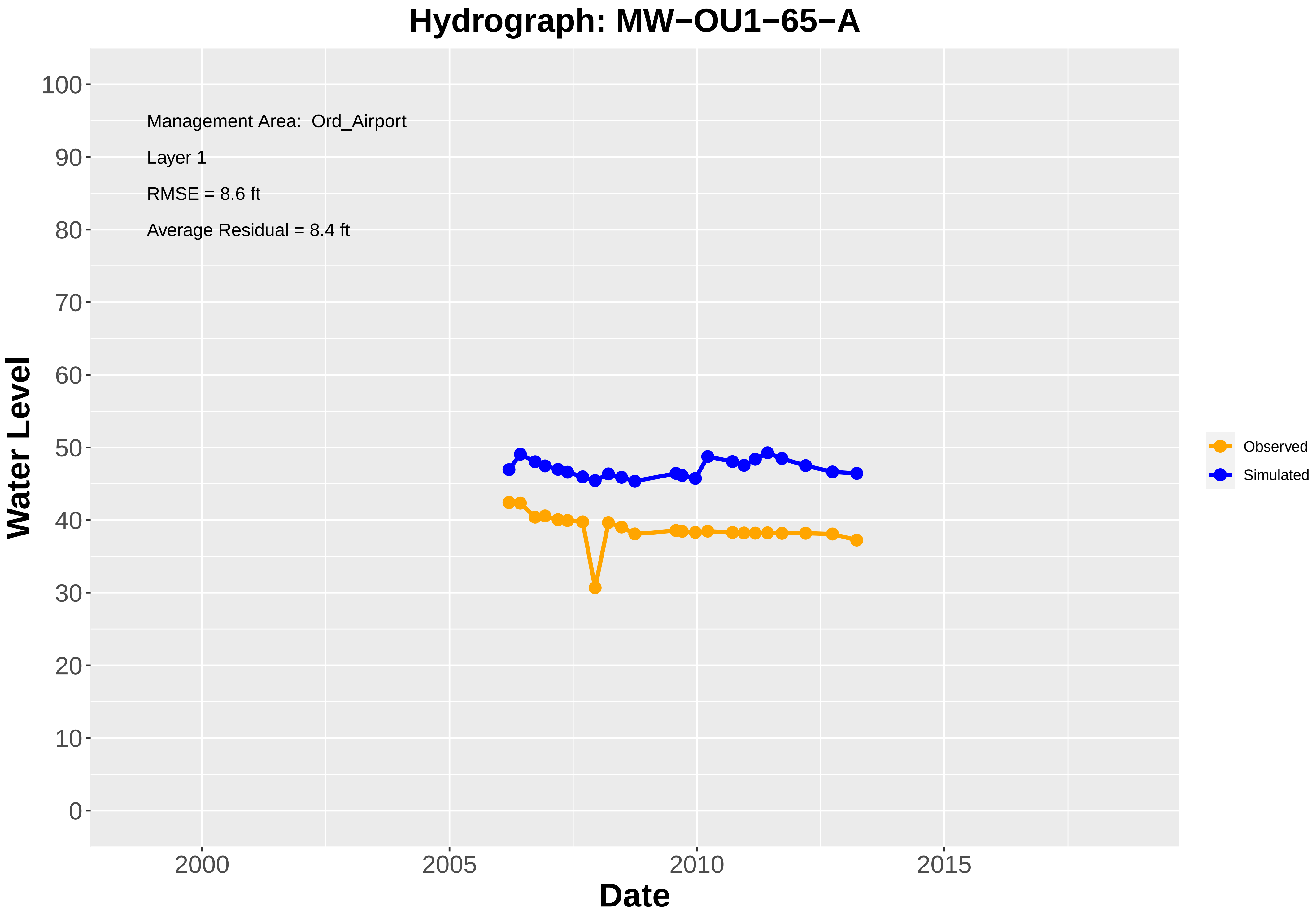

Hydrograph: MW−OU1−58−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.0 ft
Average Residual = 9.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

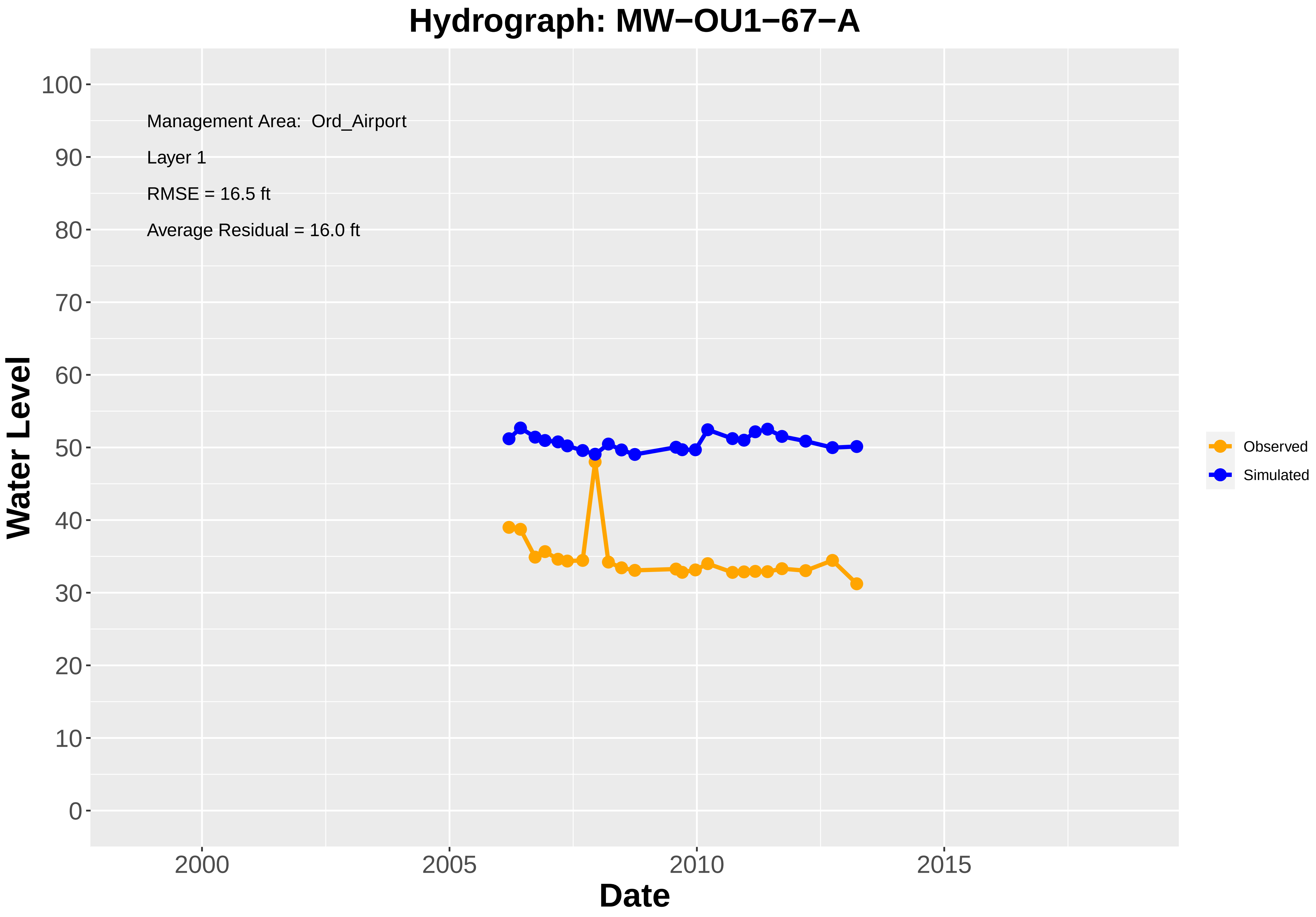

Hydrograph: MW−OU1−59−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.4 ft
Average Residual = 8.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

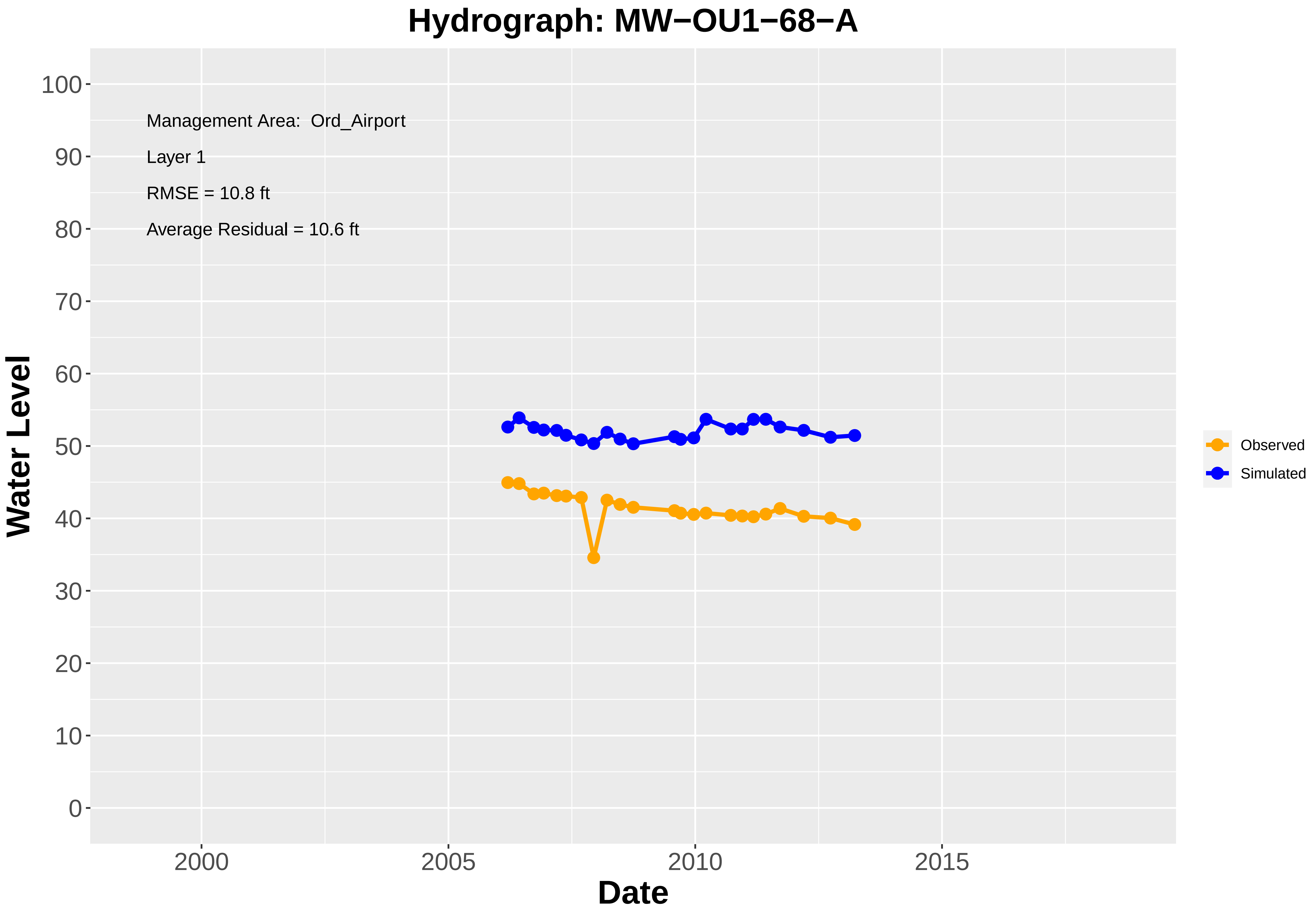

Hydrograph: MW−OU1−61−A
Management Area: Ord_Airport
Layer 1
RMSE = 17.3 ft
Average Residual = 16.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

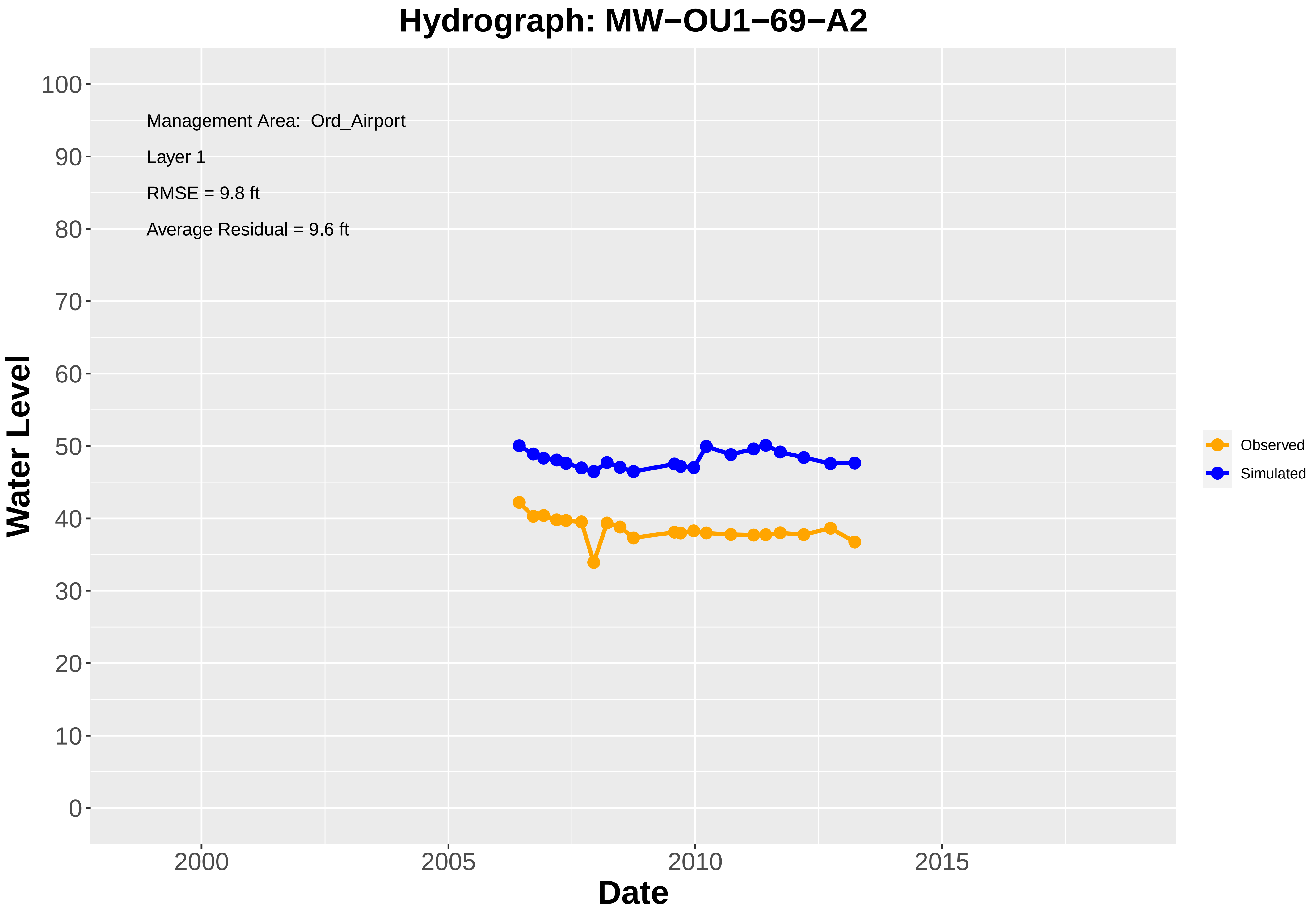

Hydrograph: MW−OU1−64−A1
Management Area: Ord_Airport
Layer 1
RMSE = 9.3 ft
Average Residual = 9.1 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

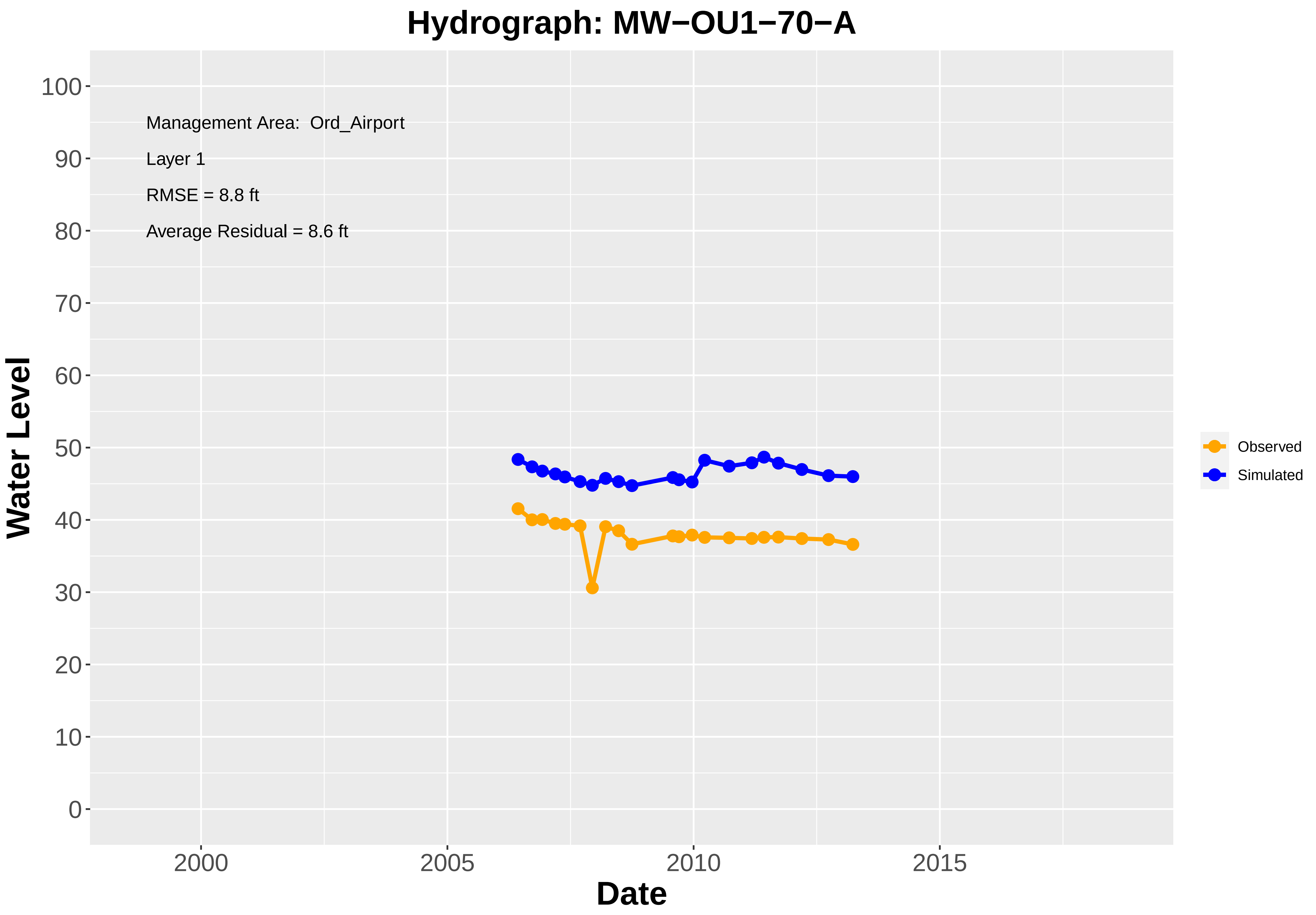

Hydrograph: MW−OU1−64−A2
Management Area: Ord_Airport
Layer 1
RMSE = 8.9 ft
Average Residual = 8.7 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−65−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.6 ft
Average Residual = 8.4 ft
Water Level
Date
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Observed
Simulated

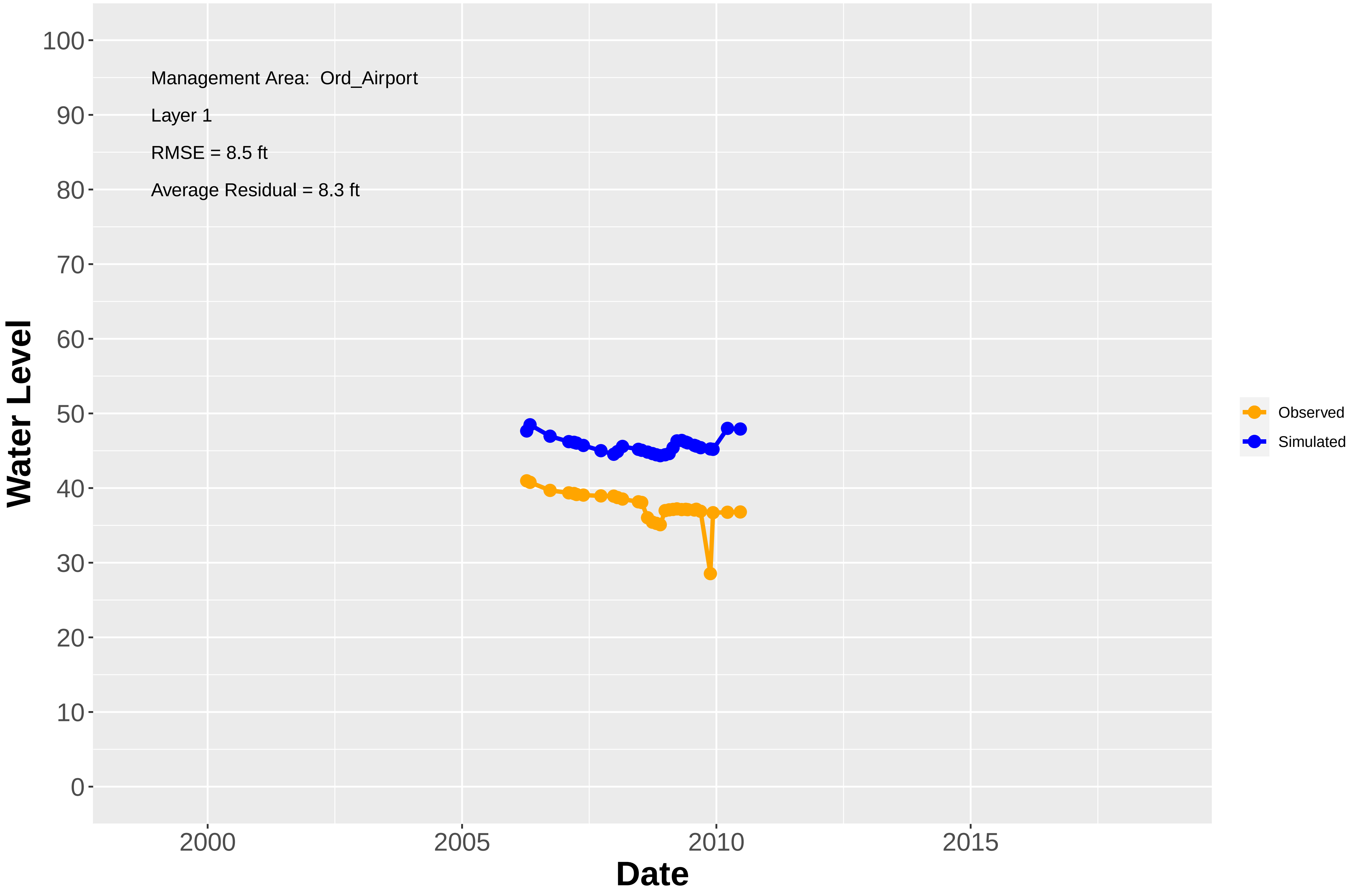

Hydrograph: MW−OU1−67−A
Management Area: Ord_Airport
Layer 1
RMSE = 16.5 ft
Average Residual = 16.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

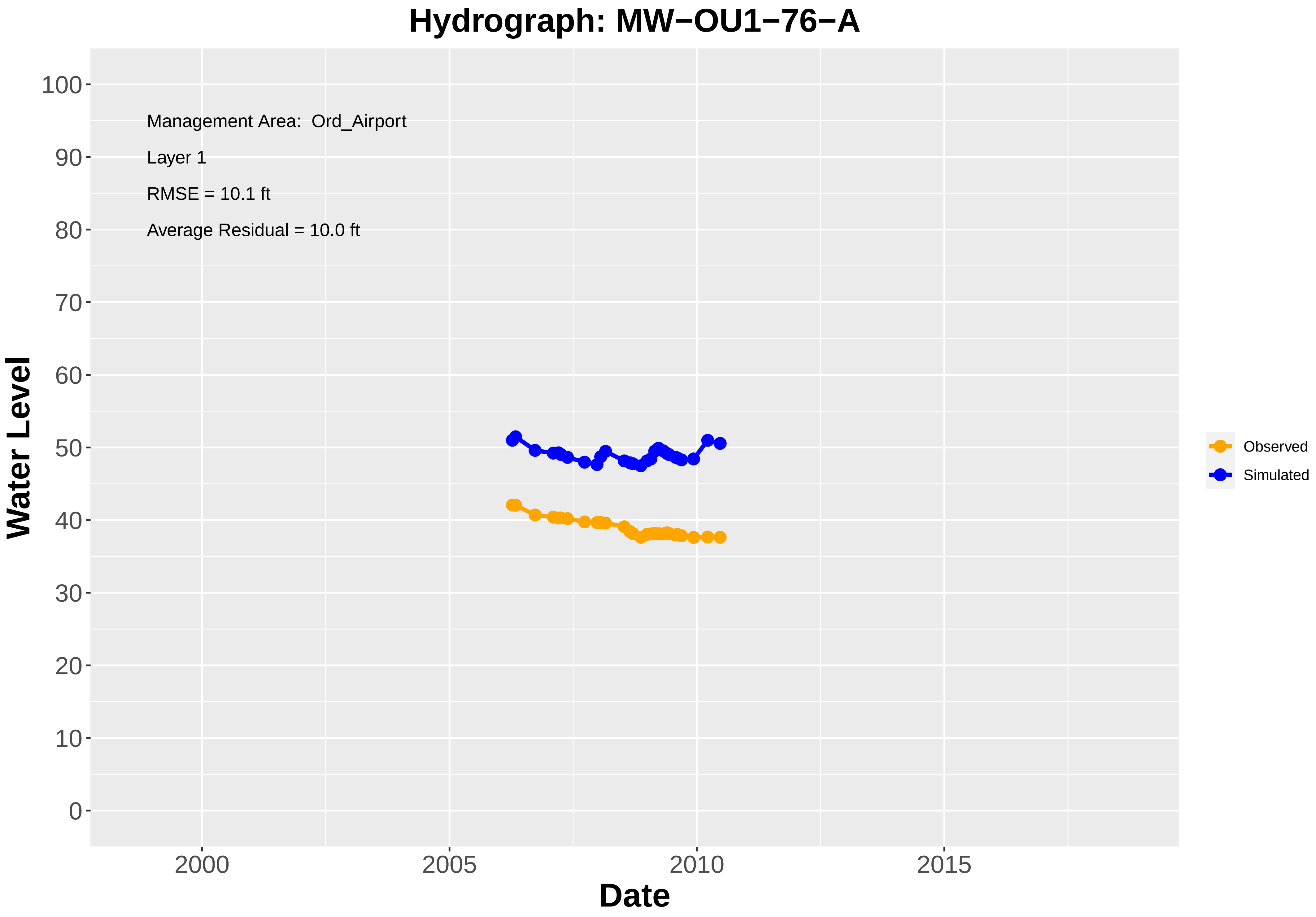

Hydrograph: MW−OU1−68−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.8 ft
Average Residual = 10.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−69−A2
Management Area: Ord_Airport
Layer 1
RMSE = 9.8 ft
Average Residual = 9.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

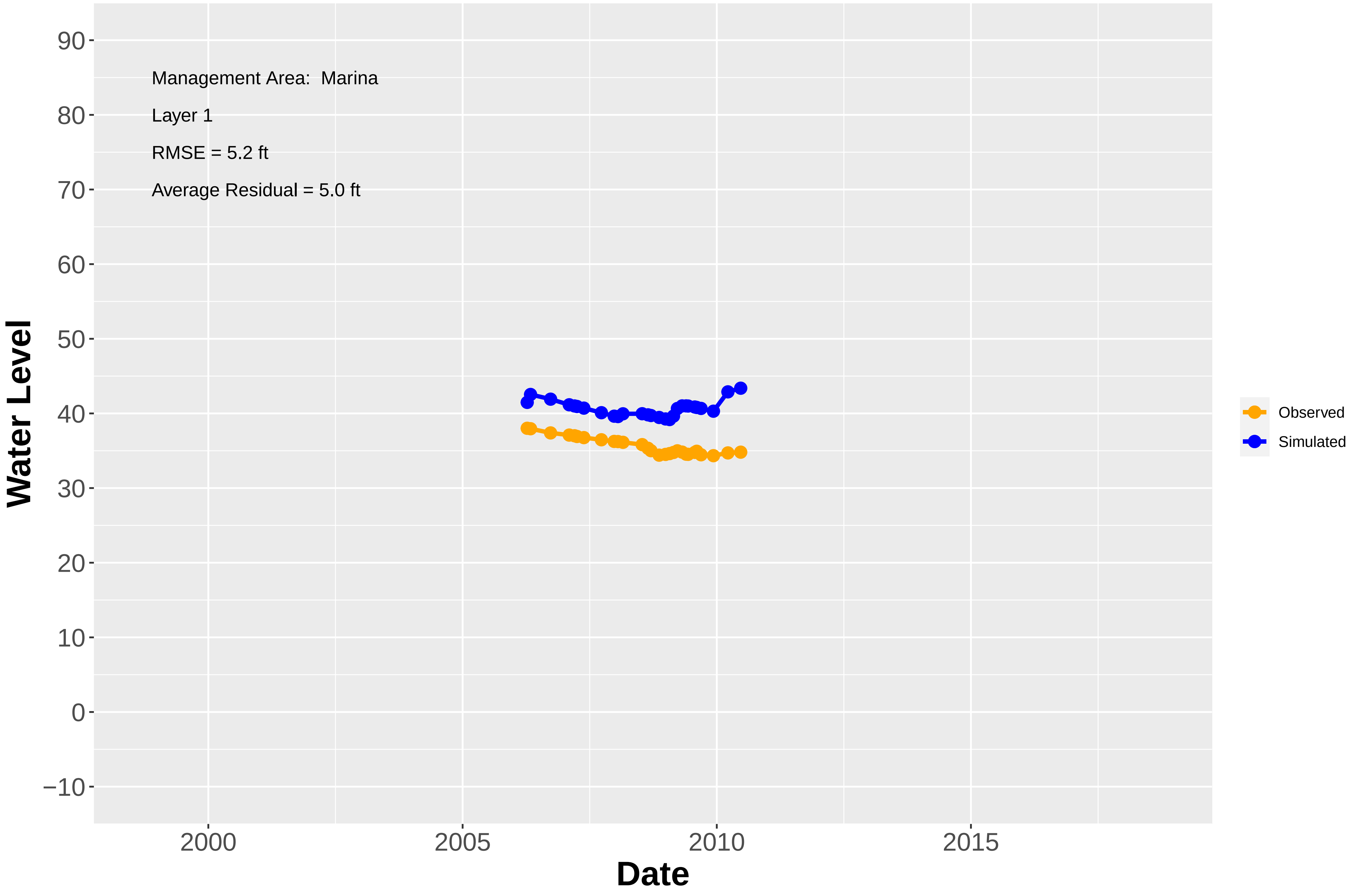

Hydrograph: MW−OU1−70−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.8 ft
Average Residual = 8.6 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

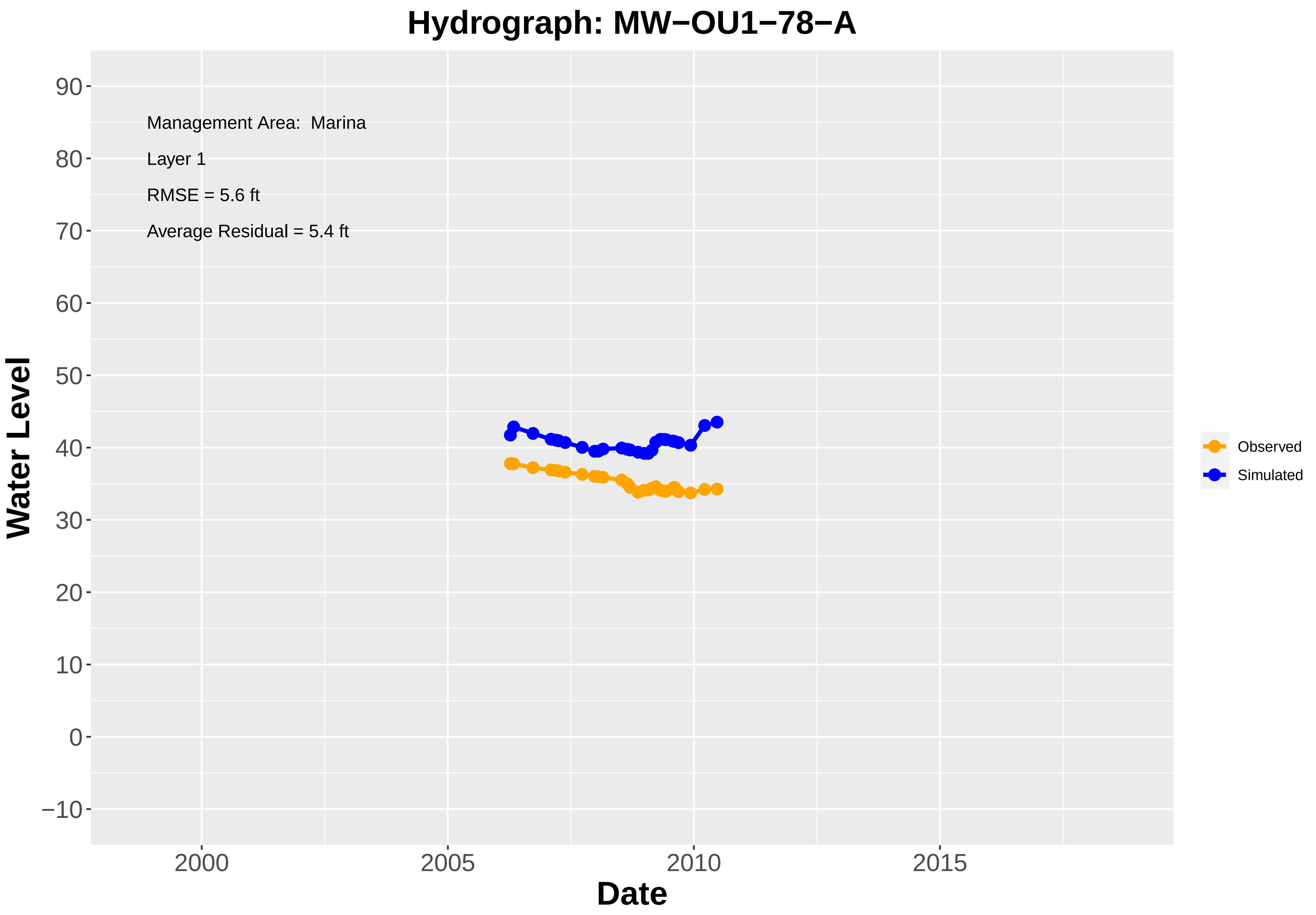
Hydrograph: MW−OU1−75−A

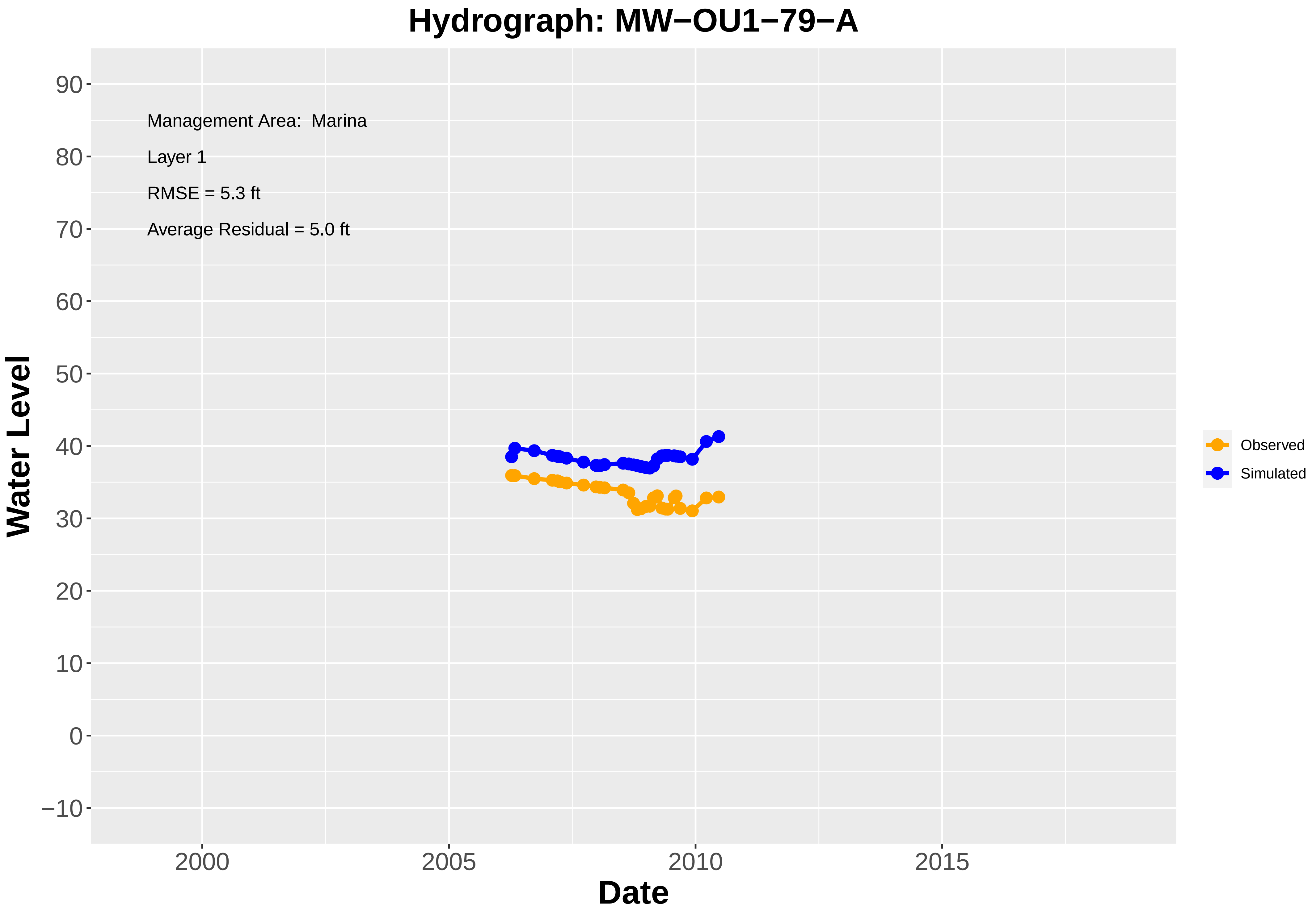


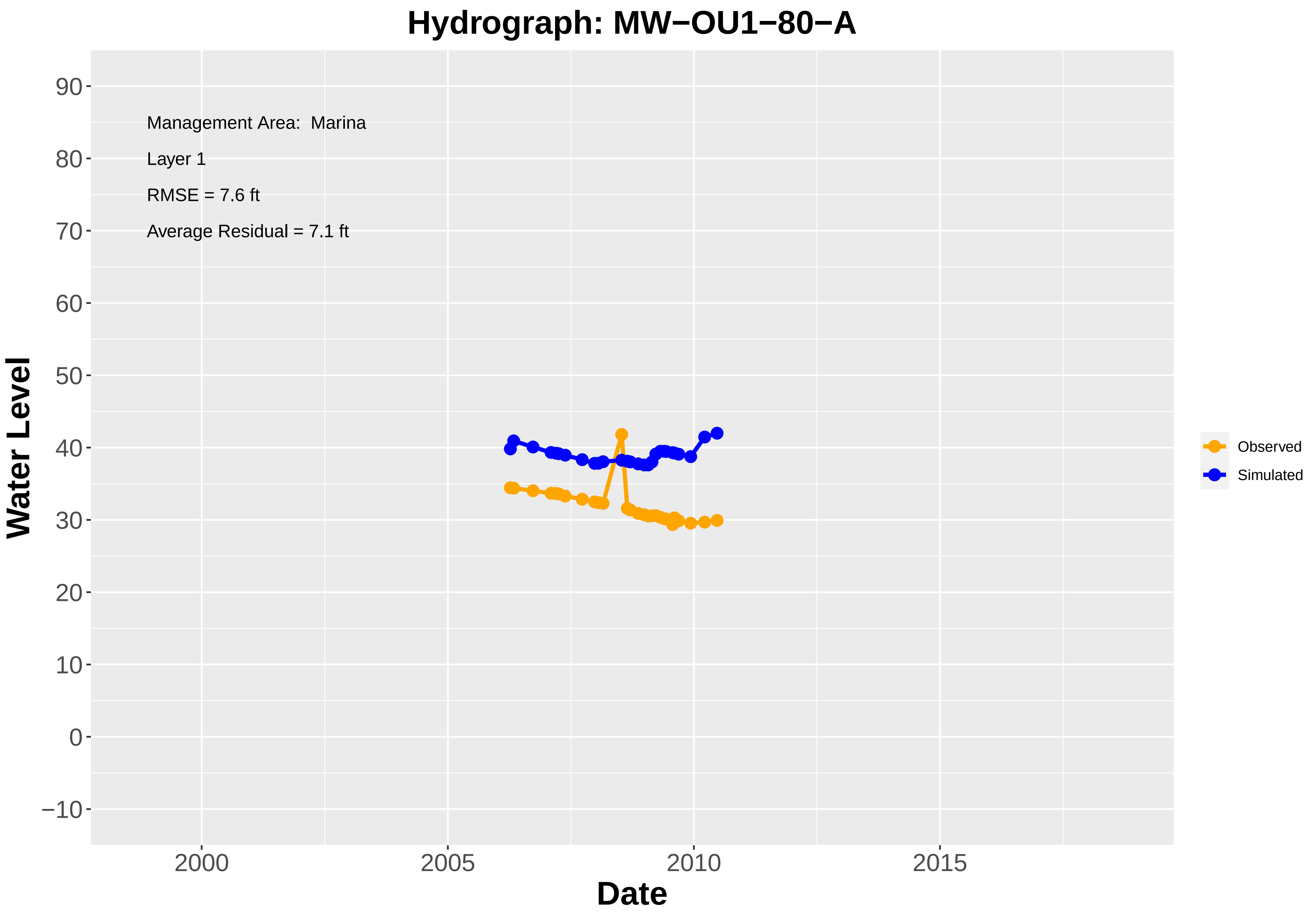

Hydrograph: MW−OU1−76−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.1 ft
Average Residual = 10.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

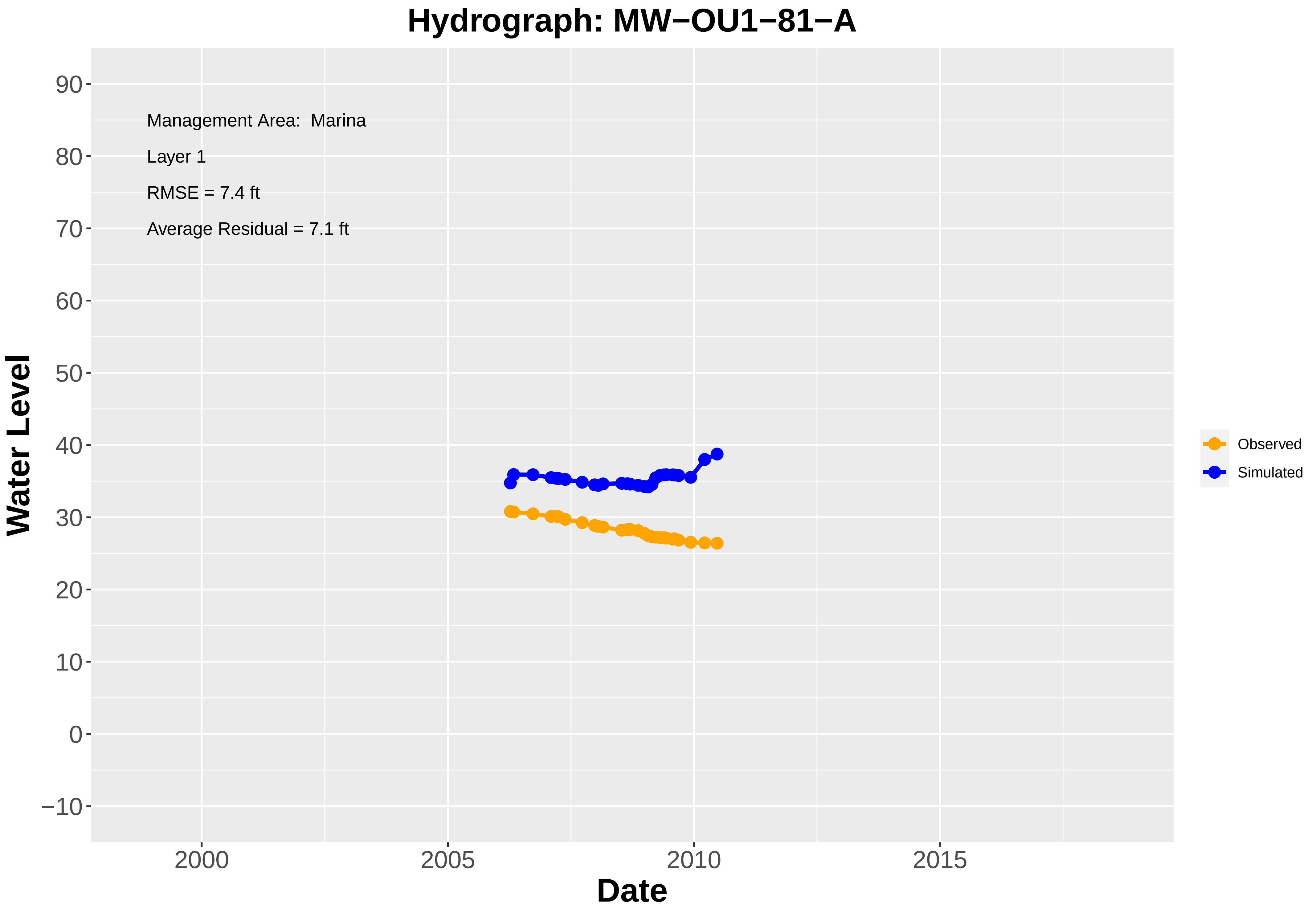
Hydrograph: MW−OU1−77−A

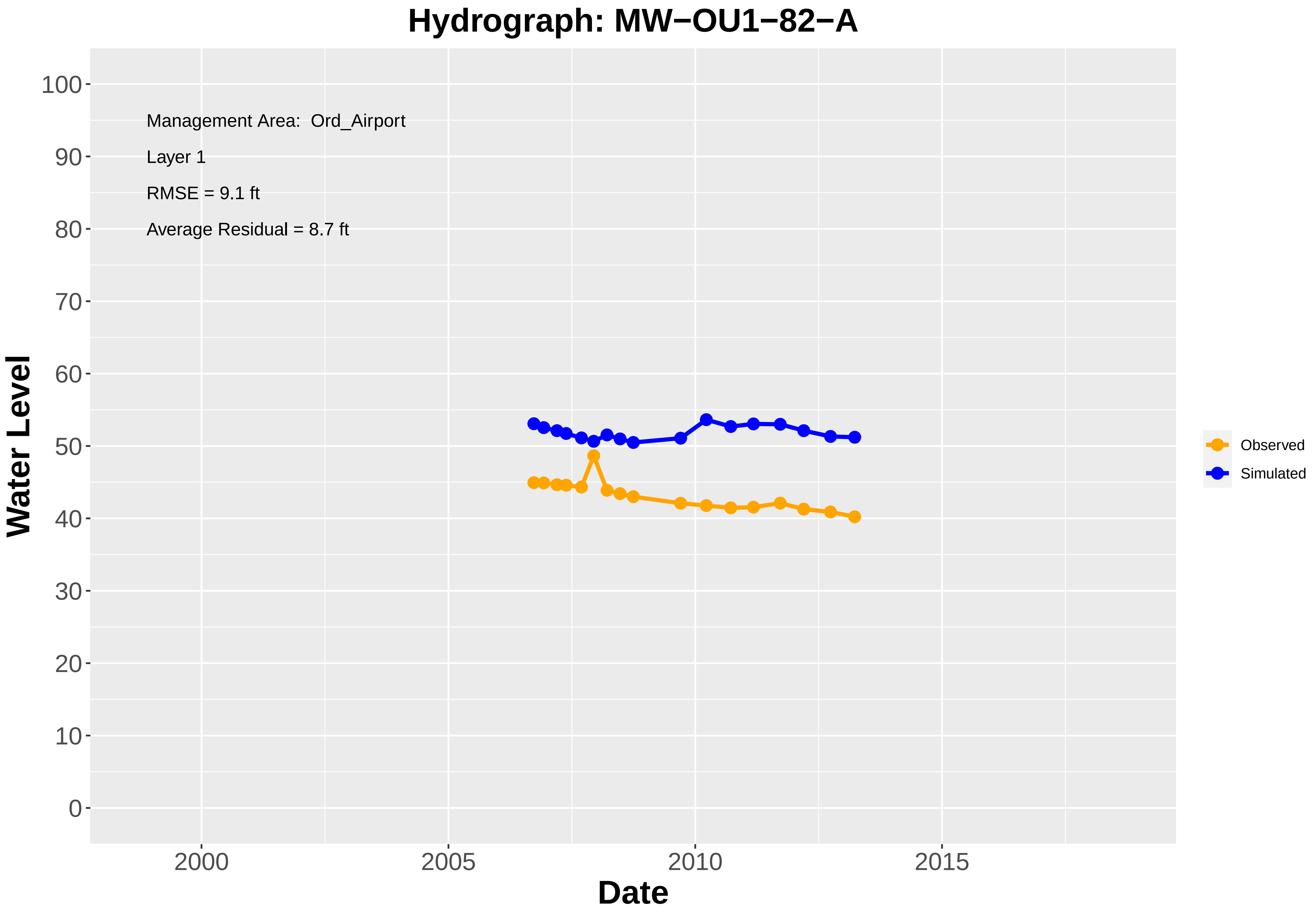


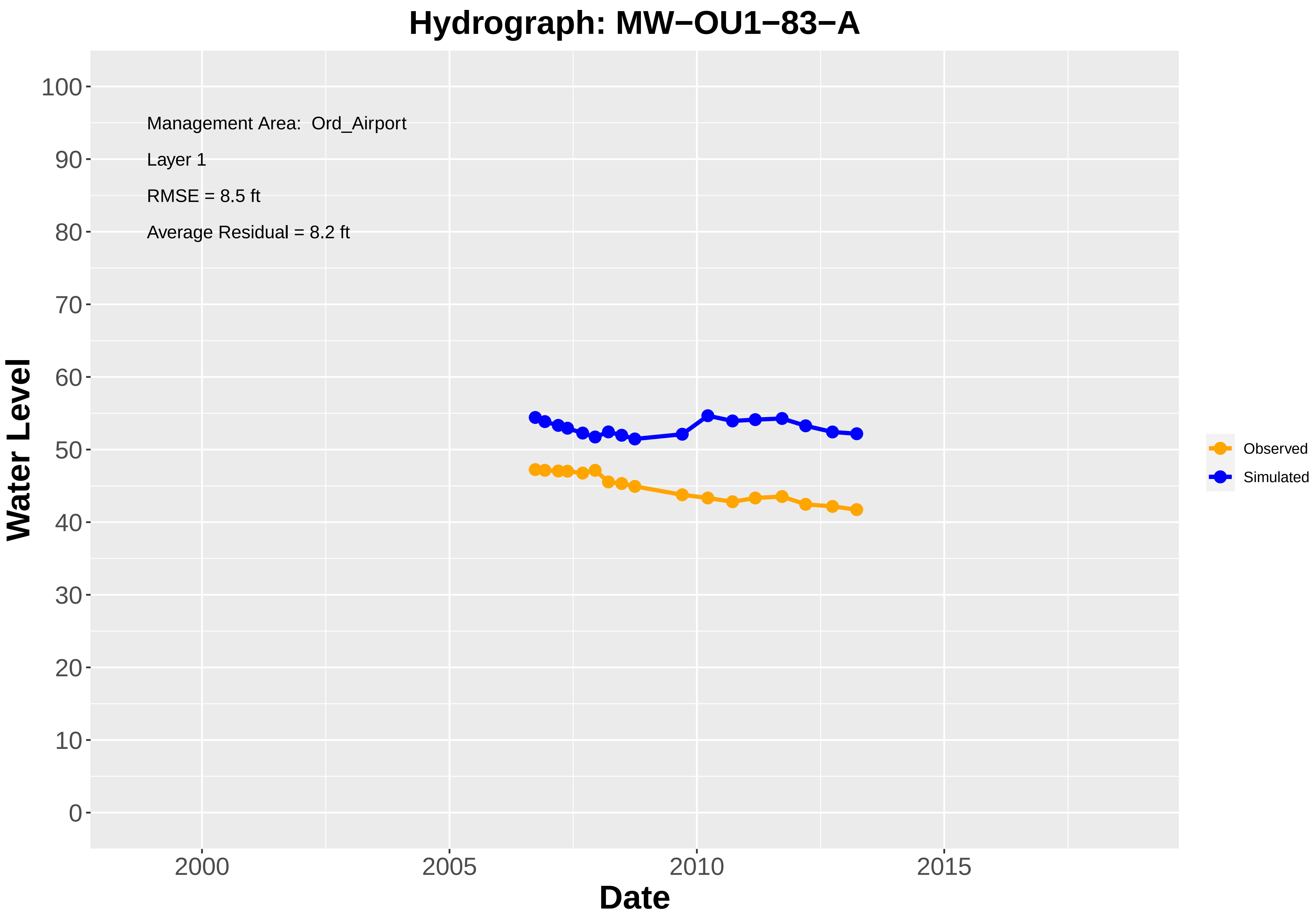

Hydrograph: MW−OU1−78−A
Management Area: Marina
Layer 1
RMSE = 5.6 ft
Average Residual = 5.4 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

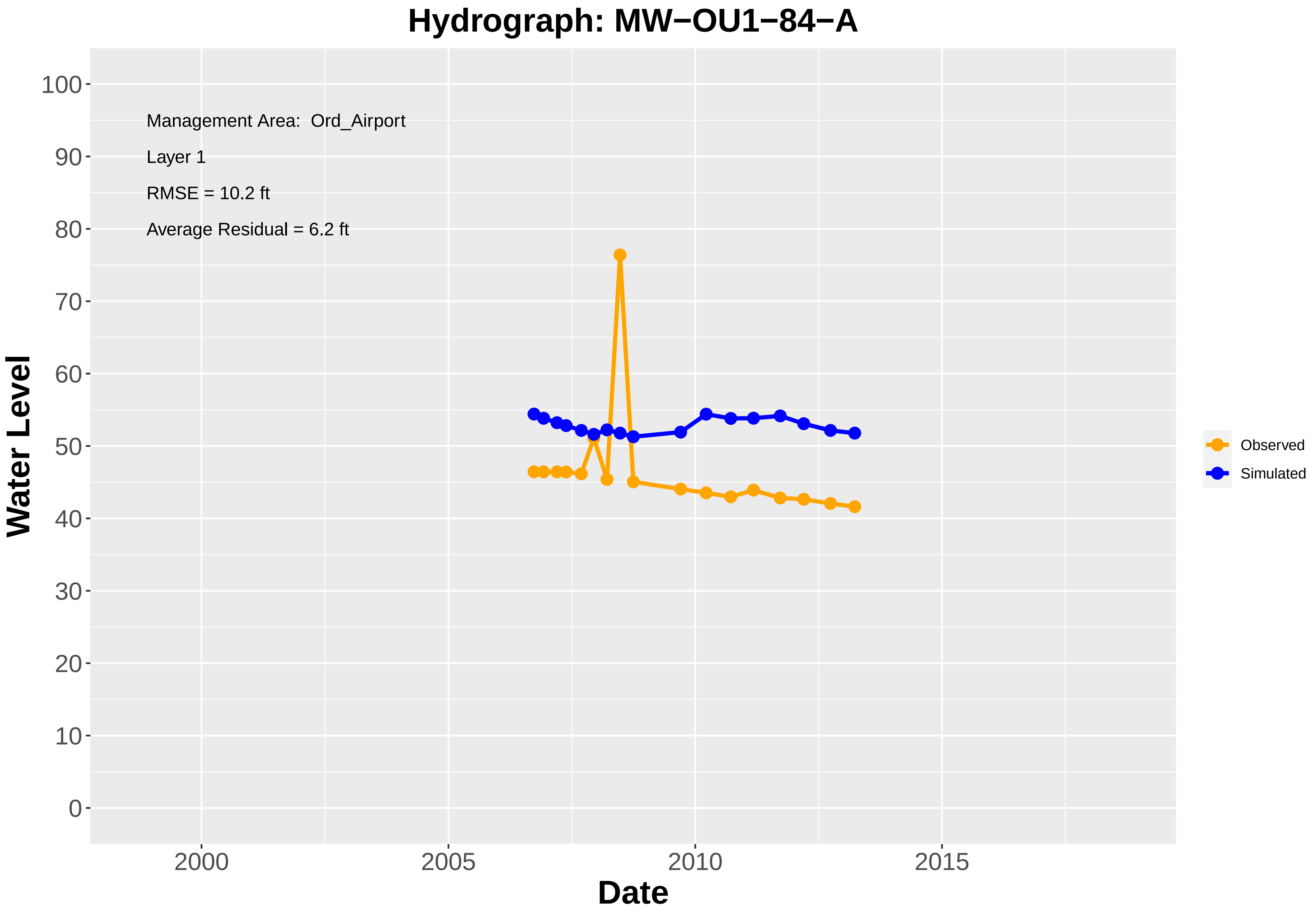

Hydrograph: MW−OU1−79−A
Management Area: Marina
Layer 1
RMSE = 5.3 ft
Average Residual = 5.0 ft
Water Level
Date
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU1−80−A
Management Area: Marina
Layer 1
RMSE = 7.6 ft
Average Residual = 7.1 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated

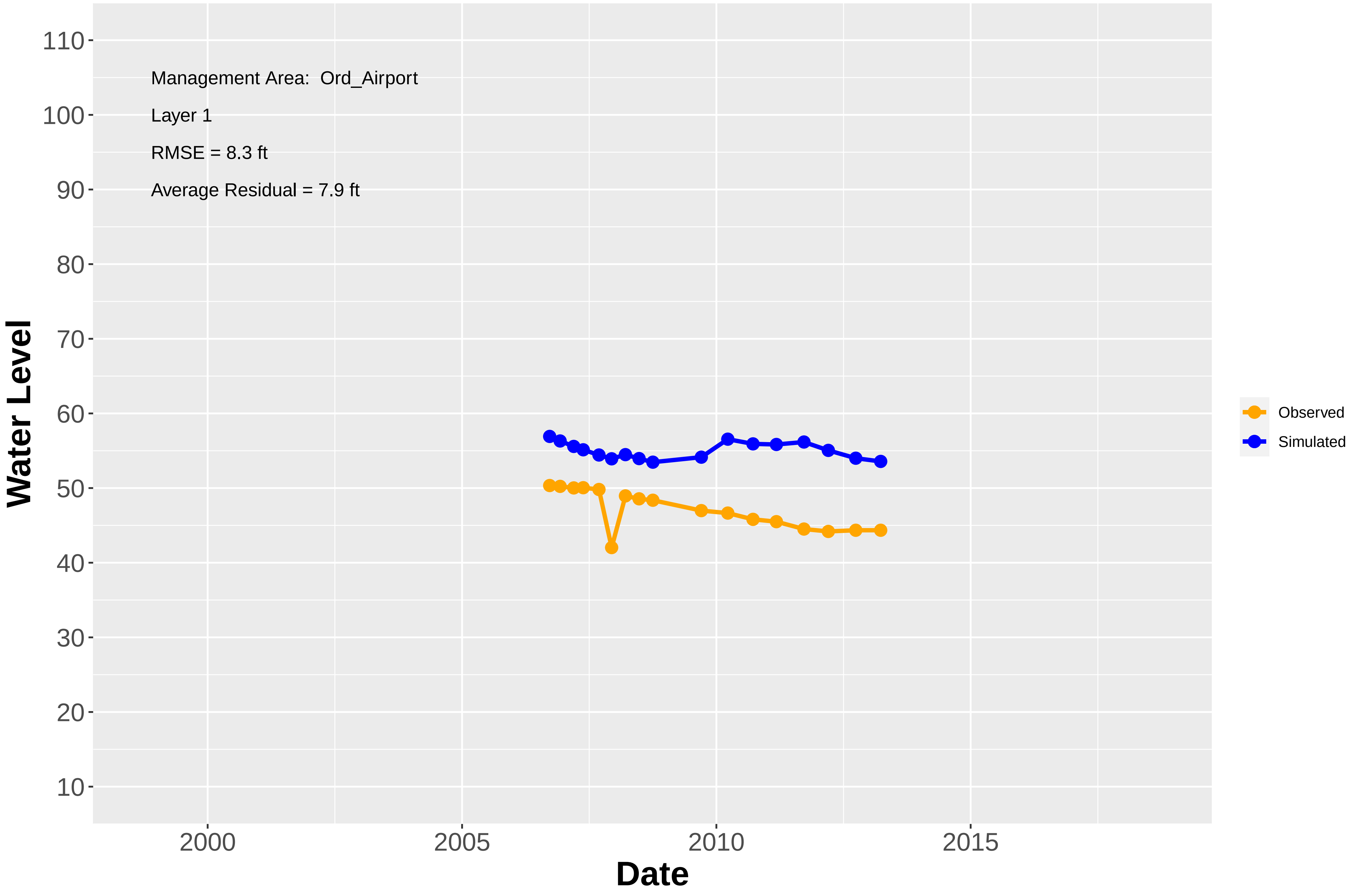

Hydrograph: MW−OU1−81−A
Management Area: Marina
Layer 1
RMSE = 7.4 ft
Average Residual = 7.1 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated

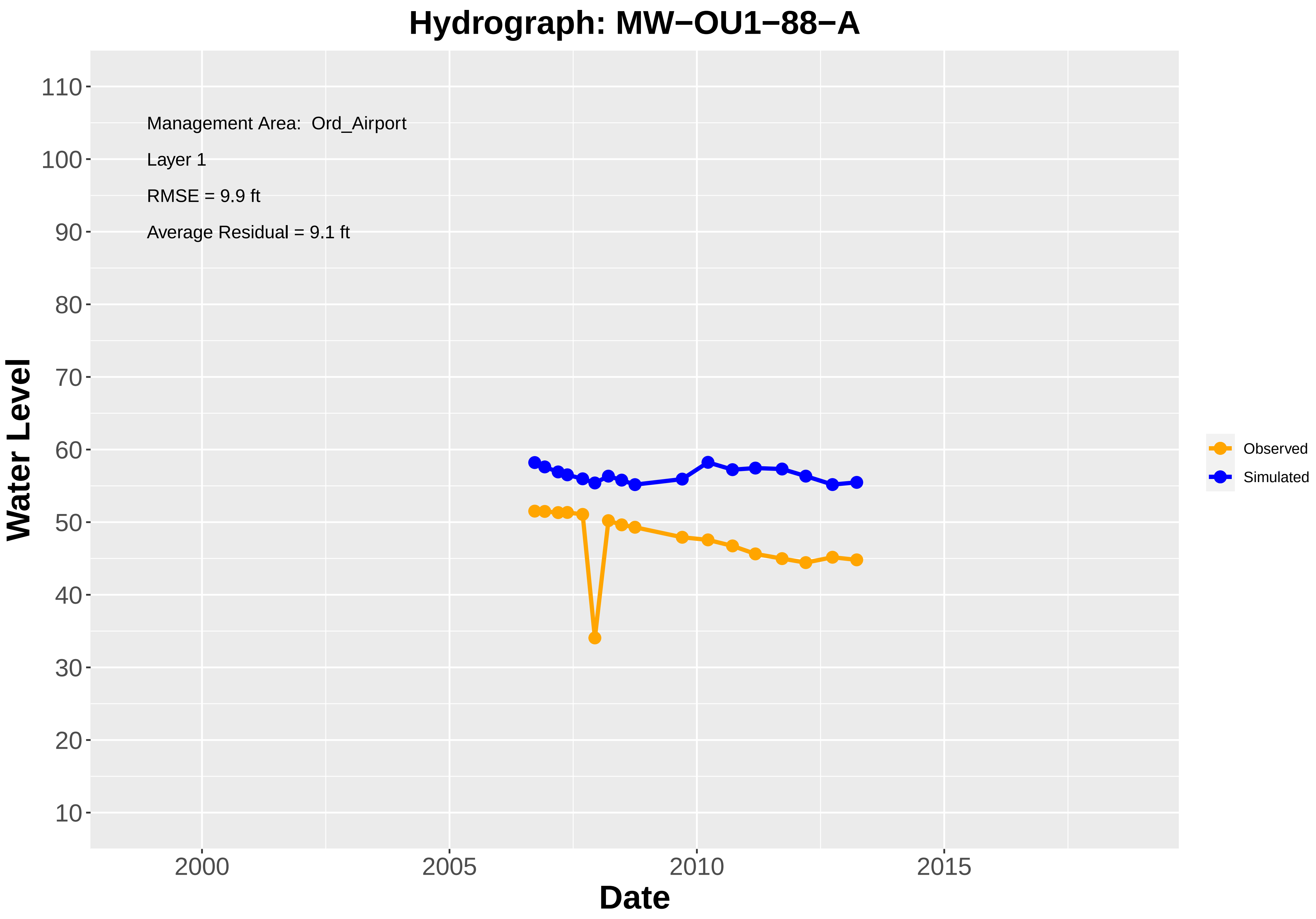

Hydrograph: MW−OU1−82−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.1 ft
Average Residual = 8.7 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

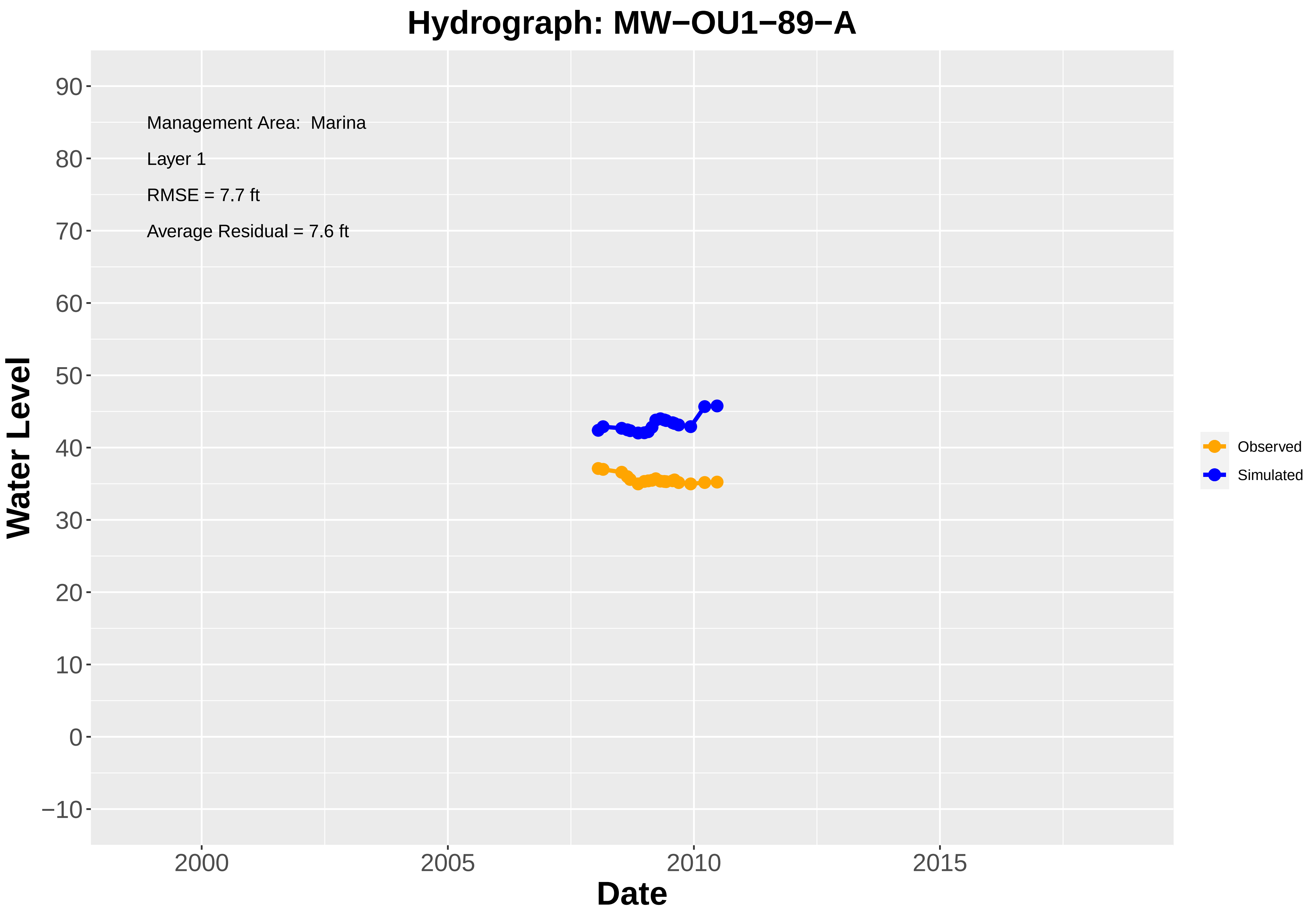

Hydrograph: MW−OU1−83−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.5 ft
Average Residual = 8.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

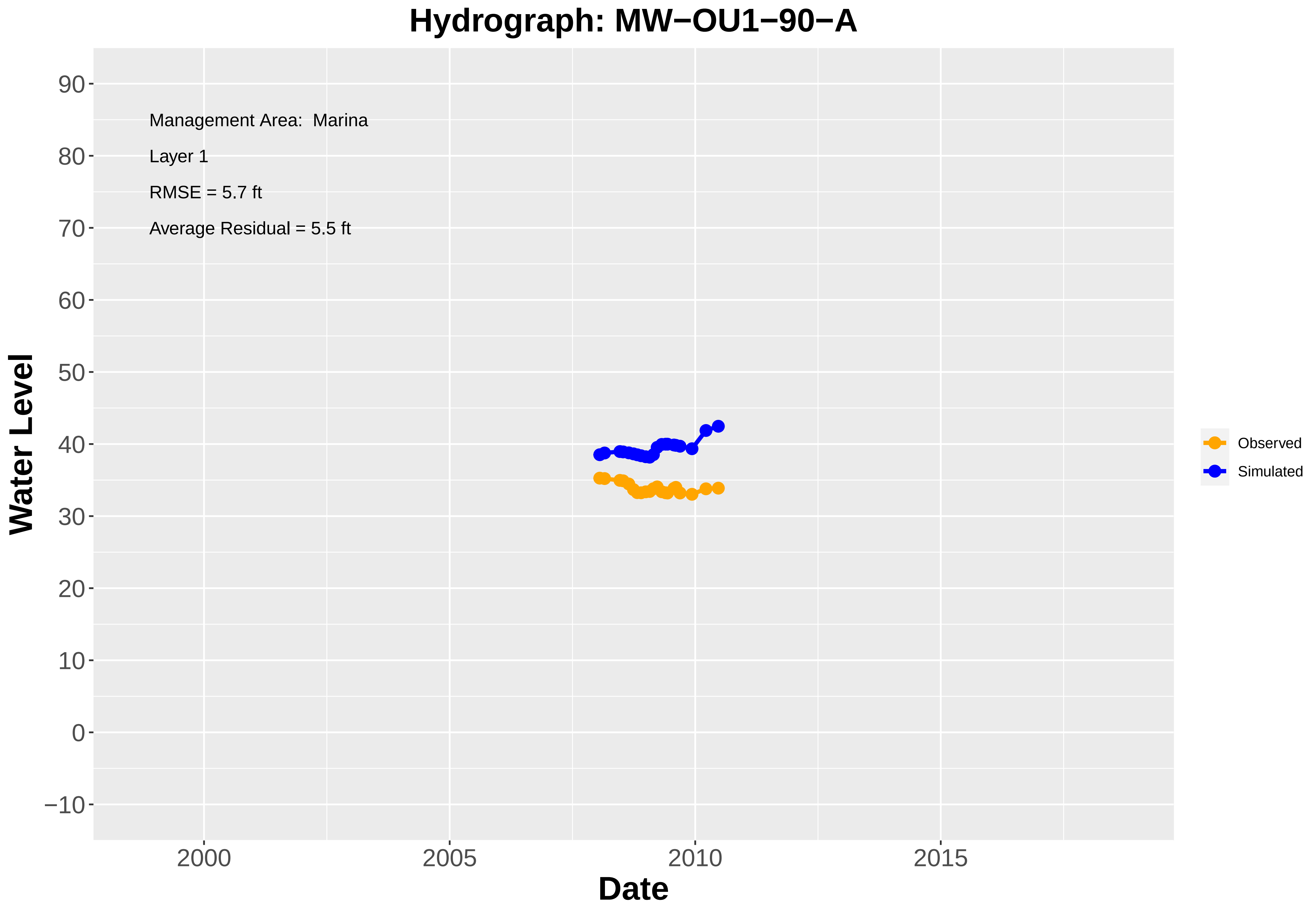

Hydrograph: MW−OU1−84−A
Management Area: Ord_Airport
Layer 1
RMSE = 10.2 ft
Average Residual = 6.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

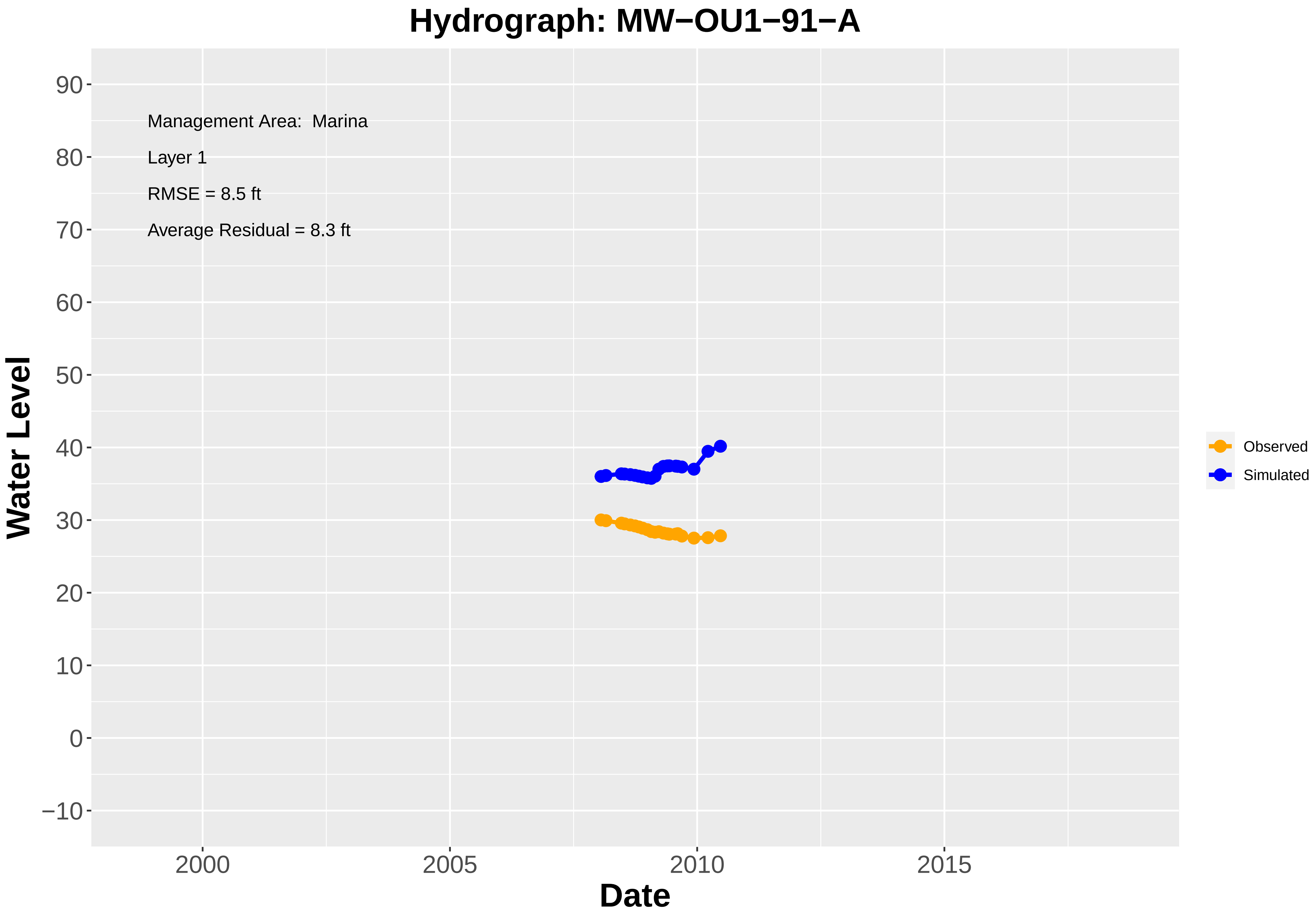
Hydrograph: MW−OU1−86−A

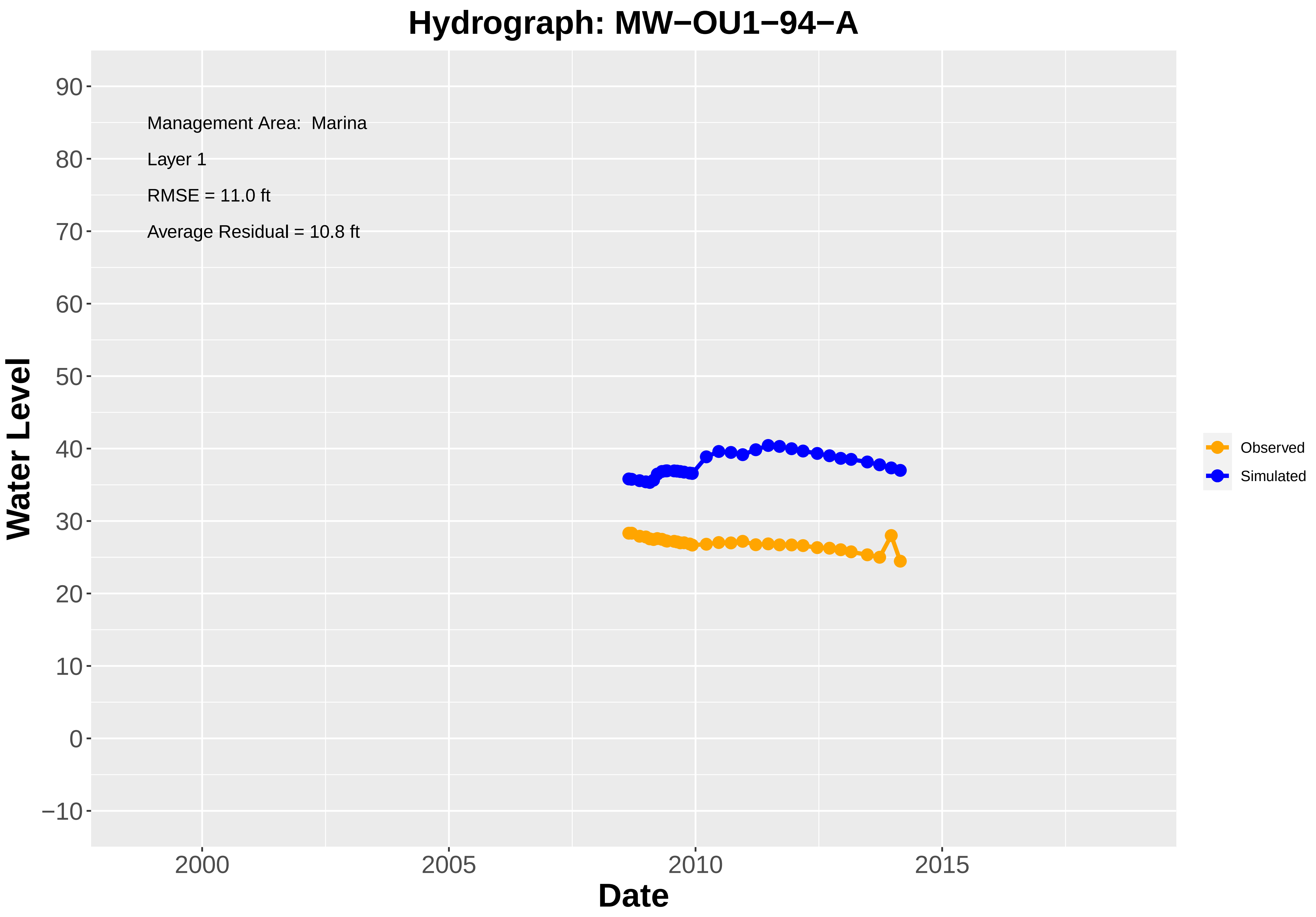



Hydrograph: MW−OU1−88−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.9 ft
Average Residual = 9.1 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

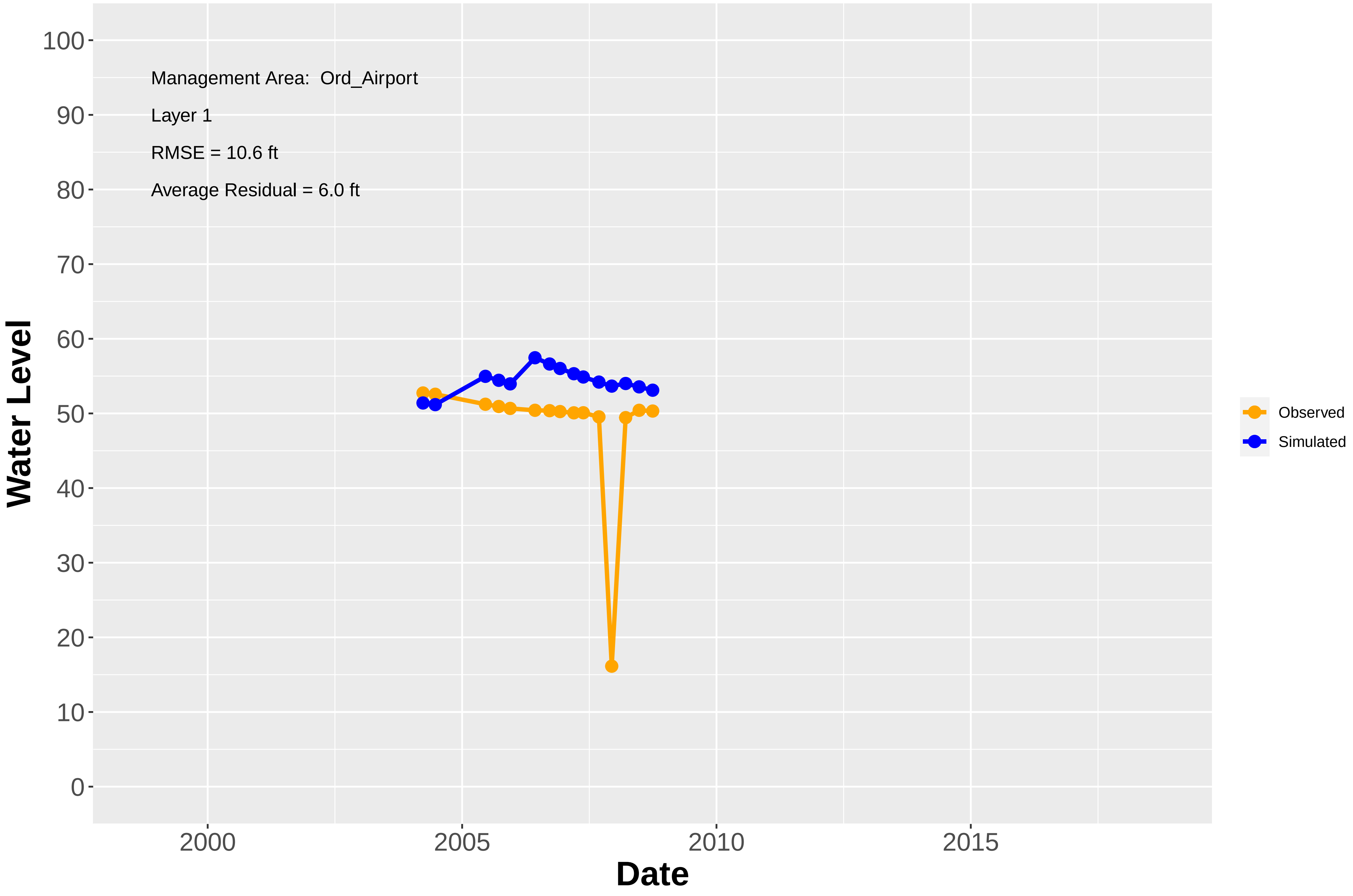

Hydrograph: MW−OU1−89−A
Management Area: Marina
Layer 1
RMSE = 7.7 ft
Average Residual = 7.6 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−90−A
Management Area: Marina
Layer 1
RMSE = 5.7 ft
Average Residual = 5.5 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

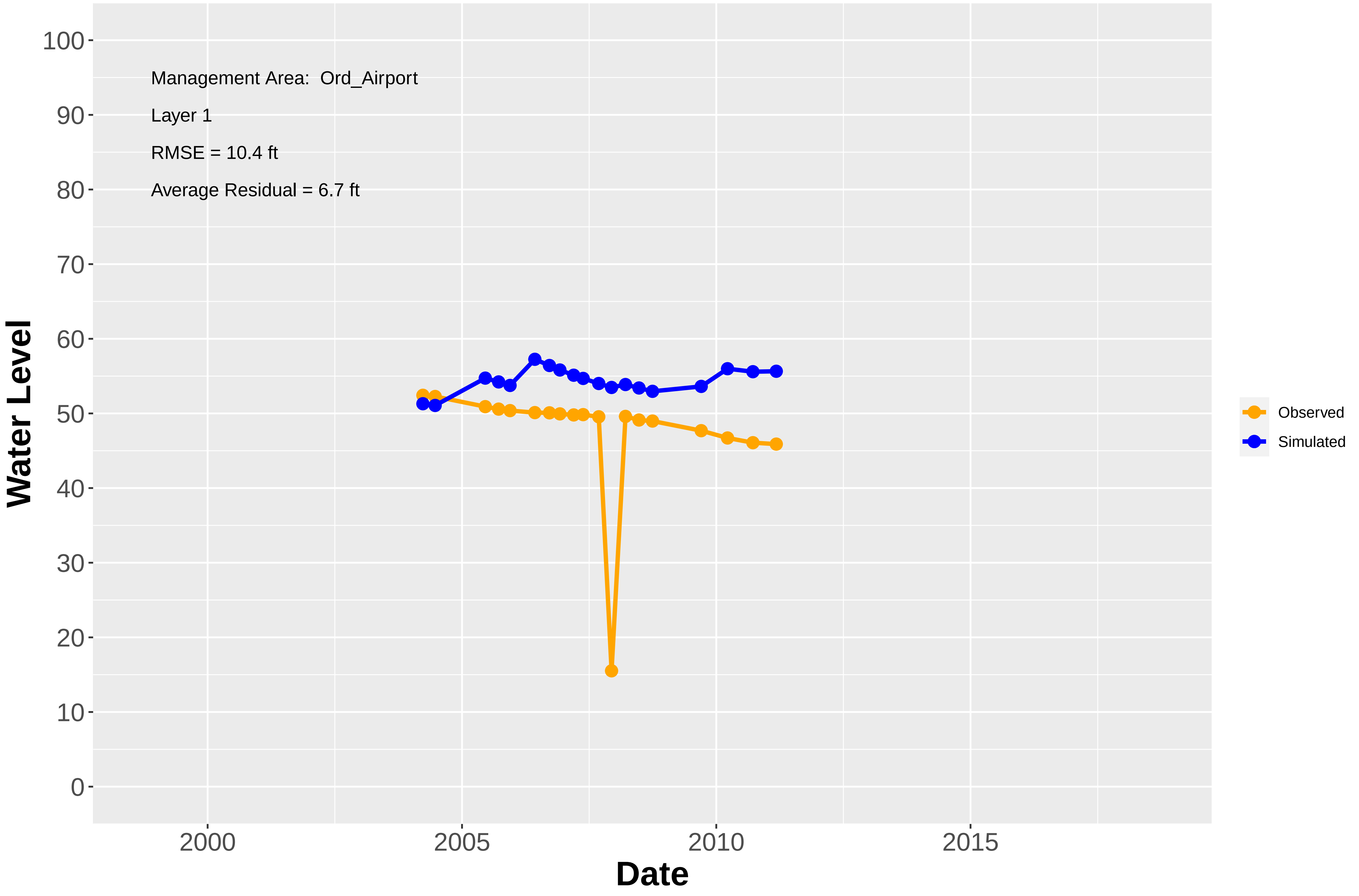

Hydrograph: MW−OU1−91−A
Management Area: Marina
Layer 1
RMSE = 8.5 ft
Average Residual = 8.3 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU1−94−A
Management Area: Marina
Layer 1
RMSE = 11.0 ft
Average Residual = 10.8 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

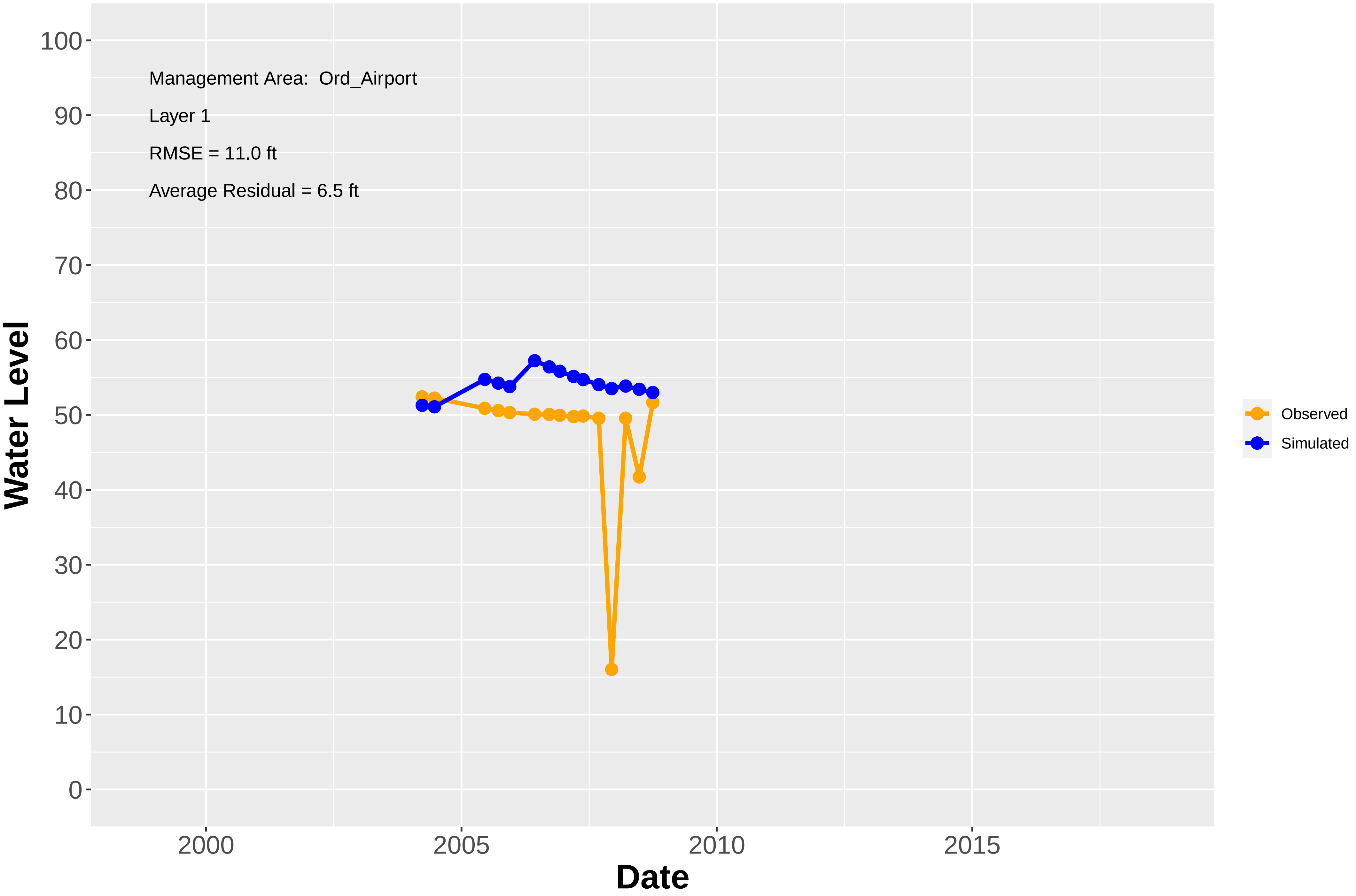
Hydrograph: MW−OU1−ERD−01−A



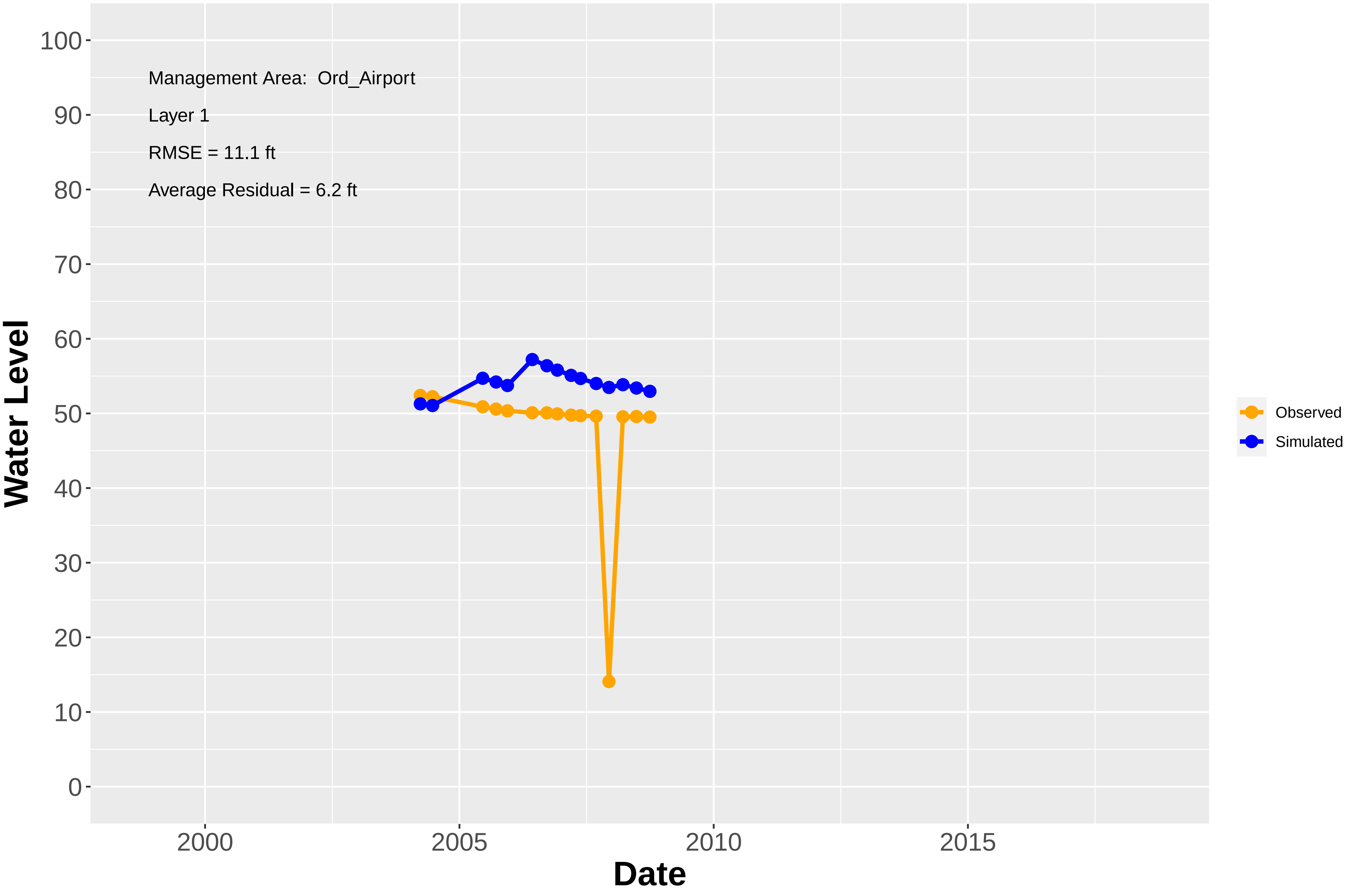
Hydrograph: MW−OU1−ERD−02−A



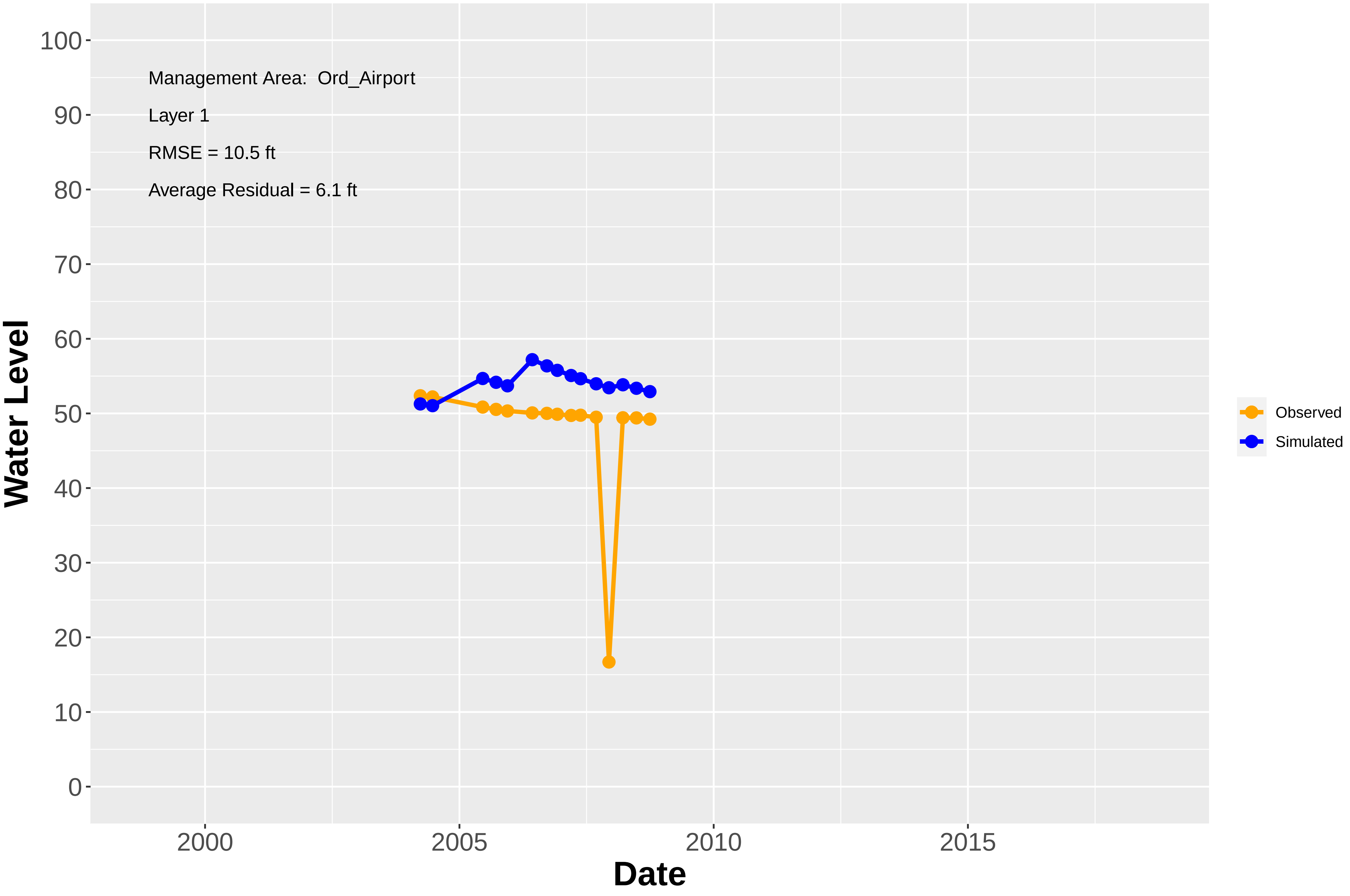
Hydrograph: MW−OU1−ERD−03−A



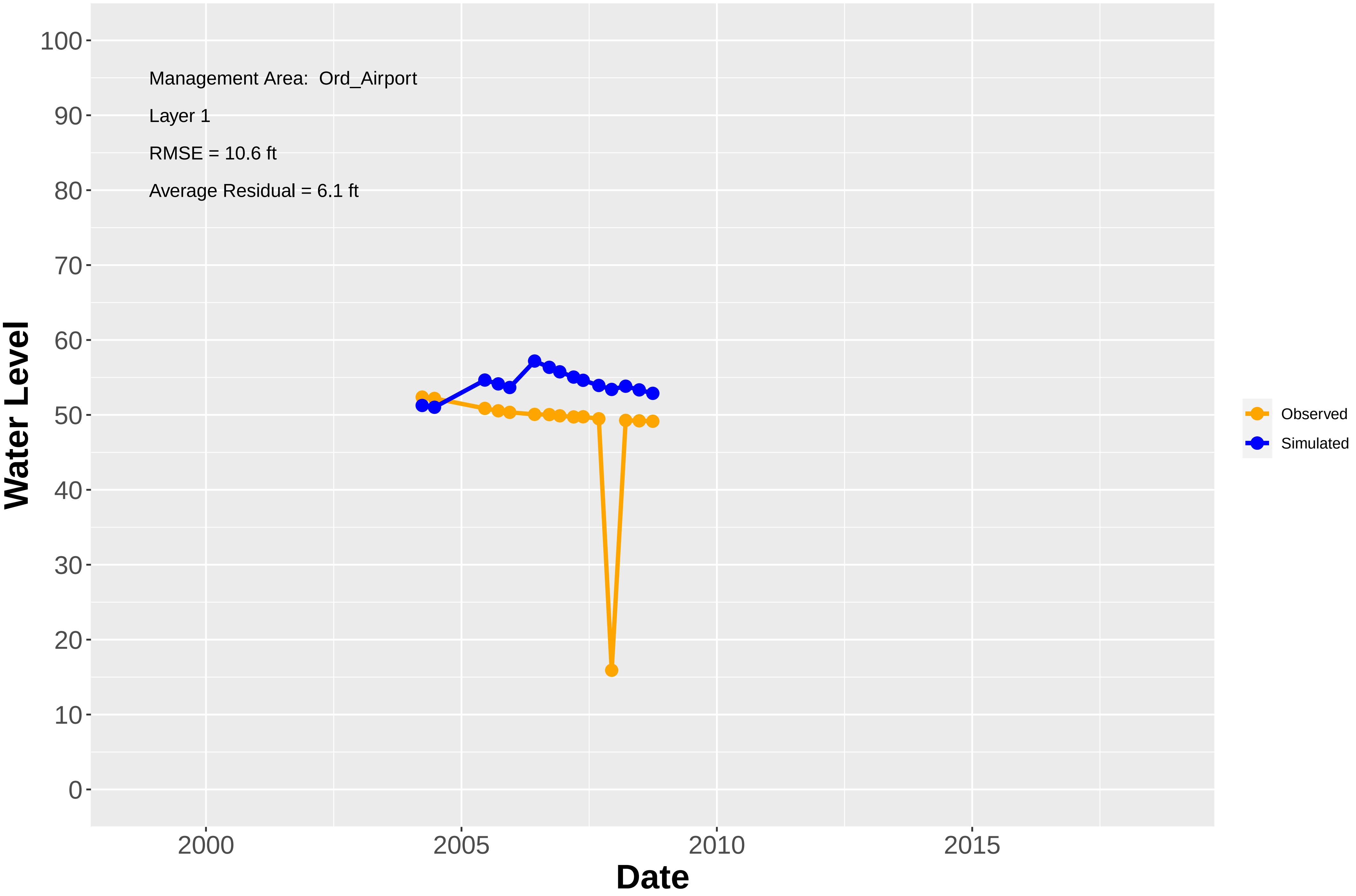
Hydrograph: MW−OU1−ERD−04−A

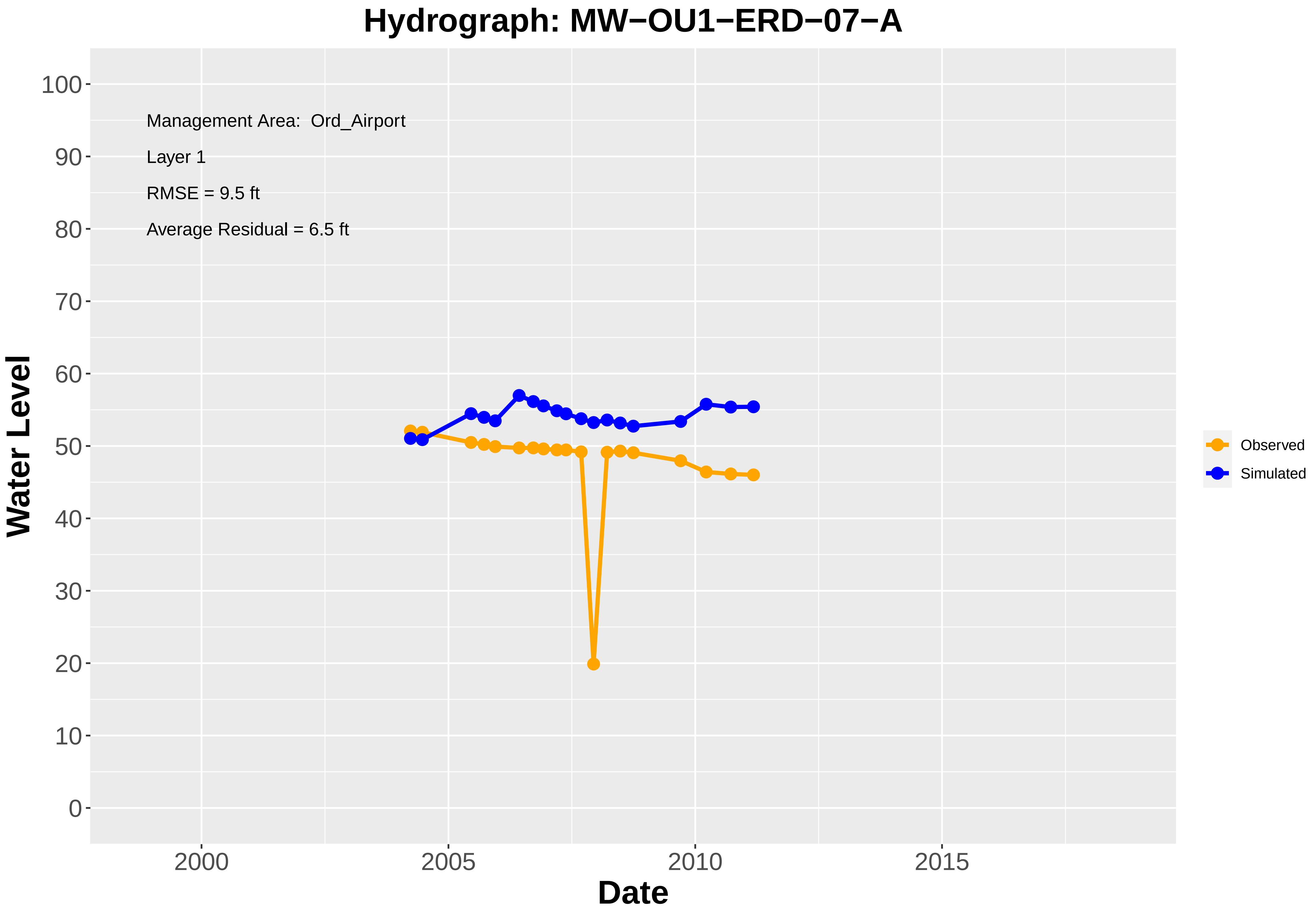


Hydrograph: MW−OU1−ERD−05−A

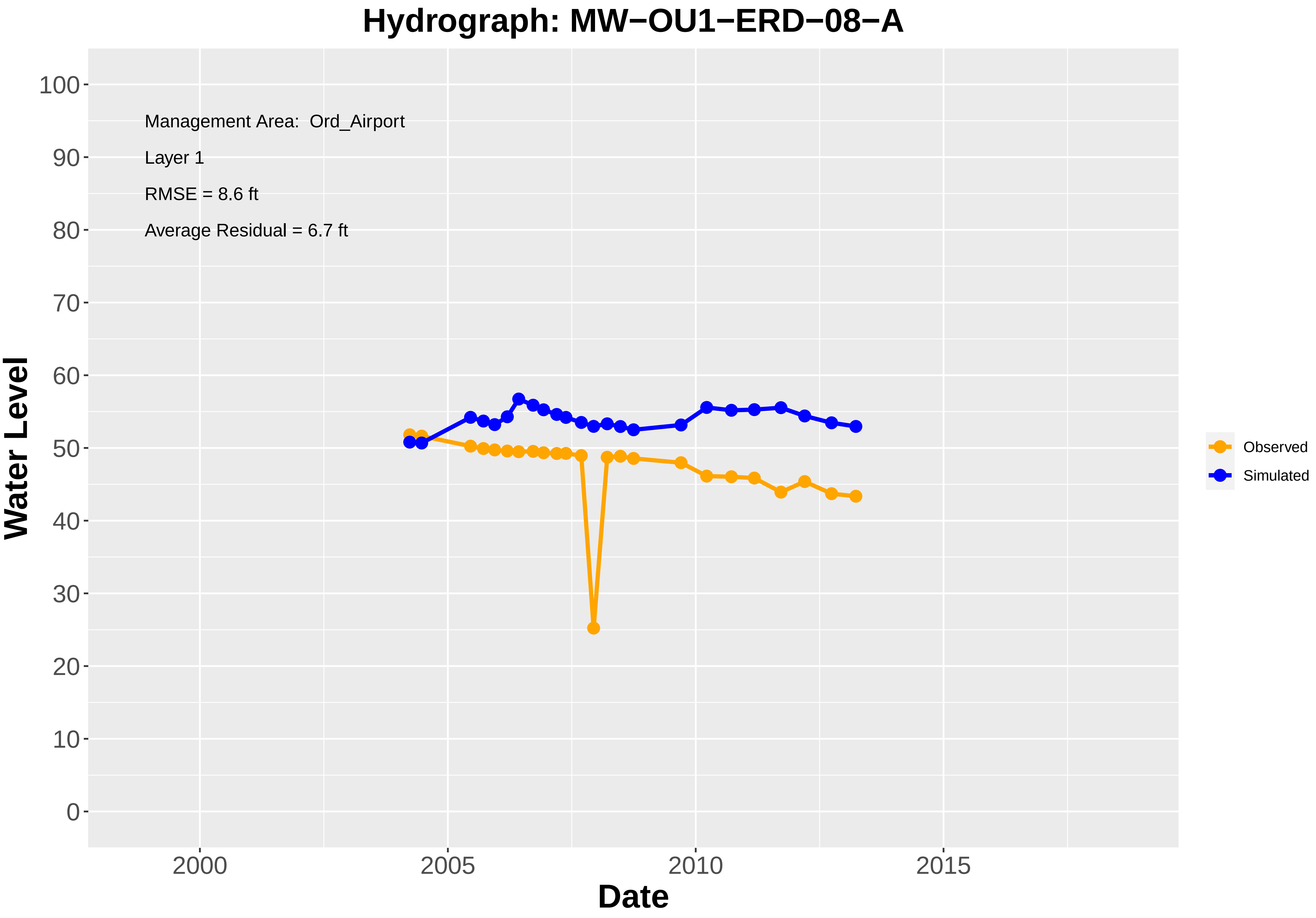


Hydrograph: MW−OU1−ERD−06−A

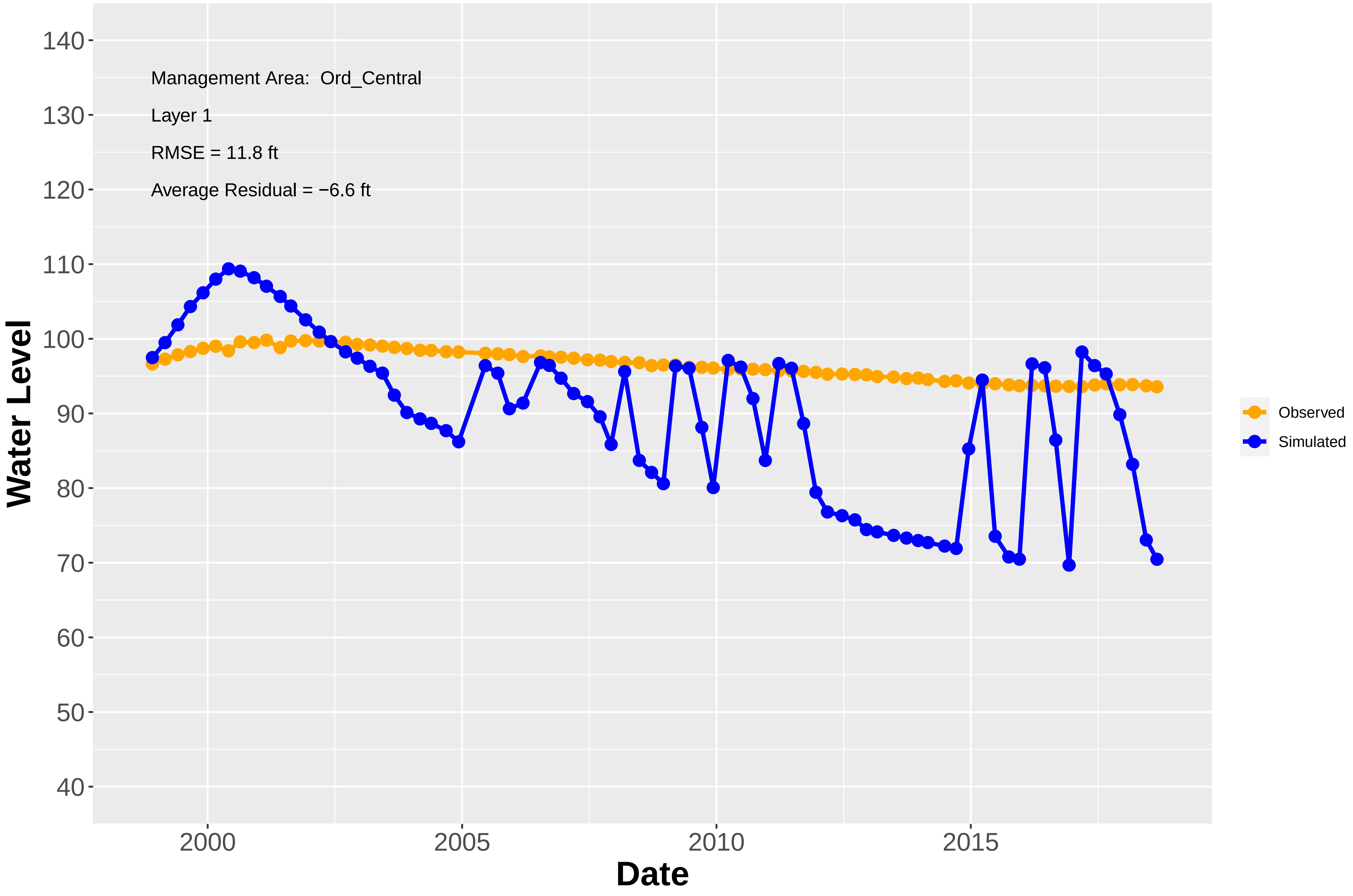


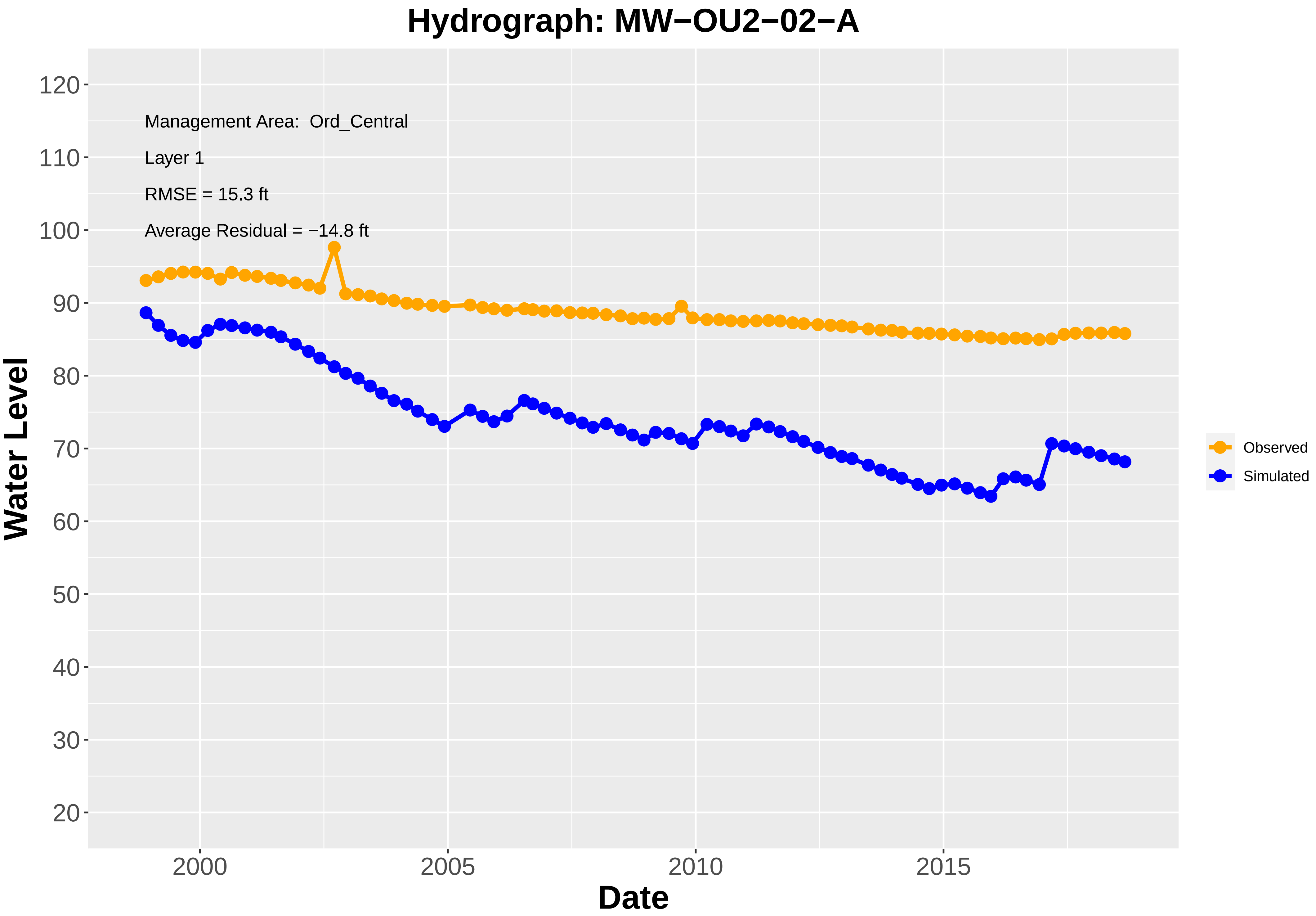


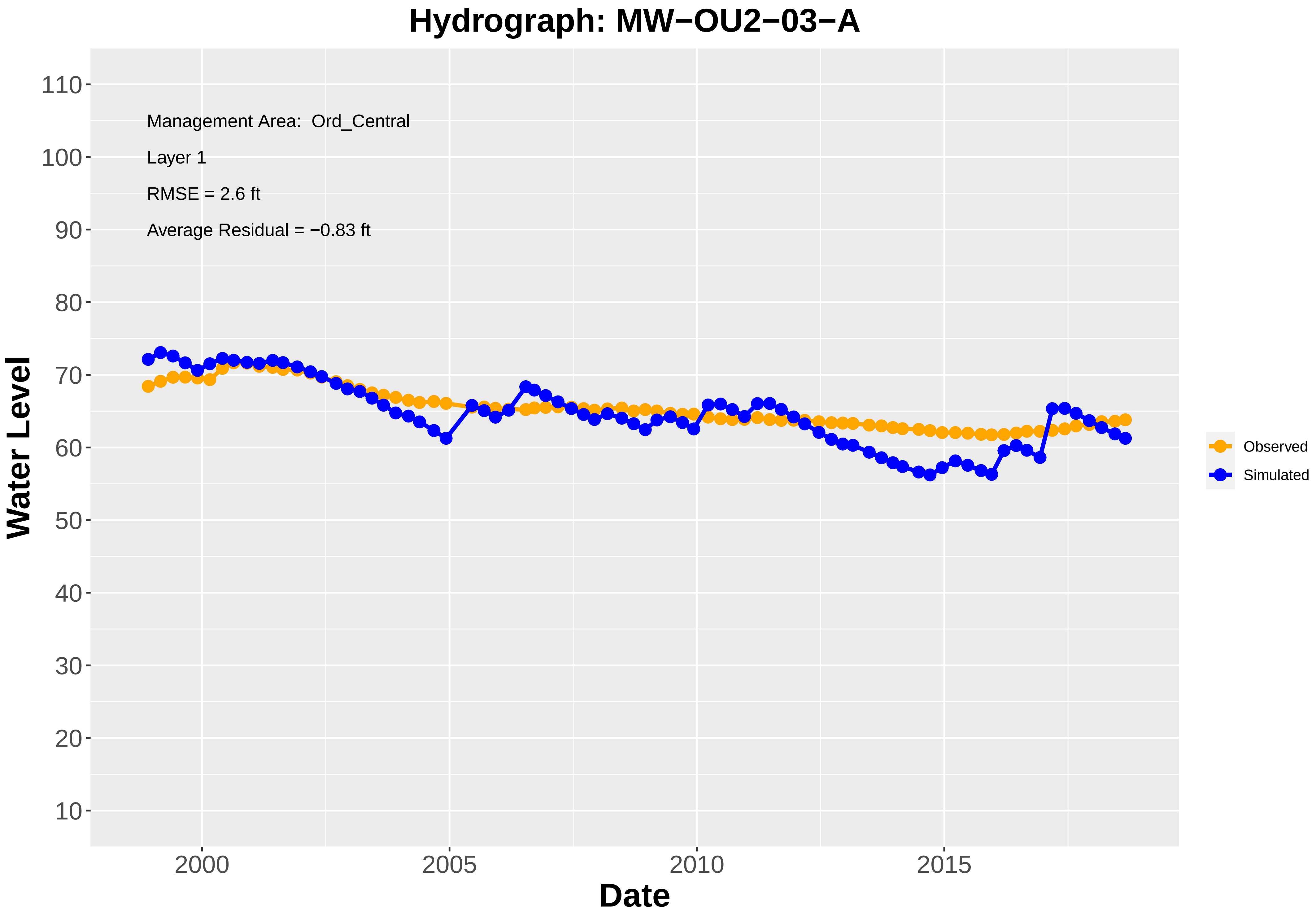
Hydrograph: MW−OU1−ERD−07−A
Management Area: Ord_Airport
Layer 1
RMSE = 9.5 ft
Average Residual = 6.5 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU1−ERD−08−A
Management Area: Ord_Airport
Layer 1
RMSE = 8.6 ft
Average Residual = 6.7 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

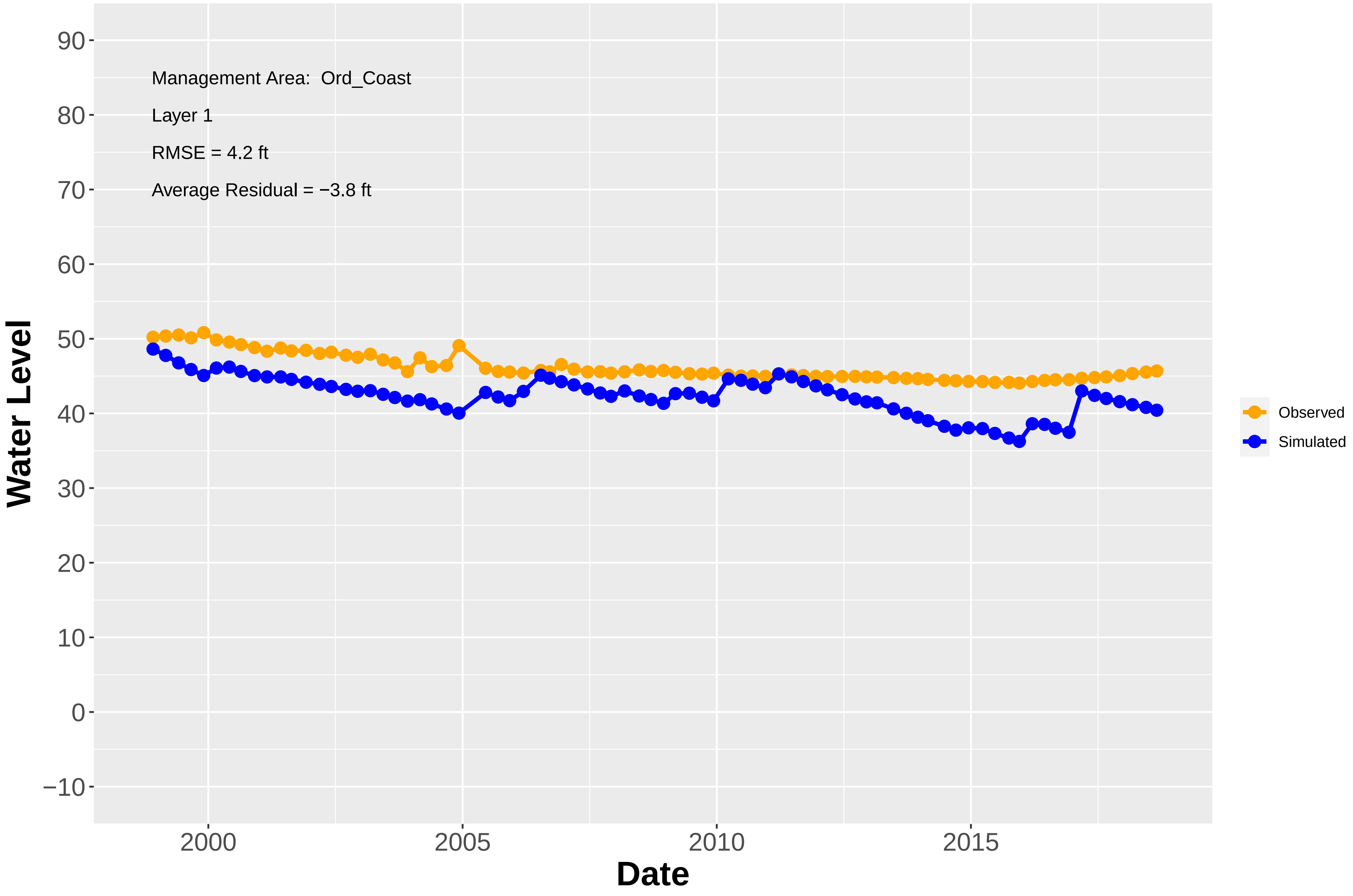
Hydrograph: MW−OU2−01−A

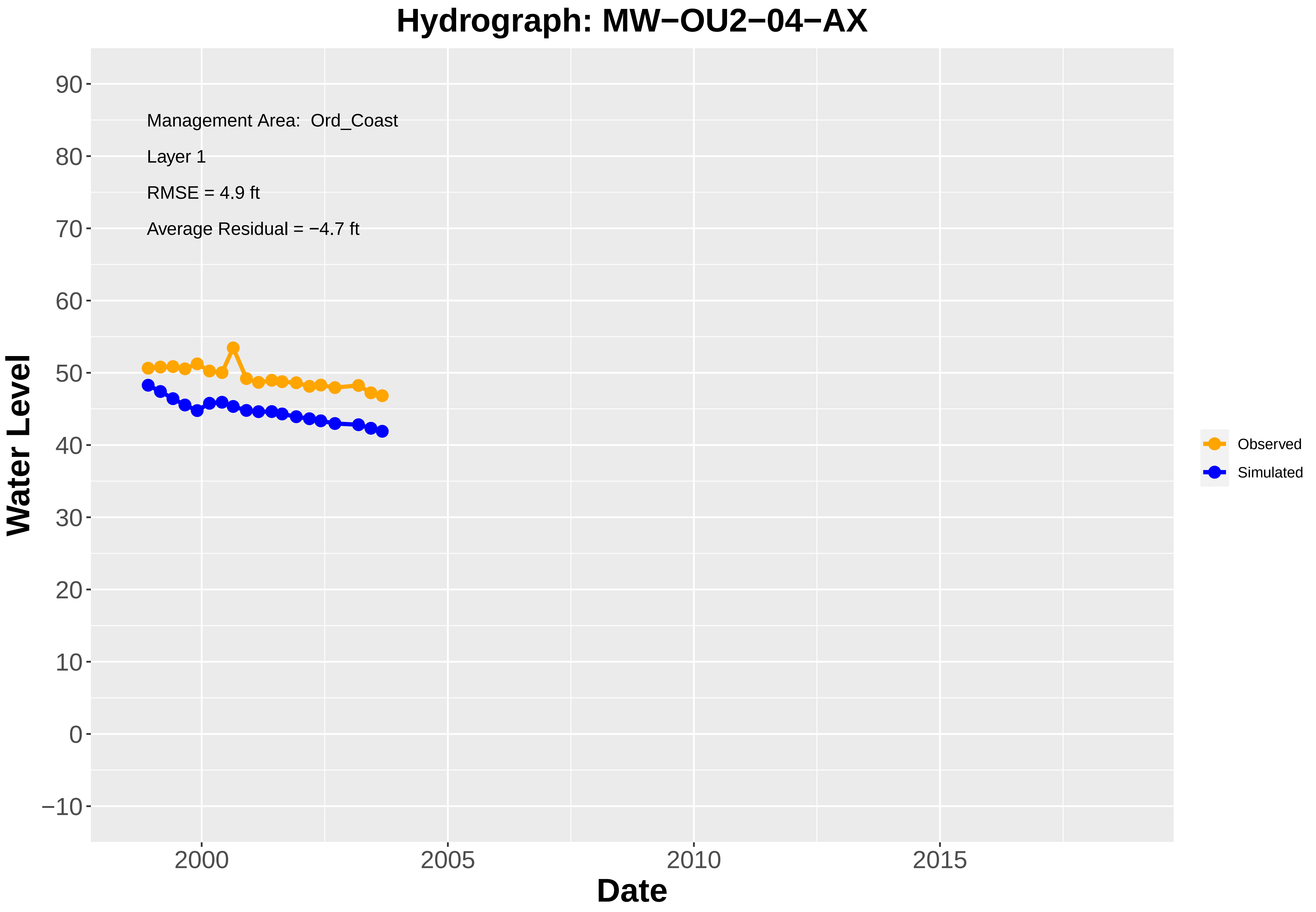


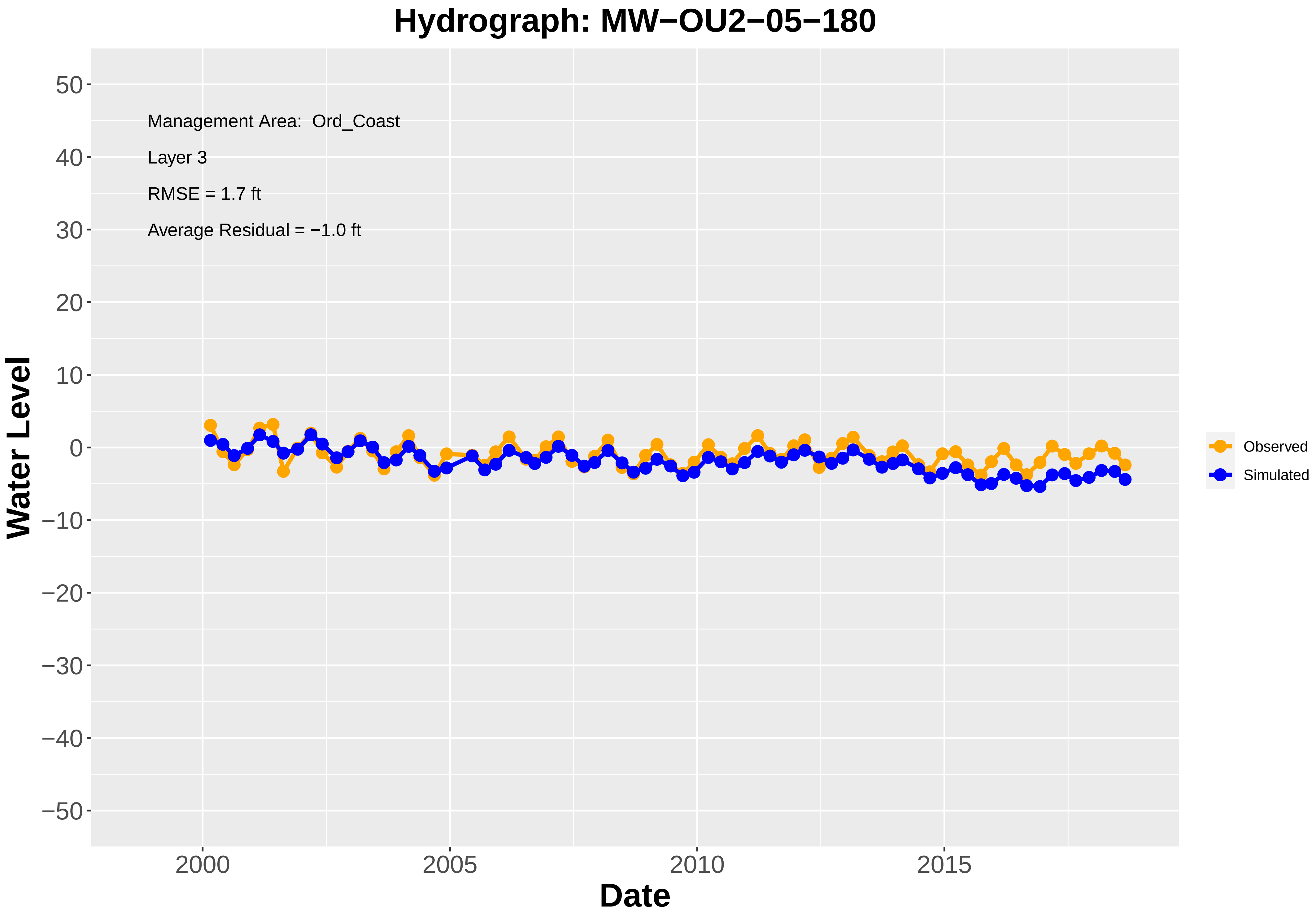

Hydrograph: MW−OU2−02−A
Management Area: Ord_Central
Layer 1
RMSE = 15.3 ft
Average Residual = −14.8 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

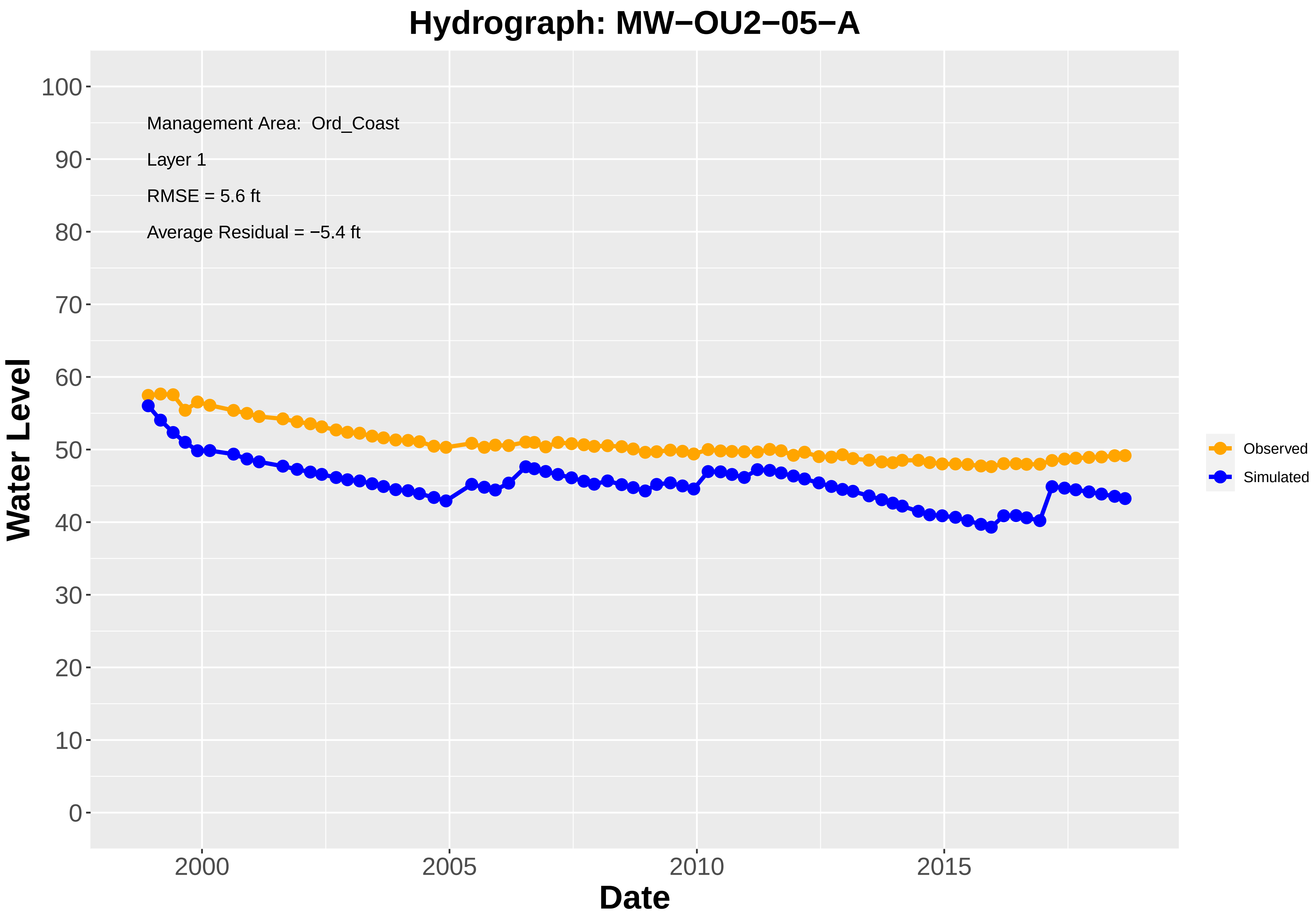

Hydrograph: MW−OU2−03−A
Management Area: Ord_Central
Layer 1
RMSE = 2.6 ft
Average Residual = −0.83 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

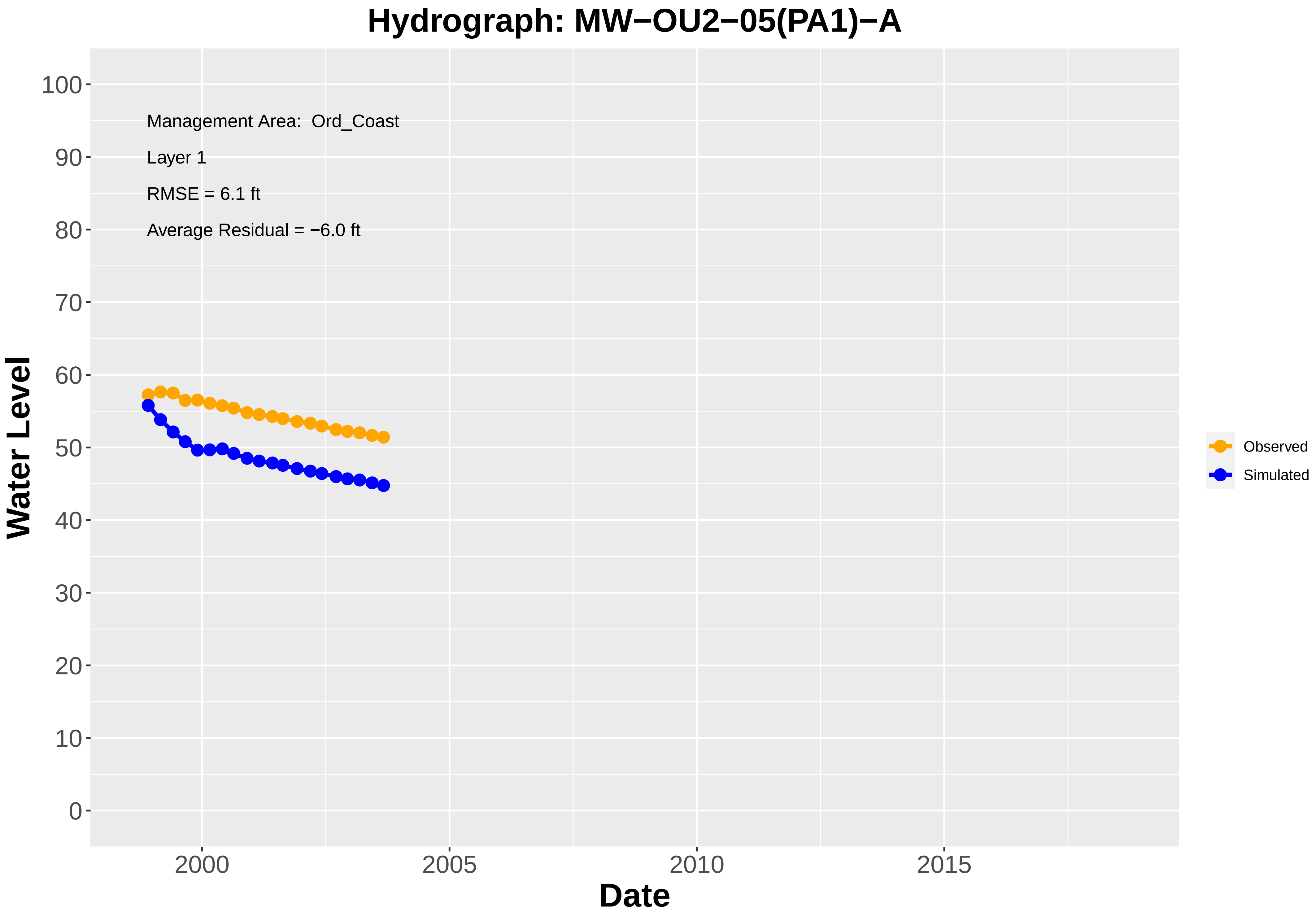
Hydrograph: MW−OU2−04−A

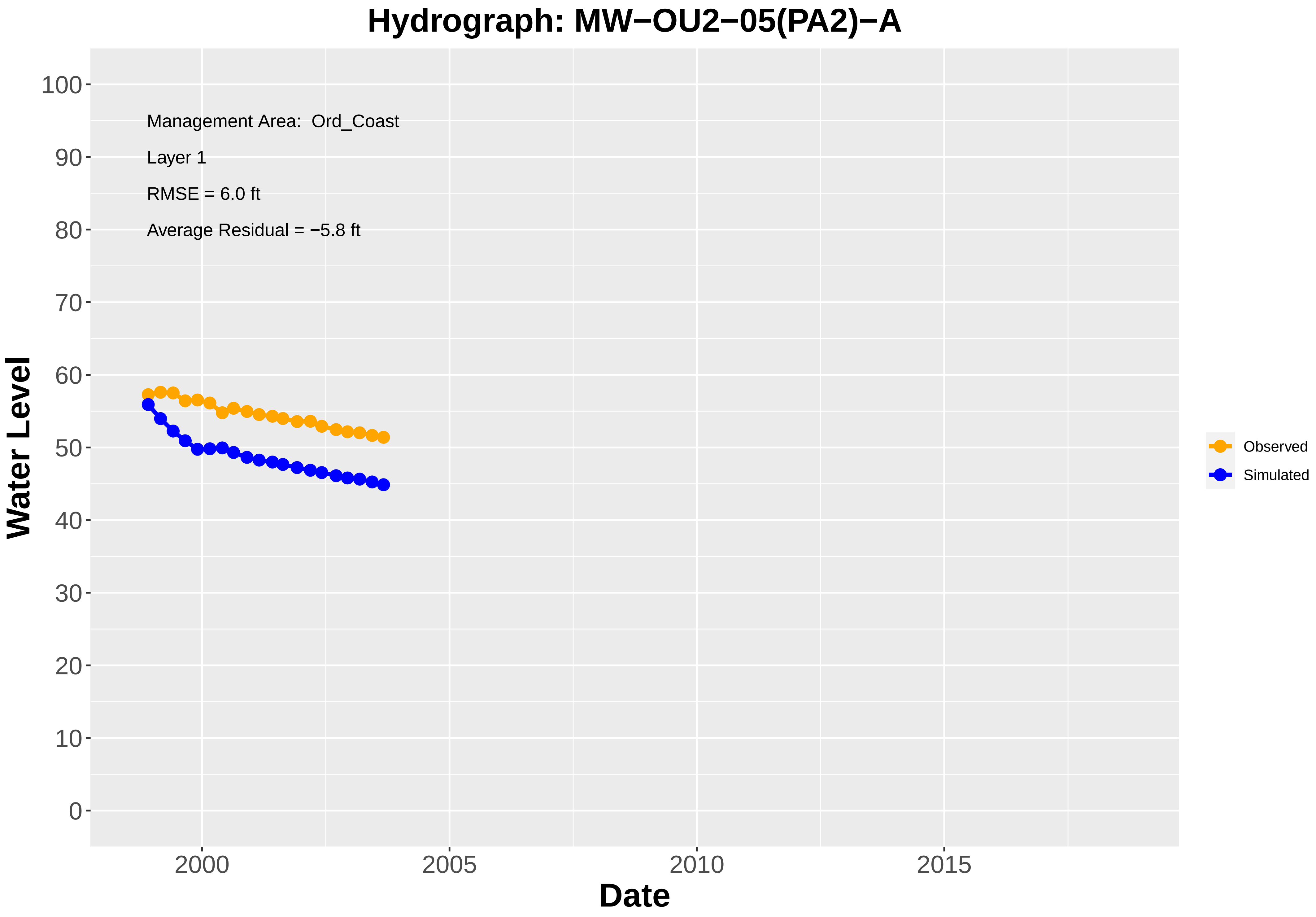


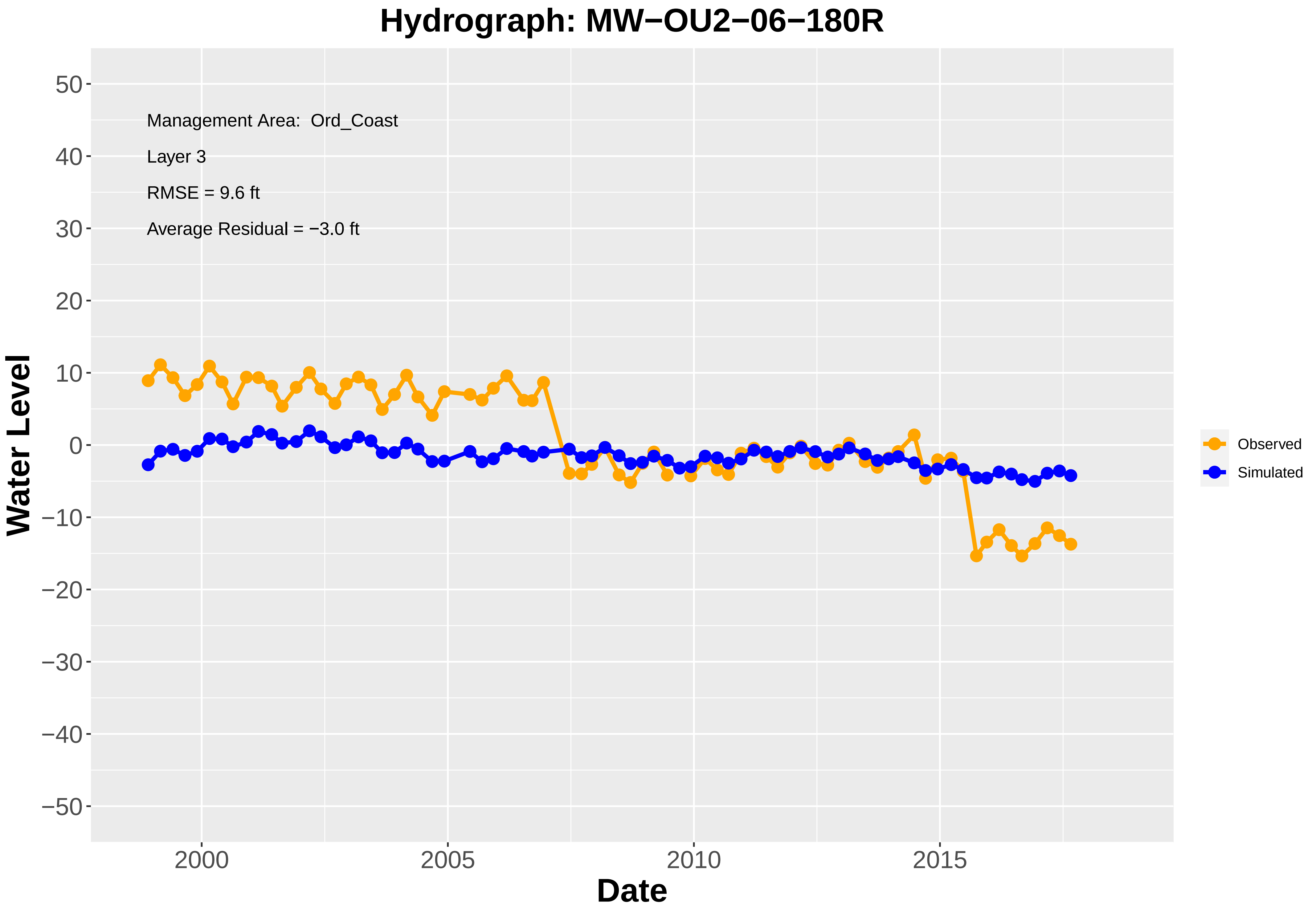

Hydrograph: MW−OU2−04−AX
Management Area: Ord_Coast
Layer 1
RMSE = 4.9 ft
Average Residual = −4.7 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
2000
2005
2010
2015
Date
Observed
Simulated

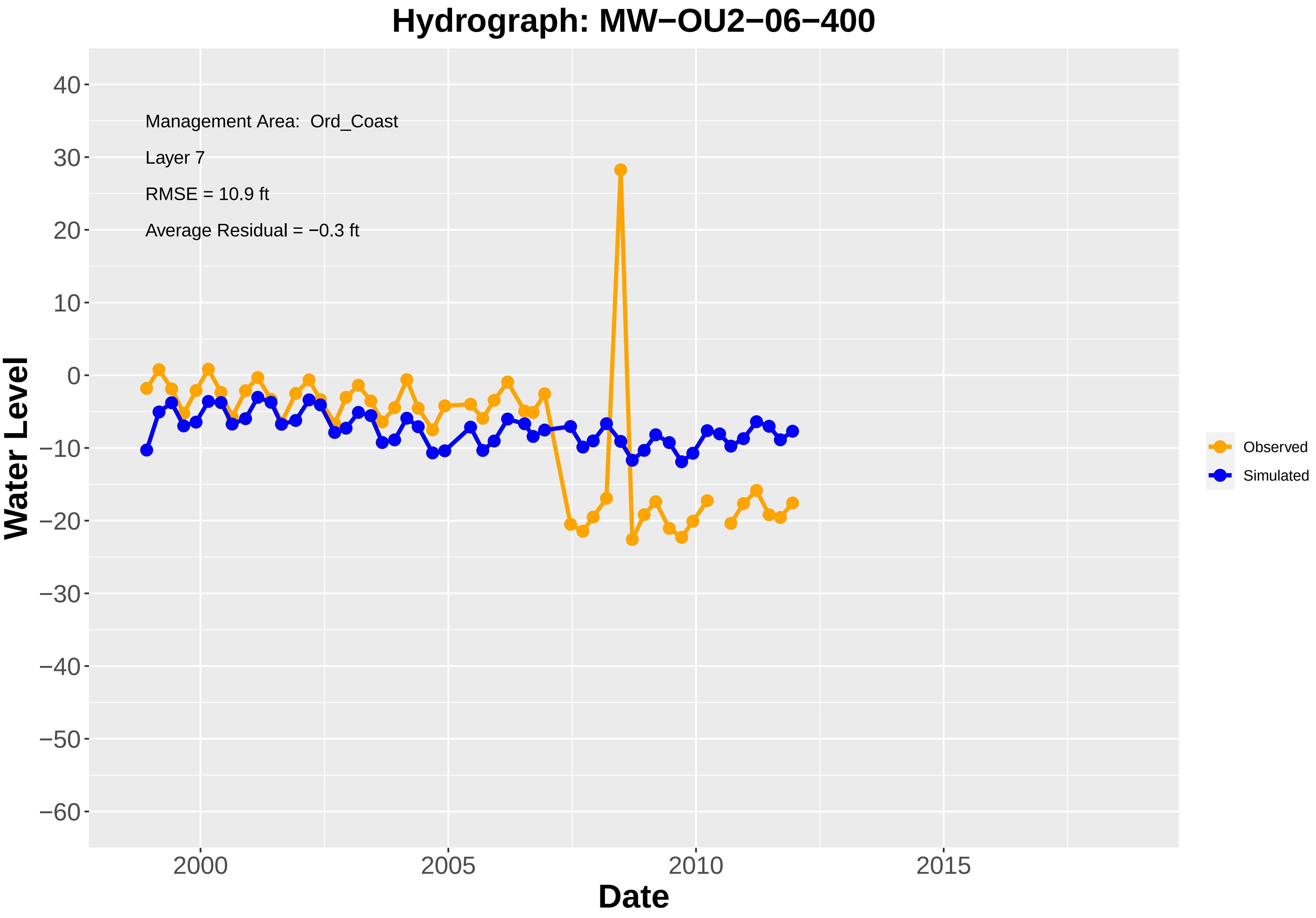

Hydrograph: MW−OU2−05−180
Management Area: Ord_Coast
Layer 3
RMSE = 1.7 ft
Average Residual = −1.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

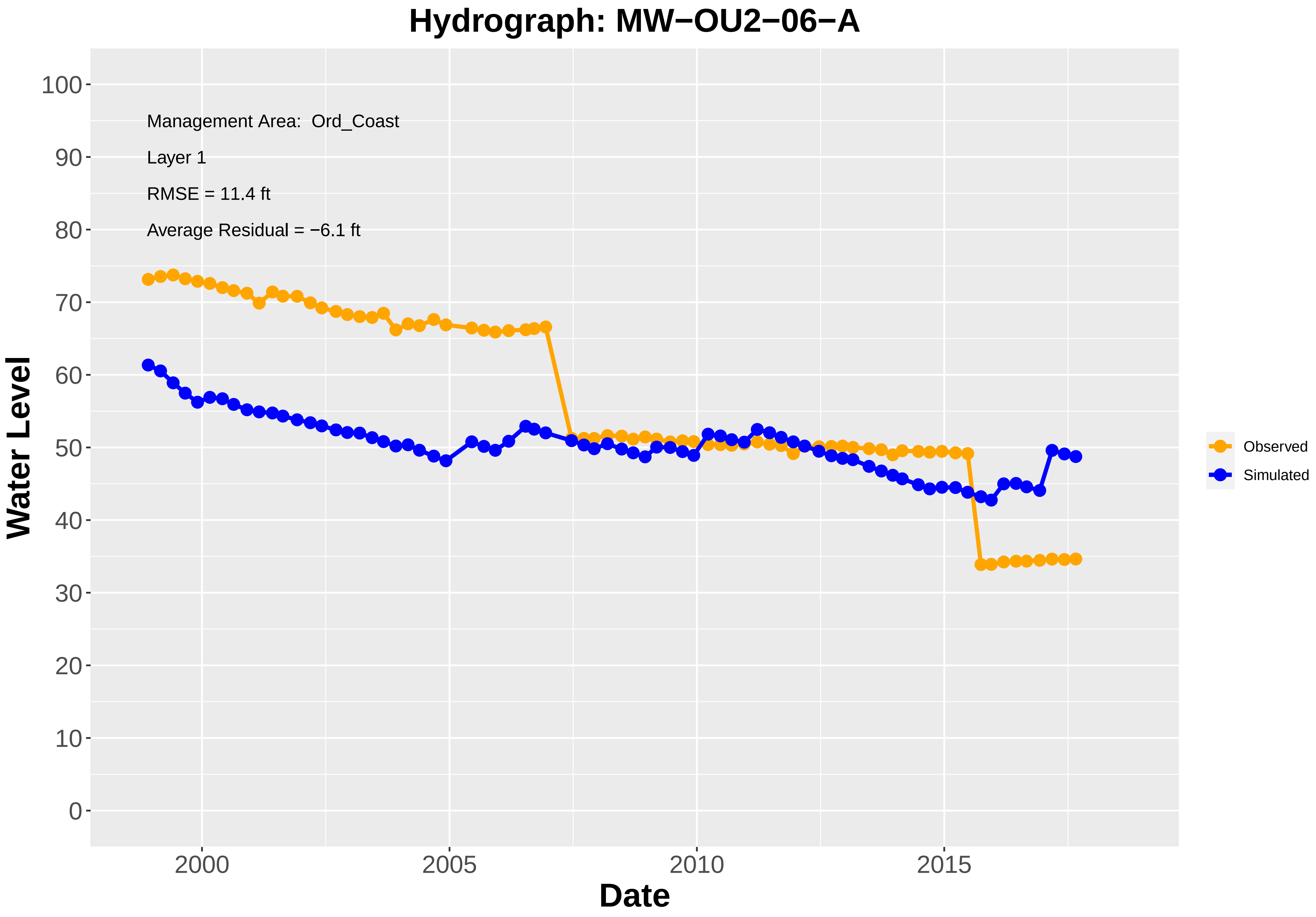

Hydrograph: MW−OU2−05−A
Management Area: Ord_Coast
Layer 1
RMSE = 5.6 ft
Average Residual = −5.4 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

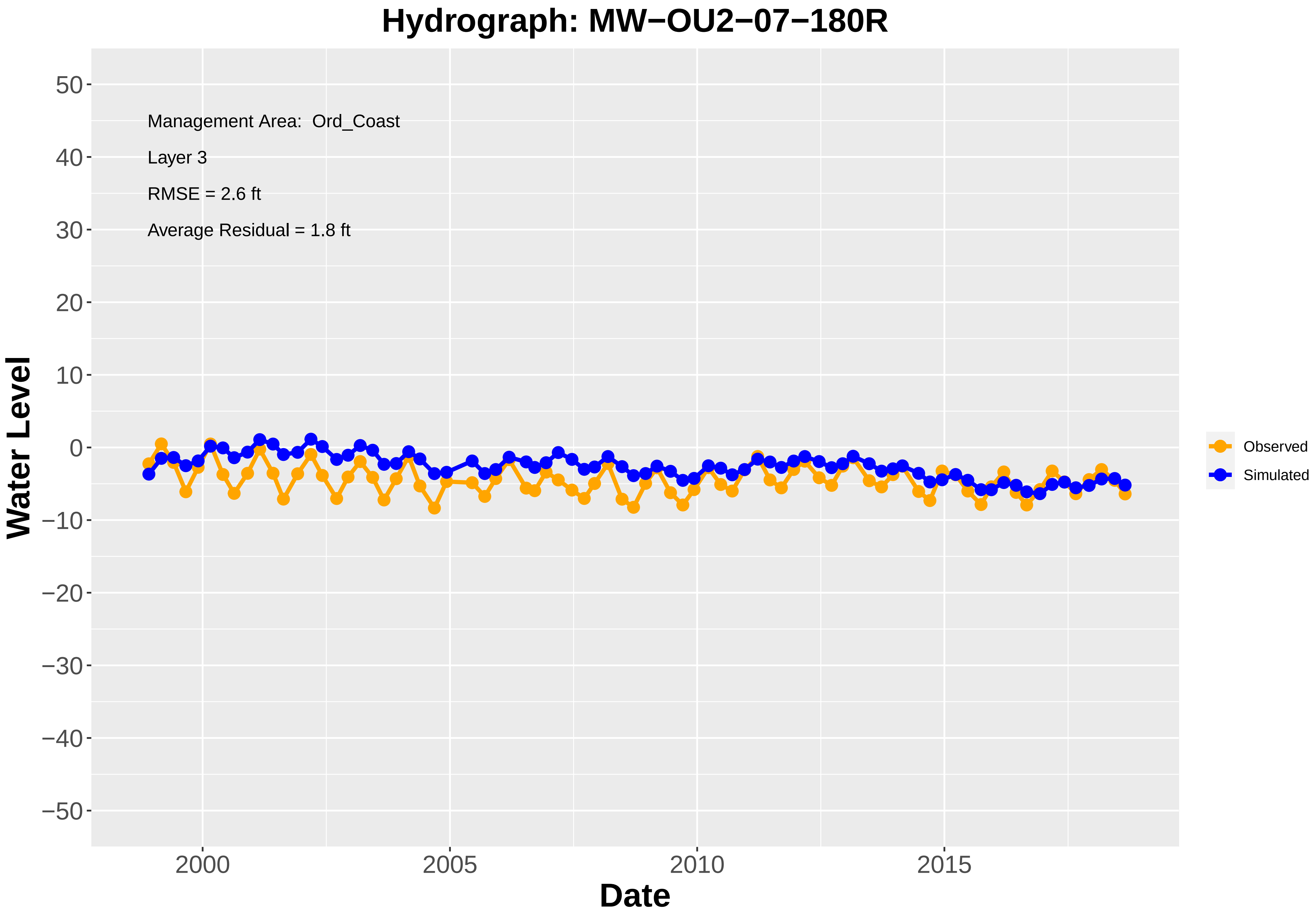

Hydrograph: MW−OU2−05(PA1)−A
Management Area: Ord_Coast
Layer 1
RMSE = 6.1 ft
Average Residual = −6.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

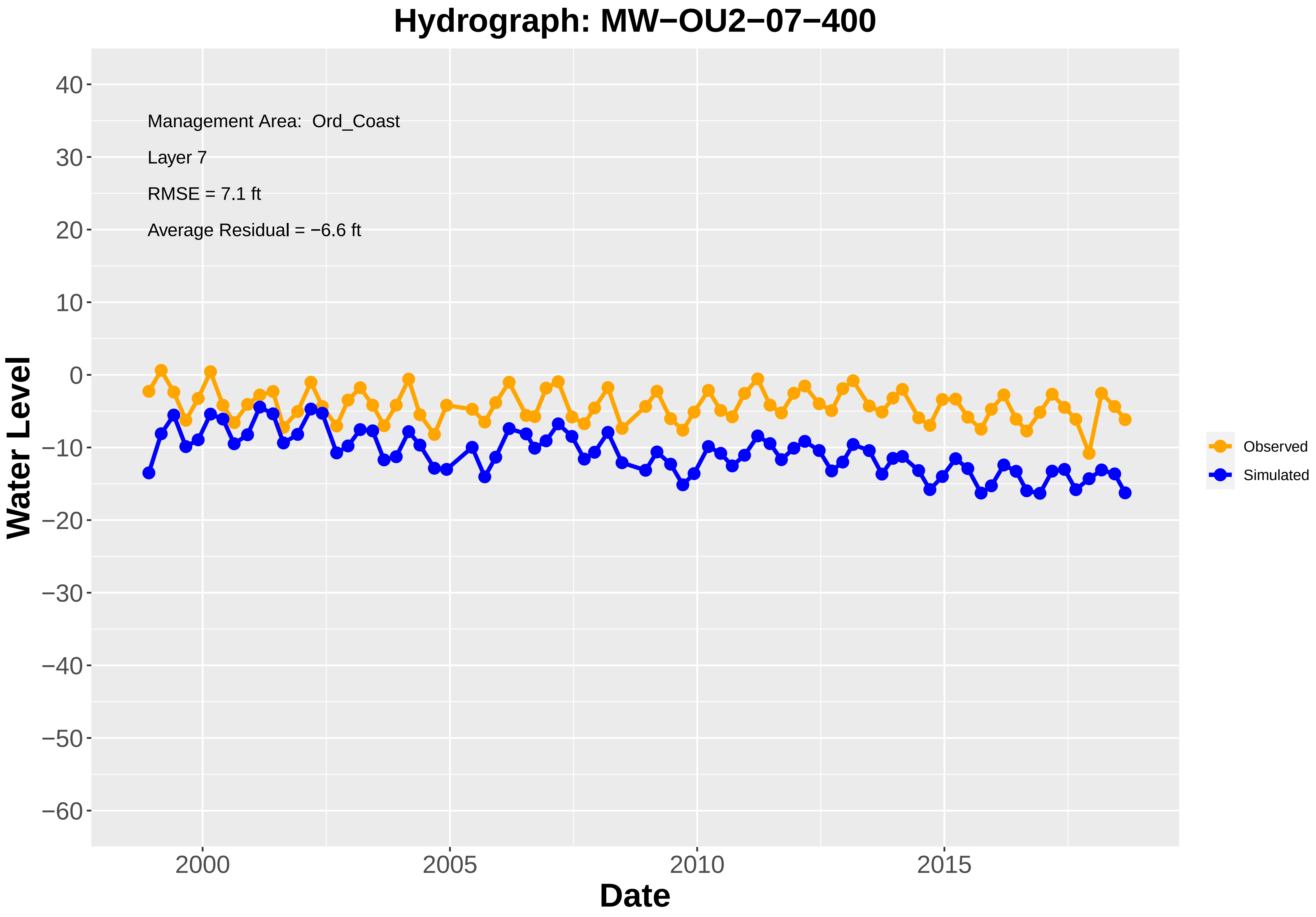

Hydrograph: MW−OU2−05(PA2)−A
Management Area: Ord_Coast
Layer 1
RMSE = 6.0 ft
Average Residual = −5.8 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

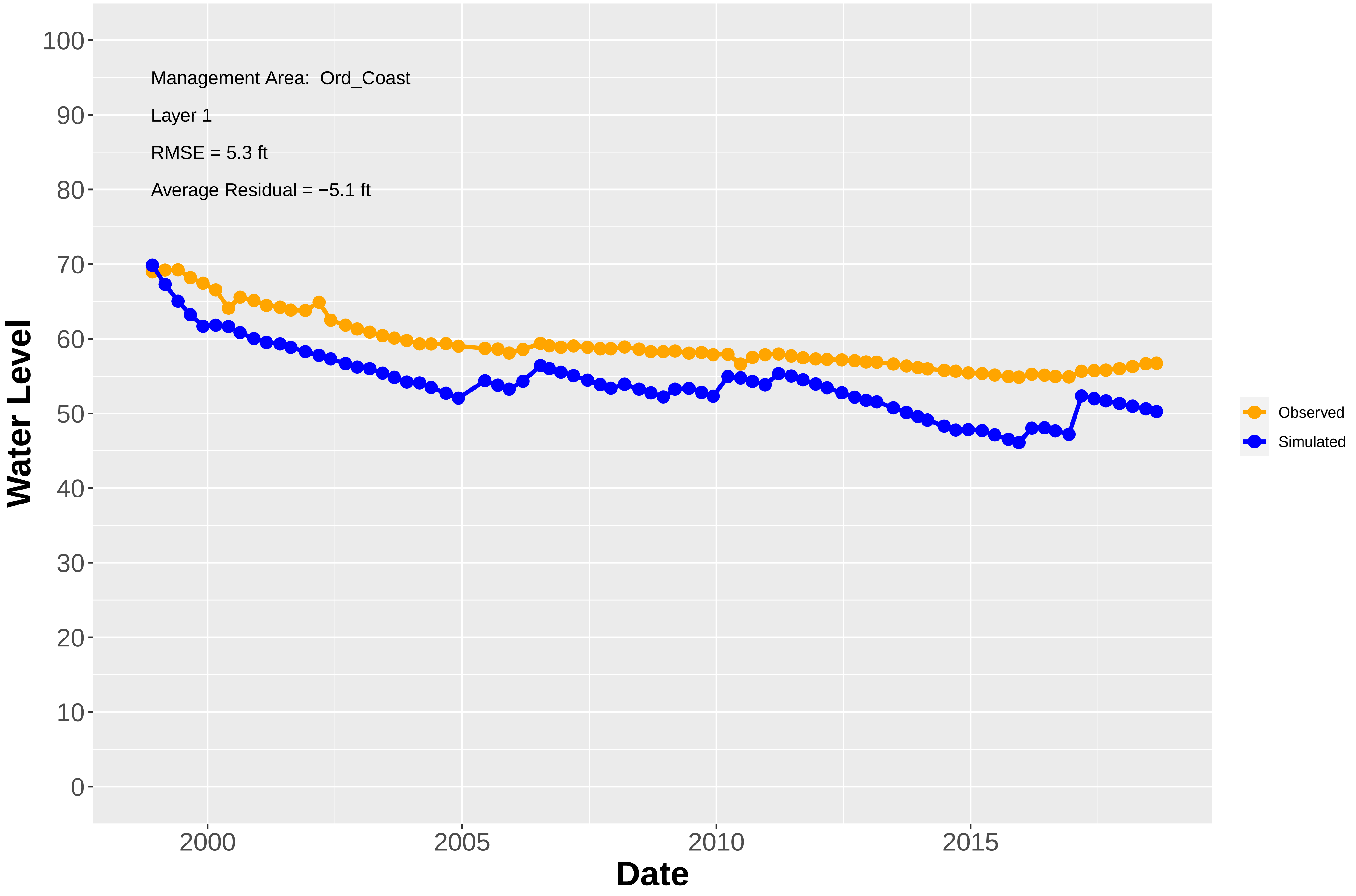

Hydrograph: MW−OU2−06−180R
Management Area: Ord_Coast
Layer 3
RMSE = 9.6 ft
Average Residual = −3.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−06−400
Management Area: Ord_Coast
Layer 7
RMSE = 10.9 ft
Average Residual = −0.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

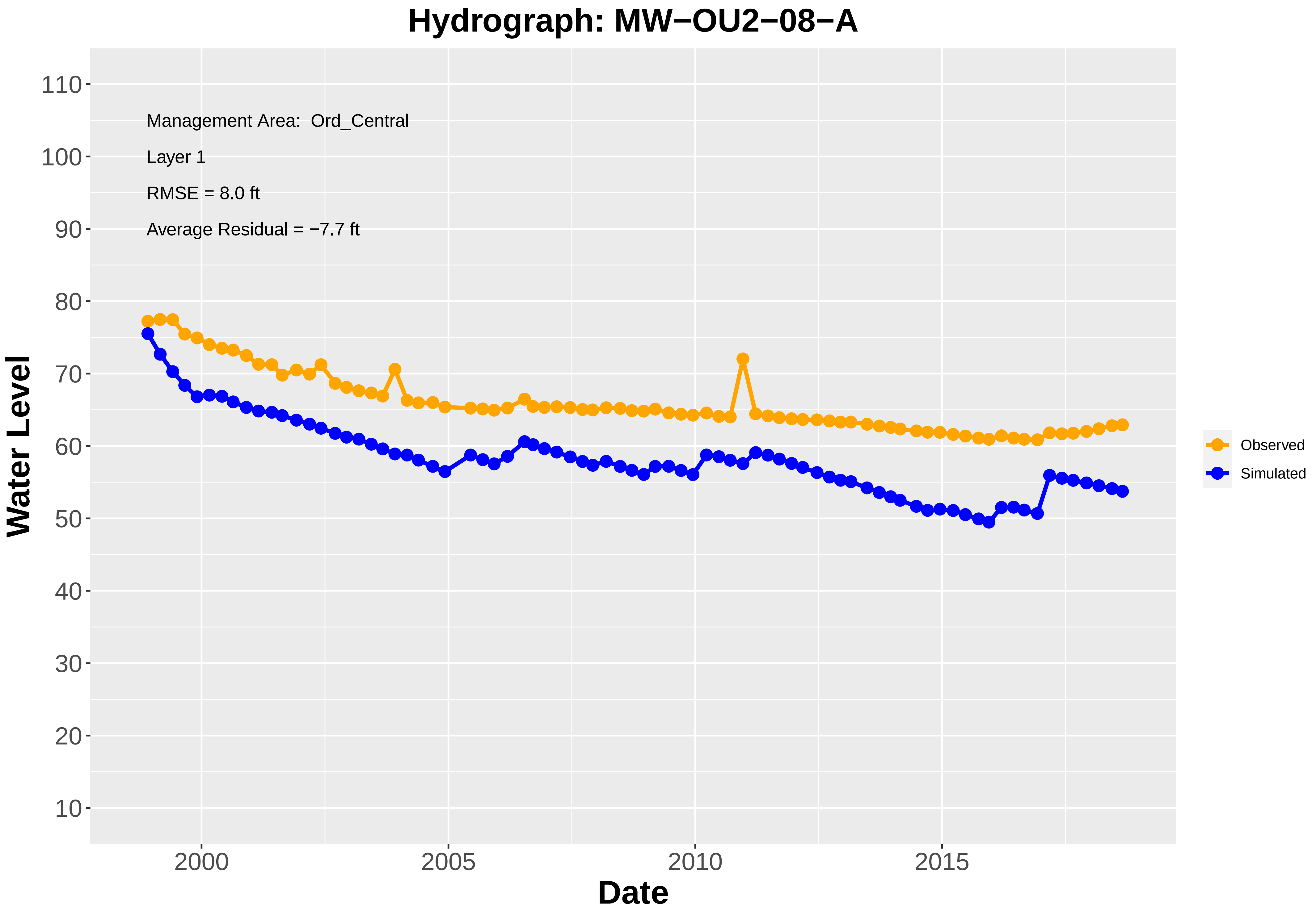

Hydrograph: MW−OU2−06−A
Management Area: Ord_Coast
Layer 1
RMSE = 11.4 ft
Average Residual = −6.1 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

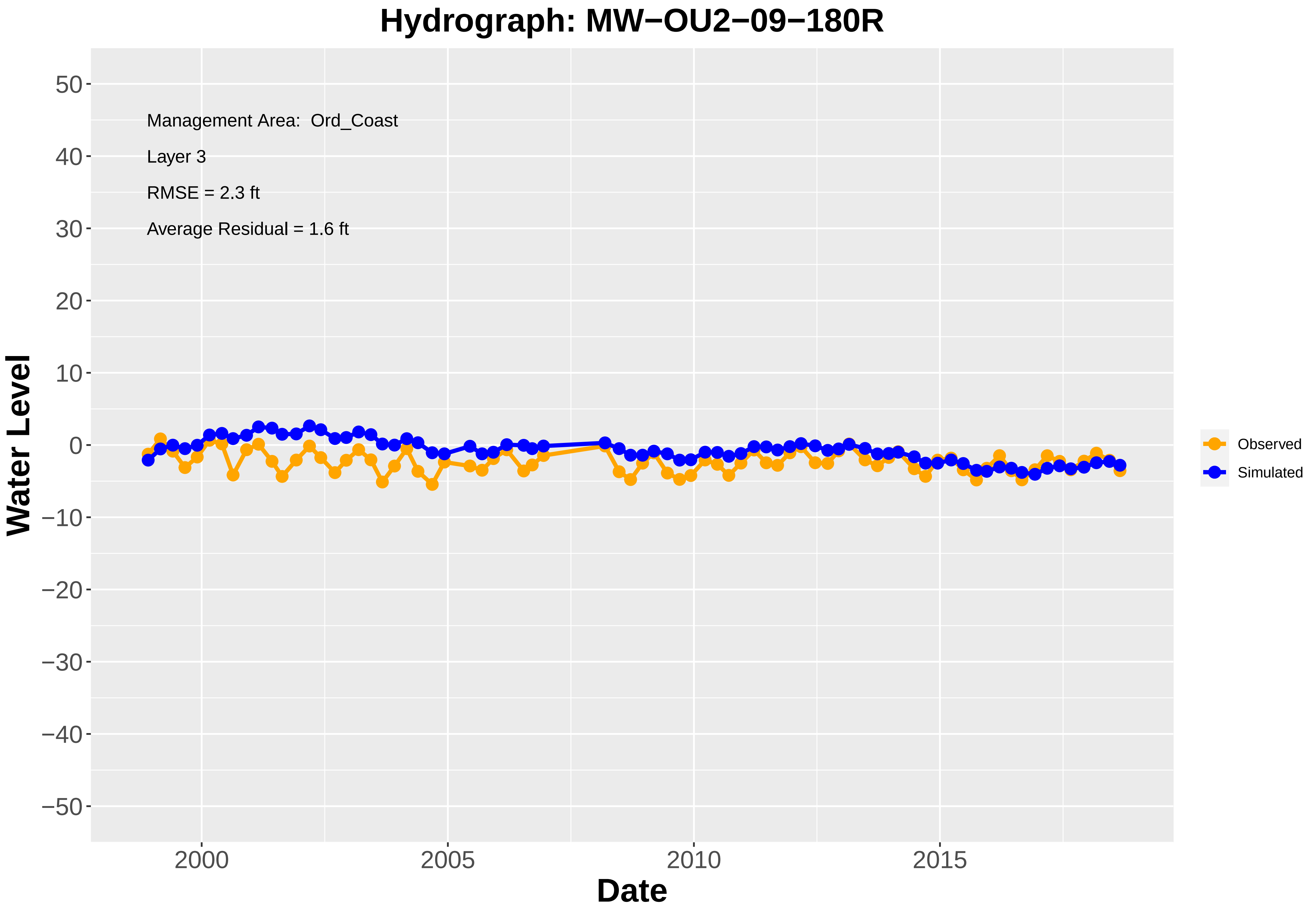

Hydrograph: MW−OU2−07−180R
Management Area: Ord_Coast
Layer 3
RMSE = 2.6 ft
Average Residual = 1.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

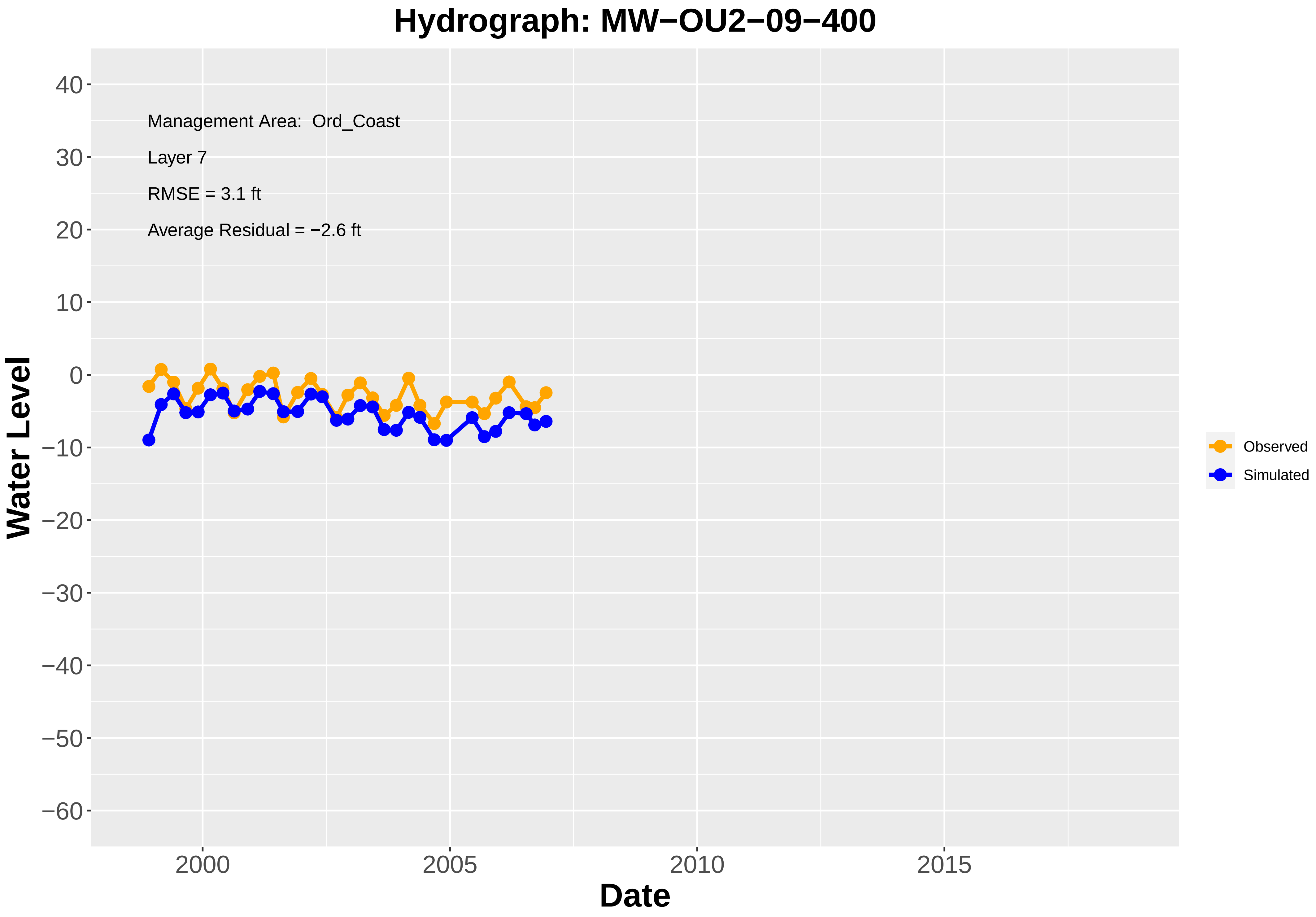

Hydrograph: MW−OU2−07−400
Management Area: Ord_Coast
Layer 7
RMSE = 7.1 ft
Average Residual = −6.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

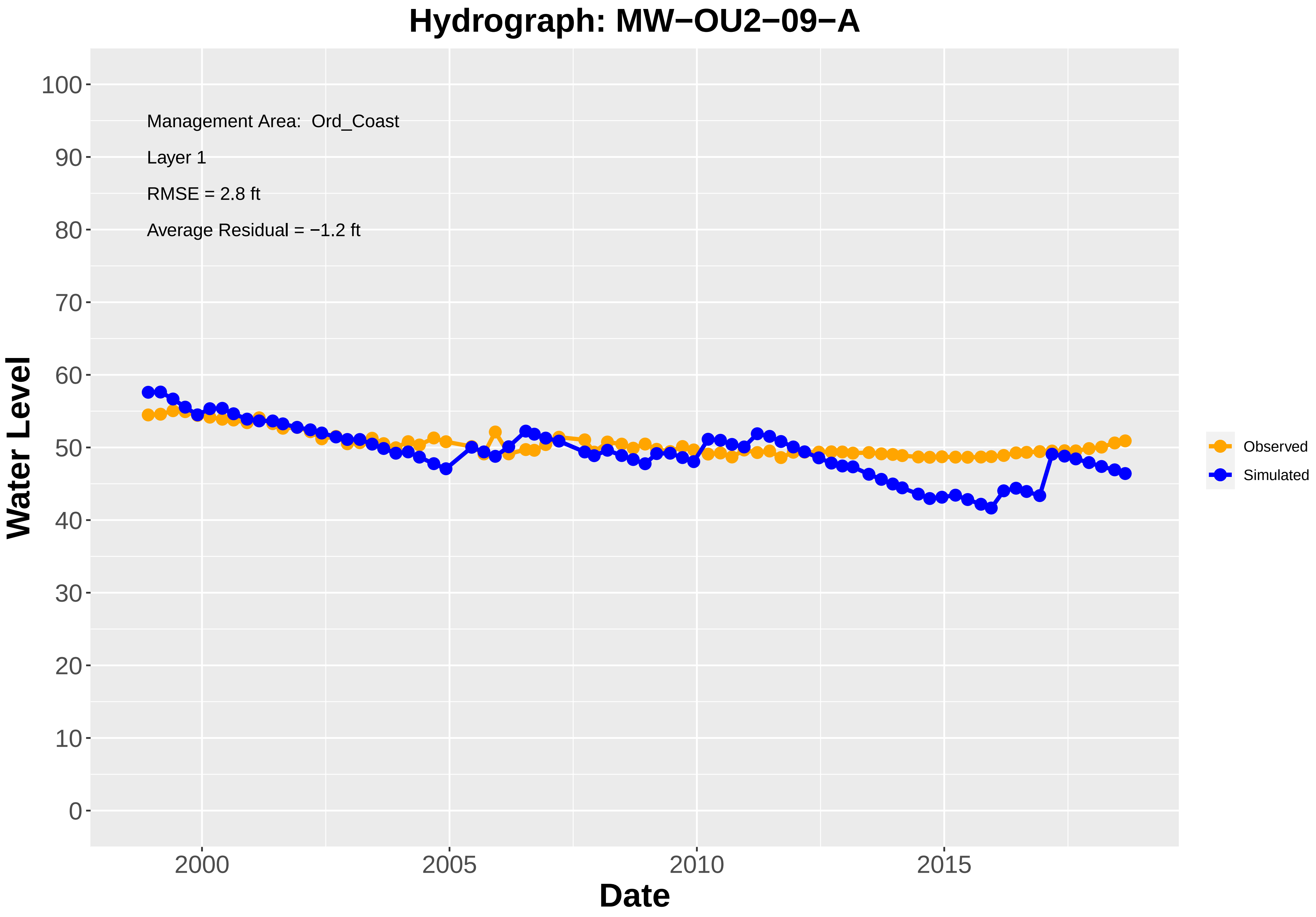


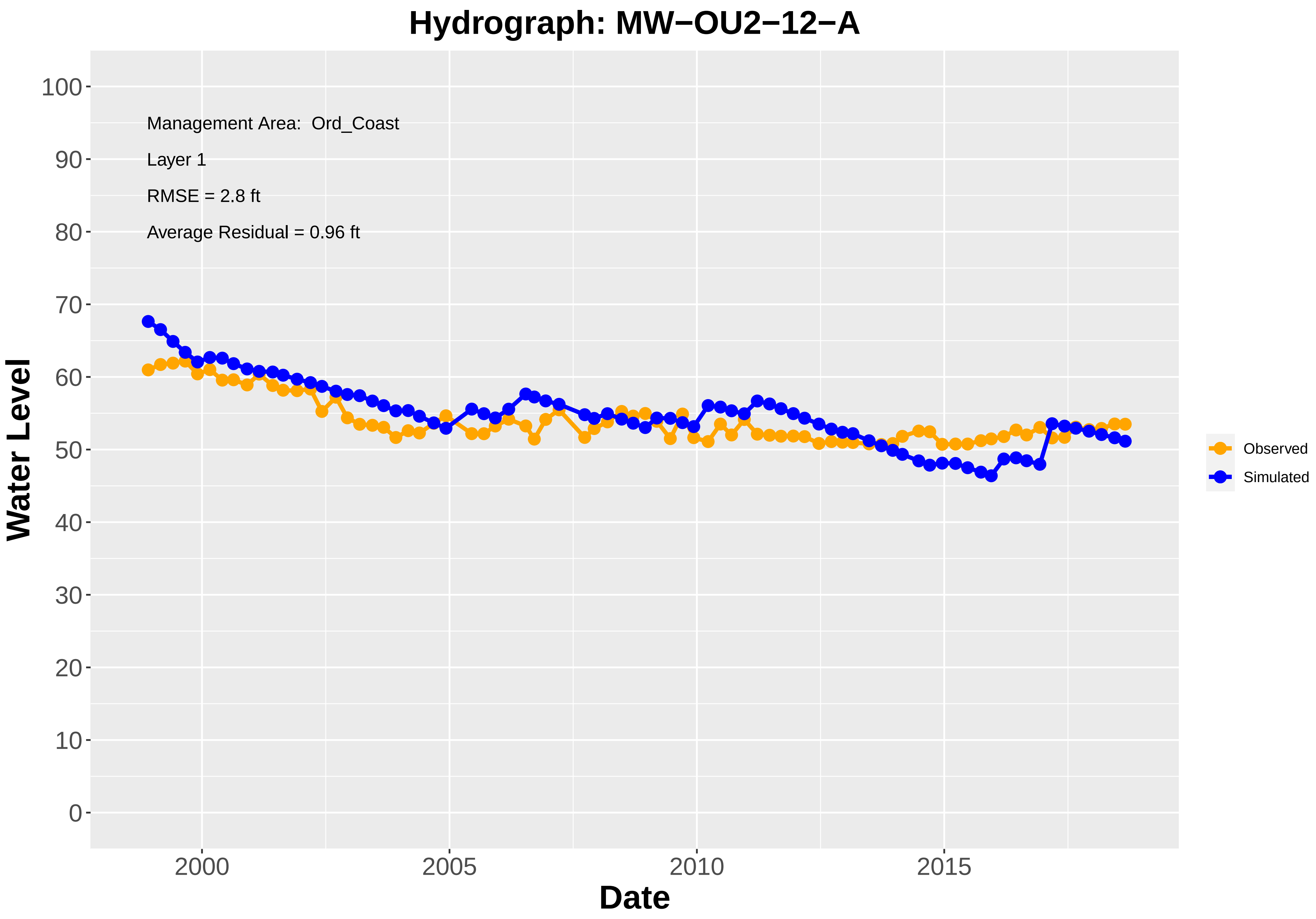
Hydrograph: MW−OU2−07−A

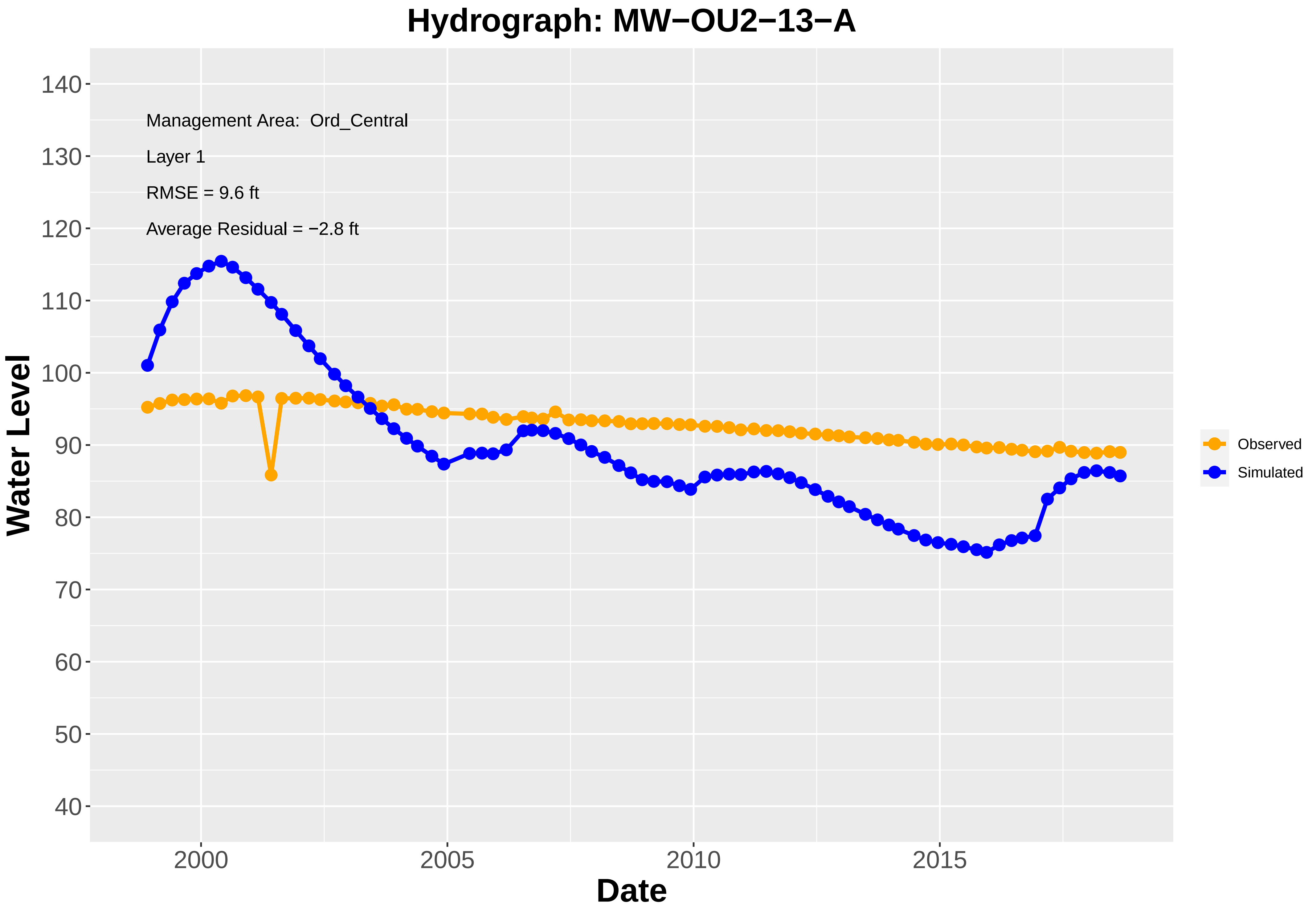

Hydrograph: MW−OU2−08−A
Management Area: Ord_Central
Layer 1
RMSE = 8.0 ft
Average Residual = −7.7 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

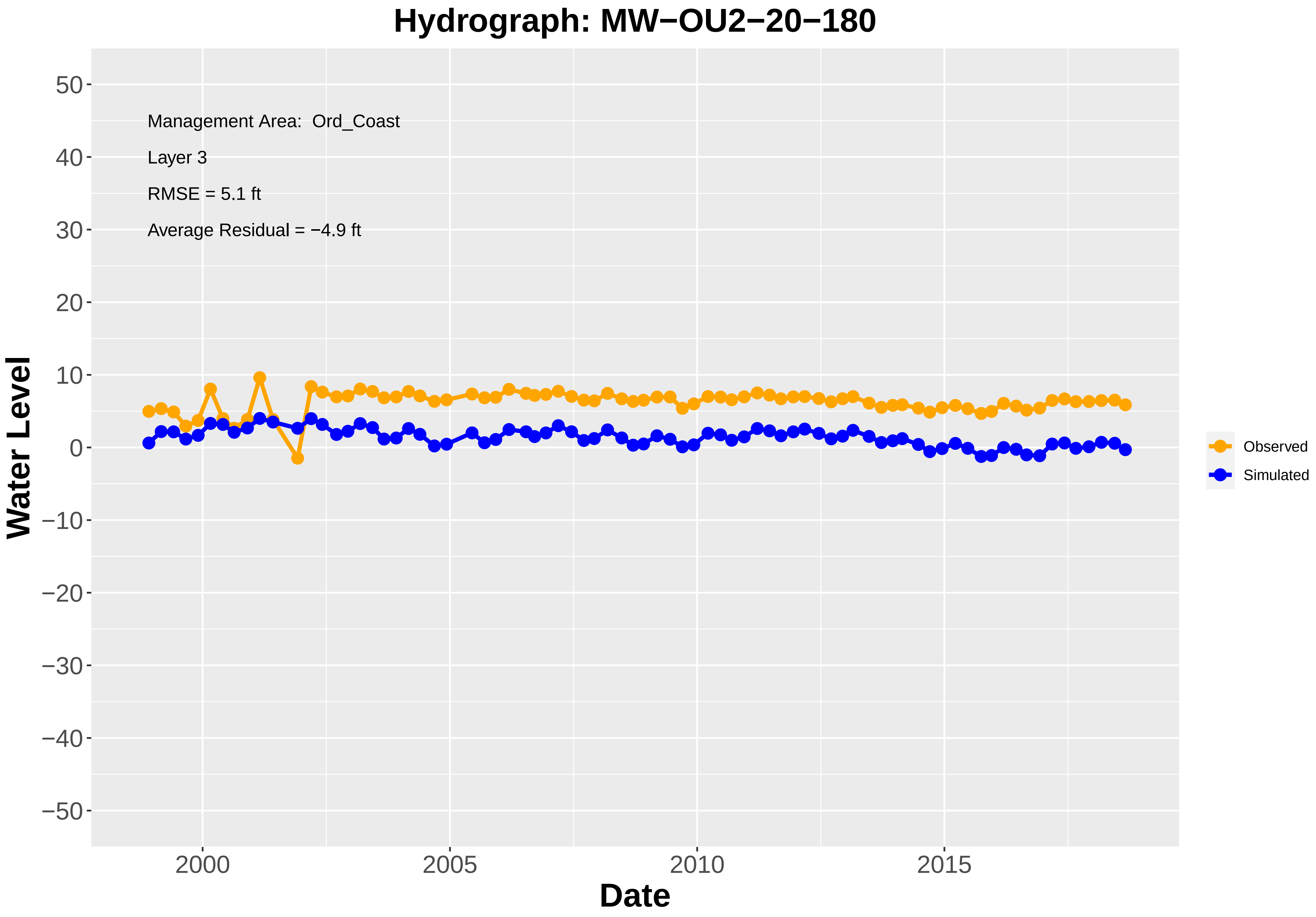

Hydrograph: MW−OU2−09−180R
Management Area: Ord_Coast
Layer 3
RMSE = 2.3 ft
Average Residual = 1.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−09−400
Management Area: Ord_Coast
Layer 7
RMSE = 3.1 ft
Average Residual = −2.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

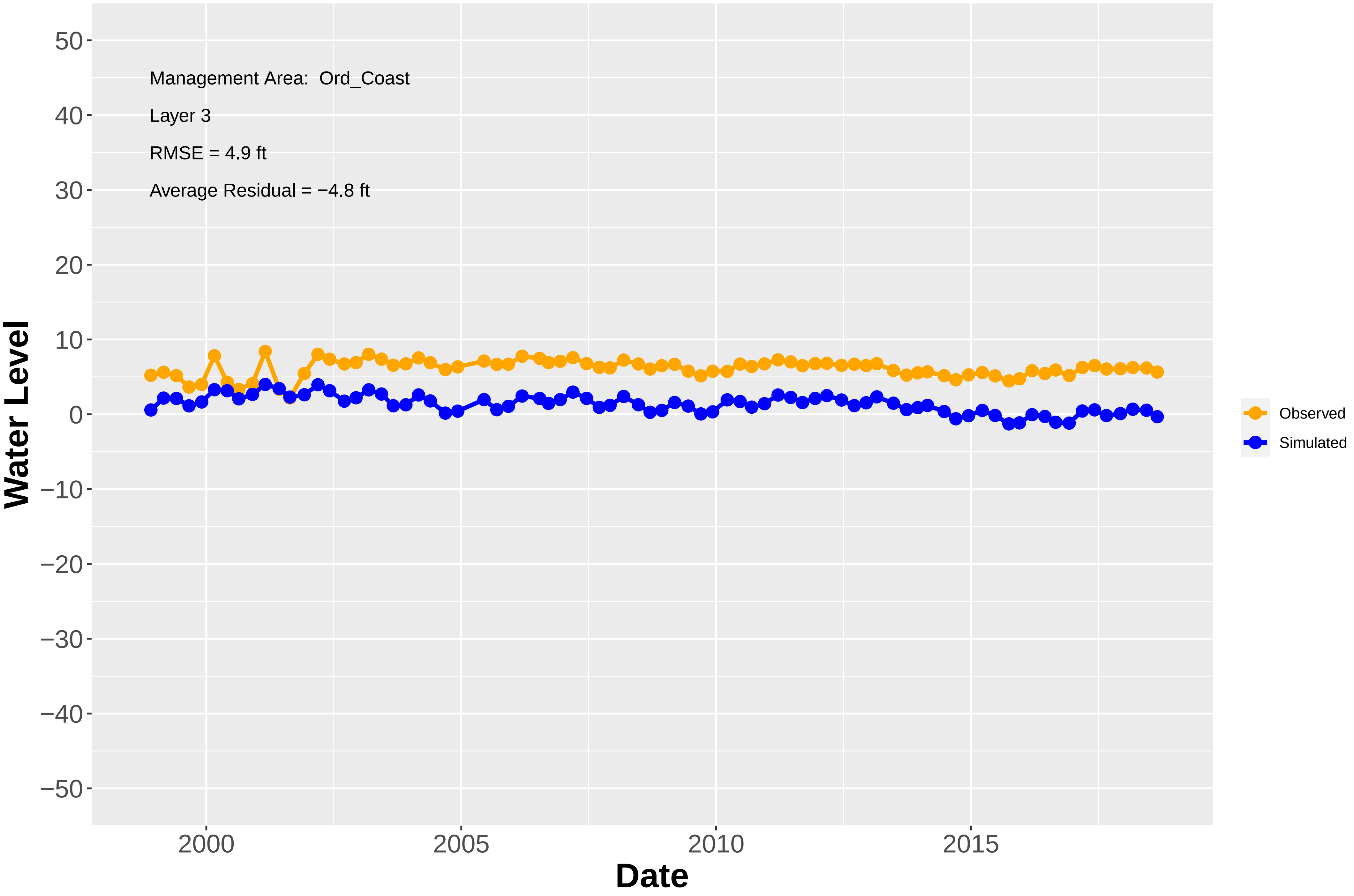

Hydrograph: MW−OU2−09−A
Management Area: Ord_Coast
Layer 1
RMSE = 2.8 ft
Average Residual = −1.2 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
Date
2000
2005
2010
2015
Observed
Simulated

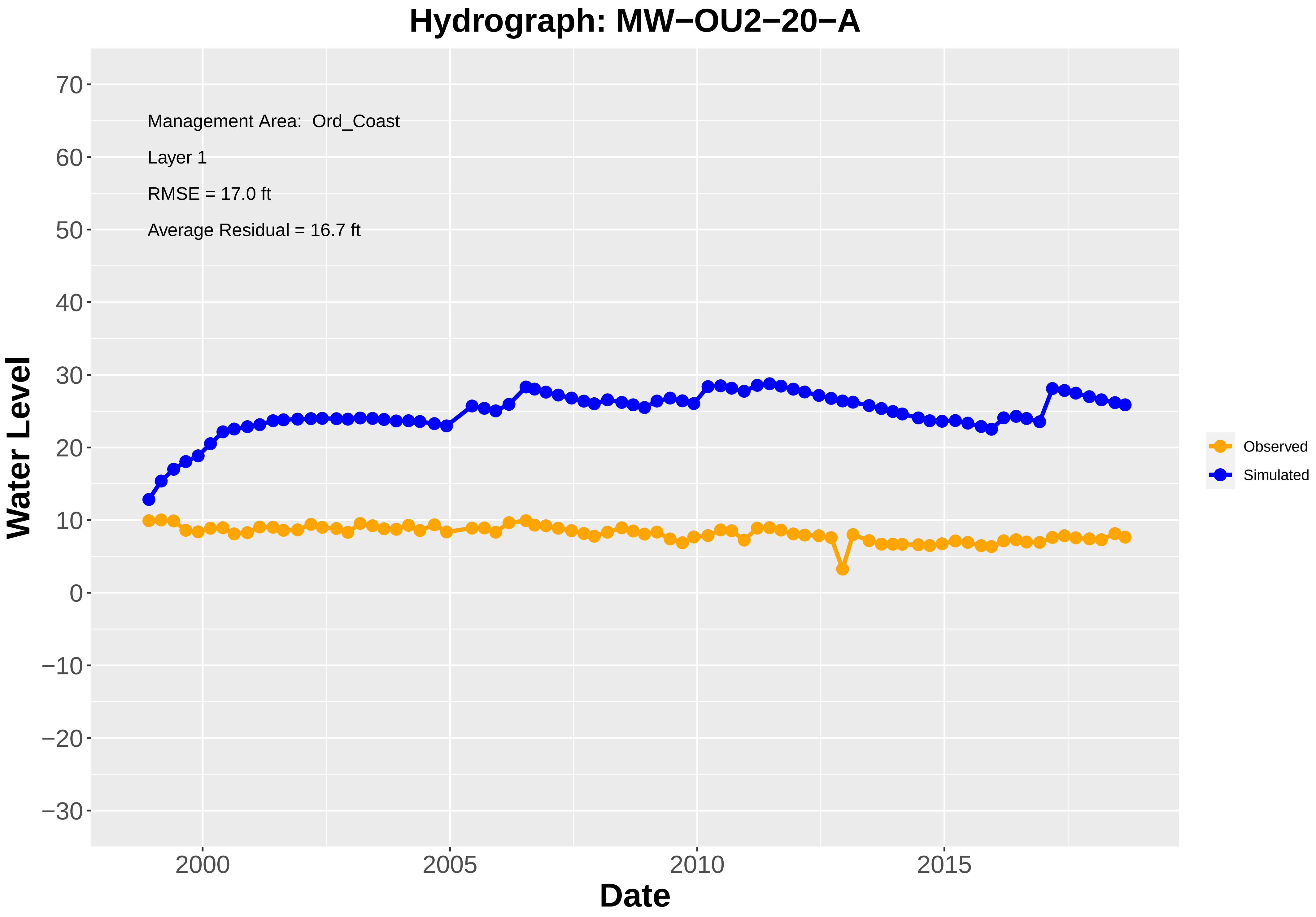

Hydrograph: MW−OU2−12−A
Management Area: Ord_Coast
Layer 1
RMSE = 2.8 ft
Average Residual = 0.96 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

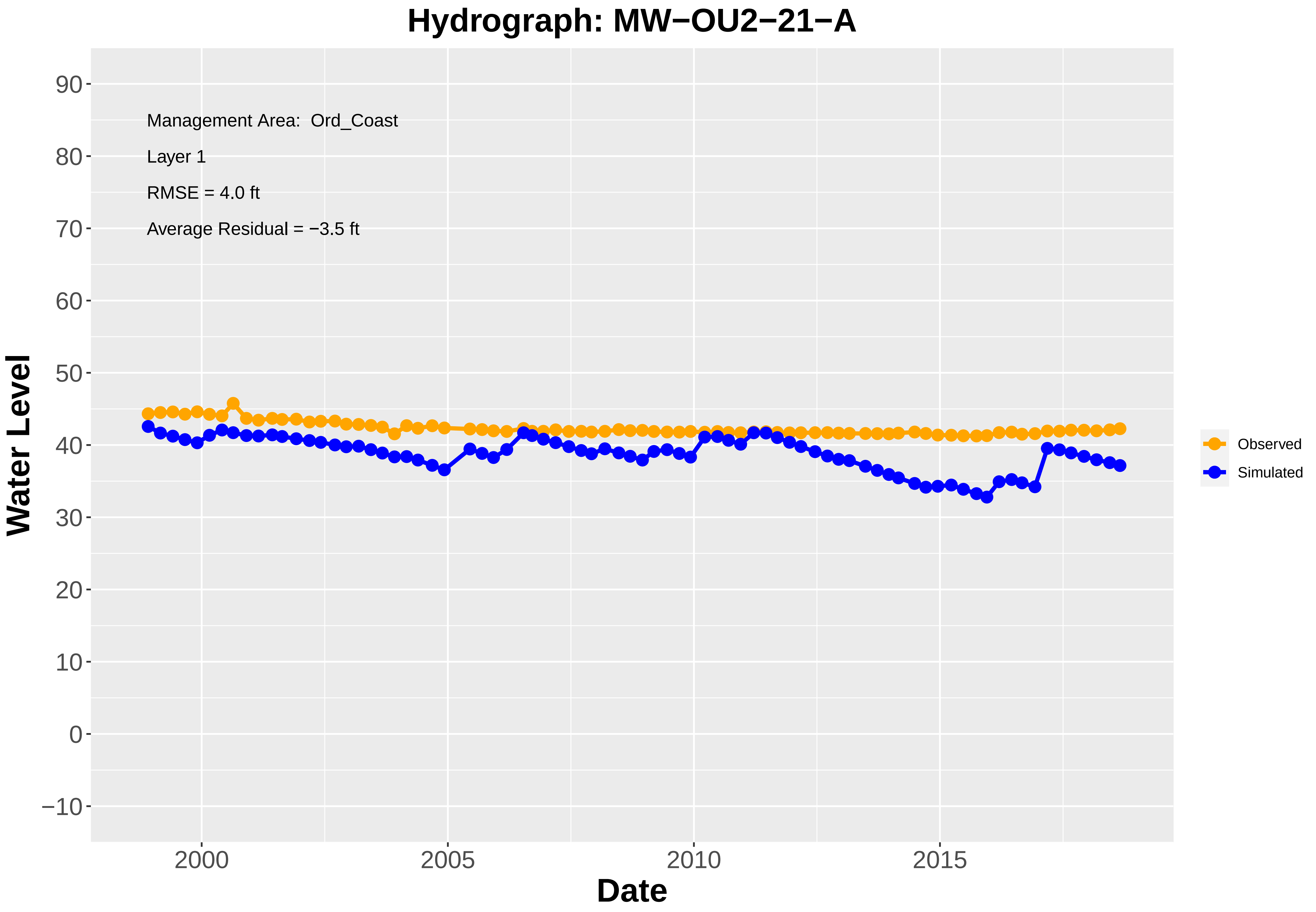

Hydrograph: MW−OU2−13−A
Management Area: Ord_Central
Layer 1
RMSE = 9.6 ft
Average Residual = −2.8 ft
Water Level
140
130
120
110
100
90
80
70
60
50
40
Date
2000
2005
2010
2015
Observed
Simulated

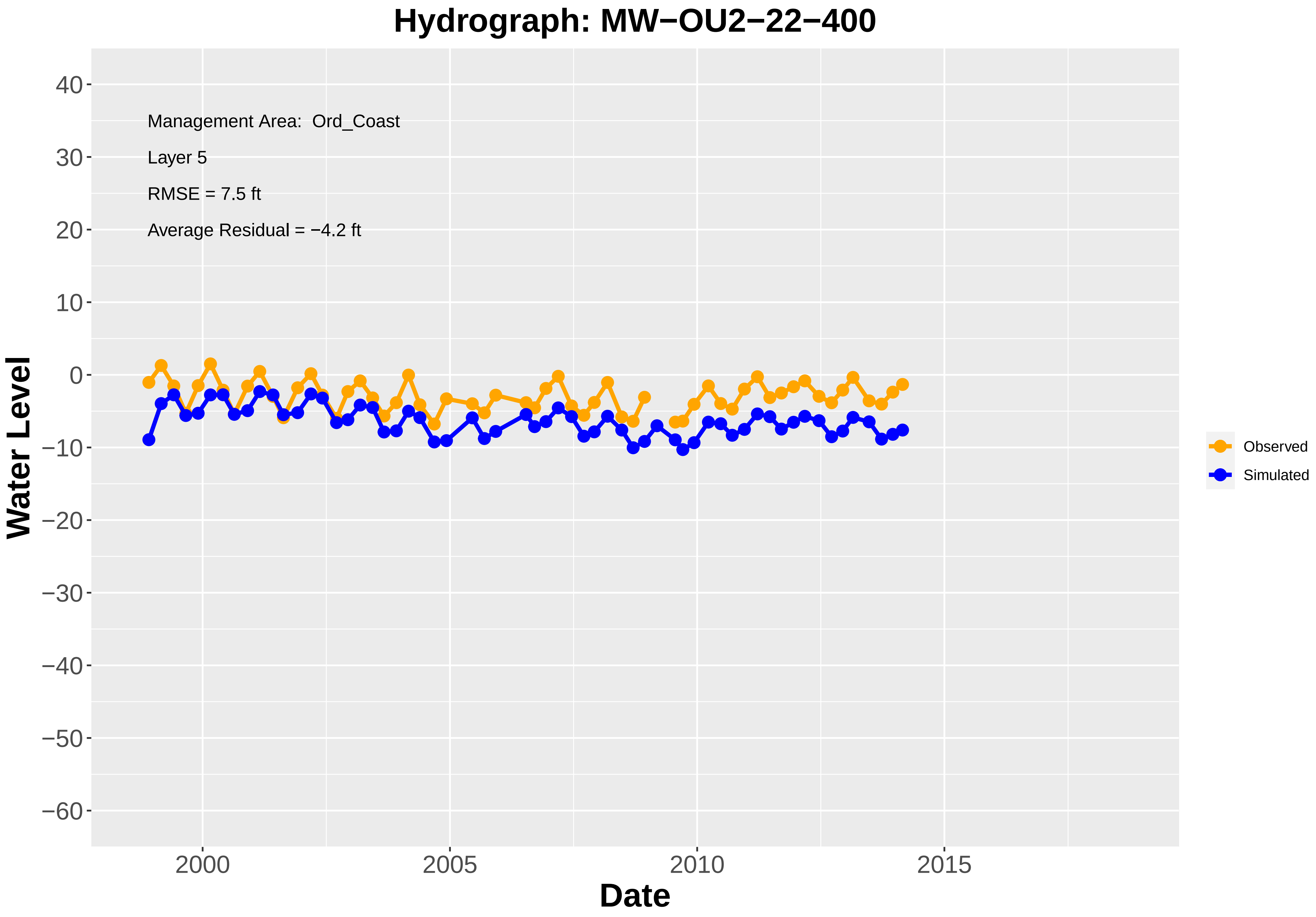

Hydrograph: MW−OU2−20−180
Management Area: Ord_Coast
Layer 3
RMSE = 5.1 ft
Average Residual = −4.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

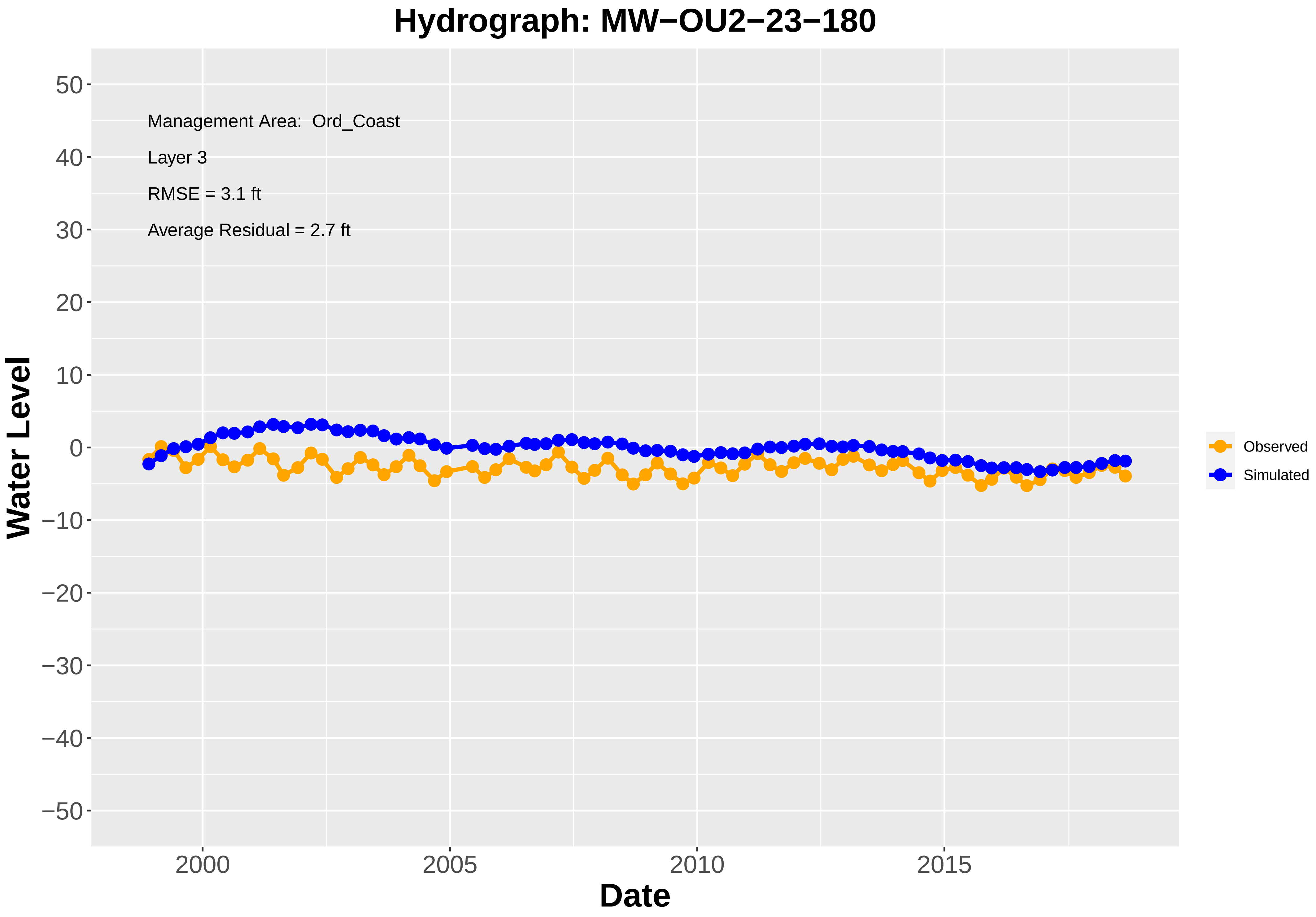
Hydrograph: MW−OU2−20−180X

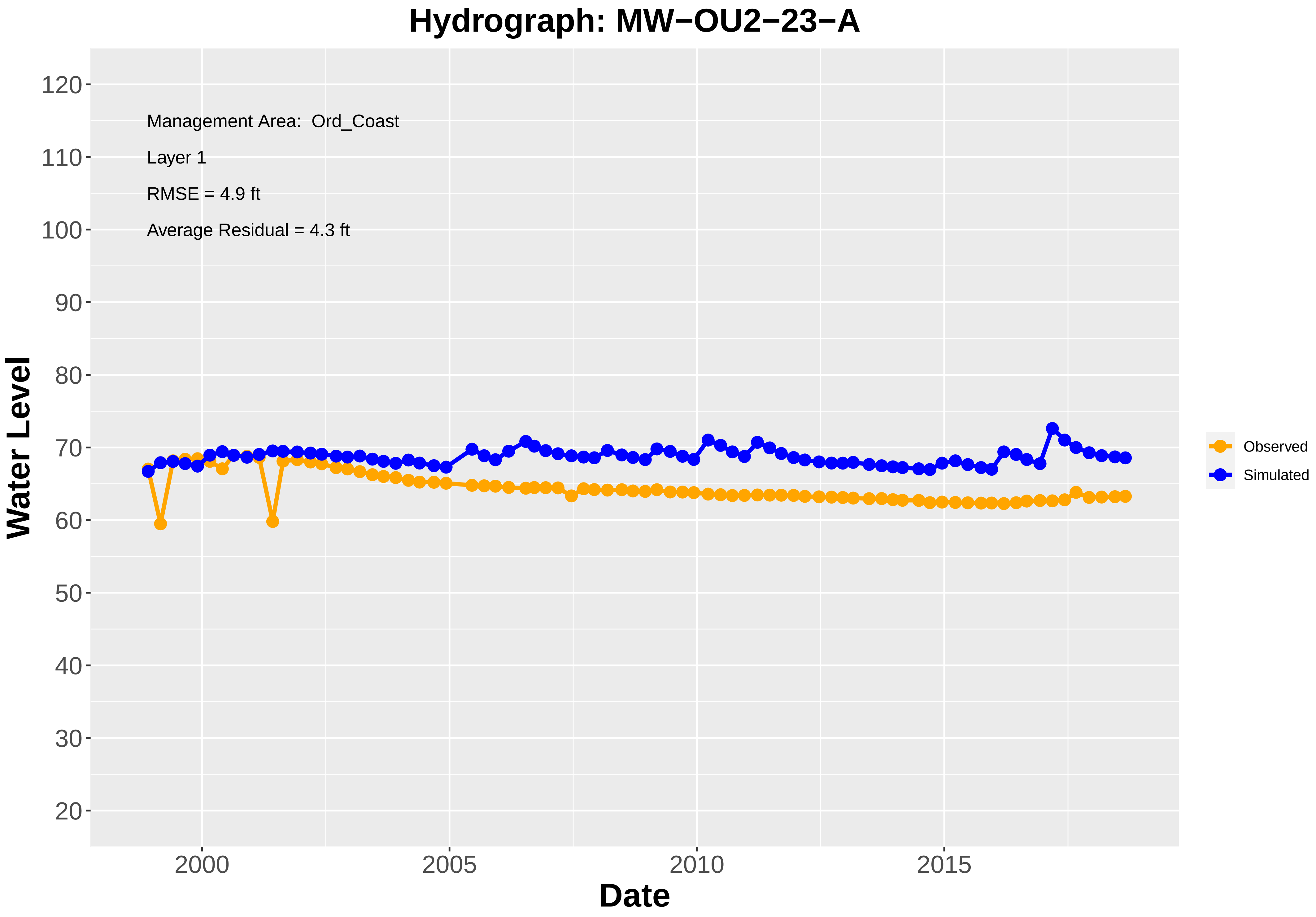



Hydrograph: MW−OU2−20−A
Management Area: Ord_Coast
Layer 1
RMSE = 17.0 ft
Average Residual = 16.7 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
Date
2000
2005
2010
2015
Observed
Simulated

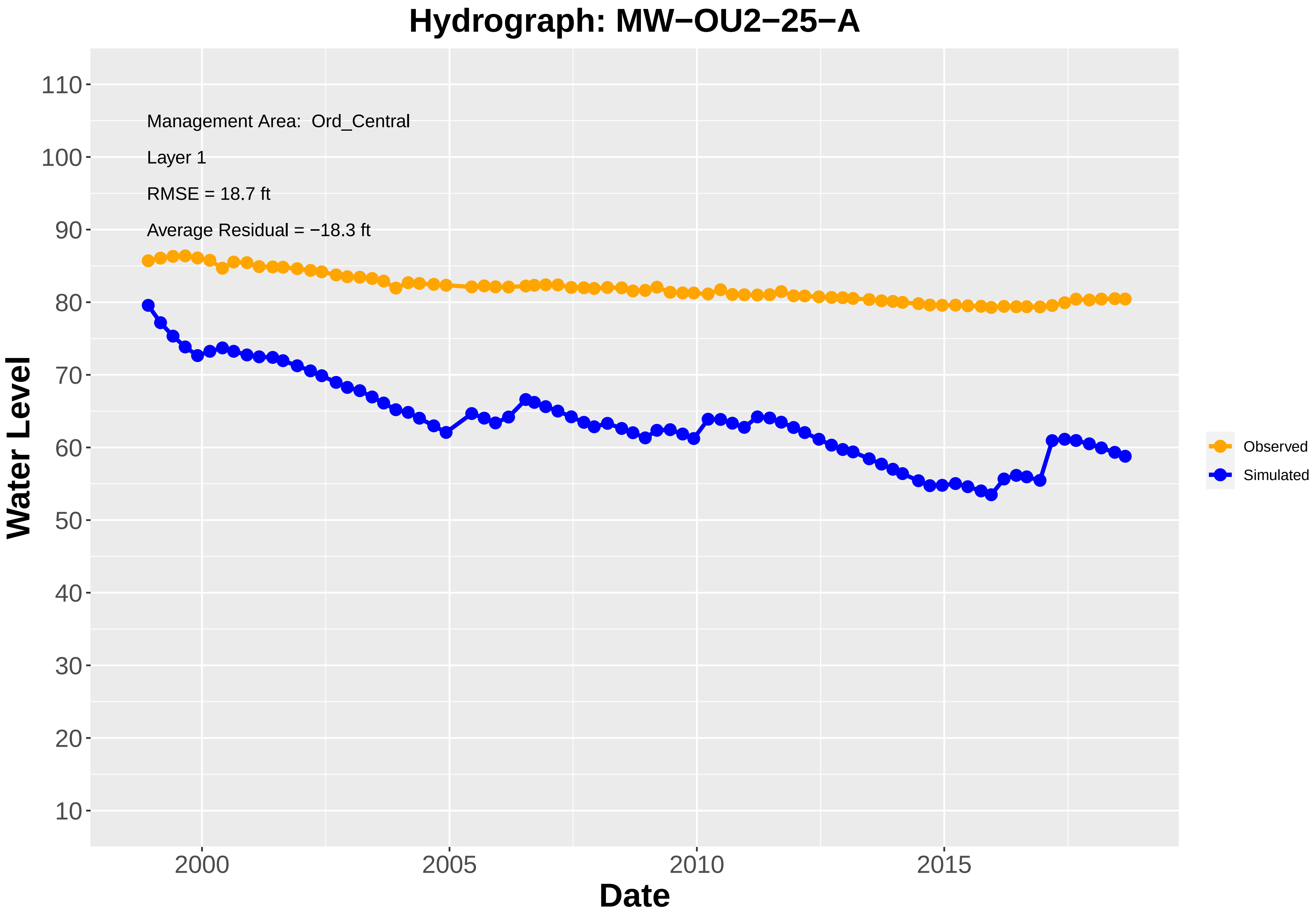

Hydrograph: MW−OU2−21−A
Management Area: Ord_Coast
Layer 1
RMSE = 4.0 ft
Average Residual = −3.5 ft
Water Level
90
80
70
60
50
40
30
20
10
0
−10
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−22−400
Management Area: Ord_Coast
Layer 5
RMSE = 7.5 ft
Average Residual = −4.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

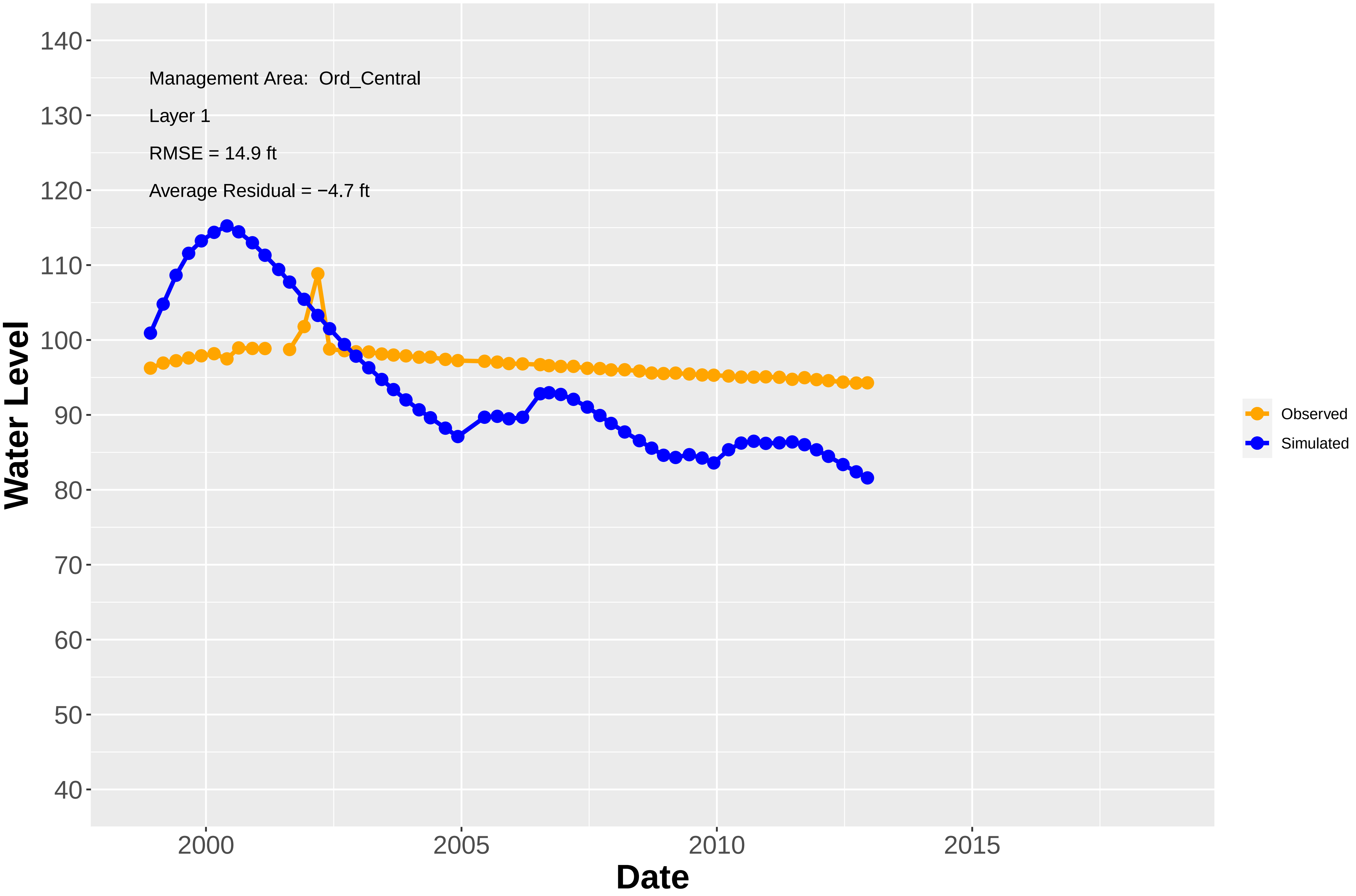

Hydrograph: MW−OU2−23−180
Management Area: Ord_Coast
Layer 3
RMSE = 3.1 ft
Average Residual = 2.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

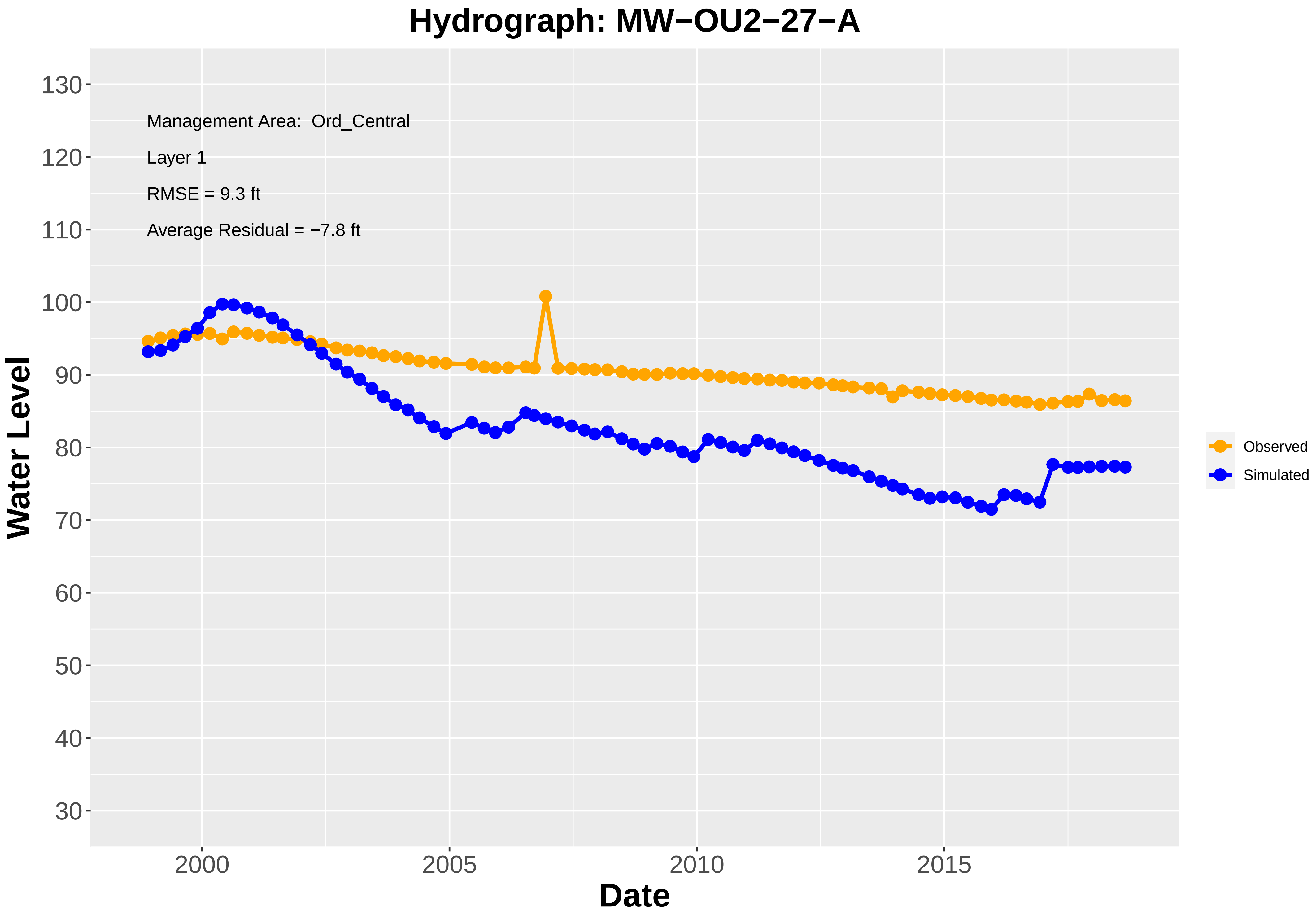

Hydrograph: MW−OU2−23−A
Management Area: Ord_Coast
Layer 1
RMSE = 4.9 ft
Average Residual = 4.3 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

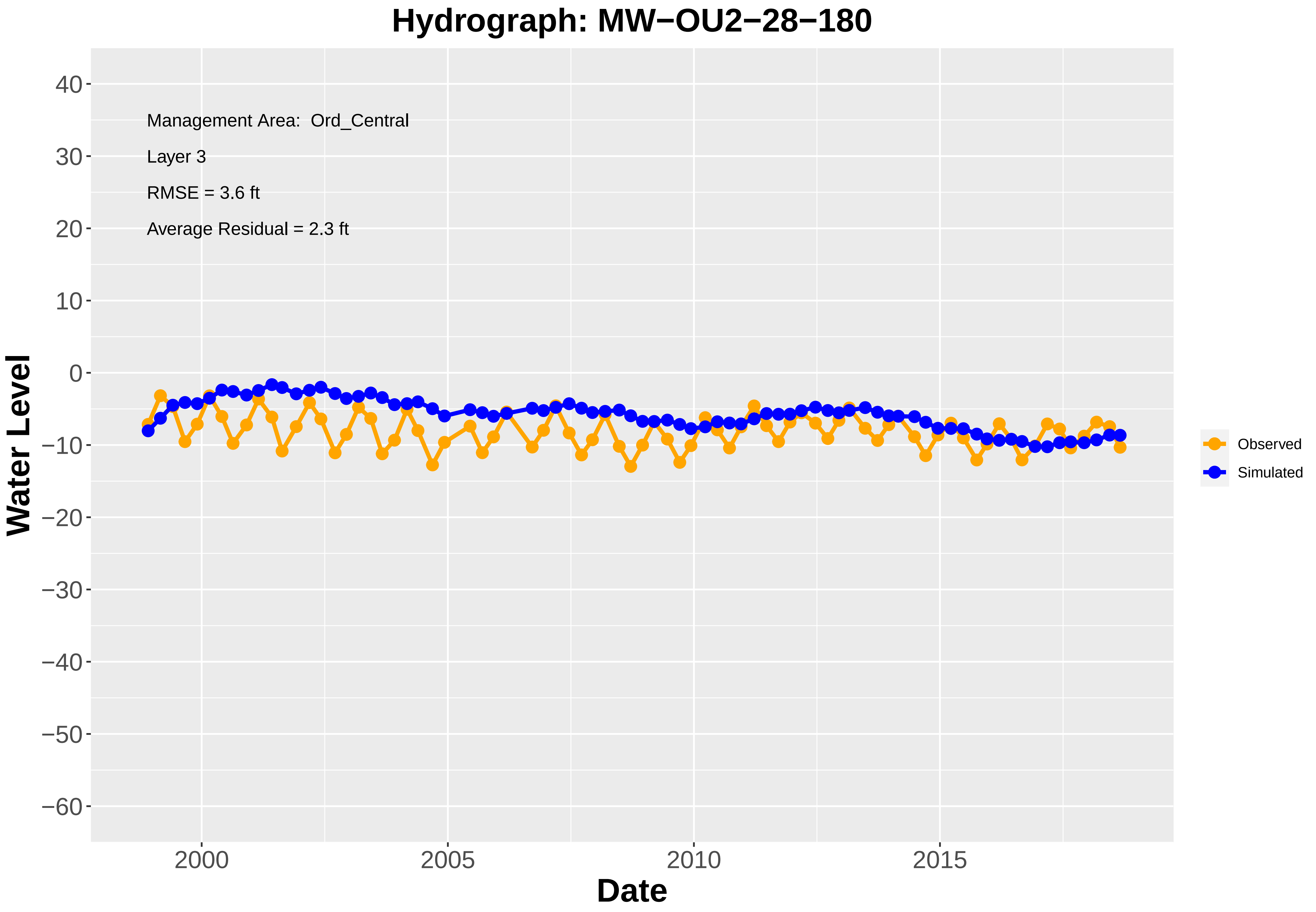
Hydrograph: MW−OU2−24−180


Hydrograph: MW−OU2−25−A
Management Area: Ord_Central
Layer 1
RMSE = 18.7 ft
Average Residual = −18.3 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

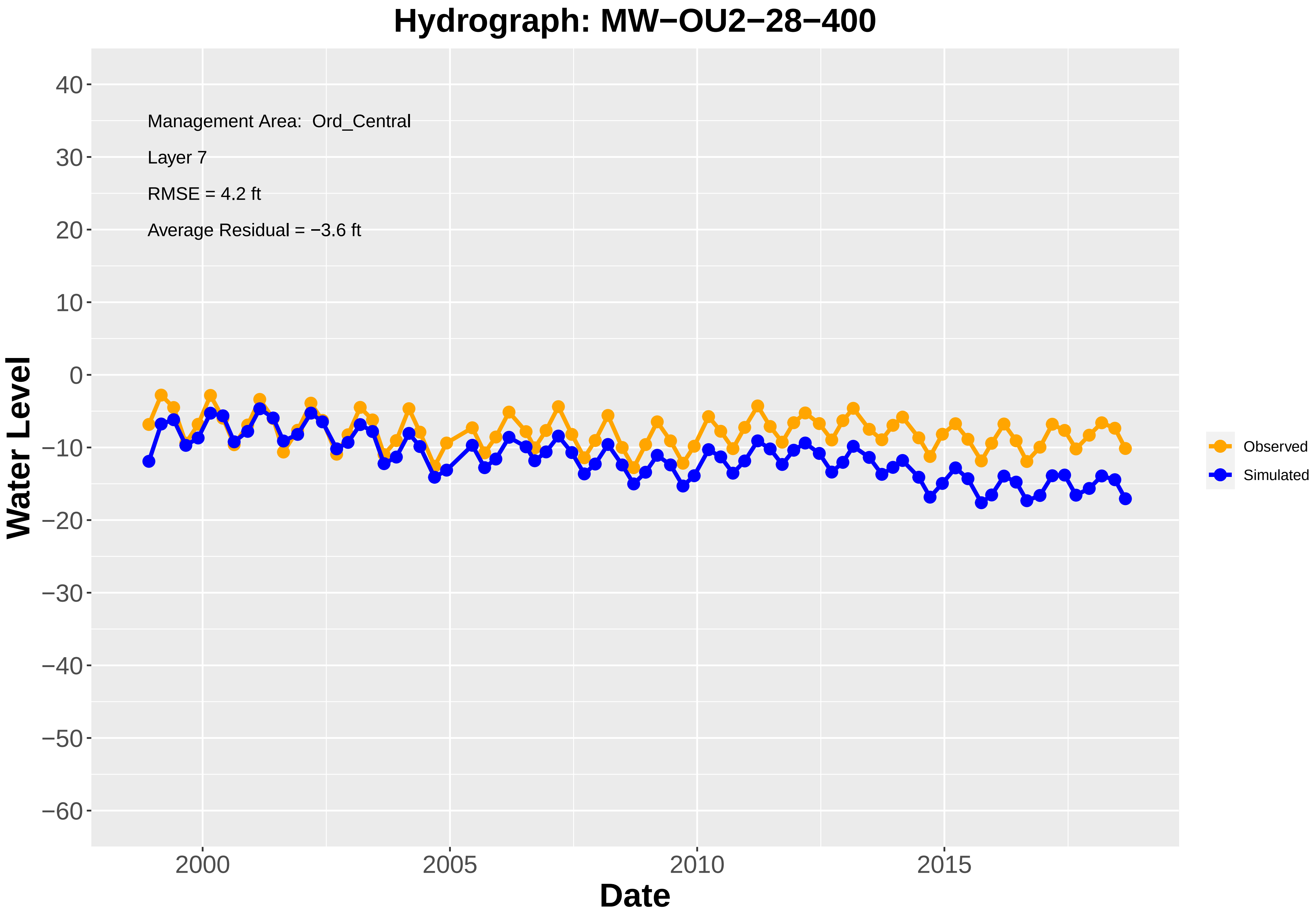
Hydrograph: MW−OU2−26−A



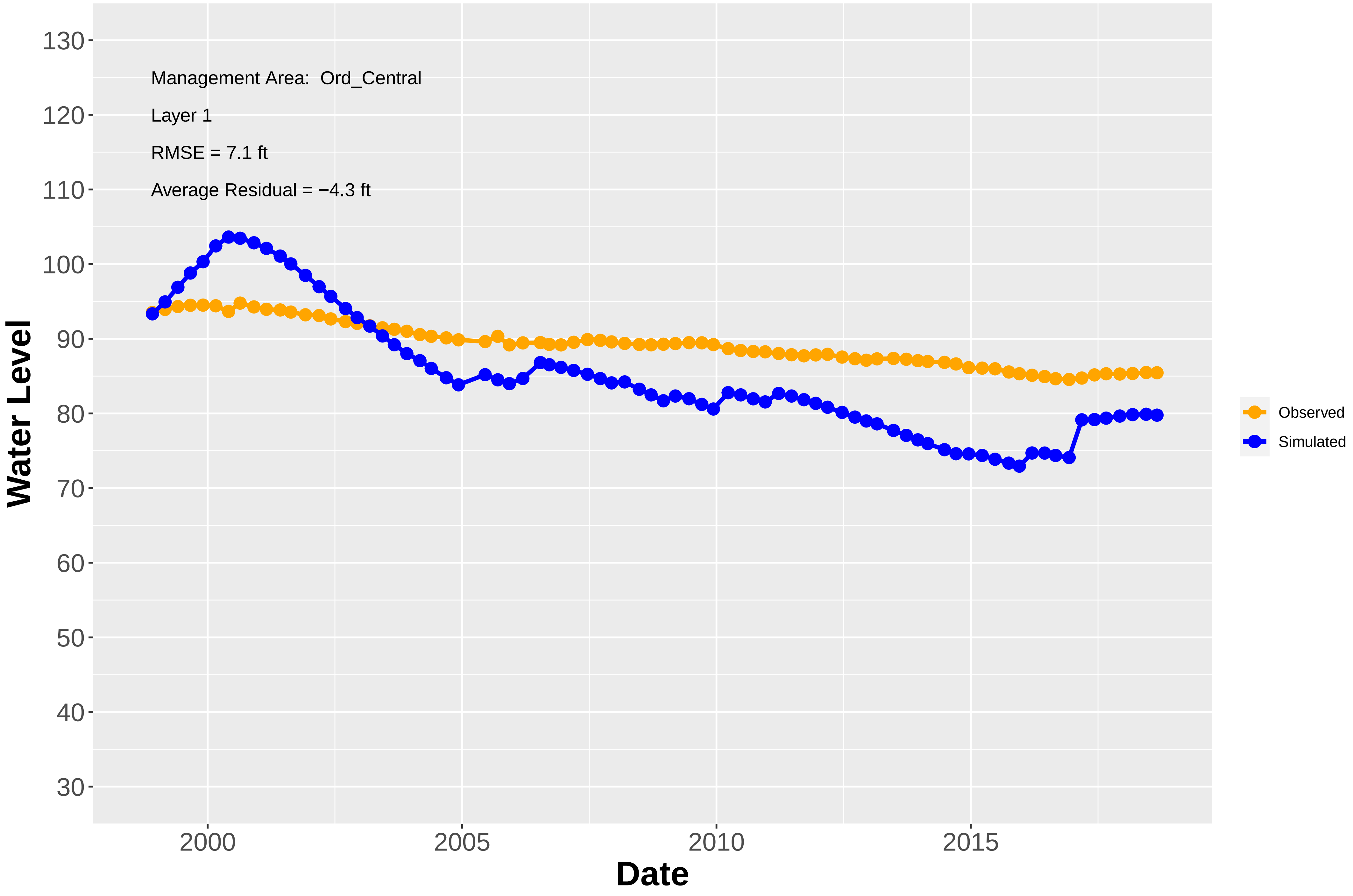

Hydrograph: MW−OU2−27−A
Management Area: Ord_Central
Layer 1
RMSE = 9.3 ft
Average Residual = −7.8 ft
130
120
110
100
90
80
70
60
50
40
30
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

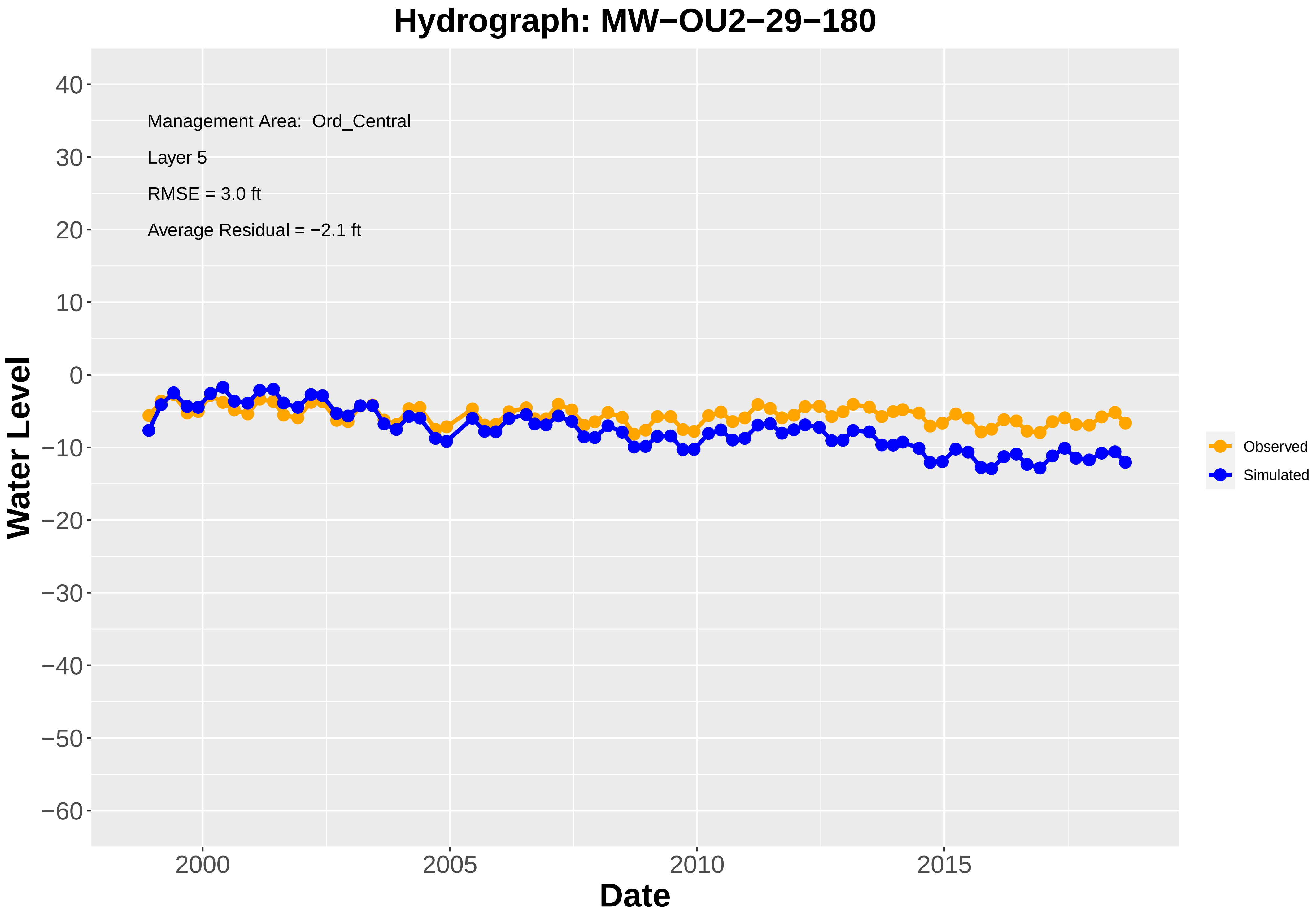


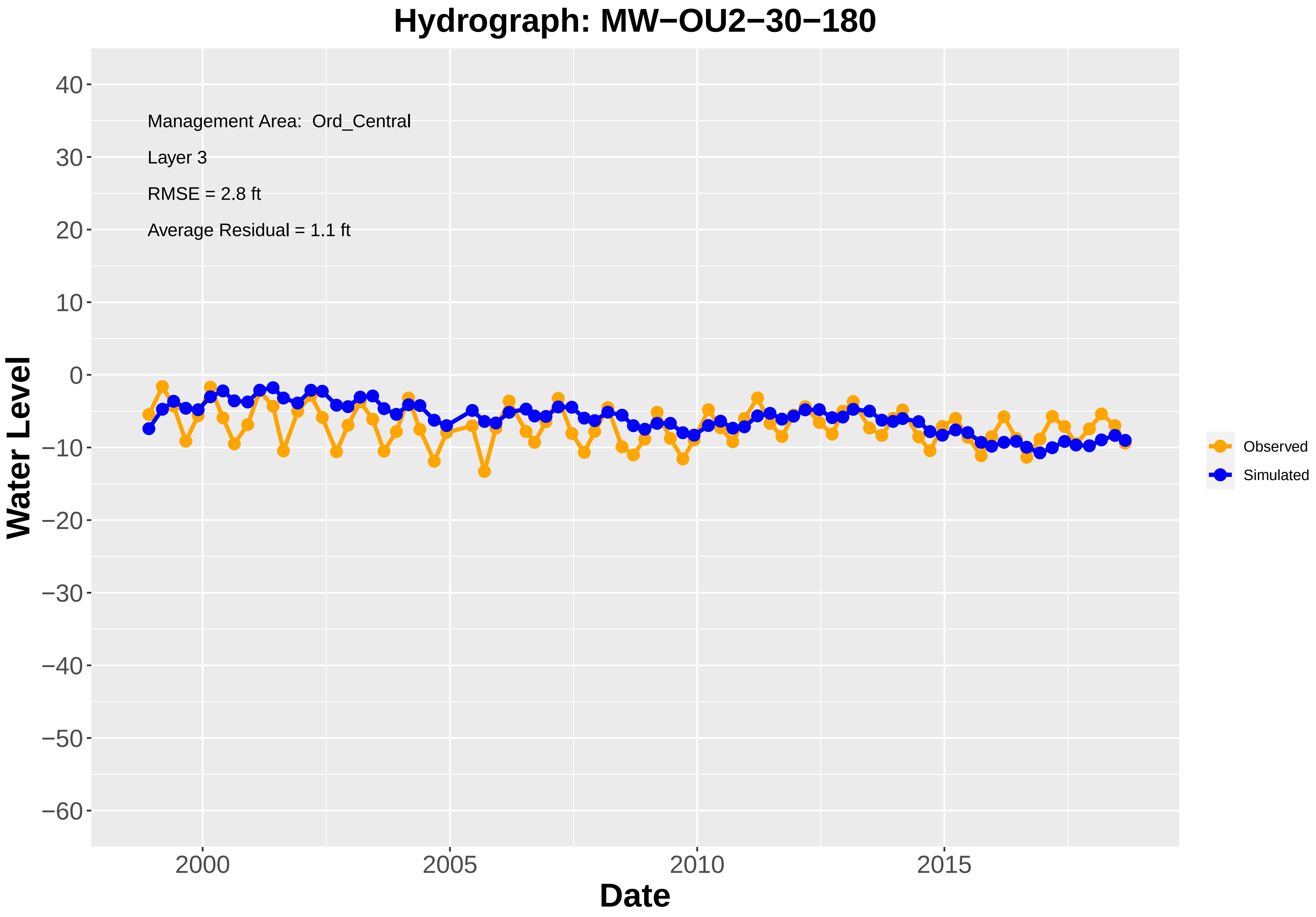
Hydrograph: MW−OU2−28−180
Management Area: Ord_Central
Layer 3
RMSE = 3.6 ft
Average Residual = 2.3 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

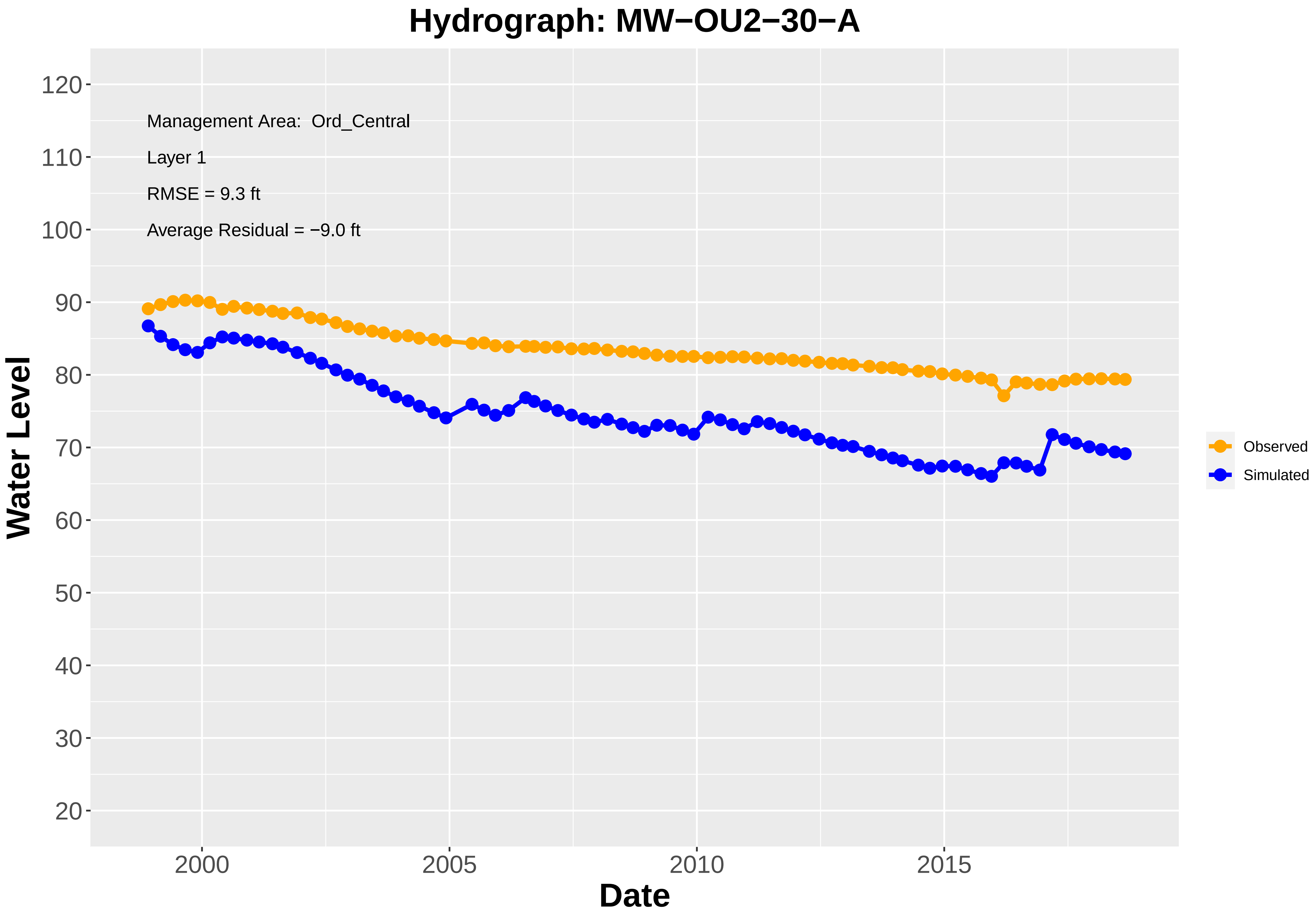

Hydrograph: MW−OU2−28−400
Management Area: Ord_Central
Layer 7
RMSE = 4.2 ft
Average Residual = −3.6 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

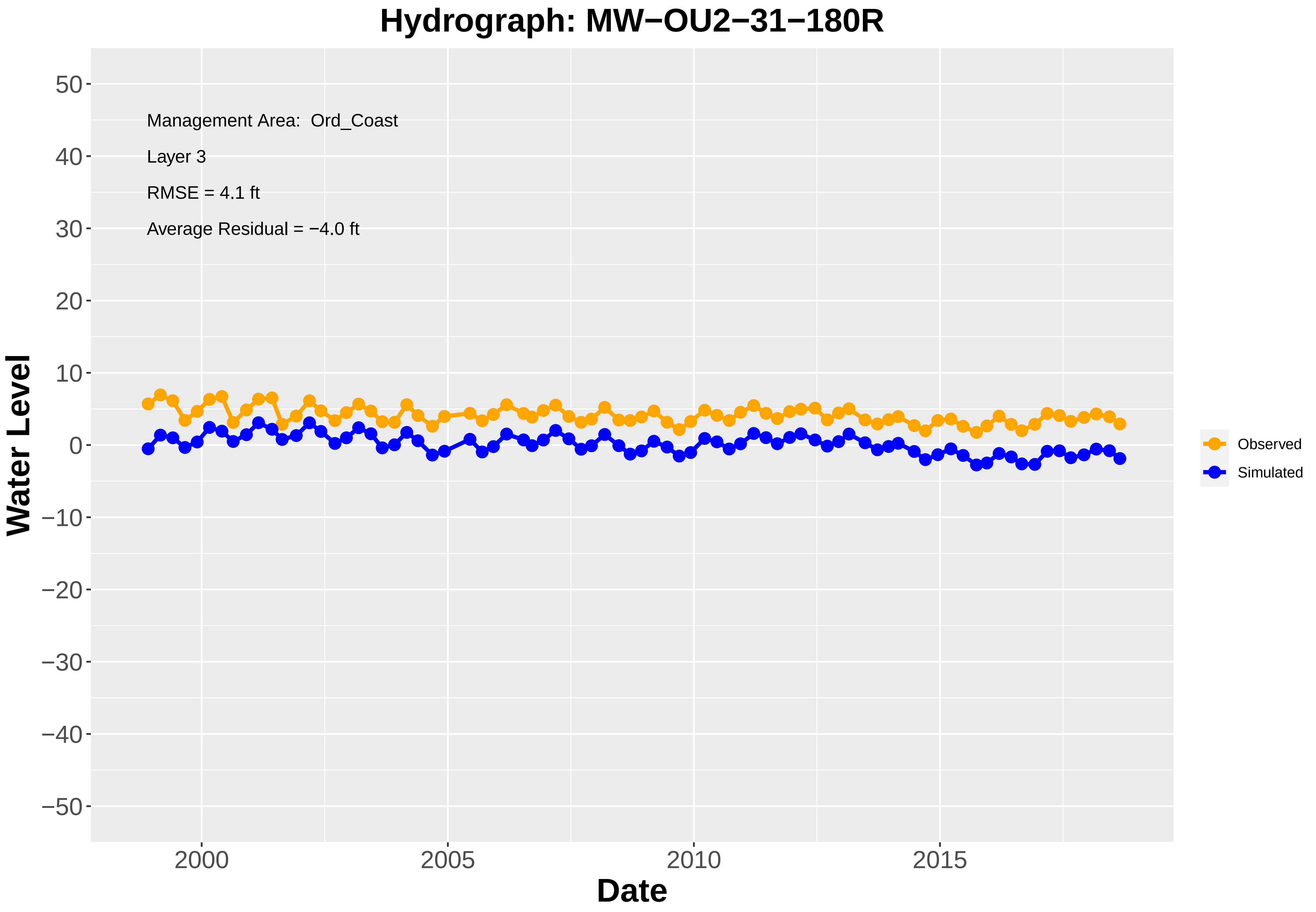
Hydrograph: MW−OU2−28−A

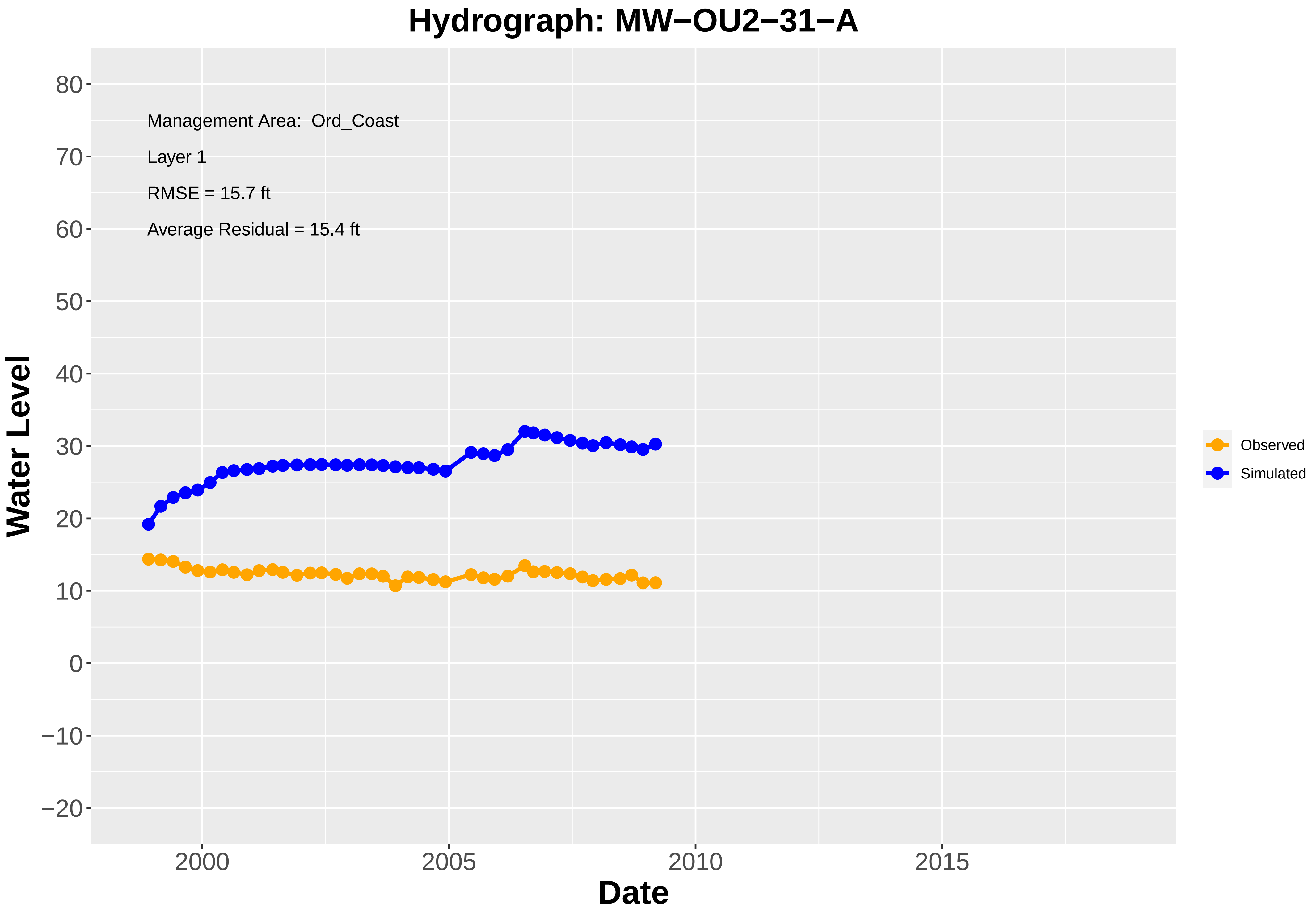



Hydrograph: MW−OU2−29−180
Management Area: Ord_Central
Layer 5
RMSE = 3.0 ft
Average Residual = −2.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

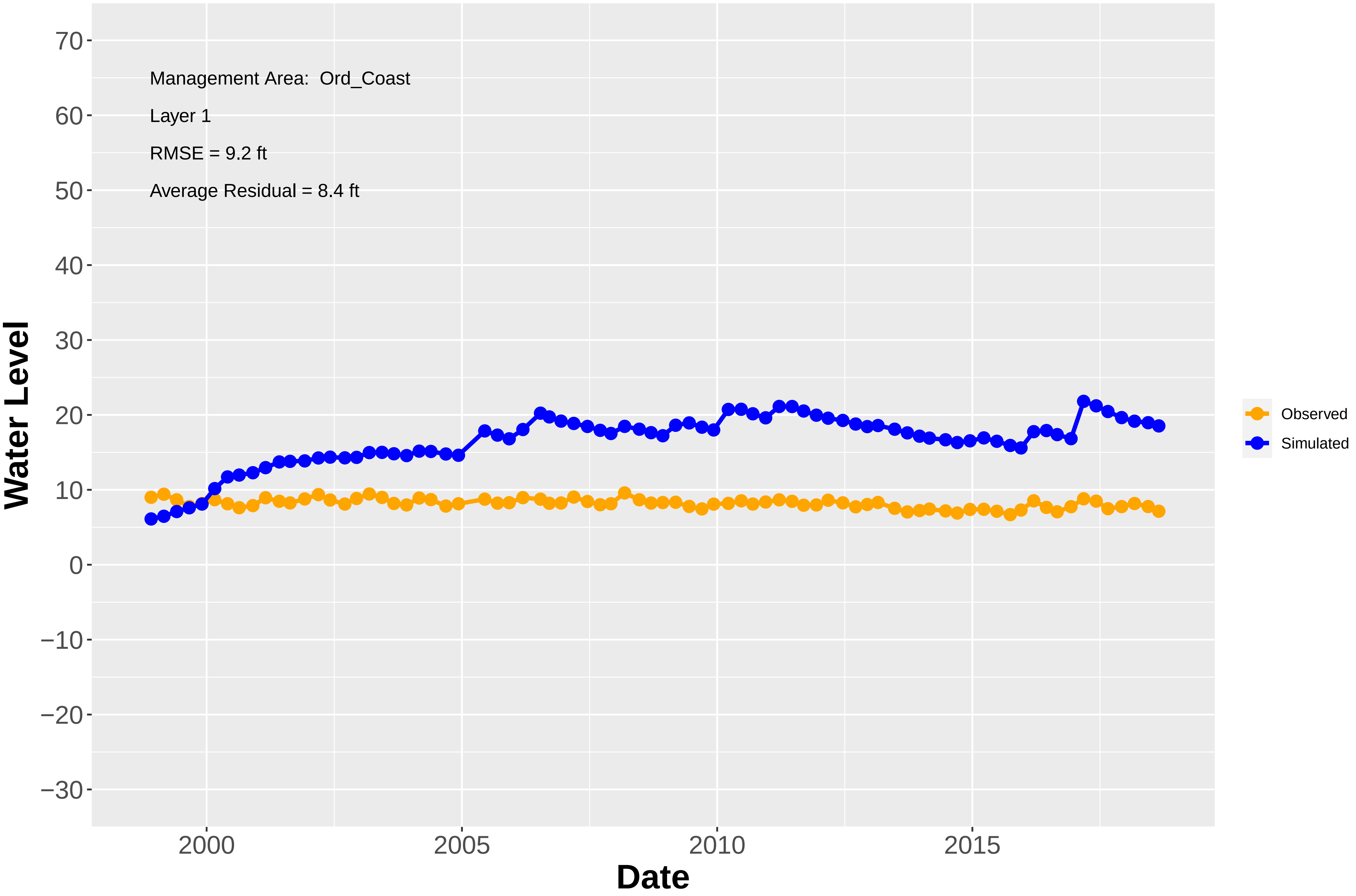

Hydrograph: MW−OU2−30−180
Management Area: Ord_Central
Layer 3
RMSE = 2.8 ft
Average Residual = 1.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

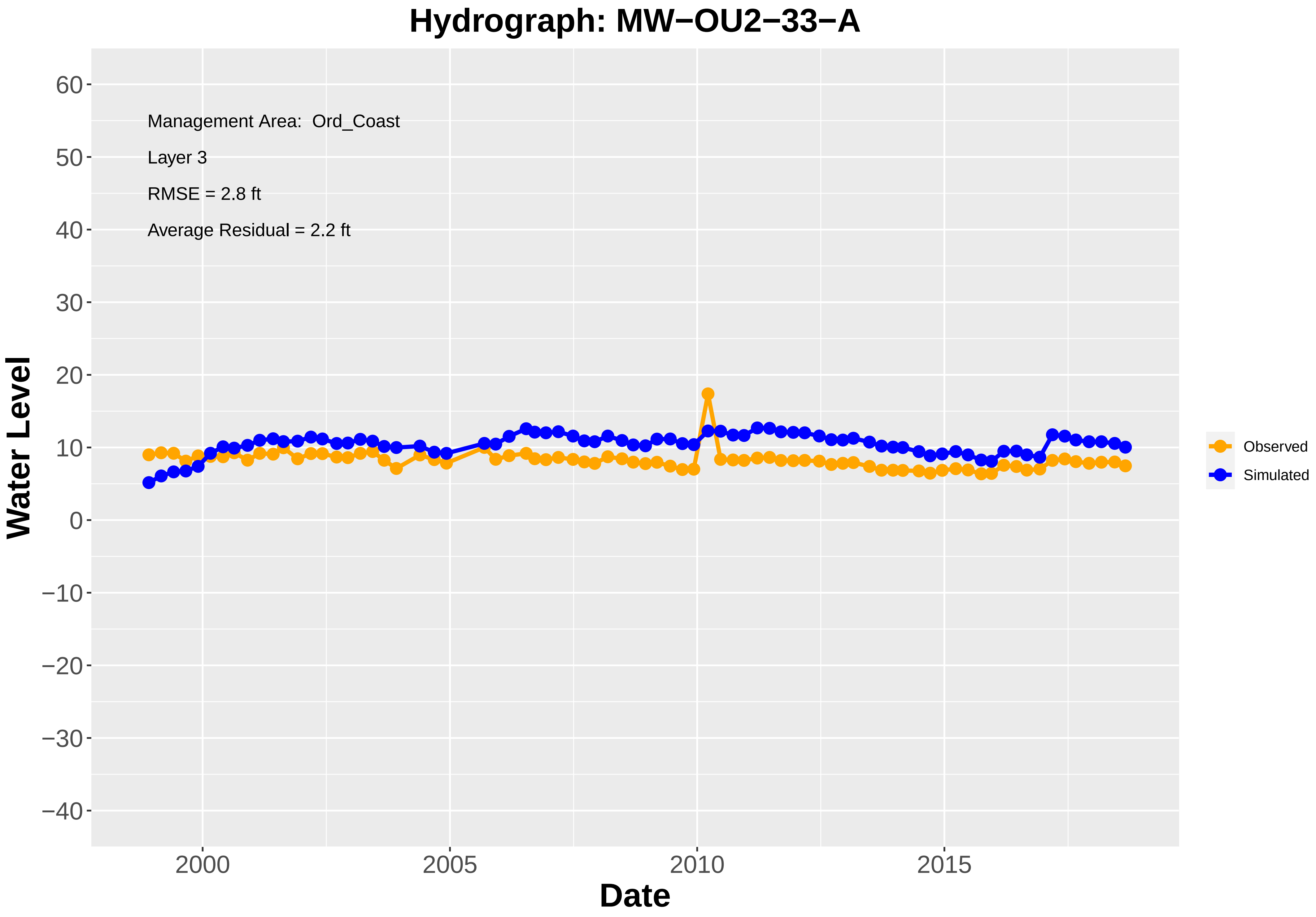

Hydrograph: MW−OU2−30−A
Management Area: Ord_Central
Layer 1
RMSE = 9.3 ft
Average Residual = −9.0 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−31−180R
Management Area: Ord_Coast
Layer 3
RMSE = 4.1 ft
Average Residual = −4.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−31−A
Management Area: Ord_Coast
Layer 1
RMSE = 15.7 ft
Average Residual = 15.4 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

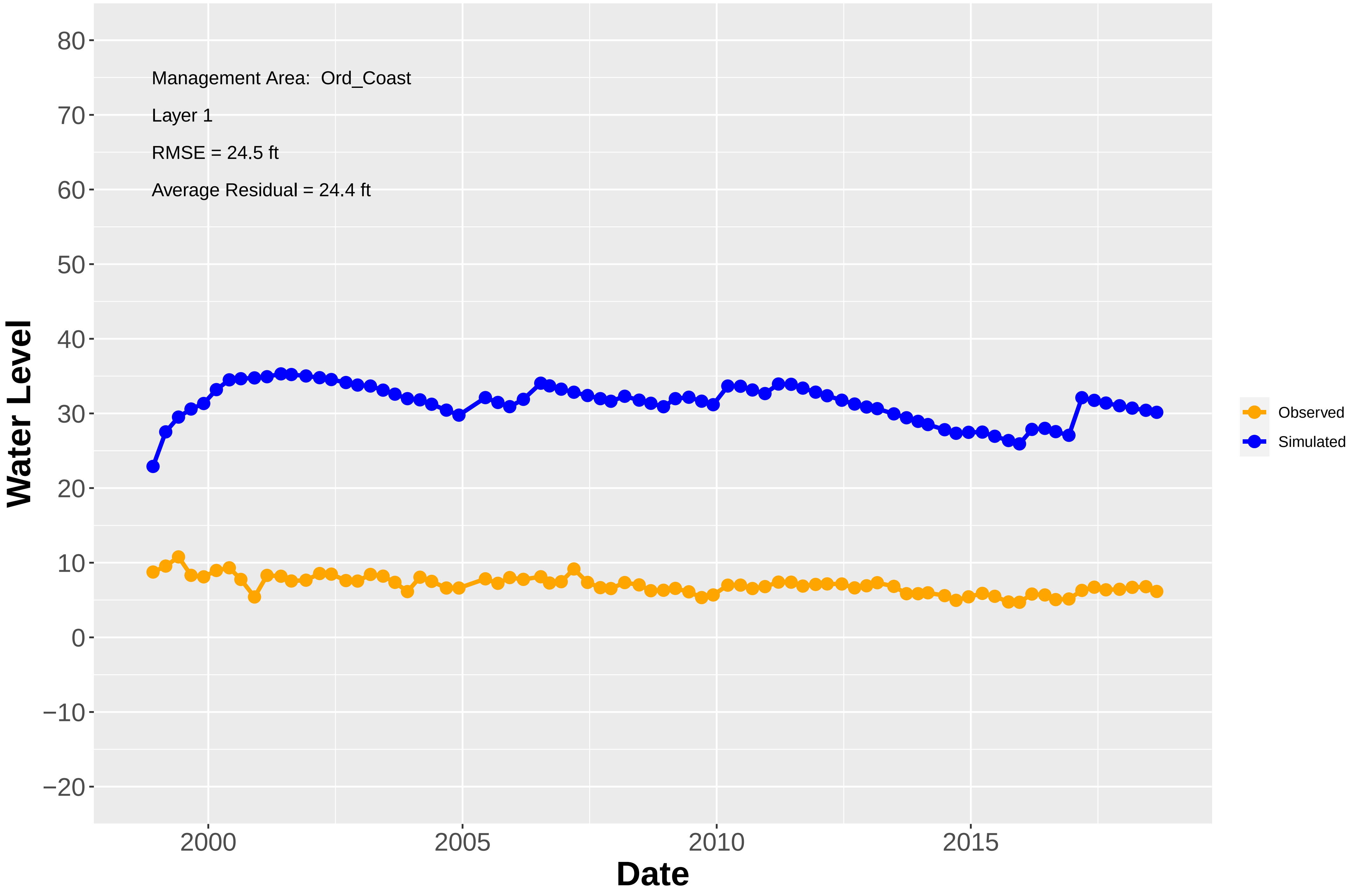
Hydrograph: MW−OU2−32−A

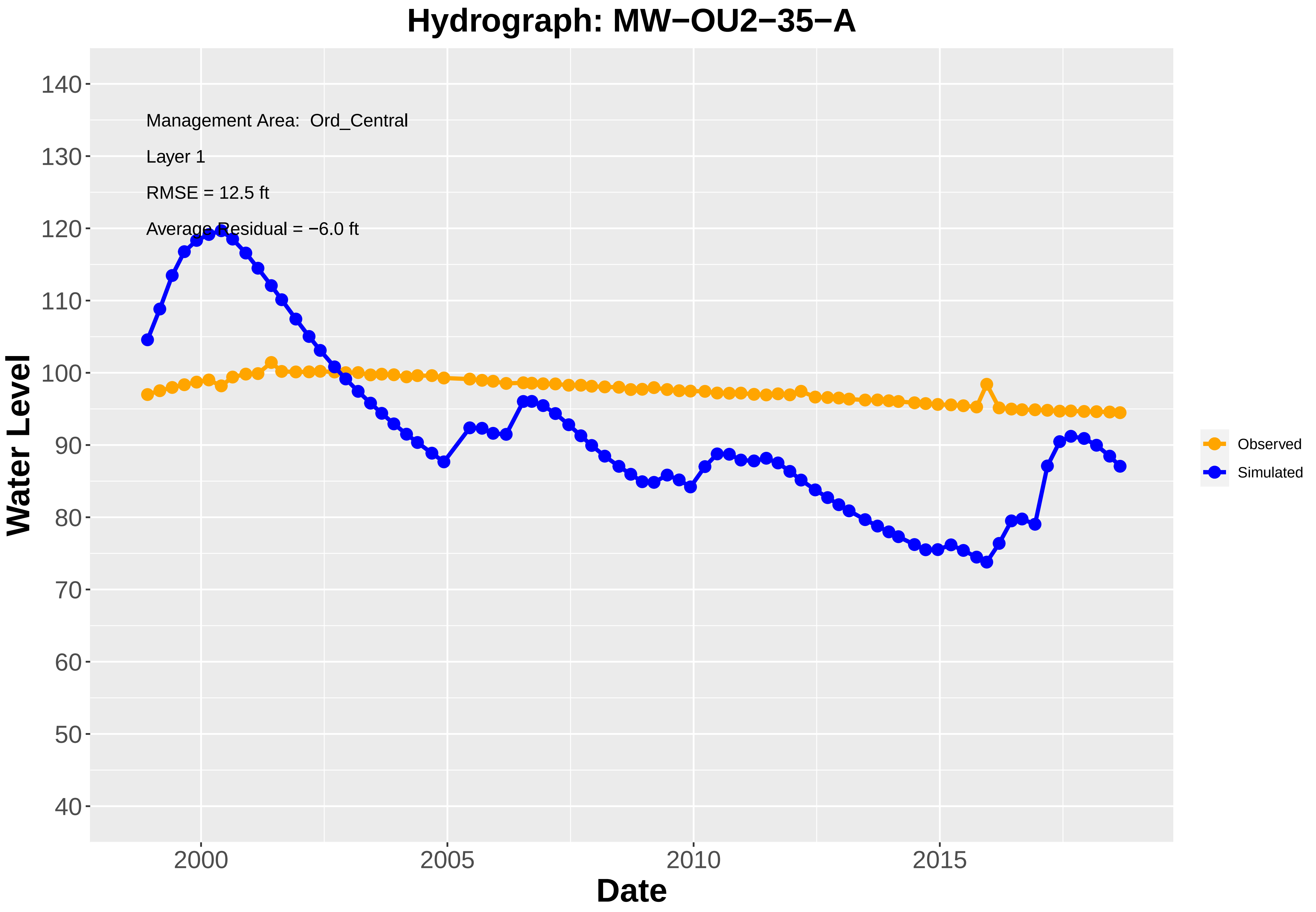




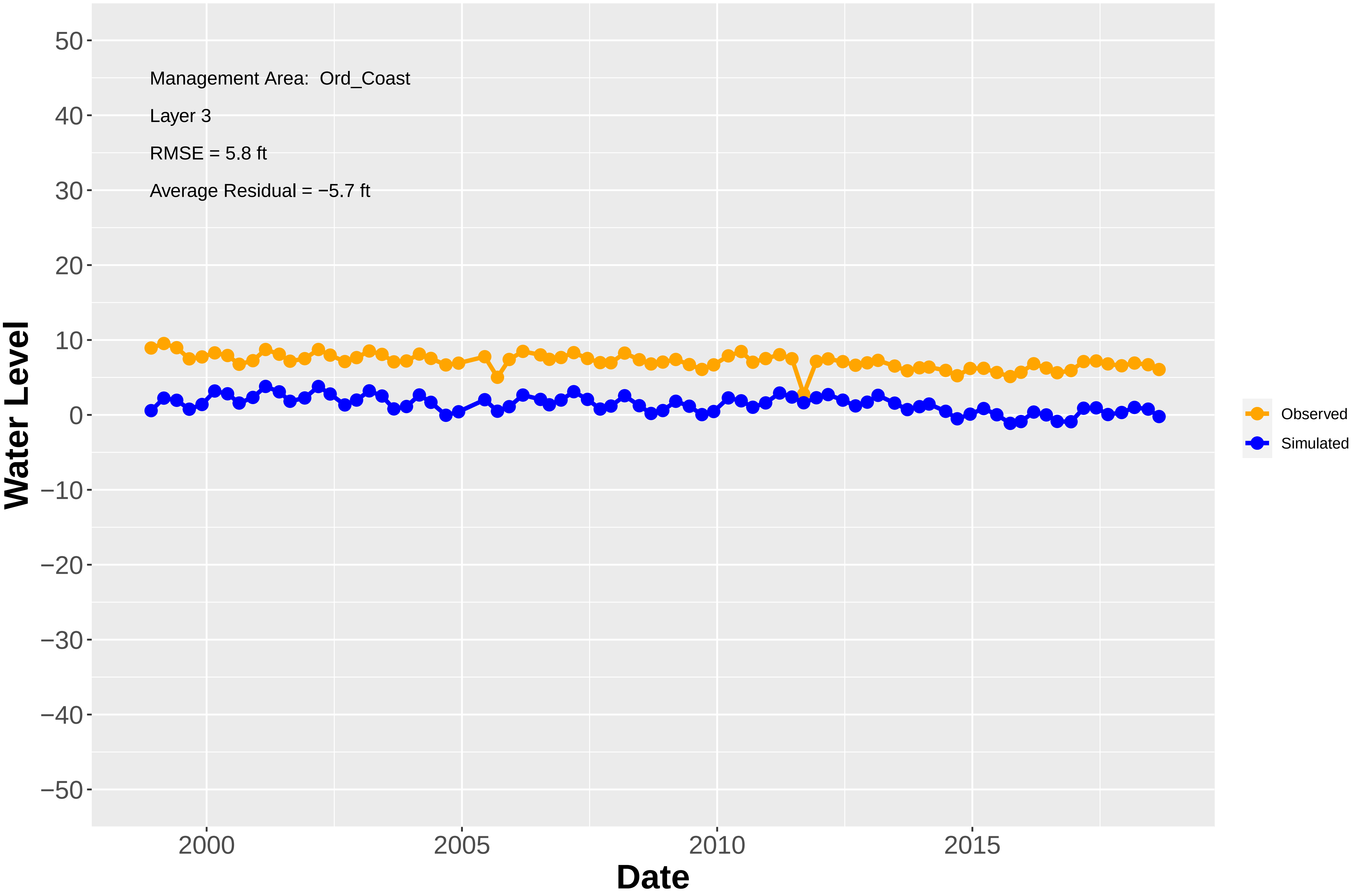
Hydrograph: MW−OU2−33−A
Management Area: Ord_Coast
Layer 3
RMSE = 2.8 ft
Average Residual = 2.2 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

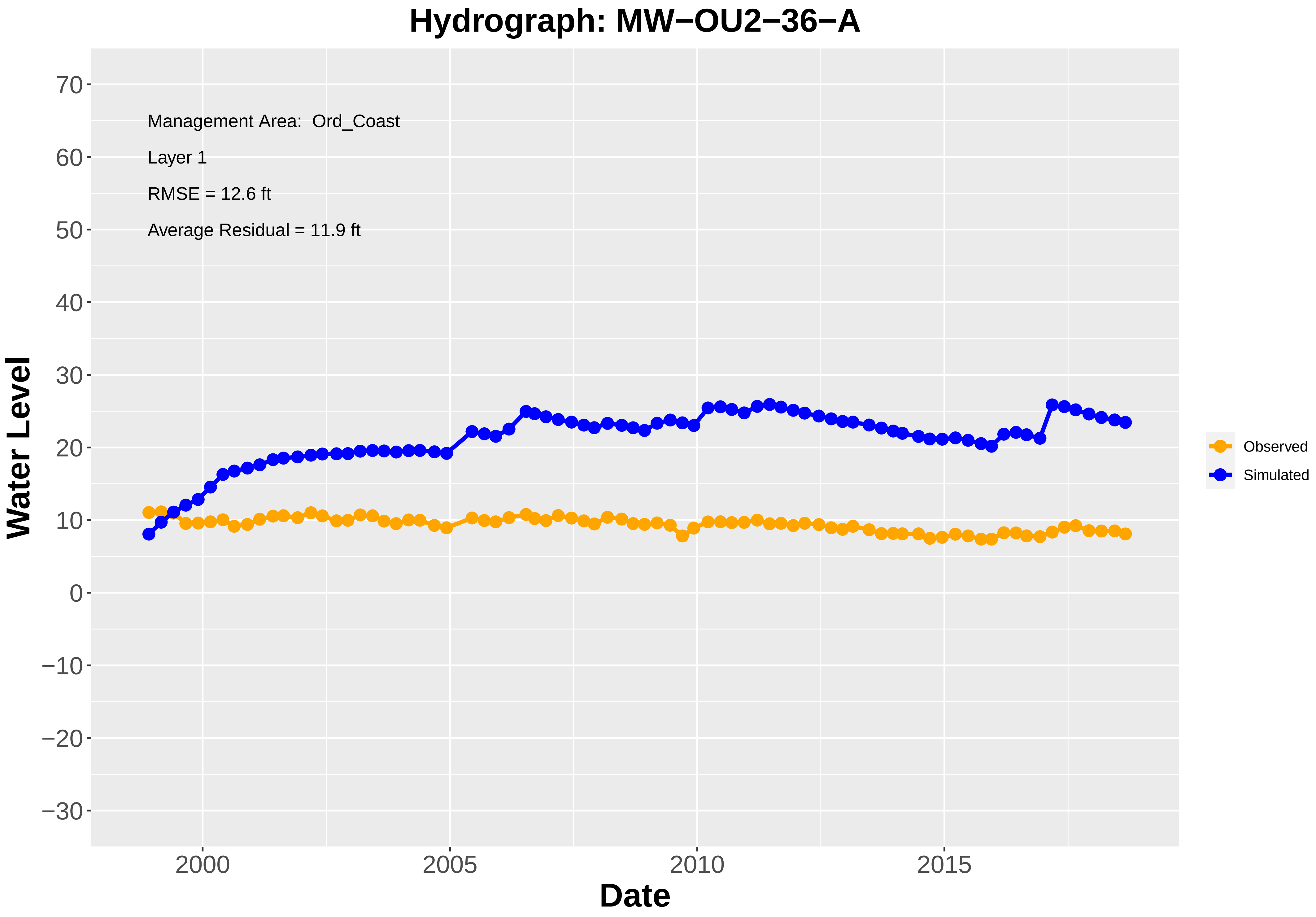
Hydrograph: MW−OU2−34−A



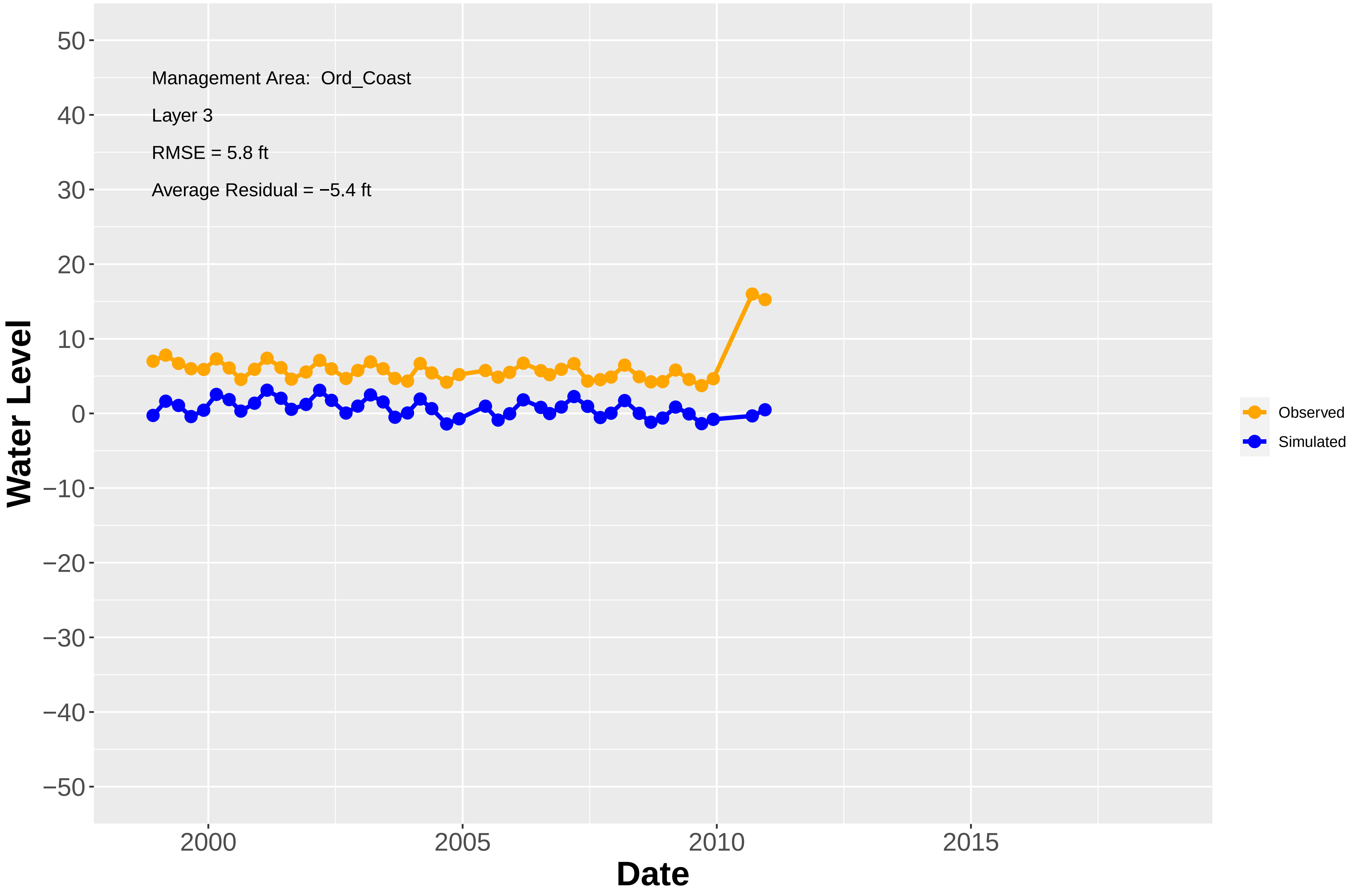

Hydrograph: MW−OU2−35−A
Management Area: Ord_Central
Layer 1
RMSE = 12.5 ft
Average Residual = −6.0 ft
Water Level
140
130
120
110
100
90
80
70
60
50
40
Date
2000
2005
2010
2015
Observed
Simulated

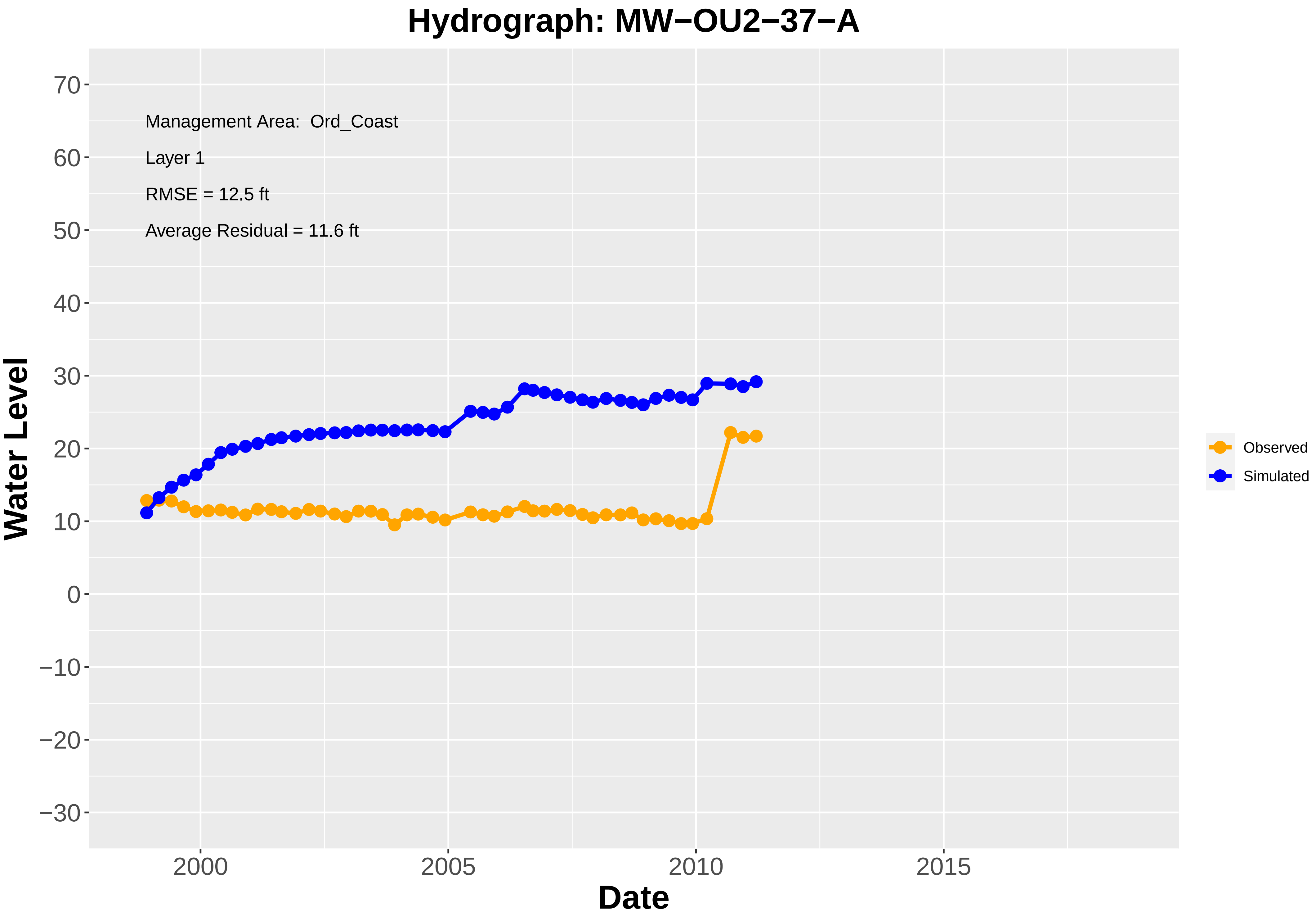
Hydrograph: MW−OU2−36−180



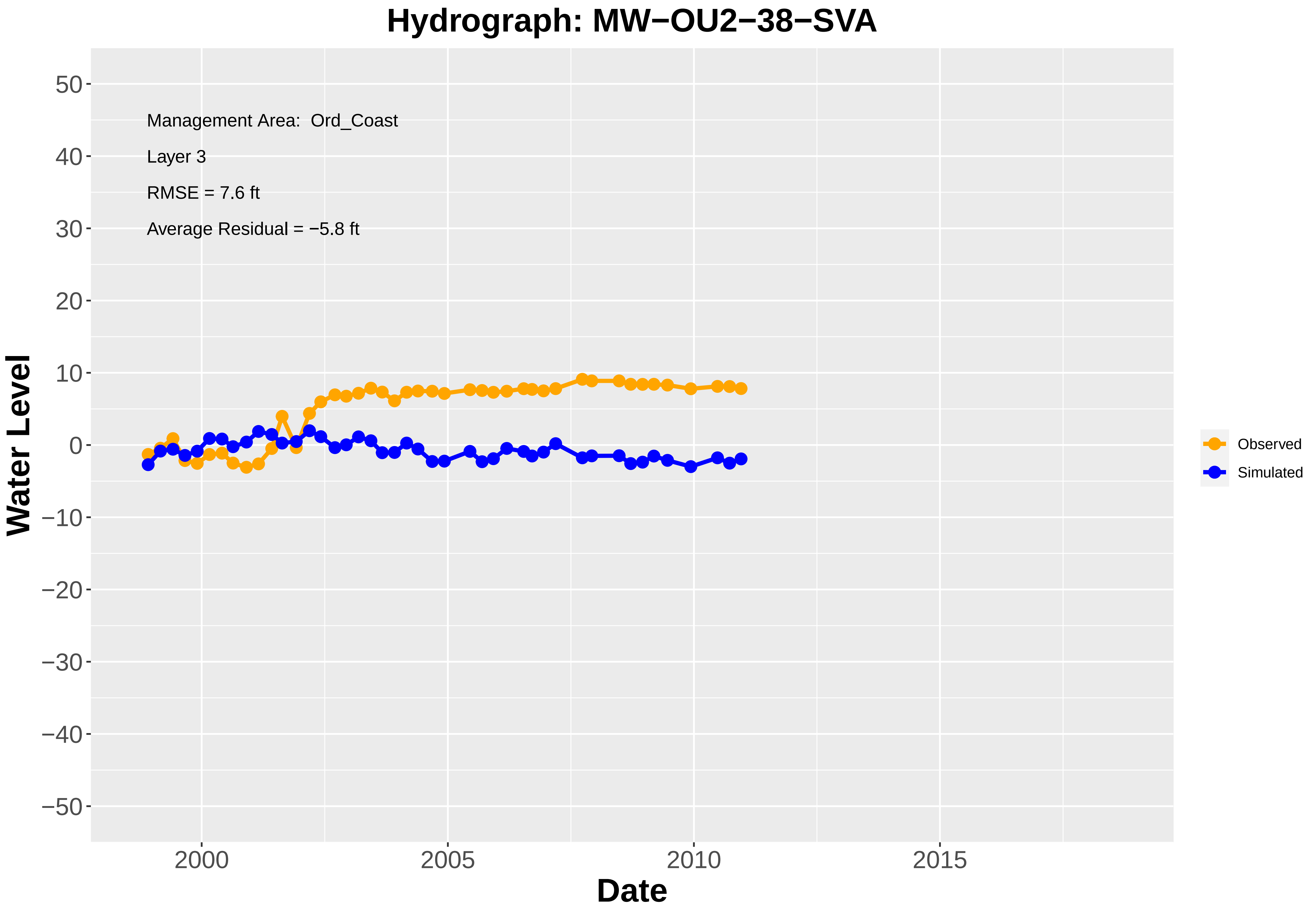

Hydrograph: MW−OU2−36−A
Management Area: Ord_Coast
Layer 1
RMSE = 12.6 ft
Average Residual = 11.9 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
Date
2000
2005
2010
2015
Observed
Simulated

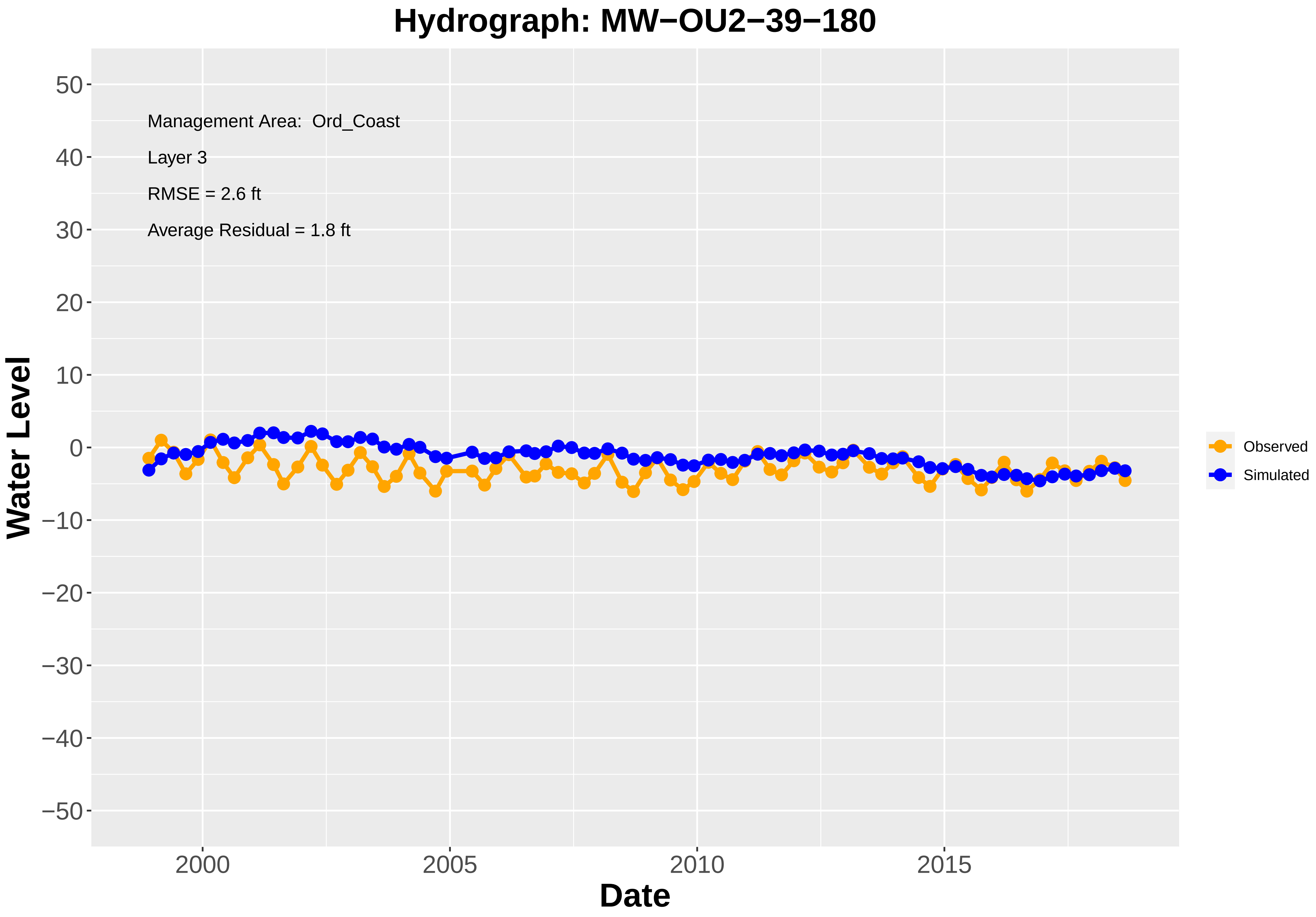
Hydrograph: MW−OU2−37−180

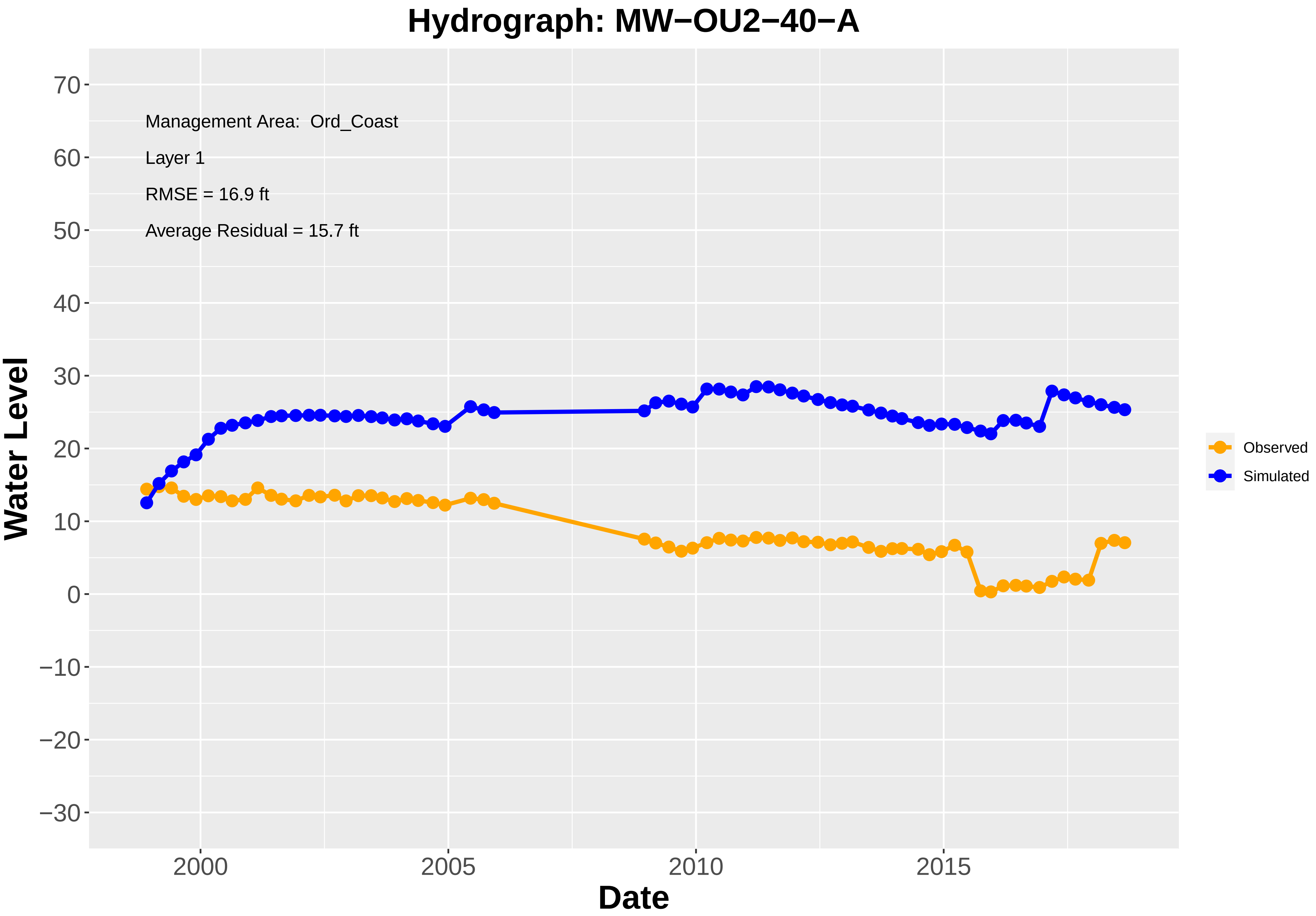


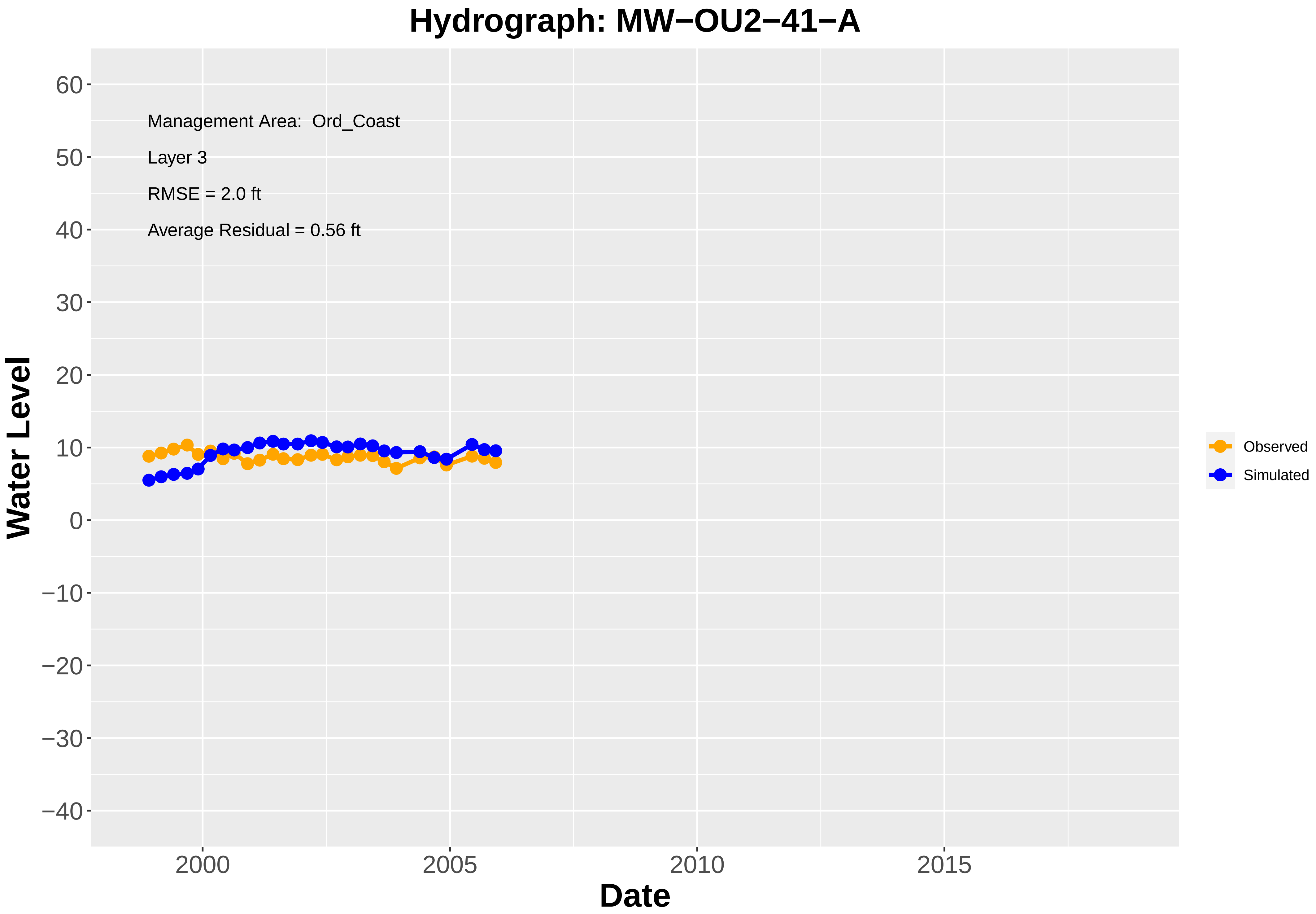


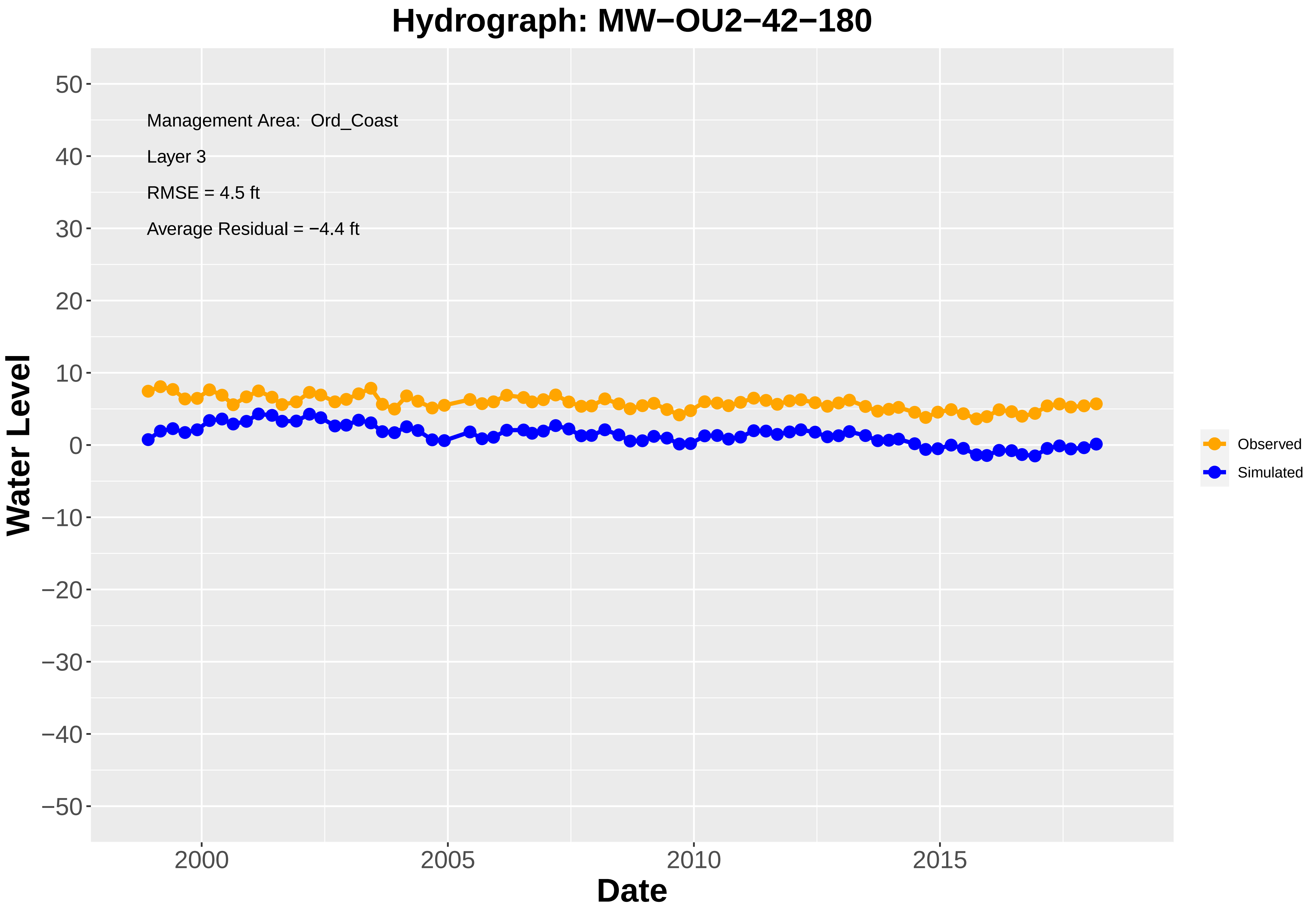
Hydrograph: MW−OU2−37−A
Management Area: Ord_Coast
Layer 1
RMSE = 12.5 ft
Average Residual = 11.6 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
Date
2000
2005
2010
2015
Observed
Simulated

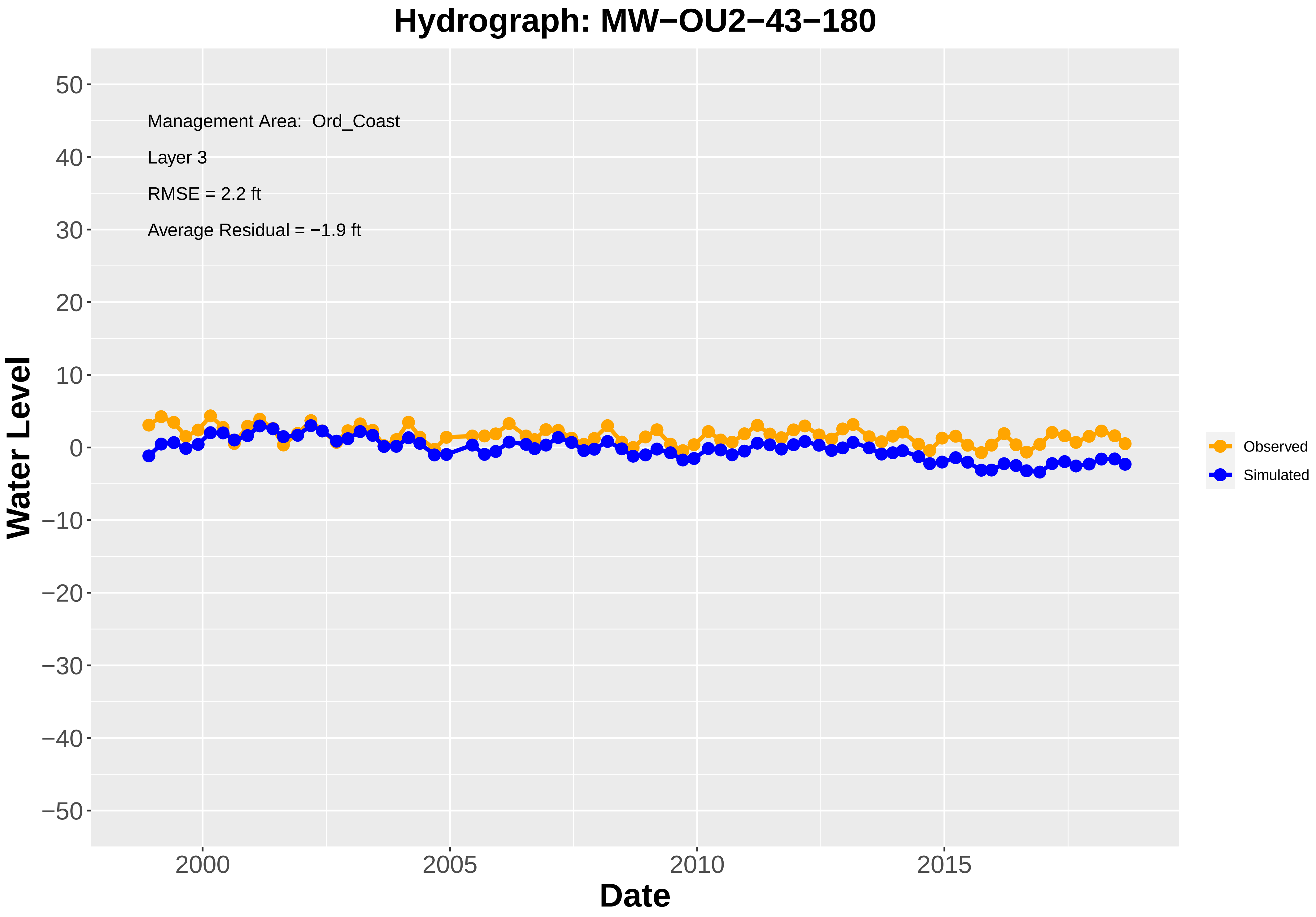

Hydrograph: MW−OU2−38−SVA
Management Area: Ord_Coast
Layer 3
RMSE = 7.6 ft
Average Residual = −5.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−39−180
Management Area: Ord_Coast
Layer 3
RMSE = 2.6 ft
Average Residual = 1.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

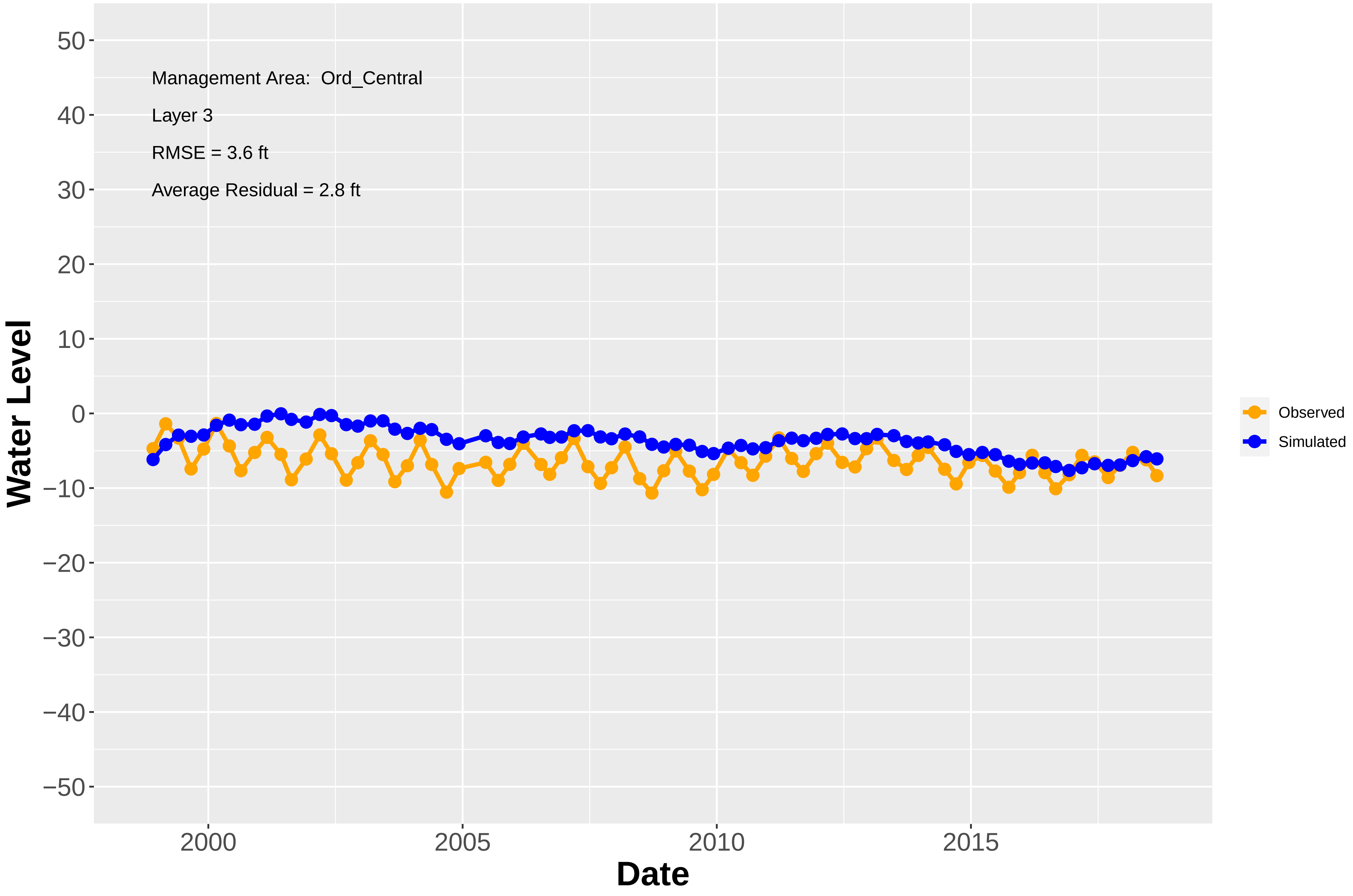

Hydrograph: MW−OU2−40−A
Management Area: Ord_Coast
Layer 1
RMSE = 16.9 ft
Average Residual = 15.7 ft
Water Level
70
60
50
40
30
20
10
0
−10
−20
−30
Date
2000
2005
2010
2015
Observed
Simulated

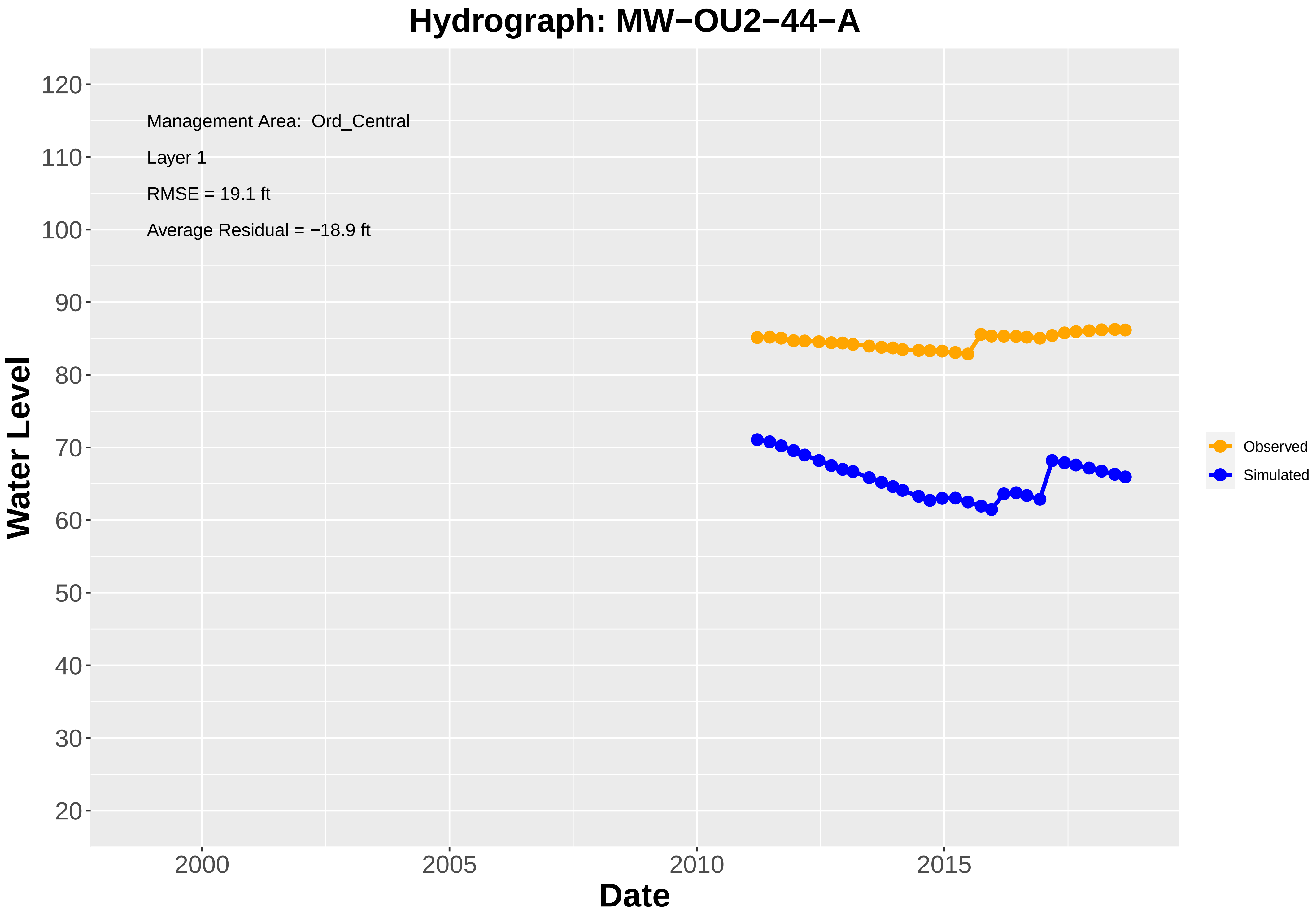

Hydrograph: MW−OU2−41−A
Management Area: Ord_Coast
Layer 3
RMSE = 2.0 ft
Average Residual = 0.56 ft
60
50
40
30
20
10
0
−10
−20
−30
−40
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−42−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.5 ft
Average Residual = −4.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

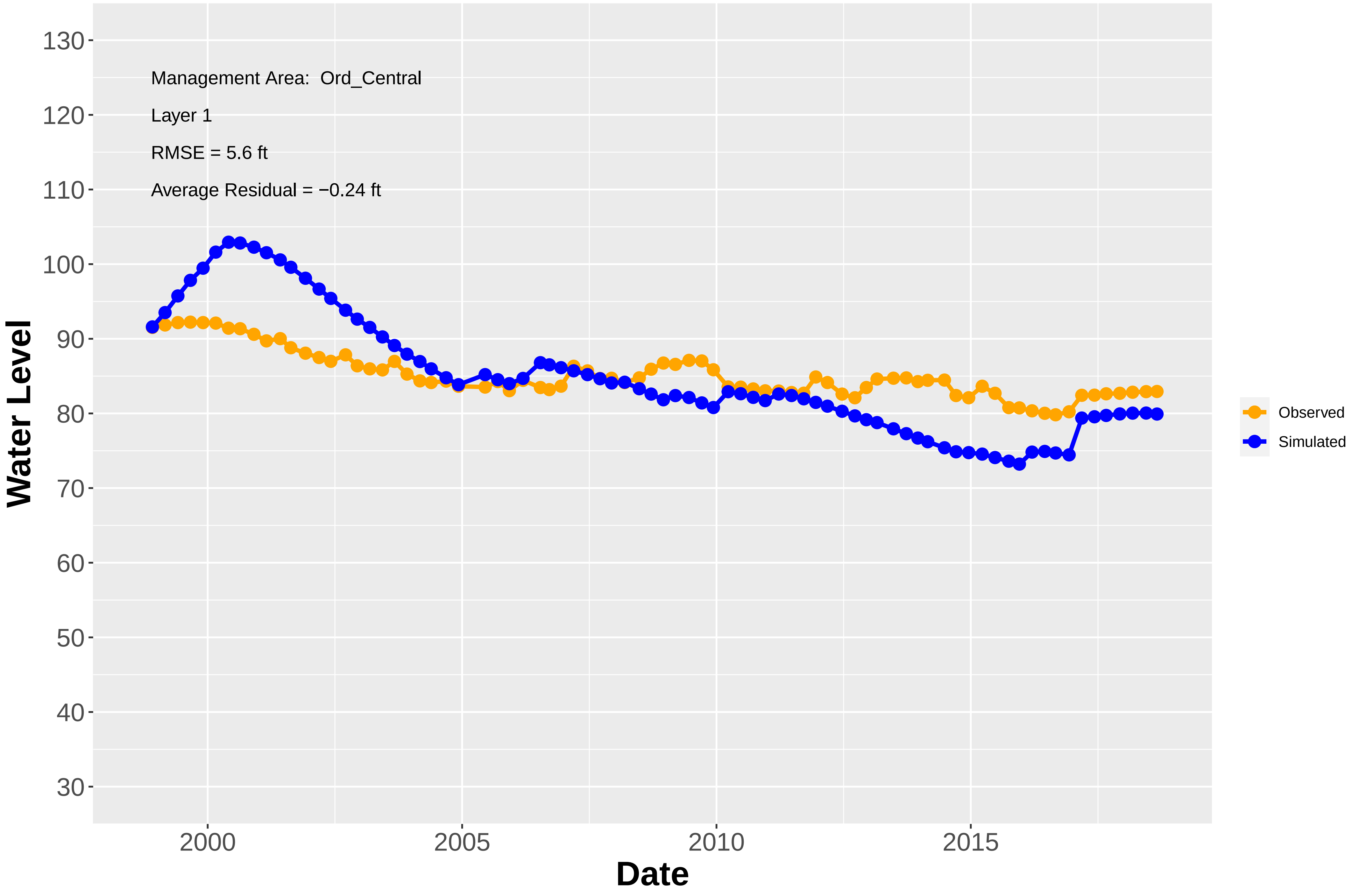

Hydrograph: MW−OU2−43−180
Management Area: Ord_Coast
Layer 3
RMSE = 2.2 ft
Average Residual = −1.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

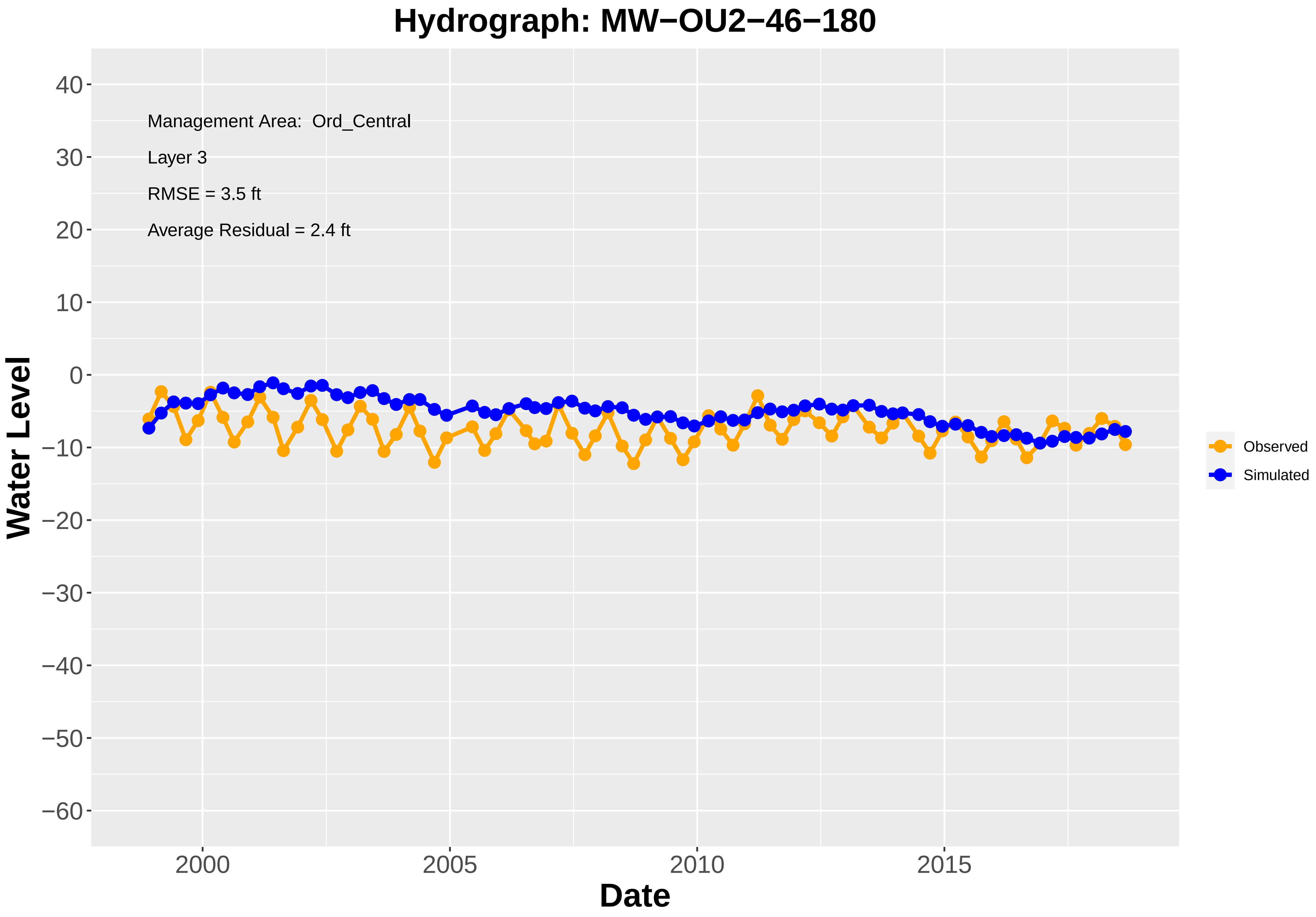
Hydrograph: MW−OU2−44−180

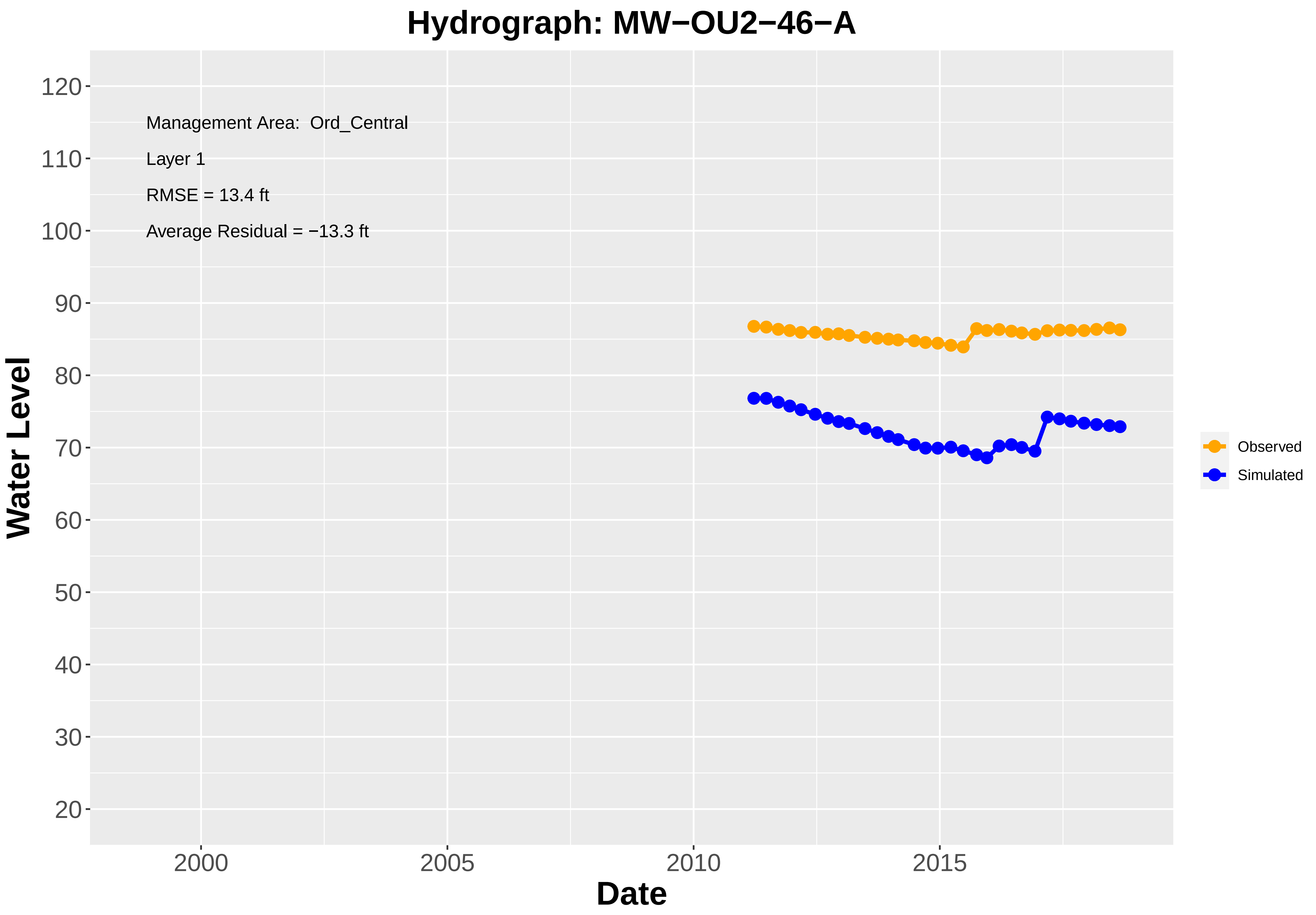


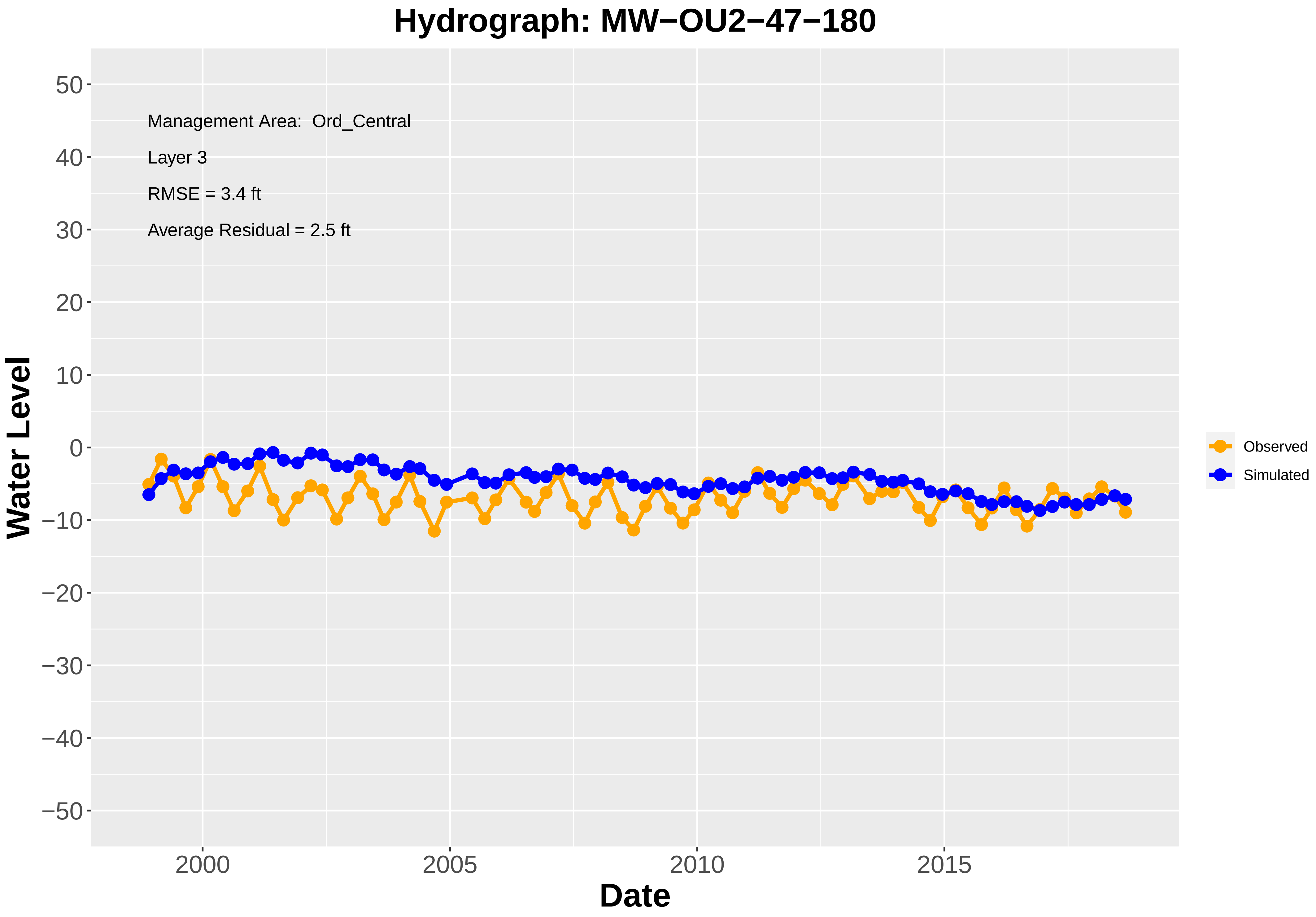

Hydrograph: MW−OU2−44−A
Management Area: Ord_Central
Layer 1
RMSE = 19.1 ft
Average Residual = −18.9 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

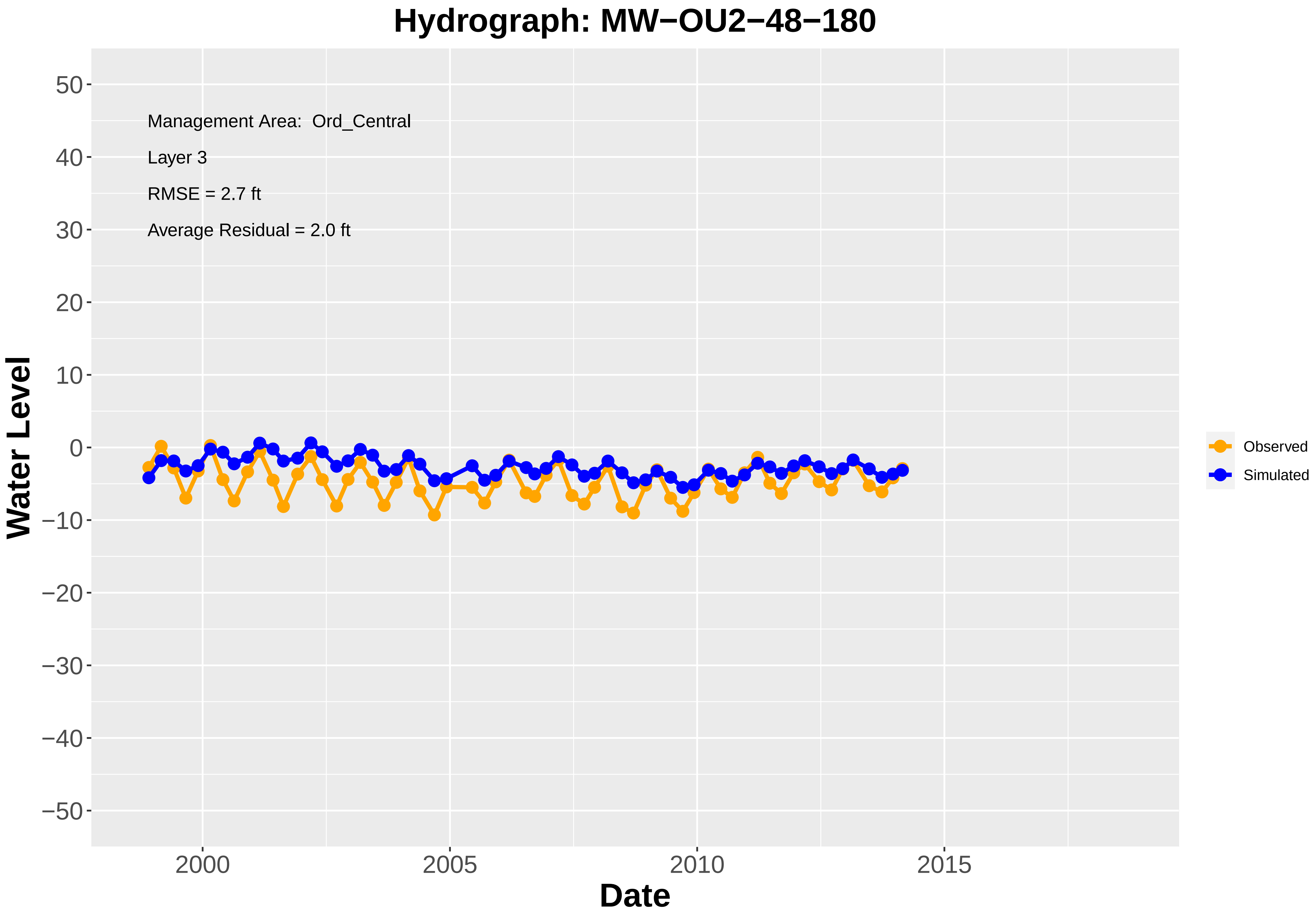
Hydrograph: MW−OU2−45−A

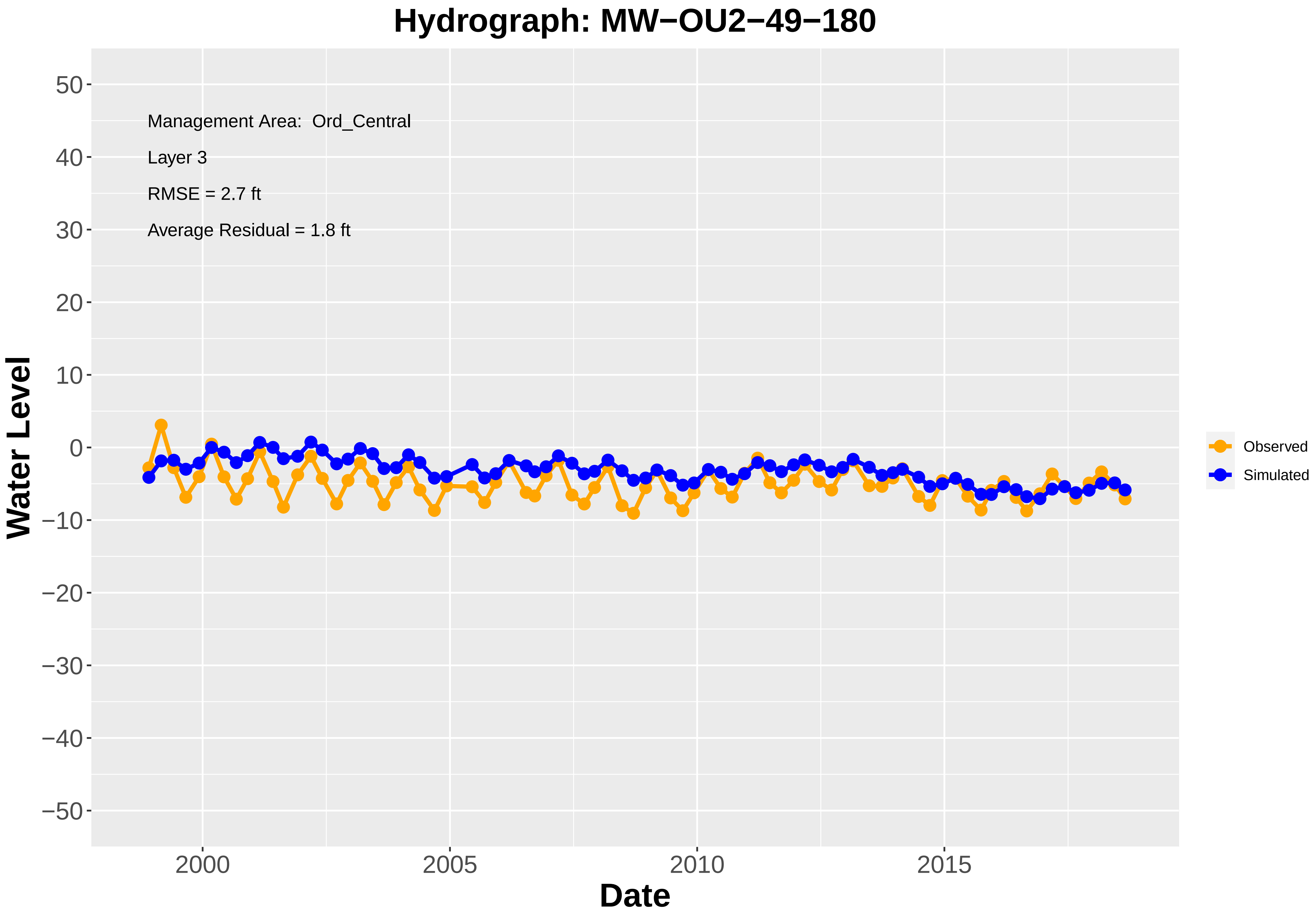



Hydrograph: MW−OU2−46−180
Management Area: Ord_Central
Layer 3
RMSE = 3.5 ft
Average Residual = 2.4 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

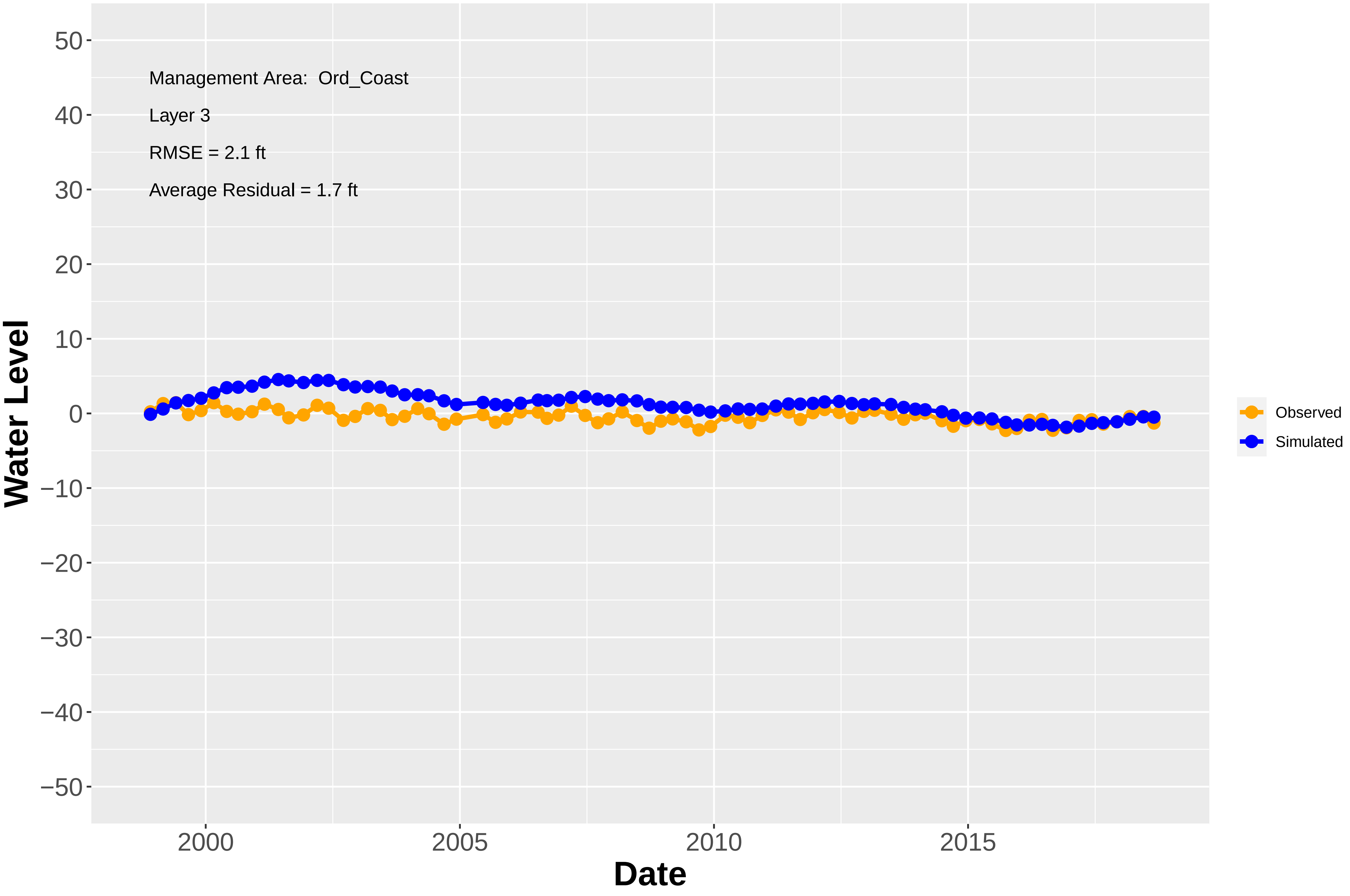

Hydrograph: MW−OU2−46−A
Management Area: Ord_Central
Layer 1
RMSE = 13.4 ft
Average Residual = −13.3 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−47−180
Management Area: Ord_Central
Layer 3
RMSE = 3.4 ft
Average Residual = 2.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

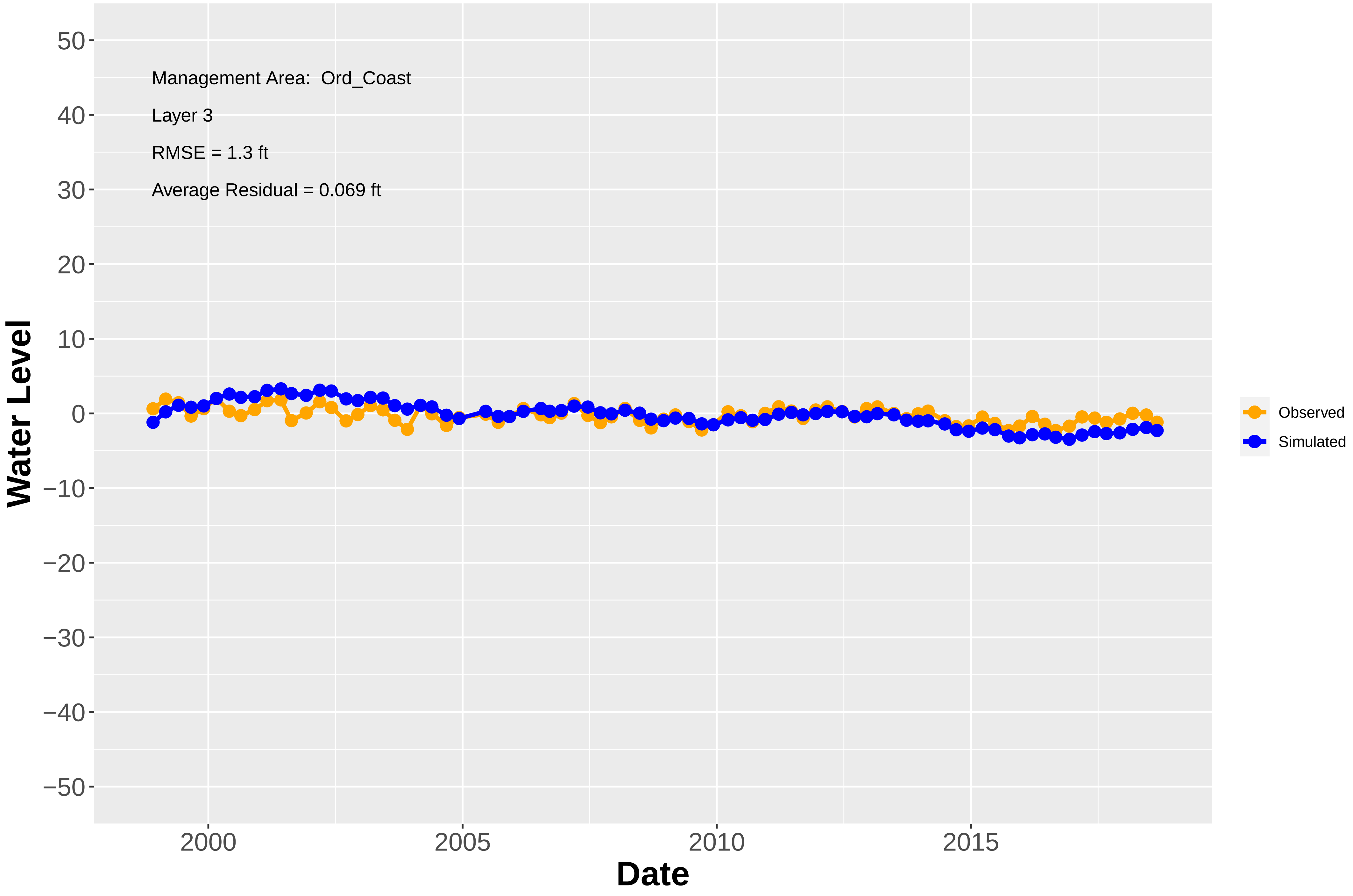

Hydrograph: MW−OU2−48−180
Management Area: Ord_Central
Layer 3
RMSE = 2.7 ft
Average Residual = 2.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: MW−OU2−49−180
Management Area: Ord_Central
Layer 3
RMSE = 2.7 ft
Average Residual = 1.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

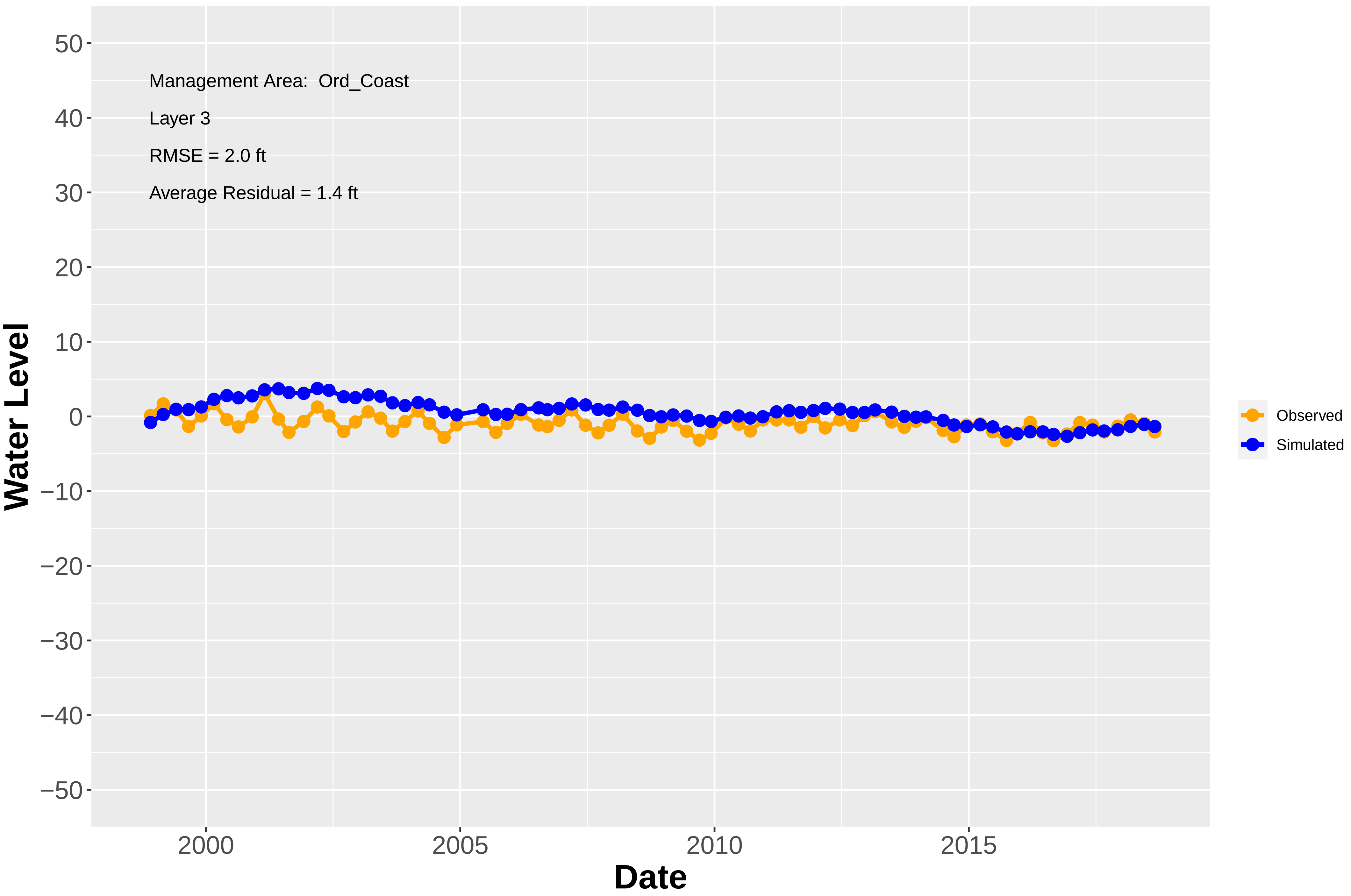
Hydrograph: MW−OU2−50−180

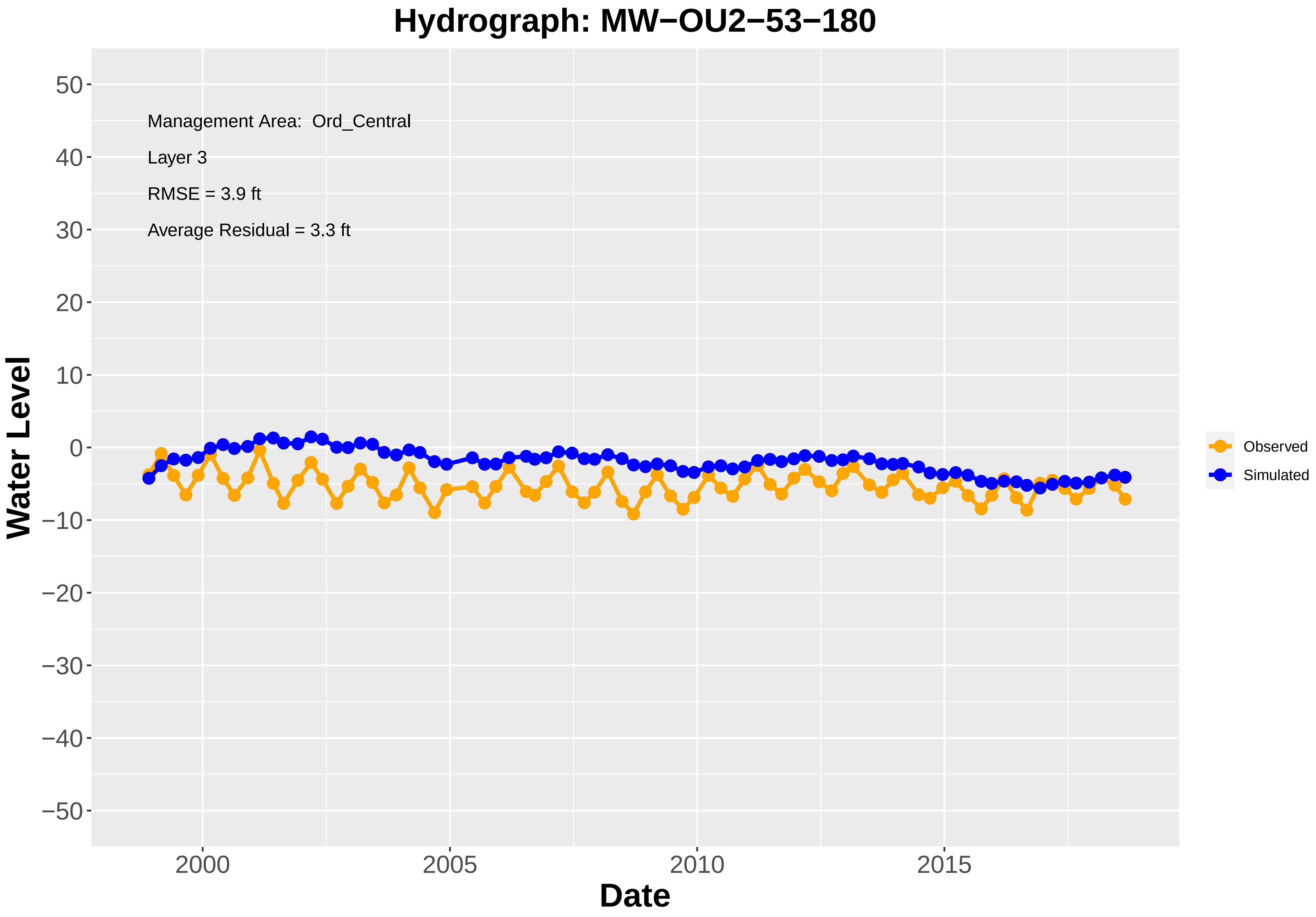


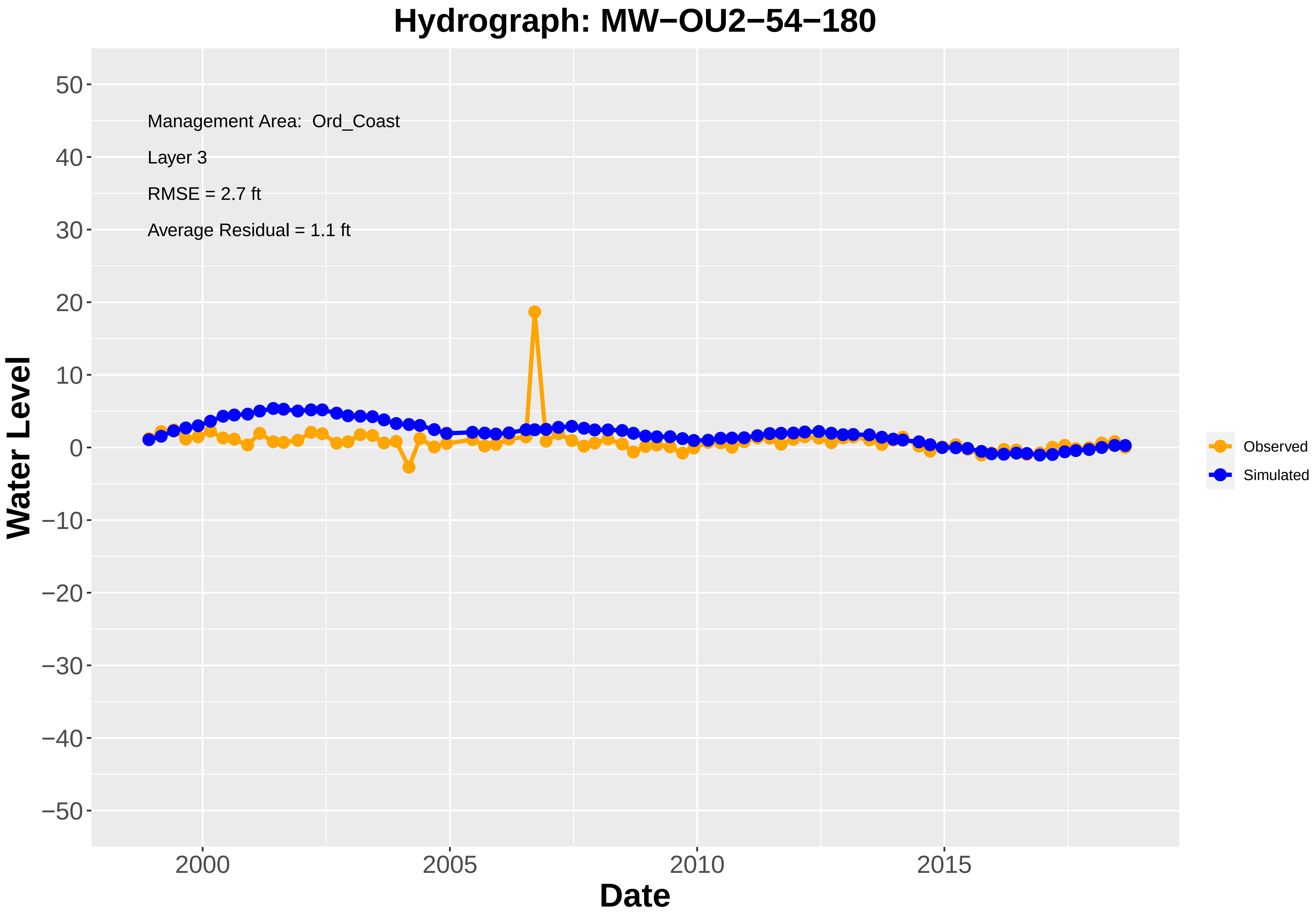
Hydrograph: MW−OU2−51−180

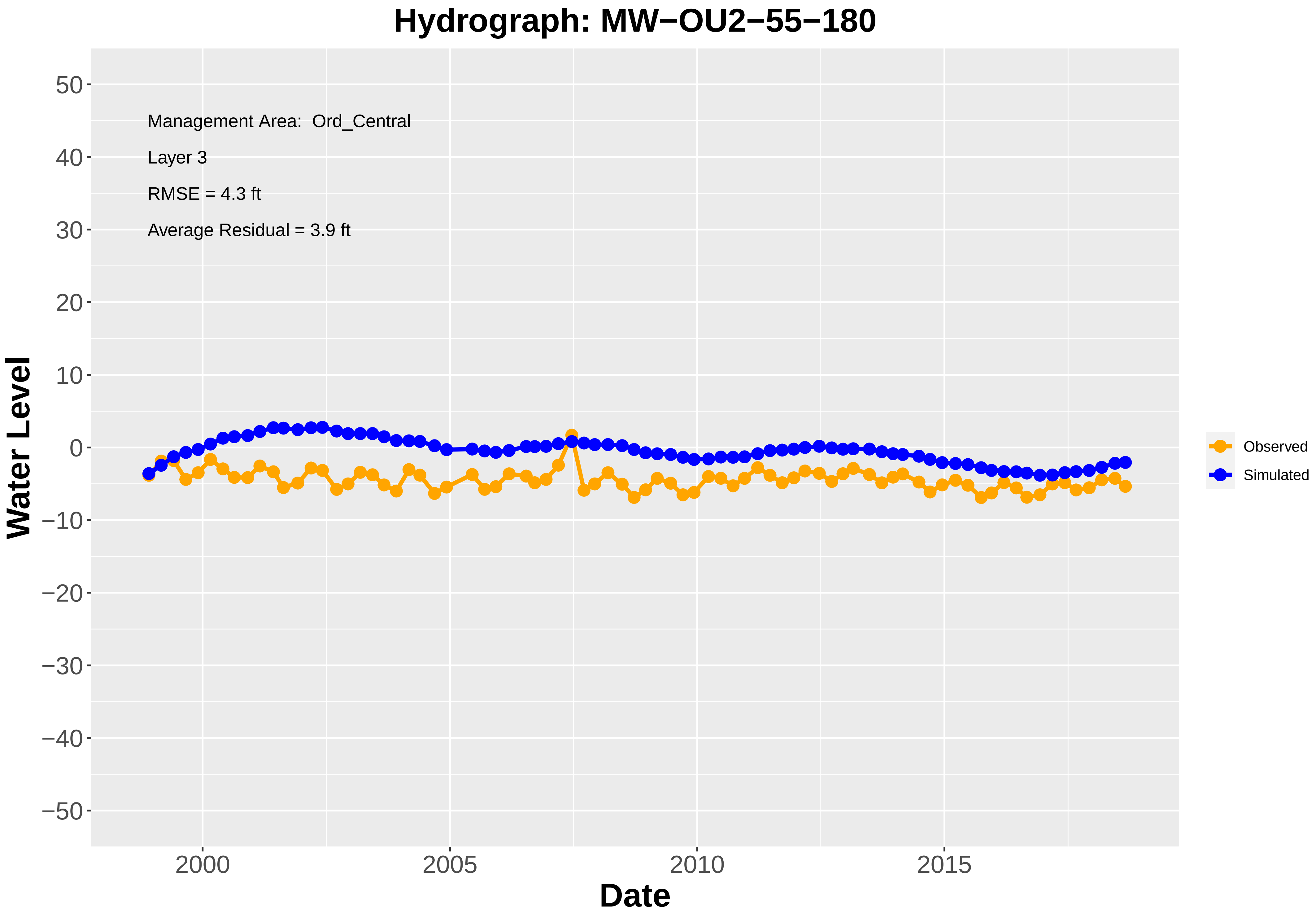


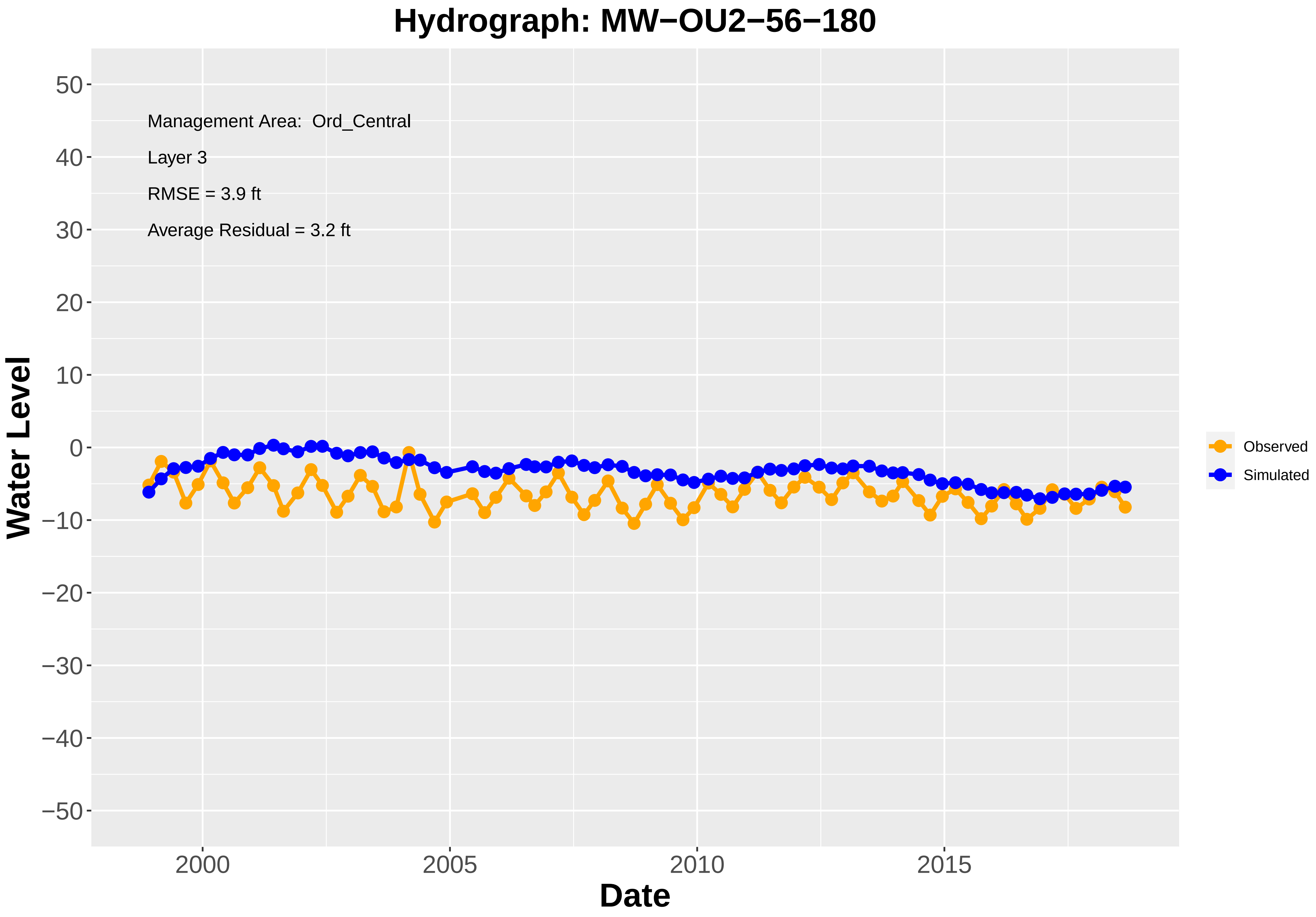
Hydrograph: MW−OU2−52−180

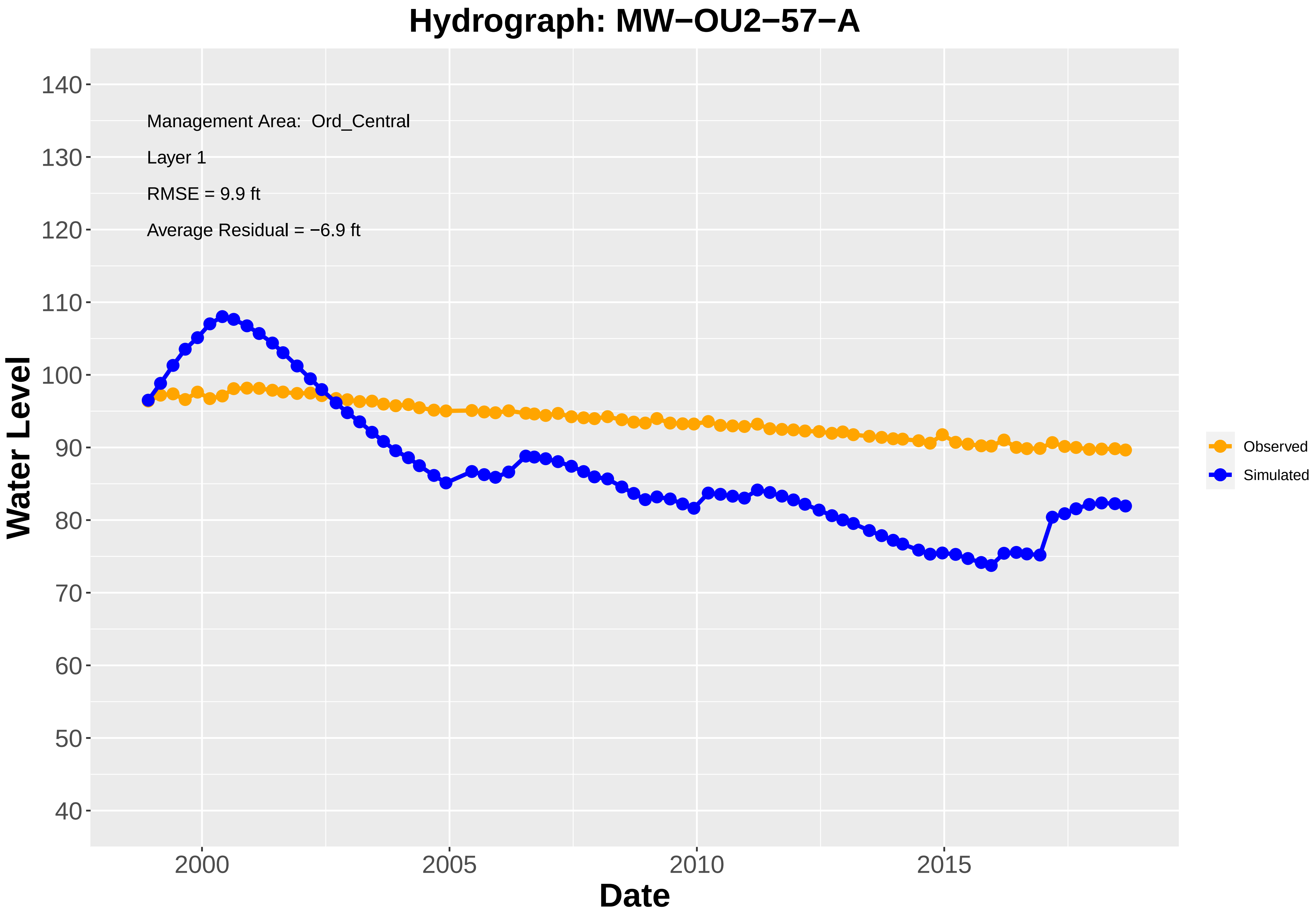



Hydrograph: MW−OU2−53−180
Management Area: Ord_Central
Layer 3
RMSE = 3.9 ft
Average Residual = 3.3 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

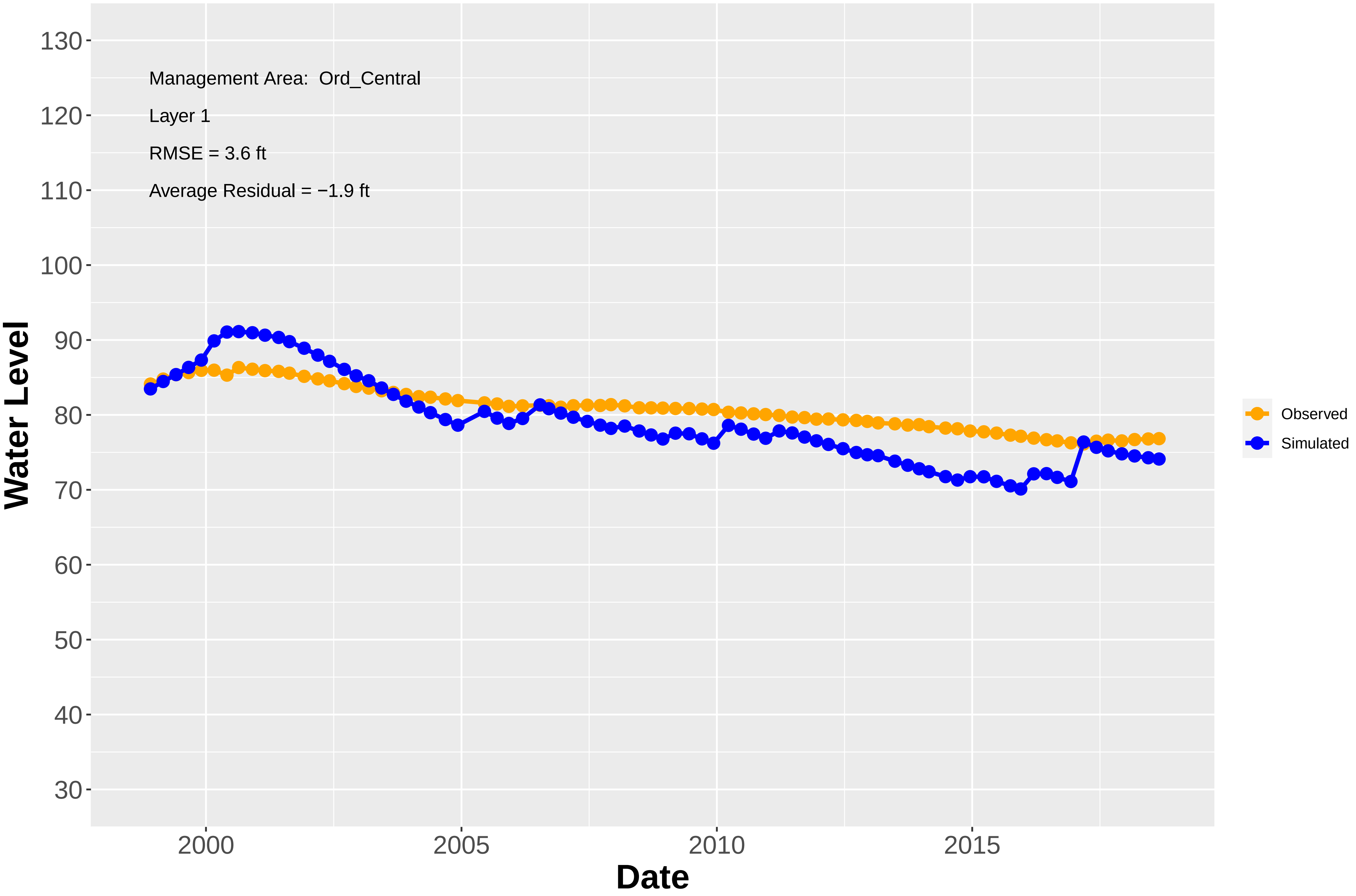

Hydrograph: MW−OU2−54−180
Management Area: Ord_Coast
Layer 3
RMSE = 2.7 ft
Average Residual = 1.1 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−55−180
Management Area: Ord_Central
Layer 3
RMSE = 4.3 ft
Average Residual = 3.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

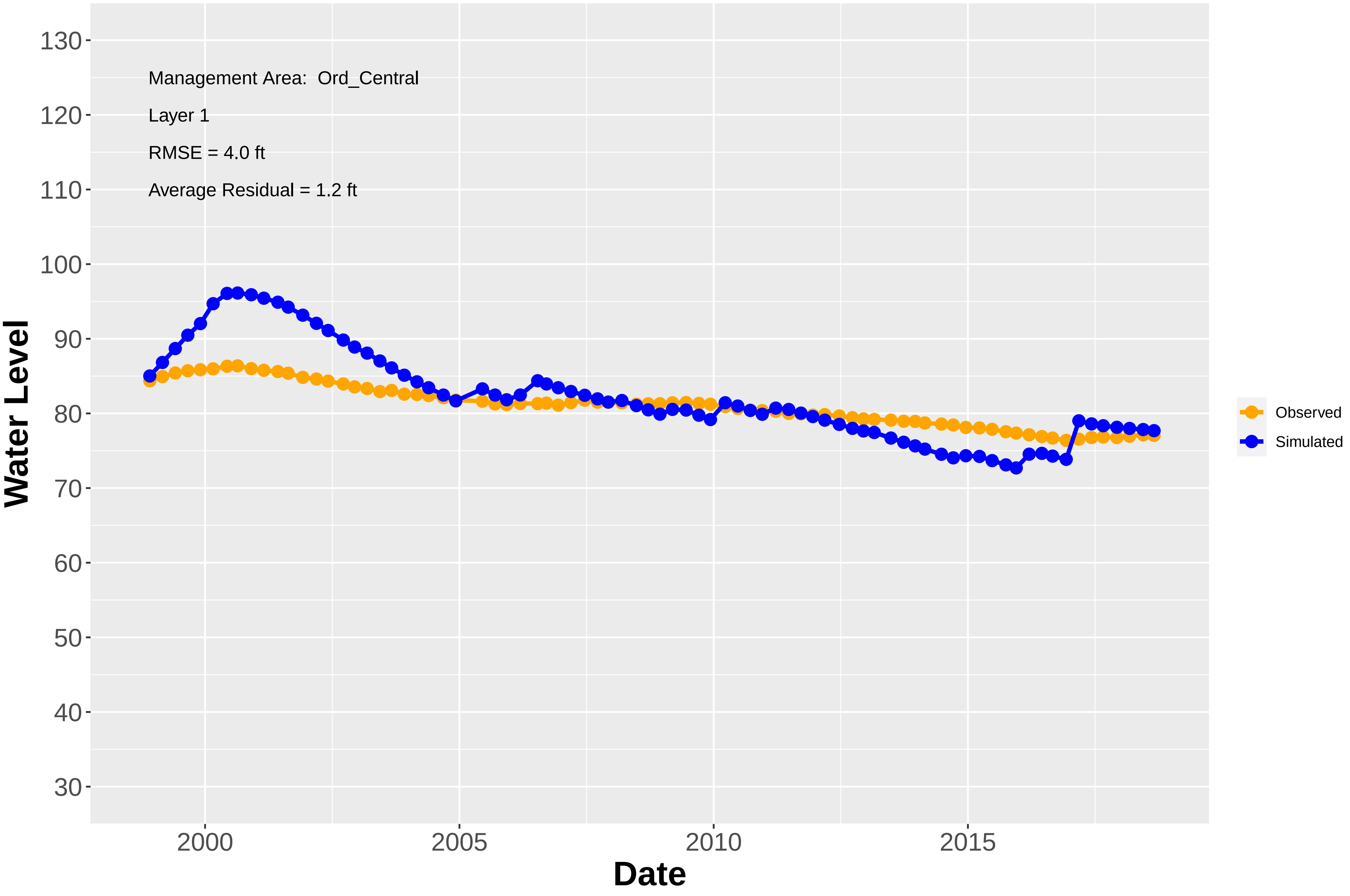

Hydrograph: MW−OU2−56−180
Management Area: Ord_Central
Layer 3
RMSE = 3.9 ft
Average Residual = 3.2 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

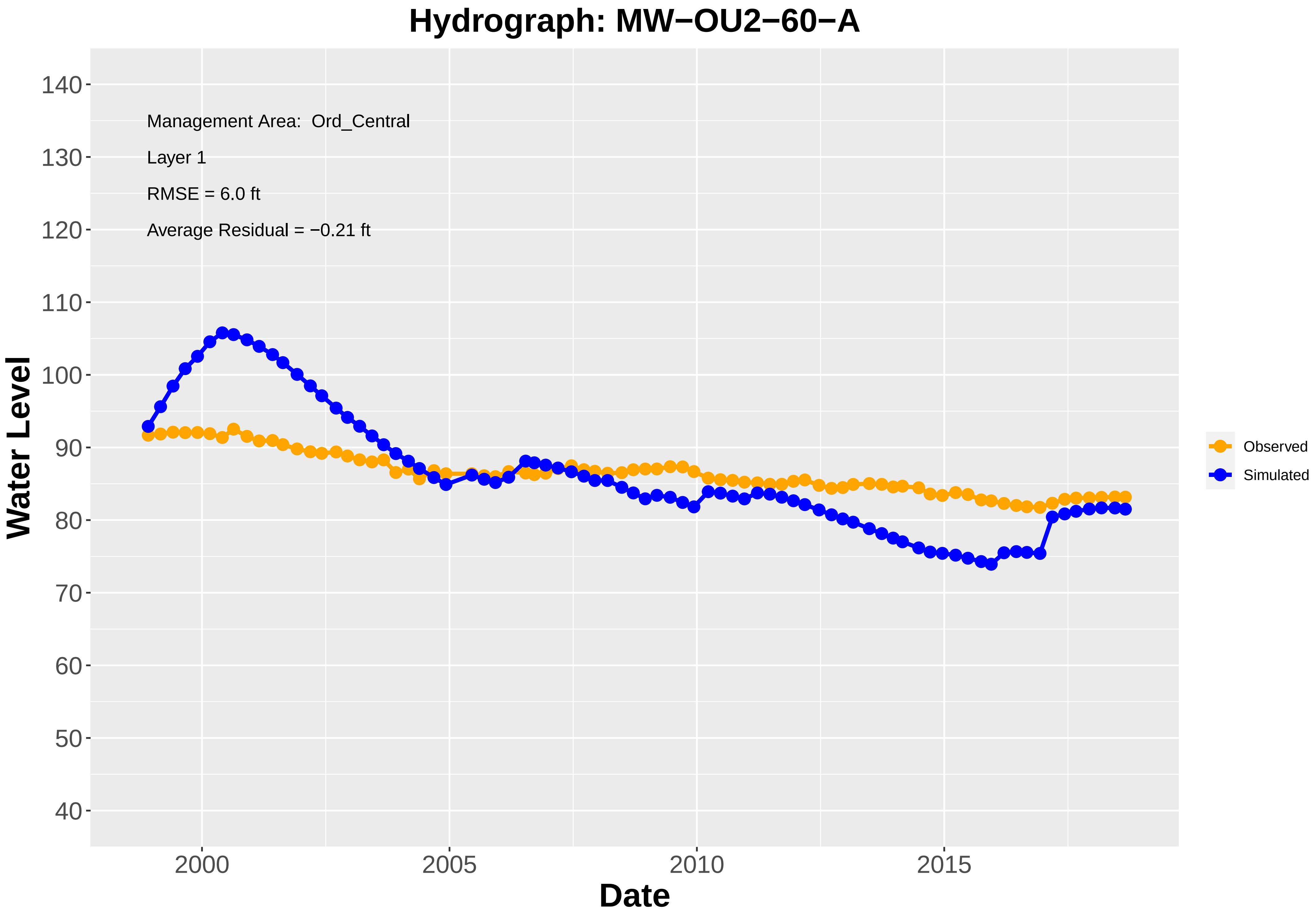

Hydrograph: MW−OU2−57−A
Management Area: Ord_Central
Layer 1
RMSE = 9.9 ft
Average Residual = −6.9 ft
Water Level
140
130
120
110
100
90
80
70
60
50
40
2000
2005
2010
2015
Date
Observed
Simulated

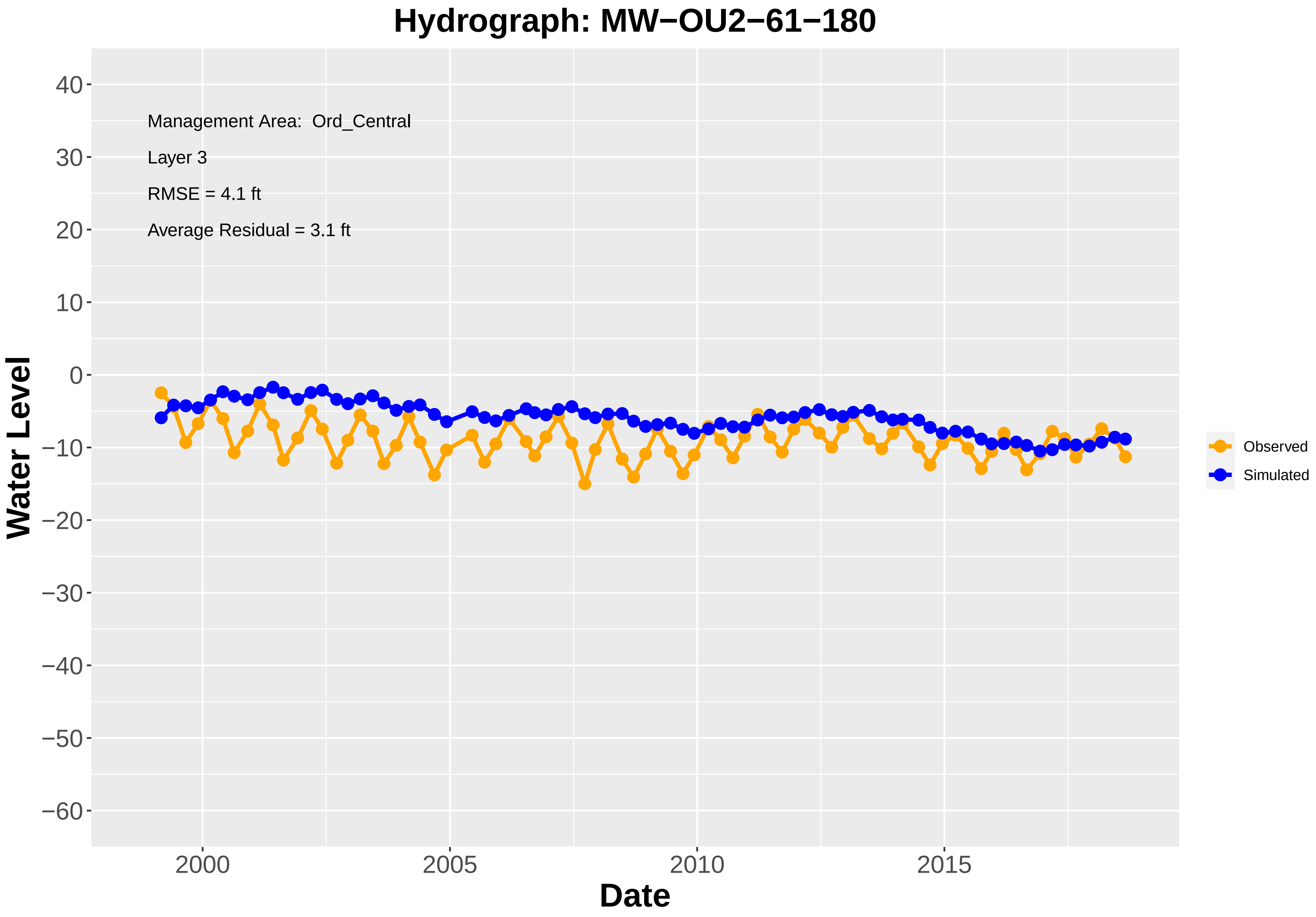
Hydrograph: MW−OU2−58−A

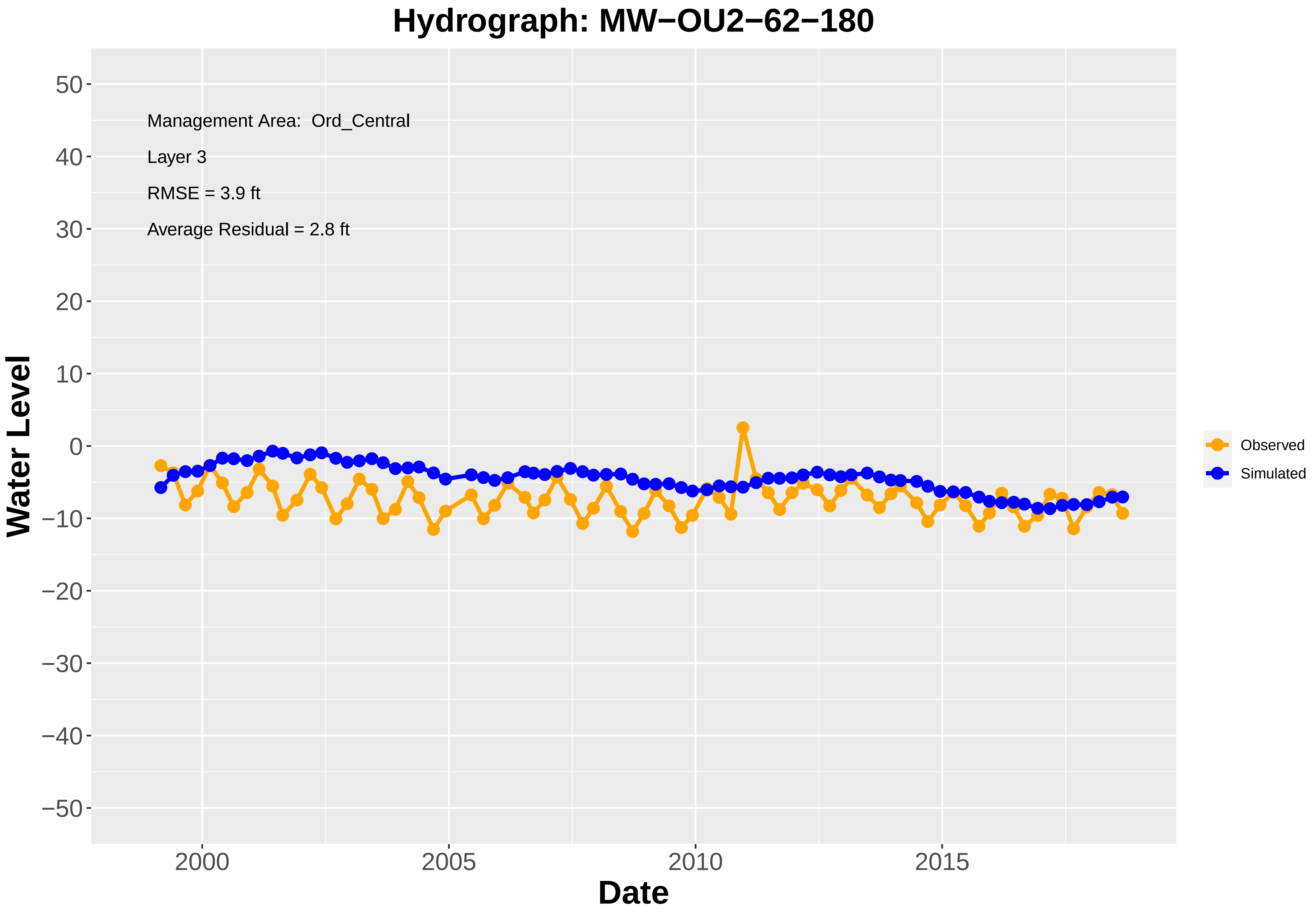


Hydrograph: MW−OU2−59−A

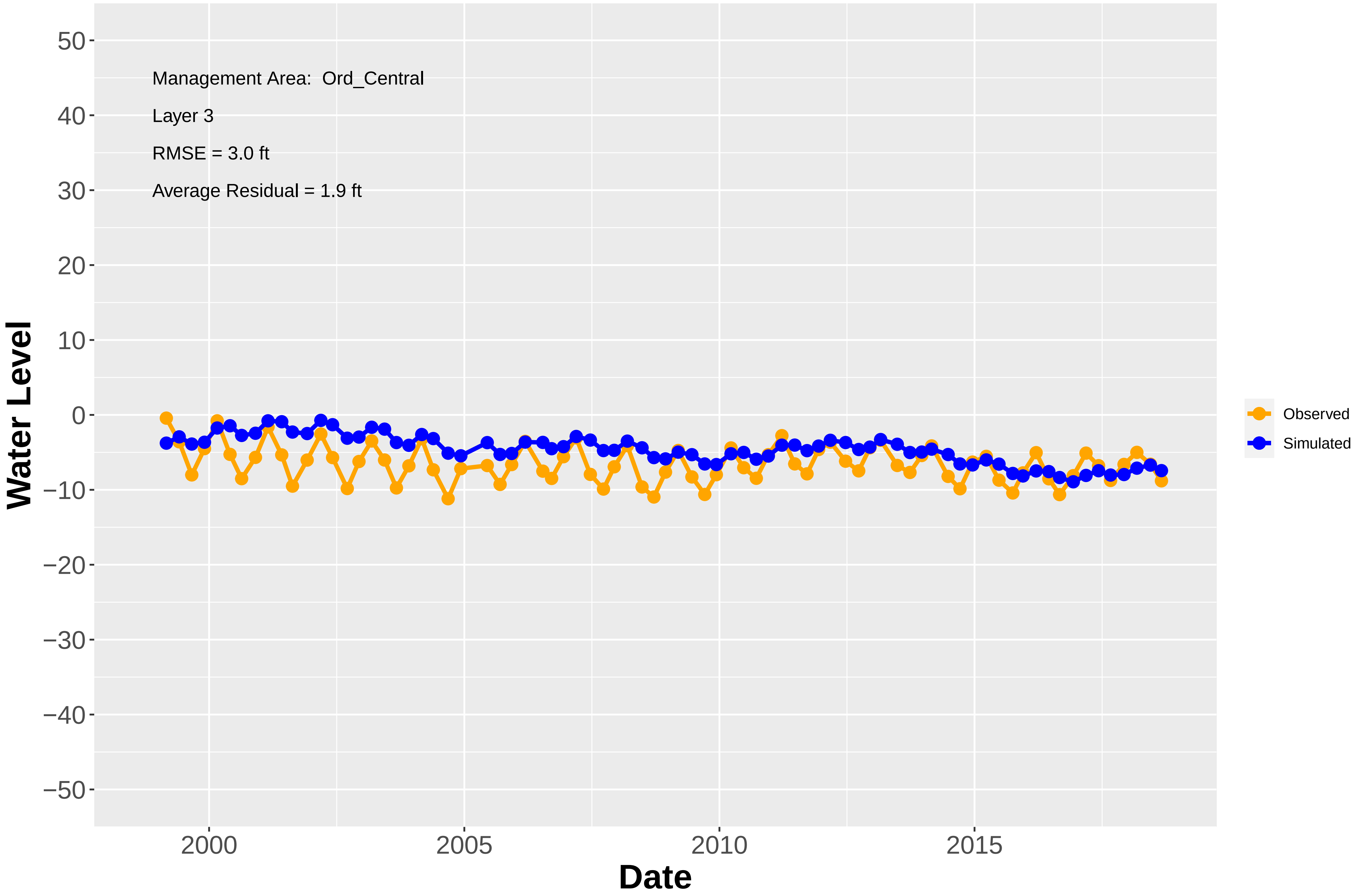


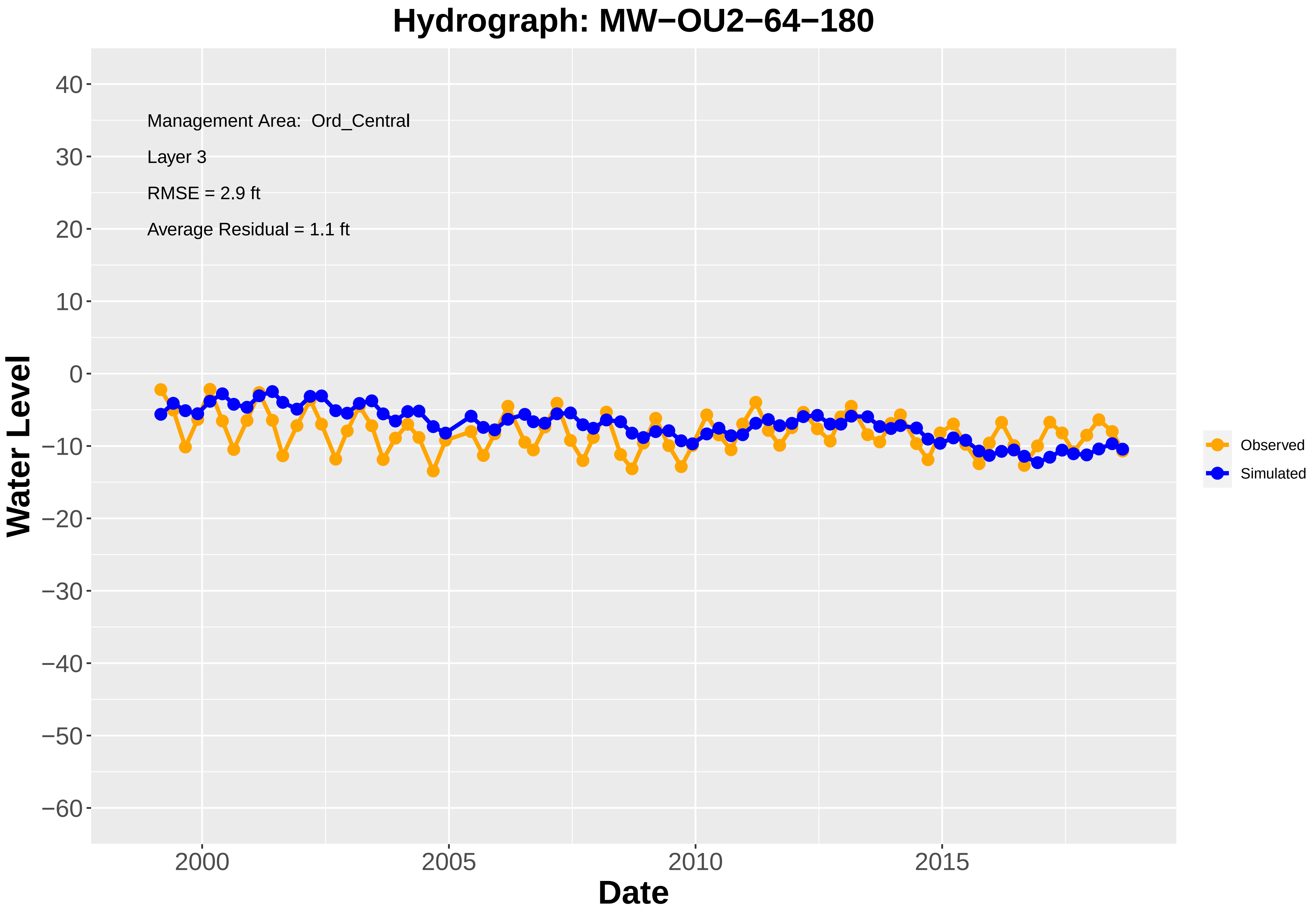

Hydrograph: MW−OU2−60−A
Management Area: Ord_Central
Layer 1
RMSE = 6.0 ft
Average Residual = −0.21 ft
Water Level
140
130
120
110
100
90
80
70
60
50
40
Date
2000
2005
2010
2015
Observed
Simulated

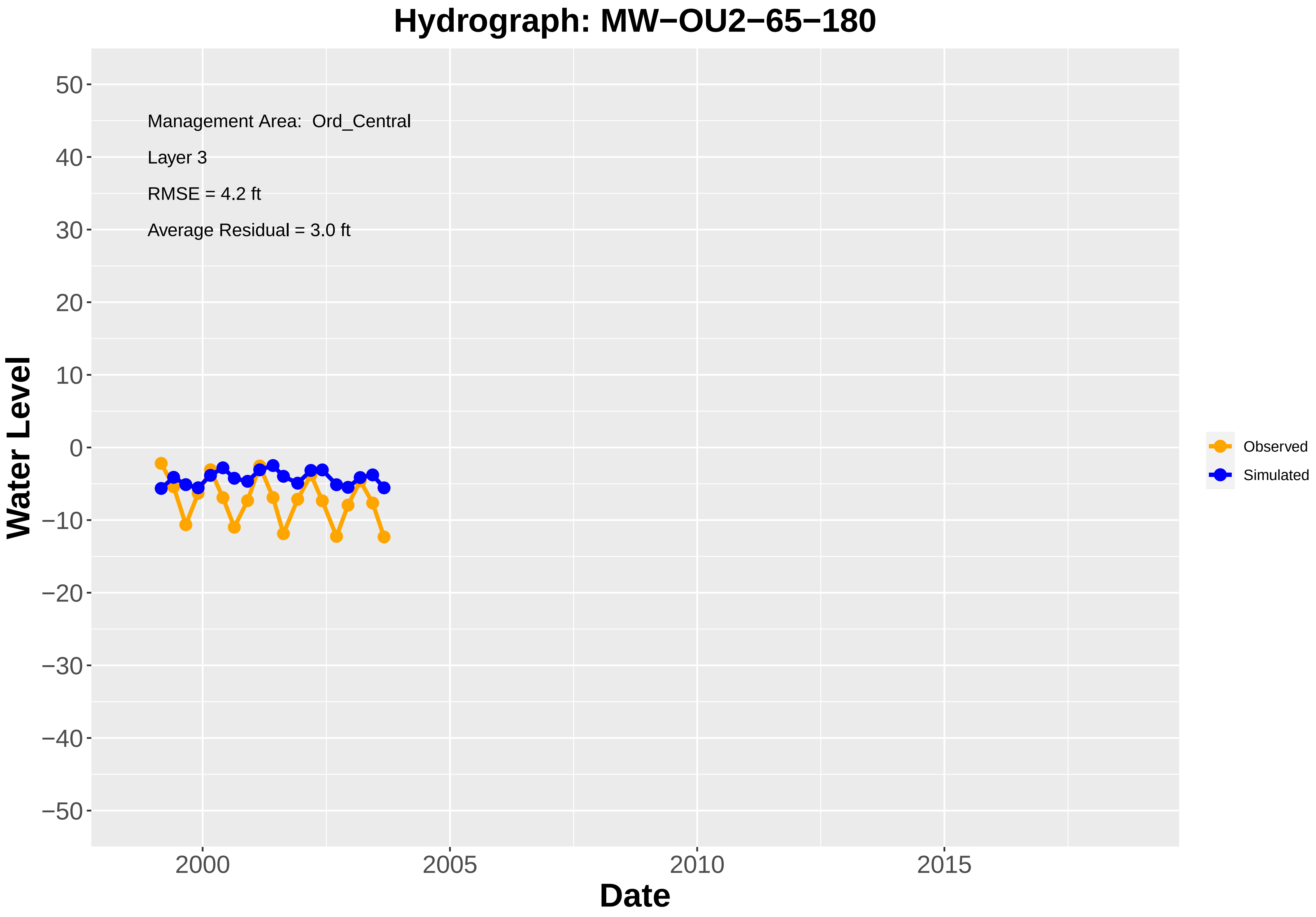

Hydrograph: MW−OU2−61−180
Management Area: Ord_Central
Layer 3
RMSE = 4.1 ft
Average Residual = 3.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

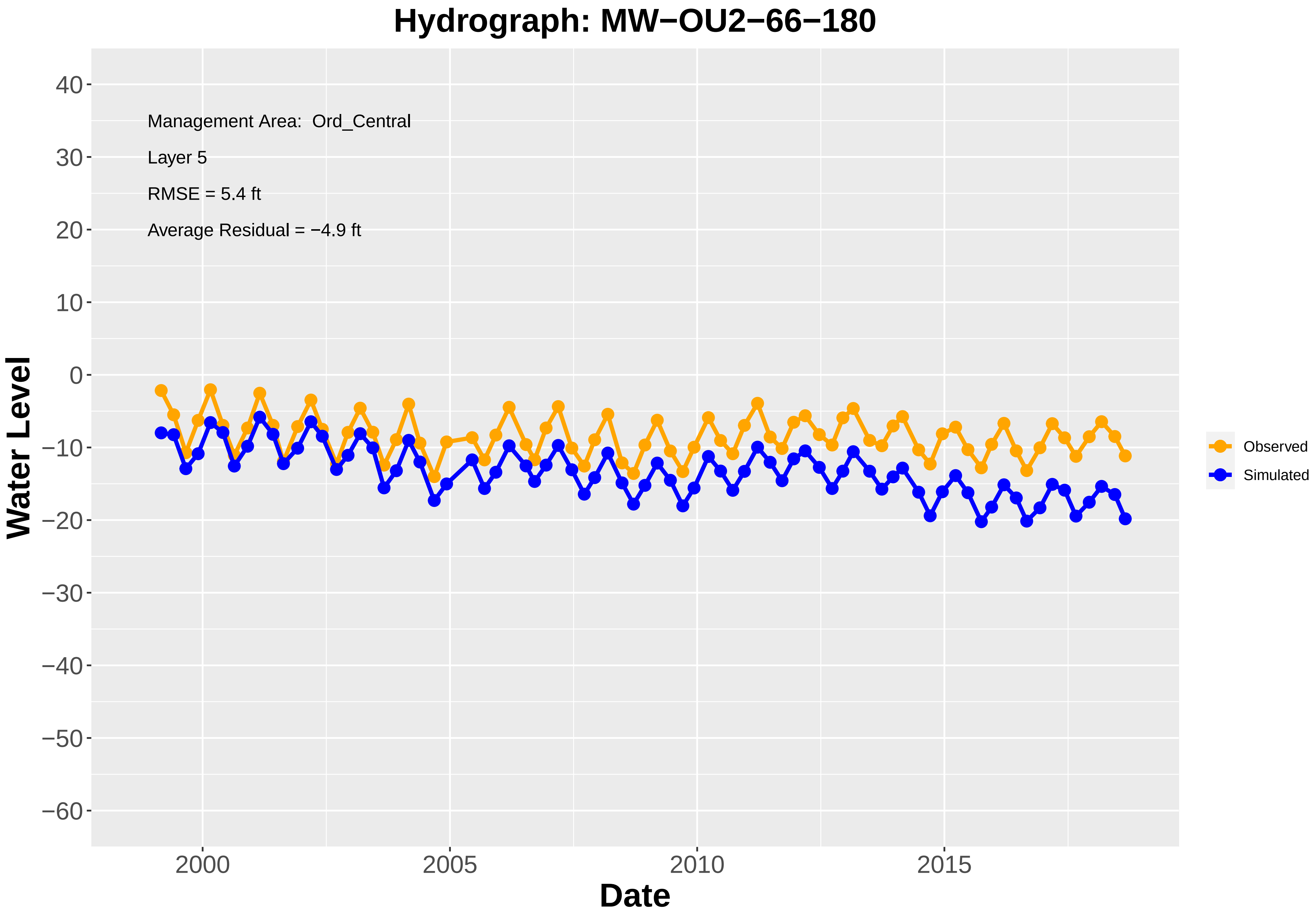

Hydrograph: MW−OU2−62−180
Management Area: Ord_Central
Layer 3
RMSE = 3.9 ft
Average Residual = 2.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: MW−OU2−63−180

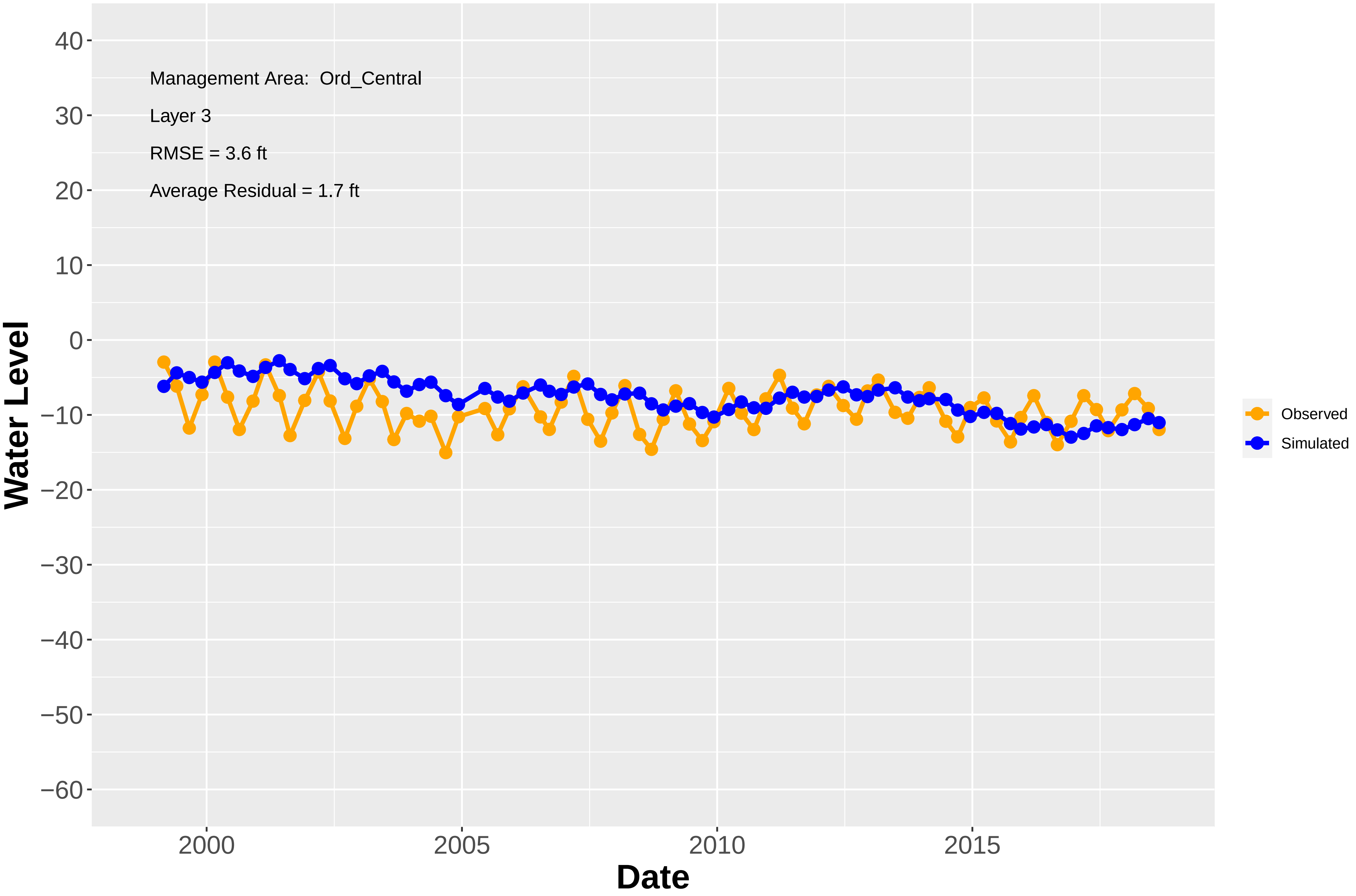


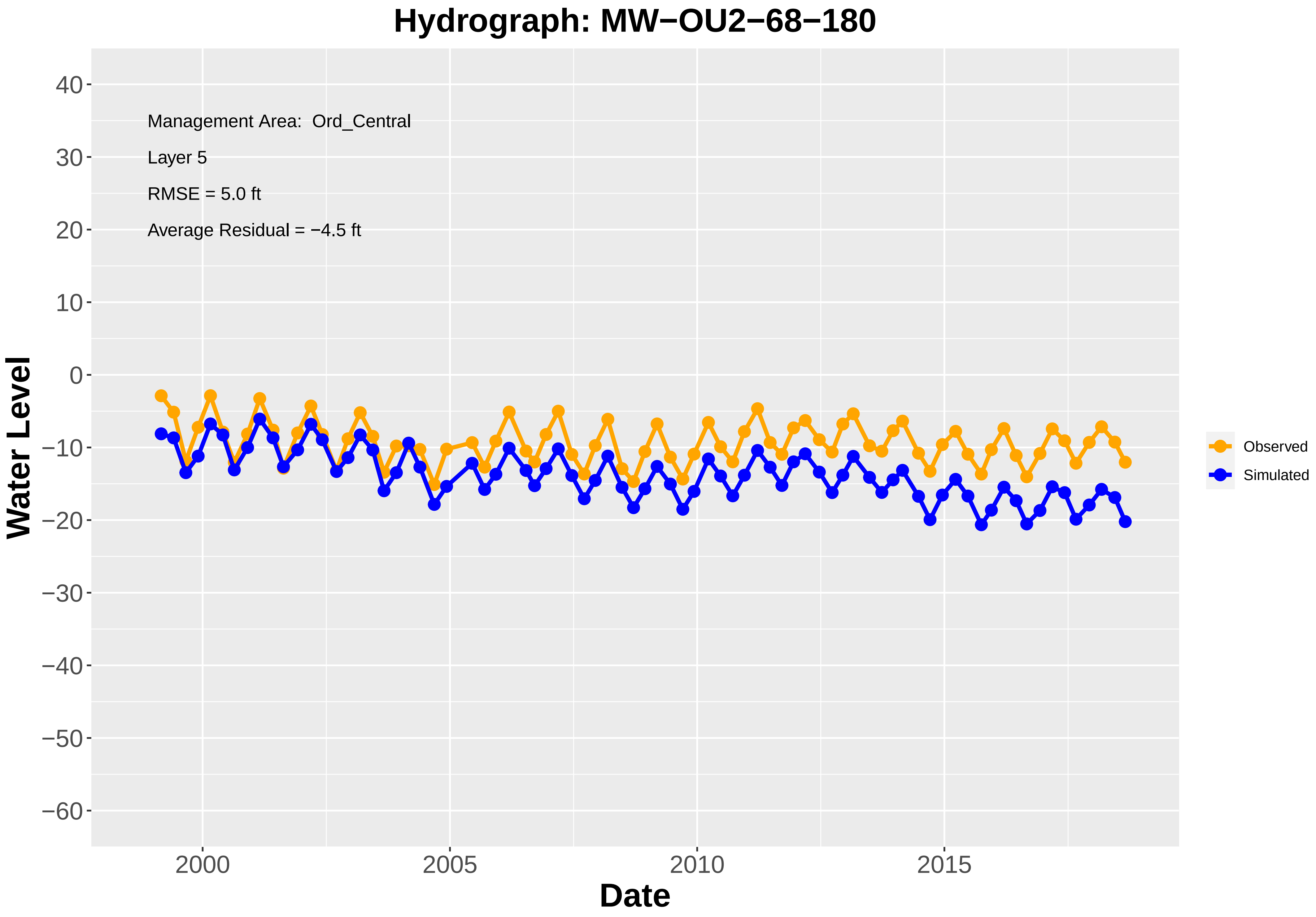

Hydrograph: MW−OU2−64−180
Management Area: Ord_Central
Layer 3
RMSE = 2.9 ft
Average Residual = 1.1 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

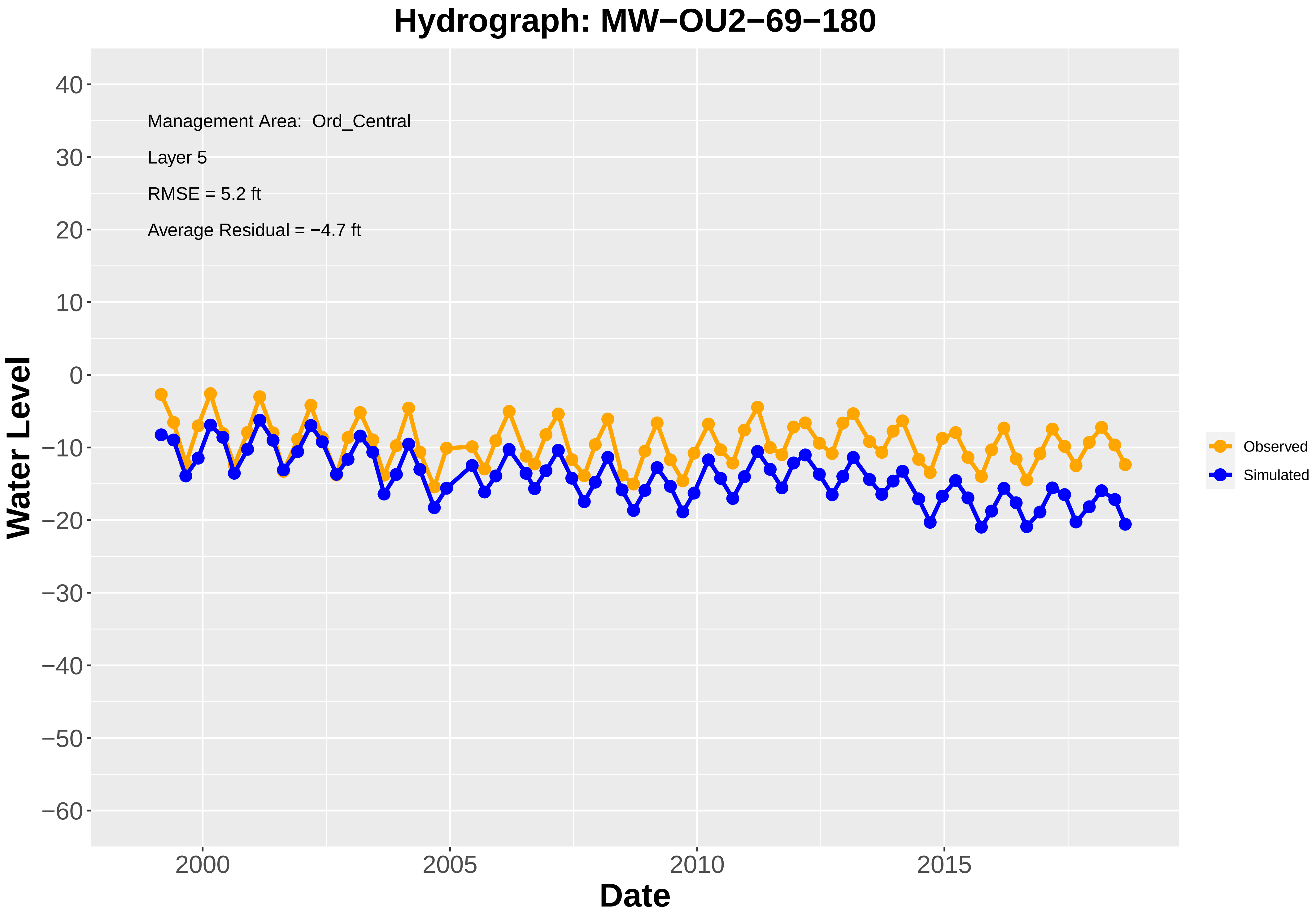

Hydrograph: MW−OU2−65−180
Management Area: Ord_Central
Layer 3
RMSE = 4.2 ft
Average Residual = 3.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

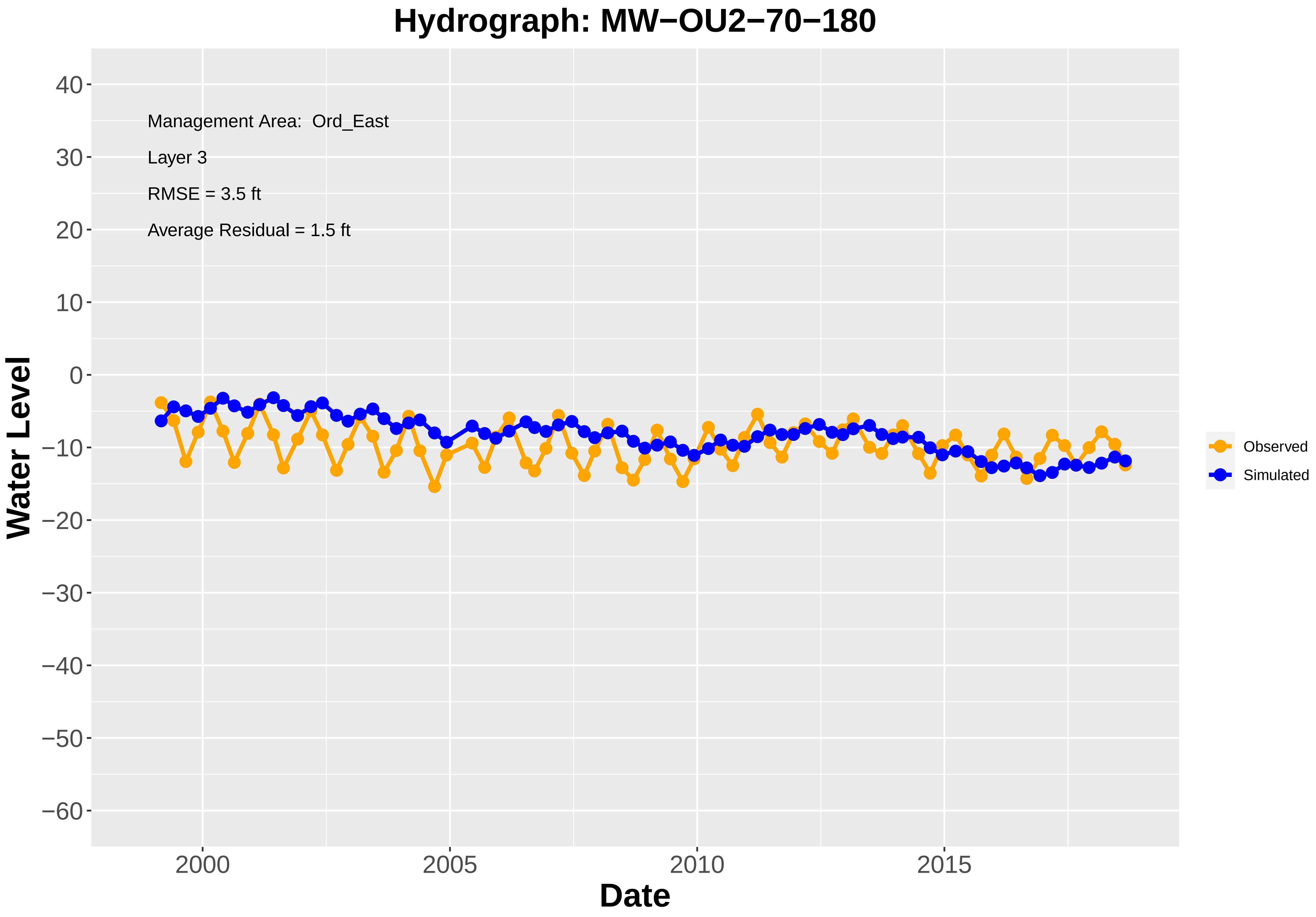

Hydrograph: MW−OU2−66−180
Management Area: Ord_Central
Layer 5
RMSE = 5.4 ft
Average Residual = −4.9 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

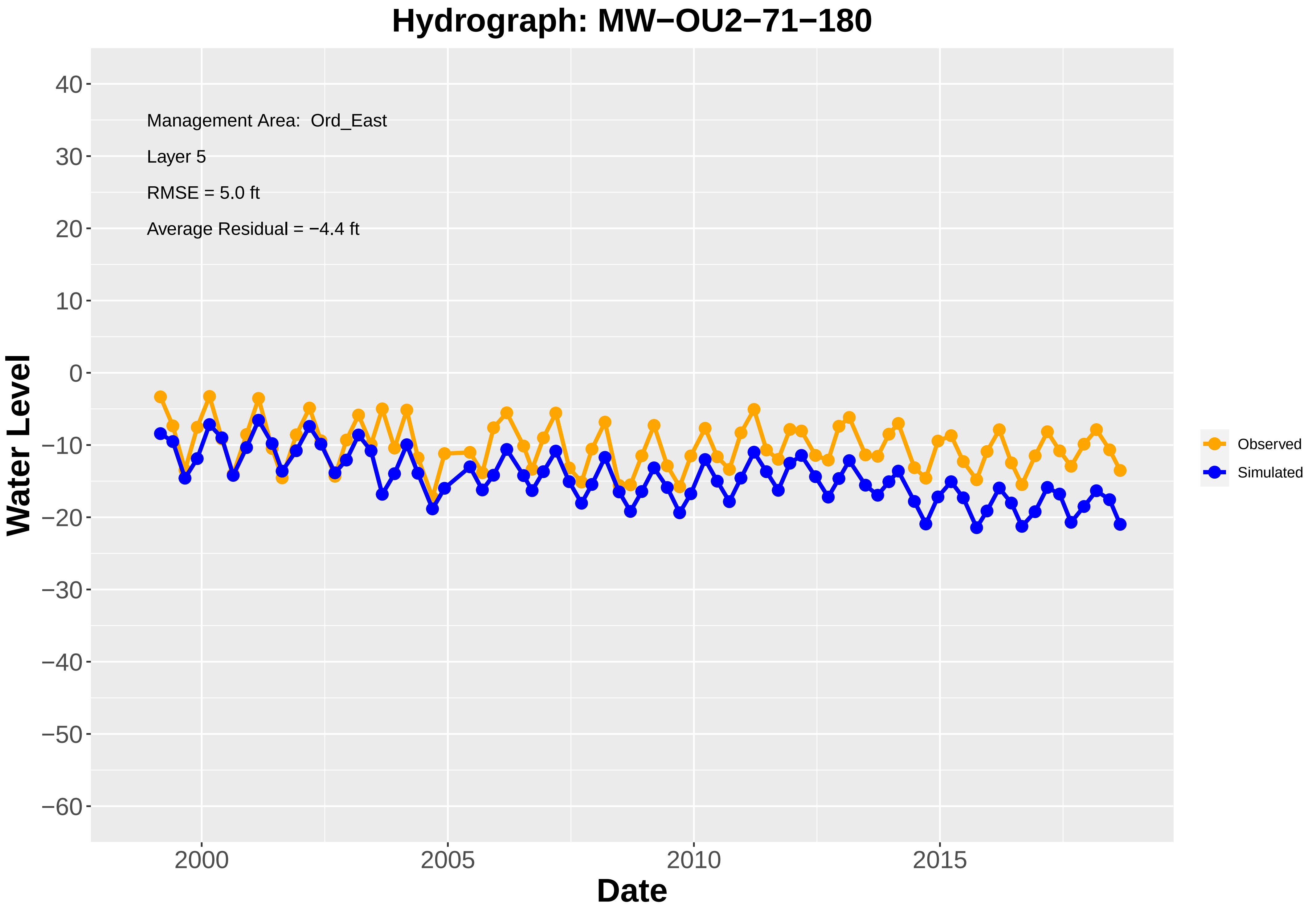
Hydrograph: MW−OU2−67−180

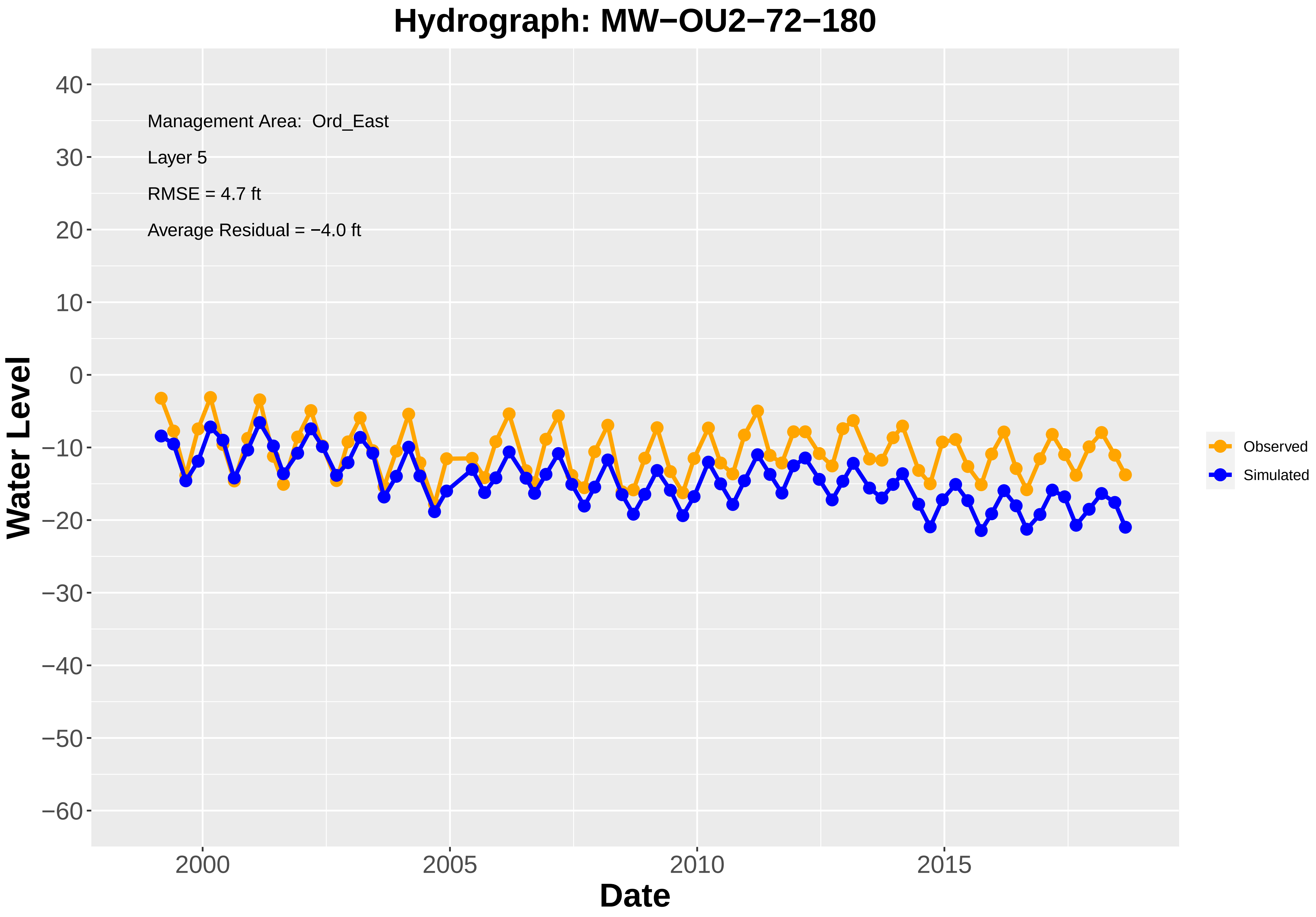


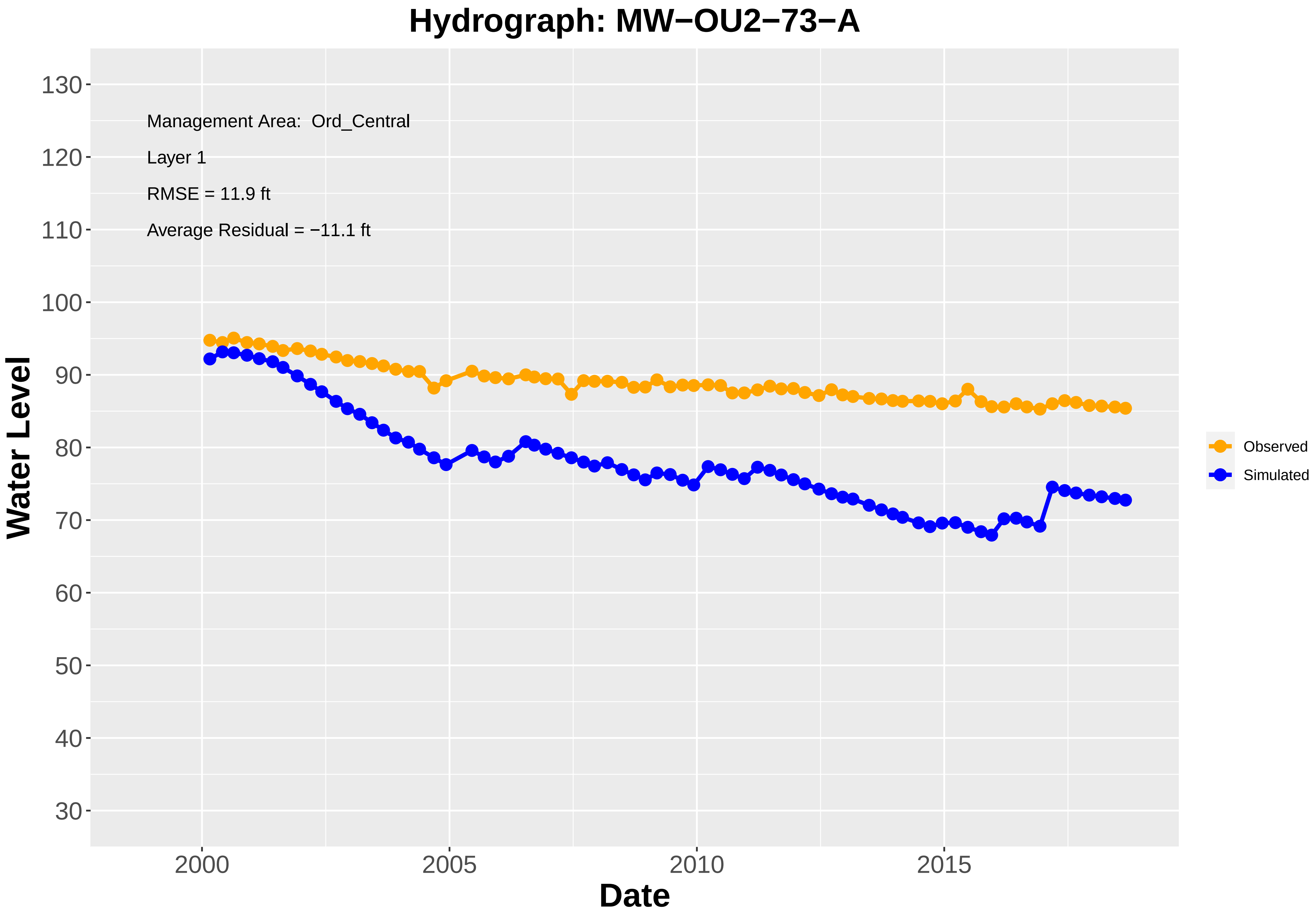

Hydrograph: MW−OU2−68−180
Management Area: Ord_Central
Layer 5
RMSE = 5.0 ft
Average Residual = −4.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

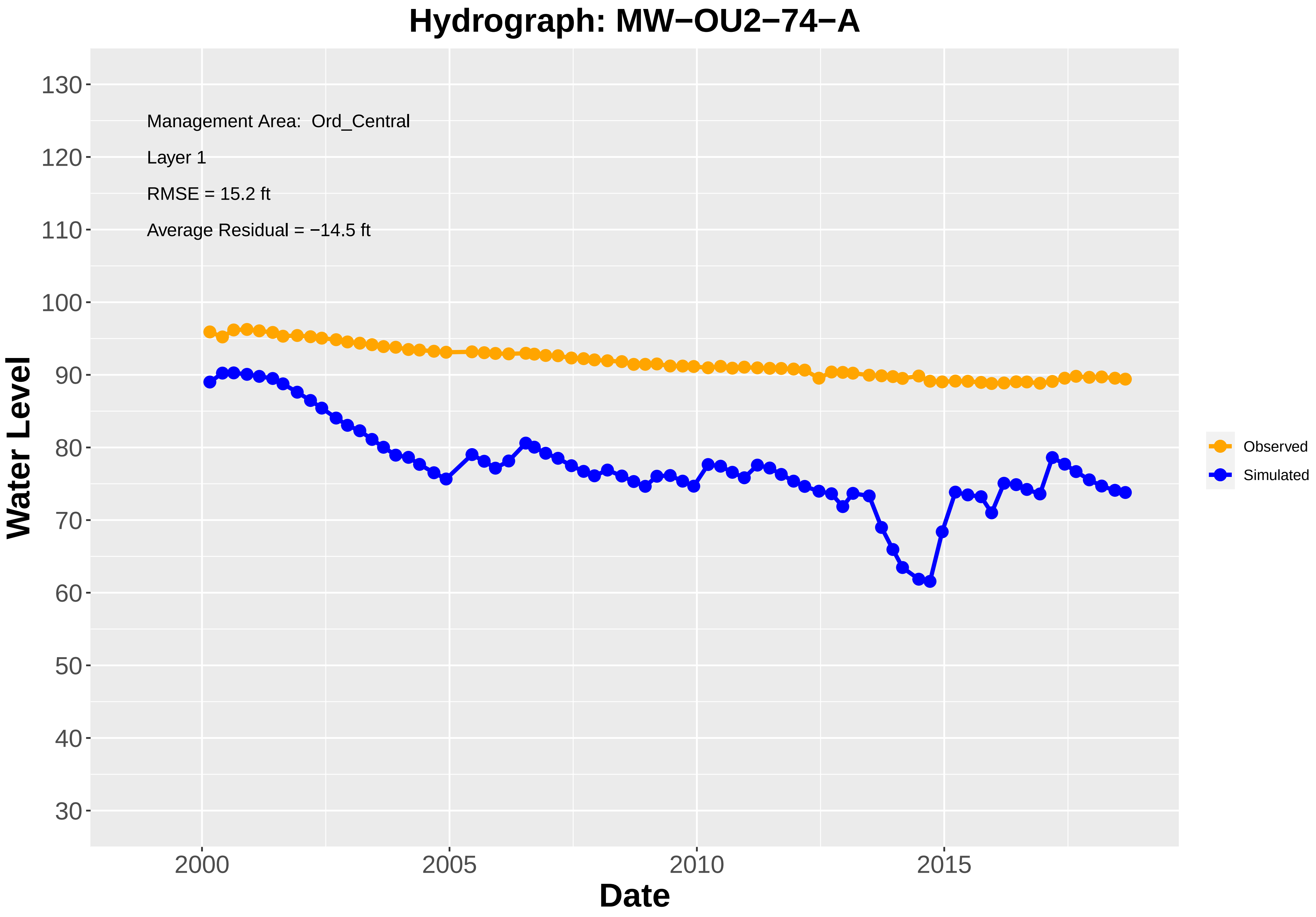

Hydrograph: MW−OU2−69−180
Management Area: Ord_Central
Layer 5
RMSE = 5.2 ft
Average Residual = −4.7 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

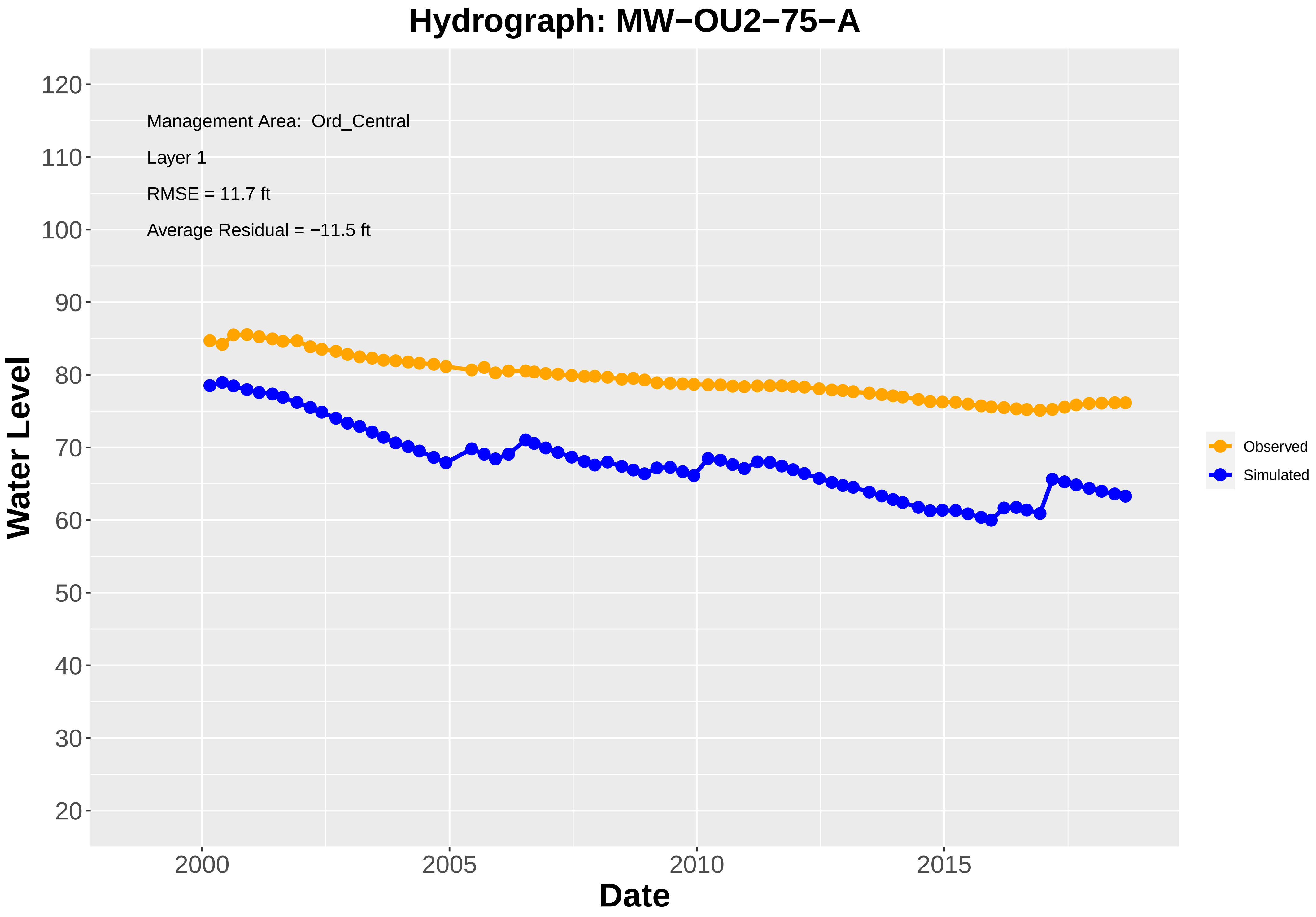

Hydrograph: MW−OU2−70−180
Management Area: Ord_East
Layer 3
RMSE = 3.5 ft
Average Residual = 1.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−71−180
Management Area: Ord_East
Layer 5
RMSE = 5.0 ft
Average Residual = −4.4 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

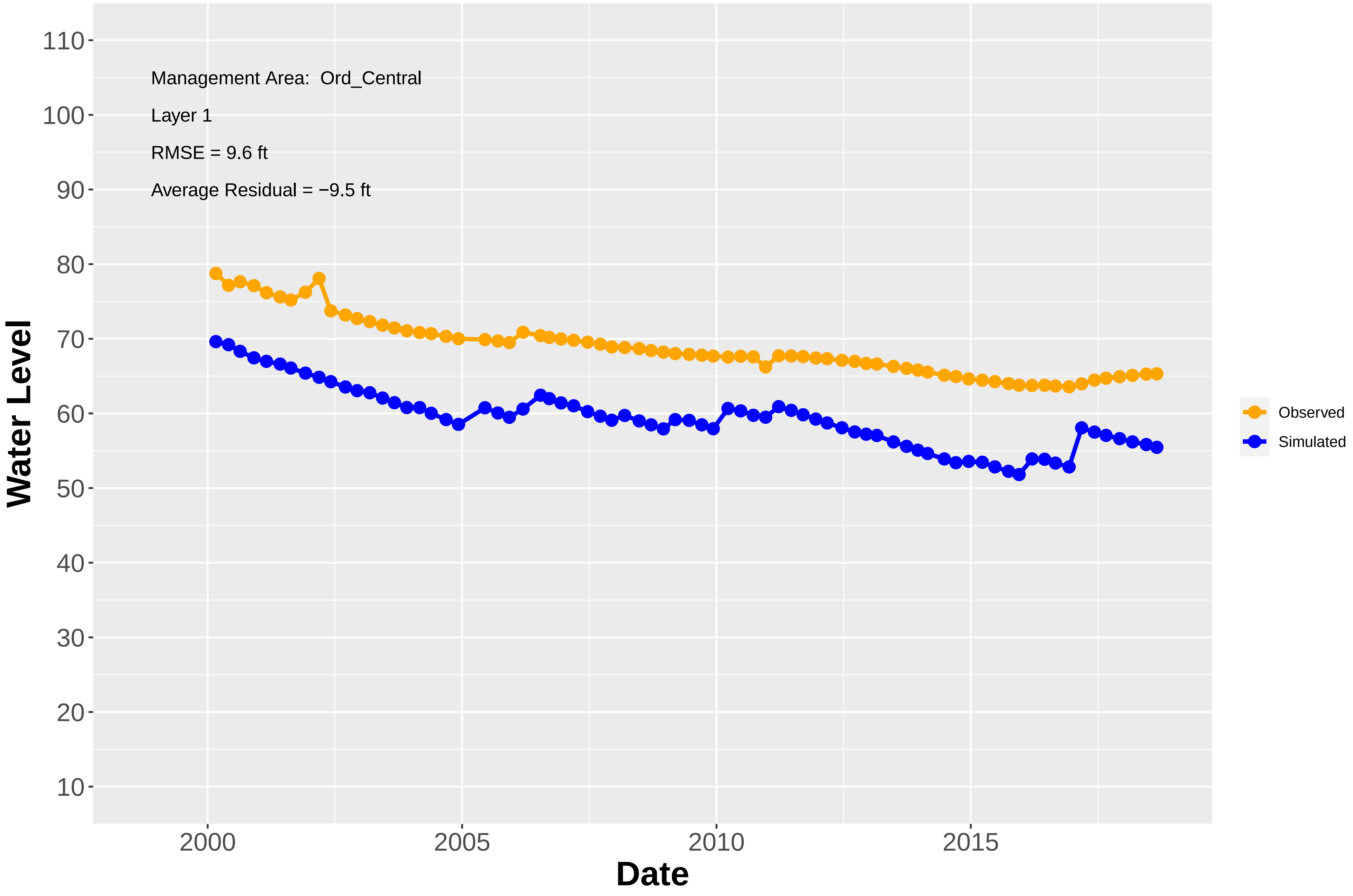

Hydrograph: MW−OU2−72−180
Management Area: Ord_East
Layer 5
RMSE = 4.7 ft
Average Residual = −4.0 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

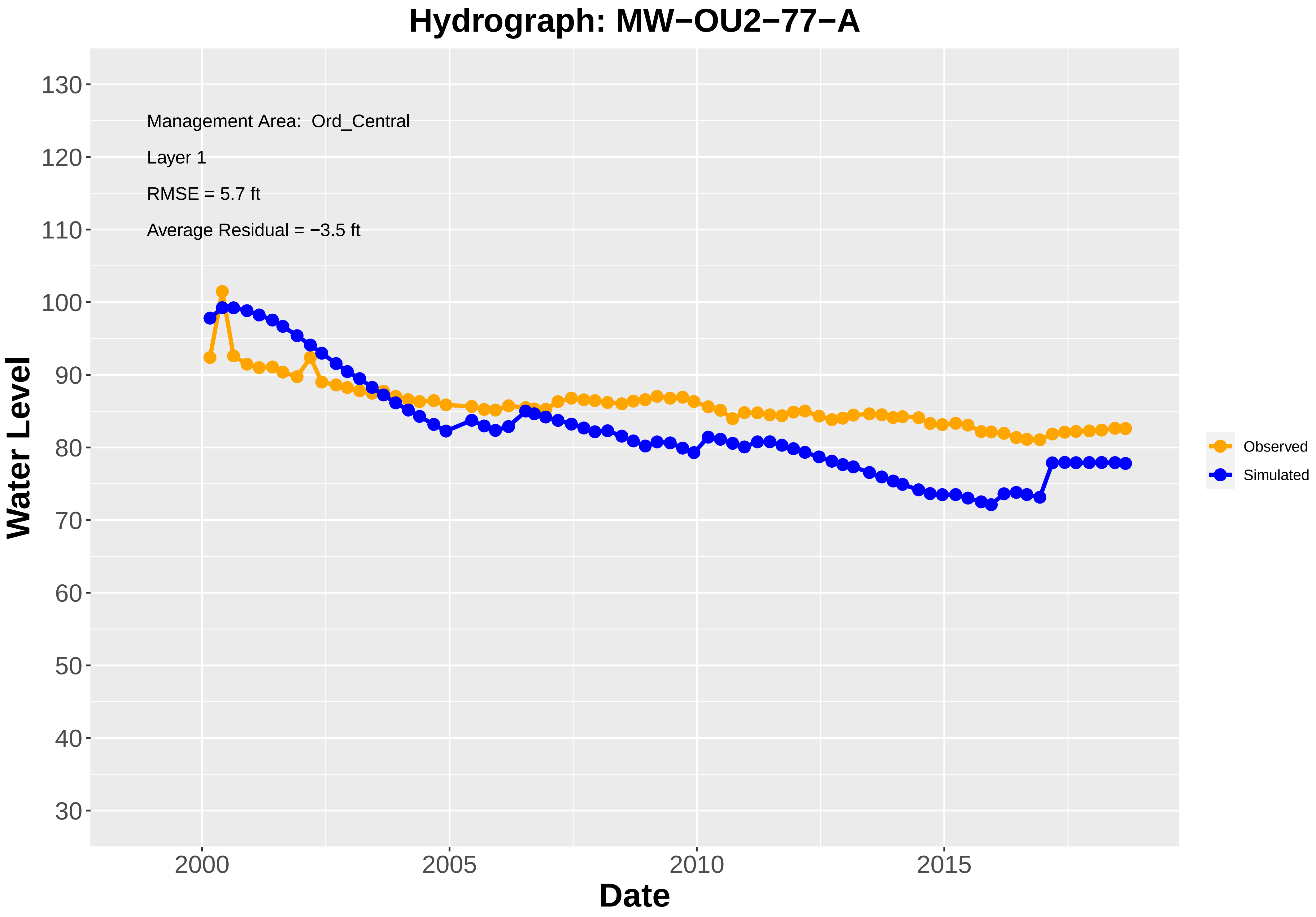

Hydrograph: MW−OU2−73−A
Management Area: Ord_Central
Layer 1
RMSE = 11.9 ft
Average Residual = −11.1 ft
Water Level
130
120
110
100
90
80
70
60
50
40
30
Date
2000
2005
2010
2015
Observed
Simulated

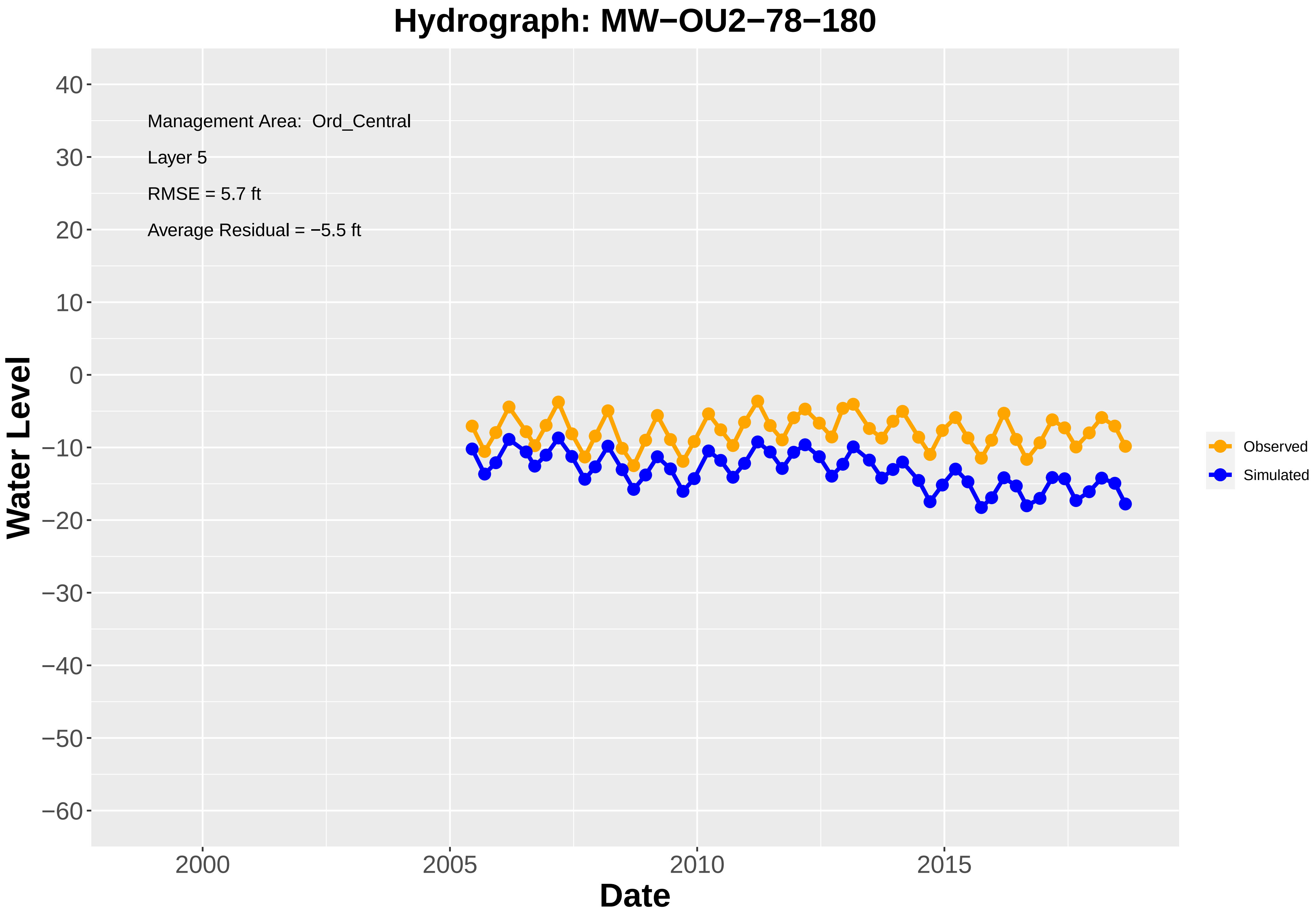

Hydrograph: MW−OU2−74−A
Management Area: Ord_Central
Layer 1
RMSE = 15.2 ft
Average Residual = −14.5 ft
Water Level
130
120
110
100
90
80
70
60
50
40
30
2000
2005
2010
2015
Date
Observed
Simulated

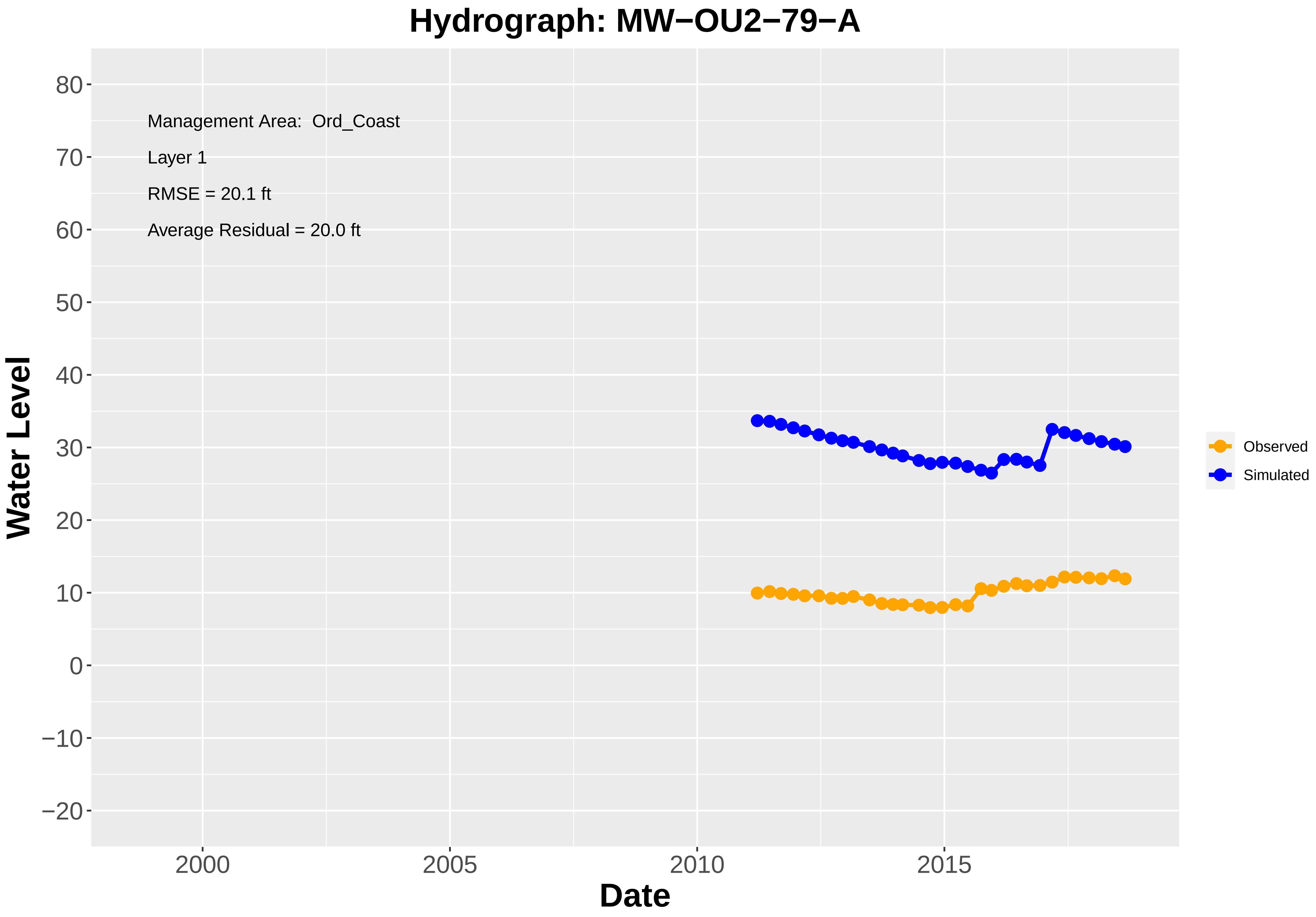

Hydrograph: MW−OU2−75−A
Management Area: Ord_Central
Layer 1
RMSE = 11.7 ft
Average Residual = −11.5 ft
Water Level
120
110
100
90
80
70
60
50
40
30
20
Date
2000
2005
2010
2015
Observed
Simulated

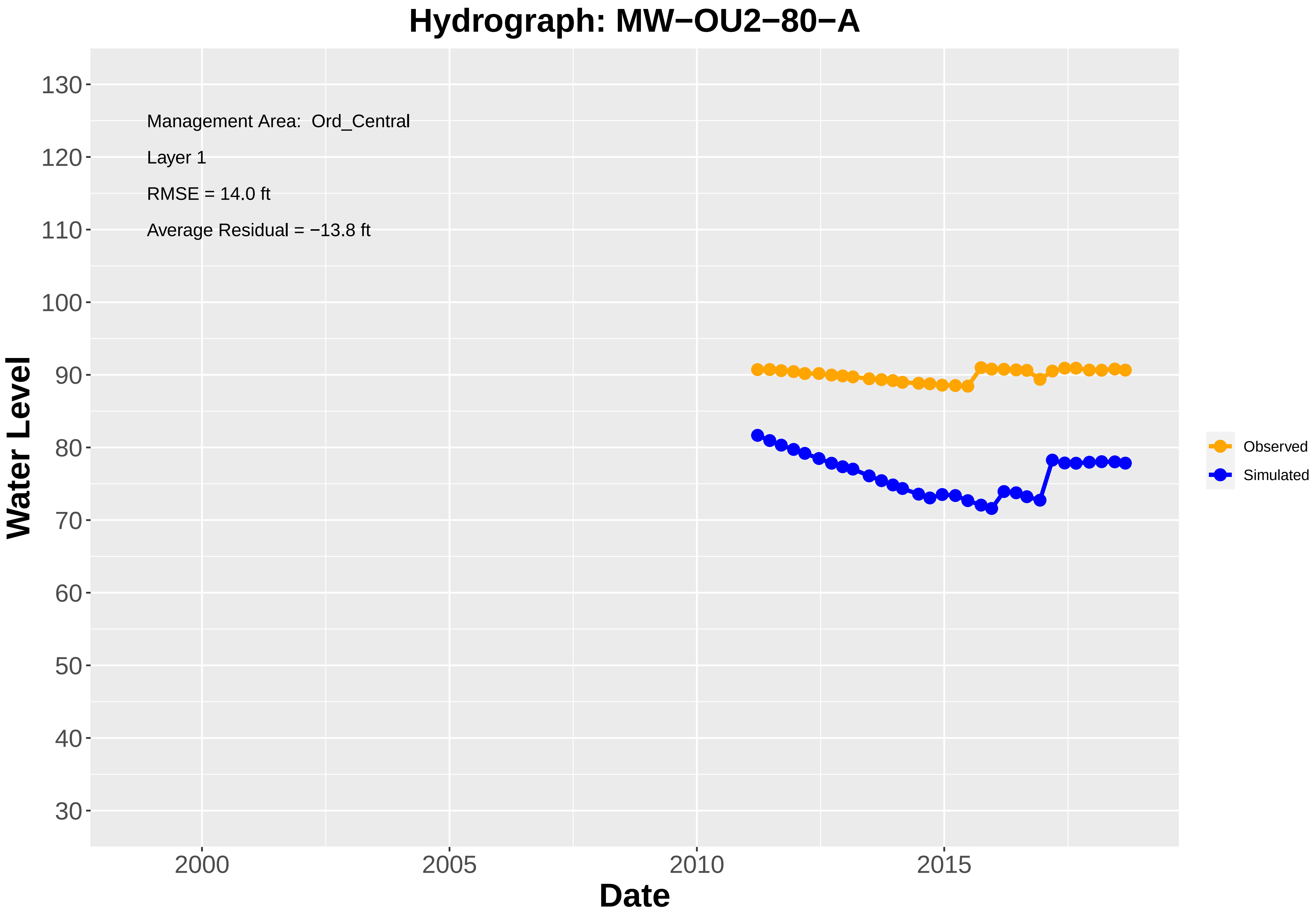
Hydrograph: MW−OU2−76−A

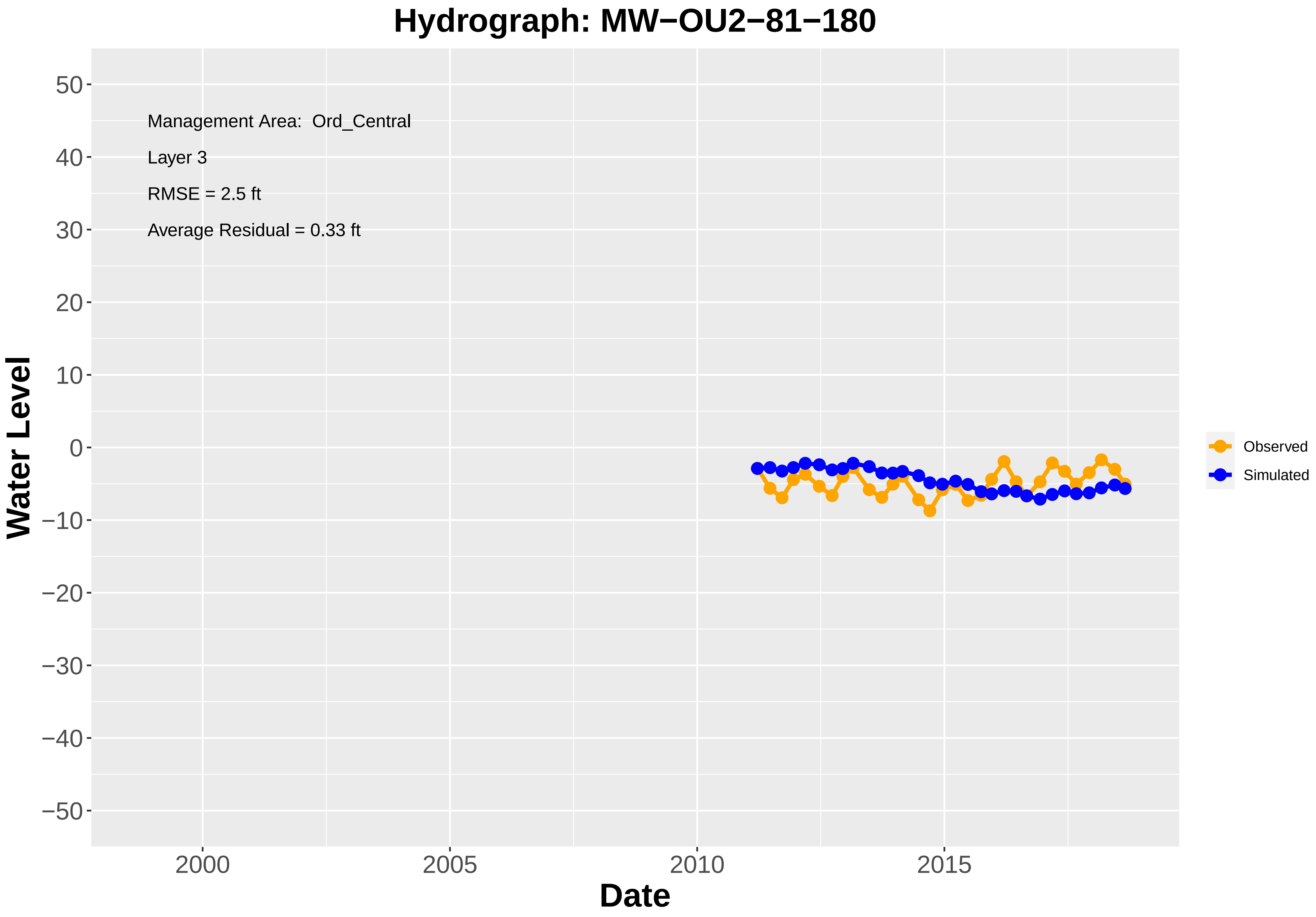


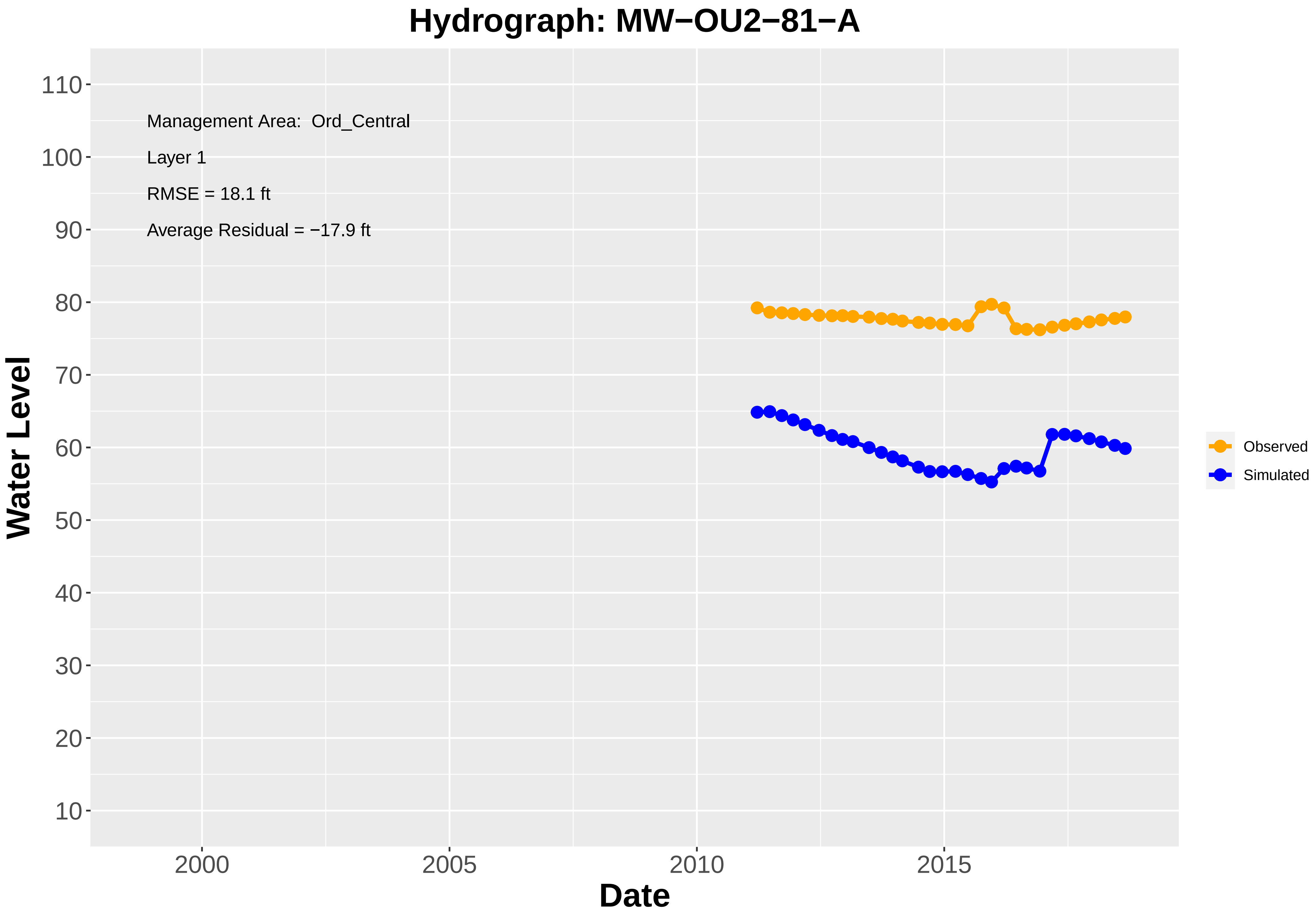

Hydrograph: MW−OU2−77−A
Management Area: Ord_Central
Layer 1
RMSE = 5.7 ft
Average Residual = −3.5 ft
Water Level
130
120
110
100
90
80
70
60
50
40
30
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: MW−OU2−78−180
Management Area: Ord_Central
Layer 5
RMSE = 5.7 ft
Average Residual = −5.5 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
Date
2000
2005
2010
2015
Observed
Simulated

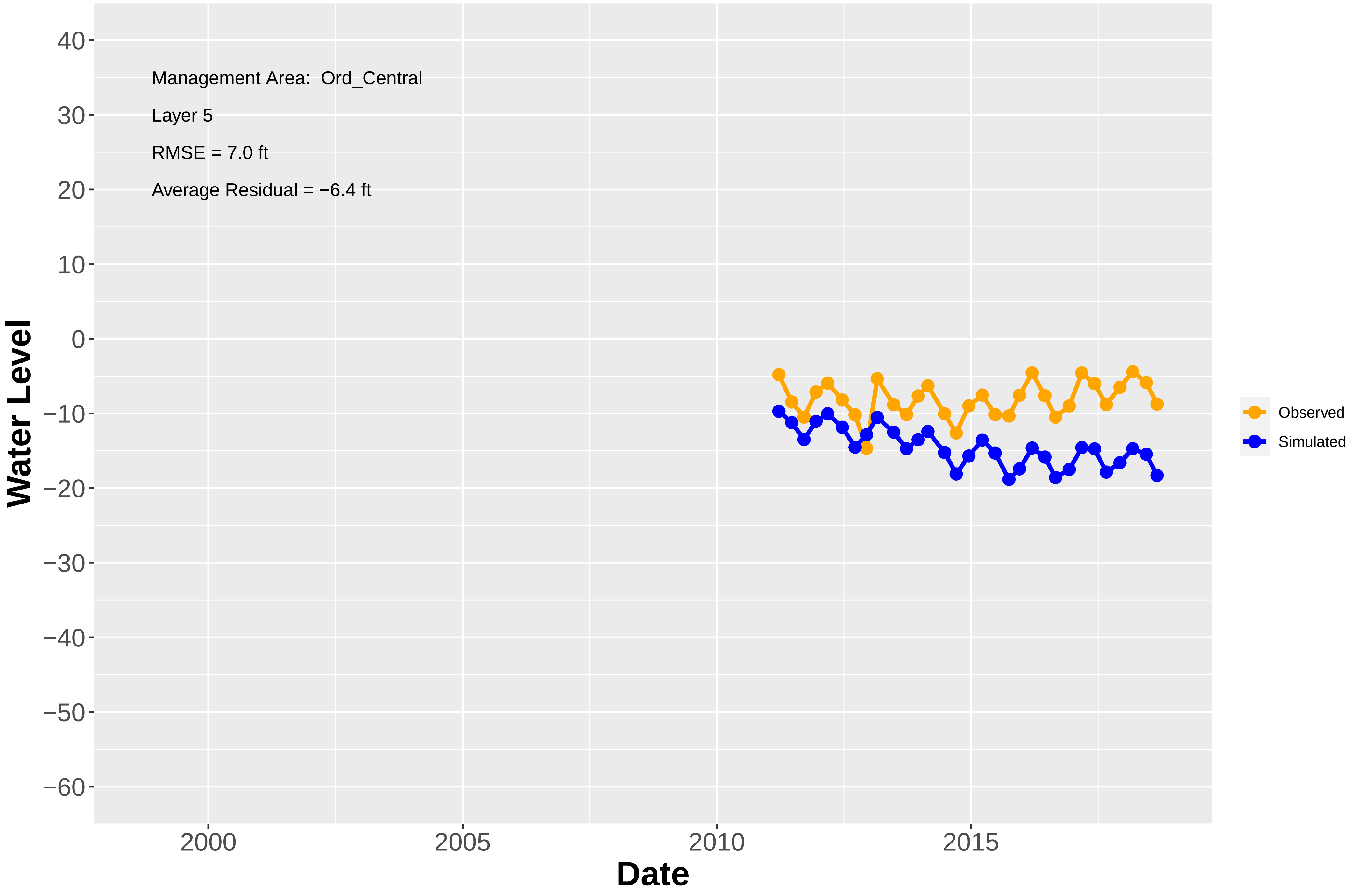

Hydrograph: MW−OU2−79−A
Management Area: Ord_Coast
Layer 1
RMSE = 20.1 ft
Average Residual = 20.0 ft
Water Level
80
70
60
50
40
30
20
10
0
−10
−20
2000
2005
2010
2015
Date
Observed
Simulated

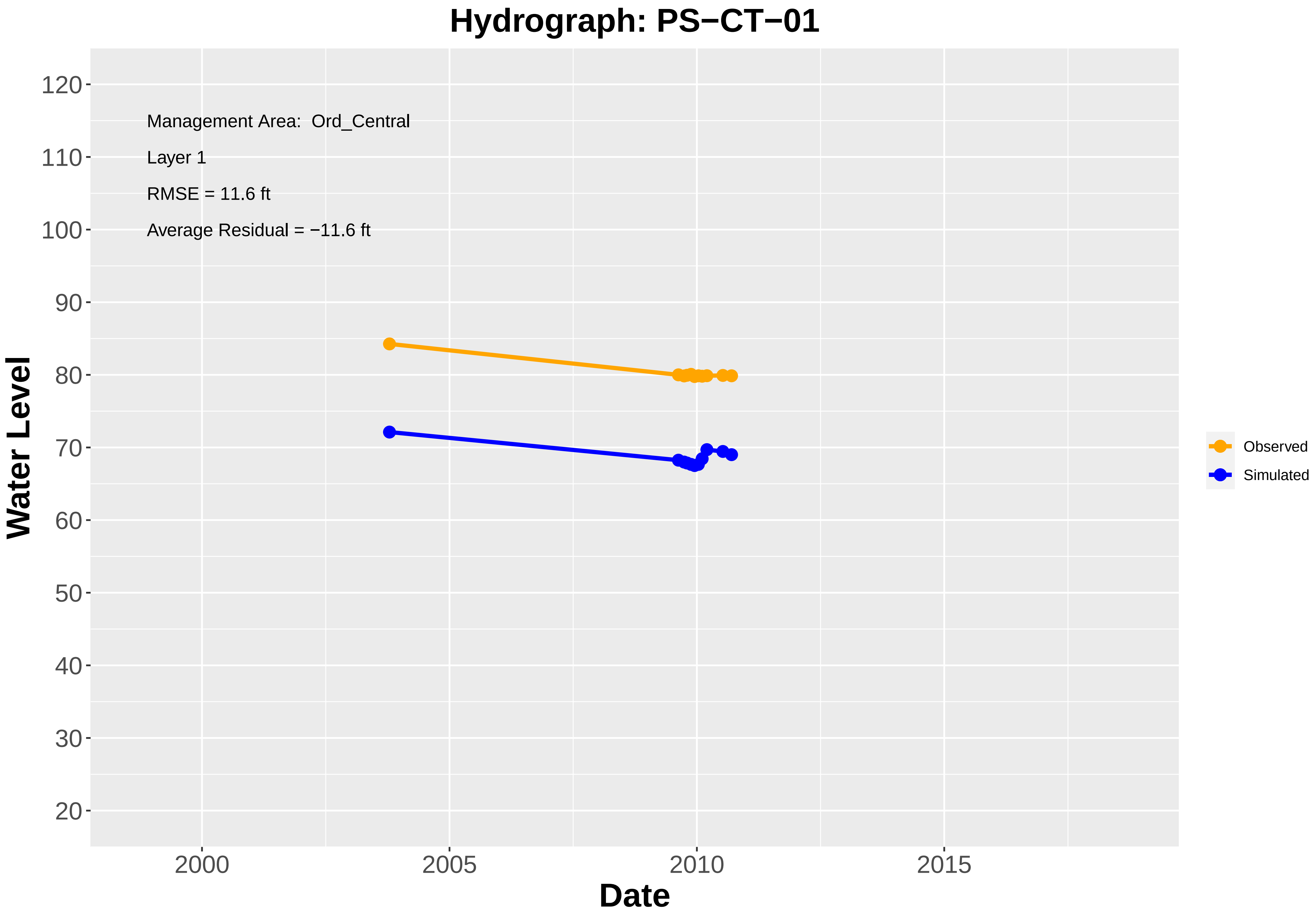

Hydrograph: MW−OU2−80−A
Management Area: Ord_Central
Layer 1
RMSE = 14.0 ft
Average Residual = −13.8 ft
Water Level
130
120
110
100
90
80
70
60
50
40
30
Date
2000
2005
2010
2015
Observed
Simulated

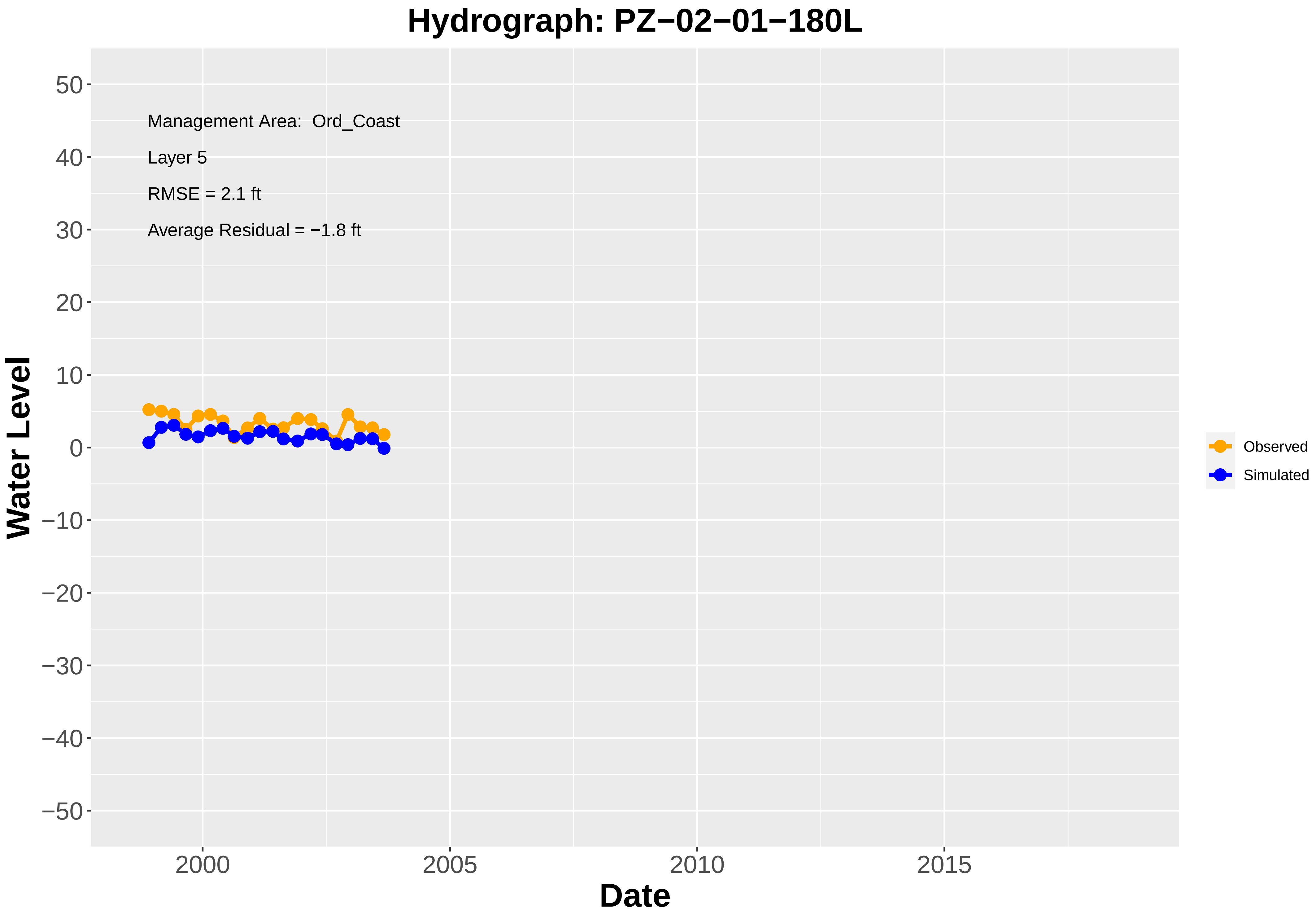

Hydrograph: MW−OU2−81−180
Management Area: Ord_Central
Layer 3
RMSE = 2.5 ft
Average Residual = 0.33 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

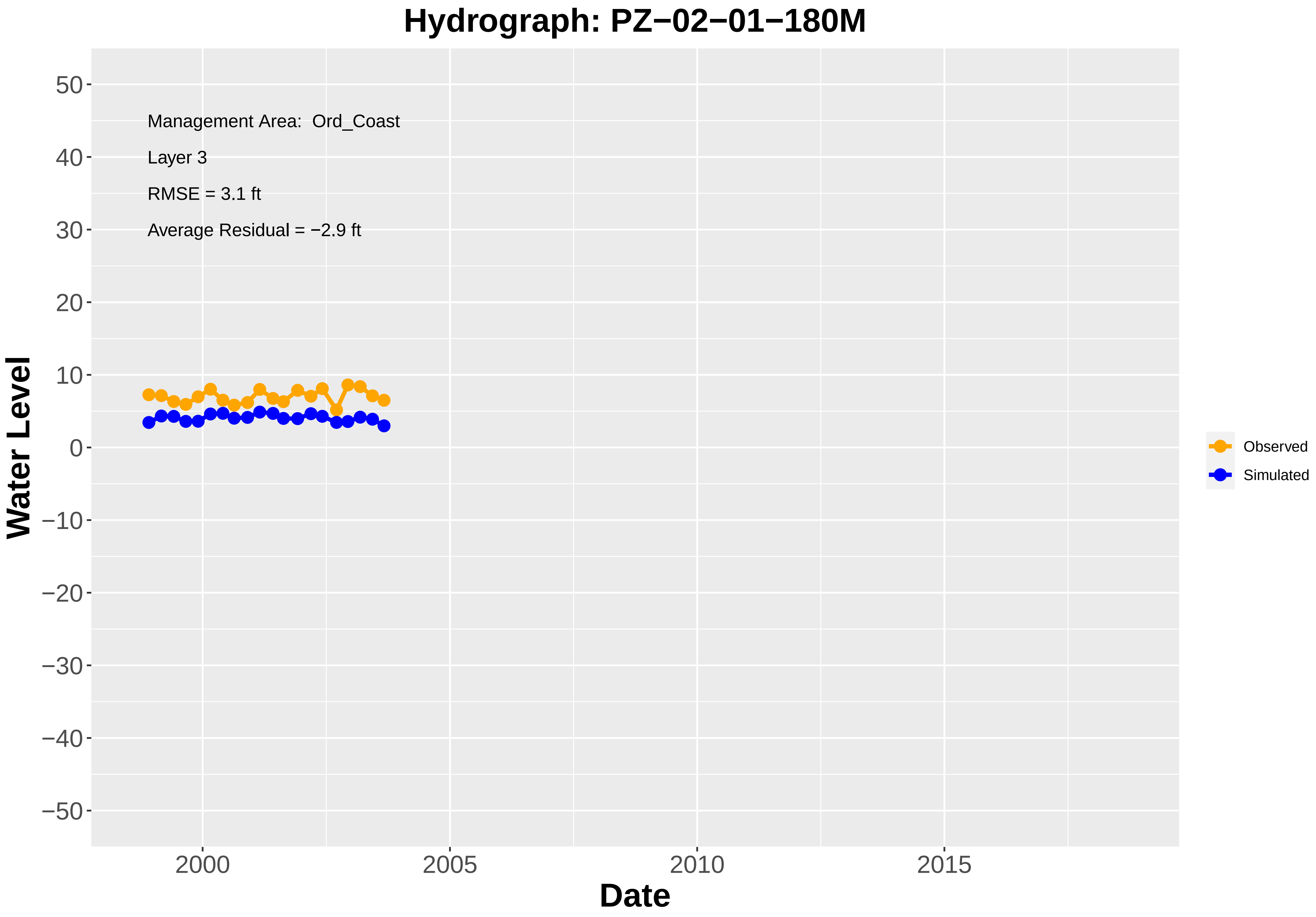

Hydrograph: MW−OU2−81−A
Management Area: Ord_Central
Layer 1
RMSE = 18.1 ft
Average Residual = −17.9 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

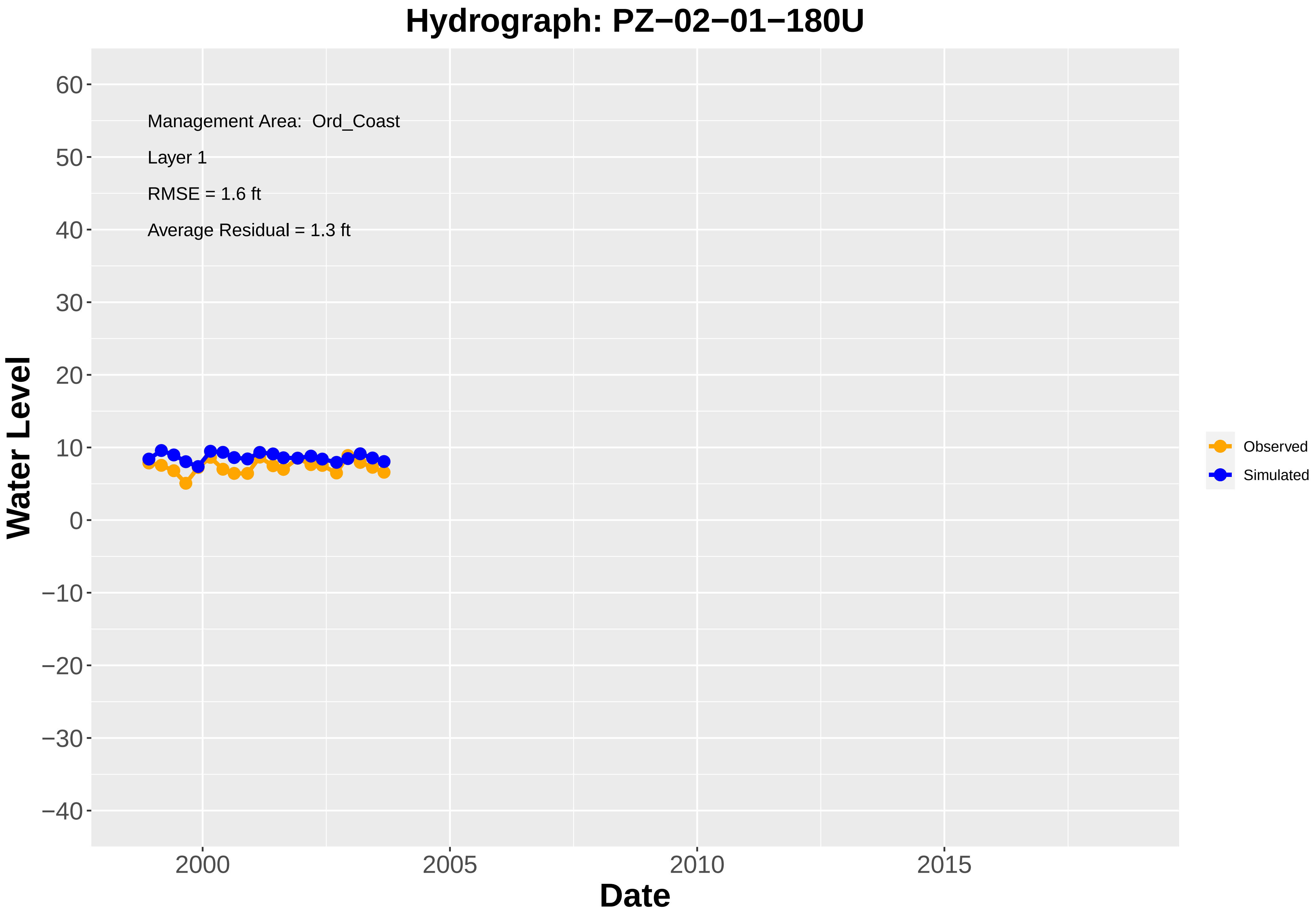
Hydrograph: MW−OU2−82−180



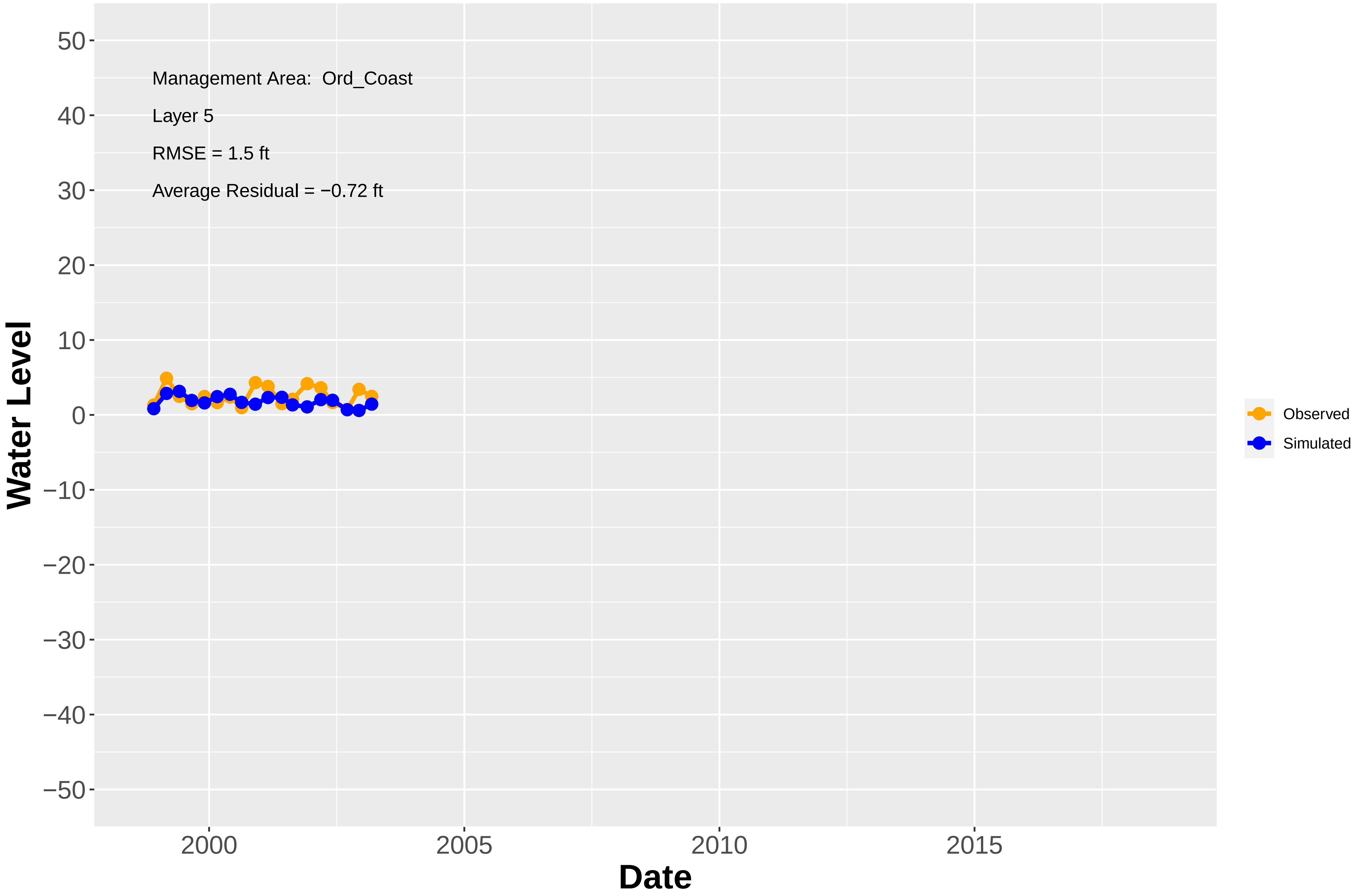

Hydrograph: PS−CT−01
Management Area: Ord_Central
Layer 1
RMSE = 11.6 ft
Average Residual = −11.6 ft
120
110
100
90
80
70
60
50
40
30
20
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

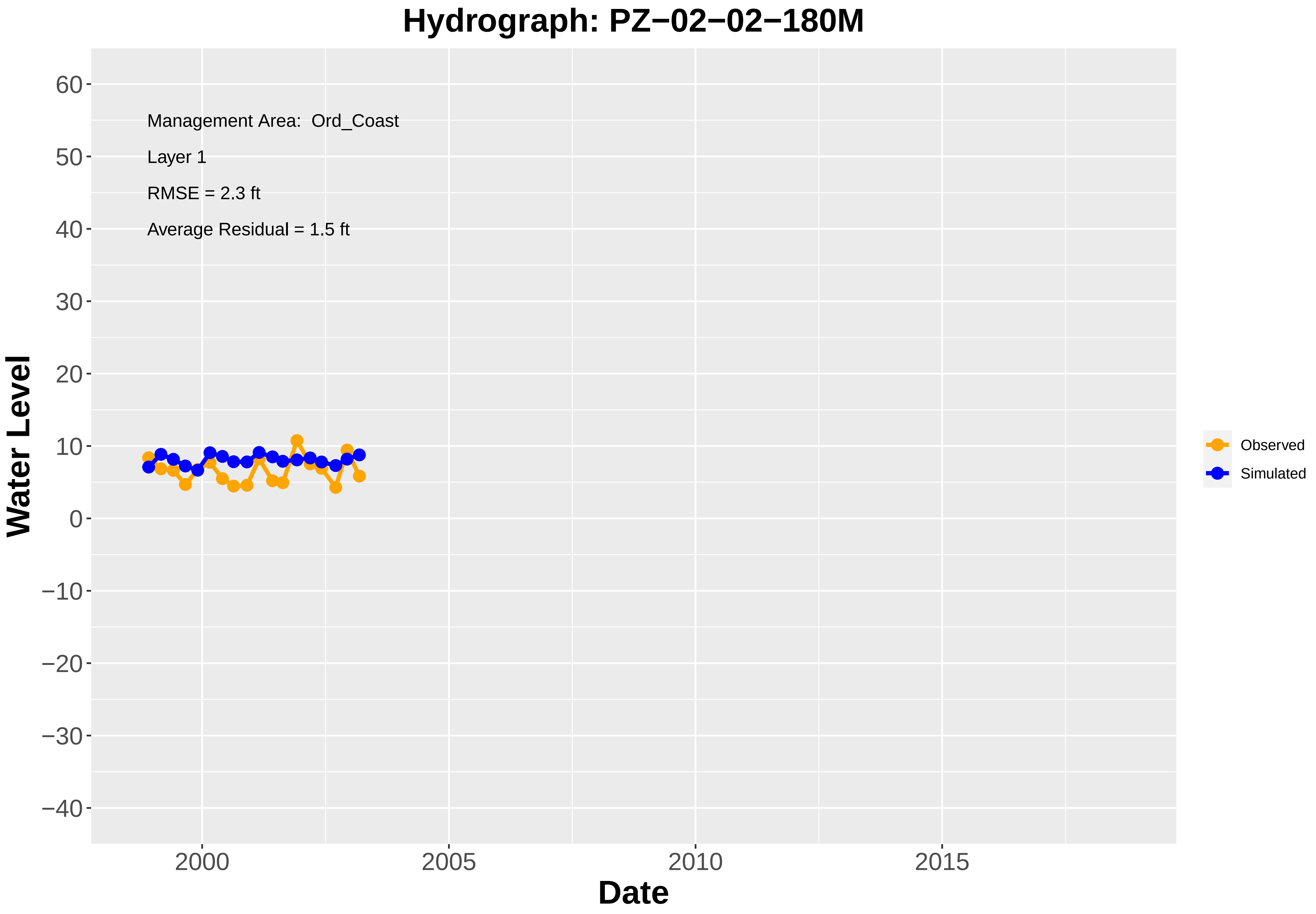

Hydrograph: PZ−02−01−180L
Management Area: Ord_Coast
Layer 5
RMSE = 2.1 ft
Average Residual = −1.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

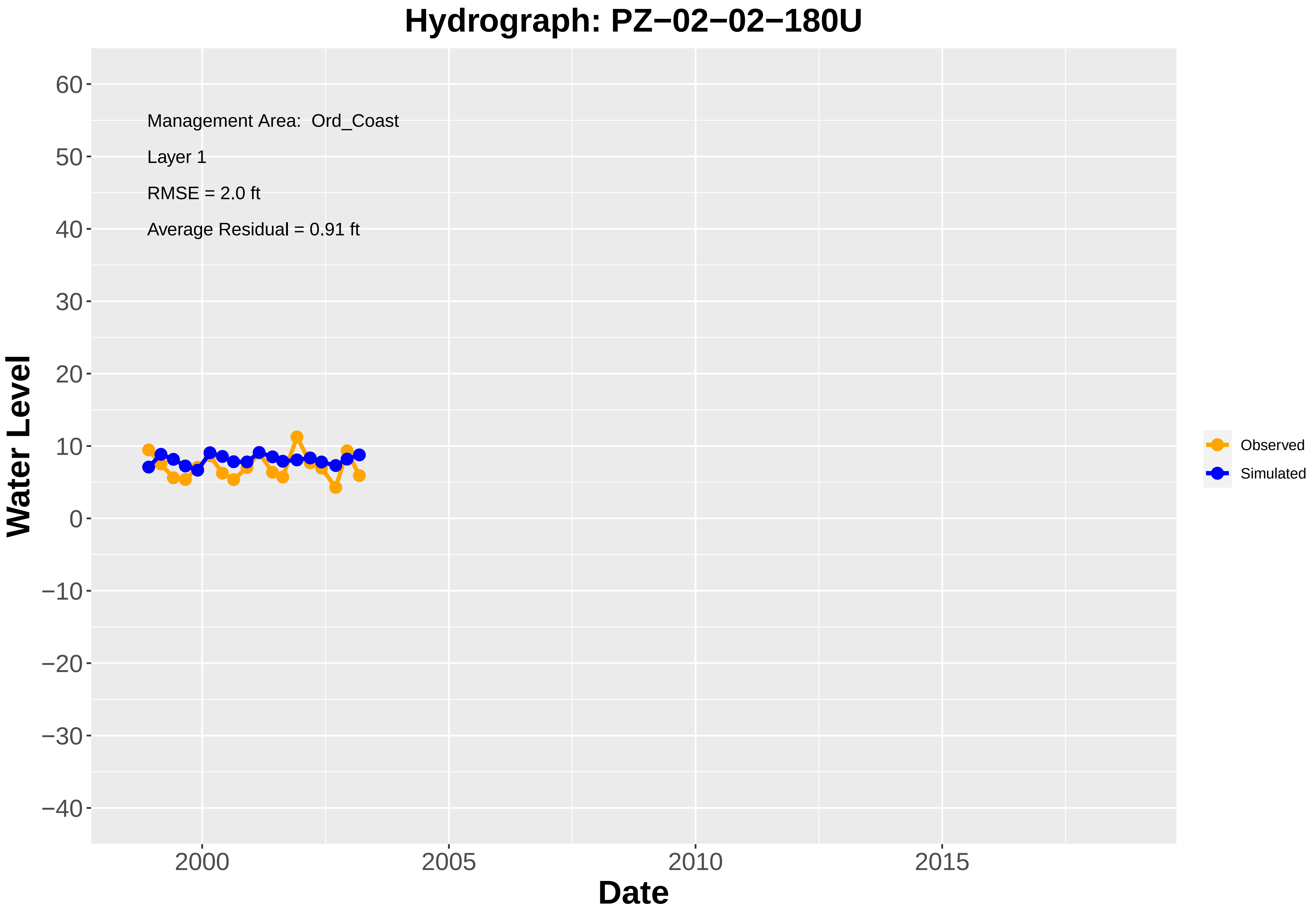

Hydrograph: PZ−02−01−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.1 ft
Average Residual = −2.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

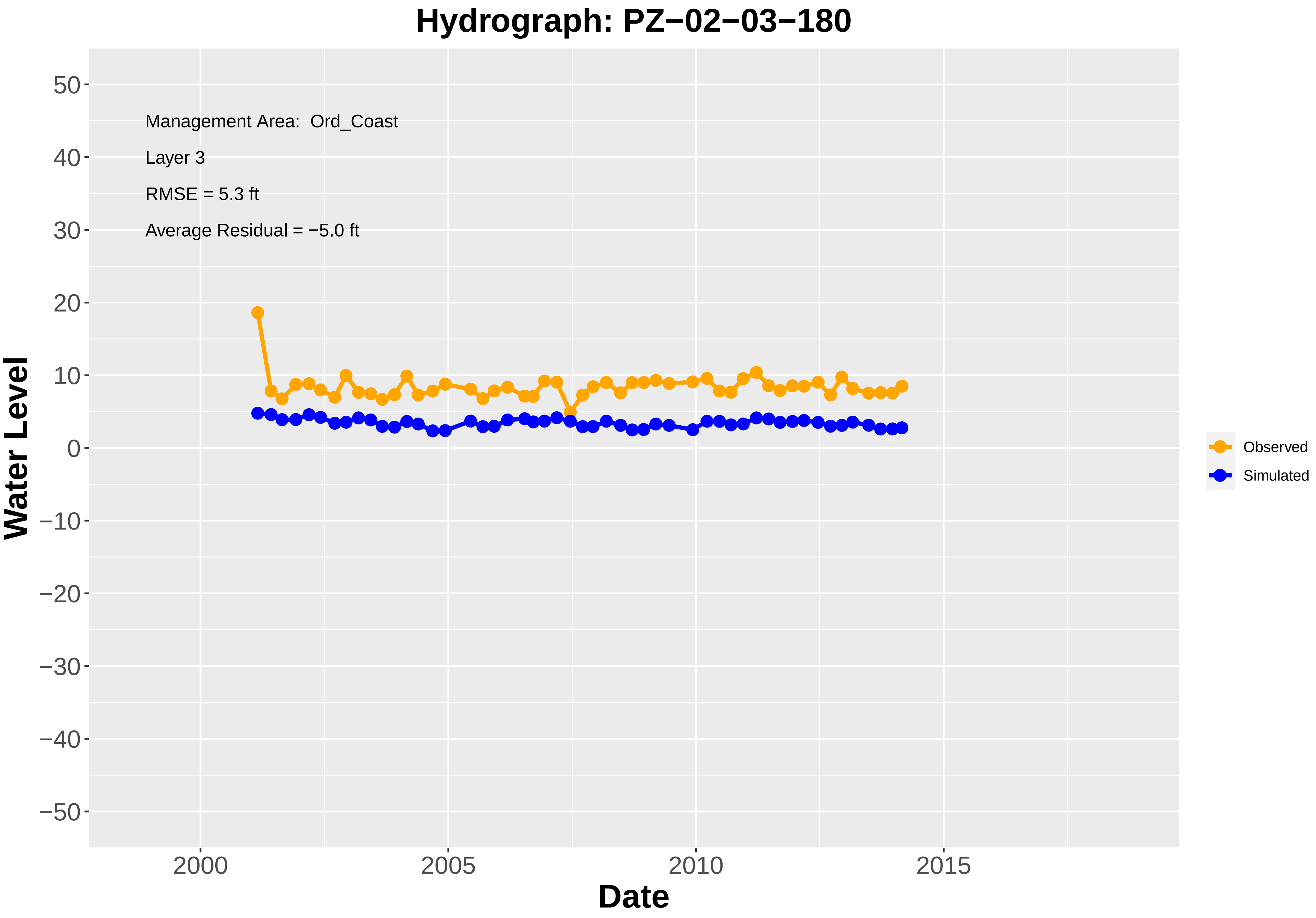

Hydrograph: PZ−02−01−180U
Management Area: Ord_Coast
Layer 1
RMSE = 1.6 ft
Average Residual = 1.3 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

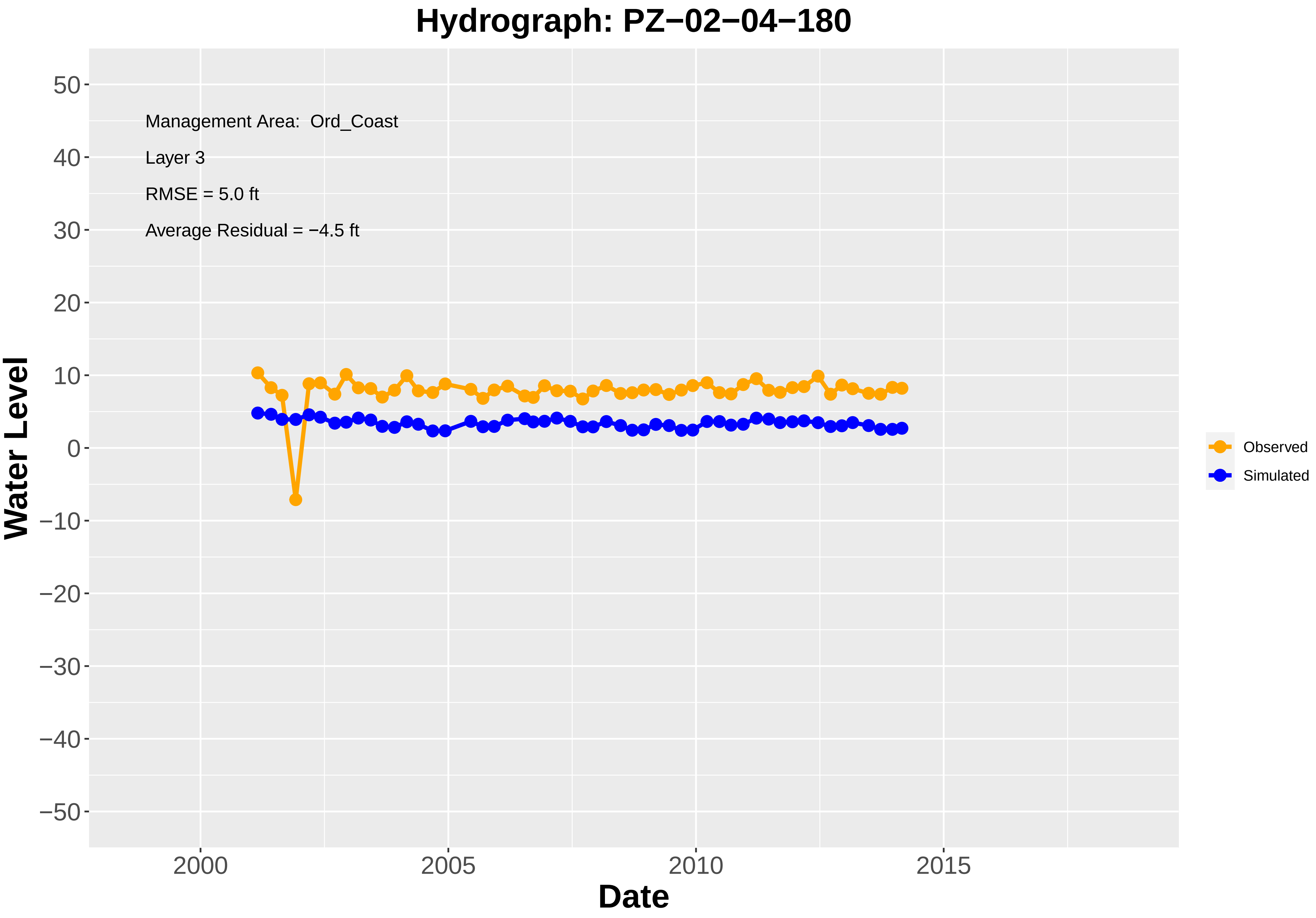
Hydrograph: PZ−02−02−180L

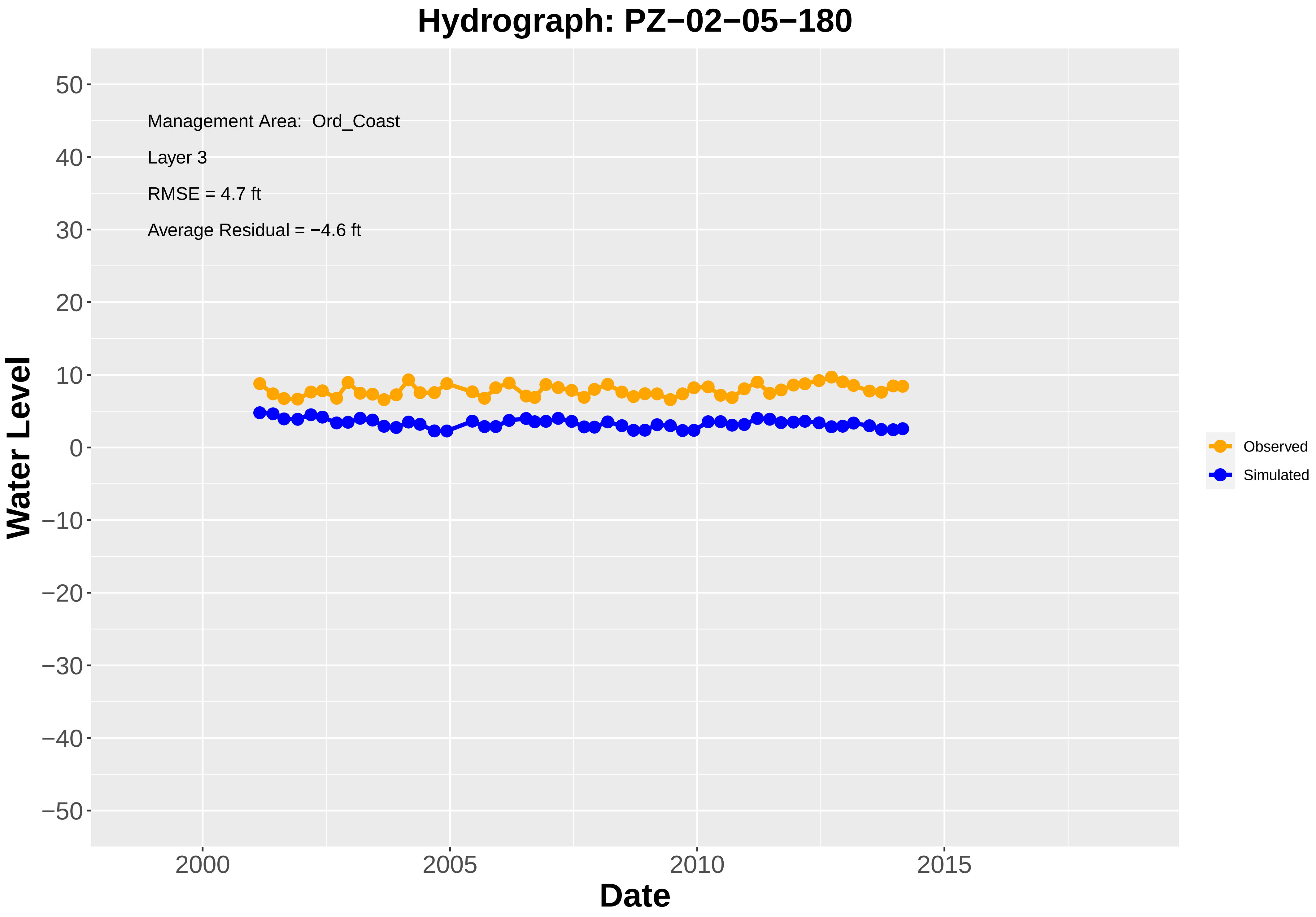


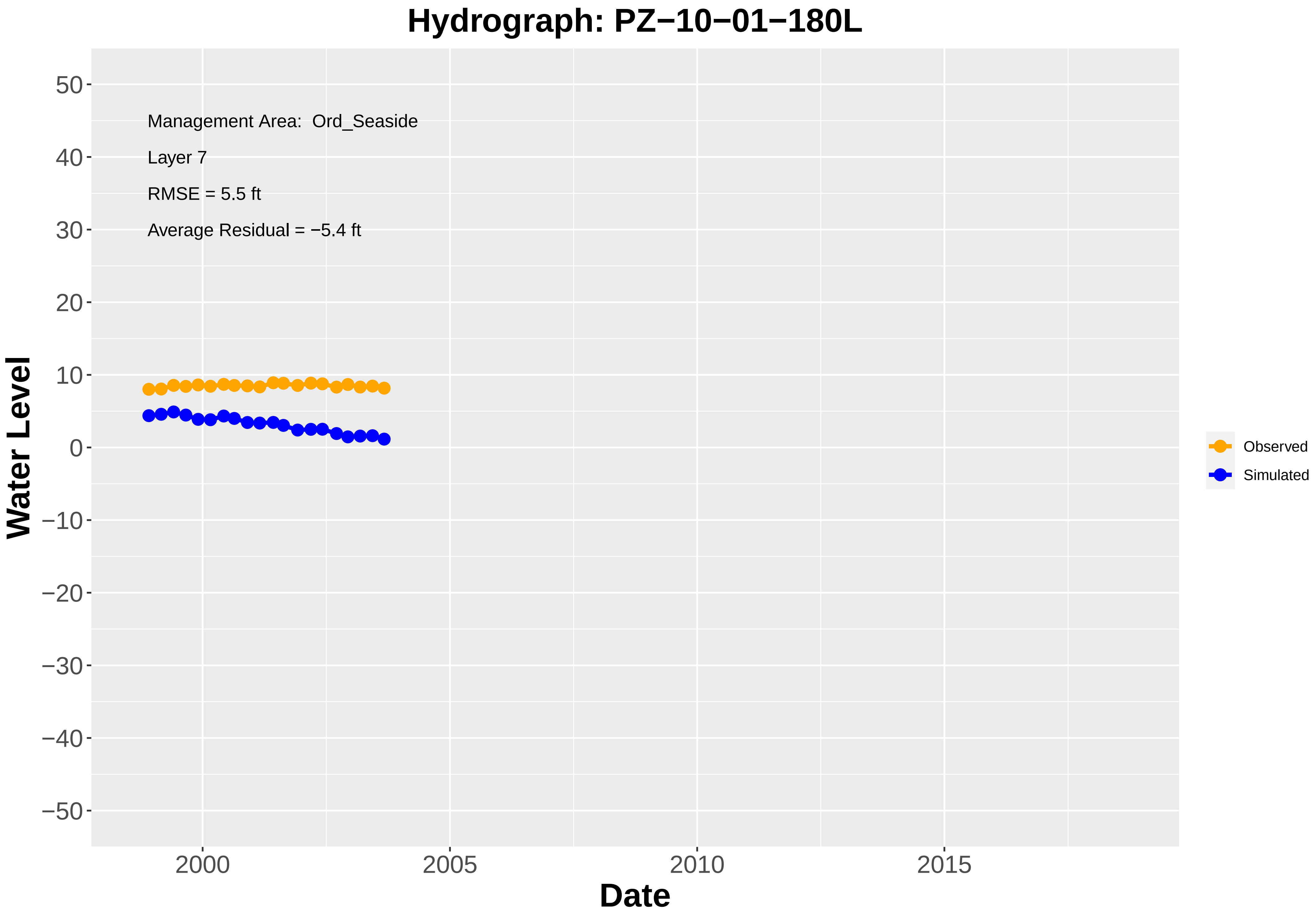

Hydrograph: PZ−02−02−180M
Management Area: Ord_Coast
Layer 1
RMSE = 2.3 ft
Average Residual = 1.5 ft
Water Level
60
50
40
30
20
10
0
−10
−20
−30
−40
Date
2000
2005
2010
2015
Observed
Simulated

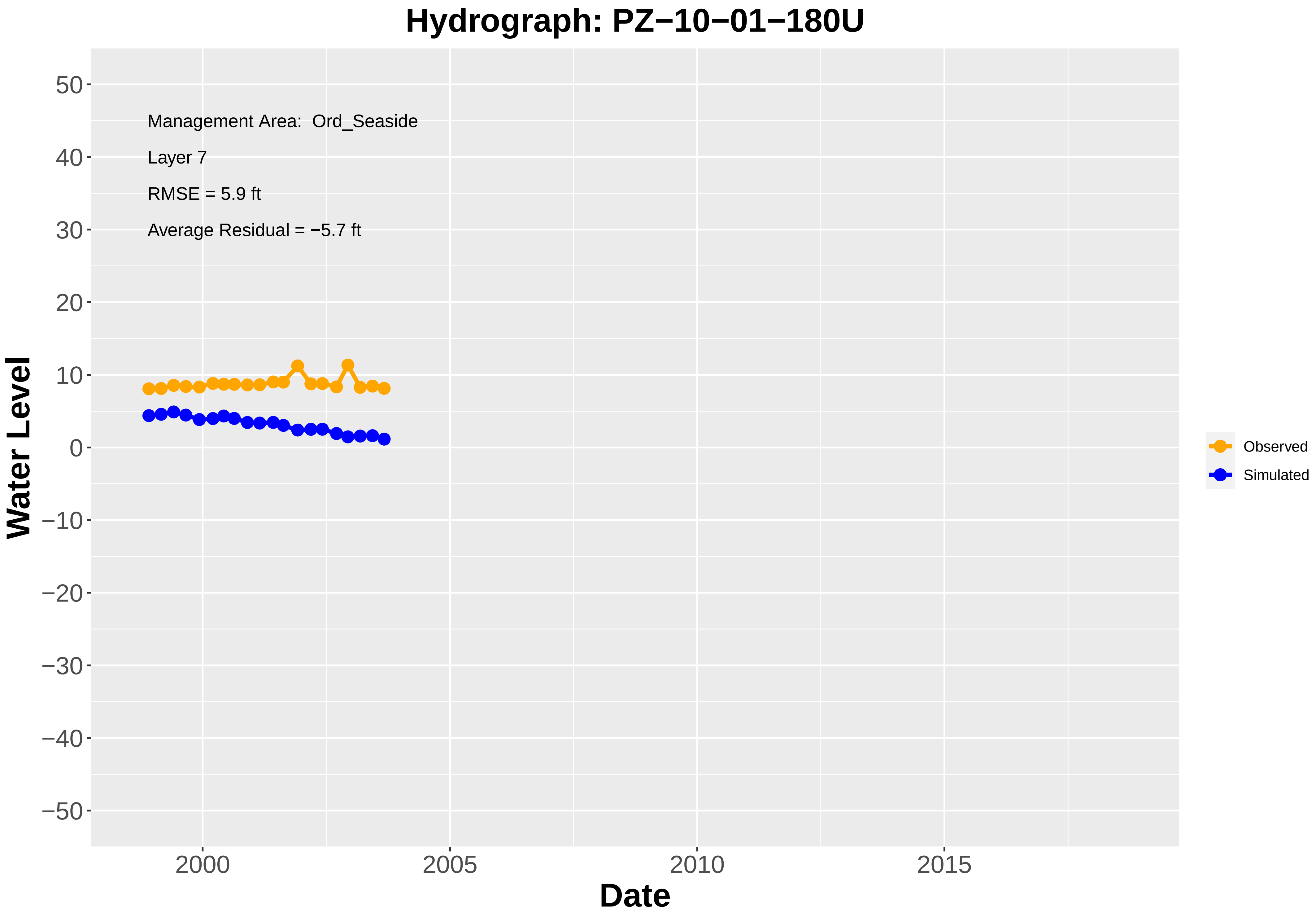

Hydrograph: PZ−02−02−180U
Management Area: Ord_Coast
Layer 1
RMSE = 2.0 ft
Average Residual = 0.91 ft
60
50
40
30
20
10
0
−10
−20
−30
−40
Water Level
2000
2005
2010
2015
Date
Observed
Simulated

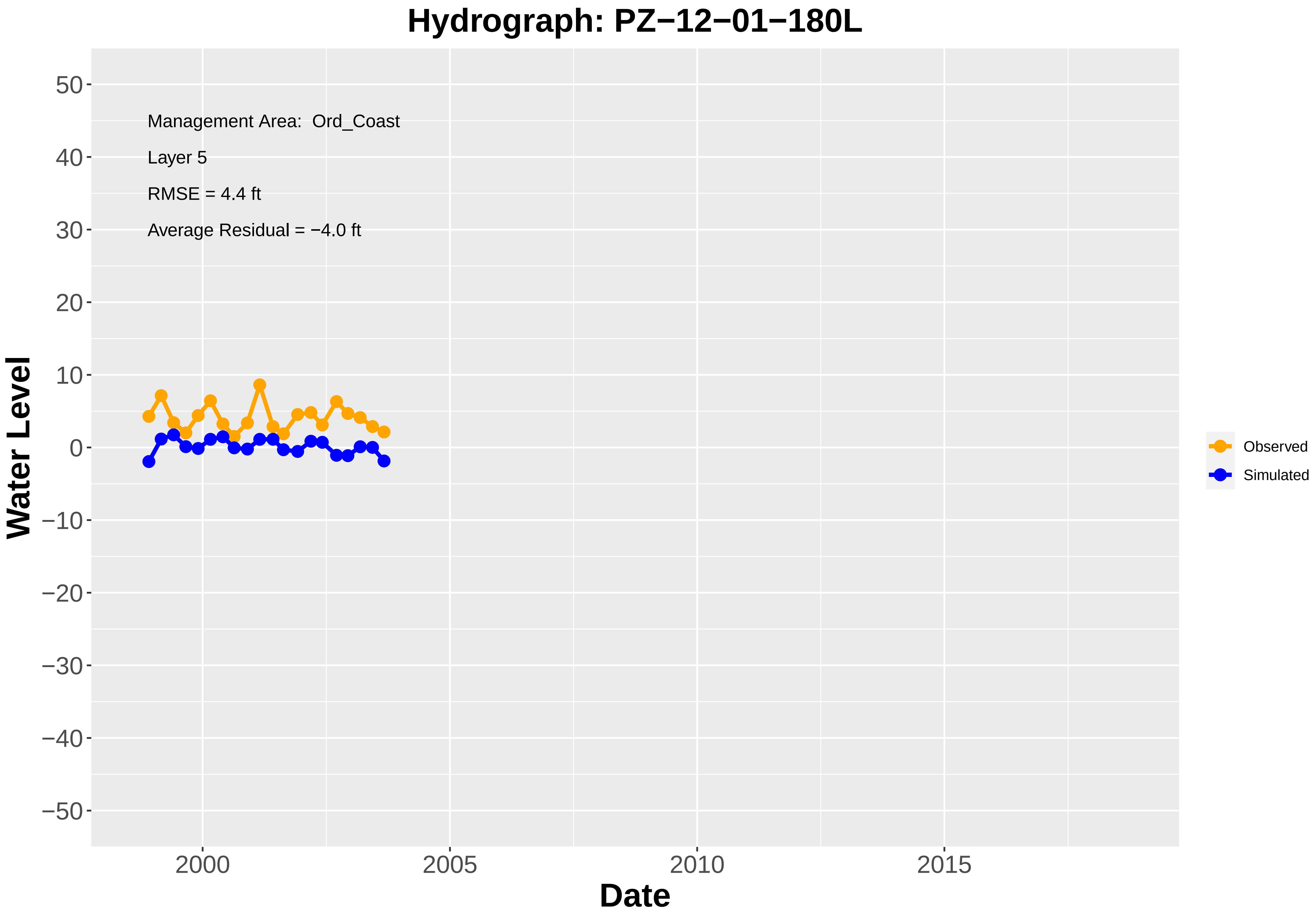

Hydrograph: PZ−02−03−180
Management Area: Ord_Coast
Layer 3
RMSE = 5.3 ft
Average Residual = −5.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

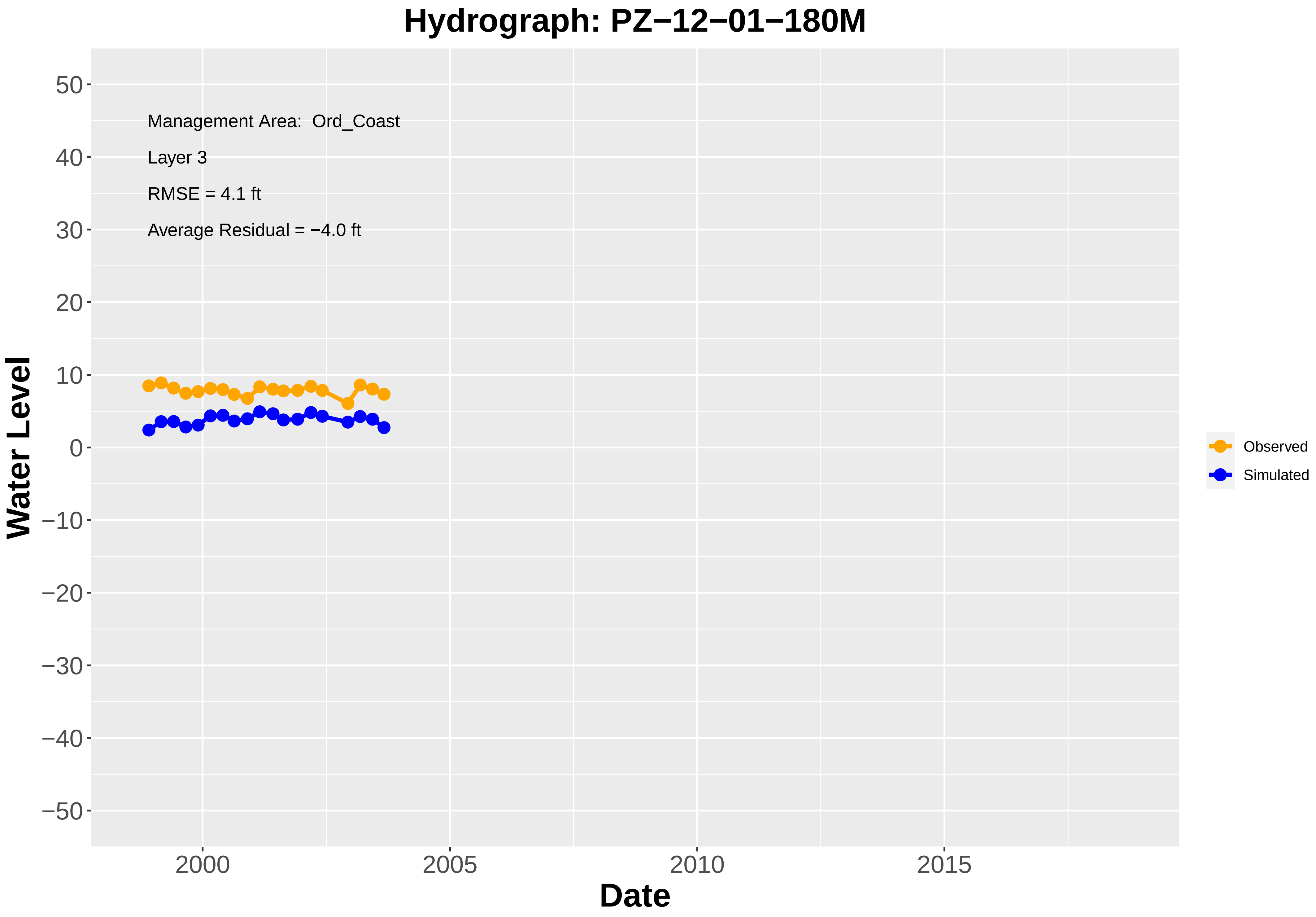

Hydrograph: PZ−02−04−180
Management Area: Ord_Coast
Layer 3
RMSE = 5.0 ft
Average Residual = −4.5 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

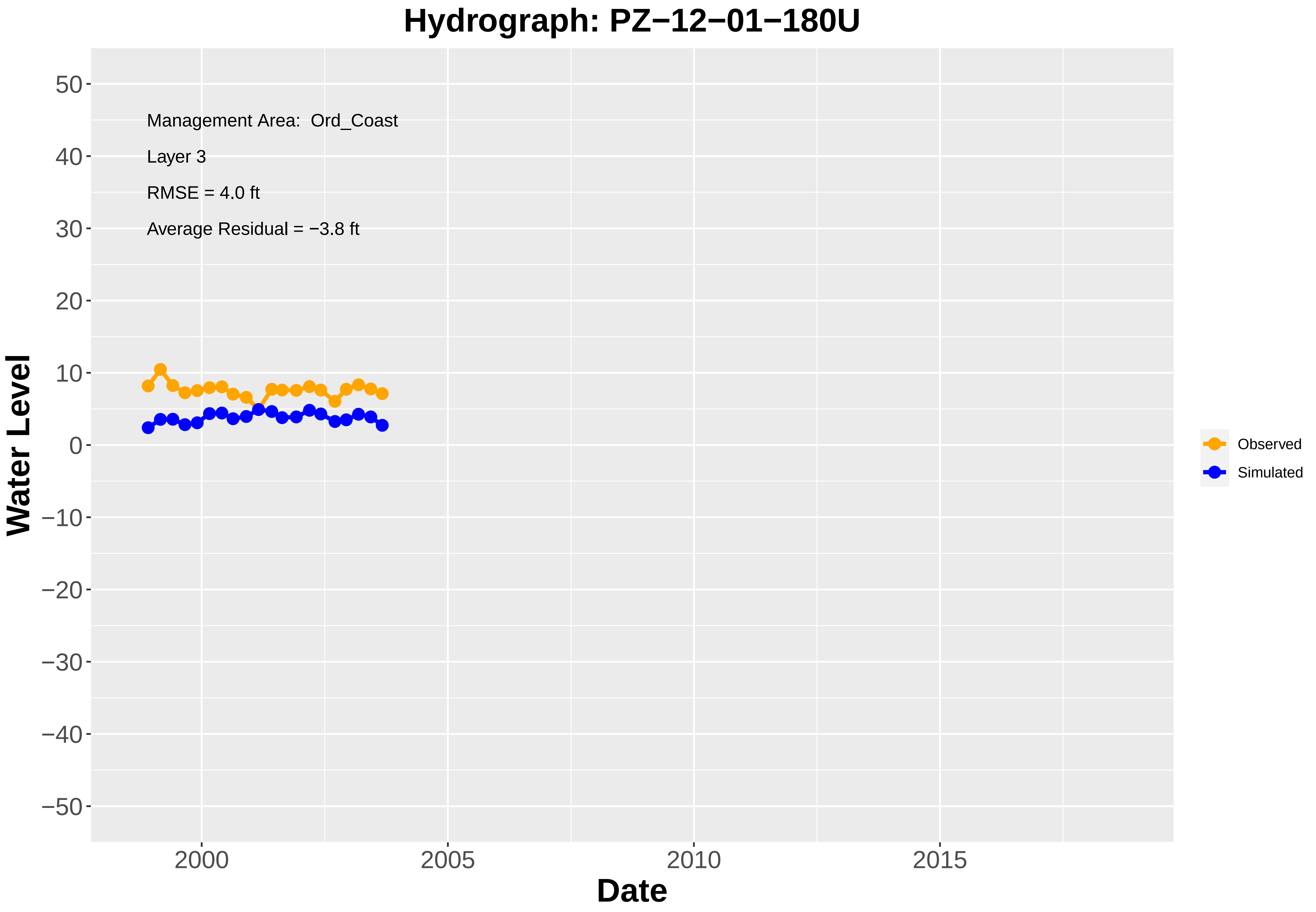

Hydrograph: PZ−02−05−180
Management Area: Ord_Coast
Layer 3
RMSE = 4.7 ft
Average Residual = −4.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: PZ−10−01−180L
Management Area: Ord_Seaside
Layer 7
RMSE = 5.5 ft
Average Residual = −5.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated

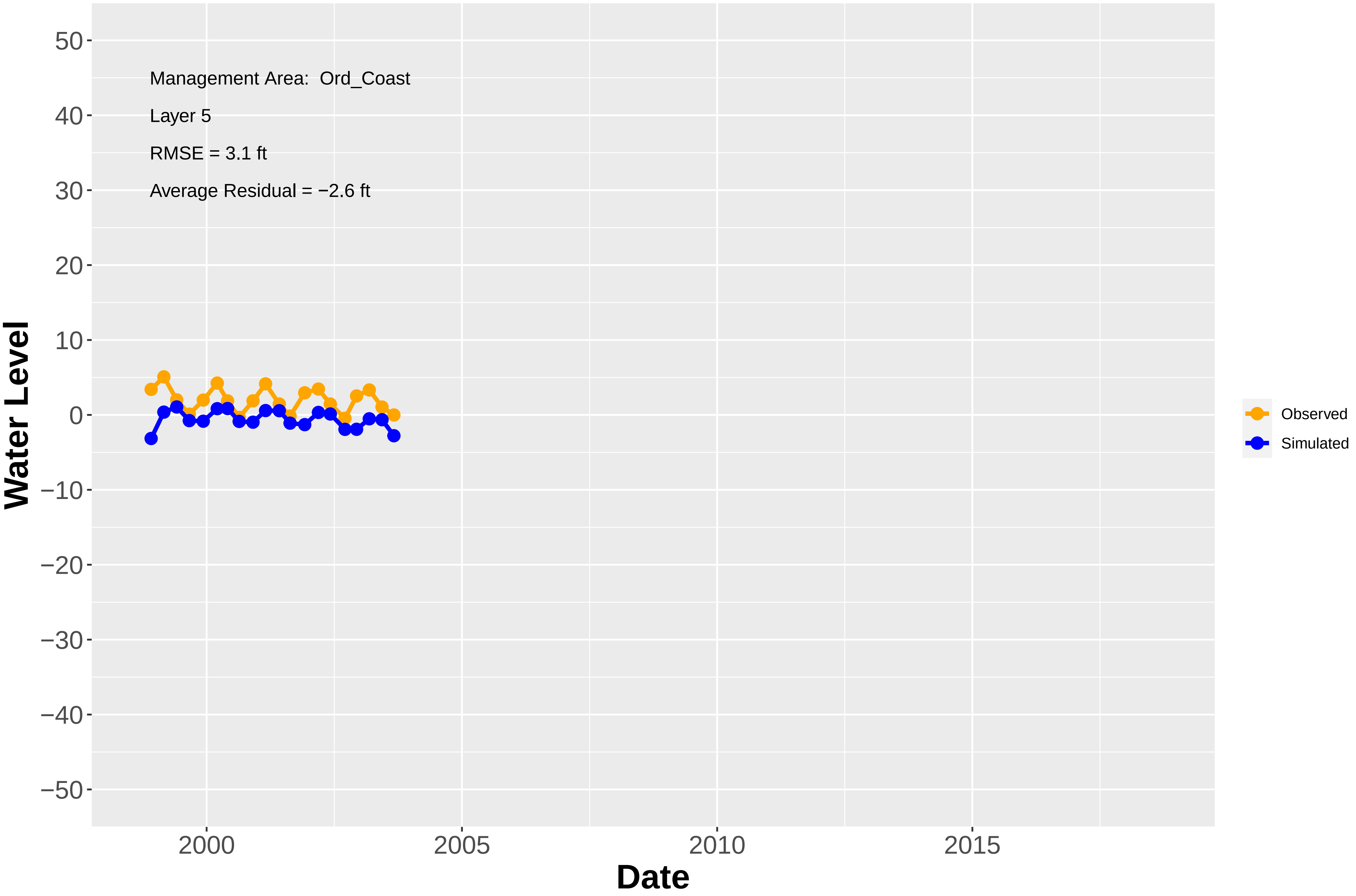

Hydrograph: PZ−10−01−180U
Management Area: Ord_Seaside
Layer 7
RMSE = 5.9 ft
Average Residual = −5.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: PZ−12−01−180L
Management Area: Ord_Coast
Layer 5
RMSE = 4.4 ft
Average Residual = −4.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

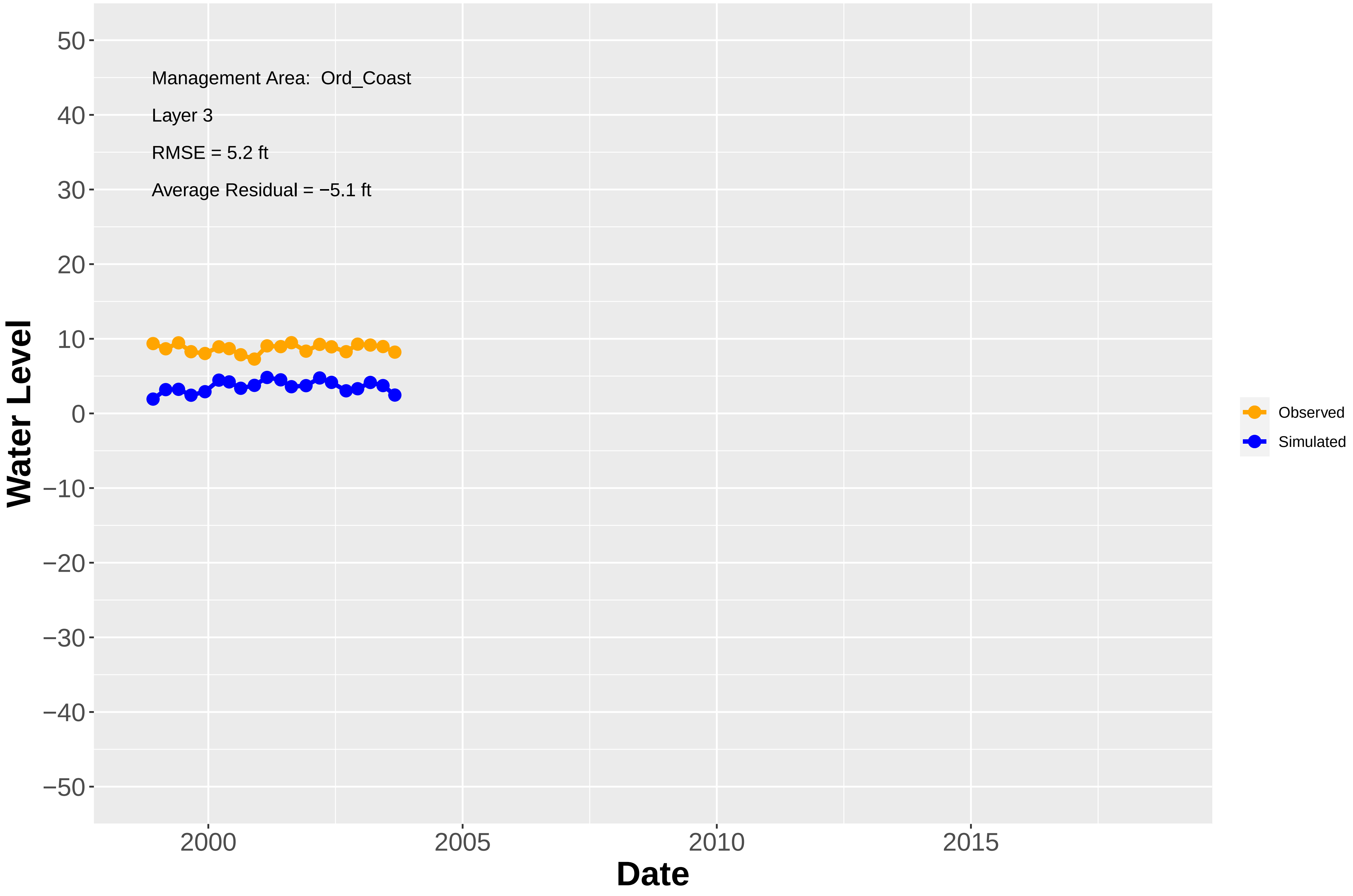

Hydrograph: PZ−12−01−180M
Management Area: Ord_Coast
Layer 3
RMSE = 4.1 ft
Average Residual = −4.0 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

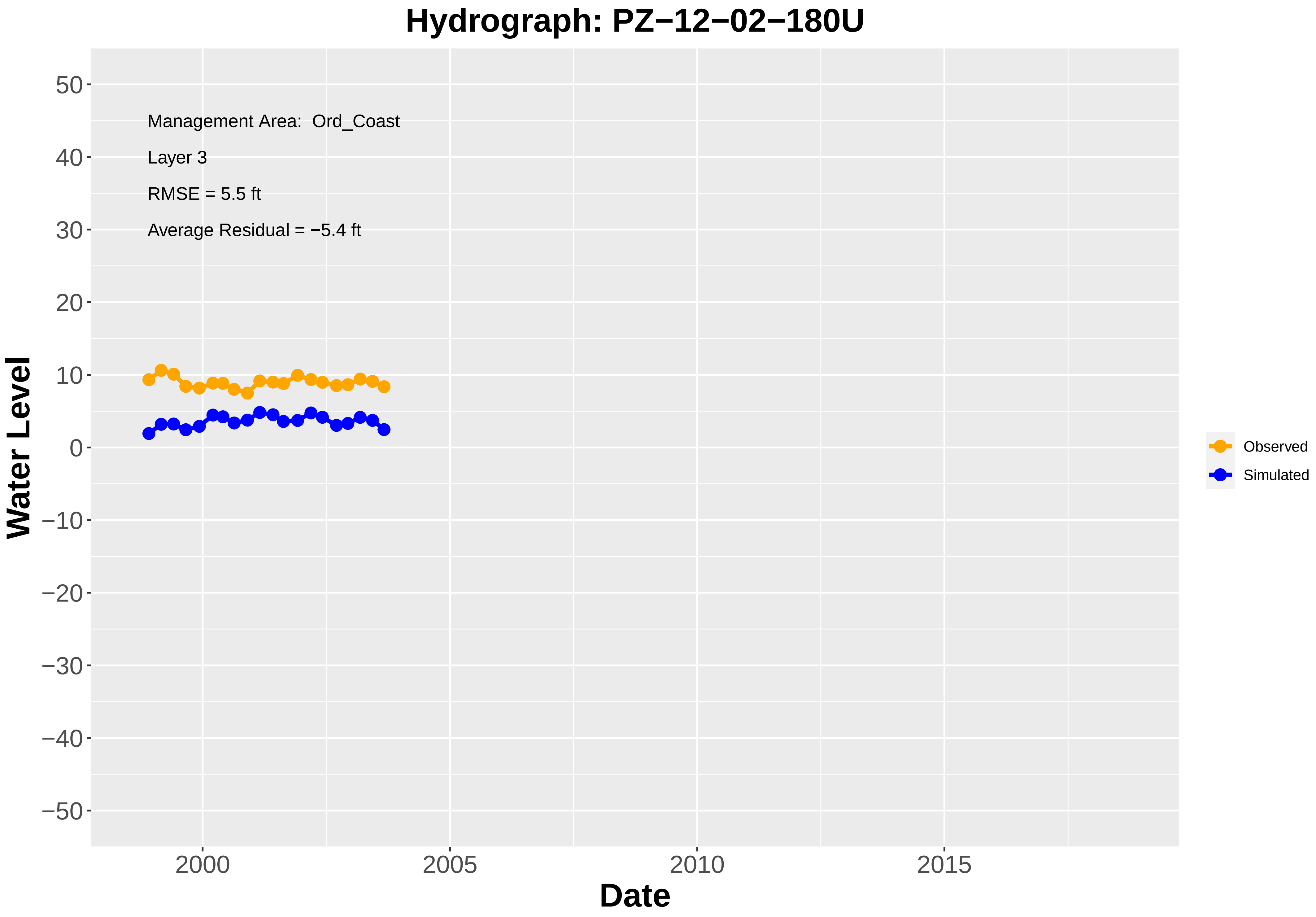

Hydrograph: PZ−12−01−180U
Management Area: Ord_Coast
Layer 3
RMSE = 4.0 ft
Average Residual = −3.8 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

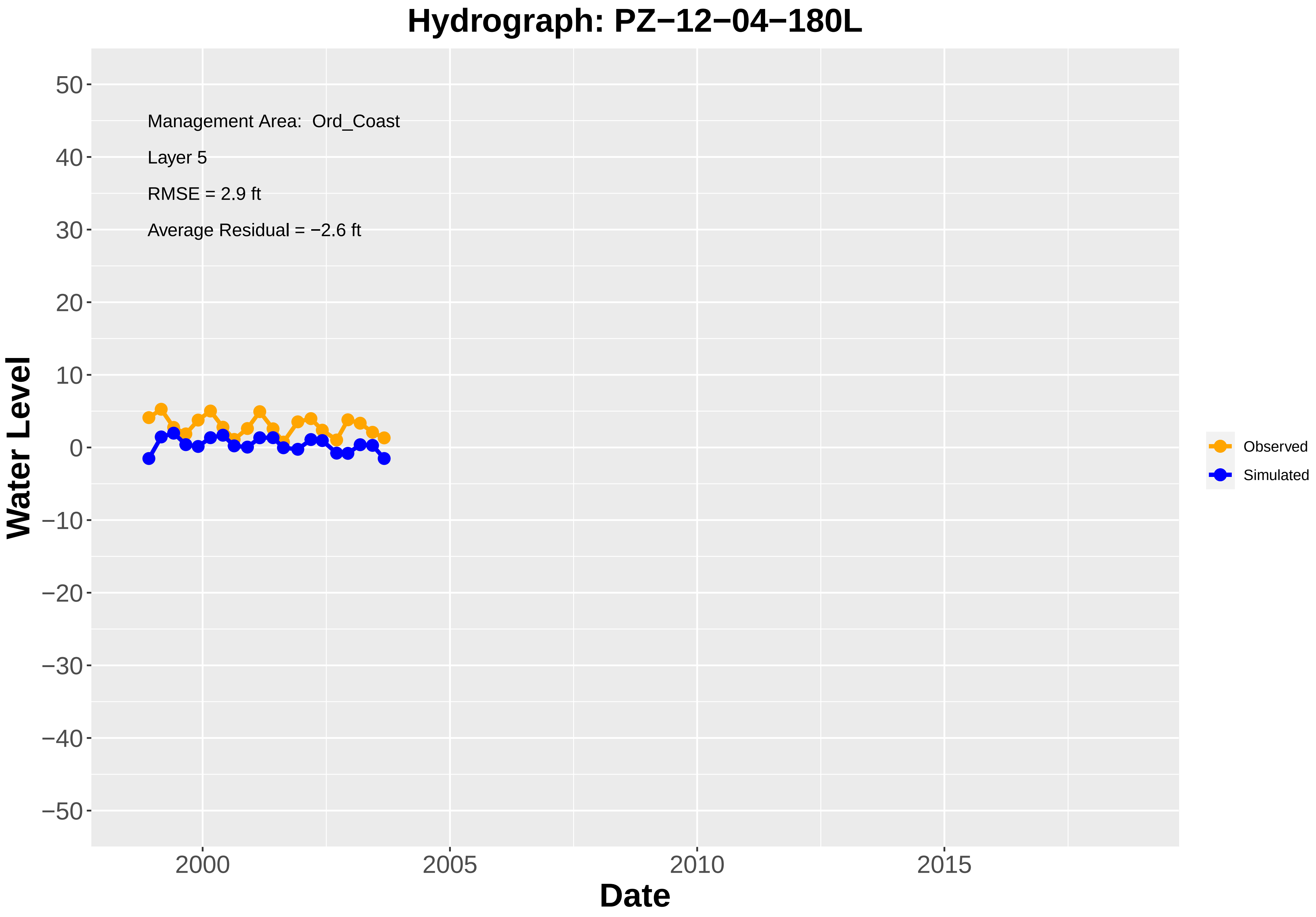
Hydrograph: PZ−12−02−180L

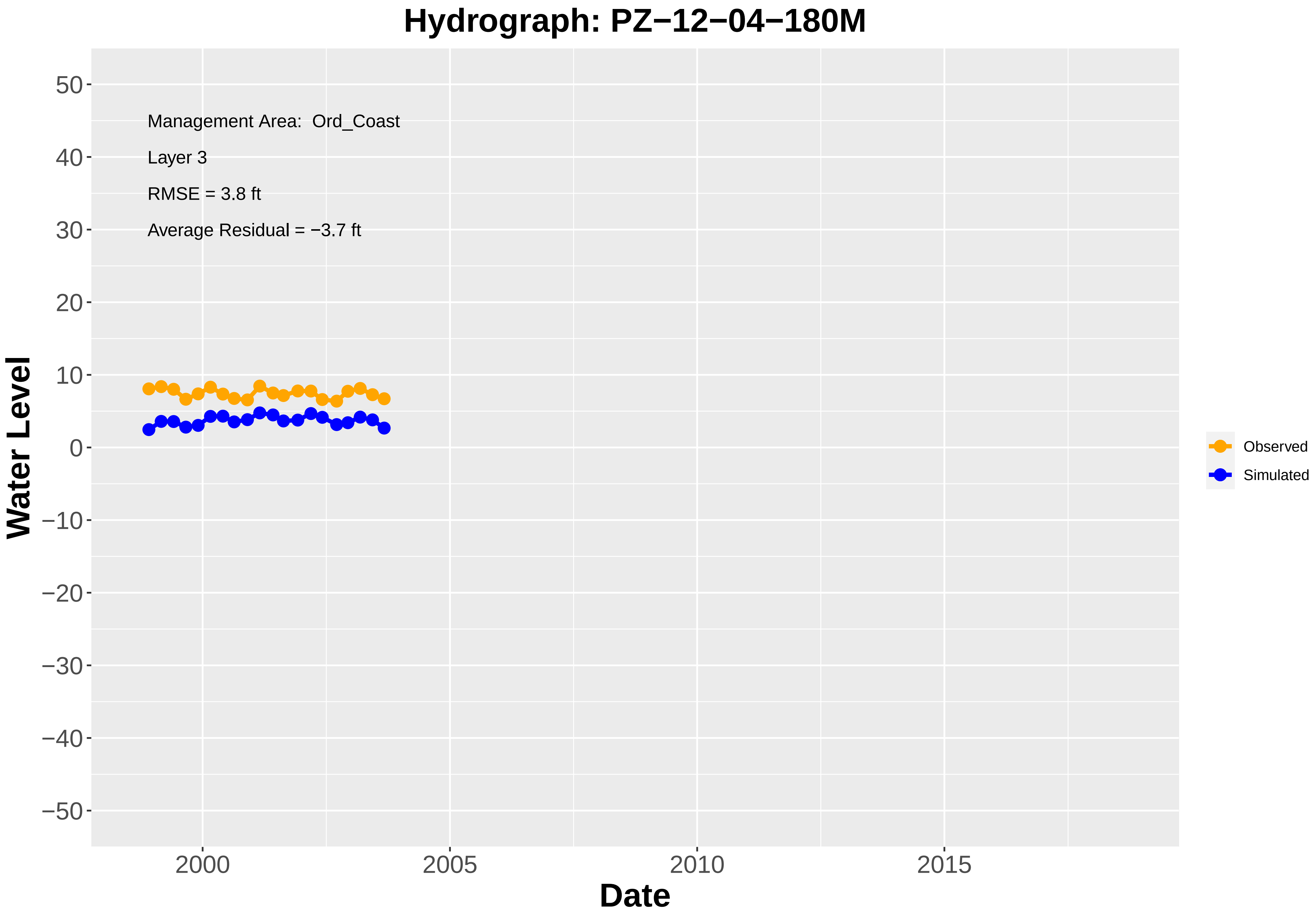


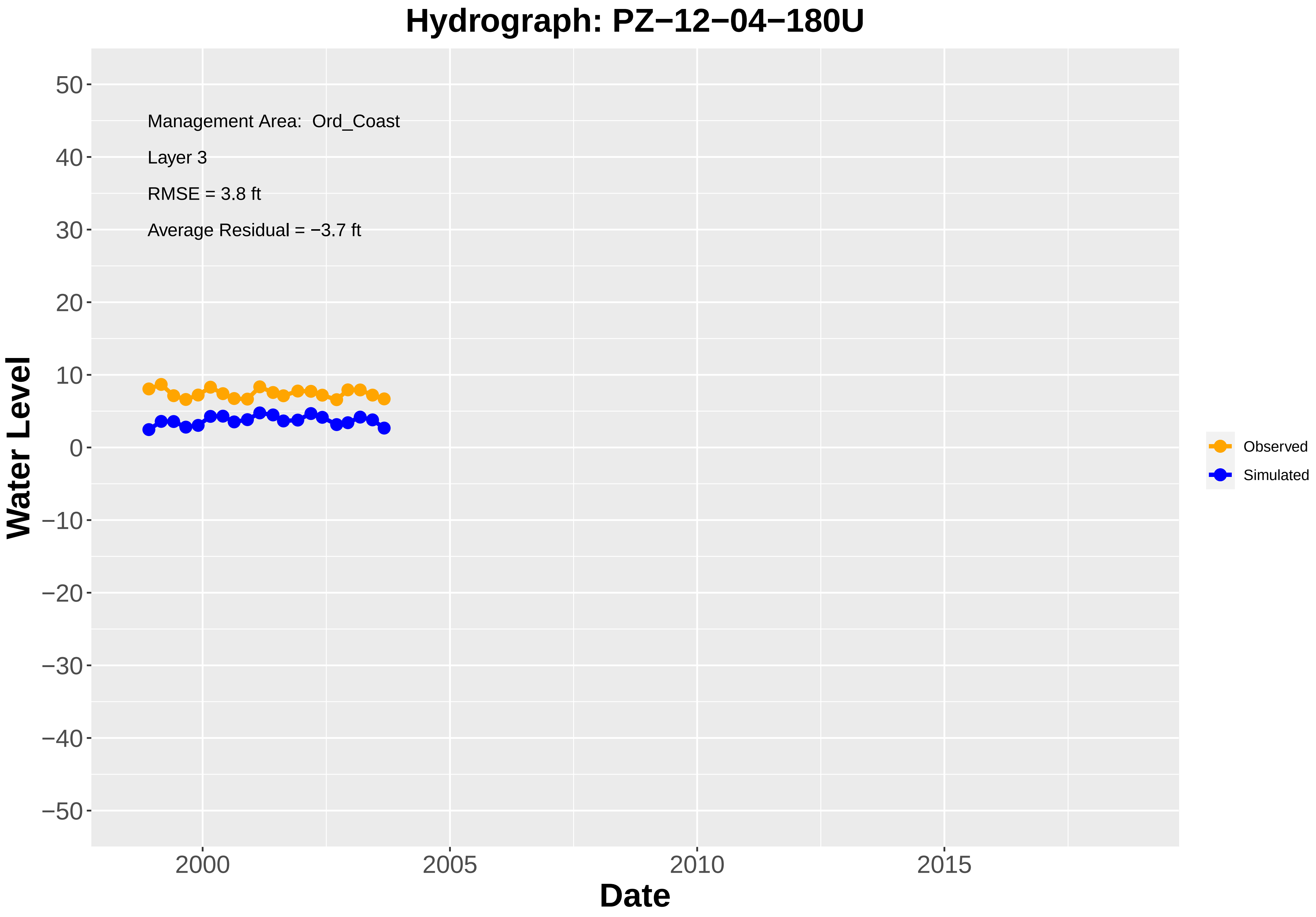
Hydrograph: PZ−12−02−180M

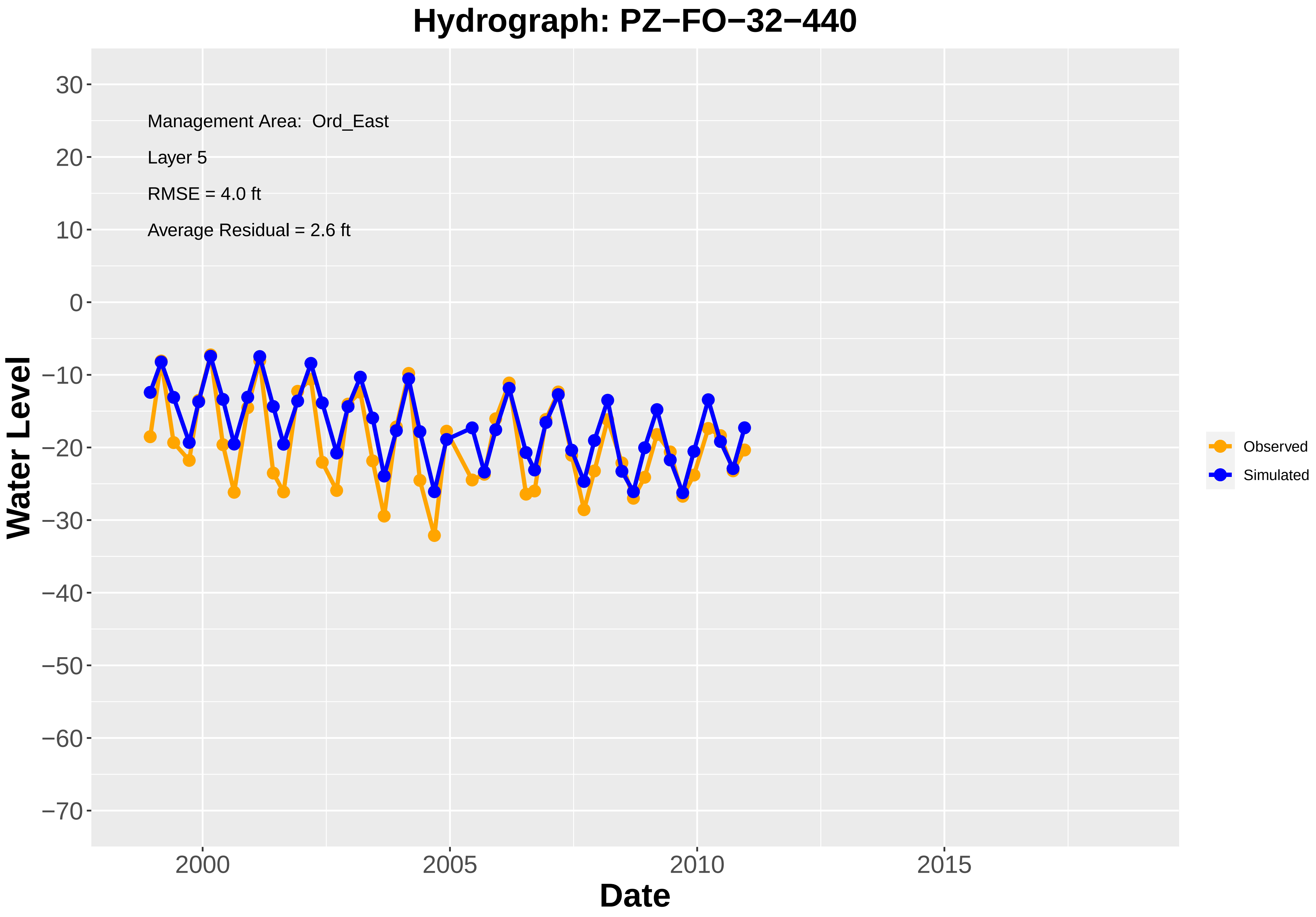



Hydrograph: PZ−12−02−180U
Management Area: Ord_Coast
Layer 3
RMSE = 5.5 ft
Average Residual = −5.4 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

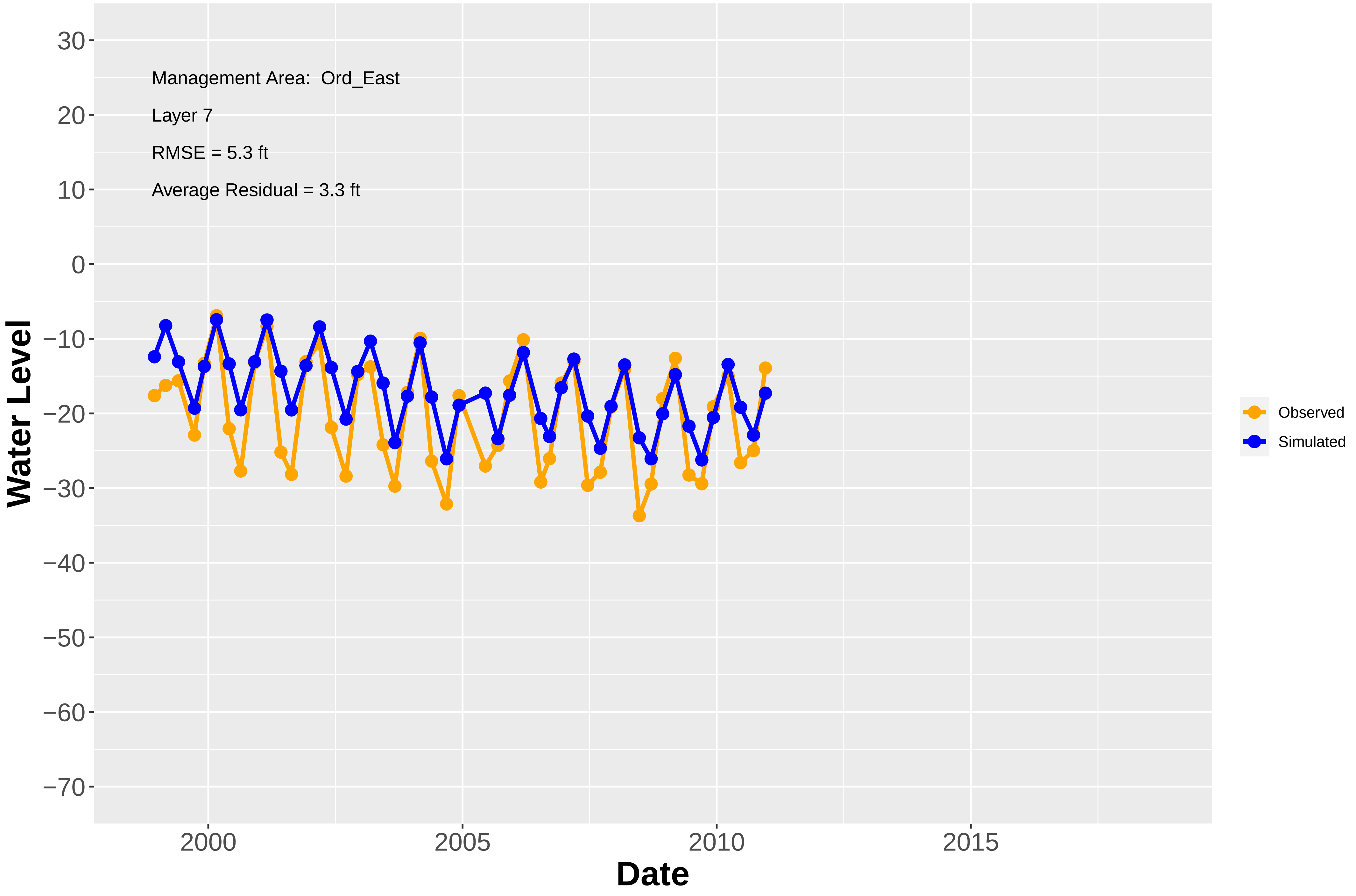

Hydrograph: PZ−12−04−180L
Management Area: Ord_Coast
Layer 5
RMSE = 2.9 ft
Average Residual = −2.6 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

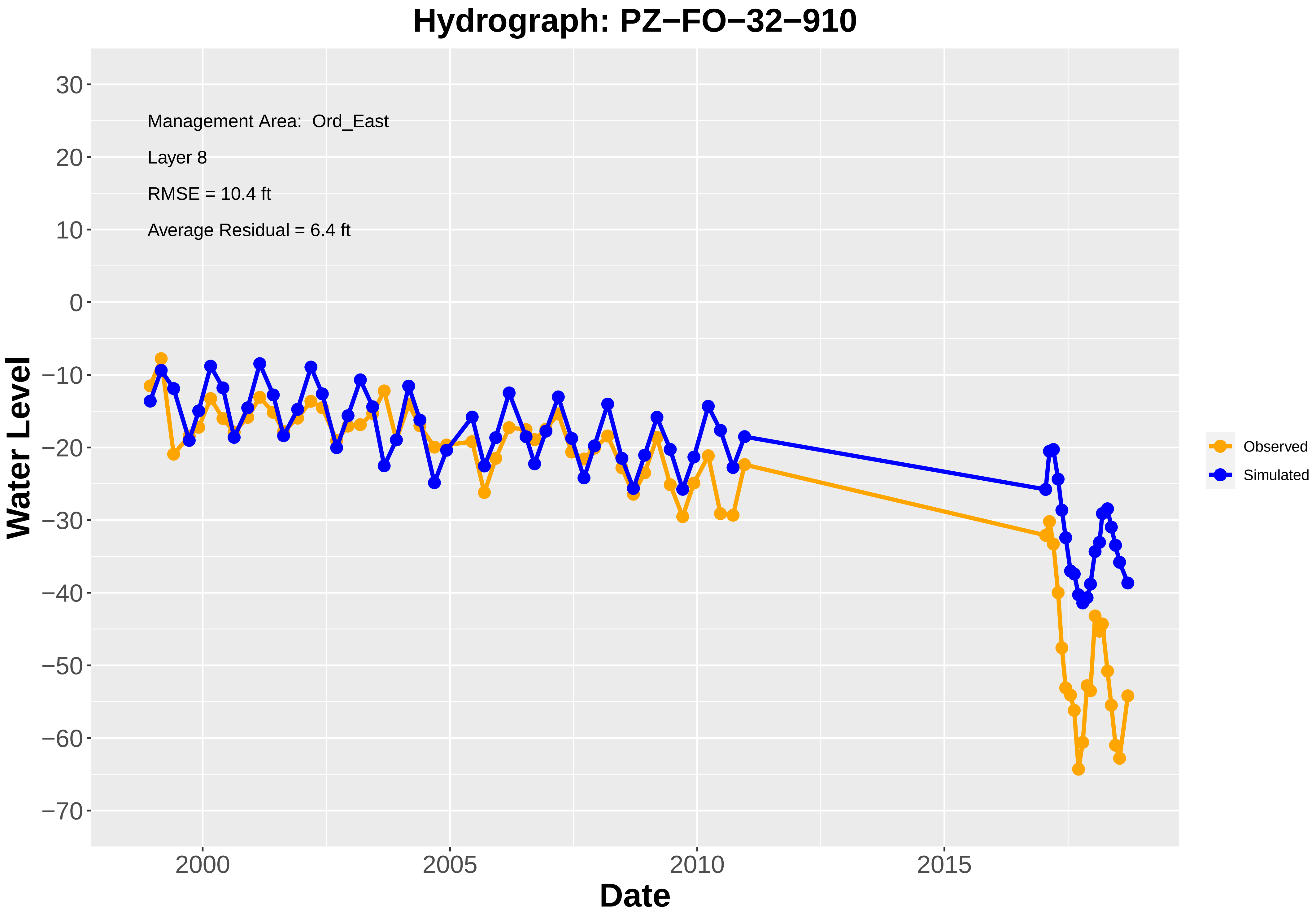

Hydrograph: PZ−12−04−180M
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: PZ−12−04−180U
Management Area: Ord_Coast
Layer 3
RMSE = 3.8 ft
Average Residual = −3.7 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
Date
2000
2005
2010
2015
Observed
Simulated

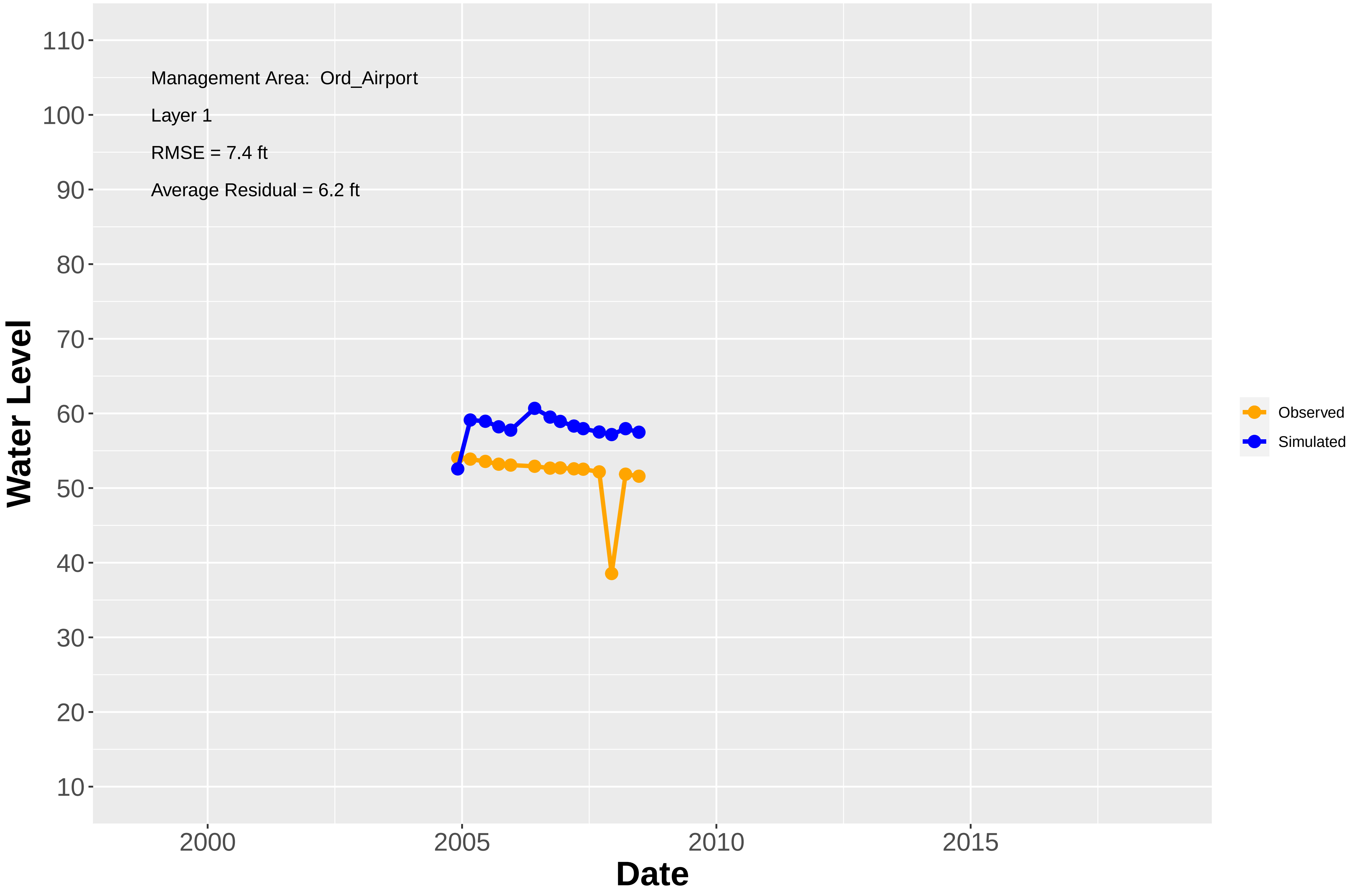

Hydrograph: PZ−FO−32−440
Management Area: Ord_East
Layer 5
RMSE = 4.0 ft
Average Residual = 2.6 ft
Water Level
Date
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
2000
2005
2010
2015
Observed
Simulated

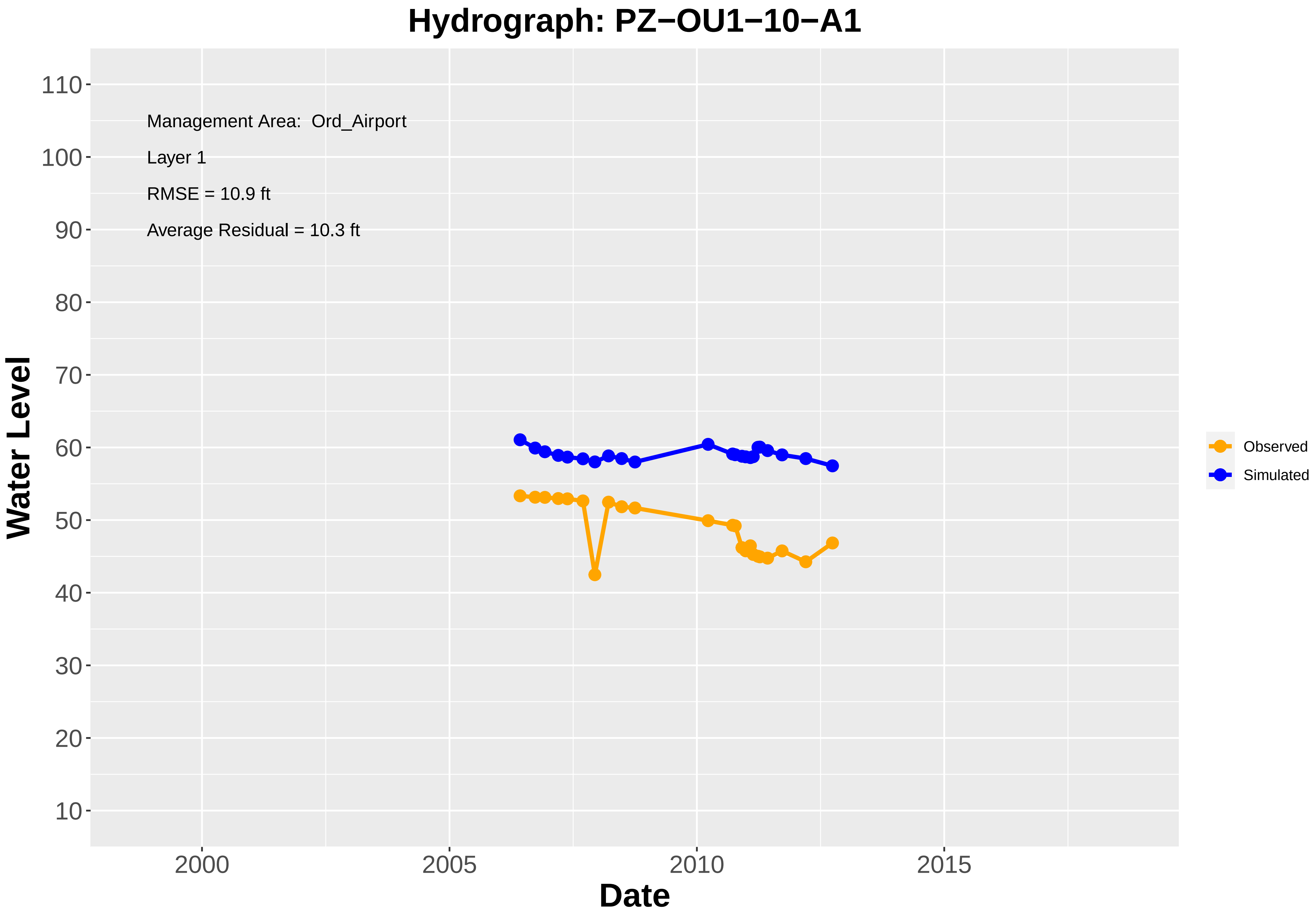
Hydrograph: PZ−FO−32−610

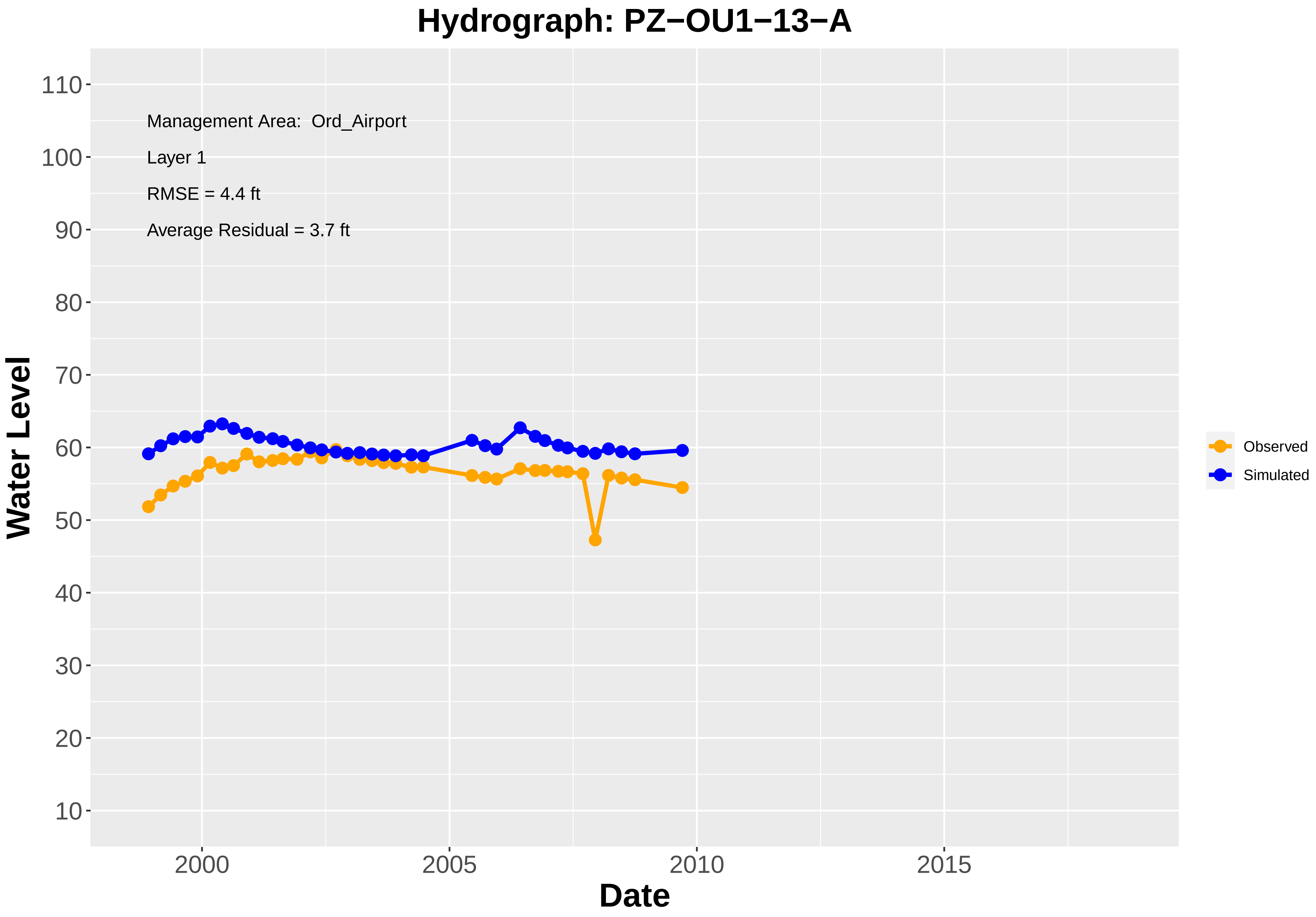


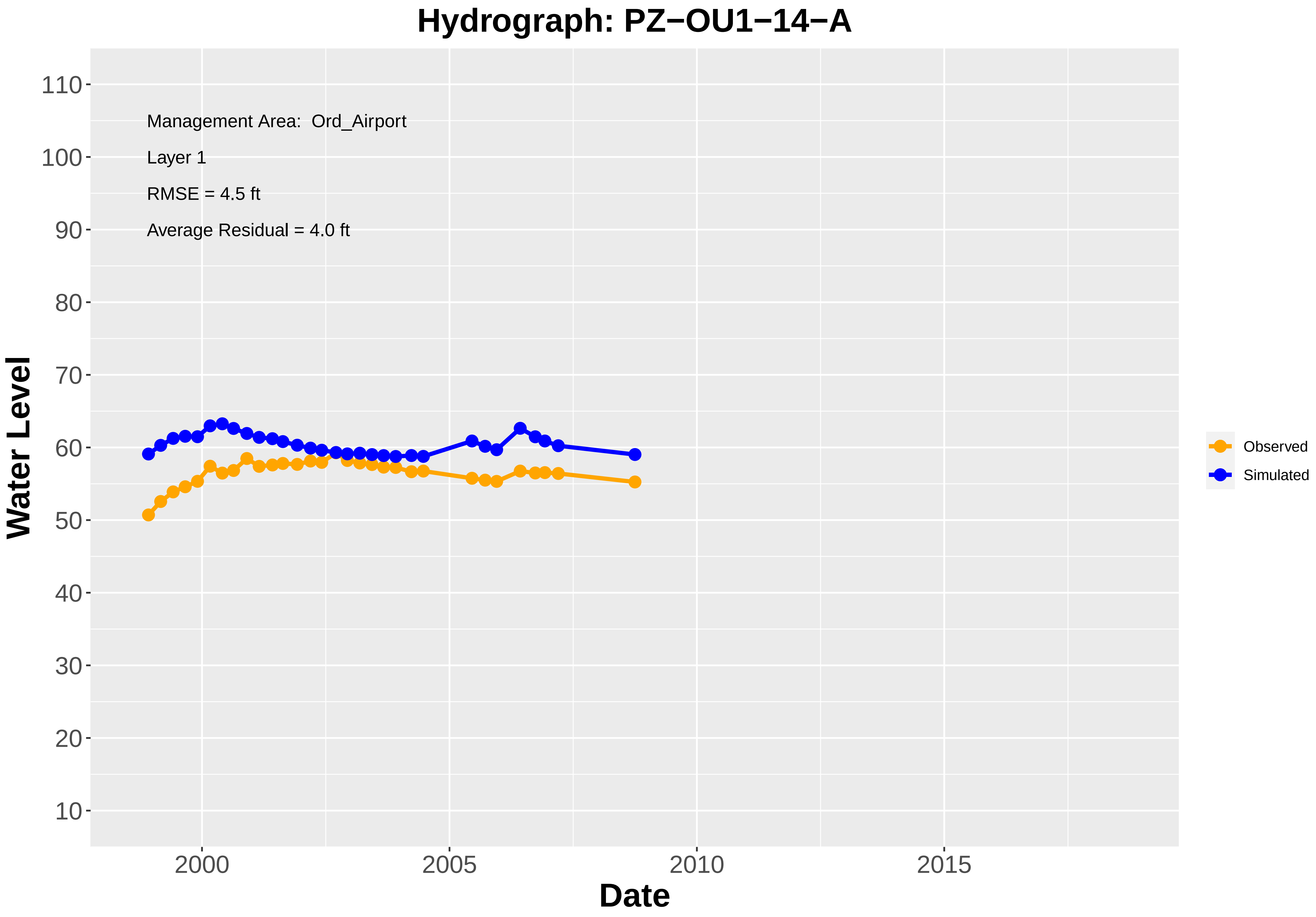

Hydrograph: PZ−FO−32−910
Management Area: Ord_East
Layer 8
RMSE = 10.4 ft
Average Residual = 6.4 ft
Water Level
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
Date
2000
2005
2010
2015
Observed
Simulated

Hydrograph: PZ−OU1−02−A1

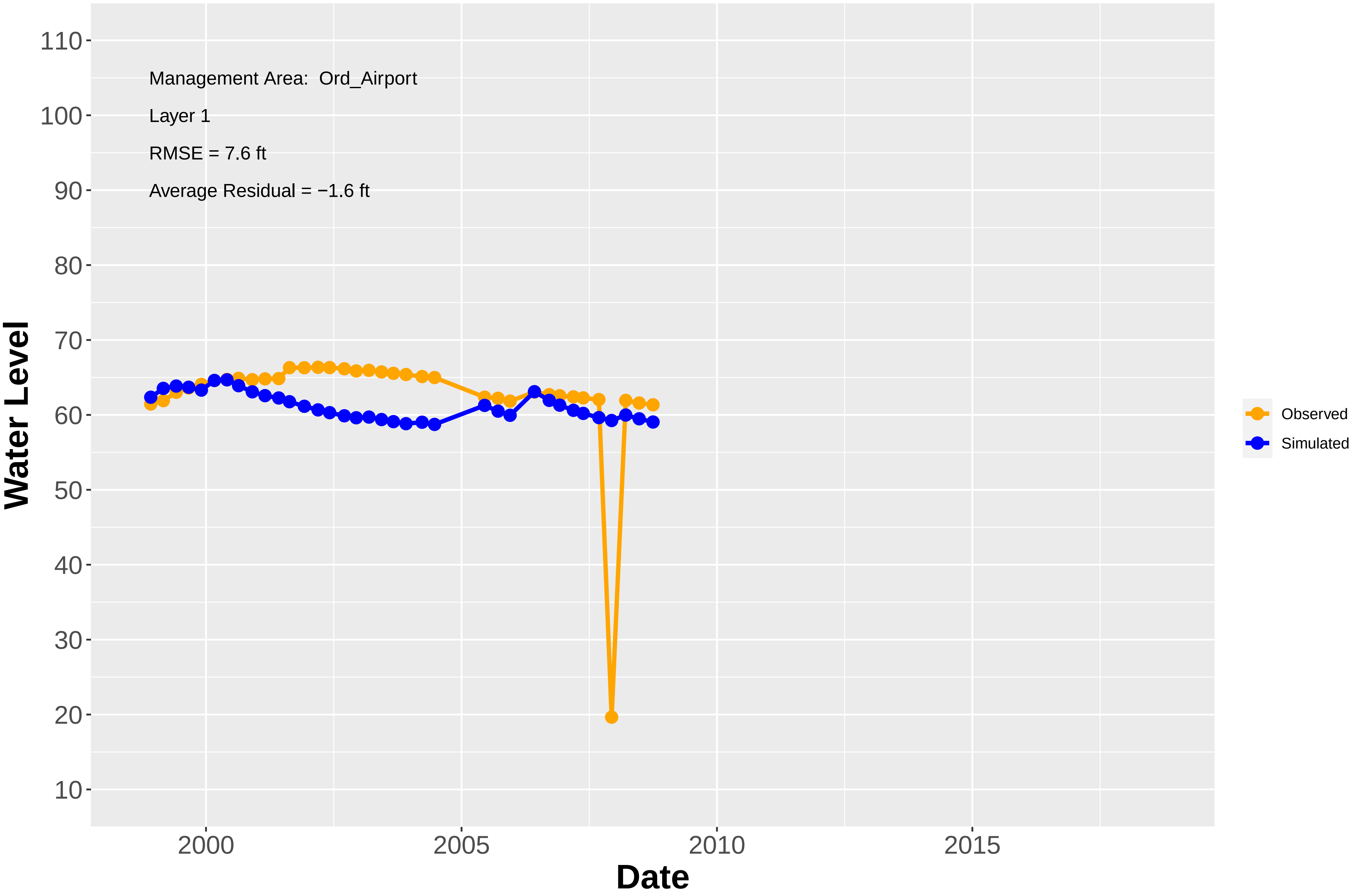


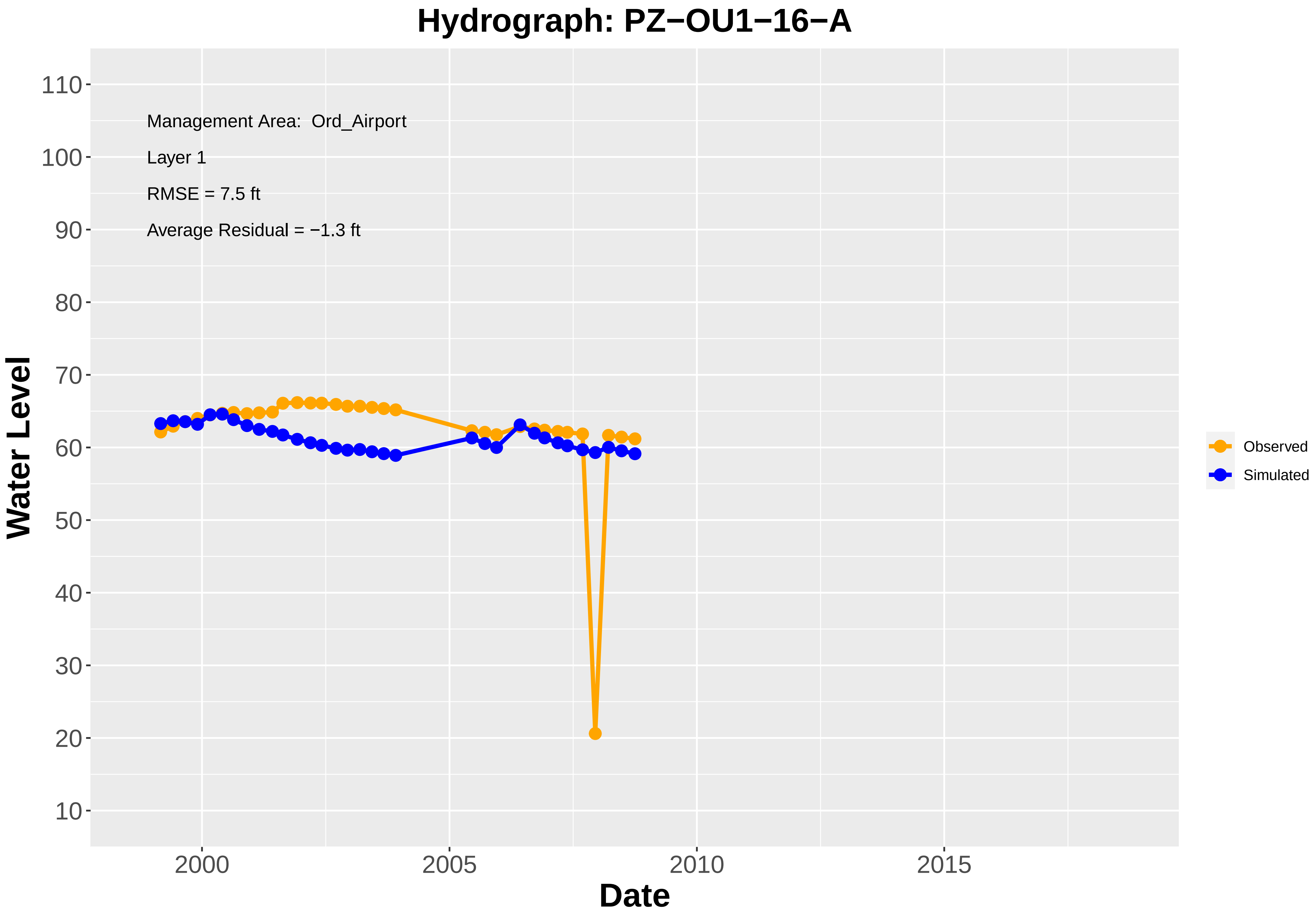

Hydrograph: PZ−OU1−10−A1
Management Area: Ord_Airport
Layer 1
RMSE = 10.9 ft
Average Residual = 10.3 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
Date
2000
2005
2010
2015
Observed
Simulated

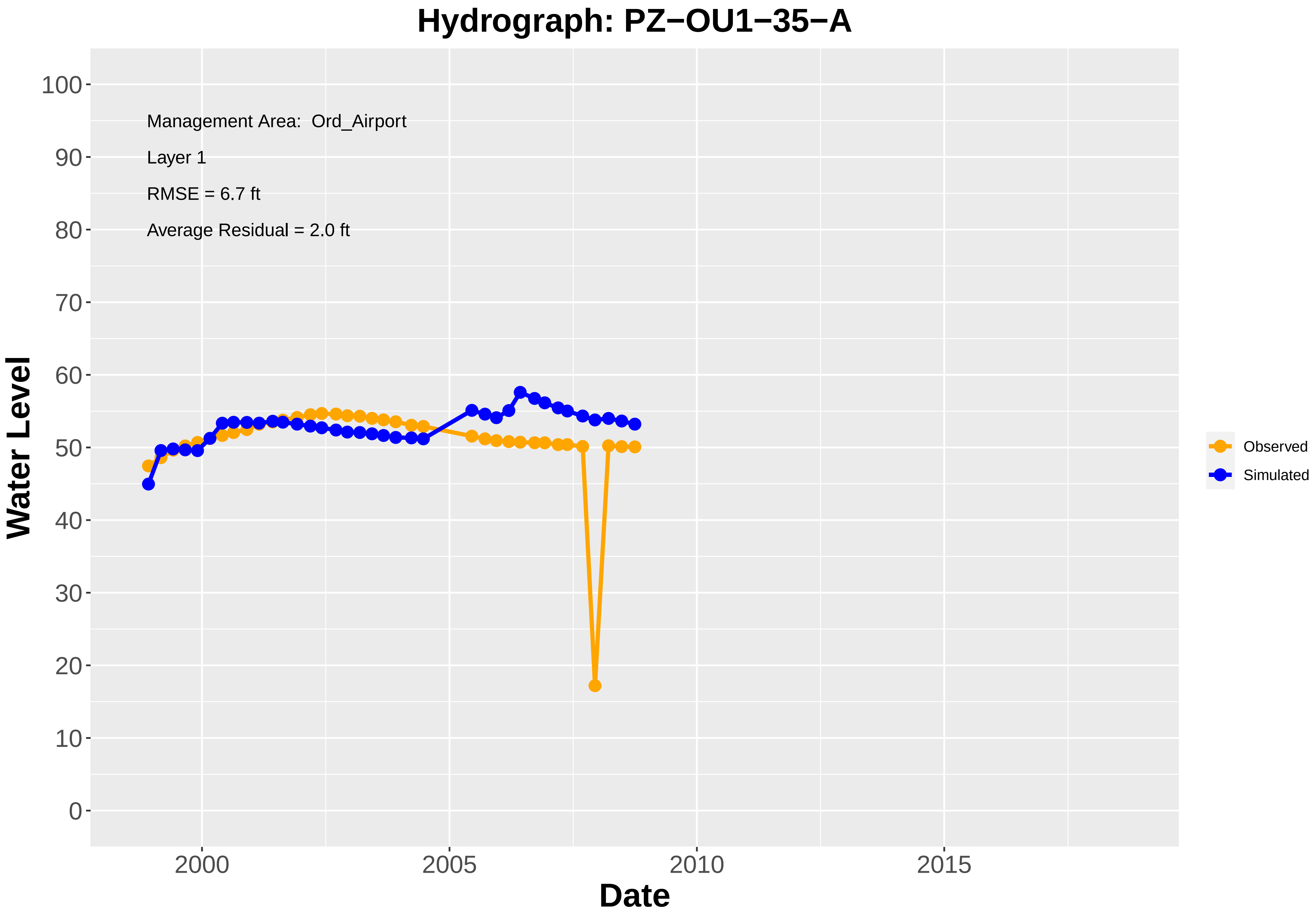

Hydrograph: PZ−OU1−13−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.4 ft
Average Residual = 3.7 ft
110
100
90
80
70
60
50
40
30
20
10
Water Level
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: PZ−OU1−14−A
Management Area: Ord_Airport
Layer 1
RMSE = 4.5 ft
Average Residual = 4.0 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated

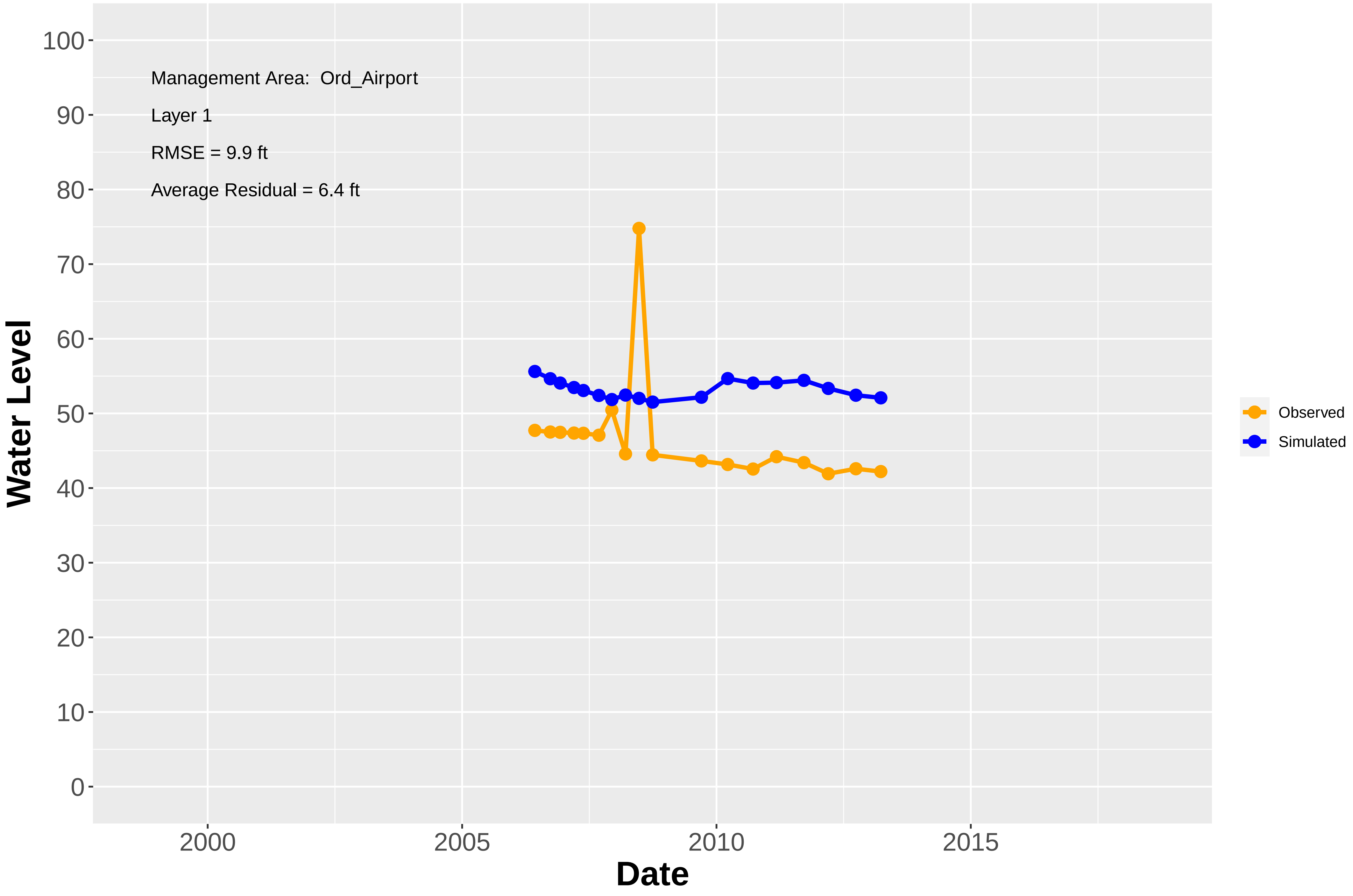
Hydrograph: PZ−OU1−15−A



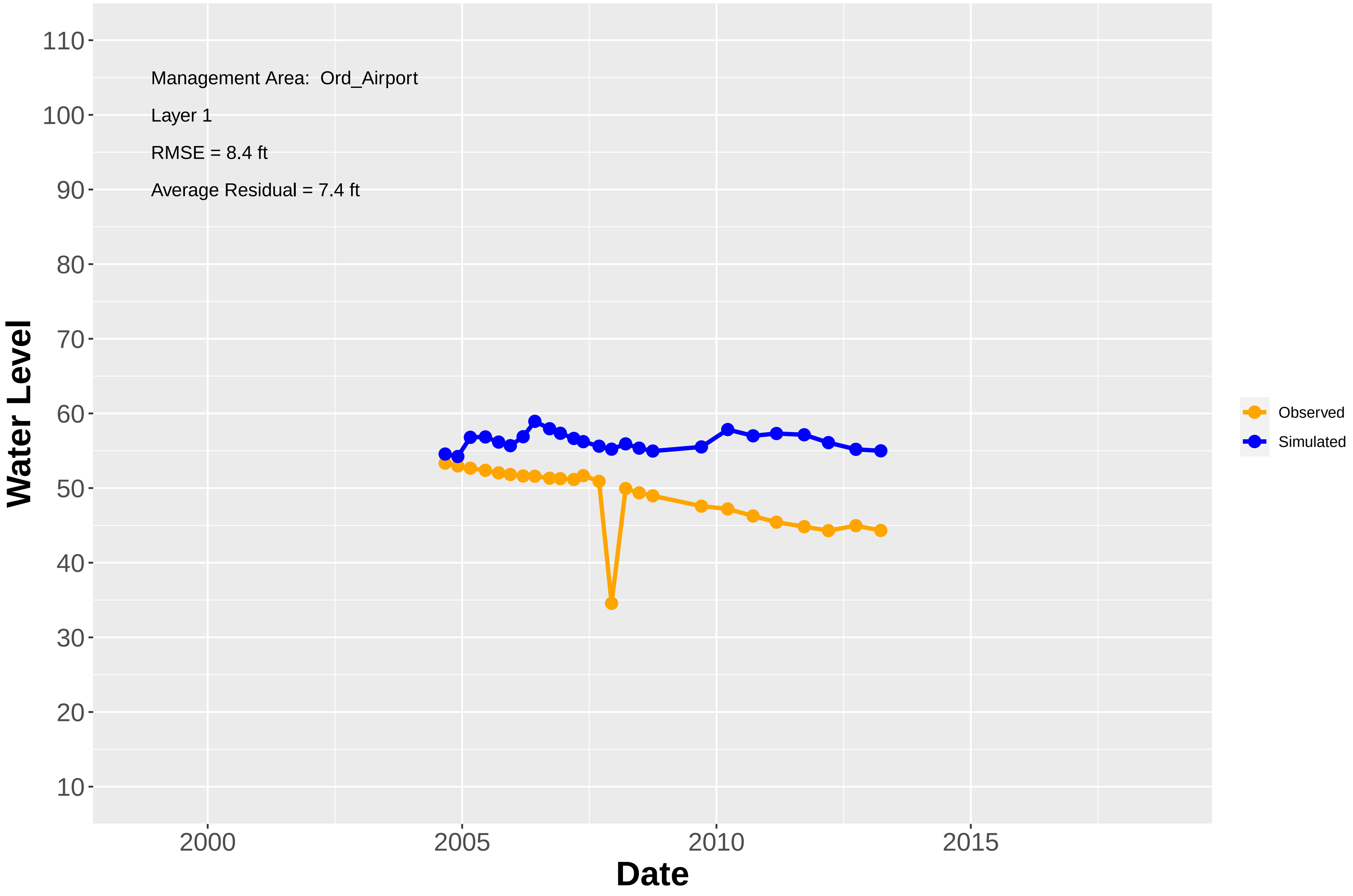

Hydrograph: PZ−OU1−16−A
Management Area: Ord_Airport
Layer 1
RMSE = 7.5 ft
Average Residual = −1.3 ft
Water Level
110
100
90
80
70
60
50
40
30
20
10
2000
2005
2010
2015
Date
Observed
Simulated


Hydrograph: PZ−OU1−35−A
Management Area: Ord_Airport
Layer 1
RMSE = 6.7 ft
Average Residual = 2.0 ft
Water Level
100
90
80
70
60
50
40
30
20
10
0
2000
2005
2010
2015
Date
Observed
Simulated

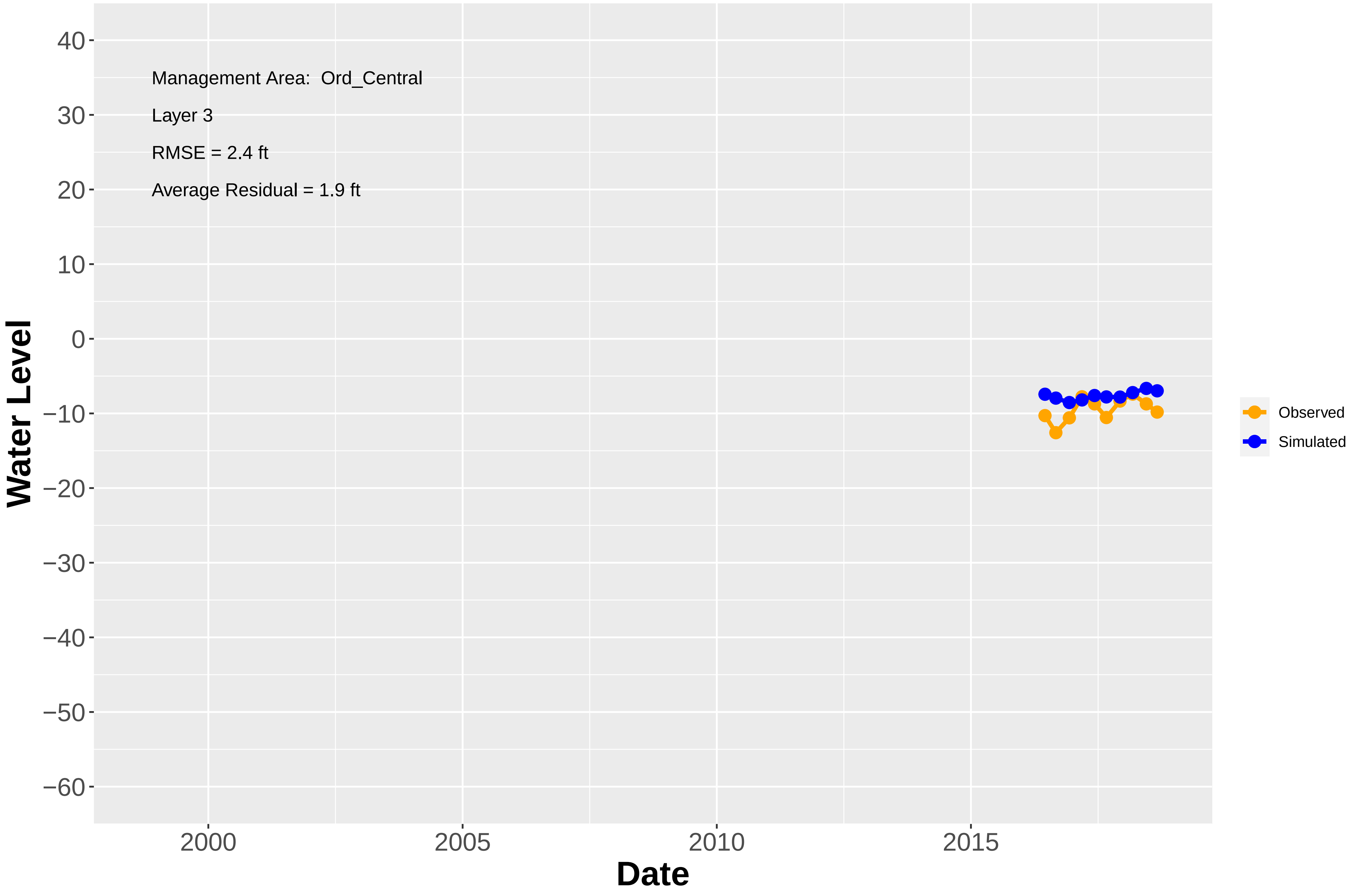
Hydrograph: PZ−OU1−46−AD2

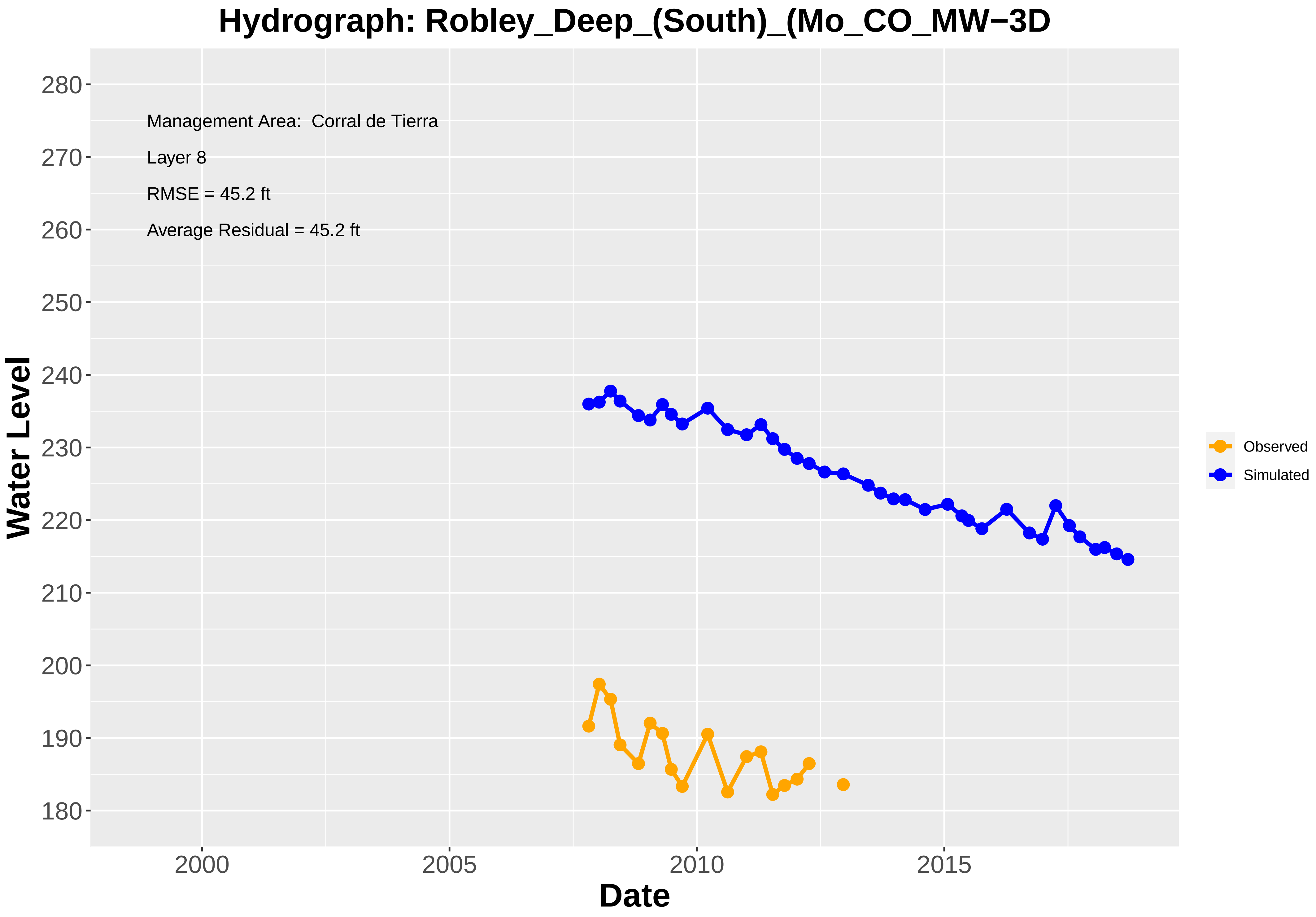


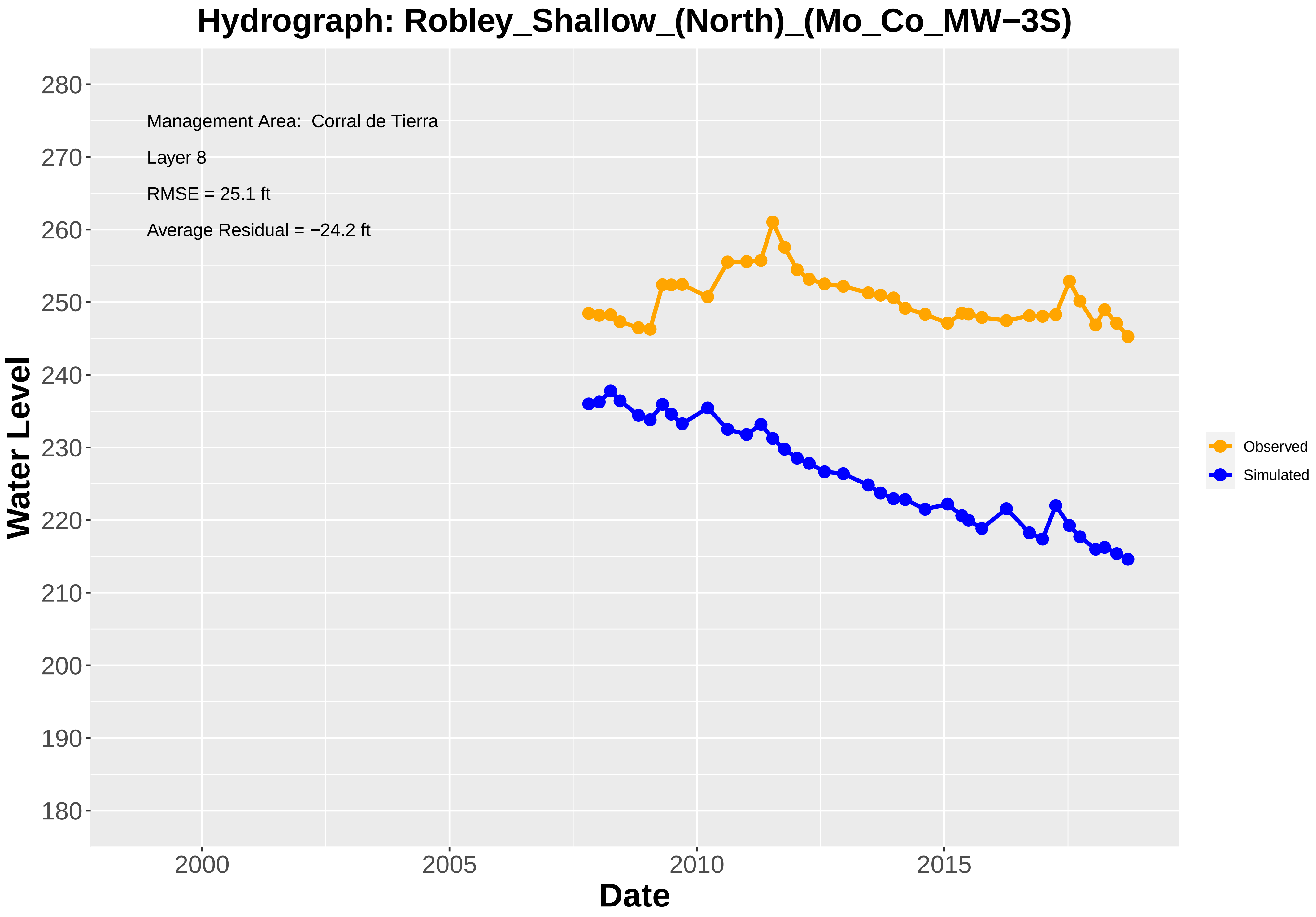
Hydrograph: PZ−OU1−49−A1

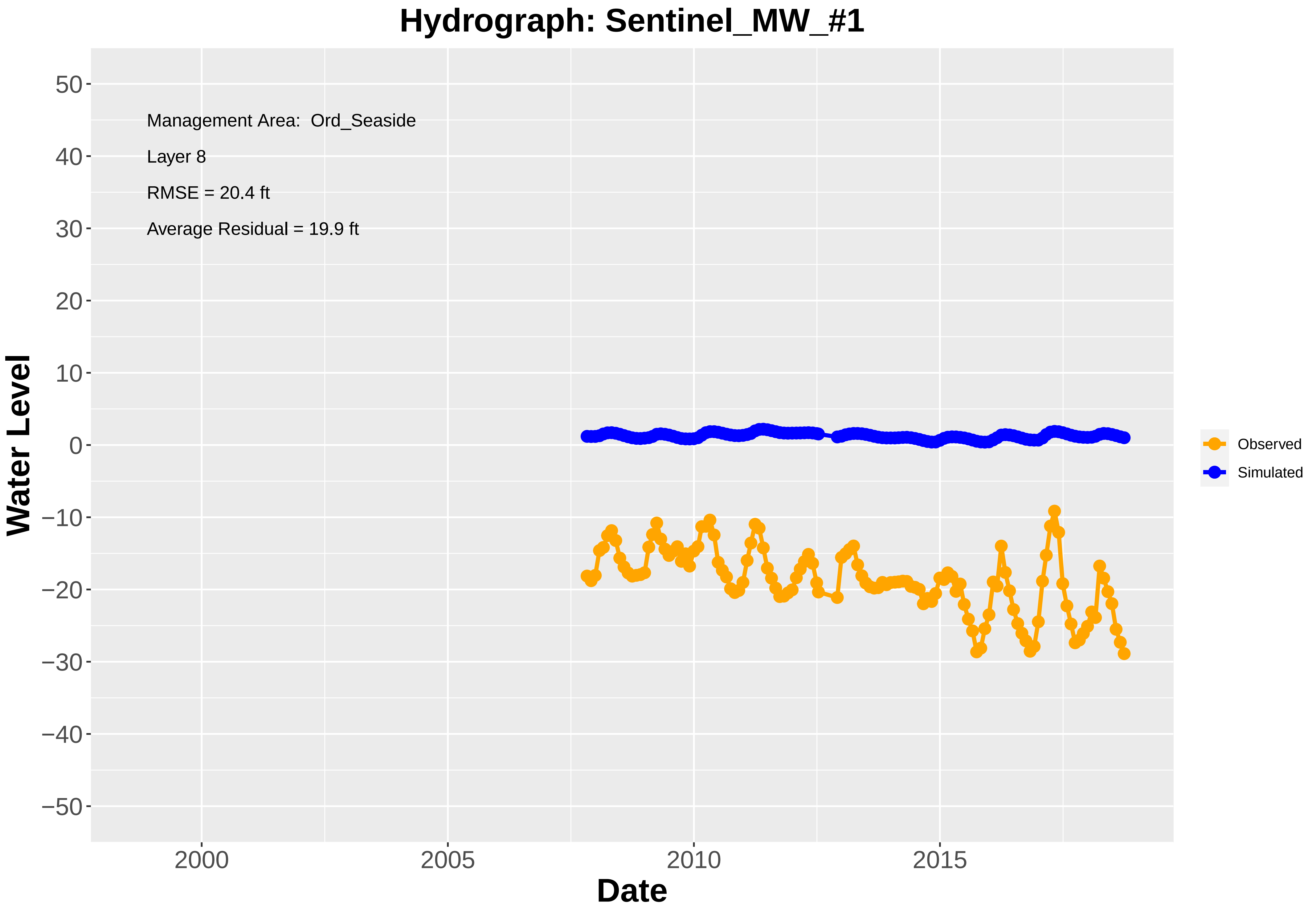


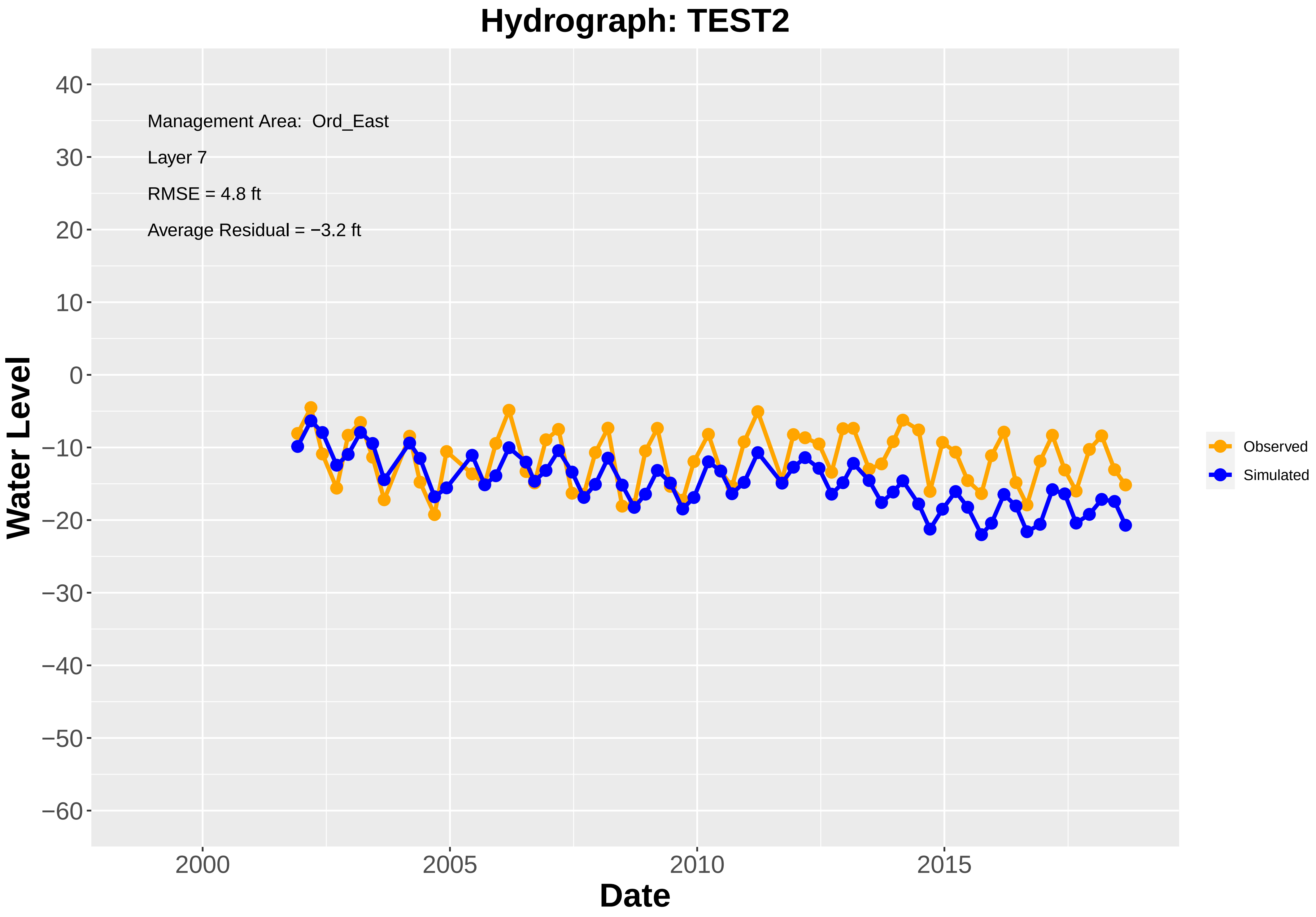
Hydrograph: PZ−OU2−06−180




Hydrograph: Robley_Deep_(South)_(Mo_CO_MW−3D
Management Area: Corral de Tierra
Layer 8
RMSE = 45.2 ft
Average Residual = 45.2 ft
Water Level
280
270
260
250
240
230
220
210
200
190
180
2000
2005
2010
2015
Date
Observed
Simulated

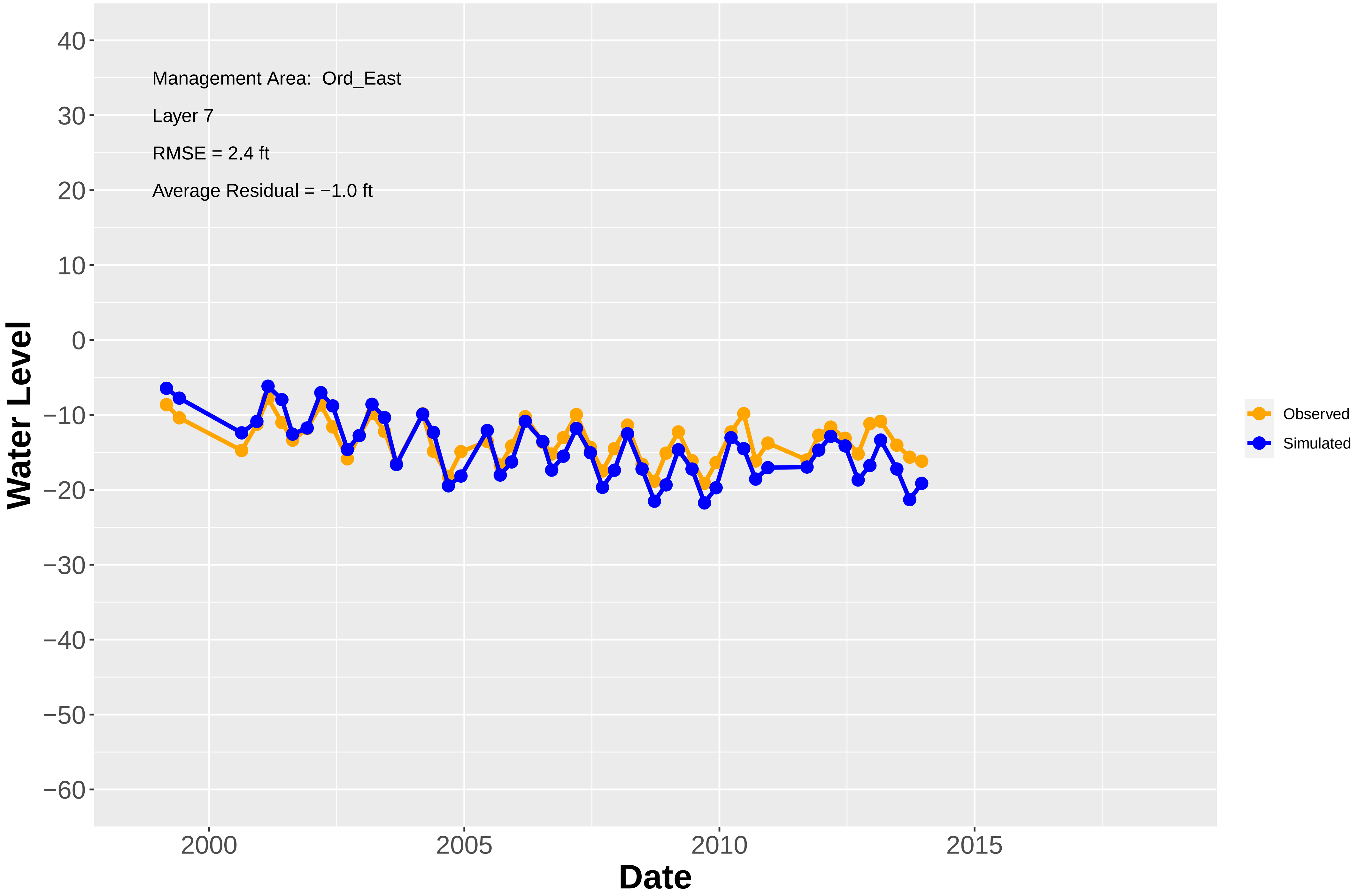

Hydrograph: Robley_Shallow_(North)_(Mo_Co_MW−3S)
Management Area: Corral de Tierra
Layer 8
RMSE = 25.1 ft
Average Residual = −24.2 ft
Water Level
280
270
260
250
240
230
220
210
200
190
180
Date
2000
2005
2010
2015
Observed
Simulated


Hydrograph: Sentinel_MW_#1
Management Area: Ord_Seaside
Layer 8
RMSE = 20.4 ft
Average Residual = 19.9 ft
Water Level
50
40
30
20
10
0
−10
−20
−30
−40
−50
2000
2005
2010
2015
Date
Observed
Simulated



Hydrograph: TEST2
Management Area: Ord_East
Layer 7
RMSE = 4.8 ft
Average Residual = −3.2 ft
Water Level
40
30
20
10
0
−10
−20
−30
−40
−50
−60
2000
2005
2010
2015
Date
Observed
Simulated

Hydrograph: TEST4



Appendix 6C

Technical Memorandum: Monterey Subbasin Modeling, dated April 2, 2021

MONTGOMERY
& ASSOCIATES
Water Resource Consultants

Groundwater experts since 1984

TECHNICAL MEMORANDUM

DATE: April 2, 2021 PROJECT #: 9100

TO: SVBGSA Advisory Committee

CC: Donna Meyers

FROM: Abby Ostovar, Greg Nelson, Staffan Schorr, and Derrik Williams

SUBJECT: Monterey Subbasin Modeling

INTRODUCTION

Two groundwater models have been developed that encompass the Monterey Subbasin, and which could potentially be used to prepare the Monterey Subbasin Groundwater Sustainability Plan (GSP). These models include:

- The **Salinas Valley Integrated Hydrologic Model (SVIHM)** developed by the U.S. Geological Survey (USGS)), including its future version, the Salinas Valley Operational Model, or SVOM, which encompass the entire Salinas Valley Groundwater Basin; and
- The **Monterey Subbasin Model** developed by Marina Coast Water District Groundwater Sustainability Agency's (MCWD GSA) consultant EKI Environment & Water, Inc. (EKI), which encompasses the Monterey Subbasin and incorporates observed boundary conditions with the adjoining Seaside Subbasin and the 180/400 Foot Aquifer Subbasin.

SVBGSA recently obtained the SVIHM, and Montgomery & Associates (M&A) has been reviewing the SVIHM and developing water budgets based on model results. M&A's review suggests that the SVIHM does not accurately reflect hydrologic conditions in the Monterey Subbasin. SVIHM calibration efforts primarily focus on other portions of the Salinas Valley Groundwater Basin where there is significant agricultural groundwater use. The SVIHM was not calibrated to any groundwater level data from the Seaside Subbasin and included only one calibration location in the Monterey Subbasin. M&A believes the SVIHM is not detailed or accurate in the Monterey Subbasin.

The Monterey Subbasin Model focuses on conditions within the Monterey Subbasin and has incorporated over 30,000 water level measurements from the Monterey Subbasin in its calibration. It also incorporates water level data from the 180/400-Foot Aquifer Subbasin and Seaside Subbasin to establish transient boundary conditions and account for conditions in these adjoining subbasins. EKI has worked closely with M&A to incorporate feedback regarding conditions in the Corral de Tierra area and the 180/400-Foot Aquifer Subbasin.

Due to the limitations of the SVHIM in its representation of the Monterey Subbasin and the more robust calibration of the Monterey Subbasin Model for this subbasin, SVBGSA and MCWD GSA plan to use the Monterey Subbasin Model for developing the Monterey Subbasin GSP. The Monterey Subbasin Model will also form the basis for the seawater intrusion model that SVBGSA has received grant funding to develop for the Monterey Subbasin.

MODELING COLLABORATION

EKI and M&A began collaborating on modeling while developing the SGMA Round 3 Planning Grant application for the Monterey Subbasin. Based on this application, MCWD received grant funds to develop the Monterey Subbasin Model, and SVBGSA received grant funds to develop a seawater intrusion model for the Monterey Subbasin.

EKI engaged M&A during the Monterey Subbasin Model development process to review the model’s layering and structure, connectivity of the aquifers, input data such as historical groundwater elevations and extractions, boundary conditions with adjacent subbasins, and calibration. EKI and M&A will continue to collaborate in the interpretation of model results.

M&A will use the Monterey Subbasin Model as the basis for the seawater intrusion model for the Monterey Subbasin. Aquifer layers in the Monterey Subbasin Model will be extended north into the 180/400 Aquifer Subbasin in a manner that is consistent with SVIHM layering and incorporate boundary conditions and flows from the SVIHM. Development of the seawater intrusion model will begin upon completion and calibration of the Monterey Subbasin Model.

Since these are grant funded, no additional funding is needed for the modeling other than consultant staff time, and both agencies will have access to both models. SVBGSA and MCWD have a collaborative working relationship.

MODEL COMPARISON

M&A has been reviewing and interrogating the SVIHM model. The SVIHM was provided in a provisional and preliminary status, meaning that the USGS can, and likely will, update and change the model prior to its release to the public. The Monterey Subbasin and Seaside Subbasin are included in the SVIHM; however, model development and calibration in these subbasins appears not to have been performed to the same degree as other areas of the Model. For example, the SVIHM did not include any water level calibration points in the Seaside Subbasin and only one calibration location in the Monterey Subbasin.

Model calibration is an assessment of how a model simulates observed historical conditions. Generally, a model’s calibration is evaluated through calibration statistics – comparing simulated groundwater elevations to measured groundwater elevation data. One commonly used statistic is known as the scaled root mean squared residual of the error between simulated water levels and observed water levels. A general rule of thumb in assessing model calibration is that the model is considered adequately calibrated when the scaled root mean squared error is less than 10%. The basin-wide statistics of the SVIHM meet these criteria (see Attachment A).

In the Monterey Subbasin, the SVIHM includes only one location containing calibration data; and an assessment of the Subbasin calibration cannot be adequately performed using the limited measurements from only this one data location. To check the accuracy of the SVIHM in the Subbasin, M&A compared simulated groundwater elevations from the SVIHM to an additional 4,555 observed water levels from 55 locations in the Monterey Subbasin. With the additional data. The root mean squared error of the residuals is over 7%, which indicates reasonable calibration (see Attachment B).

However, comparing simulated and observed hydrographs across the Subbasin shows that the model results do not match measured data in many areas: particularly in the Corral De Tierra. Some hydrographs have opposite trends, indicating the model is not adequately calibrated in this area. Attachment C includes some example hydrographs that illustrate certain wells with inadequate calibration. Measured data on these hydrographs are shown with black dots, and simulated data are shown with blue lines. The clear difference between measured and simulated trends on these plots results in poor confidence in the model’s ability to simulate at least parts of the Monterey Subbasin. This poor confidence only applies to the Monterey Subbasin; much of the rest of the model is well calibrated.

In the Corral de Tierra area, only the bottom three layers of the SVIHM are active. These three layers represent the bedrock (bottom layer) and part of the El Toro Primary Aquifer System (other two active layers). This model configuration raises concerns over the adequacy of hydrogeologic representation of the Corral de Tierra area.

In contrast to the SVIHM, the Monterey Subbasin Model being developed by EKI currently has a root mean squared error residual of less than 2% (Attachment D). Calibration of the Monterey Subbasin model is ongoing, and all results are still preliminary. The Monterey Subbasin Model also has more detailed and more accurate representation of the hydrogeology in the Corral de Tierra area, which was developed incorporating input from M&A. EKI has also included additional groundwater level data for calibration throughout the Monterey Subbasin, totaling 30,555 observations from 608 wells. Thus, because of the more accurate calibration and hydrogeologic representation of the Monterey Subbasin within the Monterey Subbasin Model, SVBGSA plans to use the Monterey Subbasin Model for the development of the Monterey Subbasin GSP.

MODEL COMPATIBILITY

To assess model compatibility, EKI and M&A have been collaborating on modeling and most recently have compared information from the Monterey Subbasin Model and the SVIHM. This includes analyzing conditions along the boundary of the 180/400-Foot Aquifer Subbasin and beneath the Salinas River. Groundwater levels along this boundary are being compared to ensure the two models are compatible and simulate this boundary comparably. Model layering and hydrogeologic representation have also been reviewed and appear to reasonably match. In some areas, the Monterey Subbasin Model has greater vertical resolution with more refined aquifer layers. In general, however, the Monterey Subbasin Model layer is compatible with the SVIHM layering.

In the future, when the SVIHM becomes public, the information from the Monterey Subbasin Model could be incorporated into the SVIHM. Additionally, SVBGSA could expand the seawater intrusion model into the 180/400-Foot Aquifer Subbasin by incorporating SVIHM parameters so that it can model the impacts of valley-wide projects on seawater intrusion.

CONCLUSION

A detailed description of the Monterey Subbasin Model will be included as an appendix to the Monterey Subbasin GSP, which will be made available for public review and comment. In addition, the Monterey Subbasin Model will be submitted to the California Department of Water Resources as part of the GSP. It will be available for future use by the USGS and others as part of basin-wide modeling efforts.

All groundwater models are tools to help understand groundwater conditions and how factors may change groundwater conditions. Given the complexity of groundwater interactions, models provide the best tool for understanding of these interactions and their effects. Exact numbers will change as the Model is refined and updated; however, it will not likely change the direction and approach of groundwater management.

Attachments:

Attachment A: SVIHM Calibration Statistics for entire Salinas Valley Groundwater Basin

Attachment B: SVIHM Calibration Statistics for Monterey Subbasin (with added water level observations)

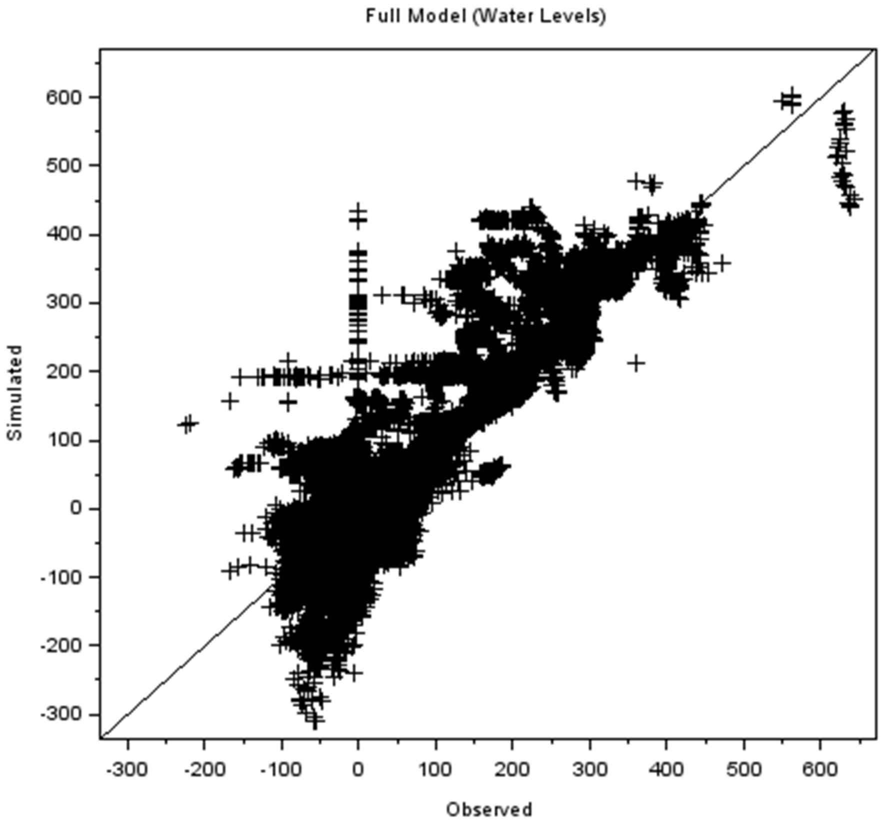
Attachment C: Measured and SVIHM Simulated Hydrographs for Monterey Subbasin

Attachment D: Monterey Subbasin Model Preliminary Calibration Statistics (as of 3/29/2021)

SVIHM Note:

This data (model and/or model results) are preliminary or provisional and are subject to revision. This model and model results are being provided to meet the need for timely best science. The model has not received final approval by the U.S. Geological Survey (USGS). No warranty, expressed or implied, is made by the USGS or the U.S. Government as to the functionality of the model and related material nor shall the fact of release constitute any such warranty. The model is provided on the condition that neither the USGS nor the U.S. Government shall be held liable for any damages resulting from the authorized or unauthorized use of the model.

ATTACHMENT A
SVIHM CALIBRATION STATISTICS FOR ENTIRE SALINAS VALLEY GROUNDWATER BASIN



Number of Values: 52719

Mean Residual: 1.811

Mean Absolute Residual: 36.33

Root-Mean-Squared-Residual: 53.01

Residual Standard Deviation: 52.98

Range in Observations: 868

Scaled Mean Residual [%]: 0.21

Scaled Mean Absolute Residual [%]: 4.19

Scale Root-Mean-Squared-Residual [%]: 6.11

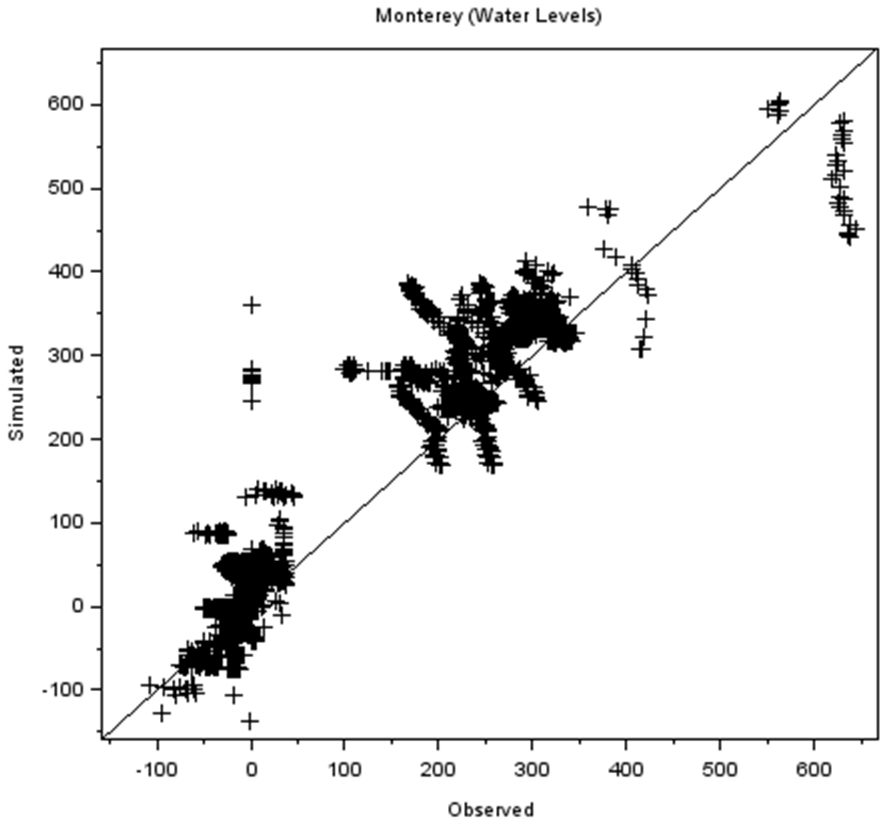
Scaled Residual Standard Deviation [%]: 6.1

Coefficient of Determination (R^2): 0.837

Note: All reported statistics are in feet unless otherwise noted.

All model results are provisional and subject to revision.

ATTACHMENT B
SVIHM CALIBRATION STATISTICS FOR MONTEREY SUBBASIN (WITH ADDED WATER LEVEL OBSERVATIONS)



Number of Values: 4555

Mean Residual: -30.102

Mean Absolute Residual: 40

Root-Mean-Squared-Residual: 55.12

Residual Standard Deviation: 46.18

Range in Observations: 751

Scaled Mean Residual [%]: -4.01

Scaled Mean Absolute Residual [%]: 5.33

Scale Root-Mean-Squared-Residual [%]: 7.34

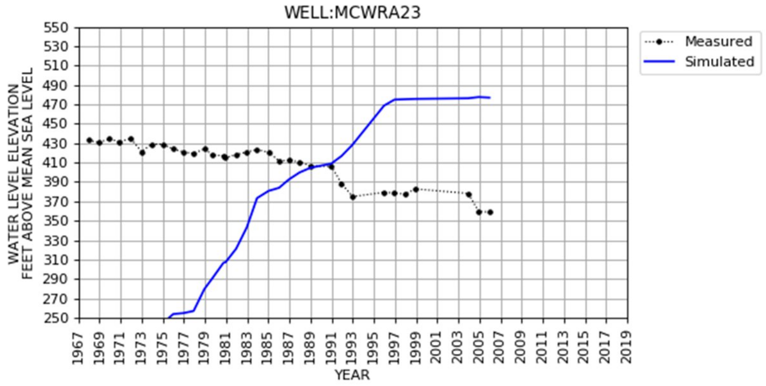
Scaled Residual Standard Deviation [%]: 6.15

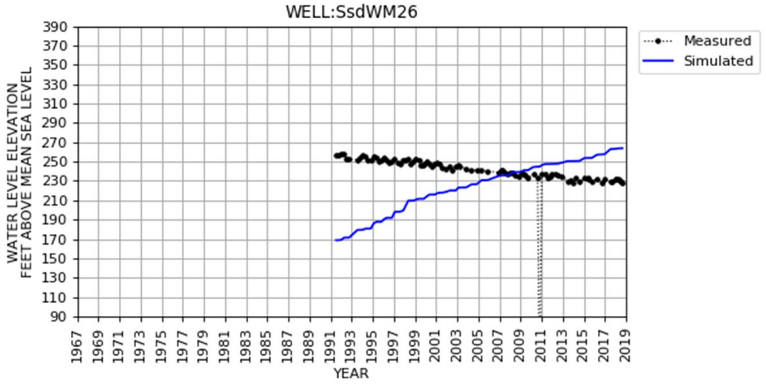
Coefficient of Determination (R^2): 0.865

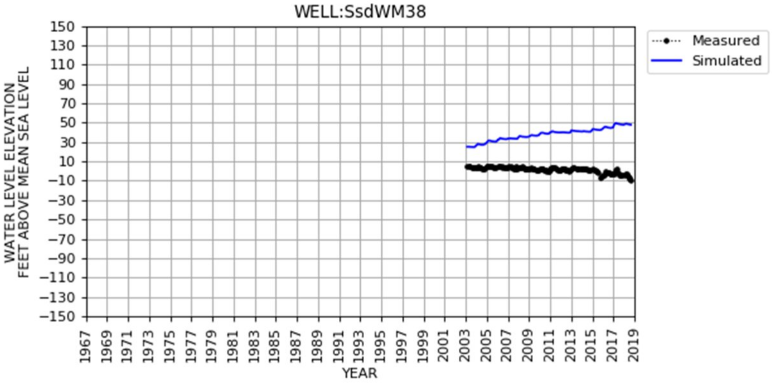
Note: All reported statistics are in feet unless otherwise noted.

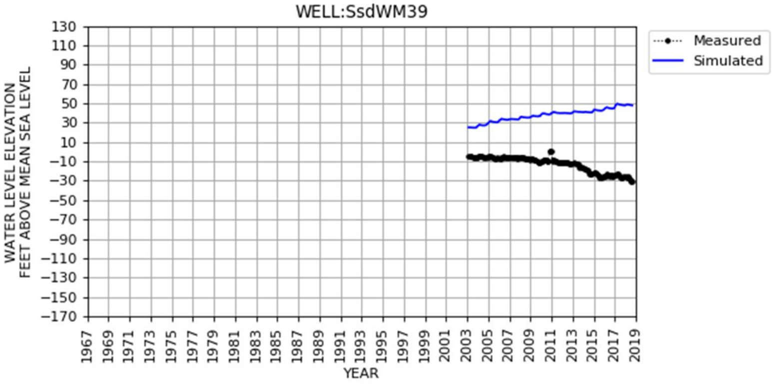
All model results are provisional and subject to revision

ATTACHMENT C
MEASURED AND SVIHM SIMULATED HYDROGRPAHS
FOR MONTEREY SUBBASIN


WELL:MCWRA23


WELL:SsdWM26


WELL:SsdWM38

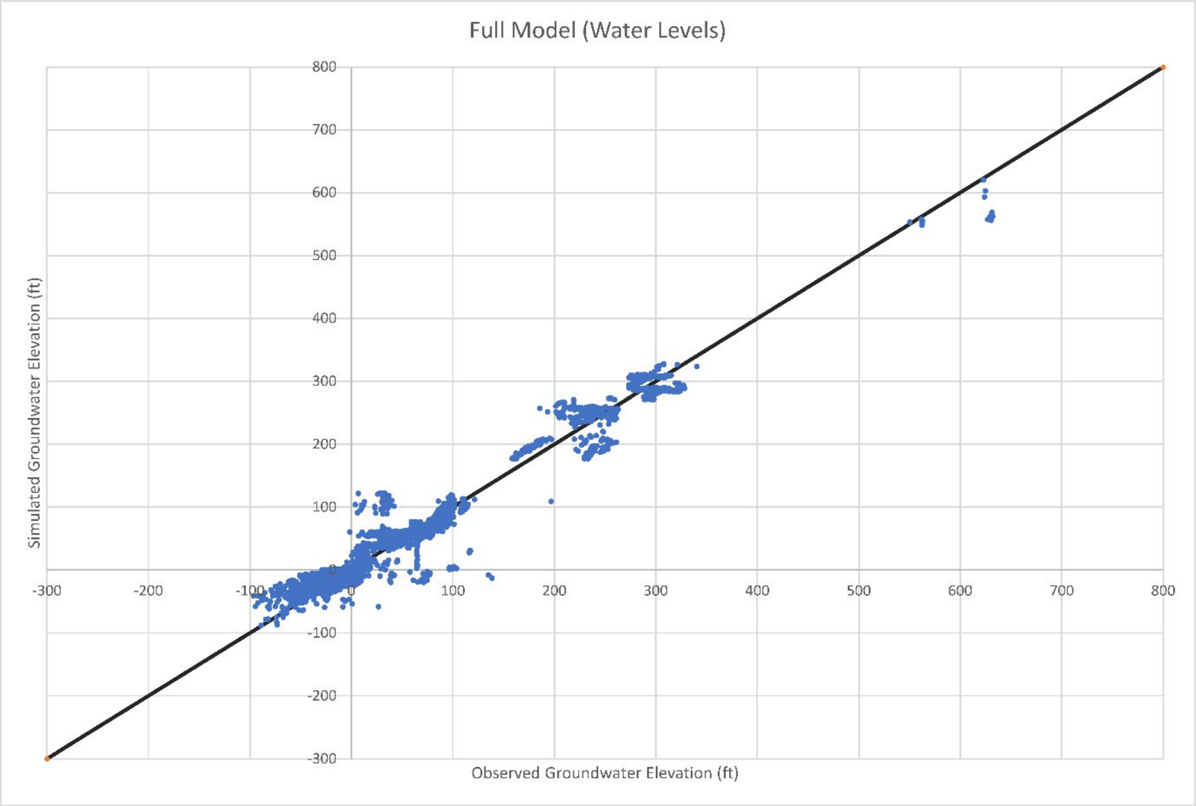

WELL:SsdWM39

Note: All reported statistics are in feet unless otherwise noted.

All model results are provisional and subject to revision

ATTACHMENT D

MONTEREY SUBBASIN MODEL PRELIMINARY CALIBRATION STATISTICS (AS OF 3/29/2021)



Number of Wells:	608
Number of Observations:	30555
Mean Residual (ft):	-1.93
Mean Absolute Residual (ft):	8.38
Root-Mean-Squared Residual (ft):	12.77
Residual Standard Deviation (ft):	12.62
Range in Observations (ft):	728.44
Scaled Mean Residual [%]:	-0.26%
Scaled Mean Absolute Residual [%]:	1.15%
Scaled Root-Mean-Squared Residual [%]:	1.75%
Scaled Residual Standard Deviation [%]:	1.73%
Coefficient of Determination (R^2):	0.94

Note: All results are preliminary and subject to revision.

Appendix 7A

MCWRA CASGEM Monitoring Plan

CASGEM Monitoring Plan for High and Medium Priority Basins in the Salinas Valley Groundwater Basin

March 10, 2015

Monterey County Water Resources Agency
893 Blanco Circle
Salinas, CA 93901

This page intentionally left blank.

Table of Contents

1.0 Introduction 2
  1.1 Scope and Purpose 2
2.0 Groundwater Basin Descriptions and Hydrogeology 2
  2.1 Overall Setting 3
  2.2 180/400 Foot Aquifer 3
  2.3 East Side Aquifer 5
  2.4 Forebay Aquifer 5
  2.5 Upper Valley Aquifer 5
  2.6 Paso Robles Area 5
  2.7 Langley Area 6
  2.8 Corral de Tierra Area 7
3.0 Groundwater Level Monitoring 9
  3.1 Monitoring History 9
  3.2 Monitoring Network Rationale 9
  3.3 CASGEM Monitoring Network and Data Gaps 10
    3.3.1 180/400 Foot Aquifer 11
    3.3.2 East Side Aquifer 12
    3.3.3 Forebay Aquifer 13
    3.3.4 Upper Valley Aquifer 14
    3.3.5 Paso Robles Area 19
    3.3.6 Langley Area 20
    3.3.7 Corral de Tierra Area 20
4.0 Monitoring Procedures 25
  4.1 Monitoring Frequency and Timing 25
  4.2 Well Locations 26
  4.3 Reference Points 26
  4.4 Field Methods 29
    4.4.1 Graduated steel tape 29
    4.4.2 Electric water level meter 29
    4.4.3 Sonic water level meter 30
    4.4.4 Pressure transducer 30
  4.5 Data Collection, Processing, and Reporting 31
5.0 References 32

List of Tables

Table 1 – DWR Basin Nomenclature, Numbering and Prioritization 2
Table 2 – Recommended Monitoring Network Density by Subbasin 10
Table 3 – CASGEM Network Compared to Target Minimum Density Numbers 10
Table 4 – Vertical Distribution of Wells in 180/400 Foot Aquifer 11

List of Figures

Figure 1 – Groundwater Basins and Subbasins in Monterey County....4
Figure 2 – Langley Area Subbasin and Hydrogeologic Subareas....8
Figure 3 – 180/400 Foot Aquifer Subbasin....15
Figure 4 – East Side Aquifer Subbasin....16
Figure 5 – Forebay Aquifer Subbasin....17
Figure 6 – Upper Valley Aquifer Subbasin....18
Figure 7 – Paso Robles Area Subbasin....22
Figure 8 – Langley Area Subbasin....23
Figure 9 – Corral de Tierra Area Subbasin....24
Figure 10 – Distribution of Seasonal High Groundwater Elevations by Month....27
Figure 11 – Distribution of Seasonal Low Groundwater Elevations by Month....28

Appendices

Appendix A – Letter to United States Army Corps of Engineers
Appendix B – Report on Salinas Valley Water Conditions for the Fourth Quarter of Water Year 2013-2014
Appendix C – CASGEM Network Well Data Summary
Appendix D – Transducer Specifications

List of Acronyms and Abbreviations

CASGEM	California Statewide Groundwater Elevation Monitoring
DWR	California Department of Water Resources
MCWRA	Monterey County Water Resources Agency
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
WY	Water Year

1.0 Introduction

This monitoring plan has been developed by the Monterey County Water Resources Agency (MCWRA) to meet requirements of the California Department of Water Resources (DWR) California Statewide Groundwater Elevation Monitoring (CASGEM) program. The plan to covers monitoring of groundwater elevations within high and medium priority alluvial subbasins identified in DWR Bulletin 118 that are located in Monterey County, and for which a Monitoring Entity has not yet been designated. This monitoring plan provides information on the groundwater basins, the wells to be sampled, and the monitoring schedule and methods.

1.1 Scope and Purpose

The monitoring plan presents descriptions of the groundwater subbasins; monitoring schedule and well network distribution; procedures for collecting and reporting the groundwater elevation data; and a description of the monitoring plan rationale.

This groundwater monitoring plan can be revised as necessary when refinements are made to the monitoring network to address program needs and data gaps. Revisions will be submitted to DWR when additions or removal of wells from the monitoring network occur.

2.0 Groundwater Basin Descriptions and Hydrogeology

Monterey County is located in the Central Coast Hydrologic Region. Thirteen basins and subbasins are identified in DWR Bulletin 118 as being partially or fully located within Monterey County (Figure 1).

This monitoring plan addresses seven of the subbasins in the Salinas Valley Groundwater Basin, specifically those which DWR has prioritized as “high” or “medium” (Table 1). Three of the basins - Cholame Valley (3.5), Lockwood Valley (3-6), and Peach Tree Valley (3-32) - have been prioritized as “low” or “very low” and will be covered by a subsequent monitoring plan.

Table 1 - DWR Basin Nomenclature, Numbering, and Prioritization

Subbasin Name	Basin/Subbasin Number	Basin Prioritization
180/400 Foot Aquifer	3-4.01	High
East Side Aquifer	3-4.02	High
Forebay Aquifer	3-4.04	Medium
Upper Valley Aquifer	3-4.05	Medium
Paso Robles Area	3-4.06	High
Langley Area	3-4.09	Medium
Corral de Tierra Area	3-4.10	Medium

The remaining three basins in Monterey County - Carmel Valley (3-7), Pajaro Valley (3-2), and the Seaside Area (3-4.08) - have a designated Monitoring Entity. The Monterey Peninsula Water Management District (MPWMD) is the Monitoring Entity for the Carmel Valley and Seaside basins; Santa Cruz County Environmental Health Services is the Monitoring Entity for the Pajaro Valley basin. The Paso Robles Area will be monitored both by MCWRA and the San Luis Obispo County Flood Control & Water Conservation District, with monitoring split along the county lines.

2.1 Overall Setting

The Salinas Valley is an intermontane alluvial basin extending 120 miles southeast from the Monterey Bay to Paso Robles. Although the valley fill is as thick as 15,000 feet, all of the principal water-bearing sediments lie within 2,000 feet of the ground surface (Showalter et al, 1983). These water-bearing sediments consist of Tertiary and Quaternary marine and terrestrial sediments, including the Pliocene Purisima Formation, the Plio-Pleistocene Paso Robles Formation, the Pleistocene Aromas Formation, and the Pleistocene to Holocene Valley Fill.

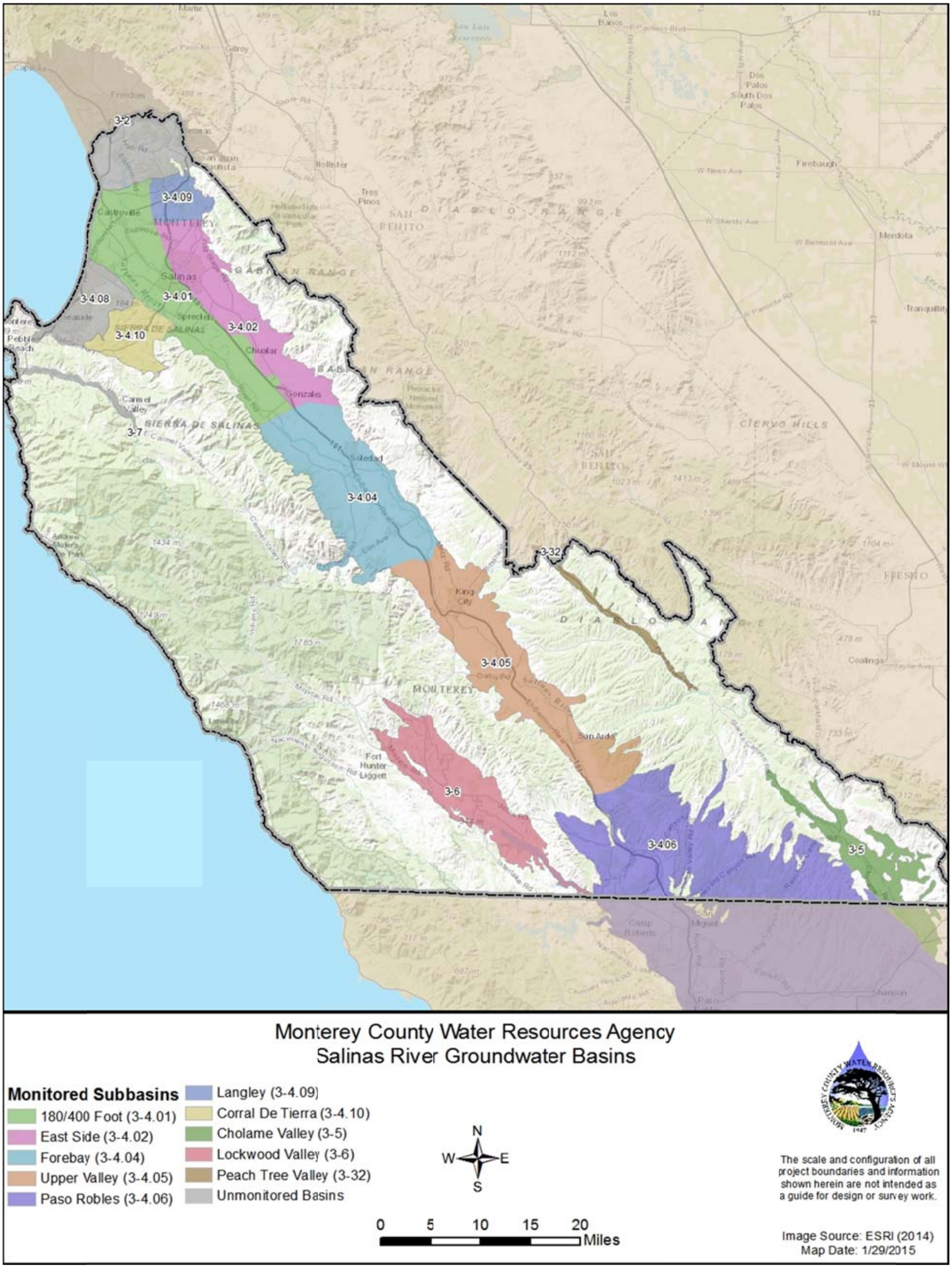
2.2 180/400 Foot Aquifer

The 180/400 Foot Aquifer subbasin is located in the northwestern part of the Salinas Valley basin. The northeastern boundary of the 180/400 Foot Aquifer subbasin is shared with the East Side Aquifer subbasin; the Forebay Aquifer subbasin lies on southeastern boundary, near the City of Gonzales. Monterey Bay abuts the northwestern boundary of the 180/400 Foot Aquifer subbasin.

The 180-Foot Aquifer ranges from 50 to 150 feet in thickness and is confined by an overlying blue clay layer, known as the Salinas Aquitard, which ranges from 25 to 100 feet thick. The Salinas Aquitard thins to the east and south of the subbasin and is present only in this subbasin. The 180-Foot Aquifer consists of interconnected layers of sand, gravel, and clay that are separated from the 400-Foot Aquifer by blue marine clay and other discontinuous aquifers and aquitards ranging from 10 to 70 feet in thickness. The 400-Foot Aquifer has an average thickness of 200 feet and consists of sands, gravels, and clay lenses (DWR, 2003). The blue marine clay aquitard has been reported to be absent in some areas of the 180/400 Foot Aquifer subbasin (Kennedy/Jenks, 2004).

There is a third water-bearing unit underlying the 180/400 Foot Aquifer subbasin, often referred to as the Deep Aquifer, which is separated from the overlying 400-Foot Aquifer by a blue marine clay aquitard (DWR, 2003). The Deep Aquifer is a confined unit that has been less developed than the 180-Foot and 400-Foot Aquifers, but wells are increasingly being drilled into this unit, so it will be included in the monitoring plan for this subbasin.

Figure 1 – Groundwater Basins and Subbasins in Monterey County



2.3 East Side Aquifer

The East Side Aquifer subbasin is located in the northeastern portion of the Salinas Valley basin, bounded by the foothills of the Gabilan Range to the northeast and Highway 101 to the southwest (Kennedy/Jenks 2004).

The East Side Aquifer subbasin is dominated by poorly bedded sequences of gravel, silt, sand, gravelly/sandy clay, and clay. In portions of the East Side Aquifer subbasin, decomposed granite is a prominent component of the sediments (Kennedy/Jenks, 2004). The primary water-bearing units of the East Side Aquifer subbasin are the same units that are present in the 180/400 Foot Aquifer subbasin. However, the near-surface Salinas Aquitard is not present in the East Side Aquifer subbasin, and the aquitard that separates the 180-Foot and 400-Foot Aquifers is less continuous in the East Side Aquifer subbasin, leading to semi-confined to unconfined conditions for much of the groundwater (DWR, 2003).

2.4 Forebay Aquifer

The Forebay Aquifer subbasin is located in the central portion of the Salinas Valley basin, bounded by the Sierra de Salinas and Gabilan Range to the west and east, respectively. The Forebay subbasin is bounded to the north by the 180/400 Foot Aquifer and East Side Aquifer subbasins. The southern boundary of the Forebay Aquifer subbasin is shared with the Upper Valley Aquifer subbasin (DWR, 2003).

Many of the same hydrostratigraphic units that comprise the 180/400 Foot Aquifer subbasin are present in the Forebay Aquifer subbasin, though the aquitard separating the two water bearing units in the northern subbasin is absent in the Forebay Aquifer subbasin. Groundwater in the Forebay Aquifer subbasin is unconfined and occurs in lenses of sand and gravel that are interbedded with massive units of finer grained material (DWR, 2003).

2.5 Upper Valley Aquifer

The Upper Valley Aquifer subbasin occupies a stretch of the Salinas Valley groundwater basin from just south of Greenfield, CA to San Ardo, CA. The northern border of the Upper Valley Aquifer subbasin is shared with the Forebay Aquifer subbasin, while the southern border is shared with the Paso Robles Area subbasin.

Groundwater in the Upper Valley Aquifer subbasin is unconfined and is derived primarily from an aquifer of unconsolidated to semi-consolidated and interbedded gravel, silt, sand, and alluvial fan and river deposits (DWR, 2003).

2.6 Paso Robles Area

The Paso Robles Area subbasin is partially located in Monterey County, though the majority of the subbasin is located in San Luis Obispo County. The Upper Valley Aquifer subbasin forms the northern boundary of the Paso Robles Area subbasin.

Groundwater in the Paso Robles Area subbasin is found in two formations: Holocene age alluvium and the Pleistocene age Paso Robles Formation. Groundwater in the fine- to coarse-grained sand, pebbles, and boulders of the alluvium is unconfined while groundwater in the Paso Robles Formation is generally confined (DWR, 2003).

The Paso Robles Groundwater Basin Computer Model (Model) has characterized flow in the basin using four vertical groundwater zones: one in the alluvium and three within the Paso Robles Formation (SLOCFCWD, 2014).

2.7 Langley Area

The Langley Area subbasin is located in the northeastern part of the Salinas Valley groundwater basin. Portions of the Langley Area subbasin are underlain by granitic bedrock that is not considered to be a viable water-bearing unit. In the remaining areas of the Langley Area subbasin, the groundwater supply is derived from shallow, well-sorted sands separated by confining layers of interbedded clays and silty clays (DWR, 2003).

A study of hydrogeology in northern Monterey County was conducted by Fugro West, Inc. (Fugro) and included most of the Langley Area subbasin. The Fugro study further divided the subbasin, as it is defined by DWR, into hydrogeologic subareas using factors such as well yields, depth to bedrock, volume of groundwater storage, and sources of recharge (Fugro, 1995). Two of the hydrogeologic subareas defined by the Fugro study are coincident with approximately 75% of the Langley Area subbasin: Highlands South and Granite Ridge (Figure 2).

The Highlands South subarea consists of saturated Aromas Sands (interbedded sands, clay, and gravel) overlying the Purisima Formation (semi-consolidated units of fine sand, clay, and silt), which has not proved a viable aquifer (Fugro, 1995). The Highlands South hydrogeologic subarea, as defined by the Fugro report, covers approximately 46% of the Langley Area subbasin.

The Granite Ridge subarea is characterized by a thin layer of Aromas Sands overlying granitic bedrock or weathered granite. Wells in the Granite Ridge subarea are typically completed in either granular materials (Aromas Sands and weathered granite); fresh granite; or other consolidated formations (Fugro, 1995). Approximately 29% of the Langley Area is coextensive with the Granite Ridge subarea.

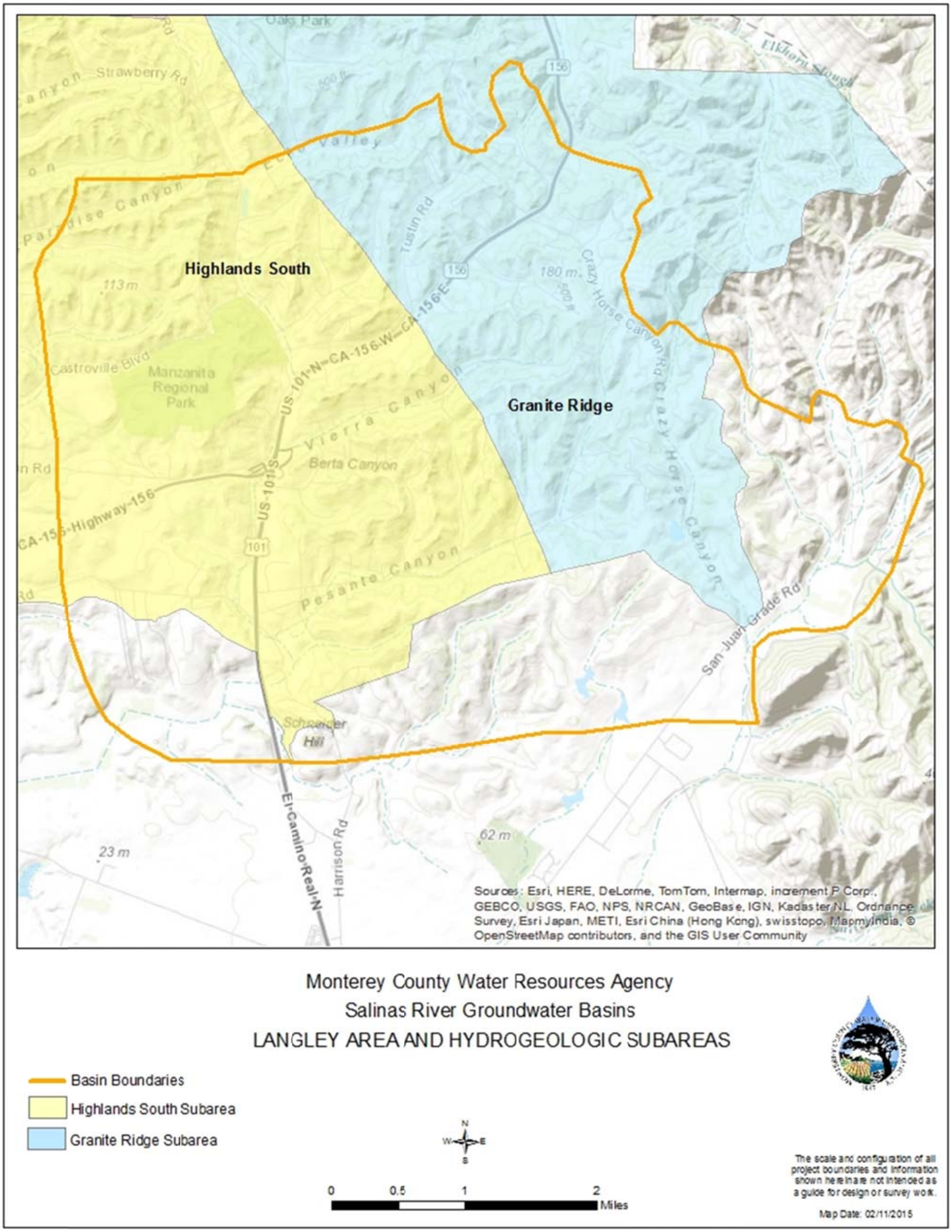
The transition between hydrogeologic conditions of the Highlands South and Granite Ridge subareas is gradual and occurs slightly east of the center of the Langley Area. The transition is characterized by the thinning of saturated sediments to the east, eventually thinning to the extent that the granitic bedrock is above regional saturation (Fugro, 1995).

2.8 Corral de Tierra Area

The Corral de Tierra Area subbasin is located to the west of the 180/400 Foot Aquifer subbasin and contains portions of the former Fort Ord and other unincorporated areas. It is bounded to the northwest by the Seaside Area subbasin.

Groundwater in the Corral de Tierra Area subbasin comes primarily from the Paso Robles Formation, which consists of sand, gravel, and clay interbedded with minor calcareous beds. The poorly consolidated marine sandstone of the Santa Margarita Formation also yields water in the Corral de Tierra Area subbasin (DWR, 2003). A previous study which included the Corral de Tierra Area found that although there are thick sequences of low permeability material in some areas of the subbasin that may limit vertical hydraulic communication between aquifer units, a comparison of water level data shows general consistency between wells screened in different units (Geosyntec, 2007).

Figure 2 – Langley Area Subbasin and Hydrogeologic Subareas



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

3.0 Groundwater Level Monitoring

The following sections discuss the history of groundwater level monitoring in the Salinas Valley groundwater basin; current monitoring activities in the basin; and the proposed network of CASGEM monitoring wells. Data gaps in the monitoring network are also identified and discussed.

3.1 Monitoring History

Groundwater level measurements in the Salinas Valley groundwater basin have been ongoing, in some form, since the 1940s. Presently, MCWRA conducts monthly and annual surveys of groundwater levels to monitor fluctuations in water level and determine relative changes in storage over time. Data collected through the MCWRA groundwater level monitoring program also contributes to analysis of seawater intrusion in coastal groundwater zones.

MCWRA maintains a small network of dedicated monitoring wells where groundwater level data is recorded by a pressure transducer on an hourly basis. However, the distribution of the dedicated monitoring wells is limited; much of the groundwater level data is collected from privately-owned agricultural production wells where owners have granted permission to MCWRA. MCWRA collects groundwater level measurements from over four hundred wells on an annual basis; on a monthly basis, groundwater levels are measured in about one quarter of these wells.

3.2 Monitoring Network Rationale

The CASGEM network is of a combination of dedicated monitoring wells that are owned by MCWRA and wells that are owned by private individuals who elected to participate in the CASGEM program.

The MCWRA-owned monitoring wells were selected for inclusion in the program due to their distribution throughout Monterey County, the availability of detailed and reliable well construction data, and relative ease of data collection.

In the selection of privately owned wells, preference was given to wells that are in the MCWRA monthly groundwater level monitoring program, since the minimum number of data points for CASGEM reporting are already being gathered. MCWRA also considered wells that are in the annual groundwater level monitoring program. Wells in the annual program are currently measured only once per year, so additional staff effort will be required to schedule a second visit in order to satisfy the biannual measurement criteria for CASGEM reporting.

Additional privately owned wells were sought in areas where dedicated monitoring wells are not available. MCWRA filled as many data gaps as possible with privately owned wells, working toward a target minimum density of 10 wells per 100 square miles of groundwater basin.

Approximately one third of the land in the Corral de Tierra Area is federal property. MCWRA has reached out to the United States Army Corps of Engineers (USACE), which owns the property, seeking participation in the CASGEM program (Appendix A). As of the date of this monitoring plan, USACE has not responded to MCWRA's letter. As such, the land owned by USACE is considered a data gap in the Corral de Tierra Area. The following subbasin-specific discussions address data gaps in the MCWRA CASGEM network in more detail.

MCWRA considered the availability of reliable well construction data choosing CASGEM wells. Where appropriate, wells were also selected to provide coverage of vertically distinct aquifers.

Table 2 - Recommended Monitoring Well Network Density by Subbasin

Subbasin Name	Subbasin Area in Monterey County (mi^2)	Federal Land Area of Subbasin (mi^2)	Wells Needed for Target Minimum Density
High and Medium Priority (10 wells per 100 mi^2)			
180/400 Foot Aquifer	132	0	13
East Side Aquifer	90	0	9
Forebay Aquifer	147	0	15
Upper Valley Aquifer	153	0	15
Paso Robles Area	221	0	22
Langley Area	24	0	2
Corral de Tierra Area	35	12	4
Total wells in High and Medium Priority Subbasins			**80**

3.3 CASGEM Monitoring Network and Data Gaps

This section describes the number and distribution of wells in the CASGEM monitoring network of each subbasin, identifies data gaps in some of the monitored subbasins, and outlines the approach for addressing data gaps where applicable.

As shown in Table 3, the CASGEM network meets the target minimum density in some subbasins, while additional wells are required in other subbasins in order to meet the target.

Table 3 – CASGEM Network Compared to Target Minimum Density Numbers

Subbasin Name	Target Minimum Density	CASGEM Wells	Voluntary Wells	Wells Remaining to Meet Target Minimum Density
180/400 Foot Aquifer	13	22	1	0[a]
East Side Aquifer	9	8	0	1
Forebay Aquifer	15	9	2	11[b]
Upper Valley Aquifer	15	3	0	12
Paso Robles Area	22	1	0	21
Langley Area	2	3	0	0[c]
Corral de Tierra Area	4	2	0	2
TOTAL	**80**	**48**	**3**	**47**

Notes

(a) Additional wells will be sought to address a data gap in the vertical distribution of the well network as funding is available.

(b) Forebay Aquifer CASGEM wells include multiple well clusters, so only four geographic locations are covered by the nine wells.

(c) Additional wells will be sought to address data gaps in horizontal distribution of the well network as funding is available.

3.3.1 180/400 Foot Aquifer

The CASGEM well network for the 180/400 Foot Aquifer subbasin is shown on Figure 3. MCWRA has fifteen (15) dedicated monitoring wells in the 180/400 Foot Aquifer subbasin, all of which will be included in the CASGEM network. Some of the monitoring wells consist of clusters of multiple nested wells at a single location, with each well in the cluster monitoring a different aquifer. The CASGEM well network includes seven (7) privately owned wells; where the well owner has granted permission for MCWRA to include his/her well in the CASGEM program. There is also one (1) voluntary well in the 180/400 Foot Aquifer subbasin.

Data Gaps – Horizontal Distribution of Wells

The 180/400 Foot Aquifer subbasin is 132 square miles. Based on the target minimum density of ten (10) wells per 100 square miles, this subbasin should have 13 monitoring wells to meet the needs of the CASGEM program. MCWRA has met the target minimum density in the 180/400 Foot Aquifer subbasin with a network distributed throughout the basin, as shown in Figure 3.

Data Gaps – Vertical Distribution of Wells

As discussed in Section 2.2, the 180/400 Foot Aquifer subbasin has three distinct water-bearing zones, each separated by a blue marine clay aquitard. All three aquifers will be monitored by the wells in the CASGEM network, as shown in Table 4.

Table 4 - Vertical Distribution of Wells in 180/400 Foot Aquifer

Aquifer Zone	Dedicated Monitoring Wells	Privately Owned CASGEM Wells	Total Wells
180-Foot Aquifer	8	1	9
400-Foot Aquifer	3	5	8
180/400 Foot Aquifers	4	0	4
Deep Aquifer	0	1	1
TOTAL	**15**	**7**	**22**

As shown in Table 4, eight (8) of the MCWRA dedicated monitoring wells are constructed with screens in the 180-Foot Aquifer, as is one (1) of the privately owned wells. Three (3) of the MCWRA monitoring wells are constructed with screens in the 400-Foot Aquifer, as are five (5) of the privately owned wells. Groundwater elevations in the Deep Aquifer will be monitored at one (1) well location where permission has been granted by the well owner.

Two sets of the MCWRA dedicated monitoring wells (four total wells) are constructed in areas recognized as hydrogeologic transition zones between the 180/400 Foot Aquifer and the East Side Aquifer, and between the 180/400 Foot Aquifer and the Forebay Aquifer. The transition zone between the 180/400 Foot Aquifer and the East Side Aquifer is distinguished by a shift from predominantly fluvial facies, common to the 180/400 Foot Aquifer, to predominately alluvial fan facies (Kennedy/Jenks, 2004). The transition from the 180/400 Foot Aquifer to the Forebay Aquifer is characterized by thinning and/or pinching out of the near surface confining unit, the Salinas Aquitard (DWR, 2003).

Although the site-specific geology at these monitoring wells suggests that the wells are more representative of the East Side Aquifer or Forebay Aquifer, MCWRA has assigned these four wells to the 180/400 Foot Aquifer subbasin because they are geographically located in this basin, as directed by DWR (staff communication, 2015). If an opportunity arises in the future to adjust the groundwater basin/subbasin boundaries, wells like these will be useful for defining transitional zones and aligning basin boundaries with known hydrogeology.

Though MCWRA has met the target minimum density in the 180/400 Foot Aquifer, there is only one well monitoring the Deep Aquifer Zone, which suggests a data gap in the CASGEM network. MCWRA will address this data gap by evaluating the possibility of including new privately owned wells in the CASGEM program, and will reach out to well owners seeking participation when an appropriate well is found. Additionally, while there are no funds accessible at present to drill new monitoring wells, MCWRA will consider this option if funding becomes available.

3.3.2 East Side Aquifer

The CASGEM network for the East Side Aquifer subbasin is shown on Figure 4. MCWRA has two (2) dedicated monitoring wells in the East Side Aquifer subbasin, both of which will be included in the CASGEM network. The CASGEM well network also includes six (6) privately owned wells in the East Side Aquifer subbasin.

Data Gaps – Horizontal Distribution of Wells

The East Side Aquifer subbasin has an approximate area of 90 square miles, suggesting that the subbasin should have nine (9) monitoring wells to meet the CASGEM program target minimum density. The CASGEM network in this monitoring plan, which consists of eight (8) wells, is one well short of this target minimum density.

There remains an area in the central portion of the subbasin of approximately 26 square miles (29% of the subbasin area) where there are no monitoring wells. MCWRA continues to seek suitable privately owned wells in this area for inclusion in the CASGEM program. Additionally, as funding opportunities become available, MCWRA will consider the installation of new monitoring wells in this area of the East Side Aquifer subbasin.

Data Gaps – Vertical Distribution of Wells

Groundwater in the East Side Aquifer is semi-confined to unconfined, as discussed in Section 2.3 of this document. For purposes of monitoring in this subbasin, MCWRA distinguishes the unconfined (shallow) portion of the aquifer from the semi-confined (deeper) portion, though there is not a continuous confining layer present at all locations within the subbasin.

Recognizing this distinction, the East Side Aquifer CASGEM network includes wells that are screened in both unconfined and semi-confined water-bearing zones: two (2) of the wells are screened in the shallow zone and one (1) is screened in the deeper zone.

Five (5) of the wells in the CASGEM network have screens in both zones. These wells have been included in the CASGEM network because there are few MCWRA program wells (i.e. potential CASGEM wells) in this subbasin that are screened in a discrete aquifer zone. Despite having screened intervals in both the shallow and deep zones, viable groundwater elevation data can be gleaned from these wells. Trends in the groundwater elevation data from these dual-screened wells is compared to that from wells that are screened in a discreet zone, and professional judgment is used to determine which zone is best represented by the dual-screened well and how the data fits with overall data trends seen in other wells across the basin.

MCWRA will evaluate the possibility of including additional privately owned wells, including ones that may not currently be in a monitoring program, to resolve data gaps in the East Side Aquifer. Preference will be given to wells that are screened in a single water-bearing zone. As funding becomes available, the option to install new monitoring wells will also be considered.

3.3.3 Forebay Aquifer

The CASGEM network for the Forebay Aquifer subbasin is shown on Figure 5. MCWRA has nine (9) dedicated monitoring wells in the Forebay Aquifer subbasin, all of which will be included in the CASGEM network. The nine (9) monitoring wells cover four (4) geographic locations within the basin, divided as follows: three (3) clusters of two (2) nested wells each and one (1) cluster of three (3) nested wells. The Forebay Aquifer subbasin also includes two (2) voluntary wells.

Data Gaps – Horizontal Distribution of Wells

The Forebay Aquifer subbasin is approximately 147 square miles, indicating a need for 15 monitoring wells in order to achieve the target minimum density. For the purposes of horizontal distribution, the CASGEM network in the Forebay Aquifer subbasin will cover four (4) locations due to the nested construction at some of the monitoring well pairs. An additional 11 wells are required to meet the target minimum density for this subbasin.

MCWRA does not currently have funding to support installation of an additional 11 monitoring wells in the Forebay Aquifer subbasin. However, as funding opportunities become available, MCWRA will review the possibility of installing additional wells to address data gaps in the CASGEM network. In the meantime, MCWRA will continue to evaluate existing privately owned wells and, as deemed appropriate, entreat the permission of the well owners for inclusion of more wells into the CASGEM network.

Data Gaps – Vertical Distribution of Wells

The Forebay Aquifer is considered to be an unconfined aquifer. As such, there are no data gaps in the vertical distribution of the CASGEM network. The current wells, and any additional wells that may be incorporated in the future, will be monitoring the same vertical water-bearing zone.

3.3.4 Upper Valley Aquifer

The CASGEM network for the Upper Valley Aquifer subbasin is shown on Figure 6. The CASGEM network will include the three (3) wells: one (1) dedicated monitoring well owned by MCWRA in the Upper Valley Aquifer subbasin and two (2) privately owned wells.

Data Gaps – Horizontal Distribution of Wells

The Upper Valley Aquifer subbasin is 153 square miles; therefore, 15 monitoring wells are required to meet the target minimum density for the subarea. To meet this target, the Upper Valley Aquifer subbasin will require an additional 12 wells.

MCWRA does not currently have plans or funding to install any additional monitoring wells in the Upper Valley Aquifer subbasin to alleviate the data gap in this subbasin. However, should funding become available, MCWRA will explore the installation of dedicated monitoring wells where data gaps exist in the CASGEM network. Until such funding becomes available, MCWRA will seek additional participation from private well owners whose wells are deemed suitable to achieve the needs of the CASGEM program.

Data Gaps – Vertical Distribution of Wells

The Upper Valley Aquifer is considered to be an unconfined aquifer. As such, there are no data gaps in the vertical distribution of the CASGEM network. The current wells, and any additional wells that may be incorporated in the future, will be monitoring the same vertical water-bearing zone.

Figure 3 – 180/400 Foot Aquifer Subbasin

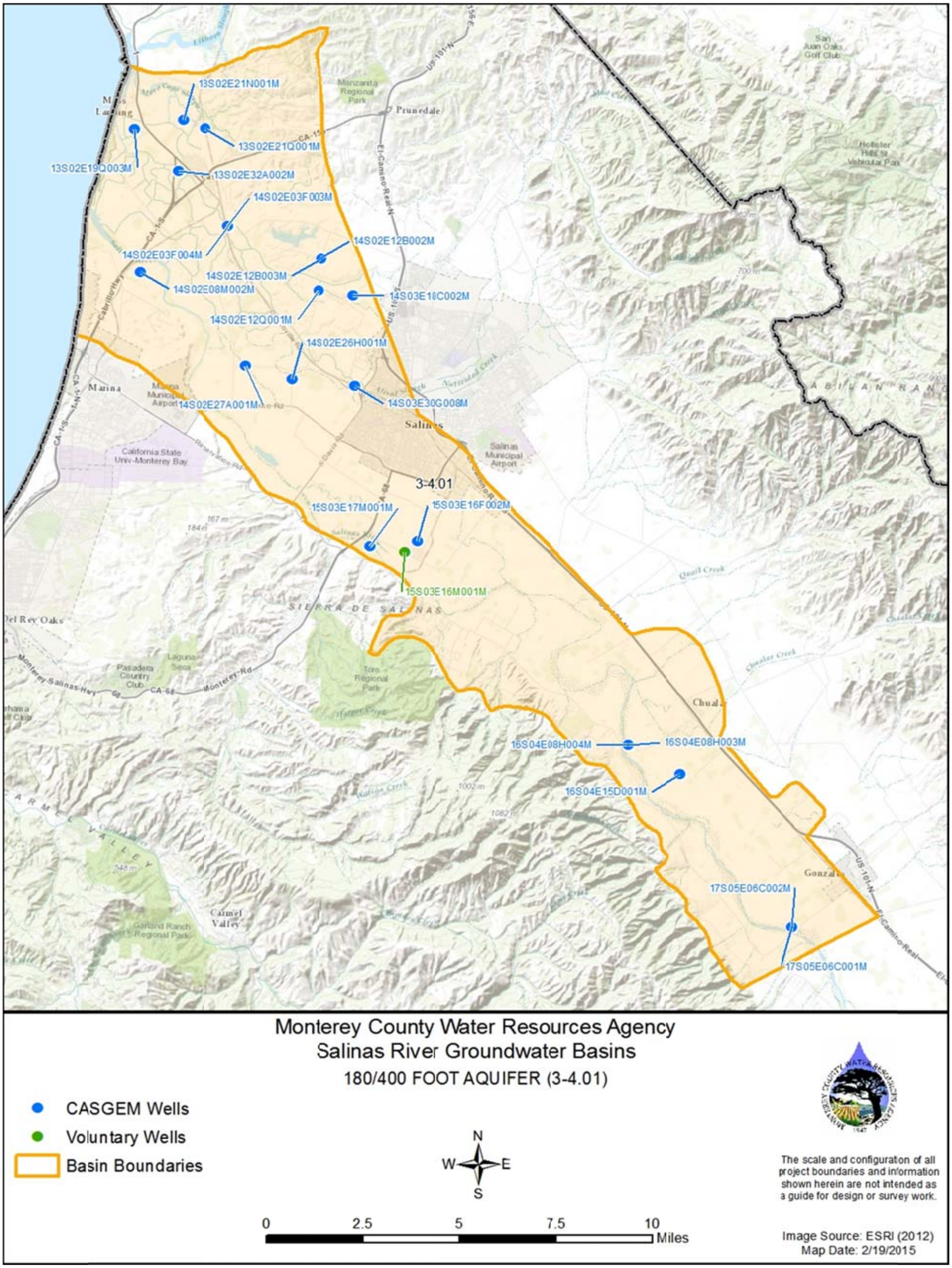


Figure 4 – East Side Aquifer Subbasin

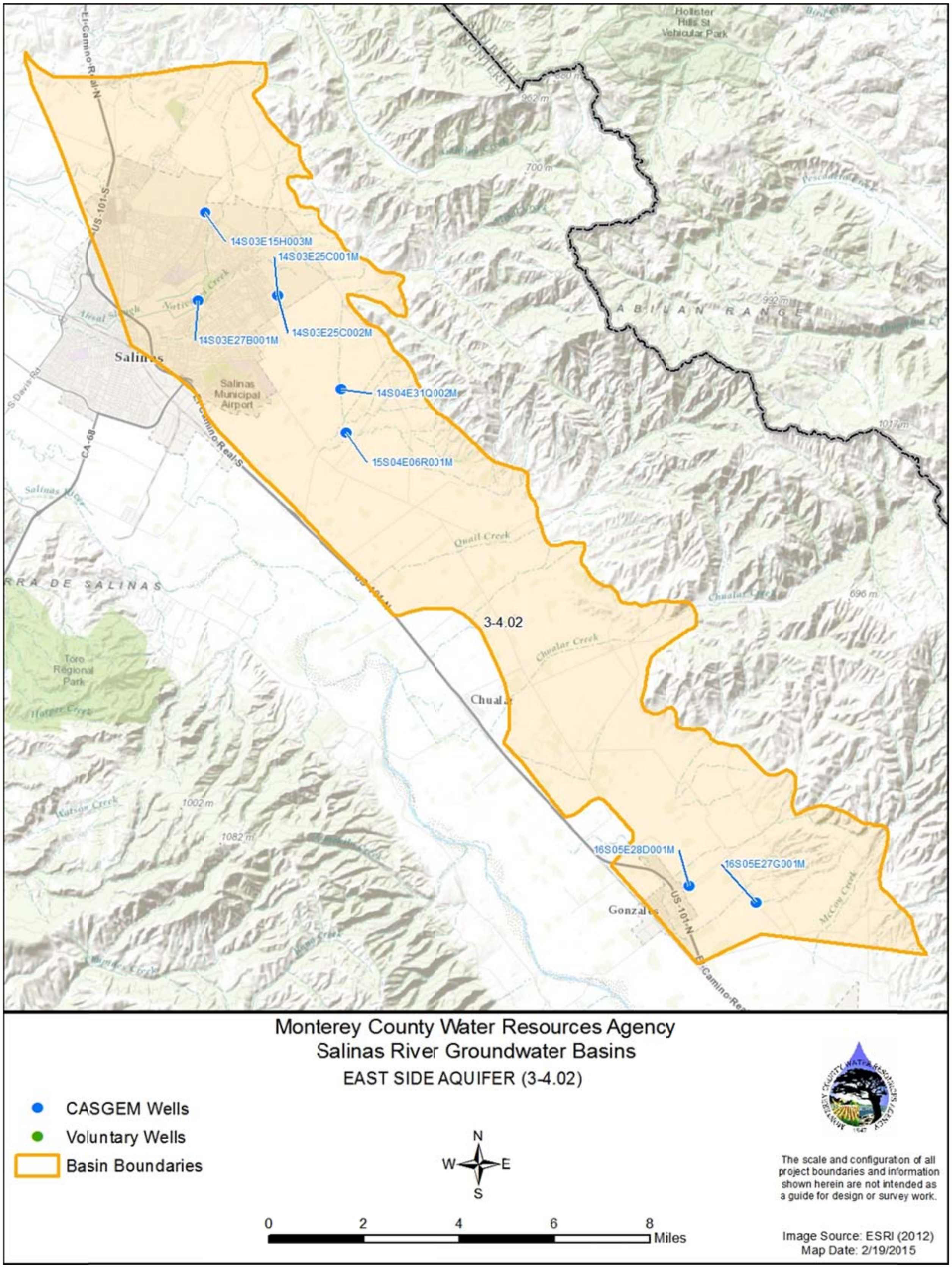


Figure 5 – Forebay Aquifer Subbasin

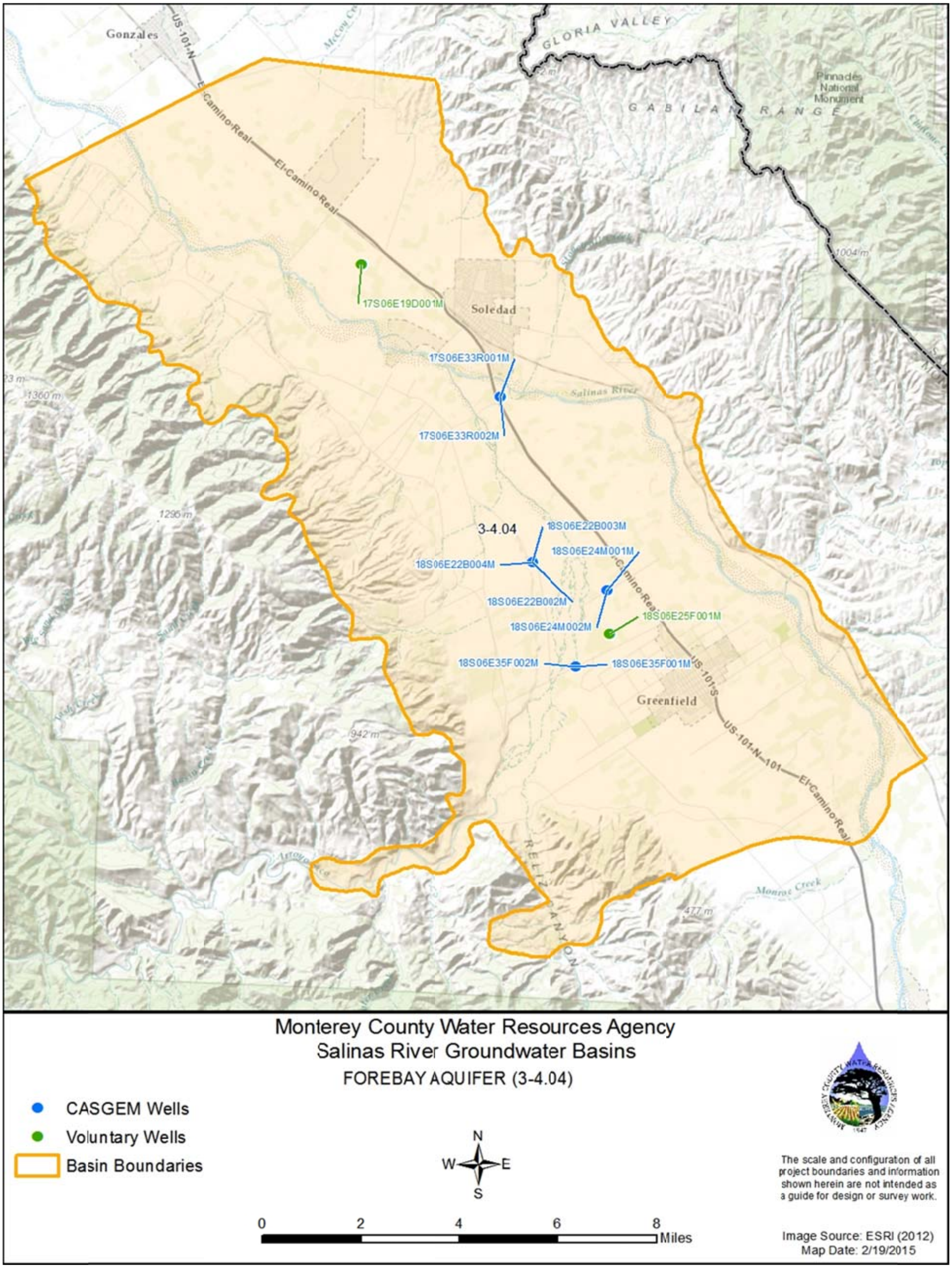
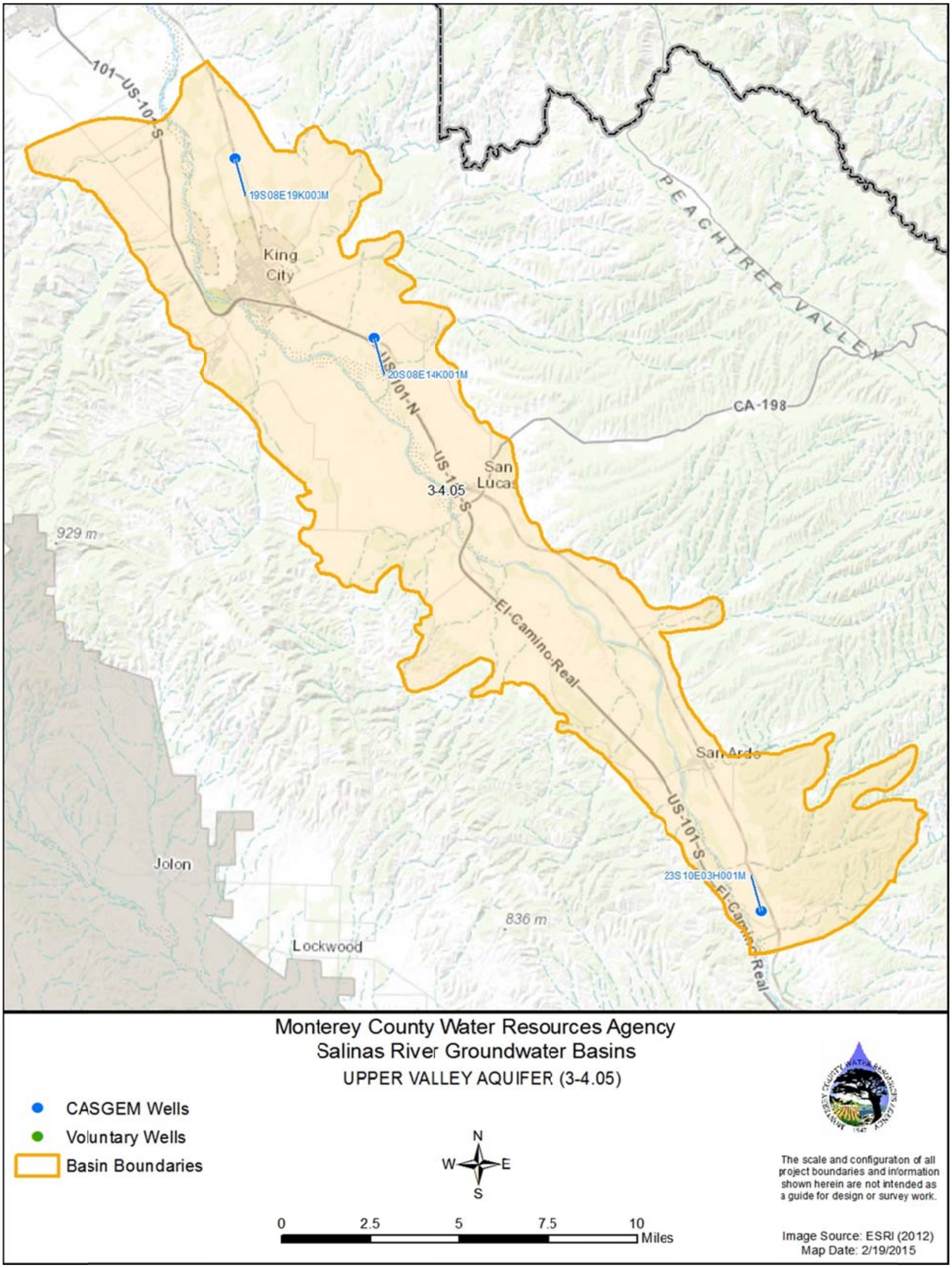


Figure 6 – Upper Valley Aquifer Subbasin



3.3.5 Paso Robles Area

The Paso Robles Area subbasin is located in both Monterey and San Luis Obispo counties, as shown on Figure 7. The subbasin is split by the county lines, with approximately 221 square miles of the Paso Robles Area located in Monterey County. Based on the area within Monterey County, 22 monitoring wells would be required to meet the target minimum density for the subarea. The remainder of the Paso Robles Area subbasin will be monitored by the San Luis Obispo County Flood Control & Water Conservation District.

MCWRA has one (1) dedicated monitoring well in the Paso Robles Area subbasin, which will be included in the CASGEM network (Figure 7). The San Luis Obispo County portion of the Paso Robles Area is currently monitored by fourteen (14) wells, as shown on Figure 7 (SLOCFCWD, 2014); one of these wells is very close to the Monterey County/San Luis Obispo County line.

MCWRA does not currently have plans or funding to install any additional monitoring wells in the Paso Robles Area Subbasin, though if funding becomes available, the construction of new monitoring wells will be explored as a mechanism for addressing this data gap in the CASGEM network. Consideration will be given to the San Luis Obispo County CAGSEM network when evaluating installation of new wells or incorporation of privately owned wells from the subbasin in the CASGEM network, as it is monitoring of the basin a whole that is the priority.

Data Gaps – Horizontal Distribution of Wells

With only one well located in the Paso Robles Area, there is a data gap to address in this subbasin; 21 additional wells are required to meet the target minimum density. MCWRA will continue to investigate the possibility of locating privately owned wells for the CASGEM program, while also considering the installation of additional monitoring wells should a funding mechanism become available. As discussed above, the existing CASGEM network in the San Luis Obispo County portion of the subbasin will be considered when evaluating augmentation of the monitoring network in the Monterey County portion of the subbasin.

Data Gaps – Vertical Distribution of Wells

As discussed in Section 2.6 of this Monitoring Plan, the Paso Robles Groundwater Basin Computer Model (Model) has characterized flow in the basin using four vertical groundwater zones: one in the alluvium and three within the Paso Robles Formation (SLOCFCWD, 2014).

The one (1) monitoring well that currently comprises the CASGEM network in this subbasin is monitoring the unconfined alluvial unit. Any future wells that are brought into the CASGEM program will be evaluated and selected with consideration given to the zone that is monitored by the well. Similarly, any new monitoring wells that may be installed in this area will be designed such that all of the zones defined by the Model are monitored.

3.3.6 Langley Area

The Langley Area subbasin is approximately 24 square miles in area. Based on the target minimum density, the CASGEM network for this subbasin should include two (2) wells. MCWRA does not have any dedicated monitoring wells in the Langley Area subbasin, but three (3) CASGEM wells have been located for this subbasin (Figure 8).

Data Gaps – Horizontal Distribution of Wells

The three (3) CASGEM wells in the Langley Area are located in the eastern half of the subbasin, leaving a data gap in the western portion of the subbasin, near the boundary with the 180/400 Foot Aquifer subbasin. MCWRA has identified possible privately owned wells that are located in the data gap area and continues to work with the well owners toward inclusion of these wells in the CASGEM program. In addition, should funding become available, MCWRA will consider this area as a candidate for installation of new monitoring wells.

Data Gaps – Vertical Distribution of Wells

The dominant water-bearing unit in the Langley Area is the Aromas Red Sands. Based on the depth of the CASGEM wells, the Aromas Red Sands are being monitored, so there are no apparent vertical data gaps to address. Other geologic units present in the Langley Area are neither alluvial nor considered to be water-bearing.

3.3.7 Corral de Tierra Area

The Corral de Tierra subbasin is approximately 35 square miles in area, so four (4) monitoring wells are required to meet the target minimum density for the subarea. MCWRA does not have any dedicated monitoring wells in the Corral de Tierra subbasin; however, MCWRA has identified two (2) CASGEM wells in this subbasin (Figure 9).

Data Gaps – Horizontal Distribution of Wells

Land that is part of the former Fort Ord, now owned by the United States Army Corps of Engineers (USACE), occupies the northwestern, and part of the northeastern, areas in the Corral de Tierra Area subbasin. MCWRA has contacted USACE seeking their participation in the CASGEM program, but has yet to receive a response (Appendix A). MCWRA cannot access the USACE land, therefore, the CASGEM network will be limited to the eastern/southeastern areas of the subbasin. The two (2) CASGEM wells are located in the south-central part of the Corral de Tierra Area, leaving a data gap in the eastern part of the subbasin.

Though MCWRA does not currently have funding to install any additional monitoring wells in the Corral de Tierra Area subbasin, this will be explored as a possibility if funding becomes available. MCWRA has been unable to secure approval for participation from the well owners contacted in this portion of the subbasin, but staff continues to look for privately owned wells and will assess the feasibility of incorporating such wells into the CASGEM network as a means of addressing data gaps. In addition, MCWRA will coordinate with USACE if that agency becomes willing to allow access to wells on the federal land at some point in the future.

Data Gaps – Vertical Distribution of Wells

Previous studies indicate that there is no significant limitation on vertical communication between the two water-bearing units in this subbasin and that wells screened in both units exhibit similar water levels (Geosyntec, 2007). Any additional wells added to the network to address horizontal data gaps will simply enhance monitoring of the same units.

Figure 7 – Paso Robles Area Subbasin

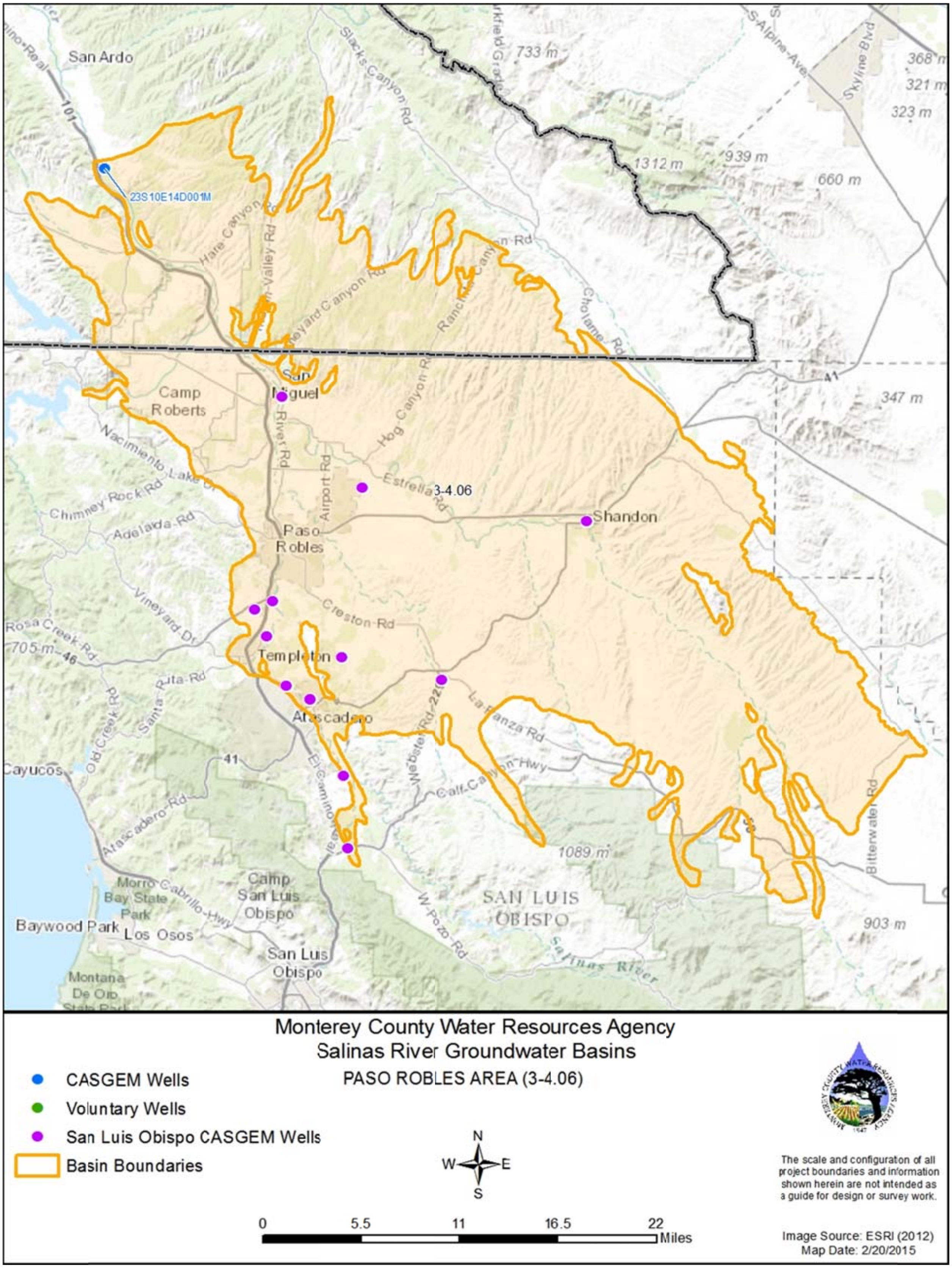


Figure 8 – Langley Area Subbasin

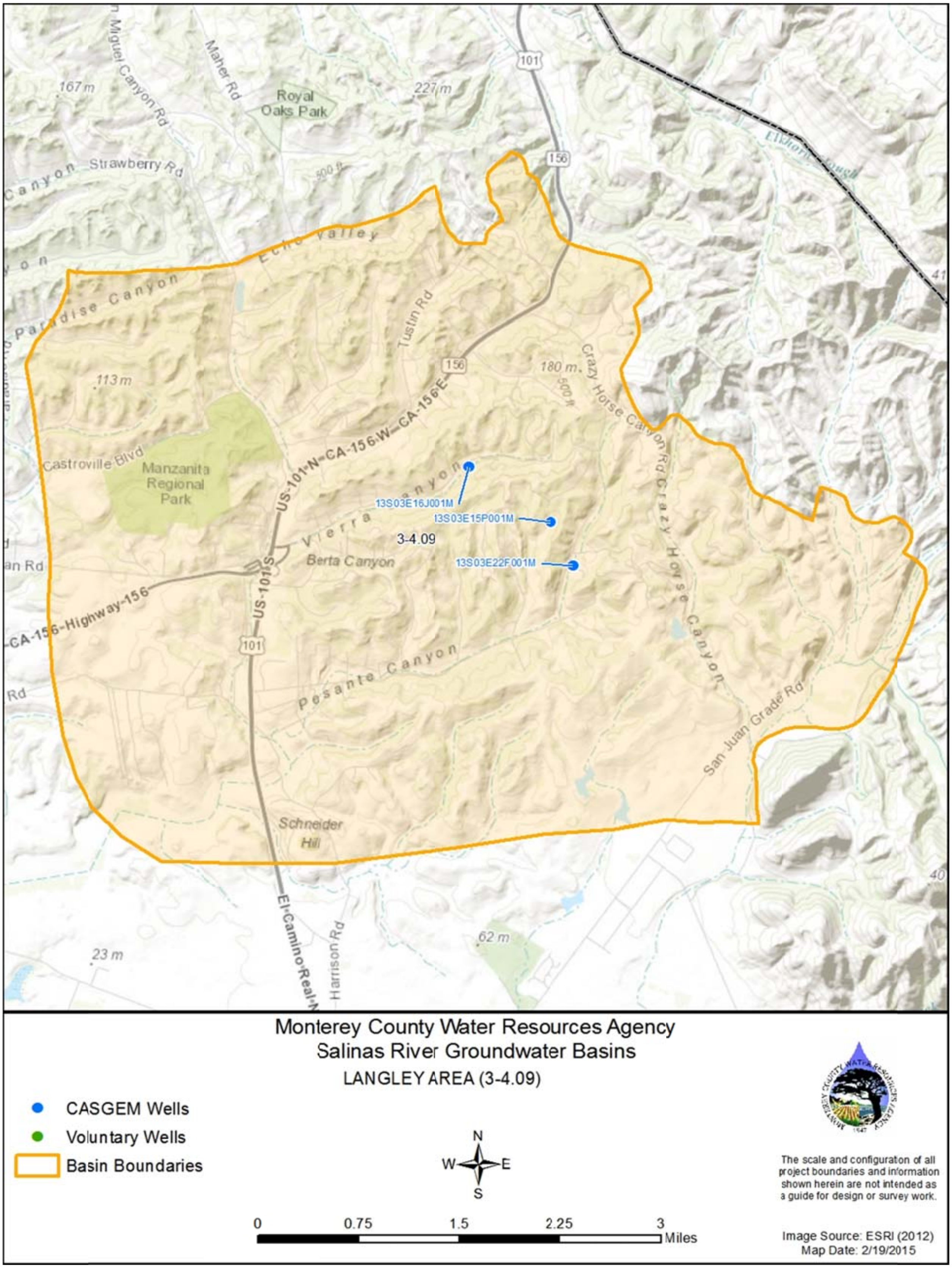
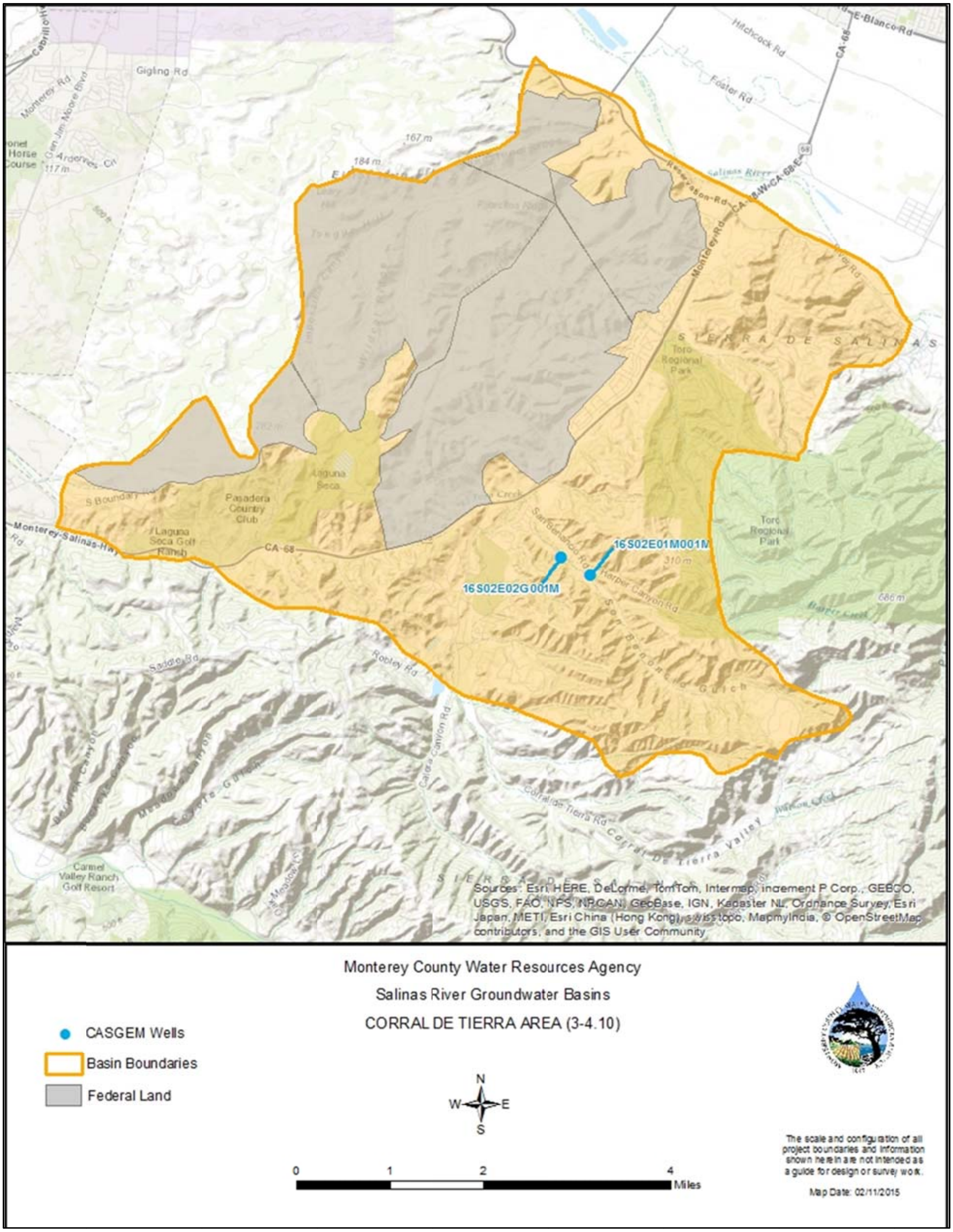


Figure 9 – Corral de Tierra Area Subbasin



4.0 Monitoring Procedures

This section addresses the various procedures and protocols involved in collecting, processing, and reporting data from wells in the CASGEM network.

4.1 Monitoring Frequency and Timing

Nineteen (19) of the CASGEM wells are currently, and will continue to be, measured on a monthly basis. The three (3) voluntary wells are also measured monthly. MCWRA will use the monthly measurements from August and either January, February, or March to satisfy the biannual CASGEM reporting criteria.

To determine the monthly distribution of seasonal high and low groundwater elevations, MCWRA analyzed measurements from approximately 50 wells throughout the Salinas Valley Groundwater Basin. This included wells in the 180/400 Foot Aquifer, East Side Aquifer, Forebay Aquifer, and Upper Valley Aquifer. The measurements were collected during eight (8) different Water Years (WY): WY 1985, representative of near normal conditions; WY 1991, representative of dry conditions; and the six most recent Water Years, WY 2009 through WY 2014. MCWRA reports this data on a quarterly basis; a sample report is included in Appendix B.

Based on this analysis of historical data, August is typically representative of seasonal low conditions (Figure 10). A relaxation of groundwater levels, or seasonal high conditions, is evident during the period from January to March (Figure 11). Data from these three months will be evaluated and the highest groundwater elevation from that series will be submitted to the CASGEM online submittal system. The month chosen to be representative of the seasonal high groundwater conditions will be consistent across all data groups.

Nineteen (19) of the CASGEM wells are equipped with pressure transducers which collect depth to water data on an hourly basis. This data will be synthesized so that biannual measurements representing seasonal high and low conditions are available for CASGEM reporting. The groundwater level measurement collected at noon on the fifteenth day of the month will be selected and compared to other monthly data to ensure that it is a representative value. Data from the month of August will be used to represent the seasonal low and a fall/winter measurement from either January, February, or March will be used to represent the seasonal high; the same month will be used as was selected based on monthly well measurements, as discussed above.

Four (4) of the wells in the CASGEM network are currently measured once per year, during the period from November to January. Based on the recent analysis of seasonal groundwater highs, this period will be shifted to cover the months from January through March. An additional measurement event will be added during the month of August for these wells in order to also capture the seasonal groundwater low.

Appendix C contains a summary of the frequency and timing of measurement of wells in the CASGEM network. Any new wells that are brought into the CASGEM program will be monitored on a biannual basis, with data collection occurring on the same schedule as the other wells that are measured twice a year.

4.2 Well Locations

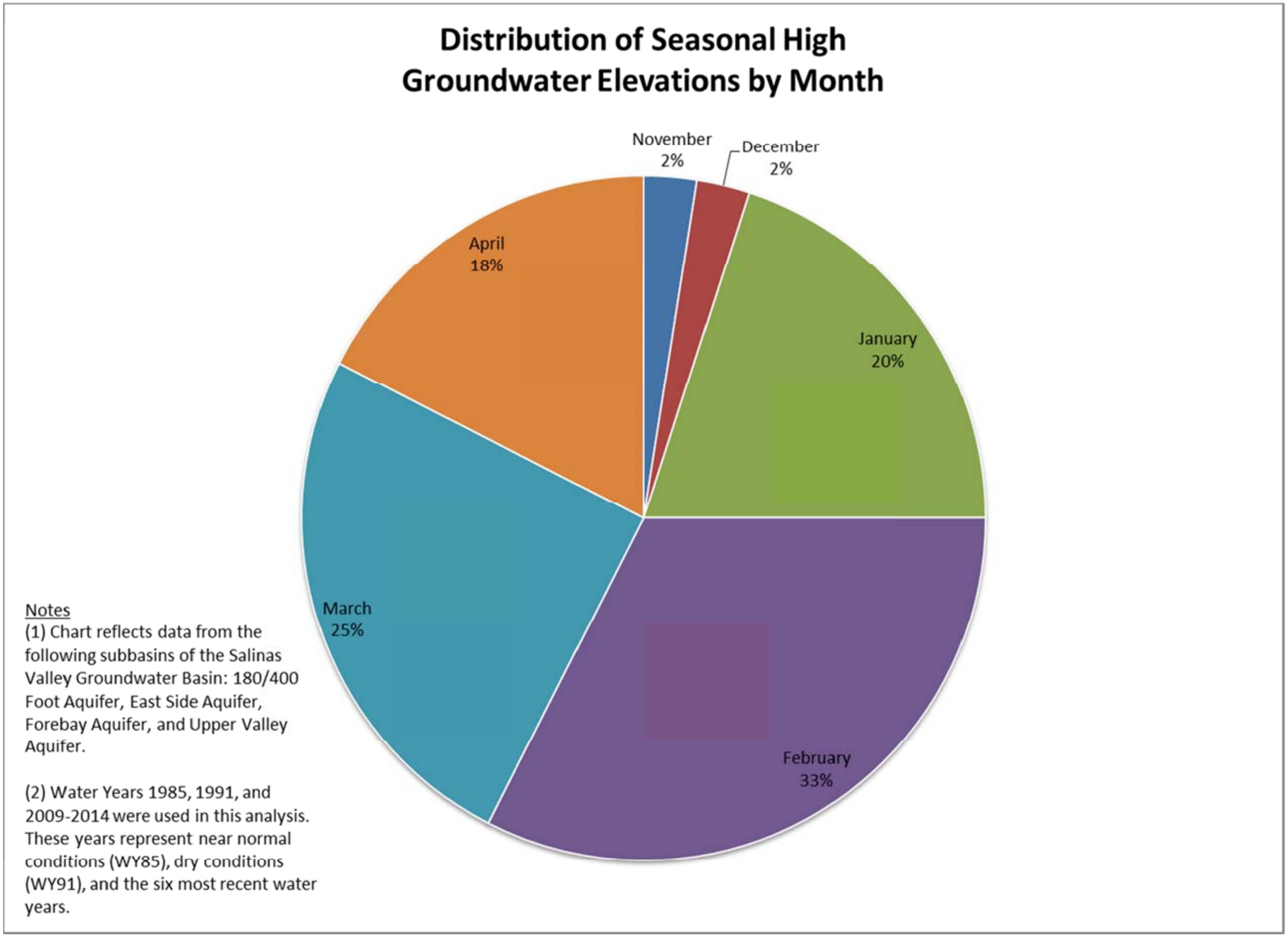
The latitude and longitude of each well was collected using a handheld GPS unit, which has accuracy to within one (1) meter. Coordinates for wells in the CASGEM network are shown in Appendix A. Any wells incorporated into the CASGEM network in the future will be geographically located using a similar method.

4.3 Reference Points

All of the wells that comprise the CASGEM network described herein are currently part of a groundwater level monitoring program conducted by MCWRA. As part of the existing monitoring programs, reference points (RP) have been established for all of the wells. To ensure consistency in measuring depth to water, a description of each well's RP is recorded in a field data collection notebook. In many cases, photographs have also been taken of the RP. Reference point elevations have been determined for all wells that are currently in a monitoring program; this data is listed in Appendix A.

A reference point will be determined for any new wells that are brought into the CASGEM network. Reference point elevations are determined using a digital elevation model from the United States Geological Survey (USGS) with a cell size of 32 feet by 32 feet.

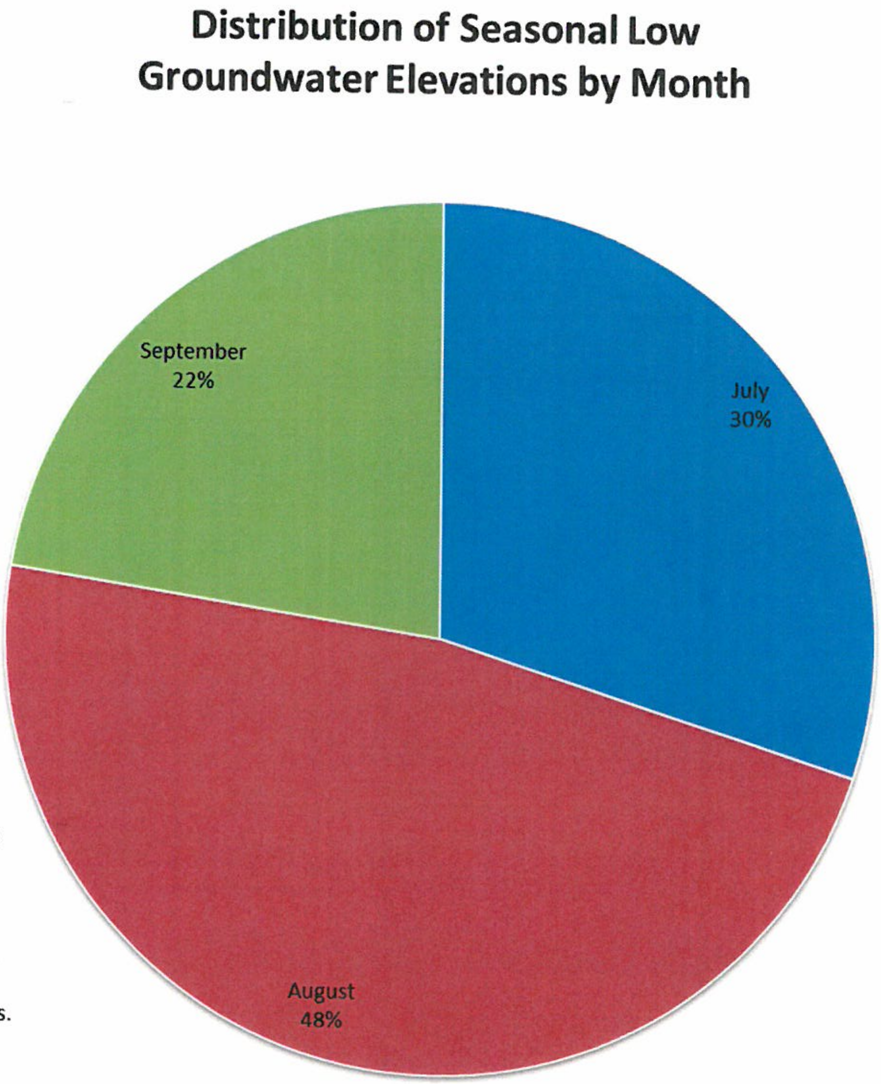
Figure 10 – Distribution of Seasonal High Groundwater Elevations by Month



Notes
(1) Chart reflects data from the following subbasins of the Salinas Valley Groundwater Basin: 180/400 Foot Aquifer, East Side Aquifer, Forebay Aquifer, and Upper Valley Aquifer.

(2) Water Years 1985, 1991, and 2009-2014 were used in this analysis. These years represent near normal conditions (WY85), dry conditions (WY91), and the six most recent water years.

Figure 11 – Distribution of Seasonal Low Groundwater Elevations by Month



Notes

(1) Chart reflects data from the following subbasins of the Salinas Valley Groundwater Basin: 180/400 Foot Aquifer, East Side Aquifer, Forebay Aquifer, and Upper Valley Aquifer.

(2) Water Years 1985, 1991, and 2009-2014 were used in this analysis. These years represent near normal conditions (WY85), dry conditions (WY91), and the six most recent water years.

4.4 Field Methods

Groundwater elevation data collected from wells in the CASGEM network is intended to reflect static conditions. Best efforts will be made to ensure that wells have not recently been pumped prior to collecting a data point. Depth to water measurements will be made using one or more of the methods discussed in the following sections. Measurement methods described in the following sections are based on the Department of Water Resources document *Groundwater Elevation Monitoring Guidelines* (December 2010) with some alterations specific to wells in the monitored basins/subbasins described in this Monitoring Plan.

4.4.1 Graduated steel tape

Prior to measurement:

- Ensure that the reference point on the well can be clearly determined. Check notes in the field data collection notebook.
- Review the notes and comments for previous measurements in the field data collection notebook to determine if there are any unique circumstances at this well.
- Take note of whether oil has previously been present at this well; this will be recorded in the comments section of the data form.

Making a measurement:

- Use the previous depth to water measurement to estimate a length of tape that will be needed.
- Lower the tape into the well, feeling for a change in the weight of the tape, which typically indicates that either (a) the tape has reached the water surface or (b) the tape is sticking to the side of the well casing.
- Continue lowering the tape into the well until the next whole foot mark is at the reference point. This value on the tape should be recorded in the field data collection notebook.
- Bring the tape to the surface and record the number of the wetted interval to the nearest foot.
- If an oil layer is present, read the tape at the top of the oil mark to the nearest foot. Note in the comments section of the data form that oil was present.
- Repeat this procedure a second time and note any differences in measurement in the field data collection notebook.

4.4.2 Electric water level meter

This method of measurement employs a battery-powered water level meter and a small probe attached to a ruled length of cable. Depth to water measurements collected using this equipment are recorded to the nearest tenth of an inch. This instrument is sometimes referred to as a “sounder”.

Prior to measurement:

- Review the field data sheet for the well and note whether oil has been present at this well in the past. The electric water level meter should not be used in wells where oil is present.
- Ensure that the reference point on the well can be clearly determined. Check notes in the field data collection notebook.
- Confirm that the water level meter is functioning and is turned on so that the beeping indicator will operate properly.

Making a measurement:

- Review previous depth to water measurements for the well to estimate the length of tape that will be needed.
- Lower the electrode into the well until the indicator sounds, showing the probe is in contact with the water surface.
- Place the tape against the reference point and read the depth to water to the nearest 0.1 foot. Record this value on the field data sheet.
- Make a second measurement and note any differences in measurement in the field data collection notebook.

4.4.3 Sonic water level meter

This meter uses sound waves to measure the depth to water in a well. The meter must be adjusted to the air temperature outside the well; there is a card with reference temperatures in the case with the sonic meter.

Making a measurement:

- Insert the meter probe into the access port and push the power-on switch. Record the depth from the readout.
- Record the depth to water measurement in the field data collection notebook.

4.4.4 Pressure transducer

Automated water-level measurements are made with a pressure transducer attached to a data logger. Pressure transducers are lowered to a depth below the water level in the well and fastened to the well head at a reference point. Data points are logged on an hourly basis. MCWRA uses factory-calibrated, vented pressure transducers (Appendix D). MCWRA staff collects the pressure transducer data once per quarter. During the data collection process, data loggers are stopped, and the data is downloaded onto a laptop, and then the data logger is reactivated and scheduled to begin collecting data again on the next hour. Upon return from the field, data is processed and reviewed for errors.

4.5 Data Collection, Processing, and Reporting

Following completion of all fieldwork, data is transcribed from field data sheets and checked for errors before being loaded into MCWRA's Oracle platform database. All data will be stored in the MCWRA database before being uploaded to the CASGEM website. Submittal of data to the CASGEM website will occur at a minimum of twice per year, no later than January 1 and July 1, per DWR CASGEM program guidelines.

Bi-annual submittal of data to the CASGEM website will include the following for each well in the CASGEM network, as described in the DWR document *CASGEM Procedures for Monitoring Entity Reporting*:

- Well identification number
- Measurement date
- Reference point and land surface elevation, in feet, using NAVD88 vertical datum
- Depth to water, in feet
- Method of measuring water depth
- Measurement quality codes
- Measuring agency identification
- Comments about measurement, if applicable

The following information will also be submitted to the CASGEM online system, as it is required by DWR unless otherwise noted:

- Monitoring Entity name, address, telephone number, contact person name and email address, and any other relevant contact information
- Groundwater basins being monitored (both entire and partial basins)
- State Well Identification number (recommended)
- Decimal latitude/longitude coordinates of well (NAD83)
- Groundwater basin or subbasin
- Reference point elevation of the well, in feet, using NAVD88 vertical datum
- Elevation of land surface datum at the well, in fee, using NAVD88 vertical datum
- Use of well
- Well completion type (e.g. single well, nested well, or multi-completion well)
- Depth of screened interval(s) and total depth of well, in feet, if available
- Well Completion Report number (DWR Form 188), if available

5.0 References

Department of Water Resources, 2010. *California Statewide Groundwater Elevation Monitoring (CASGEM) Program Procedures for Monitoring Entity Reporting*.

Department of Water Resources, 2010. *Groundwater Elevation Monitoring Guidelines*.

Fugro West, Inc., 1995. *North Monterey County Hydrogeologic Study, Volume I, Water Resources*.

Geosyntec Consultants, 2007. *El Toro Groundwater Study, Monterey County, California*.

Kennedy/Jenks Consultants, 2004. *Final Report - Hydrostratigraphic Analysis of the Salinas Valley*.

San Luis Obispo County Flood Control & Water Conservation District, 2014. *CASGEM Monitoring Plan for High and Medium Priority Groundwater Basins in the San Luis Obispo County Flood Control and Water Conservation District.*

Showalter, P., Akers, J.P., and Swain, L.A., 1983, Design of a ground-water quality monitoring network for the Salinas River Basin, California: U.S. Geological Survey Water-Resources Investigation Report 83-4049, 74 p.

This page intentionally left blank.

Appendix A

This page intentionally left blank.

MONTEREY COUNTY

WATER RESOURCES AGENCY

PO BOX 930
SALINAS , CA 93902
(831)755-4860
FAX (831) 424-7935

DAVID E. CHARDAVOYNE
GENERAL MANAGER

STREET ADDRESS
893 BLANCO CIRCLE
SALINAS, CA 93901-4455

David Eisen
United States Army Corps of Engineers
Fort Ord BRAC Office
PO Box 5008
Monterey, CA 93944-504

February 13, 2015

Dear Mr. Eisen:

On behalf of the Monterey County Water Resources Agency (MCWRA) I am writing to request the U.S. Army Corps of Engineers' voluntary participation in the California Statewide Groundwater Elevation Monitoring (CASGEM) program.

On November 4, 2009, the State Legislature amended the California Water Code with Senate Bill SBx7-6, which resulted in development of the CASGEM program by the California Department of Water Resources (DWR). As part of the CASGEM program, MCWRA is the designated Monitoring Entity for certain groundwater basins in Monterey County, including the Salinas Valley Groundwater Basin.

The U.S. Army Corps of Engineers (USACE) owns multiple parcels of land, specifically portions of the former Fort Ord, which are located in the Salinas Valley Groundwater Basin. MCWRA is seeking USACE's voluntary participation in the CASGEM program because the existing monitoring well network does not extend to this area of the groundwater basin.

MCWRA has no specific knowledge as to the location of monitoring wells on USACE property, so consent to participate in the CASGEM program would require disclosure of well information and either permission for MCWRA to access these wells or an arrangement wherein USACE would provide data to MCWRA. If USACE is considering participation, MCWRA can discuss this in more detail as needed.

As part of the CASGEM program, MCWRA would submit certain data about USACE wells to DWR for inclusion in a statewide database. The database will be available to the public for local and state entities to evaluate and monitor groundwater conditions. MCWRA will report the following to DWR for any well included in the CASGEM program:

- Depth to static (non-pumping) groundwater level, reported two times per year, beginning in 2015
- Approximate well location, within 1,000 feet of the actual well location
- Screened interval(s) and depth of the well as provided on the well log
- General category of well use (i.e. monitoring, public supply, domestic)

MCWRA sincerely appreciates your consideration of voluntary participation in the CASGEM program. Please feel free to contact MCWRA at 831-755-4860 if you have any questions. Additional information about the CASGEM program is also available from DWR at www.water.ca.gov/groundwater/casgem.

Regards,

David E. Chardavoyne

David E. Chardavoyne
General Manager

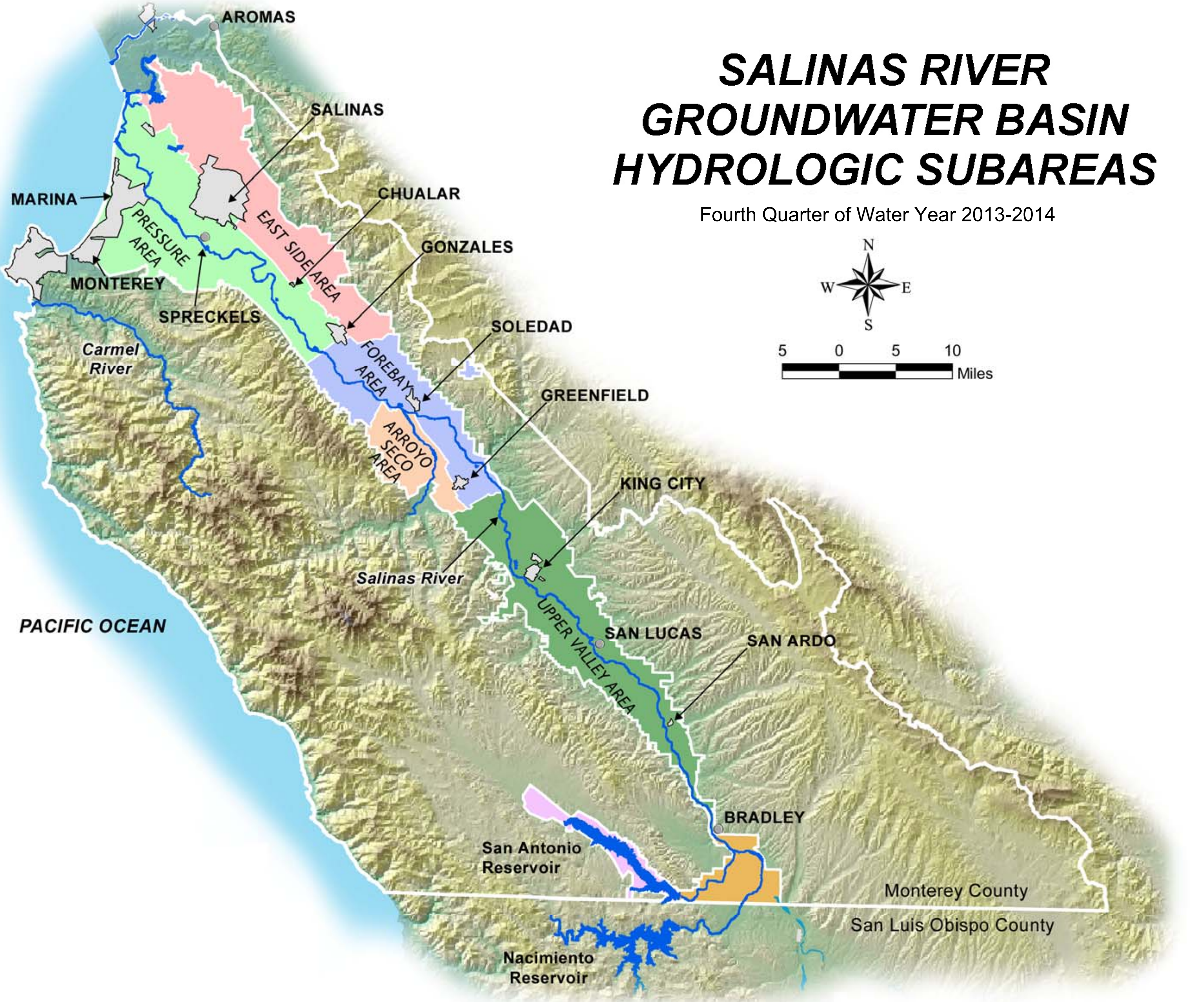
Cc: California Department of Water Resources - C. Michael McKenzie, PG

Appendix B

This page intentionally left blank.

SALINAS RIVER GROUNDWATER BASIN HYDROLOGIC SUBAREAS

Fourth Quarter of Water Year 2013-2014



MONTEREY COUNTY WATER RESOURCES AGENCY
BOARD OF DIRECTORS

MEETING DATE:	October 27, 2014	**AGENDA ITEM:**	
AGENDA TITLE:	RECEIVE REPORT ON SALINAS VALLEY WATER CONDITIONS FOR THE FOURTH QUARTER OF WATER YEAR 2013-2014		
Consent (X)	**Action ( )**	**Information ( )**	
SUBMITTED BY: **PHONE:**	Robert Johnson 755-4860	**PREPARED BY:** **PHONE:**	Peter Kwiek, Jess Barreras 755-4860
DEADLINE FOR BOARD ACTION:	October 27, 2014		

RECOMMENDED BOARD ACTION:

Receive report on Salinas Valley water conditions for the fourth quarter of Water Year 2013-2014.

PRIOR RELEVANT BOARD ACTION:

A report was last presented to the Board on September 22, 2014, covering the third quarter of Water Year 2013-2014.

DISCUSSION/ANALYSIS:

This report covers the fourth quarter of Water Year 2013-2014 (WY14), July through September, 2014. It provides a brief overview of water conditions in the Salinas Valley with discussion of precipitation, reservoir storage, and ground water level trends. Data for each of these components are included as graphs and tables in Attachments A through I.

Precipitation – The fourth quarter of WY14 brought less than normal rainfall to Salinas and King City. Cumulative totals for the quarter were 0.11 inches (55% of normal rainfall for the quarter) at the Salinas Airport, while no measurable rainfall was logged in King City, which, on average, receives a total of 0.17 inches during the months of July through September.

Attachment A contains graphs for both stations showing monthly and cumulative precipitation data for the current and a normal water year. Tables with precipitation values shown on the graphs and percent of normal precipitation are also presented in Attachment A.

Rainfall data for Salinas and King City should be considered preliminary until verified by National Weather Service data at a later date.

Reservoirs - The following table compares fourth quarter storage at Nacimiento and San Antonio reservoirs for the past two years. Storage in Nacimiento Reservoir is 46,763 acre-feet lower than in September 2013, while storage in San Antonio Reservoir is 8,547 acre-feet lower.

Reservoir	September 30, 2014 (WY14) Storage in acre-feet	September 30, 2013 (WY13) Storage in acre-feet	Difference in acre-feet
Nacimiento	63,850	110,613	-46,763
San Antonio	12,266	20,813	-8,547

Graphs for both reservoirs showing daily storage for the last five water years and average daily storage are included as Attachments B and C.

Ground Water Levels – More than 80 wells are measured monthly throughout the Salinas Valley to monitor seasonal ground water level fluctuations. Data from approximately 50 of these wells is used in the preparation of this report. The measurements are categorized by hydrologic subarea, averaged, and graphed to compare current water levels with selected past conditions. Graphs for individual subareas, showing the current year's water level conditions, last year's conditions (WY13), dry conditions (WY91), and near-normal conditions (WY85), are found in Attachments D through H. Attachment I is a summary of water level changes for all subareas.

Ground water level measurements indicate that, by the end of the fourth quarter of WY14, water levels were recovering in the Pressure and East Side Subareas, but not in the Forebay or Upper Valley Subareas. Over the past month, average ground water levels rose by four feet in the Pressure 180-Foot Aquifer, two feet in the Pressure 400-Foot Aquifer, and one foot in the East Side Subarea while declining by two feet in the Forebay Subarea and one foot in the Upper Valley Subareas.

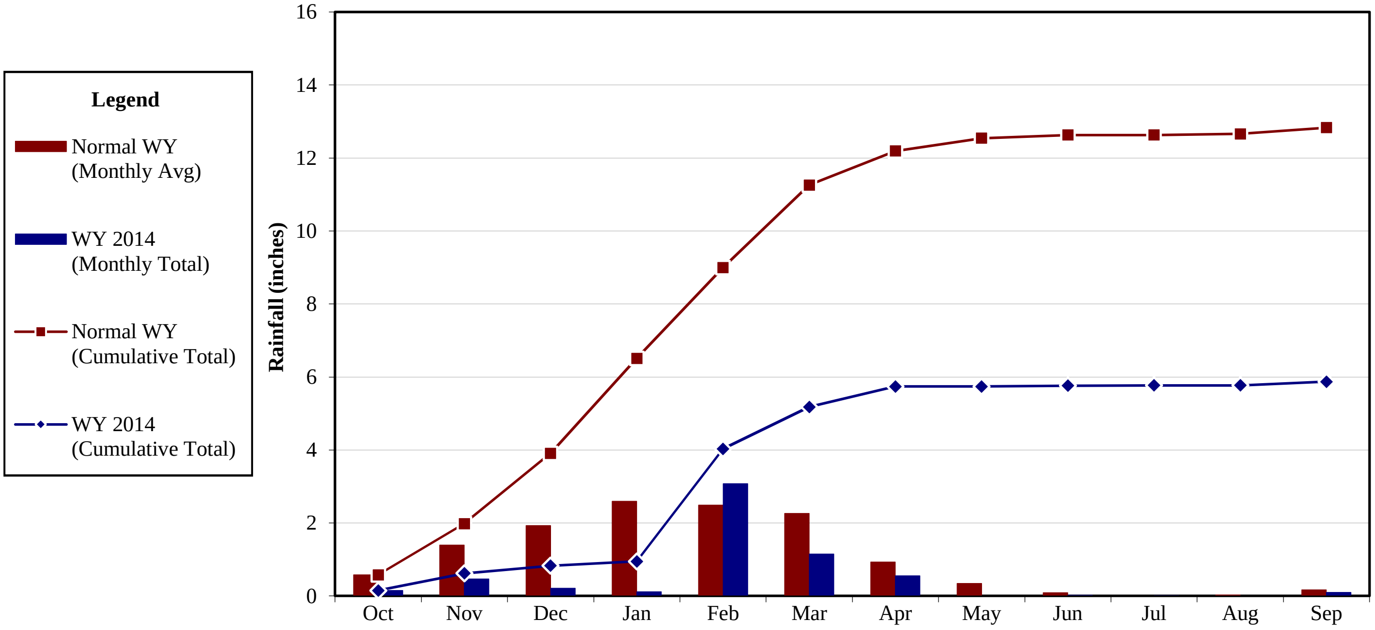
Compared to September 2013, average ground water levels in September 2014 were eight to twelve feet lower in all subareas, as shown in Attachment I.

When compared to WY85, which is considered to be a year of near normal ground water conditions, current water levels are 25 feet lower in the East Side Subarea, 10 feet lower in the Pressure 180-Foot Aquifer, eight feet lower in the Forebay Subarea and six feet lower in the Upper Valley Subarea. Water levels in the Pressure 400-Foot Aquifer are two feet higher than in WY85.

Average ground water levels for the fourth quarter of WY14 have fallen to WY91 levels in the Forebay Subarea, while falling below WY91 levels in both the East Side and Upper Valley Subareas. In the Pressure 180-Foot Aquifer, water levels equaled WY91 levels in August 2014 before recovering by two feet by the end of the quarter. By contrast, throughout the fourth quarter, water levels in the Pressure 400-Foot Aquifer remained eight to 10 feet higher than in WY91.

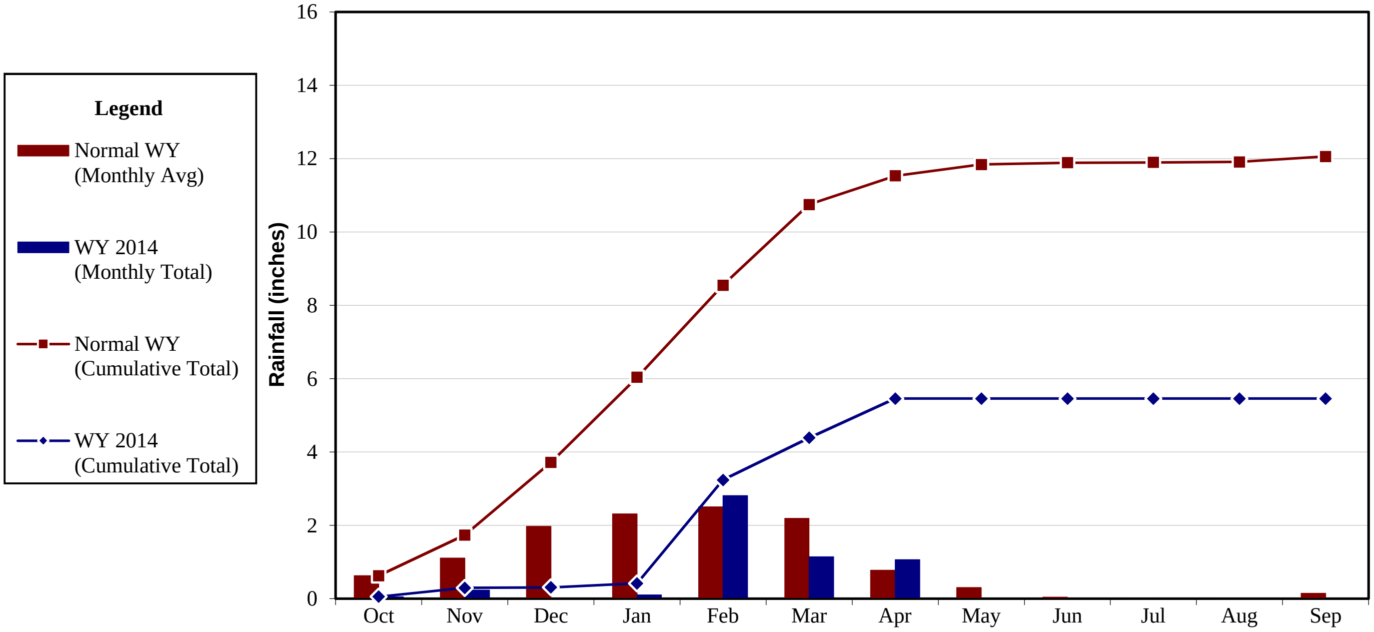
FINANCIAL IMPACT:	**YES ( )** **NO (X)**
FUNDING SOURCE:	
COMMITTEE REVIEW AND RECOMMENDATION:	None
ATTACHMENTS:	1. Salinas Valley Hydrologic Subareas Map 2. Salinas and King City Precipitation Graphs, Attachment A 3. Nacimiento and San Antonio Reservoir Graphs, Attachments B and C 4. Salinas Valley Monthly Water Level Graphs for Each Subarea, Attachments D through H 5. Generalized Ground Water Trends, Attachment I.
APPROVED:	______________________________ **General Manager** **Date**

SALINAS AIRPORT RAINFALL
WATER YEAR 2014



	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monthly Rainfall (WY 2014)	0.15	0.47	0.21	0.12	3.08	1.15	0.56	0.00	0.02	0.01	0.00	0.10
Monthly Rainfall (Normal WY*)	0.58	1.40	1.93	2.60	2.49	2.26	0.93	0.35	0.09	0.00	0.03	0.17
Percent of Normal for Month	26%	34%	11%	5%	124%	51%	60%	0%	22%	N/A	0%	59%
Cumulative Rainfall (WY 2014)	0.15	0.62	0.83	0.95	4.03	5.18	5.74	5.74	5.76	5.77	5.77	5.87
Cumulative Rainfall (Normal WY*)	0.58	1.98	3.91	6.51	9.00	11.26	12.19	12.54	12.63	12.63	12.66	12.83
Percent of Cumulative Normal	26%	31%	21%	15%	45%	46%	47%	46%	46%	46%	46%	46%

KING CITY RAINFALL
WATER YEAR 2014

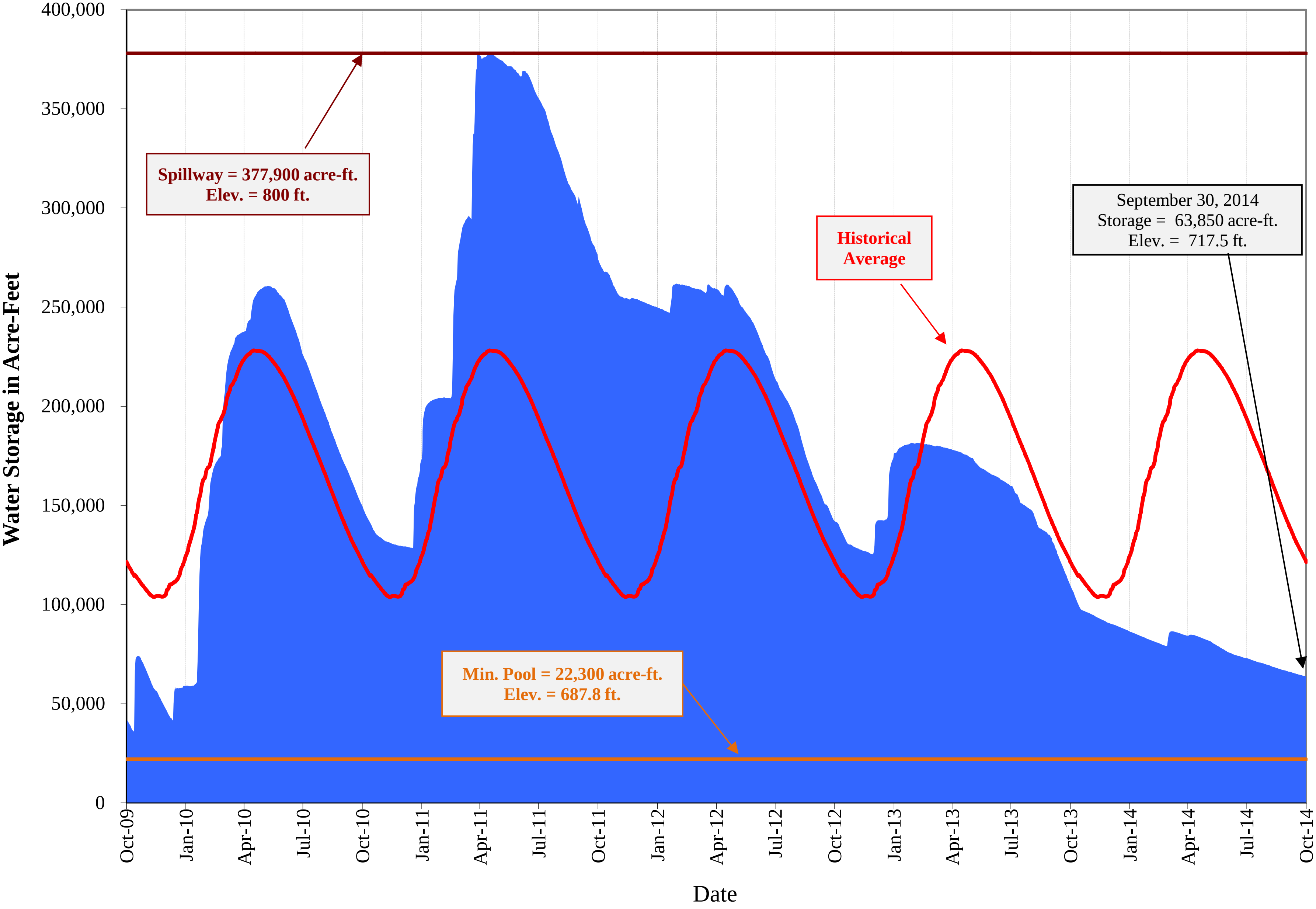


	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Monthly Rainfall (WY 2014)	0.06	0.24	0.01	0.11	2.82	1.15	1.07	0.00	0.00	0.00	0.00	0.00
Monthly Rainfall (Normal WY*)	0.63	1.11	1.98	2.32	2.51	2.20	0.78	0.31	0.05	0.01	0.01	0.15
Percent of Normal for Month	10%	22%	1%	5%	112%	52%	137%	0%	0%	0%	0%	0%
Cumulative Rainfall (WY 2014)	0.06	0.30	0.31	0.42	3.24	4.39	5.46	5.46	5.46	5.46	5.46	5.46
Cumulative Rainfall (Normal WY*)	0.63	1.74	3.72	6.04	8.55	10.75	11.53	11.84	11.89	11.90	11.91	12.06
Percent of Cumulative Normal	10%	17%	8%	7%	38%	41%	47%	46%	46%	46%	46%	45%

*Average precipitation over the most recent 30-year period ending in a decade (1981-2010)

ATTACHMENT A

NACIMIENTO RESERVOIR
DAILY STORAGE



Spillway = 377,900 acre-ft.
Elev. = 800 ft.

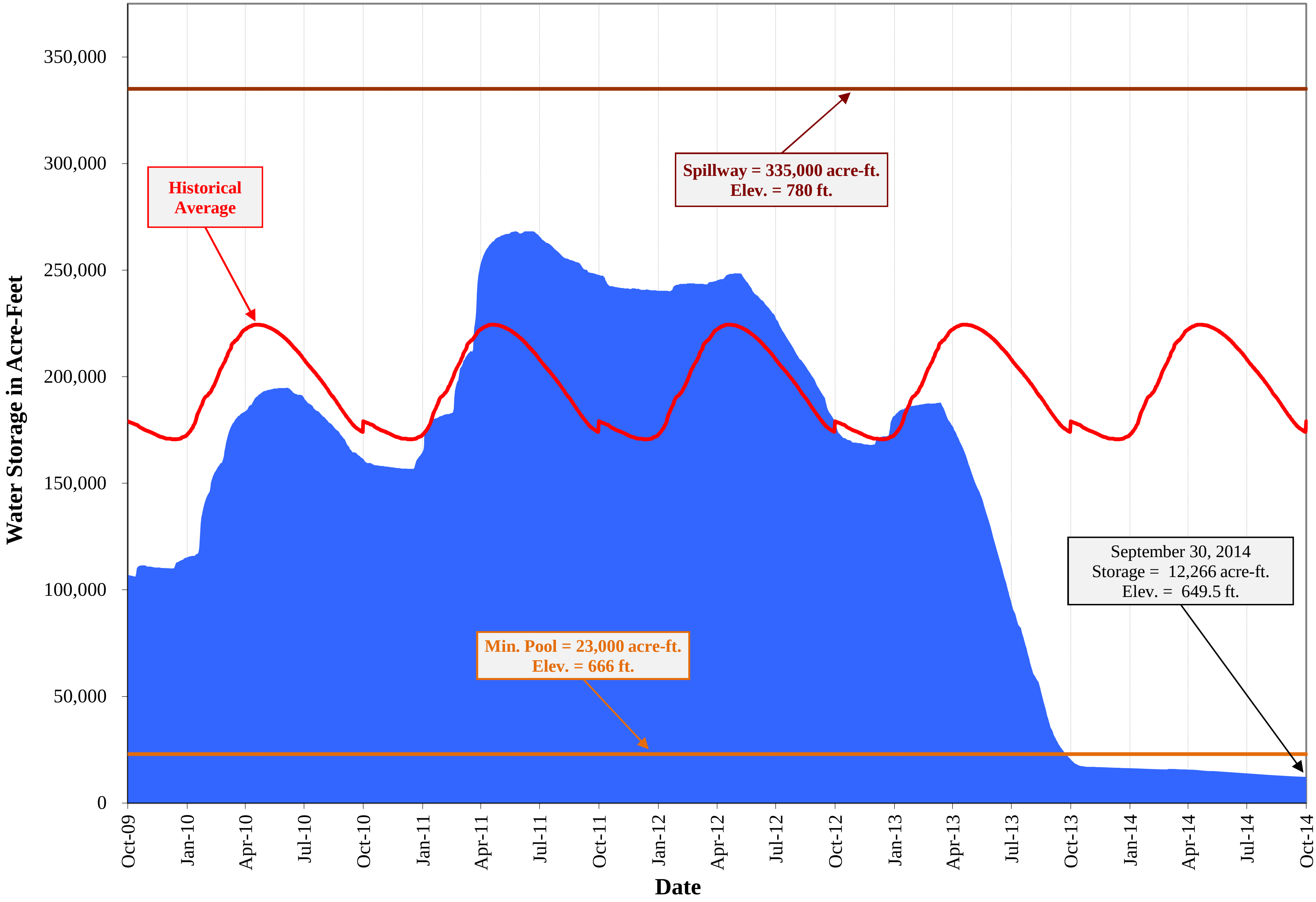
Historical Average

September 30, 2014
Storage = 63,850 acre-ft.
Elev. = 717.5 ft.

Min. Pool = 22,300 acre-ft.
Elev. = 687.8 ft.

ATTACHMENT B

SAN ANTONIO RESERVOIR
DAILY STORAGE



Historical Average

Spillway = 335,000 acre-ft.
Elev. = 780 ft.

Min. Pool = 23,000 acre-ft.
Elev. = 666 ft.

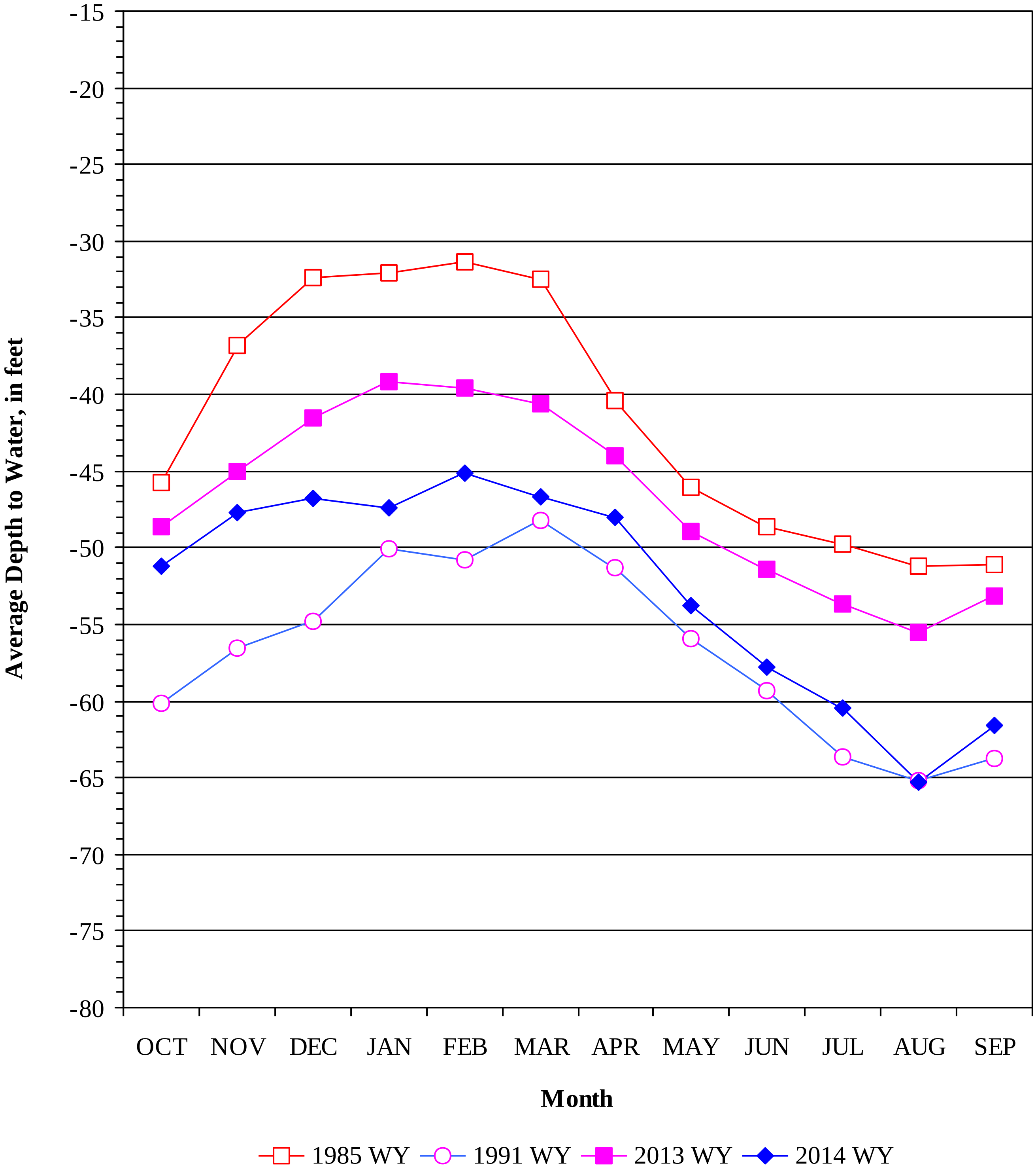
September 30, 2014
Storage = 12,266 acre-ft.
Elev. = 649.5 ft.

ATTACHMENT C

HISTORIC GROUND WATER TRENDS

PRESSURE 180-FOOT AQUIFER

5 Wells

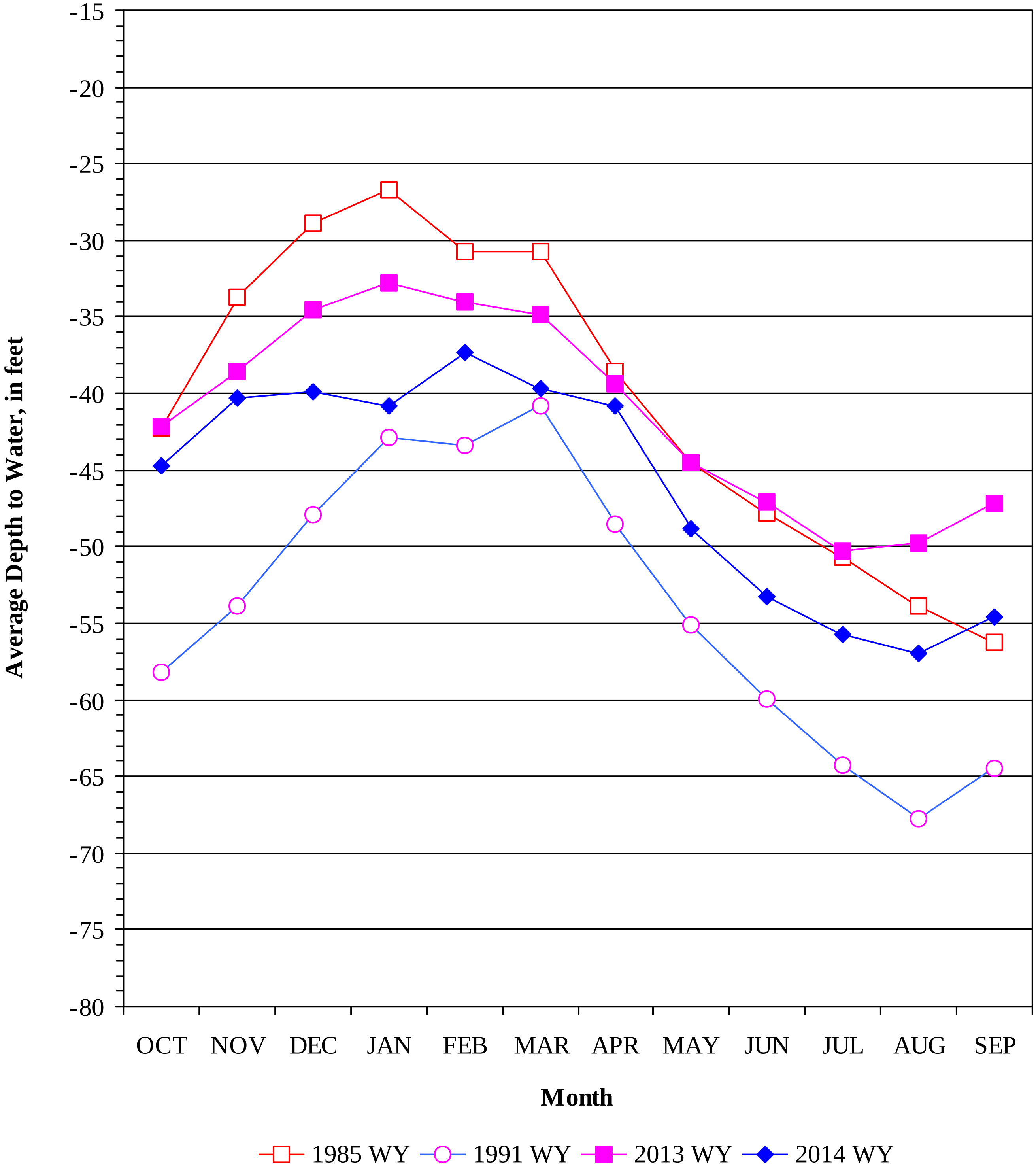


ATTACHMENT D

HISTORIC GROUND WATER TRENDS

PRESSURE 400-FOOT AQUIFER

11 Wells

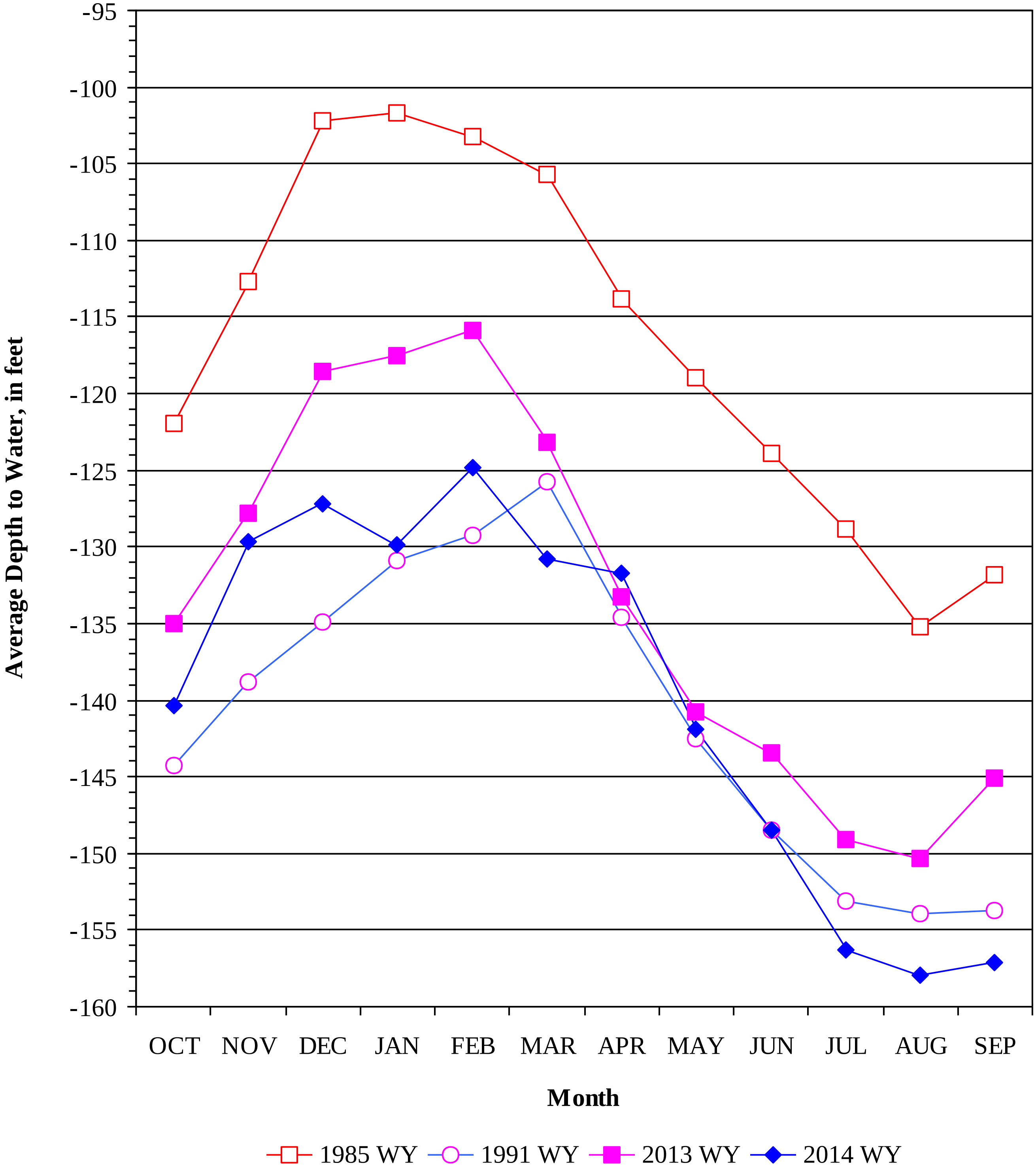


ATTACHMENT E

HISTORIC GROUND WATER TRENDS

EAST SIDE SUBAREA

11 Wells

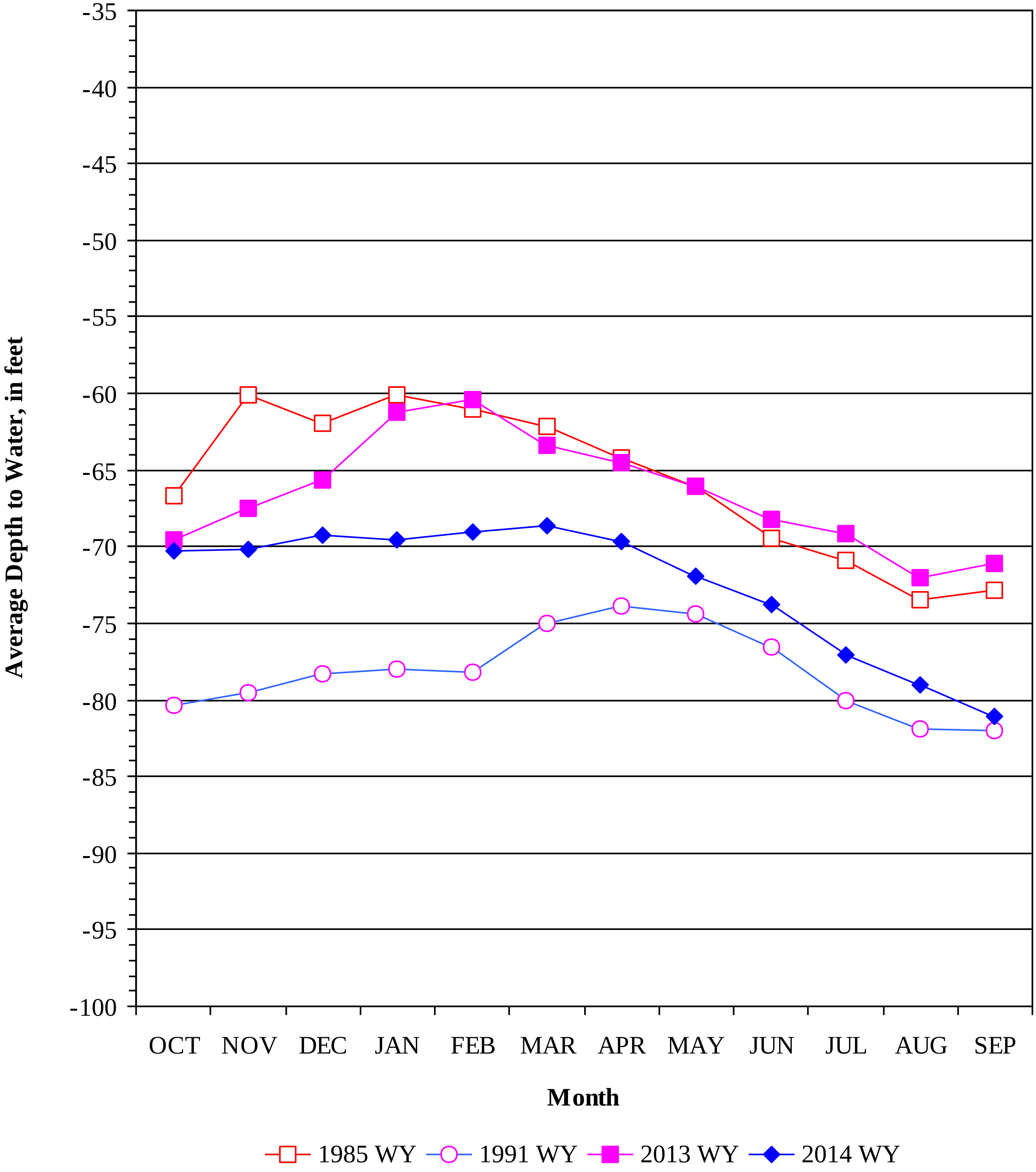


ATTACHMENT F

HISTORIC GROUND WATER TRENDS

FOREBAY SUBAREA

10 Wells

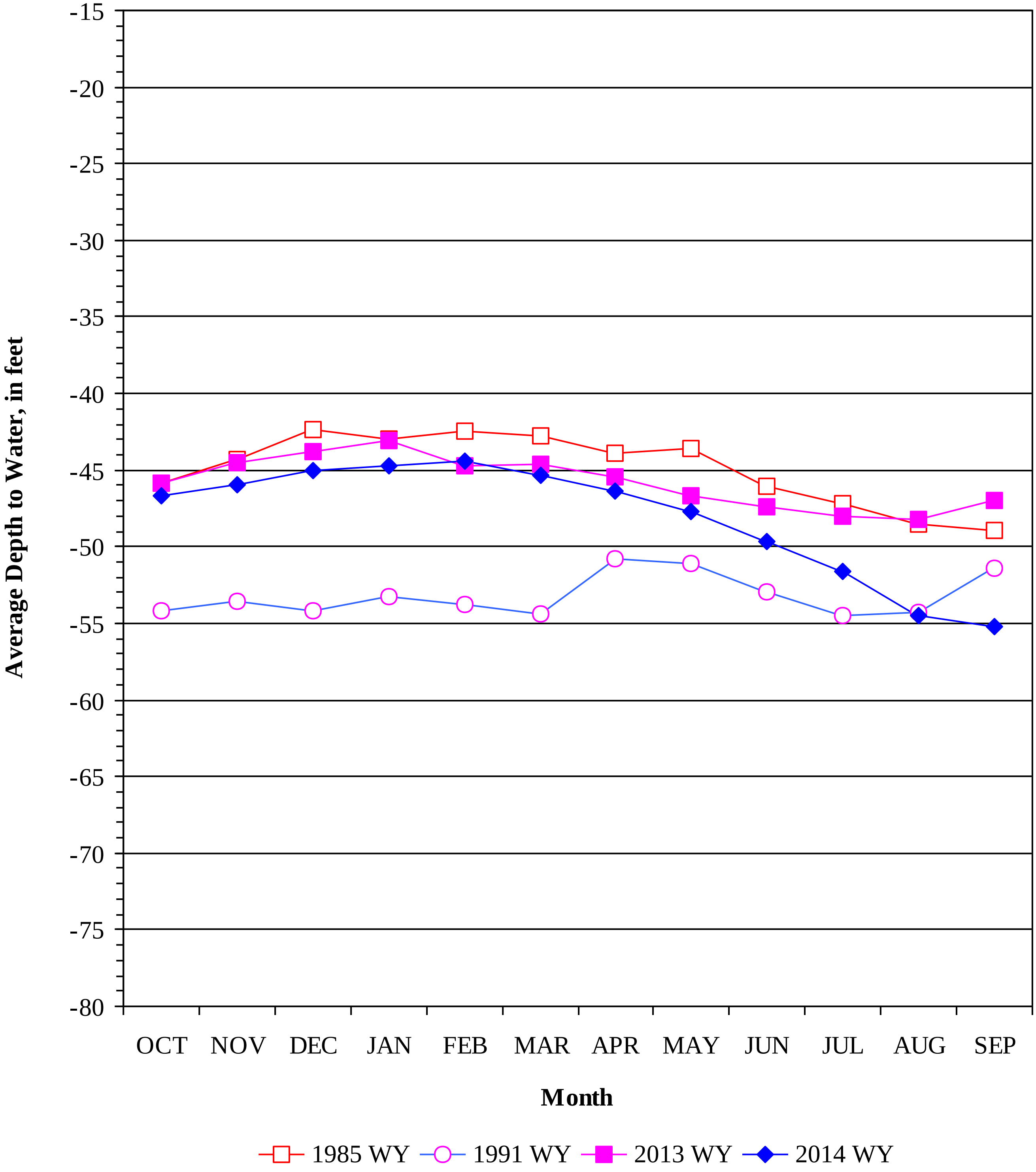


ATTACHMENT G

HISTORIC GROUND WATER TRENDS

UPPER VALLEY SUBAREA

9 Wells



ATTACHMENT H

Generalized Ground Water Trends
September 2014

Area	September 2014 Depth to Water	1 Year Change	Change From WY 1985	1 Month Change
Pressure 180-Foot Aquifer	**62'**	**down 8'**	**down 10'**	**up 4'**
Pressure 400-Foot Aquifer	**55'**	**down 7'**	**up 2'**	**up 2'**
East Side Subarea	**157'**	**down 12'**	**down 25'**	**up 1'**
Forebay Subarea	**81'**	**down 10'**	**down 8'**	**down 2'**
Upper Valley Subarea	**55'**	**down 8'**	**down 6'**	**down 1'**

September water levels, compared to last year, range from 12' lower to 7' lower.

September water levels, compared to WY 1985, range from 25' lower to 2' higher.

September changes in water levels over the last month range from 2' lower to 4' higher.

ATTACHMENT I

Appendix C

This page intentionally left blank.

Table C.1 - CASGEM Network Well Data Summary

Associated Basin/Subbasin	State Well Identification Number	Local Well Designation	Latitude	Longitude	Reference Point Elevation (NAVD88, ft)	Ground Surface Elevation (NAVD88, ft)	Well Use	Well Completion Type	Depth of Screened Interval (ft-bgs)	Total Depth (ft-bgs)	Well Completion Report Number (DWR Form 188)	Frequency of Measurements	Timing of Measurements to be Submitted
3-4.01 180/400 Foot Aquifer	13S02E19Q003M	75	36.780798	-121.784687	18	not available	irrigation	single	1220-1550	1562	071658	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	13S02E21N001M	2432	36.784731	-121.761804	17.3	16.7	irrigation	single	369-550	550	not available	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	13S02E21Q001M	SELA22633	36.781644	-121.751387	12.4	12.8	dedicated monitoring	single	105-155	157	E011401	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	13S02E32A002M	10161	36.765339	-121.763589	10.6	not available	irrigation	single	300-600	600	not available	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E03F003M	ESPB22635	36.745480	-121.739493	28.2	28.7	dedicated monitoring	single	420-450	455	E011400	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E03F004M	ESPA22636	36.745391	-121.739314	24.2	24.7	dedicated monitoring	single	154-204	205	E011399	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E08M002M	239	36.727523	-121.780250	14.6	13.5	irrigation	single	314-325, 367-399, 426-456	500	71883	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E12B002M	RODA14455	36.734316	-121.695850	55.5	56.1	dedicated monitoring	single	210-260	265	338411	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E12B003M	RODB14456	36.734282	-121.695864	55.9	56.1	dedicated monitoring	single	350-380	390	338410	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E12Q001M	1707	36.722108	-121.696473	64	62	domestic	single	273-280, 288-292	619	not available	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E26H001M	AMST22651	36.688875	-121.707934	37.7	38.1	dedicated monitoring	single	287-337	339	E011403	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S02E27A001M	MCFD22632	36.693296	-121.729435	24.7	25.1	dedicated monitoring	single	240-290	293	E011398	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S03E18C001M	BORA15009	36.720722	-121.680556	54.8	55.1	dedicated monitoring	single	165-215	225	201242	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S03E18C002M	BORB15010	36.720736	-121.680531	54.9	55.1	dedicated monitoring	single	270-320, 365-385	395	201241	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	14S03E30G008M	MKTC22650	36.686880	-121.678517	44.3	44.8	dedicated monitoring	single	240-290	293	E011402	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	15S03E16F002M	1862	36.629202	-121.647449	59.5	58.5	irrigation	single	427-445, 485-570	592	81037	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	15S03E16M001M*	1359	36.624978	-121.653213	59.5	58.2	irrigation	single	not available			monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	15S03E17M001M	1480	36.626540	-121.669184	49.2	47.6	irrigation	single	128-160, 165-180	271	25902	monthly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	16S04E08H003M	CHEB21205	36.555033	-121.546546	91.5	88.9	dedicated monitoring	nested	240-290	295	491023	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	16S04E08H004M	CHEA21208	36.555022	-121.546558	90.6	88.8	dedicated monitoring	nested	85-135	140	491023	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	16S04E15D001M	BRME10389	36.544407	-121.522009	102	103.3	dedicated monitoring	single	170-189, 314-358	384	100604	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	17S05E06C001M	GZWB21201	36.488323	-121.468404	119.7	120.1	dedicated monitoring	nested	250-290	300	491020	hourly	(1) August (2) Jan. to Mar.
3-4.01 180/400 Foot Aquifer	17S05E06C002M	GZWA21202	36.488324	-121.468395	119.7	120.105	dedicated monitoring	nested	60-110	115	491020	hourly	(1) August (2) Jan. to Mar.

Notes
ft = feet
ft-bgs = feet below ground surface
* = voluntary well

Table C.1 - CASGEM Network Well Data Summary

Associated Basin/Subbasin	State Well Identification Number	Local Well Designation	Latitude	Longitude	Reference Point Elevation (NAVD88, ft)	Ground Surface Elevation (NAVD88, ft)	Well Use	Well Completion Type	Depth of Screened Interval (ft-bgs)	Total Depth (ft-bgs)	Well Completion Report Number (DWR Form 188)	Frequency of Measurements	Timing of Measurements to be Submitted
3-4.02 East Side Aquifer	14S03E15H003M	752	36.717412	-121.622173	126	not available	irrigation	single	200-775	784	38491	monthly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	14S03E25C001M	FALB22618	36.692754	-121.594058	143.8	144.2	dedicated monitoring	single	570-670	680	773476	hourly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	14S03E25C002M	FALA22619	36.692725	-121.594032	143.8	144.2	dedicated monitoring	single	175-195, 240-260, 300-360	370	768985	hourly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	14S03E27B001M	15126	36.690611	-121.624200	42	42	Irrigation	single	60-335	348	not available	monthly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	14S04E31Q002M	806	36.666105	-121.569391	104	103	irrigation	single	250-390, 400-550, 580-640, 690-710	710	552493	monthly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	15S04E06R001M	1726	36.651722	-121.566933	93.7	92.5	irrigation	single	190-270, 345-390, 430-776	786	not available	monthly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	16S05E27G001M	2519	36.512244	-121.407957	272	271.5	irrigation	single	281-322, 368-410, 512-543, 565-631, 694-757, 793-930, 966-1,091	1,122	50822	monthly	(1) August (2) Jan. to Mar.
3-4.02 East Side Aquifer	16S05E28D001M	871	36.516669	-121.432772	169	168	irrigation	single	200-215, 242-368, 408-425, 448-460, 480-508, 639-695, 754-762, 798-808	832	not available	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	17S06E19D001M*	1485	36.442444	-121.368184	170	170	irrigation	single	not available	170	not available	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	17S06E33R001M	VidaDeep21209	36.404756	-121.316169	197.4	198.0	dedicated monitoring	nested	200-250	260	491019	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	17S06E33R002M	VidaShallow21210	36.404723	-121.316163	197.6	198.0	dedicated monitoring	nested	50-115	120	491019	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E22B002M	LosCochesC18449	36.356198	-121.303324	227.4	227.9	dedicated monitoring	nested	510-580	590	490996	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E22B003M	LosCochesB21066	36.356178	-121.303292	228.5	229.0	dedicated monitoring	nested	220-270	280	490996	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E22B004M	LosCochesA21314	36.356206	-121.303260	227.8	228.3	dedicated monitoring	nested	40-90	95	490996	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E24M001M	HUD B18467	36.348507	-121.275550	232.5	233.0	dedicated monitoring	nested	193-243	253	490994	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E24M002M	HUD A21067	36.348475	-121.275639	232.5	233.0	dedicated monitoring	nested	70-120	130	490994	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E25F001M*	1495	36.335895	-121.274486	254.5	not available	irrigation	single	not available	120	not available	monthly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E35F001M	THNB18502	36.325857	-121.286318	265.6	266.1	dedicated monitoring	nested	198-248	258	490995	hourly	(1) August (2) Jan. to Mar.
3-4.04 Forebay Aquifer	18S06E35F002M	THNA21068	36.325833	-121.286378	265.7	266.1	dedicated monitoring	nested	60-110	120	490995	hourly	(1) August (2) Jan. to Mar.

Notes
ft = feet
ft-bgs = feet below ground surface
* = voluntary well

Table C.1 - CASGEM Network Well Data Summary

Associated Basin/Subbasin	State Well Identification Number	Local Well Designation	Latitude	Longitude	Reference Point Elevation (NAVD88, ft)	Ground Surface Elevation (NAVD88, ft)	Well Use	Well Completion Type	Depth of Screened Interval (ft-bgs)	Total Depth (ft-bgs)	Well Completion Report Number (DWR Form 188)	Frequency of Measurements	Timing of Measurements to be Submitted
3-4.05 Upper Valley Aquifer	19S08E19K003M	1379	36.261416	-121.143185	282	not available	irrigation	single	130-178	212	114600	monthly	(1) August (2) Jan. to Mar.
3-4.05 Upper Valley Aquifer	20S08E14K001M	1735	36.190341	-121.071326	347.2	not available	irrigation	single	115-145, 148-205	236	43828	monthly	(1) August (2) Jan. to Mar.
3-4.05 Upper Valley Aquifer	23S10E03H001M	SArdoN19447	35.959280	-120.871501	463.6	461	dedicated monitoring	single	72-132	142	490983	monthly	(1) August (2) Jan. to Mar.
3-4.06 Paso Robles Area	23S10E14D001M	SArdoS19450	35.936241	-120.866068	465.8	463.1	dedicated monitoring	single	72-132	142	490086	monthly	(1) August (2) Jan. to Mar.
3-4.09 Langley Area	13S03E15P001M	13572	36.795258	-121.63002	365.1	364	domestic	single	300-430	430	199702	biannual	(1) August (2) Jan. to Mar.
3-4.09 Langley Area	13S03E16J001M	13625	36.801055	-121.641165	270	270	domestic	single	104-244	252	38447	biannual	(1) August (2) Jan. to Mar.
3-4.09 Langley Area	13S03E22F001M	13950	36.790570	-121.626689	236.2	235	domestic	single	260-270, 280-290, 310-320	334	22780	biannual	(1) August (2) Jan. to Mar.
3-4.10 Corral de Tierra Area	16S02E01M001M	16797	36.568031	-121.707315	406	405	domestic	single	80-120, 160-180	294	43634	biannual	(1) August (2) Jan. to Mar.
3-4.10 Corral de Tierra Area	16S02E02G001M	16820	36.570536	-121.713413	371	370	domestic	single	320-340, 360-440	448	38099	monthly	(1) August (2) Jan. to Mar.

Notes
ft = feet
ft-bgs = feet below ground surface
* = voluntary well

Appendix D

This page intentionally left blank.

Level **TROLL**® 400, 500 & 700 Data Loggers

Get water level data the way you want it, when you want it with industry-leading water level/pressure and temperature data loggers. By partnering with In-Situ® Inc., you receive durable Level TROLL® Data Loggers that provide years of service, accurate results, intuitive software, and real-time functionality.

Be Effective

- **Increase productivity:** Reduce training and installation time with In-Situ Inc.'s intuitive software platform and integrated components. Patented twist-lock connectors, included on Level TROLL Loggers and RuggedCable® Systems, ensure error-free deployments.
- **Set up real-time networks:** Access data 24/7 and receive event notifications when you connect data loggers to telemetry systems, radios, or other third-party data collection platforms. Control gates, pumps, alarms, and other equipment by using built-in Modbus/RS485, SDI-12, or 4-20 mA communication protocols.
- **Streamline analysis and reporting**: Automate water level corrections and post-processing, graph data, and accelerate report generation with Win-Situ® Software. Easily export data to Excel®, a web-based management service, or data analysis software.

Be Reliable

- **Deploy in all environments:** Install loggers in fresh water, saltwater, and contaminated waters. Solid titanium, sealed construction outperforms and outlasts specially-coated data loggers.
- **Log accurate data:** Get optimal accuracy under all operating conditions. Sensors undergo NIST®-traceable factory calibration across the full pressure and temperature range. For applications requiring the highest levels of accuracy, use a vented (gauged) system.
- **Get long-lasting operation:** Reduce trips to the field with low-power loggers that typically operate for 10 years.

Be In-Situ

- Receive **free**, 24/7 technical support and online resources.
- Order data loggers and accessories from the In-Situ e-store.
- Get guaranteed 7-day service for maintenance (U.S.A. only).

Applications

- Aquifer characterization: slug tests & pumping tests
- Coastal: tide/harbor levels & wetland/estuary research
- Hydrologic events: crest stage gages, storm surge monitoring, & flood control systems
- Long-term, real-time groundwater & surface water monitoring
- Mining & remediation

Level **TROLL**® 400, 500 & 700 Data Loggers

General	*Level TROLL 400*	*Level TROLL 500*	*Level TROLL 700*	*BaroTROLL*
Temperature ranges[1]	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)	Operational: -20-80° C (-4-176° F) Storage: -40-80° C (-40-176° F) Calibrated: -5-50° C (23-122° F)
Diameter	1.83 cm (0.72 in.)	1.83 cm (0.72 in.)	1.83 cm (0.72 in.)	1.83 cm (0.72 in.)
Length	21.6 cm (8.5 in.)	21.6 cm (8.5 in.)	21.6 cm (8.5 in.)	21.6 cm (8.5 in.)
Weight	197 g (0.43 lb)	197 g (0.43 lb)	197 g (0.43 lb)	197 g (0.43 lb)
Materials	Titanium body; Delrin® nose cone	Titanium body; Delrin nose cone	Titanium body; Delrin nose cone	Titanium body; Delrin nose cone
Output options	Modbus/RS485, SDI-12, 4-20 mA	Modbus/RS485, SDI-12, 4-20 mA	Modbus/RS485, SDI-12, 4-20 mA	Modbus/RS485, SDI-12, 4-20 mA
Battery type & life[2]	3.6V lithium; 10 years or 2M readings	3.6V lithium; 10 years or 2M readings	3.6V lithium; 10 years or 2M readings	3.6V lithium; 10 years or 2M readings
External power	8-36 VDC	8-36 VDC	8-36 VDC	8-36 VDC
Memory ***Data records***[3] ***Data logs***	2.0 MB 130,000 50	2.0 MB 130,000 50	4.0 MB 260,000 50	1.0 MB 65,000 2
Log types	Linear, Fast Linear, and Event	Linear, Fast Linear, and Event	Linear, Fast Linear, Linear Average, Event, Step Linear, True Logarithmic	Linear
Fastest logging rate	2 per second	2 per second	4 per second	1 per minute
Fastest output rate	Modbus: 2 per second SDI-12 & 4-20 mA: 1 per second	Modbus: 2 per second SDI-12 & 4-20 mA: 1 per second	Modbus: 2 per second SDI-12 & 4-20 mA: 1 per second	Modbus: 2 per second SDI-12 & 4-20 mA: 1 per second
Real-time clock	Accurate to 1 second/24-hr period	Accurate to 1 second/24-hr period	Accurate to 1 second/24-hr period	Accurate to 1 second/24-hr period
Sensor Type/ Material	Piezoresistive; titanium	Piezoresistive; titanium	Piezoresistive; titanium	Piezoresistive; titanium
Range	*Absolute (non-vented)* 30 psia: 11 m (35 ft) 100 psia: 60 m (197 ft) 300 psia: 200 m (658 ft) 500 psia: 341 m (1120 ft)	*Gauged (vented)* 5 psig: 3.5 m (11.5 ft) 15 psig: 11 m (35 ft) 30 psig: 21 m (69 ft) 100 psig: 70 m (231 ft) 300 psig: 210 m (692 ft) 500 psig: 351 m (1153 ft)	*Absolute (non-vented)* 30 psia: 11 m (35 ft) 100 psia: 60 m (197 ft) 300 psia: 200 m (658 ft) 500 psia: 341 m (1120 ft) 1000 psia: 693 m (2273 ft) *Gauged (vented)* 5 psig: 3.5 m (11.5 ft) 15 psig: 11 m (35 ft) 30 psig: 21 m (69 ft) 100 psig: 70 m (231 ft) 300 psig: 210 m (692 ft) 500 psig: 351 m (1153 ft)	30 psia (usable up to 16.5 psi; 1.14 bar)
Burst pressure	Max. 2x range; burst > 3x range	Max. 2x range; burst > 3x range	Max. 2x range; burst > 3x range	Vaccum/over-pressure above 16.5 psi damages sensor
Accuracy @ 15° C[4]	±0.05% full scale (FS)	±0.05% FS	±0.05% FS	±0.05% FS
Accuracy (FS)[5]	±0.1% FS	±0.1% FS	±0.1% FS	±0.1% FS
Resolution	±0.005% FS or better	±0.005% FS or better	±0.005% FS or better	±0.005% FS or better
Units of measure	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH$_2$O, inH$_2$O Level: in., ft, mm, cm, m	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH$_2$O, inH$_2$O Level: in., ft, mm, cm, m	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH$_2$O, inH$_2$O Level: in., ft, mm, cm, m	Pressure: psi, kPa, bar, mbar, mmHg, inHg, cmH$_2$O, inH$_2$O
Temperature Sensor	Silicon	Silicon	Silicon	Silicon
Accuracy & resolution	±0.1° C; 0.01° C or better	±0.1° C; 0.01° C or better	±0.1° C; 0.01° C or better	±0.1° C; 0.01° C or better
Units of measure	Celsius or Fahrenheit	Celsius or Fahrenheit	Celsius or Fahrenheit	Celsius or Fahrenheit
Warranty[6]	3 years	3 years	3 years	3 years
Notes	[1] Temperature range for non-freezing liquids. [2] Typical battery life when used within the factory-calibrated temperature range. [3] 1 data record = date/time plus 2 parameters logged (no wrapping) from device within the factory-calibrated temperature range. [4] Across factory-calibrated pressure range. [5] Across factory-calibrated pressure and temperature ranges. [6] Up to 5-year (total) extended warranties are available for all sensors—call for details. Delrin is a registered trademark of E.I. du Pont de Nemours and Company.			

Every Application & Budget

Use maintenance-free, non-vented systems for long-term monitoring and at flood-prone or high-humidity sites.

Use high-accuracy, vented systems to conduct aquifer tests and to view barometrically compensated water level data in real time.

Forgot to set a level reference at the beginning of a deployment? Automate level corrections by using Win-Situ Software's post-level correction Wizard.

BaroTROLL® Data Logger

Using a non-vented system? Collect barometric pressure and temperature data with a titanium BaroTROLL Data Logger in order to compensate data for barometric pressure fluctuations.

Calculating barometric efficiency? Use the BaroTROLL Logger with vented systems.

Win-Situ® Baro Merge® Software automates post correction of water level data.

CE FC

Specifications are subject to change without notice.

In-Situ Inc.

Call to purchase or rent—www.in-situ.com

221 East Lincoln Avenue, Fort Collins, Colorado, U.S.A. 80524
1-800-446-7488 (toll-free in U.S.A. and Canada)
1-970-498-1500 (U.S.A. and international)

Nov. 2013 (T4; 2K)

Appendix 7B

MPWMD CASGEM Monitoring Plan

MONTEREY PENINSULA
WATER
MANAGEMENT DISTRICT

CASGEM Monitoring Plan

April 18, 2012

Contents

Introduction 1

Regional Geologic Setting for the Seaside Groundwater Basin 1

- Water Bearing Formations 1
- Restrictive Structures 4
- Recharge Areas 4
- Groundwater Level Trends 5
- Groundwater Storage 5

Monitoring Plan Rationale 5

Well Network 6

Monitoring Schedule 6

Description of Field Methods 6

Regional Geologic Setting for the Carmel Valley Alluvial Aquifer 8

Historical Water Levels for the Carmel Valley Alluvial Aquifer 8

Monitoring Plan Rationale 8

Well Network 10

Monitoring Schedule 10

Description of Field Methods 10

References 12

Figures

Figure 1. Seaside Groundwater Basin CASGEM Monitor Wells……………………………3

Figure 2. Carmel Valley Alluvial Aquifer CASGEM Monitor Wells……………………….9

Tables

Table 1. Attribute Data for MPWMD Monitor Wells in and Near the Seaside Basin …...7

Table 2. Attribute Data for MPWMD Monitor Wells in and Near the Seaside Basin ….11

Introduction

The Monterey Peninsula Water Management District (MPWMD or District) is participating in the California Statewide Groundwater Elevation Monitoring Program (CASGEM) which is administered by the Department of Water Resources (DWR). This groundwater monitoring plan lays the foundation for this monitoring effort and provides information on the wells to be sampled, monitoring schedule, and the characteristics of the groundwater basins. This plan contains two parts because MPWMD will be providing monitor well data from the Seaside Groundwater Basin as well as the Carmel Valley Alluvial Aquifer under the CASGEM.

Regional Geologic Setting for the Seaside Groundwater Basin

Water Bearing Formations

The Seaside Groundwater Basin consists of a sedimentary sequence of water-bearing materials that overlie the relatively impermeable Monterey Formation of Miocene age and older crystalline rocks. From oldest to youngest, the water-bearing units of the Seaside Basin are the Miocene Santa Margarita Sandstone (Tsm), the Tertiary and Quaternary “continental deposits” (QTc), and the Pleistocene and Holocene Aromas Sand and Older Dunes (Qe and Qt) (Yates and others 2005 and GTC 1986).

The Santa Margarita Sandstone corresponds to the “Santa Margarita Aquifer” and is a loose to weakly-cemented, marine sandstone with stratigraphic thickness up to approximately 300 feet. The upper portion of this deposit is medium-grained clean sand. With increasing depth and proximity to the underlying Monterey Formation, the clay content of the unit increases (Yates and others 2005).

The continental deposits correspond to the “Paso Robles Aquifer” and consist of a complex sequence of interbedded sand, gravel, and clay deposits. These deposits are more than 600 feet thick in some portions of the basin. The water-bearing portions of the continental deposits are thick lenses of sand and gravel of limited areal extent (Yates and others 2005).

The Aromas Sand and Older Dunes are surficial deposits that are of minor importance in the basin. The deposits are unconfined, in direct hydraulic communication with the ocean, and are only saturated in the extreme coastal portion of the basin (Yates and others 2005).

Surface outcrops within the area are limited primarily to alluvial sands and terrace deposits. Small areas of the Paso Robles and Santa Margarita Aquifers outcrop in the eastern portion of the Seaside Basin.

Monterey Peninsula Water Management District

Figure 1. Seaside Groundwater Basin CASGEM Monitor Wells, Seaside, Monterey County, California

)

Restrictive Structures

Structural deformation of the basin has resulted in varying thickness and depths of all of the geologic units across the basin (Yates and others 2005, GTC 1986, and DWR 1974). Basin structure is relatively well understood in the Laguna Seca and coastal subareas where production wells are numerous. Subsurface information in those areas reveals a complex arrangement of faults, anticlines, and synclines. Prominent among them is the Laguna Seca Anticline that uplifts the Monterey Formation and forms the boundary between the northern and southern subbasins. The Paso Robles and the Santa Margarita Aquifers thicken toward the eastern end of the southern subbasin as a result of a syncline. The Seaside and Ord Terrace faults create abrupt increases in basin thickness within the coastal parts of the southern and northern subbasins.

In the Seaside Basin, faults are associated with abrupt changes in basin thickness but appear to have little effect on groundwater flow where permeable units are present on both sides of the fault. All of the faults are steep normal or reverse faults, and most of them exhibit a combination of horizontal displacement (right-lateral) and vertical displacement (downthrown block on the north). All of them trend southeast-northwest. The Chupines fault forms the southern boundary of the basin where it juxtaposes relatively impermeable units of the Monterey Formation against the Santa Margarita Sandstone and continental deposits. The next fault to the north – the Seaside fault – passes obliquely through the southern subbasin. It is associated with as much as 500 feet of vertical displacement of the top of the Monterey Formation and it truncates the southern extent of the Santa Margarita Sandstone and continental deposits. Groundwater appears to flow freely across the Seaside fault in shallow aquifer horizons. Farther north, the Ord Terrace fault is similar to the Seaside fault, with as much as 450 feet of displacement of the top of the Monterey Formation. Neither the Seaside nor Ord Terrace faults are a significant barrier to groundwater flow.

The Seaside Basin does not appear to have a regional confining layer equivalent to the Salinas Valley Aquiclude that overlies the 180-Foot Aquifer throughout most of the coastal part of the Salinas Valley. The first clay layers encountered in the boreholes for four monitoring wells installed by MPWMD between Seaside and the Main Garrison area on the former Fort Ord are thin (less than 20 feet) and of inconsistent elevation.

Based on calibration of a groundwater flow model of the Laguna Seca area (the eastern part of the southern subbasin), the hydraulic conductivities for the Paso Robles and Santa Margarita Aquifers were estimated to be 2 ft/day and 3-5 ft/day, respectively. Similarly, calibrated storativity values were estimated to be 0.08 in unconfined aquifers and 0.0006 in confined aquifers.

Recharge Areas

The largest native sources of recharge to the basin are deep percolation of rainfall, irrigation water, and pipe leaks (Yates and others 2005, GTC 1986, and Muir 1982). This recharge occurs throughout the basin and is facilitated by the generally sandy soils. Septic system leach fields also contribute small amounts of groundwater recharge. The largest non-native source of recharge to the basin is by groundwater recharge via injection wells. Since 1998, MPWMD has injected over 4,300 acre-feet into specialized Aquifer Storage and Recovery (ASR) wells the northern subbasin.

A significant percentage of groundwater yield near the coast consists of groundwater inflow from inland areas. In addition, groundwater can flow to or from offshore areas depending on the elevation of groundwater levels near the coast. If coastal water levels are below sea level, groundwater flows onshore (landward). Initially, this onshore flow may not be salty if offshore parts of the aquifer still contain residual freshwater from previous decades when groundwater flow was greater or past periods when sea levels were lower. It is estimated that approximately 1,100 acre-feet of onshore flow from the offshore part of the Santa Margarita Aquifer occurred in 2002 (Yates and others 2005).

Groundwater Level Trends

Groundwater level monitoring in production and monitoring wells within the basin has generally shown declines in the period from the 1960's to the present. Most groundwater extraction in the Seaside Basin is from the coastal part of the northern subbasin. Hydrographs for that area show a significant decline in water levels in almost all wells in the Santa Margarita Aquifer since 1995. In many of these wells, water levels were consistently above sea level prior to 1995 and are now consistently below sea level. The net decline in spring water levels between 1995 and 2002 was 10-15 feet in many wells, and the amount of seasonal drawdown from spring to fall each year has also increased from less than 5 feet to 15 feet (Yates and others 2005). The hydrographs for some wells in the Paso Robles Aquifer have also been declining, while others have been rising. These patterns are more strongly related to groundwater extraction than to climatic conditions.

Groundwater Storage

The storage capacity of the Seaside Groundwater Basin was estimated to be 564,700 acre-feet in 1990 (SGD 1990). This estimate included a component for offshore storage and assumed a weighted average specific yield value of 12%. Of this total, the estimated storage for the onshore parts of the coastal subareas was 162,300 acre-feet, with 9,000 acre-feet estimated to be above sea level. More recent storage capacity estimates based on a specific yield value of 8% suggest that the amount of usable groundwater storage capacity in the coastal area of the basin is 6,200 acre-feet (Yates and others 2005).

Monitoring Plan Rationale

Monitor wells selected for CASGEM monitoring are distributed to give a good representation of groundwater conditions of the Seaside Groundwater Basin. However, it should be noted that large areas of the basin do not have adequate monitor well coverage due to the lack of historical development and land-use restrictions (i.e., inland firing ranges of the former Fort Ord).

Well Network

The well network consists of 22 wells located primarily in and near the coastal subareas of the Seaside Groundwater Basin. Many of these wells are paired and labeled deep and shallow to represent where they are screened in the aquifer. The list of monitoring wells for the Seaside Ground Water Basin is provided in Table 1. It is our understanding that Monterey County Water Resources Agency will be reporting on monitor wells that are located in and near the inland portions of the basin.

Monitoring Schedule

Wells for the CASGEM program will be monitored twice a year, once at the end of September and once at the end of March.

Description of Field Methods

Depth to the water table is measured directly with electric measuring tape to the nearest hundredth of a foot.

Table 1.

Well Name	State Well No.	Well Owner's Name	Date Drilled	DWR Well Drillers Report	MCHD Permit	Data Type	Hole Depth (feet)	Well Depth (feet)	Screened Interval (feet)	Strata Seal (feet)	Casing Type	Geologic Unit	Elevation (feet AMSL) (pre-2008)	Reference Point Elevation (feet AMSL)	Ground Level Elevation (feet AMSL)
Northern Coastal Subarea (and vicinity)															
MSC-Shallow	15S/1E-15N3	MPWMD	5/25/1990	338413		wl, wq	720	695	490 - - 680	95 - 275	2" pvc	QTc	80.58 (s1)	80.10	77.23
MSC-Deep	15S/1E-15N2	MPWMD	5/25/1990	338425		wl, wq	920	865	810 - 850	725 - 775	2" pvc	Tsm	80.78 (s1)	80.29	77.25
PCA-E (Multiple) Shallow	15S/1E-15K5	MPWMD	4/16/1990	338402	W5748	wl, wq	863	410	350 - 400	110 - 150	2" pvc	QTc	69.31(s1)	68.51	68.8
PCA-E (Multiple) Deep	15S/1E-15K4	MPWMD	4/16/1990	338402	W5748	wl, wq	863	710	650 - 700	580 - 620	2" pvc	Tsm	69.31(s1)	68.54	68.8
Ord Terrace-Shallow	15S/1E-23Ca	MPWMD	8/5/1999	- -		wl, wq	530	340	280 - 330	- -	2" pvc	Tsm (upper)	230 (e1)	228.65	228.74
MPWMD #FO-09-Shallow	15S/1E-11Pa	MPWMD	8/16/1994	- -		wl, wq	1,110	660	610 - 650	500 - 540	2" pvc	QTc/Tp	119.11 (s3)	118.89	118.61
MPWMD #FO-09-Deep	15S/1E-11Pb	MPWMD	8/16/1994	- -		wl, wq	1,110	840	790 - 830	700 - 765	2" pvc	Tsm	119.15 (s3)	118.85	118.61
MPWMD #FO-10-Shallow	15S/1E-12Fa	MPWMD	9/3/1996	442738	WSAL 96-118	wl, wq	1,500	650	620 - 640	480 - 500	2" pvc	QTc	201.19 (s3)	200.85	200.45
MPWMD #FO-10-Deep	15S/1E-12Fc	MPWMD	9/3/1996	442738	WSAL 96-118	wl, wq	1,500	1,420	1,380 - 1,410	1,280 - 1,300	2" pvc	Tp	201.10 (s3)	201.03	200.45
Seaside Middle School-Shallow		MPWMD		EO100046		wl		670	570-650		2" pvc	QTc		333.35	333.35
Seaside Middle School-Deep		MPWMD		EO100047		wl		1,080	730--950		4" pvc	Tsm		332.62	332.62
CDM MW-1(Beach Range 8)	15S/1E-02Pa	MPWMD	11/12/2003			wl		140	130-140		2" pvc	Qod/Qar		93.15	93.81
CDM MW-2 (Ord Village Lift Sta.)	15S/1E-15Ga	MPWMD	11/17/2003			wl		91	81-91		2" pvc	Qod/Qar		63.51	63.82
Northern Inland Subarea (and vicinity)															
MPWMD #FO-07-Shallow	15S/1E-13La	MPWMD	7/12/1994	- -		wl	940	650	600 - 640	520 - 540	2" pvc	QTc	473.94 (s3)	470.19	473.95
MPWMD #FO-07-Deep	15S/1E-13Lb	MPWMD	7/12/1994	- -		wl	940	850	800 - 840	700 - 750	2" pvc	Tsm	473.97 (s3)	470.15	473.95
MPWMD #FO-08-Shallow	15S/1E-12Qa	MPWMD	7/25/1994	- -		wl	1,110	790	740 - 780	640 - 690	2" pvc	QTc	378.53 (s3)	378.04	379.13
MPWMD #FO-08-Deep	15S/1E-12Qb	MPWMD	7/25/1994	- -		wl	1,110	950	900 - 940	830 - 850	2" pvc	Tsm	378.54 (s3)	378.10	379.13
Southern Coastal Subarea (and vicinity)															
Plumas '90 Test	15S/1E-27J6	MPWMD	4/25/1990	338414		wl	550	485	430 - 470	- -	2" pvc	Tsm	158.41(s2)	157.83	157.83
CDM MW-3 (End Tioga Rd.)	15S/1E-22De	MPWMD				wl		59	49-59			Qod/Qar		33.81	34.44
CDM MW-4 (Seaside Beach lot)	15S/1E-21Ka	MPWMD				wl		53	43-53			Qod/Qar		18.69	19.24
Laguna Seca Subarea (and vicinity)															
MPWMD #FO-04-Shallow (E)	15S/1E-26Na	MPWMD	10/26/1988	192669		wl	320	320	260 - 300	- -	2" pvc	QTc	168.95 (s4)	168.23	168.43
MPWMD #FO-04-Deep (W)	15S/1E-26Nb	MPWMD	10/24/1988	192670		wl	640	580	500 - 560	340 - 345	2" pvc	Tsm	168.27 (s4)	167.44	167.79

NOTES:
1. Well Numbers are unofficial designations; not verified with DWR-assigned well numbers.
2. Geologic Unit refers to the unit adjacent to the screened interval: Qod/Qar = Quaternary "Older Dunes and Aromas Sand" (Dune aquifer); QTc = Tertiary and Quaternary "continental deposits" (Paso Robles aquifer); Tsm = Tertiary "Santa Margarita Sandstone" (Santa Margarita aquifer); Tp = "Purisima Formation"; and Tm = "Monterey Formation".
3. Elevation = reference point elevation at the wellhead: (e1) = estimated with Paulin altimeter; (e2) = estimated from topo map; (s1) = surveyed by Land Data Services (LDS) (Jul 20, 1990); (s2) = surveyed by LDS (Aug 27, 1992); (s3) = surveyed by Sandis Humber Jones (1995 and 1997); (s4) = surveyed, source uncertain; (s5) = surveyed by MPWMD (Jun 6, 1997).
4. "- -" in a blank cell means not applicable or not available. "- -" in a Screened Interval cell indicates multiple screen intervals.
5. Data Type refers to MPWMD data collected: wl = water level; wq = water quality.
6. Well completion data at sites MPWMD #FO-01, 2, and 3 are documented in "Fort Ord Ground Water Monitoring Well Project", Staal, Gardner & Dunne, Inc. (SGD), Jan 1987.
7. Well completion data at site MPWMD #FO-04 are documented in "Supplemental Hydrogeologic Assessment, Monterey Research Park, Laguna Seca Subarea", SGD, Nov 1988.
8. Well completion data at site MPWMD #FO-05 and 6 are documented in "Laguna Seca Ranch, Supplemental Hydrogeologic Assessment", SGD, Jul 12, 1991.
9. Well completion data for MSC, PCA-W, PCA-E, Plumas '90 Test and Paralta Test sites are documented in individual reports for each of these sites, SGD, Jul 1990.
10. Well completion data for Justin Court site are documented in "Additional Investigations of Ryan Ranch's Water Supply", John Logan, Jun 27, 1981.
11. Well completion data for LS Pistol Range, York Rd-West, Seca Place, and Robley Rd sites are documented in "Phase II Hydrogeologic Investigation, Laguna Seca Subarea", SGD, Sep 1988.
13. Well completion data for LS Driving Range (SCS Deep) and LS No. 1 Subdivision sites are listed in Appendix B of "Phase II Hydrogeologic Investigation, Laguna Seca Subarea", SGD, Sep 1988.
14. Geologic unit picks for MPWMD FO-09 and FO-10 sites from Feeney and Rosenberg, Mar 31, 2003 (Figure 4).
15. The well at the location of "Blue Larkspur-East End" has been described in LSS Phase II and III reports as "LSR '59 Pond Test". However, based on information and notes from DWR Log #43668, it appears that "LSR '59 Pond Test" well has been misinterpreted to be located at the east end of Blue Larkspur Lane. Accordingly, well completion data for "Blue Larkspur-East End" are not known.
16. In addition to the wells shown in this table, the MPWMD utilizes water level data from selected CAW production wells as part of its monthly groundwater storage tracking program in the coastal subareas of the basin.
17. It should be noted that the Seaside Basin Watermaster conducted a wellhead elevation survey of monitor and production wells in 2008. Please see MPWMD Seaside Basin Watertmaster Memorandum 2008-05 for updated wellhead reference elevation data.

Regional Geologic Setting for the Carmel Valley Alluvial Aquifer

The 36-mile-long Carmel River drains 255 square miles of the central coast of California (Figure 2). The watershed includes the Santa Lucia Mountains to the south and the Sierra del Salinas to the north. Bedrock in the basin is mainly Sur Series crystalline rock (granite, gneiss, schist) or Monterey Shale with significant outcrops of sandstone and volcanics (Page and Mathews, 1984). Mean annual rainfall varies from about 14 inches along the northeast perimeter of the basin to over 40 inches in the high peaks (up to approximately 5,000 feet in elevation) of the southern portion (James, 1999). Upper reaches on the Carmel River flow through steep-sided canyons, while the lower 16 miles is a relatively flat alluvial valley to the ocean that ranges in width from 300 to 4,500 feet. The average annual runoff at the San Clemente Dam site is 69,200 acre-feet (James, 1999). Bankfull flow is 2,200 cubic feet per second (cfs) near the mouth. On March 10, 1995, the river peaked at 16,000 cfs, which is the largest recorded (gaged) event on the Carmel River.

The unconsolidated sediments of the younger alluvium is the most significant water bearing unit in the Carmel Valley Alluvial Aquifer (Figure 2). The valley floor is composed of Holocene age poorly consolidated boulders, gravel, sand, and silt deposited by the Carmel River. Clay layers are thin and uncommon. However, silt becomes more common in the lower part of the valley. Aquifer thickness ranges from 30 feet at the drainage basin narrows to about 180 feet 1 mile upstream from the Carmel River lagoon (Kapple, 1984).

Recharge to the aquifer comes primarily through river infiltration which is about 85 percent of the net recharge. During normal to above normal rainfall years the water table recovers completely from the dry seasonal lows.

Historical Water Levels for the Carmel Valley Alluvial Aquifer

In general, the water table of the Carmel Valley Alluvial Aquifer recovers fairly rapidly with the onset of the rainy season and an increase in stream flow. For example, after the two year drought of 1976-1977, precipitation that began in January of 1978 caused water levels to recover by February 1978 (Kapple, 1984).

Monitoring Plan Rationale

Monitor wells selected for CASGEM monitoring are distributed to give a good representation of groundwater conditions of Carmel Valley Alluvial Aquifer.

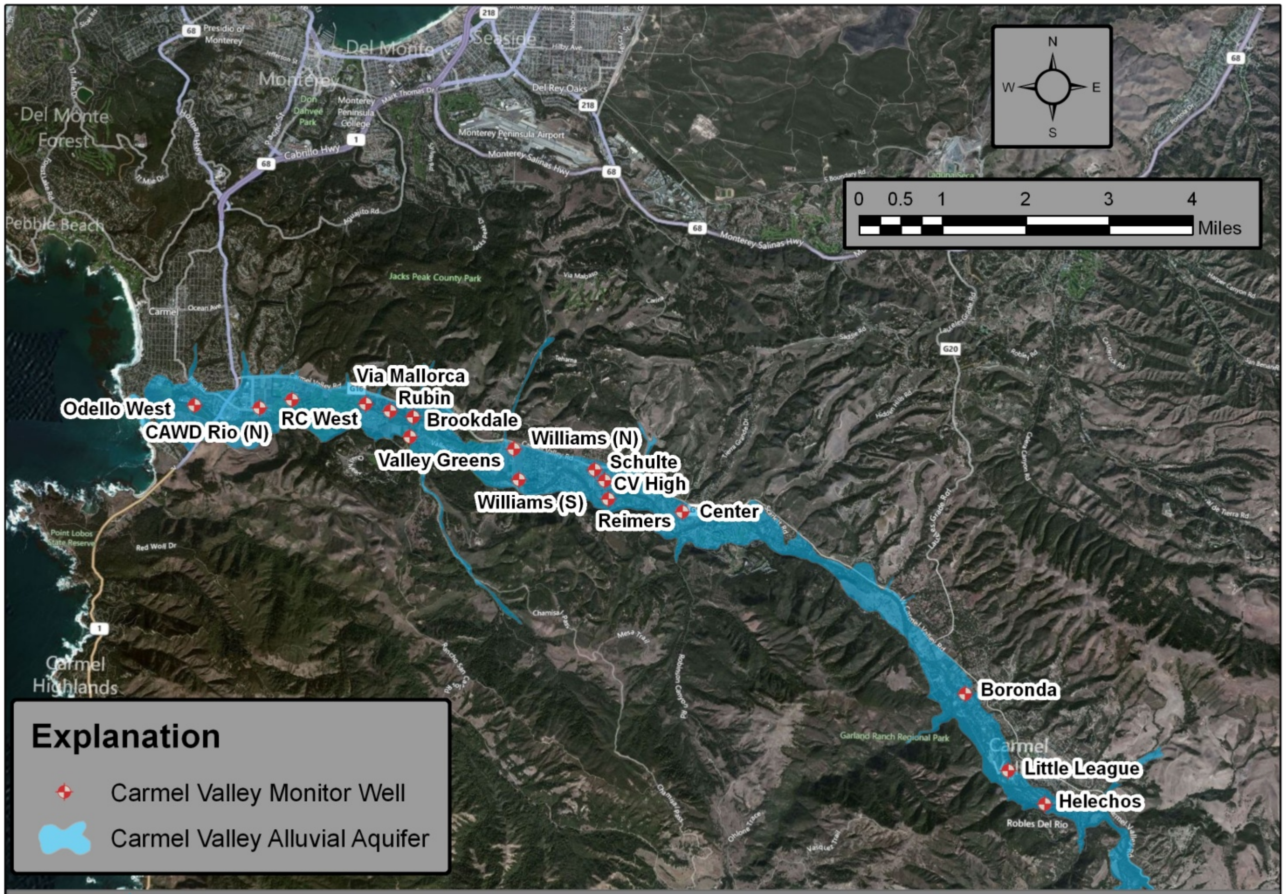


Figure 2. Carmel Valley Alluvial Aquifer CASGEM Monitor Wells, Carmel Valley, Monterey County, California

Well Network

The well network in the Carmel Valley Alluvial Aquifer consists of 16 wells. These wells are spread throughout the alluvial aquifer to establish groundwater elevation trends. Monitor well information for the Carmel Valley Alluvial Aquifer is provided in Table 2.

Monitoring Schedule

Wells for the CASGEM program will be monitored twice a year, once at the end of September and once at the end of March.

Description of Field Methods

Depth to the water table is measured directly with electric measuring tape to the nearest hundredth of a foot.

Table 2. Attribute Data for Carmel Valley Alluvial Aquifer Monitor Wells

River Mile[1]	Distance from River (feet)	Well Common Name	State Well No.[2]	Well Owner's Name	Aquifer Subunit[3]	Date Drilled	DWR Drillers Log	Well Type[4]	Data Collection[5]	Well Depth (feet)	Screened Interval (feet)	Reference Point Elevation (feet AMSL)[6]	Ground Level Elevation (feet AMSL)[6]	Other Name Designations or Notes
0.72	250	Odello West - near CAWD (W)	T16S/R1W-13Lc	MPWMD	4	3/10/1989	Y	DMW	WL, WQ	130	120-129	15.10 (e)	15.74	MW3(D), CSD_Deep, CSD_TURN_WEST
1.65	790	CAWD-Rio North (D)	T16S/R1E-18Mc	MPWMD	4	8/27/1993	492664	DMW	WL	159	54-154	25.88 (s)	25.88	
2.13	1350	RC West Monitor	T16S/R1E-18Ka	MPWMD	4	9/10/1993	492668	DMW	WL	100	40-90	38.00 (a)	38.00	5th Hole West Course
3.25	280	Via Mallorca	T16S/R1E-17Lc	MPWMD	4	7(?)/84	N	DMW	WL	115	5-115	47.38 (s)	47.75	see DMA Phase III, 1/85 report
3.56	80	Rubin	T16S/R1E-17Jd	MPWMD	3	7(?)/84	N	DMW	WL	95	5-95	48.59 (s)	50.14	see DMA Phase III (1/85) , Suppl Data, Vol. 1
3.85	350	Brookdale Drive	T16S/R1E-17J4	MPWMD	3	5/27/1981	Y	DMW	WL, WQ	39	29-34	57.58 (s)	57.96	
3.86	900	Valley Greens Drive	T16S/R1E-17R2	MPWMD	3	5/22/1981	Y	DMW	WL, WQ	50	40-45	68.18 (s)	68.44	VG&SC
5.44	2400	Williams North Monitor	T16S/R1E-22Da	MPWMD	3	9/15/1993	492670	DMW	WL	77	32-72	100.00 (e)	99.43	east side of Williams Ranch Road right-of-way
5.57	50	Williams South Monitor	T16S/R1E-22Fc	MPWMD	3	7/84?	N	DMW	WL	100	5-100	87.08 (s)	87.33	see DMA Phase III (1/85) , Suppl Data, Vol. 1
6.53	2300	Schulte Road	T16S/R1E-23E4	MPWMD	3	5/28/1981	Y	DMW	WL, WQ	58	43-53	110.31(s)	110.56	
6.70	1300	Carmel Valley High School #1	T16S/R1E-23Fb	MPWMD	3	11/16/1988	Y	DMW	WL, WQ	180	60-160	112.42 (s)	112.94	16S/1E-23F(CVH)
6.72	150	Reimers #1	T16S/R1E-23La	MPWMD	3	11/9/1988	Y	DMW	WL, WQ	122	50-122	102.10 (s)	102.25	16S/1E-23L(R-1)
8.02	1390	Center Street	T16S/R1E-24N5	MPWMD	3	5/29/1981	Y	DMW	WL,WQ	57	47-52	135.04 (s)	135.54	
12.52	260	Boronda Road	T16S/R2E-33Q1	MPWMD	2	5/31/1981	137408	DMW	WL, WQ	32	22-27	220.42 (s)	218.07	
13.65	380	Little League #1	T17S/R2E-03La	MPWMD	2	9/24/1988	192663	DMW	WL, WQ	50	30-50	251.00 (s)	251.60	LL#1
14.28	250	De Los Helechos	T17S/R2E-10B1	MPWMD	2	5/15/1981	137402	DMW	WL, WQ	28	18-23	272.62 (s)	273.00	Via Helechos

NOTES:
1. River Mile designations are referenced to the mouth of the Carmel River at Carmel Bay (i.e. RM 0.0). Distances are based on the June 1986 aerial photo enlargements (1" = 100').
2. Official State Well Number ends with a numeral, unofficial MPWMD Well Number ends with a small case letter.
3. Aquifer Subunit designations are as follows: AS1 - San Clemente Dam to Esquiline Bridge, AS2 - Esquiline Bridge to the Narrows, AS3 - Narrows to Via Mallorca Bridge, AS4 - Via Mallorca Bridge to Carmel Bay, CVU - Carmel Valley Upland.
4. DMW - Dedicated Monitor Well, PPW - Private Production Well.
5. WL - Water Level data, WQ - Water Quality data.
6. (s) = surveyed elevation, (h) = hand-leveled elevation, (a) = altimeter elevation, (e) = estimated elevation from topo map.
7. It should be noted that not all wells shown in this table are currently being monitored by the MPWMD.

References

California Department of Water Resources, 1974. Zone 11 Investigation, Carmel Valley and Seaside Groundwater Basins, Monterey County, Prepared by the DWR San Joaquin District, Fresno, CA, July 1974.

Geotechnical Consultants, Inc., 1986. Hydrogeologic Update, Fort Ord Military Reservation and Vicinity, Monterey County, California. Prepared for U.S. Department of the Army, Corps of Engineers, Sacramento District, Sacramento, CA.

James, Greg, 1999. Carmel River Basin – Surface Water Resources Data Report, Water Years 1996-1999, Monterey Peninsula Water Management District, December 1999.

Kapple, G., Mitten, H., Durbin, T., and Johnson, M., 1984. Analysis of the Carmel Valley Alluvial Groundwater Basin. U.S. Geological Survey. Water-Resources Investigations Report 83-4280.

Muir, K.S., 1982. Groundwater in the Seaside Area, Monterey County, California. U.S. Geological Survey Water Resources Investigation 82-10. Washington, D. C. September 1982.

Page, G. and G. Mathews, 1984. Carmel River Management Plan, Monterey Peninsula Water Management District, 1984.

Staal, Gardner and Dunne, Inc., 1990. Hydrogeologic Update, Seaside Coastal Groundwater Basins, Monterey County, California. Prepared for MPWMD, Monterey, CA. August 1990.

Yates E.B., Feeney, M.B. and Rosenberg, L.I., 2005. Seaside Groundwater Basin: Update on Water Resource Conditions. Prepared for MPWMD, Monterey, CA. April 2005.

Appendix 7C

Quality Assurance Project Plan for the former Fort Ord, Appendix A

BW-2785I
AR

Quality Assurance Project Plan Former Fort Ord, California Volume I, Appendix A

Final Revision 7 Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume

Prepared for:
U.S. Army Corps of Engineers
Sacramento District
1325 J Street
Sacramento, CA 95814-2922

On behalf of:
U.S. Department of the Army
Fort Ord BRAC
4463 Gigling Road, Room 101
Seaside, CA 93955

USACE Contract No. W91238-14-C-0048
Task No. 14

Prepared by:
Ahtna Environmental, Inc.
296 12th Street
Marina, CA 93933-6001

Report Date: **August 7, 2019**
Report Version: **Final**

Report Use and Limitations

Report Title:	**Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A Final Revision 7, Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume**
Prime Contractor:	Ahtna Environmental, Inc.
USACE Contract No.	W91238-14-C-0048
Task No.	14

Ahtna Environmental, Inc. (Ahtna) prepared this report at the direction of the U.S. Army Corps of Engineers (USACE) for the sole use of the U.S. Department of the Army (Army), the intended beneficiary. No other party should rely on the information contained herein without the prior written consent of the Army. This report and its interpretations, conclusions, and recommendations use the information presented in other documents, as cited in the text and listed in the references. Therefore, this report is subject to the limitations and qualifications presented in the referenced documents.

Table of Contents

Report Use and Limitations I

Acronyms and Abbreviations VI

1.0 Introduction 1

2.0 Project Management 2

2.1 Worksheets #1 and #2: Title and Approval Page 2
2.2 Worksheets #3 and #5: Project Organization and QAPP Distribution 5
2.3 Worksheets #4, #7, and #8: Personnel Qualifications and Sign-Off Sheet 6
2.4 Worksheet #6: Communication Pathways 9
2.5 Worksheet #9: Project Planning Session Summary 13

3.0 Project Quality Objectives 14

3.1 Worksheet #10: Conceptual Site Model 14
3.1.1 Background and History 14
3.1.2 Sources of Known or Suspected Hazardous Waste 14
3.1.3 Known Contaminants 15
3.1.4 Fate and Transport Considerations 15
3.1.5 Potential Receptors and Exposure Pathways 17
3.1.6 Land Use Considerations 17
3.1.7 Physiography and Topography 18
3.1.8 Geology and Hydrology 18
3.2 Worksheet #11: Project/Data Quality Objectives 20
3.2.1 Step 1: State the Problem 20
3.2.2 Step 2: Identify the Goals of the Study 22
3.2.3 Step 3: Identify Information Inputs 24
3.2.4 Step 4: Define the Boundaries of the Study 24
3.2.5 Step 5: Develop the Analytical Approach 26
3.2.6 Step 6: Specify Performance or Acceptance Criteria 33
3.2.7 Step 7: Develop the Plan for Obtaining Data 35
3.3 Worksheet #12: Measurement Performance Criteria 36
3.3.1 Worksheet #12a: VOCs - Sites 2/12 and OU2 GWTS and Sites 2/12, OU2, and OUCTP GWMP 37
3.3.2 Worksheet #12b: Metals - OU2 GWMP 40
3.3.3 Worksheet #12c: Wet Chemistry - Sites 2/12 GWTS and Sites 2/12 GWMP 42
3.4 Worksheet #13: Secondary Data Uses and Limitations 44
3.5 Worksheets #14 and #16: Project Tasks & Schedule 45
3.5.1 Project Tasks 45
3.5.2 Waste and Equipment Decontamination 45
3.5.3 Quality Control Tasks 45
3.5.4 Secondary Data 45
3.5.5 Data Management Tasks 45
3.5.6 Sample Tracking 45
3.5.7 Data Types 46
3.5.8 Data Tracking and Management 46
3.5.9 Computer Database 46

Table of Contents (continued)

3.5.10 Geographic Information System Description 47
3.5.11 Documentation 47
3.5.12 Presentation of Data 48
3.5.13 Assessment and Audit Tasks 48
3.5.14 Data Review Tasks 48
3.5.15 Documentation and Records 48
3.5.16 Project Schedule 48
3.6 Worksheet #15: Laboratory-Specific Detection/Quantitation Limits 49
3.6.1 Worksheet #15a: VOCs by EPA Method 8260-SIM 49
3.6.2 Worksheet #15b: Ion Chromatography by EPA Method 9056A 51
3.6.3 Worksheet #15c: Dissolved Metals by ICP by EPA Method 6010D 52

4.0 Sample Design 53

4.1 Worksheet #17: Sampling Design and Rationale 53
4.1.1 Worksheet #17a1: Sites 2/12 GWTS Part I 53
4.1.2 Worksheet #17a2: Sites 2/12 GWTS Part II 54
4.1.3 Worksheet #17b1: OU2 GWTS Part I 55
4.1.4 Worksheet #17b2: OU2 GWTS Part II 57
4.1.5 Worksheet #17c1: Sites 2/12 GWMP 59
4.1.6 Worksheet #17c2: OU2 GWMP 61
4.1.7 Worksheet #17c3: OUCTP A-Aquifer GWMP 66
4.1.8 Worksheet #17c4: OUCTP Upper 180-Foot Aquifer GWMP 70
4.1.9 Worksheet #17c5: OUCTP Lower 180-Foot Aquifer GWMP 72
4.2 Worksheet #18: Sampling Locations and Methods 76

5.0 Sampling Requirements 77

5.1 Worksheets #19 and #30: Sample Container, Preservation, and Hold Times 77
5.2 Worksheet #20: Field Quality Control Summary 78
5.3 Worksheet #21: Field SOPs/Methods 79
5.4 Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection 80

6.0 Analytical Requirements 81

6.1 Worksheet #23: Analytical SOPs 81
6.2 Worksheet #24: Analytical Instrument Calibration 82
6.3 Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing and Inspection 86
6.4 Worksheets #26 and #27: Sample Handling, Custody, and Disposal 87
6.5 Worksheet #28: Analytical Quality Control and Corrective Action 88
6.5.1 Worksheet #28a: VOCs 88
6.5.2 Worksheet #28b: Metals 91
6.5.3 Worksheet #28c: Wet Chemistry 93

7.0 Data Management and Data Review 94

7.1 Worksheet #29: Project Documentation and Records 94
7.1.1 Sample Collection and Field Measurement Records 94

Table of Contents (continued)

7.1.2 Analytical Records ... 96
7.1.3 Project Data Assessment Records ... 96
7.2 Worksheets #31, #32, and #33: Assessments and Corrective Action ... 97
7.2.1 Assessments and Corrective Action ... 98
7.2.2 QA Management ... 101
7.3 Worksheet #34: Data Verification and Validation Inputs ... 103
7.4 Worksheet #35: Data Verification Procedures ... 105
7.5 Worksheet #36: Data Validation Procedures ... 107
7.5.1 Stage 1 Validation ... 108
7.5.2 Stage 2A Validation ... 108
7.5.3 Stage 2B Validation ... 109
7.5.4 Stage 3 Validation ... 110
7.5.5 Stage 4 Validation ... 112
7.6 Worksheet #37: Data Usability Assessment ... 113

8.0 References ... 115

Figures

1 Former Fort Ord Location Map
2 Sites 2/12 Groundwater Monitoring Program Sampling Locations
3 Sites 2/12 Groundwater Remedy Map
4 Sites 2/12 Groundwater Treatment Plant Schematic
5A OU2 A-Aquifer Groundwater Monitoring Program Sampling Locations
5B OU2 Upper 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations
6 OU2 Groundwater Remedy and OUCTP Upper 180-Foot Aquifer Groundwater Remedy Map
7 OU2 Groundwater Treatment Plant Schematic
8A OUCTP A-Aquifer Groundwater Monitoring Program Sampling Locations
8B OUCTP Upper 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations
8C OUCTP Lower 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations
9 OU2 A-Aquifer Hydraulic Zone Map
10 OU2 Upper 180-Foot Aquifer Hydraulic Zone Map
11 OUCTP A-Aquifer Hydraulic Zone Map
12 OUCTP Upper 180-Foot Aquifer Hydraulic Zone Map
13 OUCTP Lower 180-Foot Aquifer Hydraulic Zone Map
14 OUCTP A-Aquifer EISB Groundwater Remedy Deployment Areas

Table

1 Summary of Existing Monitoring Wells and Samples Collected Annually

Attachments

A Standard Operating Procedures (SOPs)
B Resumes
C Field Documentation Forms
D Three Phase Quality Control Process and Documentation
E ADR Library and Qualifier Tables
F Analytical Laboratory Certifications
G Response to Comments on the Draft QAPP
H Response to Comments on the Draft Final QAPP

Acronyms and Abbreviations

%	percent
%D	percent difference/percent drift
°C	degrees Celsius
µg/L	micrograms per liter
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
1,2-DCA	1,2-dichloroethane
1,2-DCE (total)	total 1,2-dichloroethene
1,2-DCPA	1,2-dichloropropane
1,3-DCPE (total)	total 1,3-dichloropropene
2/12	Sites 2 and 12
ACL	Aquifer Cleanup Level
ADR	Automated Data Review
AES	Ahtna Engineering Services
Ahtna	Ahtna Environmental, Inc.
Army	U.S. Department of the Army
BCT	BRAC Cleanup Team
BEC	BRAC Environmental Coordinator
BFB	4-bromofluorobenzene
BRAC	Base Realignment and Closure
CCB	continuing calibration blanks
CCRWQCB	California Regional Water Quality Control Board, Central Coast Region
CCV	continuing calibration verification
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cis-1,2-DCE	cis-1,2-dichloroethene
COC	chemical of concern
COD	coefficient of determination
CQCR	Contractor Quality Control Report
CRF	Cooler Receipt Form
CT	carbon tetrachloride
DL	detection limit
DO	dissolved oxygen
DoD	Department of Defense
DQI	data quality indicator
DQO	data quality objective
DTSC	California Department of Toxic Substances Control
DTW	depth to water
EDD	electronic data deliverable
EISB	enhanced *in situ* bioremediation

Acronyms and Abbreviations (continued)

ELAP	Environmental Laboratory Accreditation Program
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
EW	Extraction Well
FADL	Field Activity Daily Logbook
FODIS	Fort Ord Data Integration System
FO-SVA	Fort Ord-Salinas Valley Aquitard
GAC	granular activated carbon
GC/MS	gas chromatography-mass spectrometry
GIS	geographic information system
GWMP	groundwater monitoring program
GWTP	groundwater treatment plant
GWTS	groundwater treatment system
HCl	hydrochloric acid
HLA	Harding Lawson Associates
HNO_3	nitric acid
IC	ion chromatography
ICAL	initial calibration
ICP	inductively coupled plasma
ICS	interference check sample
ICV	initial calibration verification
ID	identification
IDQTF	Intergovernmental Data Quality Task Force
LCS	laboratory control samples
LCSD	LCS duplicate
LOD	limit of detection
LOQ	limit of quantitation
MACTEC	MACTEC Engineering and Consulting, Inc.
MC	methylene chloride
MCL	maximum contaminant level
MCWD	Marina Coast Water District
mg/L	milligrams per liter
mL	milliliter
MNA	monitored natural attenuation
MPC	measurement performance criteria
MS/MSD	matrix spike/matrix spike duplicate
MSL	mean sea level
N/A	not applicable
ND	non-detect
NPL	National Priorities List

Acronyms and Abbreviations (continued)

O&M	operations and maintenance
ORP	oxidation-reduction potential
OU	operable unit
OU2	Operable Unit 2
OUCTP	Operable Unit Carbon Tetrachloride Plume
PARCCS	precision, accuracy, representativeness, comparability, completeness, sensitivity
PCE	tetrachloroethene
PDB	passive diffusion bag
PDS	post-digestion spike
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RI	Remedial Investigation
RF	response factor
ROD	Record of Decision
RPD	relative percent difference
RSD	relative standard deviation
SIM	selected ion monitoring
Sites 2/12	Sites 2 and 12
SM	Standard Methods
SOP	standard operating procedure
SRF	Sample Receipt Forms
SSHO	Site Safety and Health Officer
TAT	turnaround time
TCE	trichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene
TS	treatment system
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
VC	vinyl chloride
VOA	volatile organic analysis
VOC	volatile organic compound
Wood	Wood Environment & Infrastructure Solutions, Inc. (formerly Amec Foster Wheeler)

1.0 Introduction

On behalf of the U.S. Army Corps of Engineers (USACE), Sacramento District, Ahtna Environmental, Inc. (Ahtna) updated this Quality Assurance Project Plan (QAPP)[1] under Contract Number W91238-14-C-0048 for response actions to be performed at the former Fort Ord (Figure 1) in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or "Superfund") to address historical releases of chemicals of concern (COCs) at the former Fort Ord. The QAPP was updated and revised to:

- Update the number of wells monitored on an annual basis (Table 1), the list of wells sampled (Worksheet #17c) and the sampling location maps (Figures 2, 5A, 8A, 8B, 8C, and 9 through 13) based on newly installed wells,[2] recently decommissioned wells,[3] and recent progress in remedial actions for groundwater.[4]
- Update laboratory company name from SGS North America, Inc. to SGS.
- Update subcontractor company name from Amec Foster Wheeler to Wood Environment & Infrastructure Solutions, Inc. (Wood).
- Reference Department of Defense (DoD) Quality Systems Manual (QSM) Version 5.1.
- Update metals analysis from 6010C to 6010D.
- Reflect recent changes in project personnel.
- Update Operable Unit 2 (OU2) groundwater treatment system (GWTS) changes based on the new groundwater treatment plant (GWTP) and new extraction wells (Figure 7 and Worksheets #17b1 and #17b2).
- Include a description of how COC concentration contours and groundwater elevation contours are drawn in the quarterly reports.

This QAPP is the governing guidance document for groundwater and treatment system sampling associated with Sites 2/12, OU2, and Operable Unit Carbon Tetrachloride Plume (OUCTP) at the former Fort Ord. This QAPP details quality assurance (QA) and quality control (QC) procedures for sampling and analytical activities performed for the GWTS and the groundwater monitoring program (GWMP). The QAPP ensures the data generated are accurate, precise, complete, and representative of field conditions, and of sufficient quality to support project decisions.

---

[1] This document is Appendix A to the *Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I*. Volume I is also the governing document for sampling and analysis of soil (Appendix B), soil gas (Appendix C), and landfill gas (Appendix D). Volume II of the QAPP pertains to the former Fort Ord military munitions response program.

[2] Based on the *Monitoring Well Installation Completion Report, Former Fort Ord, California* (Well Install Completion Report; Ahtna, 2019f).

[3] Based on the *2019 Monitoring Well and Soil Gas Probe Decommissioning Completion Report, Former Fort Ord, California* (Ahtna, 2019g).

[4] The United States Environmental Protection Agency (EPA), California Department of Toxic Substances Control (DTSC) and California Regional Water Quality Control Board, Central Coast Region (CCRWQCB) agreed to these changes.

2.0 Project Management

2.1 Worksheets #1 and #2: Title and Approval Page

Site Name/Project Name: Former Fort Ord/Superfund Response Actions

Site Location: Former Fort Ord, California

Document Title: Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A Final Revision 7, Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume

Lead Organization: U.S. Army Corps of Engineers

Preparer's Name, Organization, and Contact Info: Holly Dillon, Ahtna
296 12th St, Marina, CA 93933
(831) 384-3735
hdillon@ahtna.net

Preparation Date: August 2, 2019

Project Role	Name Organization	Signature	Date
Investigative Organization's Project Manager	Derek Lieberman Ahtna	Derek J. Lieberman	7/24/2019
Investigative Organization's Program Chemist	Christopher Ohland Ahtna	Christopher Ohland	7/24/2019
Lead Organization's Technical Lead	Alex Kan USACE	KAN.ALEXANDER.1297094749 Digitally signed by KAN.ALEXANDER.1297094749 Date: 2019.08.06 14:16:59 -07'00'	
Lead Organization's Project Chemist	Jonathan Whipple USACE	WHIPPLE.JONATHAN.PAUL.1283504758 Digitally signed by WHIPPLE.JONATHAN.PAUL.1283504758 Date: 2019.08.06 14:35:12 -07'00'	

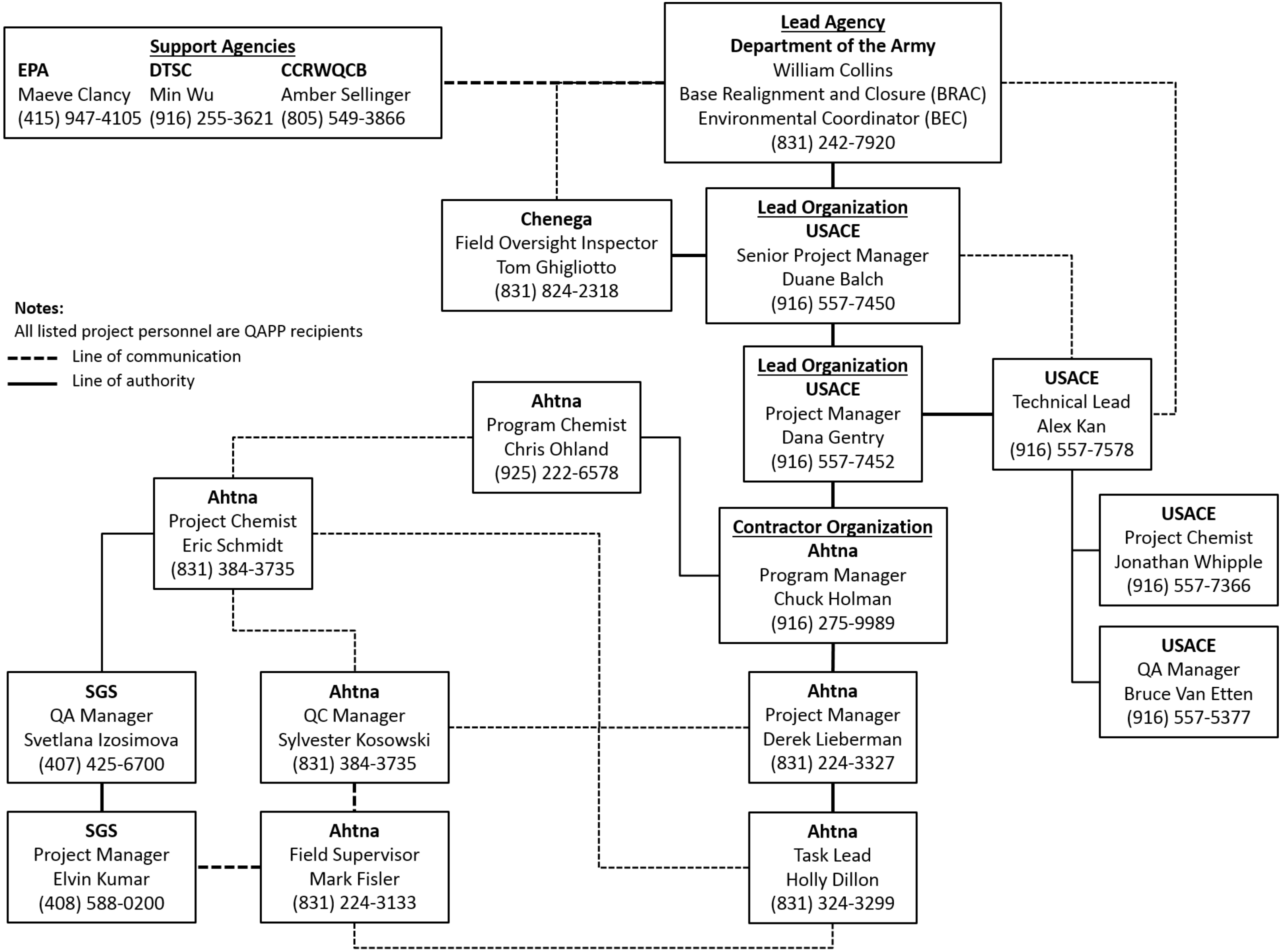
Plans and reports from previous investigations relevant to this project:

Site Name/Project Name:	Former Fort Ord/Superfund Response Actions
Site Location:	Monterey County, California
Site Number/Code:	Not Applicable (N/A)
Operable Units:	OU2, OUCTP, and Sites 2/12
Contractor Name:	Ahtna Environmental, Inc.
Contract Number:	W91238-14-C-0048
Contract Title:	Former Fort Ord Basewide Groundwater and Soil Vapor Treatment and Monitoring, Former Fort Ord, California
Work Assignment Number:	N/A
Guidance used to prepare QAPP:	Uniform Federal Policy for Quality Assurance Project Plans, Optimized UFP-QAPP Worksheets, March 2012, Revision 1. Department of Defense (DoD) Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1, 2017
Regulatory Program:	Comprehensive Environmental Response Compensation and Liability Act (CERCLA) as amended by Superfund Amendment and Reauthorization Act (SARA)
Approval Entities:	U.S. Environmental Protection Agency (EPA), California Department of Toxic Substance Control (DTSC), and Regional Water Quality Control Board, Central Coast Region (CCRWQCB)
Data Users:	U.S. Department of the Army (Army), USACE, EPA (and its consultant TechLaw, Inc.), DTSC, CCRWQCB, Army/USACE contractors, citizen groups, and members of the public
Organizational partners (stakeholders) and connection with lead organization:	USACE, Army (lead agency/owner), EPA (lead oversight agency), DTSC (support agency), and CCRWQCB (support agency)
The QAPP is (select one):	Generic:____ Project Specific:__X__

Dates and titles of QAPP documents written for previous site work:

Title	**Approval Date**
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 6	March 2018
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 5	June 2017
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 4	March 2016
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 3	June 2015
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 2	February 2014
Quality Assurance Project Plan, Superfund Response Actions, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Final Revision 1	December 21, 2012
Draft Final Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Groundwater, Appendix A, Groundwater Extraction and Treatment Systems at Operable Unit 2 and Sites 2 and 12; Groundwater Monitoring Program at Sites 2 and 12, Operable Unit 1, Operable Unit 2, and Operable Unit Carbon Tetrachloride Plume	May 31, 2011
Draft Final, QAPP/CDQMP Groundwater Monitoring Program, Sites 2 and 12, OU2 and OUCTP	January 20, 2010
Final Sampling and Analysis Plan, Operable Unit 2 and Sites 2 and 12 Groundwater Treatment Systems, Former Fort Ord	August 20, 2009

2.2 Worksheets #3 and #5: Project Organization and QAPP Distribution



2.3 Worksheets #4, #7, and #8: Personnel Qualifications and Sign-Off Sheet

Organization: Ahtna

Name	Project Title/Role	Education/ Experience[1]	Specialized Training/ Certifications[2]	Signature[3]	Date
Chuck Holman	Program Manager	Resume on file	HAZWOPER		7/24/2019
Derek Lieberman	Project Manager	Resume on file	First aid, CPR, MEC, PE, H&S, HAZWOPER, CQM	Derek J. Lieberman	7/24/2019
Christopher Ohland	Program Chemist	Resume on file	H&S, HAZWOPER	Christopher Ohland	7/24/2019
Eric Schmidt	Project Chemist	Resume on file	HAZWOPER, CQM	Eric Schmidt	7/24/2019
Holly Dillon	Task Lead	Resume on file	First aid, CPR, MEC, H&S, HAZWOPER, CQM		7/24/2019
Mark Fisler	Field Supervisor	Resume on file	First aid, CPR, MEC, HAZWOPER, CQM		7/24/2019
Sylvester Kosowski	QC Manager	Resume on file	HAZWOPER, CQM		7/24/2019

Notes:

[1] Resumes available in Attachment B.

[2] Specialized Training/Certifications Key:
CPR: cardiopulmonary resuscitation
CQM: Construction Quality Management.
H&S: health and safety training, including, but not limited to: hazard communication, fire extinguisher use, defensive driving, behavior-based safety, confined spaces.
HAZWOPER: 40-hour and current 8-hour annual refresher Hazardous Waste Operations and Emergency Response
MEC: munitions and explosives of concern recognition and safety training
PE: registered Professional Engineer

[3] Signatures indicate personnel has read and agree to implement this QAPP as written.

Worksheets #4, #7, and #8: Personnel Qualifications and Sign-Off Sheet (Continued)

Organization: Wood Environment & Infrastructure Solutions, Inc. (Wood)

Name	Project Title/Role	Education/ Experience[1]	Specialized Training/ Certifications[2]	Signature[3]	Date
Jeff Fenton	Project Manager	Resume on file	HAZWOPER		7/24/19
Scott Graham	Field Task Manager	Resume on file	HAZWOPER, first aid, CPR, MEC, CQM	Scott	7/24/19
Kevin Garrett	Project Chemist	Resume on file	Not applicable		7/24/19
Zachary Carroll	Data Validation Specialist	Resume on file	Not applicable		7/24/19

Notes:

[1] Resumes available in Attachment B.

[2] Specialized Training/Certifications Key:
CPR: cardiopulmonary resuscitation
CQM: Construction Quality Management.
HAZWOPER: 40-hour and current 8-hour annual refresher Hazardous Waste Operations and Emergency Response
MEC: munitions and explosives of concern recognition and safety training
PE: registered Professional Engineer

[3] Signatures indicate personnel has read and agree to implement this QAPP as written.

Worksheets #4, #7, and #8: Personnel Qualifications and Sign-Off Sheet (Continued)

Organization: SGS

Name	Project Title/Role, Location	Education/ Experience[1]	Specialized Training/ Certifications	Signature[2]	Date
Elvin Kumar	Project Manager, Florida	Resume on file	Not applicable		07/25/19
Svetlana Izosimova	Quality Assurance Officer, Florida	Resume on file	Not applicable		7/25/19
Caitlin Brice	General Manager, Florida	Resume on file	Not applicable	Caitlin Brice	7/25/19
Norman Farmer	Corporate Technical Director, Florida	Resume on file	Not applicable	Norm Farmer	7/25/19

Notes:

[1] Resumes available in Attachment B.

[2] Signatures indicate personnel has read and agree to implement this QAPP as written.

2.4 Worksheet #6: Communication Pathways

Communication Driver	Responsible Entity	Name	Telephone Number	Procedure (timing, pathways, documentation, etc.)
Point of Contact with lead support agency (EPA)	Lead Agency – Army BEC	William Collins	(831) 242-7920	Project materials and information will be submitted to the EPA, DTSC, and CCRWQCB as appropriate by William Collins (or designee) via e-mail or hardcopy.
Point of contact with Army Base Realignment and Closure (BRAC) Office	USACE	Alex Kan	(916) 557-7578	Materials and information regarding the project will be forwarded to Army BRAC Office through USACE Technical Lead.
Point of Contact with lead organization (USACE)	Ahtna Program Manager	Chuck Holman	(916) 275-9989	Project materials and information will be submitted to Alex Kan via e-mail or hardcopy.
Manage Project – contractor organization	Ahtna Project Manager	Derek Lieberman	(831) 384-3735	Manage project schedule and budget. Communicate project information to project team and Alex Kan. Ahtna Team liaison to Ahtna Program Manager.
Manage Project – contractor organization	Ahtna Task Lead	Holly Dillon	(831) 384-3735	Manage project fieldwork, data management, and document preparation. Communicate information to Project Manager.
Manage Project – subcontractor	Wood Project Manager	Jeff Fenton	(707) 793-3832	Manage project schedule and budget. Communicate project information to project team and Derek Lieberman.
Status Reports	Ahtna	Derek Lieberman	(831) 384-3735	Derek Lieberman will provide updates to USACE during weekly status meetings.
Stop work due to safety issues	Ahtna	Any person	(831) 384-3735	Any individual has the ability to stop work based on an unsafe work condition, or a potential for an unsafe work condition.
QAPP deviation in field	Wood Field Task Manager / Ahtna O&M Manager	Scott Graham/ Mark Fisler	(707) 364-3620/ (831) 224-3133	Notify Eric Schmidt by telephone or e-mail of variances to QAPP made in the field and the reasons within 24 hours. Eric Schmidt will notify Jonathan Whipple.

Communication Driver	**Responsible Entity**	**Name**	**Telephone Number**	**Procedure (timing, pathways, documentation, etc.)**
QAPP changes in field (modification to QAPP)	Wood Field Task Manager	Scott Graham	(707) 364-3620	Scott Graham will propose modifications to Kevin Garrett, Jeff Fenton, and Holly Dillon prior to implementation. Holly Dillon will propose an appropriate modification to Eric Schmidt and Derek Lieberman for approval. Derek Lieberman will propose a modification to Jonathan Whipple for approval. Communication regarding modification will be in writing (e-mail or hardcopy).
	Wood Project Chemist	Kevin Garrett	(303) 293-6082	
	Ahtna Program Chemist	Christopher Ohland	(925) 222-6593	
	Ahtna Project Chemist	Eric Schmidt	(831) 384-3735	
	USACE Project Chemist	Jonathan Whipple	(916) 557-7366	
QC and contract compliance	Ahtna QC Manager	Sylvester Kosowski	(831) 384-3735	Reviews project plans; assures Ahtna compliance with contract requirements.
Daily Field Progress Reports/Field QA/QC Issues	Wood Field Task Manager	Scott Graham	(707) 364-3620	Scott Graham will report field progress and field QA/QC issues daily by fax or e-mail to Jeff Fenton, Kevin Garrett, and Holly Dillon.
Laboratory Issues	SGS Project Manager	Elvin Kumar	(408) 588-0200	Elvin Kumar to notify Kevin Garrett of any problems with the laboratory (i.e. receipt of samples, instrument problems, detection limits (DLs), or any other issues that will affect the data or turnaround time (TAT) of reported results) within 24 hours of the occurrence, by phone and follow-up written communication (e-mail or hardcopy).
Field and Laboratory Data Quality Issues	Wood Project Chemist	Kevin Garrett	(303) 293-6082	Kevin Garrett will notify Jeff Fenton and Holly Dillon by phone or e-mail of field or lab QA/QC issues within one business day. Holly Dillon will notify Derek Lieberman and Eric Schmidt. Derek Lieberman will notify Jonathan Whipple.

Communication Driver	**Responsible Entity**	**Name**	**Telephone Number**	**Procedure (timing, pathways, documentation, etc.)**
Field and Analytical Corrective Actions[1]	Wood Project Chemist	Kevin Garrett	(303) 293-6082	The need for field or laboratory corrective action will be determined by Kevin Garrett and/or Holly Dillon, which will be communicated in writing to Jeff Fenton, Derek Lieberman, and laboratory contact (when appropriate) within two business days. Derek Lieberman will notify Jonathan Whipple.
Release of Analytical Data	Wood Project Chemist	Kevin Garrett	(303) 293-6082	Analytical data will not be released for use until review or validation is completed, as appropriate. Following Eric Schmidt's approval of validation findings, Kevin Garrett will release the data via e-mail to the project team.
Data import and export	Wood Data Validator	Zack Carroll	(707) 793-3873	Uploads field/fixed lab and data recorder data into the Fort Ord Data Integration System.
Hazardous or unsafe conditions that raise question of stopping work	Wood Field Task Manager / Ahtna O&M Manager	Scott Graham/ Mark Fisler	(707) 364-3620/ (831) 224-3133	Confer with Derek Lieberman and/or the Ahtna Site Safety and Health Officer (SSHO) to determine whether work needs to be stopped; the Ahtna SSHO will report stop-work decision to the Ahtna PM.
Perform field QC checks to ensure proper sampling methods, custody procedures, packaging, and shipment are performed	Ahtna QC Manager	Sylvester Kosowski	(831) 384-3735	Report result of field checks to Derek Lieberman and Eric Schmidt.
Prepare initial write-up of field generated data to be included in final reports	Ahtna Task Lead	Holly Dillon	(831) 384-3735	Confer with Derek Lieberman on questions and resolutions.

Communication Driver	**Responsible Entity**	**Name**	**Telephone Number**	**Procedure (timing, pathways, documentation, etc.)**
Database setup and data management planning	Ahtna Task Lead	Holly Dillon	(831) 384-3735	Provides information on sample and analytical reporting groups, and types of report tables required for the project.
Data verification/data validation	Wood Data Validator	Zack Carroll	(707) 793-3873	Report result of analytical QC checks to Chris Ohland.
Data review issues and corrective actions	Ahtna	Eric Schmidt	(831) 384-3735	Report result of analytical QC corrective action to Christopher Ohland and Derek Lieberman.

Notes:

[1] In the event significant corrective action is required for field or laboratory activities, information concerning the corrective action will be provided to the EPA, DTSC, and CCRWQCB by the Army within 30 days of the event, typically at the next scheduled monthly meeting of the BRAC Cleanup Team (BCT).

2.5 Worksheet #9: Project Planning Session Summary

Project Name: Former Fort Ord Basewide Groundwater and Soil Vapor Treatment and Monitoring **Projected Start Date:** Ongoing **Project Manager:** Derek Lieberman, Ahtna	**Site Name:** Former Fort Ord **Site Location:** Former Fort Ord, CA
Date of Session: October 2, 2018 **Scoping Session Purpose:** Define scope of work to be included in the QAPP	

Name	Title	Affiliation	Telephone #	E-mail Address
Derek Lieberman	Project Manager	Ahtna	(831) 384-3735	dlieberman@ahtna.net
Eric Schmidt	Project Chemist	Ahtna	(831) 384-3735	eschmidt@ahtna.net
Holly Dillon	Task Lead	Ahtna	(831) 384-3735	hdillon@ahtna.net
Andrew Mauck	Field Technician	Ahtna	(831) 384-3735	amauck@ahtna.net

Planning Session Summary:
Reviewed contract to determine QAPP requirements and reviewed QAPP Revision 6 for potential updates needed.

Action Items:
Based on this review, Ahtna will:

- Initiate QAPP Revision 7 update.
- After review of the previous four quarters of data (Fourth Quarter 2017 through Third Quarter 2018) and comparison to decision rules in the QAPP, update the list of monitoring and extraction wells to be sampled quarterly and annually. Remove wells from sampling program as allowed by decision rules. Updates to be proposed for approval by the BCT at the meeting on November 14, 2018 and to be applied to the Fourth Quarter 2018 GWMP event to be conducted in December 2018.
- Update subcontractor from Amec Foster Wheeler to Wood.
- Review SGS changes to QAPP including QSM Version 5.1 changes.

3.0 Project Quality Objectives

3.1 Worksheet #10: Conceptual Site Model

3.1.1 Background and History

The former Fort Ord is located along the Pacific Ocean in northwest Monterey County, approximately 80 miles south of San Francisco, California (Figure 1). The former military installation covered about 28,000 acres, is bounded by Monterey Bay to the west and the Santa Lucia Range to the south, and is surrounded by the cities of Del Rey Oaks, Marina, Sand City, and Seaside. State Highway 1 and the Union Pacific Railroad right-of-way traverse through the western portion of the former Fort Ord, separating the Monterey Bay beach front from the rest of the installation. The former Fort Ord served as a training and staging facility for infantry troops from 1917 until its closure in 1994. In 1990, the former Fort Ord was placed on the EPA's National Priorities List (NPL),[5] primarily due to volatile organic compounds (VOCs) found in groundwater beneath the Fort Ord Landfills. The former Fort Ord was closed in 1994 under the Base Realignment and Closure Act (BRAC).[6] Environmental remediation at the former Fort Ord is being completed pursuant to the CERCLA §121 and the National Oil and Hazardous Substances Contingency Plan.

3.1.2 Sources of Known or Suspected Hazardous Waste

Sites 2/12

When the former Fort Ord was an active military facility, Site 2 consisted of the primary sewage treatment facility for Fort Ord and Site 12 included numerous industrial activities, including vehicle maintenance and repair, furniture repair, storage of motor oils, hazardous material storage, vehicle cleaning and degreasing, and disposal of waste and oil.

OU2

The source of the OU2 groundwater contamination was from the Fort Ord Landfills. No detailed records were kept on the amount or types of wastes disposed of at the Fort Ord Landfills; however, household and commercial refuse, ash from incinerated infectious wastes, dried sewage sludge, demolition material, and small amounts of chemical waste (such as paint, waste oil, pesticides, electrical equipment, ink and epoxy adhesives) are believed to have been disposed of in the Fort Ord Landfills (Dames & Moore, 1993).

---

[5] The NPL is the list of national priorities among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The NPL is intended primarily to guide the EPA in determining which sites warrant further investigation.

[6] BRAC is the process the Department of Defense (DoD) has used to reorganize its installation infrastructure to more efficiently and effectively support its forces and increase operational readiness.

OUCTP

The apparent source of the OUCTP groundwater plume is located on what is now Lexington Court, a residential area in the northern portion of the former Fort Ord. Historical practices at this site included cleaning electronic equipment and radios.

3.1.3 Known Contaminants

Known contaminants, or COCs, were identified during Remedial Investigations at the sites and documented in the decision documents for each site. The COCs are listed in Worksheet #15a and are summarized below.

Sites 2/12

There are eight COCs for groundwater at Sites 2/12, with the primary COCs (those detected at the highest concentrations over the greatest area) identified as tetrachloroethene (PCE) and trichloroethene (TCE). Additionally, PCE and TCE are the two COCs for soil gas at Sites 2/12, which is described in the QAPP Volume I Appendix C for Soil Gas Monitoring (Ahtna, 2019c).

OU2

There are eleven COCs for groundwater at OU2, with the primary COC identified as TCE. Operations and maintenance (O&M) of the Fort Ord Landfills and the landfill gas extraction and treatment system is described separately in the QAPP Volume I, Appendix D, OU2 Landfills (Ahtna, 2019d).

OUCTP

The primary COC in groundwater at OUCTP is carbon tetrachloride (CT); however, there are eight COCs for the A-Aquifer, one COC for the Upper 180-Foot Aquifer, and two COCs in the Lower 180-Foot Aquifer.

3.1.4 Fate and Transport Considerations

Sites 2/12

There are or have been four potential migration pathways specific to Sites 2/12:

- Leaching of chemicals into underlying unsaturated zone soil.
- Diffusion of vapor phase chemicals in soil gas.
- Partitioning of chemicals between soil gas and groundwater.
- Migration of dissolved phase chemicals in groundwater.

Based on environmental conditions, historical data at Sites 2/12, and chemical-specific properties, PCE and TCE are considered to have medium to high persistence and moderate mobility. Soil types present at the site have a low retardation factor and there is insignificant adsorption of these chemicals. Additionally, PCE and TCE water solubilities and partition coefficients indicate moderate mobility. Persistence of PCE and TCE over time and the relative absence of breakdown products indicate little or no reductive dechlorination of these compounds, particularly in soil gas. Concentration-driven diffusion is likely a continuing process at Site 12 given the variation of concentration gradients in the unsaturated zone over time. Additionally, groundwater and soil gas analytical data and modeling during the Remedial

Investigation/Feasibility Study Addendum at Sites 2/12 indicated the areas of highest concentrations of PCE and TCE in soil gas were associated with concentrations of PCE and TCE in groundwater that exceed Aquifer Cleanup Levels (ACLs; AES, 2015). Groundwater contamination at Sites 2/12 affected the unconfined Upper 180-Foot Aquifer.

<u>OU2</u>

VOCs remaining in waste disposed of at the Fort Ord Landfills and VOCs detected in landfill gas have the potential to travel through soil pore space to exposure points via a number of mechanisms:

- Advection: mass transport due to bulk flow of water in which contaminants are dissolved;
- Dispersion: transport due to the groundwater flow whether or not a compound is dissolved;
- Diffusion: spreading of contaminants due to molecular diffusion in response to concentration gradients; and
- Volatilization: loss of chemical vapor to the atmosphere.

VOCs naturally undergo biological degradation processes in soil, soil gas, and groundwater; however, the rate of such degradation is limited by oxygen and nutrient sources depending upon the type of degradation that is occurring (aerobic vs. anaerobic). Further, degradation of compounds is dependent on the biological pathway available.

Groundwater contamination at OU2 affected the upper three groundwater aquifers: the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer (HLA, 1995). In the vicinity of OU2, the tops of each of these aquifers typically are first encountered at depths of about 60 feet bgs, 150 feet bgs, and 250 feet bgs, respectively. In monitoring well MW-OU2-73-A, located at the Fort Ord Landfills Area F source area, PCE and TCE are below their ACLs or not detected, but vinyl chloride is detected at the highest concentrations for the OU2 A-Aquifer. Vinyl chloride is a breakdown product in the natural reductive dechlorination process and may indicate this process is occurring locally at Fort Ord Landfills Area F.

With implementation of the remedy as prescribed in the OU2 Fort Ord Landfills Record of Decision (OU2 ROD; Army, 1994; engineered landfill cover system, and groundwater extraction and treatment system) in addition to operation of the landfill gas extraction and treatment system, impacts to the underlying groundwater from the Fort Ord Landfills have been greatly mitigated.

<u>OUCTP</u>

There are or have been four potential migration pathways specific to OUCTP:

- Leaching of chemicals into underlying unsaturated zone soil.
- Diffusion of vapor phase chemicals in soil gas.
- Partitioning of chemicals between soil gas and groundwater.
- Migration of dissolved phase chemicals in groundwater.

The CT plume appears to have originated from a training facility referred to in 1958 as “ST-11”, near what is now Lexington Court (Figure 8A), and migrated through the vadose zone beneath the vicinity of this facility and into groundwater of the A-Aquifer, the Upper 180-Foot Aquifer, and the Lower 180-Foot Aquifer; CT has not been detected in the 400-Foot Aquifer.

Hydraulic communication between the A-Aquifer and the underlying aquifers is limited to those areas west of OUCTP where the Fort Ord-Salinas Valley Aquitard (FO-SVA) clay unit pinches out, or where it was penetrated by wells without adequate sanitary seals. Two such vertical conduits were identified that resulted in the migration of CT from the A-Aquifer to the underlying Upper and Lower 180-Foot Aquifers. All identified vertical conduits have been destroyed (grouted and sealed) eliminating hydraulic communication between the A-Aquifer and the underlying aquifers. Groundwater in the Upper 180-Foot Aquifer flows to the southeast toward the apparent discontinuity in the underlying Intermediate 180-Foot Aquitard where it then recharges the Lower 180-Foot Aquifer. Groundwater in the Lower 180-Foot Aquifer primarily migrates to the east (Army, 2008).

In addition to CT, chloroform, TCE, and PCE were also present both within the vadose zone (vapor phase) and in the A-Aquifer near the source (dissolved phase). Chloroform is a biodegradation product of CT whose presence in OUCTP suggests there are native microbial bacteria acting within the subsurface to biodegrade CT. The presence of PCE and TCE in soil gas near the source area suggests these compounds were also disposed of in this area, presumably during the use of the same training facility.

In addition to CT, TCE is also present in the Lower 180-Foot Aquifer, which suggests groundwater originating from OU2 in the Upper 180-Foot Aquifer may be flowing from the southwest toward the apparent discontinuity in the Intermediate 180-Foot Aquitard (Ahtna, 2019b).

3.1.5 Potential Receptors and Exposure Pathways

Groundwater at Sites 2/12, OU2 and OUCTP currently is not used by residents within the Fort Ord area for domestic household purposes. Drinking water in the Fort Ord area is provided by the Marina Coast Water District (MCWD) and is pumped from wells that are located east of the Sites 2/12, OU2 and OUCTP areas. These supply wells are screened in the Lower 180-Foot Aquifer or deeper aquifers. Groundwater within the Sites 2/12, OU2 and OUCTP areas is located in the Prohibition Zone of the Special Groundwater Protection Zone at the former Fort Ord, within which the installation of new supply wells is restricted by Monterey County. According to Monterey County Code Title 15 Section 15.08.140, a prohibition zone is an area overlying or adjacent to a contaminant plume where water well construction is prohibited and applications for water wells will not be accepted; therefore, direct contact groundwater exposure pathways for residents potentially exposed to groundwater from the Sites 2/12, OU2 and OUCTP areas are currently incomplete and are expected to remain so in the future.

3.1.6 Land Use Considerations

Sites 2/12

In March 2004, the Army transferred the property at Site 12 and the land was redeveloped into a commercial retail area, which included construction of several big-box stores, a movie theater complex, food services, and a large parking area which is identified as The Dunes on Monterey Bay. The Army transferred the property at Site 2 in September 2006 and this land remains undeveloped and open to the general public as part of Fort Ord Dunes State Park. The Site 2 area was proposed for reuse as an aquaculture and oceanographic research facility, and later as a desalination plant (Fort Ord Reuse Authority [FORA], 1997); however, the site remains unused with the derelict sewage treatment plant facilities still onsite.

<u>OU2</u>

The OU2 area consists of the Fort Ord Landfills, which encompass approximately 120 acres of undeveloped land, as well as mixed-use residential, commercial, and undeveloped areas.

<u>OUCTP</u>

The apparent source of the OUCTP is located on what is now Lexington Court, part of the Abrams Housing Development, in the northern portion of the former Fort Ord. A groundwater contaminant plume emanating from this area ultimately extends across an area bounded by Del Monte Boulevard,

Abrams Drive, Neeson Road, and Blanco Road. The OUCTP area consists of mixed-use residential, commercial, light industrial, and undeveloped areas including habitat reserve areas.

3.1.7 Physiography and Topography

The predominant topography of the area reflects a morphology typical of the dune sand deposits that underlie the western and northern portions of the former Fort Ord. In these areas, the ground surface slopes gently to the west and northwest, draining toward Monterey Bay. Runoff is minimal because of the high rate of surface-water infiltration into the permeable dune sand. Consequently, well-developed natural drainages are absent throughout much of this area. Closed drainage depressions typical of dune topography are common. Elevations at the former Fort Ord range from approximately 50 feet above mean sea level (MSL) at Site 2 to 250 feet above MSL at the Fort Ord Landfills.

3.1.8 Geology and Hydrology

The predominant lithology is a loose, well-sorted (poorly graded) fine to medium sand. The sands represent active and recently active dunes and Pleistocene-age older dune sands. The active dune sands parallel the beach and extend several hundred feet inland. The older dune sands cover most of the northern and western portions of the former Fort Ord. Paleosols, representing former ground surfaces (silty sands) exist within these sands. These paleosols indicate that one or more cycles of dune deposition have occurred with intervening periods of soil development. The paleosols in the dunes bordering the beach indicate that older dune sand is locally present beneath the recent dune sand.

Three groundwater aquifers are in the remediation phase of cleanup activities at the former Fort Ord: the unconfined A-Aquifer, the unconfined and confined Upper 180-Foot Aquifer, and the confined Lower 180-Foot Aquifer. The aquifers consist predominantly of fine to coarse-grained sands which are separated by silty clay or clayey fine-grained sand aquitards. The A-Aquifer is located within the recent dune sands and is perched above the regional FO-SVA. To the west where the FO-SVA pinches out, the unconfined A-Aquifer and confined Upper 180-Foot Aquifer combine to form a continuous, unconfined hydrostratigraphic unit (identified as the unconfined Upper 180-Foot Aquifer). A north-trending groundwater divide in the unconfined Upper 180-Foot Aquifer exists midway between the FO-SVA and

Monterey Bay. Groundwater in the unconfined Upper 180-Foot Aquifer west of the divide flows west and discharges to the Monterey Bay. Groundwater in the unconfined Upper 180-Foot Aquifer east of the divide flows under the FO-SVA (becoming confined) toward the Salinas Valley. The Upper and Lower 180-Foot Aquifers, and portions of the 400-Foot Aquifer (locally) are contained within valley fill deposits. The Upper 180-Foot Aquifer is separated from the Lower 180-Foot Aquifer by the Intermediate 180-Foot Aquitard, which appears to be laterally discontinuous in the eastern portion of the former Fort Ord near the OU2 and OUCTP areas creating a natural conduit between the aquifers (Army, 2008).

3.2 Worksheet #11: Project/Data Quality Objectives

Data quality objectives (DQOs) are qualitative and quantitative statements that outline the decision-making process and specify the data required to support corrective actions. DQOs specify the level of uncertainty that will be accepted in results derived from data. The DQO process used for developing data quality criteria and performance specifications for decision-making is consistent with the *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4 (EPA, 2006). The DQO process consists of the following seven steps:

Step 1: State the problem

Step 2: Identify the goals of the study

Step 3: Identify information inputs

Step 4: Define the boundaries of the study

Step 5: Develop the analytical approach

Step 6: Specify performance or acceptance criteria

Step 7: Develop the plan for obtaining data

The DQOs steps are presented below for the five operable units (OUs):

- Sites 2/12
- OU2
- OUCTP A-Aquifer
- OUCTP Upper 180-Foot Aquifer
- OUCTP Lower 180-Foot Aquifer

3.2.1 Step 1: State the Problem

Concentrations of VOCs (primarily PCE, TCE and related breakdown products, and CT) are present in groundwater at the former Fort Ord at concentrations above the ACLs prescribed in the relevant RODs or Explanations of Significant Differences (ESDs), thereby requiring periodic monitoring and reporting of groundwater conditions and VOC concentrations to the CCRWQCB, DTSC, EPA, and USACE. Groundwater contamination is present in three aquifers within and adjacent to the former Fort Ord footprint: A-Aquifer, Upper 180-Foot Aquifer, and the Lower 180-Foot. Three main study areas have been identified, and comprise the majority of the GWMP: Sites 2/12 (one aquifer: Upper 180-Foot Aquifer), OU2 (two aquifers: A-Aquifer and Upper 180-Foot Aquifer) and OUCTP (three aquifers: A-Aquifer, Upper 180-Foot Aquifer, and Lower 180-Foot).

<u>Sites 2/12</u>

Groundwater in the Upper 180-Foot Aquifer beneath Sites 2/12 has been adversely impacted by eight VOCs (Worksheet #15a) that are identified in the Basewide Remedial Investigation Sites Record of Decision (RI Sites ROD; Army, 1997). These compounds are identified as COCs because they are present in groundwater at levels that pose an unacceptable risk to human health or the environment. As a result, the RI Sites ROD and the RI Sites ESD (Army, 2016) require remediation of the Upper 180-Foot Aquifer beneath and downgradient of Sites 2/12 using groundwater extraction with liquid-phase granular activated carbon (GAC) treatment and soil gas extraction with vapor-phase GAC treatment (Ahtna, 2019c). Figure 2 shows the Sites 2/12 monitoring and extraction well locations by sampling schedule, Figure 3 shows the Sites 2/12 GWTS configuration with current extraction well status, and Figure 4 shows the Sites 2/12 GWTP schematic and sampling locations. A detailed discussion of the soil vapor extraction and treatment system can be found in the Soil Gas QAPP (Ahtna, 2019c).

Improper disposal of solvents from former activities in this area led to contamination of the groundwater by COCs at concentrations above ACLs. The extent of the plume is defined by the detectable presence of PCE in groundwater, as it is the most common and widespread chemical constituent in this area. Active remedial action at Sites 2/12 consists of groundwater extraction and treatment by liquid-phase GAC since 1999, and soil gas extraction and treatment by vapor-phase GAC since 2015. Additionally, monitoring wells at Sites 2/12 are subject to seawater intrusion due to their proximity to Monterey Bay; as a result, chloride concentrations are monitored annually at select wells.

<u>OU2</u>

Groundwater in the A-Aquifer and Upper 180-Foot Aquifer beneath and downgradient from the Fort Ord Landfills has been adversely impacted by 11 VOCs. These compounds were identified as COCs (Worksheet #15a) in the OU2 ROD (Army, 1994*)* because they are present in groundwater at levels that pose an unacceptable risk to human health or the environment. As a result, the OU2 ROD and the OU2 ESD (Army, 1995) require remediation of the A-Aquifer and Upper 180-Foot Aquifer beneath and downgradient of OU2 using groundwater extraction with GAC treatment and treated water recharged to the aquifer or reused at the surface. Figures 5A and 5B show the OU2 monitoring and extraction well locations by sampling schedule, Figure 6 shows the OU2 GWTS configuration with current extraction well status, and Figure 7 shows the OU2 GWTP schematic and sampling locations.

COC migration from landfills covering 150 acres in the area has led to contamination of the groundwater by COCs at concentrations above ACLs. Three water supply wells (FO-29, FO-30, and FO-31), which MCWD owns and operates as part of the drinking water supply system for the former Fort Ord and the City of Marina, are also located near the OU2 area. The extent of the plume is defined by the detectable presence of TCE in groundwater, as it is the most common and widespread chemical constituent in this area. Active and ongoing (since 1995) remediation at OU2 consists of extraction and GAC treatment of groundwater.

Disposal of spent small arms ammunition in the Fort Ord Landfills was also identified as a possible source for metals (antimony, copper, and lead) contamination of the groundwater. Metals are not identified as COCs for groundwater in the OU2 ROD and therefore do not have ACLs. However, metals (antimony, copper, and lead) concentrations are monitored at select wells around the Fort Ord Landfills annually to validate that groundwater is not impacted by soil and spent small arms ammunition disposed of in the Fort Ord Landfills during remediation of small arms firing ranges at Fort Ord.

<u>OUCTP A-Aquifer</u>

Improper disposal of CT, used as a cleaning solvent for activities conducted in this area, lead to contamination of the groundwater (Army, 2008). The extent of the OUCTP in the A-Aquifer is defined by the detectable presence of CT in groundwater, as it is the most common and widespread chemical constituent in this area. Remedial action at OUCTP includes a combination of enhanced *in situ* bioremediation (EISB) and monitored natural attenuation (MNA). EISB treatment began with the pilot study starting in 2008 and completed in 2012 at Deployment Areas 1 and 2. Post-treatment and long-term groundwater monitoring have been conducted since 2012 (AES, 2014).

Additional monitoring wells were installed in 2011 and 2015 to close data gaps for the MNA remedy. The wells installed in 2015 indicated the CT groundwater plume was migrating northeast of the A-Aquifer groundwater divide (Figure 11) and construction of EISB Treatment Area #3 was recommended as shown in Figure 14. EISB Deployment Area 3A construction was completed and remedial operations began on December 1, 2016. Operations were completed on August 4, 2017 and post-treatment long-term performance monitoring is continuing according to the *Final Operable Unit Carbon Tetrachloride Plume Remedial Action Work Plan Addendum, Former Fort Ord, California* (Ahtna, 2016).

The effectiveness of EISB treatment is determined through periodic monitoring and reporting of groundwater quality parameters (dissolved oxygen [DO] and oxidation-reduction potential [ORP] in specific wells listed in Worksheet #17c3) and VOC concentrations (Worksheet #15a) to the CCRWQCB, DTSC, EPA, and USACE. Figure 8A shows the OUCTP A-Aquifer monitoring well locations by sampling schedule.

<u>OUCTP Upper 180-Foot Aquifer</u>

Groundwater in the Upper 180-Foot Aquifer at OUCTP has been adversely impacted by CT (Worksheet #15a) as identified in the OUCTP ROD (Army, 2008). This compound is identified as a COC because it is present in groundwater at levels that pose an unacceptable risk to human health or the environment. As a result, the OUCTP ROD requires remediation of OUCTP in the Upper 180-Foot Aquifer using groundwater extraction and treatment via the existing OU2 GWTS. Figure 8B shows the OUCTP Upper 180-Foot Aquifer monitoring well locations by sampling schedule. Figure 6 shows the location of the OUCTP Upper 180-Foot Aquifer extraction well, EW-OU2-09-180.

<u>OUCTP Lower 180-Foot Aquifer</u>

Groundwater in the Lower 180-Foot Aquifer at OUCTP has been adversely impacted by CT (Worksheet #15a) as identified in the OUCTP ROD (Army, 2008). The remediation of the Lower 180-Foot Aquifer includes MNA and contingency wellhead treatment of the nearby MCWD supply wells. Figure 8C shows the OUCTP Lower 180-Foot Aquifer monitoring well locations by sampling schedule. Groundwater in the Lower 180-Foot Aquifer has been adversely impacted by TCE at concentrations exceeding the maximum contaminant level (MCL) for drinking water, which suggests groundwater originating from OU2 in the Upper 180-Foot Aquifer may be flowing from the southwest toward the apparent discontinuity in the Intermediate 180-Foot Aquitard (Army, 2008 and Ahtna, 2019b).

3.2.2 Step 2: Identify the Goals of the Study

The primary goals associated with the Sites 2/12, OU2, and OUCTP remediation projects are to monitor the programs and verify they reflect current site conditions and whether the sites are in continued compliance with the RI Sites ROD (Army, 1997) and ESD (Army, 2016), OU2 ROD (Army, 1994) and ESD (Army, 1995), and the OUCTP ROD (Army, 2008), respectively.

OU2 and Sites 2/12 GWTSs

Data collected from the Sites 2/12 and OU2 GWTS will be used to perform the following assessments:

- Evaluate whether the GWTS are effectively and efficiently reducing concentrations of COCs in the aquifers of concern.
- Assess whether GWTS effluent meets discharge requirements before it is used for groundwater recharge or onsite for non-potable construction purposes (dust control, soil compaction, etc.).
- Evaluate when the GWTS GAC requires change-out.
- Evaluate whether the GWTS provides adequate hydraulic containment of the COC plume and prevents its migration.
- Assess whether ACLs have been achieved for COCs within project boundaries and whether closure of the site or OU is warranted.
- Assess whether the current extraction well sampling frequency is adequate to meet project objectives.

OU2, Sites 2/12, and OUCTP GWMP

The data collected from the Fort Ord GWMP are used to evaluate the following decisions:

- Are concentrations of COCs in groundwater above the relevant ROD- or ESD-prescribed ACLs?
- What is the vertical and lateral extent of relevant ROD-specified COCs in groundwater?
- Are concentrations of TCE in the Lower 180-Foot Aquifer above the MCL?
- What is the vertical and lateral extent of TCE in the Lower 180-Foot Aquifer?
- What is the source of TCE in the Lower 180-Foot Aquifer?
- What are the groundwater and aquifer conditions relative to the stability of the contaminant plumes, and what trends and temporal changes in groundwater levels and COC concentrations are taking place?
- Does the conceptual site model need to be updated or verified?
- Is closure of the site or OU, or a hydraulic zone within the site or OU, warranted if concentrations of COCs in groundwater are less than or equal to the relevant ROD- or ESD-prescribed ACLs?
- Are concentrations of chloride in monitoring wells at Sites 2/12 above the Monterey County Water Resources Agency threshold of 500 mg/L for classification as “seawater intruded”?
- Are concentrations of dissolved antimony, copper, and lead above MCLs for drinking water in wells associated with the Fort Ord Landfills?[7]

---

[7] Antimony, copper, and lead are the primary metals found in spent ammunition deposited in the Fort Ord Landfills, but are not identified as COCs for groundwater in the OU2 ROD and do not have ACLs; therefore, detected concentrations are compared to MCLs for drinking water. The Federal and California MCLs for antimony, copper and lead are the same numerical value (see Worksheet #15c). The MCL is the maximum concentration of a chemical that is allowed in public drinking water systems, though the groundwater being monitored is within the Prohibition Zone and is not intended for use as drinking water (see Section 3.1.5).

- Do post-treatment DO and ORP measurements in the OUCTP A-Aquifer monitoring wells indicate biodegradation is still occurring in the EISB Deployment Areas?

3.2.3 Step 3: Identify Information Inputs

<u>OU2 and Sites 2/12 GWTSs</u>

Inputs to decisions for the Sites 2/12 and OU2 GWTS are as follows:

- COC concentration data from extraction well samples collected to assess relative concentrations in the aquifer and whether ACLs have been met for COCs.
- COC concentration data from locations within the GWTS collected to assess whether the GWTS is operating effectively and efficiently.
- COC concentration data from TS-212-INJ and TS-OU2-INJ to confirm whether site-specific discharge requirements (Worksheet #15a) are met.
- COC concentration data from GAC treatment effluent collected to determine whether a GAC change-out is required.
- GWTS flow rate data collected to evaluate and document system operation.
- Groundwater monitoring data and/or groundwater flow modeling results to determine whether the plume is hydraulically contained.

<u>OU2, Sites 2/12, and OUCTP GWMP</u>

Decision inputs for the Fort Ord GWMP are as follows:

- Historical groundwater monitoring results and archived information.
- Historical knowledge of geologic and hydrologic conditions at Fort Ord.
- Groundwater modeling data from recent trend analysis.
- Statistical analysis of COC concentration trends on a well-by-well basis.
- ROD- or ESD-prescribed ACLs.
- State of California MCLs for drinking water.
- Fort Ord GWTS operational data and monitoring results.
- Drinking water production well data from local districts and municipalities.

3.2.4 Step 4: Define the Boundaries of the Study

The physical study boundaries for the Sites 2/12, OU2, and OUCTP groundwater remedies are described below and shown in Figure 1. Study boundaries are further divided into hydraulic zones based on the zone of groundwater with COC concentrations above ACLs and influenced by the groundwater remedy; therefore, hydraulic zones and study boundaries may be revised depending on changes in the extent of groundwater with COC concentrations above ACLs and modifications to the groundwater remedies. The long-term temporal boundaries for the remedies are indefinite; however, groundwater monitoring should continue at the sites in accordance with the decision rules presented in Step 5 of Worksheet #11 until the project objectives are met.

The overall geographic boundary for the site is the Main Garrison at the former Fort Ord including the Fritzsche Army Airfield area,[8] and the adjacent portion of the City of Marina. The lateral boundary is defined by the zone of groundwater impacted or potentially impacted by VOCs. The vertical boundary is defined by the zone of contaminated groundwater in the following aquifers or hydrogeologic units.

- A-Aquifer
- Upper 180-Foot Aquifer
- Lower 180-Foot Aquifer

The extent of groundwater with COC concentrations above ACLs is represented by the COC concentration contours shown on figures presented in quarterly and annual reports. COC analytical data are grouped by site for COC concentrations above ACLs and ArcGIS Desktop 10.4 (ESRI, 2017) is used to generate shapefiles depicting the COC concentration contours. Adjustments are made to the contours based on comparative evaluation of current COC concentrations and contours from previous quarters. If more than one sample is collected from a well in a quarterly monitoring event, the sample with the highest detected COC concentration will be used for generating the contour. The COC concentration contours can be compared to historical contours and used to optimize hydraulic zones and study boundaries, and interpret progress toward achieving remedial action objectives.

Groundwater elevations in each aquifer are represented by groundwater elevation contours shown on figures presented in quarterly and annual reports. Groundwater levels are measured each quarter at the wells listed in Worksheet #17 and compared to the wells' known top of casing elevation to determine the groundwater elevation at each well. For multi-port wells that have multiple ports in one aquifer, the groundwater level data from all the ports is averaged to determine the groundwater elevation at that location. Groundwater elevation data sets are imported into the Surfer® 15 (Golden Software, LLC) software application. Within Surfer® 15, the geostatistical gridding method (i.e., kriging) is used to interpolate a gridded surface from the groundwater elevation data. Point kriging, with a circular search ellipse and without a drift type (i.e., ordinary kriging), is used to estimate grid node values based on the known data points near the node with the data points weighted by their distance from the node. The size of the grid cells is set to approximately 30 feet by 30 feet. Once the grid is constructed, Surfer® 15 uses linear interpolation to generate contour lines of equal elevation based on the grid node values. Contour lines for each aquifer are exported from Surfer® 15 as shapefiles and imported into ArcGIS Desktop 10.4 (ESRI, 2017) for final manual adjustments, such as trimming the extents of the contours and smoothing curves. Finally, extraction well operation data are compared to measured groundwater levels at those wells and cones of depression are added manually around operating extraction wells. Groundwater elevation contours can then be used to interpret the flow characteristics of groundwater in each of the aquifers.

The time frame for decision-making relates to the quarterly monitoring and reporting schedule and periodic (e.g., annual) reporting and review cycles. With the exception of certain times of the year when

---

[8] Now the Marina Municipal Airport.

the presence of sensitive biological resources requires modification to the site or well access procedures, practical constraints on data collection are not applicable to this project.

Sites 2/12

Study boundaries at Sites 2/12 are as follows:

- The overall geographic boundary for the site is within the western Main Garrison area at the former Fort Ord.
- The lateral boundary is defined by the zone of groundwater impacted by COCs. The vertical boundary is defined by the zone of contaminated groundwater in the Upper 180-Foot Aquifer.
- Because the zone of contaminated groundwater is relatively small, limited to a single aquifer, and within the capture area of the existing extraction well network, there is currently only one hydraulic zone at Sites 2/12.

OU2

Study boundaries at OU2 are as follows:

- The overall geographic boundary for the site is the Main Garrison area and the Fort Ord Landfills at the former Fort Ord.
- The lateral boundary is defined by the zone of groundwater impacted by COCs. The vertical boundary is defined by the zone of contaminated groundwater in the A-Aquifer and Upper 180-Foot Aquifer.
- The study boundaries for OU2 are further divided into eight hydraulic zones based on the extent of the COC plumes in the A-Aquifer and Upper 180-Foot Aquifer, and groundwater extraction well network capture areas (Figures 9 and 10).

OUCTP

Study boundaries at OUCTP are as follows:

- The overall geographic boundary for the site is the Main Garrison area north of the Fort Ord Landfills at the former Fort Ord.
- The lateral and vertical boundaries are defined by the zone of groundwater impacted by COCs in the A-Aquifer, Upper 180-Foot Aquifer, and Lower 180-Foot Aquifer.
- The study boundaries for OUCTP are further divided into seven hydraulic zones based on the extent of the COC plumes in the A-Aquifer, Upper 180-Foot Aquifer and Lower 180-Foot Aquifer, and the areas of groundwater remedy influence for each aquifer (Figures 11, 12 and 13).

3.2.5 Step 5: Develop the Analytical Approach

The analytical approach has been developed by using decision rules on information inputs to support the goals of the project for the GWTSs and GWMP.

OU2 and Sites 2/12 GWTSs

Decision rules for the Sites 2/12 and OU2 GWTS have been developed to address the five major components of treatment system operation: discharge limit compliance; GAC change-out; hydraulic containment; sampling frequency; and plume remediation. Each of these components is described below.

Discharge Limit Compliance

- If analytical results indicate COC discharge limits (Worksheet #15a) are being met, then the system will continue to operate and GWTS effluent will be recharged to the aquifer.
- If analytical results indicate the discharge limit for any COC other than methylene chloride[9] is not met, then a confirmation sample will be collected and analyzed with a 24-hour TAT.
- If analytical results indicate the discharge limit for methylene chloride is not met, then the analytical results will be evaluated against QC sample analytical results associated with the same sampling event.
    - If the evaluation indicates the presence of methylene chloride above the discharge limit is not representative of groundwater conditions due to associated QC sample detections, then the OU2 GWTS will continue to operate and effluent will be recharged to the aquifer.
    - If the evaluation indicates the concentration of methylene chloride above the discharge limit is representative of groundwater conditions, then a confirmation sample will be collected from the OU2 GWTS discharge point of compliance and analyzed with a 24-hour TAT.
- If confirmation sample analytical results indicate the discharge limit for any COC is not met, then the affected GWTS will be shut down, operating conditions and GAC loading evaluated, extraction well flow rates adjusted as necessary and a variance report issued for any out-of-limits operation. Following operational changes, which may include GAC change-out, the GWTS will be restarted and re-sampled to verify compliance.
- If verification sample analytical results indicate discharge limits for COCs are being met, then the system will continue to operate and system effluent will be recharged to the aquifer.
- If verification sample analytical results indicate the discharge limit for any COC is not met, then the affected GWTS will be shut down, and operating conditions and GAC loading re-evaluated. Following operational changes, the GWTS will be restarted and re-sampled to verify compliance.

GAC Change-out

The decision rules for determining when a GAC change-out is needed at the Sites 2/12 GWTP are:

---

[9] Methylene chloride is a COC for OU2 and OUCTP in the A-Aquifer. EPA Method 8260-SIM, Analysis of Volatile Organics by GC/MS, Select Ion Monitoring (SIM) (Attachment A, SGS SOP# MS010) identifies methylene chloride as a common laboratory contaminant detected in the analysis for volatile organics.

- If analytical results for TCE and PCE from a process sample collected immediately downstream of the GAC vessel (upstream of the air stripper) are less than or equal to 90 percent (%) of ACLs, then a GAC change-out is not necessary. The Sites 2/12 system will continue to operate and the final effluent stream will continue to be recharged to the aquifer.
- If the analytical result for TCE or PCE from a process sample collected immediately downstream of the GAC vessel (upstream of the air stripper) is greater than 90% of ACLs, then a GAC change-out will be scheduled.

The *Operations and Maintenance Manual, Operable Unit 2 (OU 2) Groundwater Treatment Plant, Former Fort Ord* (OU2 GWTP O&M Manual; JV, 2018) provides procedures for O&M of the OU2 GWTS. The OU2 GWTP O&M Manual describes the conditions required for GAC change-out, but those instructions are superseded by the following based on Ahtna's experience operating GWTS using liquid-phase GAC as the primary treatment technology. At the OU2 GWTP, the average concentration of each COC in the lead GAC vessel effluent will be calculated based on analytical results from process samples collected immediately downstream of the lead GAC vessel (upstream of the second GAC vessel) during each process sampling event (where such samples are collected). Decision rules for determining when a GAC change-out at OU2 is necessary are:

- If the average concentration of each COC is less than 90% of its respective ACL (Worksheet #15a), then a GAC change-out is not necessary. The OU2 system will continue to operate and the final effluent stream will continue to be recharged to the aquifer.
- If the average concentration of any COC other than methylene chloride is equal to or greater than 90% of its ACL, a GAC change-out will be scheduled.
- If the average concentration of methylene chloride is equal to or greater than 90% of its ACL, then the analytical results for lead GAC vessel effluent sample will be evaluated against the analytical results for QC samples associated with the same sampling event.
    - If the evaluation indicates an average concentration of methylene chloride greater than 90% of its ACL is not representative of groundwater conditions due to associated QC sample detections, then a GAC change-out is not necessary. The system will continue to operate and OU2 GWTS effluent will be recharged to the aquifer.
    - If the evaluation indicates the concentration of methylene chloride above the discharge limit is representative of groundwater conditions and the average concentration of methylene chloride is equal to or greater than 90% of its ACL, a GAC change-out will be scheduled.

Hydraulic Containment

During remediation system operation, specific decision rules must be followed to demonstrate COC plume capture. The decision rules are:

- If groundwater monitoring and/or groundwater flow modeling demonstrate plume capture is occurring, then system operation will continue as currently configured. During operation, extraction well flow rates may be optimized to reduce O&M costs while maintaining plume capture.

- If the system flow rate data, in conjunction with the groundwater flow model, indicate the plume is being hydraulically contained, then the system will continue to operate.
- If groundwater monitoring and/or groundwater flow modeling indicate plume capture is not occurring, additional groundwater flow modeling will be conducted to determine whether adjustment of either extraction or recharge flow rates will improve capture or whether additional extraction wells or recharge points are required. Based on this evaluation, system reconfiguration may be recommended.

Plume Remediation

Assessment of aquifer cleanup resulting from the Sites 2/12 and OU2 GWTS is conducted through a GWMP that evaluates plume migration and COC concentrations. Extraction well monitoring data will be used for evaluating the operational status of individual extraction wells and for statistical evaluations of remediation progress. The decision rules for determining the operational status of groundwater extraction wells with respect to plume remediation are:

- An extraction well will continue to operate if any COC detected is greater than the corresponding ACL (Worksheet #15a).
- An extraction well will continue to operate if the extraction well flow rate data and analytical data from nearby wells, in conjunction with groundwater flow modeling, indicate operation of the extraction well is necessary for hydraulic containment of the plume.
- An extraction well will be shut off if COCs detected are less than the ACL for two consecutive quarterly monitoring events, and if the extraction well flow rate data and analytical data from nearby wells, in conjunction with groundwater flow modeling, indicate operation of the extraction well is no longer necessary for hydraulic containment of the plume.
- Following termination of pumping at an extraction well, the well will be incorporated into the GWMP.

Sampling Frequency

Extraction wells will be sampled quarterly when operating as part of the GWTS. The decision rules for determining the sampling frequency and monitoring status for groundwater extraction wells following termination of operation are:

- If four consecutive quarters of monitoring data show concentrations of COCs are below their respective limits of quantitation (LOQs) (Worksheet #15a) or below 10% of their respective ACLs (Worksheet #15a), whichever is greater, an annual monitoring schedule may be proposed.
- If two annual monitoring results show concentrations of COCs are below their respective LOQs or below 10% of their respective ACLs, whichever is greater, then the well may be proposed for removal from the sampling program.

- If wells adjacent to a well sampled annually, or no longer sampled, show detections of any COCs equal to or greater than their ACLs, then the well monitoring frequency may be increased to quarterly.
- If an annual well monitoring result shows a detection of any COC equal to or greater than its ACL, then the well monitoring frequency may be increased to quarterly.
- If a well is no longer needed for the program, it will be proposed for decommissioning.

Implementation of agency-approved exit strategies for Sites 2/12, OU2 and OUCTP, or portions thereof, may result in modification of these decision rules.

The statistical parameter of interest is the maximum value detected in the well or monitoring point compared to the ACLs or historical trend for that well or monitoring point. For perimeter control, the minimum value detected in the monitoring point (e.g., non-detect [ND] at the limit of detection [LOD]) is the statistical parameter of interest.

OU2, Sites 2/12, and OUCTP GWMP

The decision rules for groundwater monitoring are:

- If four consecutive quarters of monitoring data show concentrations of COCs below their respective LOQs, or below 10% of their respective ACLs (Worksheet #15a), whichever is greater, then an annual sampling schedule may be proposed.
- If two consecutive annual monitoring results show concentrations of COCs below their respective LOQs or below 10% of their respective ACLs, whichever is greater, then the well may be proposed for removal from the sampling program.[10]
- If wells adjacent to a well sampled annually, or no longer sampled, show detections of any COCs equal to or greater than their ACLs, then the well monitoring frequency may be increased to quarterly.
- If an annual well monitoring result shows a detection of any COC equal to or greater than its ACL, then the well monitoring frequency may be increased to quarterly.
- If monitoring or modeling input indicates the groundwater monitoring network no longer provides vertical or lateral control of COCs, then additional groundwater wells may be proposed to be added to the program.
- If a groundwater monitoring well is no longer needed for the program, it will be proposed for decommissioning.
- If a monitoring well in Sites 2/12 is determined to be intruded by seawater based on chloride data, the GWTS operator and Project Manager will be notified to implement possible GWTS changes.
- If concentrations of dissolved copper, lead, and antimony in select A-Aquifer wells (Worksheet #17c) exceed MCLs, the BCT will be notified.

---

[10] The well will continue to be monitored for depth to water until it is decommissioned or determined to be redundant or unnecessary water elevation data.

Decisions regarding application of passive diffusion bags (PDBs) are described in the *Technical Memorandum Passive Diffusion Bag Pilot Study Results and Recommendations* (Harding ESE, 2001).

OUCTP A-Aquifer EISB Post-Treatment Water Quality Parameter Monitoring

The parameters of interest for the OUCTP A-Aquifer are DO and ORP levels compared to the baseline values or historical trend for that well or monitoring point to evaluate the effectiveness of EISB. The decision rules for determining the monitoring frequency for post-treatment groundwater quality parameters are:

- Continue quarterly monitoring of post-treatment groundwater quality parameters if measurements indicate continued aquifer conditions are affected by the associated EISB treatment at the well; or measurements at one or more adjacent wells indicate aquifer conditions are affected by the associated EISB treatment; or measurements at one or more wells in an immediately upgradient Deployment Area indicates aquifer conditions are affected by the associated EISB treatment;
- If two consecutive quarters of post-treatment water quality parameter monitoring data show both DO and ORP measurements have returned to the approximate levels of recorded baseline conditions,[11] then water quality parameter monitoring may be reduced to an annual frequency at the well; or,
- If four consecutive quarters of post-treatment water quality parameter monitoring data show there has been no effect on the well by EISB treatment (i.e., there has been no significant deviation from recorded baseline conditions),[12] then water quality parameter monitoring may be reduced to an annual frequency at the well.
- If two consecutive annual monitoring periods of post-treatment water quality monitoring at an OUCTP A-Aquifer well show both DO and ORP have returned to the approximate levels of recorded baseline conditions,[13] then water quality parameter monitoring may be discontinued.
- If sampling a well for VOC analyses has been discontinued in accordance with the decision rules for the GWMP, then discontinuing post-treatment water quality parameter monitoring may be considered on a case-by-case basis in consultation with the BCT.

Measurement of post-treatment groundwater quality parameters in an OUCTP A-Aquifer well may be reinstated or increased in frequency should conditions change in an adjacent well or immediately upgradient Deployment Area, including additional EISB treatment.

---

[11] As presented in the *Final OUCTP Remedial Action Work Plan, Former Fort Ord, California; Appendix A OUCTP A-Aquifer Remedial Design Addendum* (OUCTP RAWP RD Addendum; AES, 2014)

[12] As presented in the OUCTP RAWP RD Addendum (AES, 2014).

[13] As presented in the OUCTP RAWP RD Addendum (AES, 2014).

Completion of Groundwater Restoration Remedial Actions[14]

The decision rules for determining when groundwater remedial actions are complete in a particular site or OU, or a hydraulic zone within the site or OU, are:

- If data collected during the GWMP indicate potential uncertainties regarding the remedy's effectiveness and/or current site conditions, or potential key data gaps, then the conceptual site model will be re-evaluated and updated.
- If COC concentrations in a well are above ACLs, then the well and its respective hydraulic zone will remain in the remediation monitoring phase.[15]
- If four consecutive quarters of monitoring data show concentrations of COCs in a well are less than or equal to their respective ACLs, the well may be evaluated for completion of the remediation monitoring phase.
  - If non-statistical data review shows all COCs in the well are ND, all detected COC concentrations are less than or equal to the ACLs, or a combination of the two, then the remediation monitoring phase is complete in the well.
  - If groundwater monitoring data do not lend themselves to a non-statistical review, then statistical analysis of the data set may be used (e.g., mean test or trend test).
  - If the selected statistical method demonstrates the 95% upper confidence limit (UCL) value is equal to or less than the ACL for the COCs where a statistical analysis was used, then the remediation monitoring phase is complete in the well.
- If a well has completed the remediation monitoring phase, then the well will enter the attainment monitoring phase.[16]
- If monitoring data show concentrations of COCs in a well are less than or equal to their respective ACLs, and it can be demonstrated COC concentrations will continue to be less than or equal to ACLs in the future, then the attainment monitoring phase is complete under any of the following conditions.
  - If all COCs in the well are ND, the LOQ is below the ACL, or a combination of ND sampling results and all detected COC concentrations are below the ACLs for eight consecutive sampling events, then a non-statistical or visual review of the COC data will be sufficient to conclude the attainment monitoring phase is complete in the well.

---

[14] Adapted from EPA, 2014a and EPA, 2014b.

[15] The remediation monitoring phase refers to the phase of the remedy where remedial activities are being implemented to reach groundwater cleanup levels selected in a remedy decision document. During this phase, groundwater sampling and monitoring data are collected to evaluate COC migration and changes in COC concentrations over time. The completion of this phase at a monitoring well typically occurs when the data collected and evaluated demonstrate that the groundwater has reached the cleanup levels for all COCs, as they are stated in the remedy decision document (EPA, 2013).

[16] The attainment monitoring phase typically occurs after it is determined the remediation monitoring phase is complete. When the attainment phase begins, data are collected to evaluate if the well has reached post remediation conditions (i.e., steady state conditions) where remediation activities, if employed, are no longer influencing the groundwater in the well (EPA, 2013).

  - If all COCs in the well are less than or equal to their respective ACLs for eight consecutive sampling events, and a statistical analysis (i.e., trend analysis) demonstrates COCs will remain less than or equal to ACLs in the future (the trend line has a statistically significant zero [steady state] or negative [decreasing] slope, and the 95% UCL value is less than or equal to the ACL), then the attainment monitoring phase is complete in the well.
  - If the well is removed from the sampling program in accordance with the decision rules applicable to GWMP decision rules presented above, then the attainment monitoring phase is complete in the well.
- If a well has completed the attainment monitoring phase and it is not needed for groundwater elevation data, then it will be proposed for decommissioning.
- If all the wells at particular site or OU, or a hydraulic zone within the site or OU have completed the attainment monitoring phase, then the attainment monitoring phase is complete for the particular site or OU, or hydraulic zone within the site or OU and the decision rules for GWMP no longer apply (i.e., sampling for COC analysis may be discontinued and the wells may be proposed for decommissioning unless needed for groundwater elevation data).
- If the attainment monitoring phase is complete at all the hydraulic zones within a site or OU, then the site or OU will be proposed for closure in a remedial action completion report.

The decision rules for the GWMP and for Completion of Groundwater Restoration Remedial Actions will be implemented concurrently; however, decision rules for determining when groundwater remedial actions are complete take precedence over the decision rules applicable to groundwater monitoring (e.g., if the attainment monitoring phase is complete at all wells in a hydraulic zone, then sampling for COC analysis is no longer necessary).

Exit strategy decision logic related to remedial process optimization and contingency measures should the remedies not progress as expected are presented in the *Final Technical Memorandum, Groundwater Remediation Exit Strategy, Sites 2/12 and OU2, Former Fort Ord, California* (MACTEC, 2009).

3.2.6 Step 6: Specify Performance or Acceptance Criteria

<u>OU2 and Sites 2/12 GWTSs</u>

The null hypotheses for the Sites 2/12 and OU2 GWTS are:

1) Concentrations of VOCs in groundwater entering the GWTS exist above the action levels
2) Concentrations of VOCs at the discharge points of compliance for the GWTS effluents are below discharge limits

The two types of decision errors that could result are a false acceptance decision error and a false rejection decision error. A false acceptance decision error for each null hypothesis would be to:

1) Assume a measured concentration is above the action level when in fact it is not.
2) Assume a measured concentration at a discharge point of compliance is below discharge limits when in fact it is not.

Consequences of the first false acceptance error might include unnecessarily treating groundwater that is not above action levels or continuation of remediation system operation after applicable ACLs have been met.

Consequences of the second false acceptance error might include delay of timely GAC change-out, resulting in discharge of water from the GWTS above discharge limits, or discontinuation of remediation system operation when applicable ACLs have not been met.

A false rejection error for each null hypothesis would be to:

1) Assume a measured concentration is not above the action level when in fact it is.
2) Assume a measured concentration at a discharge point of compliance is above the discharge limit when in fact it is not.

Consequences of the first false rejection error might include premature removal of extraction wells from the remediation system program before ACLs have been met.

Consequences of the second false rejection error might include unnecessarily performing or initiating confirmation sampling of GWTS effluent that actually met discharge limits during normal operation or remediation system shutdown, GAC change-out, and variance report issuance for effluent that met discharge limits after GAC vessel backwashing activities.

Decision errors are most likely to occur when the measured concentration is near the action level, or in the case of NDs, when the LOQ is near the action level. To control decision errors when the LOQ is near the action level, the laboratory is required to report any detections below the LOQ (but above the DL), thereby giving the data user additional information regarding trace level contamination. To control decision errors when the measured concentration is near the action level, the program is very conservative about making recommendations or changes based on individual sampling events and will require data from additional sampling or subsequent sampling events before modifying the treatment system network.

<u>OU2, Sites 2/12, and OUCTP GWMP</u>

VOCs in groundwater at the former Fort Ord range in concentration from ND to 12.3 micrograms per liter (µg/L) PCE (at Sites 2/12), 16.5 µg/L TCE (at site OU2), and 7.4 µg/L CT (at OUCTP), the primary COCs at these sites (as measured in the Third Quarter 2018 GWMP).

The null hypothesis for this project is that concentrations of VOCs in groundwater exist above the action levels. A false acceptance decision (i.e., false positive decision error) would be to assume a measured concentration is above the action level, when in fact, it is not. The consequences of this decision error would be to incur unnecessary expense to study and potentially modify the monitoring network to address an extent of contamination that does not exist.

A false rejection decision error (i.e., false negative decision error) would be to assume a measured concentration is not above the action level when in fact it is. The consequences of this decision error would be to not study or potentially modify the monitoring network, thereby resulting in an incomplete understanding of the extent of contamination and potential threat to groundwater quality.

Decision errors are most likely to occur when the measured concentration is near the action level, or in the case of NDs, when the LOQ is near the action level. To control decision errors when the LOQ is near the action level, the laboratory is required to report any detections below the LOQ (but above the DL), thereby giving the data user additional information regarding trace level contamination. To control decision error when the measured concentration is near the action level, the program is very conservative about making recommendations or changes based on individual monitoring events and will require data from additional sampling or subsequent sampling events before modifying the monitoring network.

In addition, trend analysis provides a valuable tool for assessing reliability of reporting concentrations. Furthermore, data are subjected to automated data review using an electronic system of QC checks, under the direction of a qualified chemist, using USACE and industry standards of analytical QC.

The null hypothesis is that EISB is not occurring in the Deployment Areas. A false acceptance decision (i.e., false positive decision error) would be to assume measured DO and ORP indicates there are no reducing conditions in the aquifer, when in fact there are. The consequences of this decision error would be to incur unnecessary expense to potentially perform additional EISB to establish reducing conditions in areas where they already exist.

A false rejection decision error (i.e., false negative decision error) would be to assume measured DO and ORP indicates there are reducing conditions in the aquifer, when in fact there are not. The consequences of this decision error would be to not perform additional EISB, thereby resulting in a longer period to achieve remedial action objectives.

Decision errors are most likely to occur when measured DO and ORP are near zero. To control such decision errors, the program is very conservative about making recommendations or changes based on individual monitoring events and will require data from additional sampling or subsequent sampling events before modifying the monitoring network. In addition, trend analysis provides a valuable tool for assessing reliability of reporting groundwater quality parameters.

3.2.7 Step 7: Develop the Plan for Obtaining Data

As a result of the DQO process, the optimum sampling design is derived for the Sites 2/12, OU2, and OUCTP remedies. Sample collection locations, rationales, and frequencies were established to achieve discharge compliance and provide a cost-effective means to evaluate the treatment of the impacted groundwater, and can be found in Worksheets #17a1 and #17a2 for Sites 2/12, and Worksheets #17b1 and #17b2 for OU2 and OUCTP. The EPA Method 8260-SIM (selected ion monitoring) analytical procedure for this project was selected to accurately quantify the chemicals of interest at the levels of concern. Method performance criteria for EPA Method 8260-SIM are presented in Worksheets #24 and #28a.

The overall sampling network design is described in Worksheet #17c1 through #17c5.

Sampling design considerations regarding application of PDBs are described in the *Technical Memorandum Passive Diffusion Bag Pilot Study Results and Recommendations* (Harding ESE, 2001).

3.3 Worksheet #12: Measurement Performance Criteria

The measurement performance criteria (MPC) for chemical analyses being performed for each matrix and analytical parameter are summarized in the tables below in Worksheet #12. The MPCs follow those defined in the referenced EPA method or laboratory standard operating procedures (SOPs). The quality of the data to be collected for this project will be verified through appropriate MPCs established for both sampling procedures and analytical methods. The criteria relate to data quality indicators (DQIs) consisting of precision, accuracy, representativeness, comparability, completeness, and sensitivity, commonly referred to as PARCCS parameters. The DQIs are defined as follows:

- Precision refers to the reproducibility of measurements. Precision is usually expressed as standard deviation, variance, percent difference, or range, in either absolute or relative terms.
- Accuracy refers to the degree of agreement between an observed value (such as sample results) and an accepted reference value. A measurement is considered accurate when the reported value agrees with the true value or known concentration of the spike or standard within acceptable limits.
- Representativeness describes the extent to which a sampling design adequately reflects the environmental conditions of a site. Representativeness is determined by appropriate program design, with consideration of elements such as proper well locations, drilling and installation procedures, operations process locations, and sampling locations.
- Comparability addresses the degree to which different methods or data agree or can be represented as similar. Comparability is achieved by using standard methods (SM) for sampling and analysis, reporting data in standard units, normalizing results to standard conditions, and using standard and comprehensive reporting formats.
- Completeness is a measure of the amount of valid data collected using a measurement system. Completeness is expressed as a percentage of the number of measurements that are specified in this QAPP.
- Sensitivity is the ability of a method or instrument to detect the target analytes at the level of interest. Sensitivity can be measured by calculating the percent recovery of the analytes at the LOQ, which is the minimum concentration of an analyte that can be routinely identified and quantified above the method LOQ by a laboratory.

The quality of the sampling procedures and laboratory results will be evaluated for compliance with project DQOs through a review of overall PARCCS, in accordance with procedures described in Worksheet #37 (Data Usability Assessment). The results will be summarized in an overall data usability report.

3.3.1 Worksheet #12a: VOCs - Sites 2/12 and OU2 GWTS and Sites 2/12, OU2, and OUCTP GWMP

Analytical Group/Method: VOCs by EPA Method 8260-SIM

Matrix: Groundwater (µg/L)

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
S: SOPs #1-5	Precision	RPD ≤ 30%	Field Duplicate	S
A: SGS SOP#MS010.7		Analyte RPD 1,1-DCA ≤ 15% 1,1-DCE ≤ 18% 1,2-DCA ≤ 14% 1,2-DCE (total) ≤ 17% 1,2-DCPA ≤ 14% 1,3-DCPE (total) ≤ 23% Benzene ≤ 14% CT ≤ 23% Chloroform ≤ 15% cis-1,2-DCE ≤ 15% MC ≤ 16% PCE ≤ 16% TCE ≤ 15% VC ≤ 18%	8260-SIM: LCS/LCSD and MS/MSD	A
A: SGS SOP#MS010.7	Accuracy / Precision	Analyte Recovery 1,1-DCA 81-122% 1,1-DCE 78-137% 1,2-DCA 75-125% 1,2-DCE (total) 76-127% 1,2,-DCPA 76-124% 1,3-DCPE (total) 75-120% Benzene 81-122% CT 76-136% Chloroform 80-124% cis-1,2-DCE 78-120% MC 69-135% PCE 76-135% TCE 81-126% VC 69-159%	8260-SIM: LCS and MS	A
A: SGS SOP#MS010.7	Bias	Analyte: Recovery 1,2-Dichloroethane-$_{d4}$: 74-125% Toluene-$_{d8}$: 88-111%	8260-SIM: Surrogates	A

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
S: SOPs #1-5 A: SGS SOP#MS010.7	Bias / Contamination	No analytes detected > ½ LOQ or > ⅒ the amount measured in any sample or > ⅒ the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ.	Method blank, field blank, trip blank	S&A
S: SOPs #1-5	Representative-ness	> 0°C ≤ 6°C	Cooler Temperature Blank	S
		Samples preserved to pH < 2.0	Measure pH of samples after analysis	
S: SOPs #1-5 A: SGS SOP#MS010.7	Comparability	Reasonableness	Historical data	S&A
		Qualitative measure for field sampling procedures	LCS/LCSD and MS/MSD	A
S: SOPs #1-5	Completeness	≥ 95% field completeness	Number of samples collected out of total samples planned	S
A: SGS SOP#MS010.7		≥ 90% analytical completeness	Evaluation of number of unqualified[17] results out of the total results reported	A
A: SGS SOP#MS010.7	Sensitivity	Evidence of shift in instrument response or zero setting	LCS, ICAL, CCAL	A
		Limit of quantitation	LOQ studies	

Notes on next page.

---

[17] Results qualified as estimated due to detected quantities between the LOQ and LOD will not be counted in the analytical completeness quantity assessment.

Notes:
<: less than
≤: less than or equal to
>: greater than
≥: greater than or equal to
%: percent
°C: degrees Celsius
CCAL: continuing calibration
1,1-DCA: 1,1-dichloroethane
1,1-DCE: 1,1-dichloroethene
1,2-DCA: 1,2-dichloroethane
1,2-DCE (total): total 1,2-dichloroethene
1,2-DCPA: 1,2-dichloropropane
1,3-DCPE: 1,3-dichloropropene
A: analytical
cis-1,2-DCE: cis-1,2-dichloroethene
CT: carbon tetrachloride
DL: detection limit
DQI: data quality indicator
ICAL: initial calibration
LCS: laboratory control samples
LCSD: laboratory control sample duplicate
LOQ: limit of quantitation
MC: methylene chloride
MPC: measurement performance criteria
MS: matrix spike
MSD: matrix spike duplicate
PCE: tetrachloroethene
QC: quality control
RPD: relative percent difference
S: sampling
S&A: sampling and analytical
SIM: selected ion monitoring
SOP: standard operating procedure
TCE: trichloroethene
trans-1,2-DCE: trans-1,2-dichloroethene
VOC: volatile organic compound
VC: vinyl chloride

3.3.2 Worksheet #12b: Metals - OU2 GWMP

Analytical Group: Metals by EPA Method 6010D

Matrix: Groundwater (µg/L)

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
S: SOP #3	Precision	RPD ≤ 30%	Field Duplicate	S
A: SGS SOP#MET 108.03		RPD ±20%	LCS/LCSD and MS/MSD	A
A: SGS SOP#MET 108.03	Accuracy / Bias	MS and LCS: Antimony 80-120% Copper 80-120% Lead 80-120%	LCS and MS	A
S: SOP #3 A: SGS SOP#MET 108.03		The absolute values of all analytes must be < ½ LOQ or < ⅒ the amount measured in any sample or ⅒ the regulatory limit, whichever is greater.	Method blank and field blank	S&A
S: SOP #3	Representativeness	Samples preserved to pH < 2.0	Measure pH of samples upon receipt	S
		> 0°C ≤ 6°C	Cooler Temperature Blank	
S: SOP #3	Comparability	Reasonableness	Historical data	S
A: SGS SOP#MET 108.03		Qualitative measure for field sampling procedures	LCS/LCSD and MS/MSD	A
S: SOP #3	Completeness	≥ 95% field completeness	Number of samples collected out of total samples planned	S
A: SGS SOP#MET 108.03		≥ 90% analytical completeness	Evaluation of number of unqualified results out of the total results reported[18]	A

---

[18] Results qualified as estimated due to detected quantities between the LOQ and LOD will not be counted in the analytical completeness quantity assessment.

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
A: SGS SOP#MET 108.03	Sensitivity	Evidence of shift in instrument response or zero setting	LCS, ICAL, CCAL	A
		Limit of quantitation	LOQ studies	

Notes:

≤: less than or equal to
≥: greater than or equal to
A: analytical
°C: degrees Celsius
CCAL: continuing calibration
DL: detection limit
ICAL: initial calibration
LCS/LCSD: laboratory control sample/laboratory control sample duplicate
LOQ: limit of quantitation
MS/MSD: matrix spike/matrix spike duplicate
RPD: relative percent difference
S: sampling
S&A: sampling and analytical
SOP: standard operating procedure

3.3.3 Worksheet #12c: Wet Chemistry - Sites 2/12 GWTS and Sites 2/12 GWMP

Analytical Group: Chloride by EPA Method 9056A

Matrix: Groundwater (mg/L)

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
S: SOPs #3&5	Precision	RPD ≤ 30%	Field Duplicate	S
A: SGS SOP#GN228.9		Analyte RPD Chloride ≤ 20%	Laboratory duplicates and MS/MSD (chloride only)	A
A: SGS SOP#GN228.9	Accuracy / Bias	Analyte Recovery Chloride 90-110%	LCS and MS	A
S: SOPs #3&5 A: SGS SOP#GN228.9		No analytes detected > ½ LOQ or > ⅒ the amount measured in any sample or > ⅒ the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ.	Method blank and field blank	S&A
S: SOPs #3&5	Representativeness	> 0°C ≤ 6°C	Cooler Temperature Blank	S
S: SOPs #3&5	Comparability	Reasonableness	Historical data	S
A: SGS SOP#GN228.9		Qualitative measure for field sampling procedures	LCS/LCSD and MS/MSD	A
S: SOPs #3&5	Completeness	≥ 95% field completeness	Number of samples collected out of total samples planned	S
A: SGS SOP#GN228.9		≥ 90% analytical completeness	Evaluation of number of unqualified results out of the total results reported[19]	A
	Sensitivity	Evidence of shift in instrument response or zero setting	LCS, ICAL, CCAL	A

---

[19] Results qualified as estimated due to detected quantities between the LOQ and LOD will not be counted in the analytical completeness quantity assessment.

S&A SOPs	DQIs	MPC	QC Sample or Activity Used to Assess MPC	QC Sample Assesses (S, A, or S&A)
A: SGS SOP#GN228.9		Limit of quantitation	LOQ studies	

Notes:

≤: less than or equal to

≥: greater than or equal to

A: analytical

°C: degrees Celsius

CCAL: continuing calibration

ICAL: initial calibration

DL: detection limit

LCS/LCSD: laboratory control sample/laboratory control sample duplicate

LOQ: limit of quantitation

MS/MSD: matrix spike/matrix spike duplicate

RPD: relative percent difference

S: sampling

S&A: sampling and analytical

SOP: standard operating procedure

3.4 Worksheet #13: Secondary Data Uses and Limitations

Since the groundwater sampling activities for the Sites 2/12 and OU2 GWTS and the Sites 2/12, OU2, and OUCTP GWMP are both long-term remedial action and monitoring programs and not active investigative programs, the secondary data that will be used to evaluate performance and concentration trends for both programs consist of the most recent annual monitoring reports as listed below. Secondary data and information that will be used, including originating sources, are identified below. How the secondary data will be used and the limitations on their uses are specified. Data from these documents will be utilized as appropriate.

Data Source	Data Generator	How Data Will be Used	Limitations on Data Use
Final Sites 2 and 12 Fourth Quarter 2017 through Third Quarter 2018 Groundwater and Soil Gas Monitoring and Treatment System Report, Former Fort Ord, California (Ahtna, 2019a)	Ahtna/Amec	Historical data used to evaluate GWTS performance over time	None
Final Operable Unit 2 Fourth Quarter 2017 through Third Quarter 2018 Groundwater Monitoring and Treatment System Report, Former Fort Ord, California (Ahtna, 2019e)	Ahtna/Amec	Historical data used to evaluate GWTS performance over time	None
Final Operable Unit Carbon Tetrachloride Plume Fourth Quarter 2017 through Third Quarter 2018 Groundwater Monitoring Report, Former Fort Ord, California (Ahtna, 2019b)	Ahtna/Amec	Historical data used to evaluate concentration trends	None

Note:
Amec: Amec Foster Wheeler

3.5 Worksheets #14 and #16: Project Tasks & Schedule

3.5.1 Project Tasks

Applicable SOP(s) for the project tasks outlined in this worksheet are listed in Worksheet #21 and provided in detail in Attachment A. The sampling tasks are described in Worksheets #17 and #18.

3.5.2 Waste and Equipment Decontamination

Wastewater generated during decontamination will be disposed of at the OU2 or Sites 2/12 GWTS and treated with the influent groundwater. Personal protective equipment and miscellaneous waste will be placed in large garbage bags, sealed, and disposed of in facility trash receptacles.

3.5.3 Quality Control Tasks

Implement field SOPs. Field QC samples will be collected at the frequency indicated in Worksheet #20. Samples will be analyzed by the laboratory in accordance with the stated method and the DoD QSM and this QAPP. For items related to QC, see Worksheets #11, #12, #15, #22, #24, #25, #27, and #28.

3.5.4 Secondary Data

See Worksheet #13.

3.5.5 Data Management Tasks

The following are the team members and their responsibilities for the data management process:

Program Chemist. Responsible for reviewing chain of custody forms and establishing the sample tracking system. Oversees proper use of Ahtna's sample management system and accuracy of the information entered. Reviews laboratory data for accuracy and quality and compares electronic outputs for accuracy to laboratory electronic copies. Conducts tracking of samples, forwards tracking information and received data to the database manager, and identifies the data inputs (for example, sample numbers) to use in generating tables and figures.

Database Manager. Responsible for setting up the data management system in consultation with the program chemist at the beginning of the data evaluation task. Also oversees the data management process, including data conversion/manual entry into the data management system, QC of the entered data, and preparation of the required tables and plots of the data. Coordinates with the person responsible for reviewing the entered data for QC purposes. Forwards all deliverables to the Project Manager.

Geographic Information System (GIS) Manager. Responsible for coordinating with the Project Manager to set up the geodatabase prior to sampling. Maintains spatial layers and overall geodatabase integrity and accuracy. Provides all GIS-related outputs for reports.

3.5.6 Sample Tracking

The program chemist is responsible for tracking samples in the sample tracking database to ensure that the analytical results for all samples sent for analysis are received. Copies of chains of custody from the field team are used to enter in sample identifications (IDs), collect data, and for analyses. Upon receipt of a sample receipt notice from the laboratory, the date received by the laboratory, and a date the electronic copy is due will be entered. Likewise, upon receipt of the electronic copy and electronic data deliverable (EDD), the date they are received will also be entered. The EDDs will be uploaded when received from the laboratory and will be tracked in the sample tracking table. Validation qualifiers will be added to the database and results qualified accordingly.

3.5.7 Data Types

The data will be added to the project database as they become available. The data will include new data collected in the laboratory and validated by Ahtna. The data source will be noted in the database.

3.5.8 Data Tracking and Management

Every data set received from analytical laboratories will be tracked individually. Analytical laboratory reports of chemical analysis results will be tracked in a consistent fashion. Every data set will be assigned a unique identifier. The date of receipt, status of data validation, and status of database entry for each data set will all be tracked and recorded in the project database.

Hard/Electronic Copy. Measurements made during field data collection activities will be recorded in field logbooks and sample processing logs. Field data will be reduced and summarized, tabulated, and stored along with the field logbooks and sample processing logs. All raw analytical laboratory data are stored electronically.

Data Input Procedures. Sampling information, analytical results, applicable QA/QC data, data validation qualifiers, and other field-related information will be entered into the project database for storage and retrieval during data evaluation and report development. The analytical data will be loaded into the database using EDD files received from the analytical laboratory. Validation qualifiers will be entered manually. Other available field-related data collected will be manually entered onto standard EDD templates for loading into the database. Historical data, either in hard copy or electronic form, will be manually entered on or formatted to standard EDD templates for database loading.

3.5.9 Computer Database

The technical data, field observations, laboratory analytical results, and analytical data validation will be managed using Ahtna’s and Wood’s database to store and analyze project data submissions.

The database must be protected from unauthorized access, tampering, accidental deletions or additions, and data or program loss that can result from power outages or hardware failure. The following procedures will be adopted to ensure protection:

- The master database will be stored on a network file server local to the installation of the Ahtna and Wood data management system. Members of the data management team involved in loading, modifying, or querying the database will be given access through user accounts and passwords, as well as the appropriate network server permissions.
- Copies of the master database will be stored on the local area network for access by project staff through reporting tools developed to minimize possible database corruption by users. Whenever the master database is updated or modified, it will be recopied to the local area

network to ensure that the current copy is available to users.

- Backups of the master database and its copies will be made to ensure that the data will not be lost due to problems with the network.

In addition to the internal computer database, EDDs will be uploaded to the BRAC Fort Ord Data Integration System (FODIS) database and the CCRWQCB GeoTracker database.

3.5.10 Geographic Information System Description

A project geodatabase will be set up prior to sampling by the Project Manager, database technician, and GIS technician. Ahtna will adhere to all applicable federal, DoD, and Army geospatial data standards for tasks and deliverables in this QAPP and will meet the minimum requirements for spatial data in accordance with Spatial Data Standards for Facilities, Infrastructure and Environment, current version whenever possible. Ahtna will submit the native GIS files that will include map data (.mxd) and geodatabase (.dbf) format. Ahtna will provide validated geospatial data to USACE for submission by BRAC to the FODIS database.

Each geospatial data set shall be accompanied by metadata conforming to the Federal Geographic Data Committee Content Standard for Digital Geospatial Metadata and the Army Installation Geospatial Information & Services Metadata Standard, v1. The horizontal accuracy of any geospatial data created shall be tested and reported in accordance with the National Standard for Spatial Data Accuracy and the results shall be recorded in the metadata. All data will have a datum of GCS_North American_1983 and a projection of North American Datum 1983 State Plane California Zone 4. The sea level datum used will be the National Geodetic Vertical Datum 1929 to conform with historical former Fort Ord data.

In addition to laboratory data, other physical data will be collected during field efforts. The information will be stored in the project database. Other types of data elements may be added as the field investigation needs and activities evolve.

3.5.11 Documentation

Documentation of data management activities is critical because it provides the following:

- An electronic copy record of project data management activities
- Reference information critical for database users
- Evidence that the activities have been properly planned, executed, and verified
- Continuity of data management operations when personnel changes occur

The data management plan will serve as the initial general documentation of the project data management efforts. Additional documentation will be maintained to document specific issues such as database structure definitions, database inventories, database maintenance, user requests, database issues and problems, and client contact.

3.5.12 Presentation of Data

Depending on data user needs, data presentation may consist of any of the following formats:

- Tabulated results of data summaries or raw data
- Figures showing concentration isopleths or location-specific concentrations
- Tables providing statistical evaluation or calculation results
- Presentation tools, such as ArcMap or similar analysis/presentation aids

In addition to laboratory data, other physical data will be collected during field efforts. The information will be stored in the project database. Other types of data elements may be added as the field investigation needs and activities evolve.

3.5.13 Assessment and Audit Tasks

See Worksheets #31, #32, and #33.

3.5.14 Data Review Tasks

The laboratory will make sure that the data are complete for all samples received. Laboratory data will be validated by Ahtna or Wood. Validated data and field logs will be reviewed to assess total measurement error and determine the overall usability of the data for project purposes. Final data are placed in the database with qualifiers. See Worksheets #34 though #37 for the tasks.

3.5.15 Documentation and Records

Records and field measurements of all samples will be collected in notebooks. Chains of custody and sample logs will be prepared and retained for each sample. A copy of the final QAPP will be kept at the Ahtna Marina office. Field forms are shown in Attachment C.

3.5.16 Project Schedule

A general project schedule for long-term monitoring is presented below.

Activity	Responsible Party	Frequency	Deliverable(s)	Deliverable Due Date
OU2 GWTS O&M	Ahtna	Ongoing	Quarterly and Annual Reports	Quarterly Report (Final only) due 60 days after sampling event concludes* Annual Report (Pre-Draft) due 75 days after sampling event concludes*
Sites 2/12 GWTS O&M				
OU2 GWMP		Quarterly		
Sites 2/12 GWMP				
OUCTP GWMP				

Notes:
* The conclusion of the sampling event is defined as the last day samples are collected for the event.

3.6 Worksheet #15: Laboratory-Specific Detection/Quantitation Limits

3.6.1 Worksheet #15a: VOCs by EPA Method 8260-SIM

Matrix: Groundwater (µg/L)

		Project Action Limits[1] (µg/L)								Project LOQ (µg/L)	Analytical Method Limits[2] (µg/L)		Achievable Laboratory Limits[3] (µg/L)		
						OUCTP									
		Sites 2/12		OU2		A-Aquifer	Upper 180-Foot Aquifer		Lower 180-Foot Aquifer						
Analyte	**CAS #**	**ACL**	**DCL[4]**	**ACL**	**DCL**	**ACL**	**ACL**	**DCL**	**ACL**		**DL**	**LOD and LOQ**	**DL**	**LOD**	**LOQ**
1,1-Dichloroethane	75-34-3	-	-	5	5[5]	-	-	-	-	0.50	0.03	NP	0.10	0.25	0.50
1,1-Dichloroethene	75-35-4	6	6	-	-	6	-	-	-	0.50	0.12		0.10	0.25	0.50
1,2-Dichloroethane	107-06-2	0.5	0.5	0.5	0.5	-	-	-	0.5	0.50	0.02		0.10	0.25	0.50
1,2-Dichloroethene (total)[6]	540-59-0	-	-	-	-	6	-	-	-	1.0	0.49		0.10	0.25	0.50
1,2-Dichloropropane	78-87-5	-	-	1	0.5	-	-	-	-	0.50	0.02		0.10	0.25	0.50
1,3-Dichloropropene (total)[6]	542-75-6	0.5	0.5	-	-	-	-	-	-	0.50	0.27		0.10	0.25	0.50
Benzene	71-43-2	-	-	1	0.5	-	-	-	-	0.50	0.03		0.10	0.25	0.50
Carbon Tetrachloride	56-23-5	-	-	0.5	0.5	0.5	0.5	0.5	0.5	0.50	0.02		0.10	0.25	0.50
Chloroform	67-66-3	2	2	2	2[5]	2	-	-	-	0.50	0.04		0.10	0.25	0.50
cis-1,2-Dichloroethene	156-59-2	6	6	6	6[5]	-	-	-	-	0.50	0.06		0.10	0.25	0.50
Methylene chloride	75-09-2	-	-	5	0.5	5	-	-	-	2.0	0.62		0.50	0.50	2.0
Tetrachloroethene	127-18-4	5	5	3	0.5	5	-	-	-	0.50	0.05		0.10	0.25	0.50
Trichloroethene	79-01-6	5	5	5	0.5	5	-	-	-	0.50	0.02		0.10	0.25	0.50
Vinyl Chloride	75-01-4	0.1	0.1	0.1	0.1	0.1	-	-	-	0.10	0.04		0.050	0.050	0.10

Notes on next page.

Notes:

µg/L: micrograms per liter
ACL: Aquifer Cleanup Level
CAS #: Chemical Abstracts Service Number
DCL: discharge limit
DL: detection limit
LOD: limit of detection
LOQ: limit of quantitation
NP: not provided in method
OU: Operable Unit
OUCTP: Operable Unit Carbon Tetrachloride Plume
-: not applicable

[1] ACLs and discharge limits are site-specific and identified in the relevant decision documents (Army, 1994; Army, 1995, Army, 1997; Army, 2008; and Army, 2016).

[2] Analytical method DLs, LODs and LOQs are those documented in published methods.

[3] Achievable DLs, LODs, and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. An analyte is ND at the LOD, and a measurable detection above the DL and less than the LOQ is estimated (“J-qualified”).

[4] Discharge limit for the applicable groundwater treatment system using groundwater extraction and treatment with granular activated carbon (GAC). For Sites 2/12 GWTS, discharge to areas overlying the contaminated groundwater plume need only meet ACLs (HLA, 1999).

[5] Discharge limit revised to ACL for this COC to optimize GAC usage (HLA, 1999).

[6] Total of cis- and trans- isomers.

3.6.2 Worksheet #15b: Ion Chromatography by EPA Method 9056A

Matrix: Groundwater (mg/L)

Analyte	CAS Number	Project Action Limits[1] (mg/L) Sites 2/12	Project LOQ (mg/L)	Analytical Method Limits[2] (mg/L)		Achievable Laboratory Limits[3] (mg/L)		
				DL	LOD and LOQ	DL	LOD	LOQ
Chloride	16887-00-6	250	250	0.02	Not Provided in Method	0.80	1.0	2.0

Notes:

CAS: Chemical Abstracts Service

DL: detection limit

LOD: limit of detection

LOQ: limit of quantitation

mg/L: milligrams per liter

[1] Project Action Limits are National Secondary MCLs for Drinking Water Quality.

[2] Analytical method DLs, LODs and LOQs are those documented in published methods.

[3] Achievable DLs, LODs, and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. An analyte is ND at the LOD, and a measurable detection above the DL and less than the LOQ is estimated (“J-qualified”).

3.6.3 Worksheet #15c: Dissolved Metals by ICP by EPA Method 6010D

Matrix: Groundwater (µg/L)

Analyte	CAS Number	Project Action Limits[1] (µg/L) OU2	Project LOQs (µg/L)	Analytical Method Limits[2] (µg/L)			Achievable Laboratory Limits[3] (µg/L)		
				DL	LOD	LOQ	DL	LOD	LOQ
Antimony	7440-36-0	6.0	6.0	21	Not Provided in Method	Not Provided in Method	1.0	5.0	6.0
Copper	7440-50-8	1,000	25	3.6			1.0	2.0	25
Lead	7439-92-1	15	10	28			1.1	2.0	5.0

Notes:

CAS: Chemical Abstracts Service

DL: detection limit

LOD: limit of detection

LOQ: limit of quantitation

µg/L: micrograms per liter

[1] Project Action Limits are state or federal MCLs (whichever is lower) for drinking water in OU2 wells associated with the Fort Ord Landfills. Antimony, copper, and lead are the primary metals found in spent ammunition deposited in the Fort Ord Landfills. MCLs are used to evaluate concentrations of these dissolved metals in groundwater near the Fort Ord Landfills; however, the groundwater being monitored is not intended for use as drinking water.

[2] Analytical method DLs, LODs and LOQs are those documented in published methods.

[3] Achievable DLs, LODs, and LOQs are limits that an individual laboratory can achieve when performing a specific analytical method. An analyte is ND at the LOD, and a measurable detection above the DL and less than the LOQ is estimated (“J-qualified”).

4.0 Sample Design

4.1 Worksheet #17: Sampling Design and Rationale

A summary of existing monitoring locations is listed in the worksheets below separated by site and aquifer accordingly.

4.1.1 Worksheet #17a1: Sites 2/12 GWTS Part I

Sampling Location	Activity	EPA Method	Comments/Rationale[4]	SOP Reference
TS-212-INF	GWTS monitoring[1]	8260-SIM	To measure influent COC concentrations and evaluate GWTS efficiency.	SOP #5
TS-212-GAC A			To measure COC concentrations downstream from the GAC vessel and evaluate GAC efficiency.	
TS-212-EFF			To measure COC concentrations downstream from the air stripper unit and evaluate air stripper efficiency.	
TS-212-INJ			To comply with discharge limits.	
EW-12-03-180U[6]	Groundwater Monitoring[2]	8260-SIM EPA Method 9056A SM 9056A	To measure changes in groundwater COC concentrations. To evaluate general inorganic constituents.	
EW-12-03-180M[5]				
EW-12-04-180U[6]				
EW-12-04-180M[6]				
EW-12-05-180M[3]				
EW-12-06-180M[3]				
EW-12-07-180M[3]				
EW-12-08-180U[3]				

Notes:

COC: chemical of concern	INF: influent
EFF: effluent	INJ: injection
EW: extraction well	TS: treatment system sampling port
GAC: granular activated carbon	SOP: standard operating procedure

[1] The sampling frequency is variable based on historical GAC breakthrough rates, as shown on Worksheet #17a2.

[2] Samples and water level measurements are collected quarterly or annually from the extraction wells based on the decision rules identified in Worksheet #10a.

[3] During the 3rd Quarter (Annual) sampling event, chloride is analyzed.

[4] The rationale for sampling locations and frequency is based on the RI Sites ROD and RI Sites ESD, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

[5] Pump removed from the inoperable extraction well, groundwater sampling conducted with PDBs as identified in Worksheet #17c.

[6] Well no longer sampled per decision rules (Worksheet #10a).

4.1.2 Worksheet #17a2: Sites 2/12 GWTS Part II

The *Final Operations and Maintenance Manual Volume II, Sites 2 and 12 Groundwater Remedy, Former Fort Ord, California* (Sites 2/12 GWTS O&M Manual; AES, 2009) provides procedures for O&M of the Sites 2/12 GWTS. The Sites 2/12 GWTS O&M Manual also describes the conditions required for GAC change-out in Section 4.2.3, but those instructions are superseded by Worksheet #17a2.

Sites 2/12 GWTS Sampling Frequencies[3]

Sample Point	**Weeks after GAC change-out[4]**								
	0	**12**	**21**	**30**	**36**	**42**	**44**	**46**	**48[4]**
TS-212-INF			xx		x	xx	x	xx	x
TS-212-GAC-A[1]	x[2]		x	x	x	x	x	x	x
TS-212-EFF						x	x	x	x
TS-212-INJ		x	x	x	x	x	x	x	x

Notes:

≥: greater than or equal to

%: percent

x: sample collected

xx: sample and duplicate collected

[1] Sample point immediately downstream of the GAC vessel.

[2] Sample collected no less than 2 hours after bringing a newly repacked GAC vessel online.

[3] The sampling frequency is determined based on historical COC breakthrough rates; however, the sampling frequency may be altered if there are significant operational changes.

[4] If GAC change-out is not indicated by Week 48, further sampling will be performed weekly, or at a frequency determined by the Project Manager, until GAC effluent PCE or TCE concentration is ≥ 90% of the discharge limit.

4.1.3 Worksheet #17b1: OU2 GWTS Part I

Sampling Location	Activity	Test Methods	Comments/Rationale[3]	SOP Reference
TS-OU2-INF-01*	GWTS Monitoring[1]	EPA Method 8260-SIM	To measure influent COC concentrations and evaluate GWTS efficiency.	SOP #5
TS-OU2-INF-02*				
TS-OU2-EFF-1A*			To measure COC concentrations downstream from a GAC vessel and evaluate GAC efficiency.	
TS-OU2-EFF-1B*				
TS-OU2-EFF-1C*				
TS-OU2-EFF-2A*				
TS-OU2-EFF-2B*				
TS-OU2-EFF-2C*				
TS-OU2-INJ-01*			To measure COC concentrations downstream from the GAC vessels. To comply with discharge limits (point of compliance).	
EW-OU2-01-A[5]	Groundwater Monitoring[2]	EPA Method 8260-SIM	To evaluate changes in groundwater COC concentrations.	SOP #5
EW-OU2-02-A				
EW-OU2-03-A[5]				
EW-OU2-04-A				
EW-OU2-05-A				
EW-OU2-06-A				
EW-OU2-07-A[5]				
EW-OU2-09-A				
EW-OU2-10-A				
EW-OU2-11-AR				
EW-OU2-12-A				
EW-OU2-13-A				
EW-OU2-14-A				
EW-OU2-16-A				
EW-OU2-17-A				
EW-OU2-18-A				
EW-OU2-19-A				
EW-OU2-20-A				
EW-OU2-01-180[4]				
EW-OU2-02-180R				
EW-OU2-03-180				
EW-OU2-04-180[5]				
EW-OU2-05-180				
EW-OU2-06-180				
EW-OU2-07-180[4]				
EW-OU2-08-180				
EW-OU2-09-180[6]				

Sampling Location	Activity	Test Methods	Comments/Rationale[3]	SOP Reference
EW-OU2-10-180	Groundwater Monitoring[2]	EPA Method 8260-SIM	To evaluate changes in groundwater COC concentrations.	
EW-OU2-11-180				
EW-OU2-12-180				

Notes:

COC: chemical of concern
EFF: effluent
EW: extraction well
GAC: granular activated carbon
INF: influent
INJ: injection
TS: treatment system sampling port

[1] The sampling frequency is variable based on historical GAC breakthrough rates, as shown in Worksheet #17b2.

[2] Groundwater samples and water level measurements are collected quarterly or annually from the extraction wells based on the decision rules identified in Worksheet #10a.

[3] The rationale for sampling locations and frequency is based on the OU2 ROD, OU2 ESD, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

[4] Pump removed from the inoperable extraction well, groundwater sampling conducted with PDBs as identified in Worksheet #17c5.

[5] Well no longer sampled per decision rules (Worksheet #10).

[6] Well operated to remediate the OUCTP Upper 180-Foot Aquifer as listed in Worksheet #17c4.

* The OU2 GWTP sampling locations were renamed as listed below.

New Name	Former Name
TS-OU2-INF-01	SP-IN-01
TS-OU2-INF-02	SP-IN-02
TS-OU2-EFF-1A	SP-1A-EF
TS-OU2-EFF-1B	SP-1B-EF
TS-OU2-EFF-1C	SP-1C-EF
TS-OU2-EFF-2A	SP-2A-EF
TS-OU2-EFF-2B	SP-2B-EF
TS-OU2-EFF-2C	SP-2C-EF
TS-OU2-INJ-01	SP-EF-01

4.1.4 Worksheet #17b2: OU2 GWTS Part II

The OU2 GWTP O&M Manual (JV, 2018) provides procedures for sampling of the OU2 GWTP and describes the conditions required for GAC change-out, but those instructions are superseded by Worksheet #17b2.

OU2 GWTS Sampling Frequencies[3,4]
Median GAC Cycle to be determined[5]

Sampling Point		**Weeks after GAC change-out[6]**												
		0	**1**	**2**	**3**	**4**	**5**	**9**	**13**	**16**	**19**	**22**	**24**	**26**
TS-OU2-INF-01	GAC change-out	x	x	xx	x	x	x	xx		x		xx		x
TS-OU2-INF-02		xx	x	x	x	xx	x			xx		x		xx
TS-OU2-EFF-1A[1]		x	x	x	x	x	x			x	x	x	x	x
TS-OU2-EFF-1B[1]		x								x		x		x
TS-OU2-EFF-1C[1]		x								x		x		x
TS-OU2-EFF-2A[1]		x	x	x	x	x	x			x	x	x	x	x
TS-OU2-EFF-2B[1]		x								x		x		x
TS-OU2-EFF-2C[1]		x								x		x		x
TS-OU2-INJ-01		x[2]	x	x	x	x	x	x	x	x	x	x	x	x

Notes:

TS-OU2-INF-01 (formerly SP-IN-01) = Eastern Main influent
TS-OU2-INF-02 (formerly SP-IN-02) = Western Main influent
TS-OU2-EFF-1A (formerly SP-1A-EF) = GAC 1A effluent
TS-OU2-EFF-1B (formerly SP-1B-EF) = GAC 1B effluent
TS-OU2-EFF-1C (formerly SP-1C-EF) = GAC 1C effluent
TS-OU2-EFF-2A (formerly SP-2A-EF) = GAC 2A effluent
TS-OU2-EFF-2B (formerly SP-2B-EF) = GAC 2B effluent
TS-OU2-EFF-2C (formerly SP-2C-EF) = GAC 2C effluent
TS-OU2-INJ-01 (formerly SP-EF-01) = discharge point of compliance
x: sample collected
xx: sample and duplicate collected

[1] Sample point to be immediately downstream of the lead GAC vessel.

[2] Sample collected no less than 2 hours after bringing a newly repacked GAC vessel on-line.

[3] The sampling frequency is determined based on historical COC breakthrough rates at the old OU2 GWTP; however, the sampling frequency may be altered at the discretion of the Project Manager if there are significant differences in operational conditions at the new OU2 GWTP.

[4] The sampling schedule assumes vessels GAC 1A and GAC 2A are in the lead position.

[5] The median GAC cycle for the new OU2 GWTP based on analytical results for process samples collected during the first year of operation.

[6] If GAC change-out is not indicated by Week 26, further sampling will be performed weekly or at a frequency determined by the direction of the Project Manager.

4.1.5 Worksheet #17c1: Sites 2/12 GWMP

Well Name	Cl	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
EW-12-03-180M		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-02-05-180	A	A	Q	HydraSleeve™, PDB/ SOP #3,2	RI Sites ROD/ESD
MW-02-13-180M	A	Q	Q	HydraSleeve™, PDB/ SOP #3,2	RI Sites ROD/ESD
EW-12-05-180M	A	Q	Q	Pump Spigot/SOP #5	RI Sites ROD/ESD
EW-12-06-180M	A	Q	Q	Pump Spigot/SOP #5	RI Sites ROD/ESD
EW-12-07-180M	A	Q	Q	Pump Spigot/SOP #5	RI Sites ROD/ESD
EW-12-08-180U	A	Q	Q	Pump Spigot/SOP #5	RI Sites RI/FS Addendum
MW-12-01-180		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-05-180	A		Q	HydraSleeve™/ SOP #3	RI Sites ROD/ESD
MW-12-09R-180		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-14-180M		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-15-180M		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-16-180M		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-18-180U		A	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-20-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-21-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-22-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-24-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-25-180U		A	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-26-180U		A	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-28-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-29-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-30-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-31-180M		A	Q	PDB/SOP #2	RI Sites ROD/ESD
MW-12-32-180U		Q	Q	PDB/SOP #2	RI Sites ROD/ESD
The Following Wells Are Measured for Groundwater Elevation Data Only:					
EW-12-03-180U			Q	SOP #5	Groundwater elevation trend analysis
EW-12-04-180M			Q	SOP #5	Groundwater elevation trend analysis

Well Name	Cl	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
EW-12-04-180U			Q	SOP #5	Groundwater elevation trend analysis
MW-02-06-180			Q	SOP #5	Groundwater elevation trend analysis
MW-02-10-180			Q	SOP #5	Groundwater elevation trend analysis
MW-02-13-180U			Q	SOP #5	Groundwater elevation trend analysis
MW-12-07-180			Q	SOP #5	Groundwater elevation trend analysis
MW-12-08-180			Q	SOP #5	Groundwater elevation trend analysis
MW-12-12-180L			Q	SOP #5	Groundwater elevation trend analysis
MW-12-17-180U			Q	SOP #5	Groundwater elevation trend analysis
MW-12-19-180U			Q	SOP #5	Groundwater elevation trend analysis
MW-12-19-180M			Q	SOP #5	Groundwater elevation trend analysis
MW-12-23-180U			Q	SOP #5	Groundwater elevation trend analysis
MW-12-27-180U			Q	SOP #5	Groundwater elevation trend analysis

Notes:

A: sampled on an annual basis
Cl: chloride
ESD: Explanation of Significant Differences
PDB: passive diffusion bag
Q: sampled on a quarterly basis
RI: Remedial Investigation
ROD: Record of Decision
SIM: selected ion monitoring
SOP: standard operating procedures
VOCs: volatile organic compounds

[1] The rationale for sampling locations and frequency is based on the applicable program RODs, ESDs, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

4.1.6 Worksheet #17c2: OU2 GWMP

Well Name	Cu, Pb, Sb (6010D)	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
EW-OU2-01-180		Q	Q	PDB/SOP #2	OU2 ESD
EW-OU2-02-180R[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-02-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-03-180		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-04-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-05-180		Q	Q	PDB/SOP #2	OU2 ROD
EW-OU2-05-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-06-180		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-06-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-08-180		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-09-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-10-180[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-10-A		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-11-180[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-11-AR[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-12-180[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-12-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-13-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-14-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-15-A		Q	Q	PDB/SOP #2	OU2 ESD
EW-OU2-16-A		Q	Q	Pump Spigot/SOP #5	OU2 ROD
EW-OU2-17-A[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-18-A[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-19-A[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
EW-OU2-20-A[2]		Q	Q	Pump Spigot/SOP #5	OU2 GWTP Relocation
MW-BW-02-180		Q	Q	PDB/SOP #2	OU2 ESD/OUCTP ROD
MW-BW-13-A		Q	Q	PDB/SOP #2	OU2 ROD

Well Name	**Cu, Pb, Sb (6010D)**	**VOCs (8260-SIM)**	**Water Levels**	**Sampling Methods/SOP**	**Rationale[1]**
MW-BW-14-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-BW-50-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-01-A	A	Q	Q	HydraSleeve™, PDB/ SOP #2, 3	OU2 ROD
MW-OU2-02-A	A	Q	Q	HydraSleeve™, PDB/ SOP #2, 3	OU2 ROD
MW-OU2-04-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-06-180R2		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-06-AR		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-07-180R		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-07-A		A	Q	PDB/SOP #2	OU2 ROD
MW-OU2-08-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-12-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-20-180		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-23-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-24-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-25-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-27-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-28-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-28-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-30-180		A	Q	PDB/SOP #2	OU2 ESD
MW-OU2-34-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-39-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-40-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-43-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-44-A		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-44-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-45-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-46-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-46-180		Q	Q	PDB/SOP #2	OU2 ESD

Well Name	Cu, Pb, Sb (6010D)	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MW-OU2-47-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-50-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-51-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-53-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-56-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-61-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-62-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-63-180		A	Q	PDB/SOP #2	OU2 ESD
MW-OU2-73-A	A	Q	Q	HydraSleeve™, PDB/ SOP #2, 3	OU2 ROD
MW-OU2-74-A	A	Q	Q	HydraSleeve™, PDB/ SOP #2, 3	OU2 ROD
MW-OU2-75-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-79-A		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-80-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-81-A		Q	Q	PDB/SOP #2	OU2 ROD
MW-OU2-81-180		Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-83-A		Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
The Following Wells Are Measured for Groundwater Elevation Data Only:					
EW-OU2-01-A			Q	SOP #5	Groundwater elevation trend analysis
EW-OU2-03-A			Q	SOP #5	Groundwater elevation trend analysis
EW-OU2-04-180			Q	SOP #5	Groundwater elevation trend analysis
EW-OU2-07-A			Q	SOP #5	Groundwater elevation trend analysis
MW-14-03-180			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-01-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-11-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-12-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-03-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-05-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-05-180			Q	SOP #5	Groundwater elevation trend analysis

Well Name	Cu, Pb, Sb (6010D)	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MW-OU2-09-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-09-180R			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-13-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-20-180X			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-21-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-23-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-29-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-29-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-30-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-31-180R			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-32-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-35-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-36-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-49-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-52-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-54-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-55-180			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-57-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-58-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-76-A			Q	SOP #5	Groundwater elevation trend analysis
MW-OU2-77-A			Q	SOP #5	Groundwater elevation trend analysis
PZ-OU2-06-180			Q	SOP #5	Groundwater elevation trend analysis

Notes:

A: sampled on an annual basis
Cu: copper
ESD: Explanation of Significant Differences
PB: lead
PDB: passive diffusion bag
Q: sampled on a quarterly basis
ROD: Record of Decision
Sb: antimony
SIM: selected ion monitoring
SOP: standard operating procedures
VOCs: volatile organic compounds

[1] The rationale for sampling locations and frequency is based on the applicable program RODs, ESDs, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

[2] New wells installed in 2016 to be operated and sampled once the new OU2 GWTP is online in 2018.

4.1.7 Worksheet #17c3: OUCTP A-Aquifer GWMP

Well Name	DO ORP	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
EISB-EW-01		Q	Q	PDB/SOP #2	OUCTP ROD
EISB-EW-02		A	Q	PDB/SOP #2	OUCTP ROD
EISB-EW-09		Q	Q	PDB/SOP #2	OUCTP ROD
EISB-EW-12	Q		Q	PTM/SOP #6/7	OUCTP ROD
EISB-EW-15	Q		Q	PTM/SOP #6/7	OUCTP ROD
EISB-MW-01		A	Q	PDB/SOP #2	OUCTP ROD
EW-BW-109-A		Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-112-A	Q	A	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-119-A	Q	A	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-124-A	Q	Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-132-A		A	Q	PDB/SOP #2	OUCTP ROD
EW-BW-135-A	Q	Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-144-A	Q		Q	PTM/SOP #6/7	OUCTP ROD
EW-BW-149-A	Q	Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-150-A	Q	A	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-155-A	Q	Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
EW-BW-159-A	Q		Q	PTM/SOP #6/7	OUCTP ROD
EW-BW-160-A	Q	Q	Q	PDB/SOP #2	OUCTP ROD
EW-BW-161-A	Q		Q	SOP #5	OUCTP ROD
EW-BW-164-A	Q		Q	SOP #5	OUCTP ROD
EW-BW-165-A		A	Q	PDB/SOP #2	OUCTP ROD
EW-BW-166-A	Q	Q	Q	PDB/SOP #2	OUCTP ROD
EW-BW-167-A		A	Q	PDB/SOP #2	OUCTP ROD
EW-BW-168-A		A	Q	PDB/SOP #2	OUCTP ROD
EW-BW-169-A		A	Q	PDB/SOP #2	OUCTP ROD
MP-BW-46-095		A	Q	Westbay Port/SOP #1	OUCTP ROD
MW-B-12-A		Q	Q	PDB/SOP #2	OUCTP ROD

Well Name	DO ORP	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MW-B-14-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-15-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-17-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-24-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-26-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-27-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-28-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-30-A		A	Q	SOP #5	Groundwater elevation trend analysis
MW-BW-31-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-32-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-35-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-36-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-39-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-42-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-43-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-44-A		A	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
MW-BW-48-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-49-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-56-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-58-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-60-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-65-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-66-A		Q	Q	PTM/SOP #6/7; PDB/SOP #2	OUCTP ROD
MW-BW-74-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-75-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-77-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-78-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-79-A		Q	Q	PDB/SOP #2	OUCTP ROD

Well Name	DO ORP	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MW-BW-80-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-83-A		A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-85-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-86-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-87-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-88-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-89-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-90-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-91-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-92-A		Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-93-A		Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
MW-BW-94-AR		Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
MW-BW-95-A		Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
The Following Wells Are Measured for Groundwater Elevation Data Only:					
EISB-EW-03			Q	SOP #5	Groundwater elevation trend analysis
EISB-MW-04			Q	SOP #5	Groundwater elevation trend analysis
EW-BW-92-A			Q	SOP #5	Groundwater elevation trend analysis
EW-BW-93-A			Q	SOP #5	Groundwater elevation trend analysis
EW-BW-100-A			Q	SOP #5	Groundwater elevation trend analysis
EW-BW-104-A			Q	SOP #5	Groundwater elevation trend analysis
EW-BW-126-A			Q	SOP #5	Groundwater elevation trend analysis
MP-BW-46-080			Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-48-113			Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-48-133			Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MW-40-01-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-16-A			Q	SOP #5	OUCTP ROD
MW-BW-18-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-25-A			Q	SOP #5	Groundwater elevation trend analysis

Well Name	DO ORP	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MW-BW-34-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-38-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-41-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-45-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-46-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-51-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-53-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-54-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-57-A			Q	SOP #5	OUCTP ROD
MW-BW-59-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-63-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-67-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-71-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-81-A			Q	SOP #5	Groundwater elevation trend analysis
MW-BW-82-A			Q	SOP #5	Groundwater elevation trend analysis

Notes:

A: sampled on an annual basis
DO: dissolved oxygen
ORP: oxidation-reduction potential
PDB: passive diffusion bag
PTM: post-treatment monitoring
Q: sampled on a quarterly basis
ROD: Record of Decision
SIM: selected ion monitoring
SOP: standard operating procedures

[1] The rationale for sampling locations and frequency is based on the applicable program RODs, ESDs, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

4.1.8 Worksheet #17c4: OUCTP Upper 180-Foot Aquifer GWMP

Well Name	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
EW-OU2-09-180	Q	Q	Pump Spigot/SOP #5	OUCTP ROD
MP-BW-41-231	A	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-46-170	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MW-BW-52-180	Q	Q	PDB/SOP #2	OUCTP ROD
MW-BW-57-180	Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
MW-BW-58-180	Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
MW-OU2-64-180	Q	Q	PDB/SOP #2	OUCTP ROD
MW-OU2-67-180	Q	Q	PDB/SOP #2	OUCTP ROD
MW-OU2-70-180	A	Q	PDB/SOP #2	OUCTP ROD
The Following Wells Are Measured for Groundwater Elevation Data Only:				
MP-BW-30-282		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-287		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-33-272		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-242		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-37-178		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-37-193		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-41-202		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-41-256		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-195		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-215		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-235		Q	Westbay Port/SOP #1	Groundwater elevation trend analysis
MP-BW-46-185		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-46-200		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-46-215		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MW-B-05-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-21-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-26-180		Q	SOP #5	Groundwater elevation trend analysis

Well Name	**VOCs (8260-SIM)**	**Water Levels**	**Sampling Methods/SOP**	**Rationale[1]**
MW-BW-43-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-44-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-45-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-47-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-49-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-50-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-51-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-53-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-54-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-55-180		Q	SOP #5	Groundwater elevation trend analysis
MW-BW-56-180		Q	SOP #5	Groundwater elevation trend analysis

Notes:

A: sampled on an annual basis
PDB: passive diffusion bag
PTM: post-treatment monitoring
Q: sampled on a quarterly basis
ROD: Record of Decision
SIM: selected ion monitoring
SOP: standard operating procedures

[1] The rationale for sampling locations and frequency is based on the applicable program RODs, ESDs, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

4.1.9 Worksheet #17c5: OUCTP Lower 180-Foot Aquifer GWMP

Well Name	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
Airfield	Q	Q	PDB/SOP #2	OUCTP ROD
EW-OU2-07-180	Q	Q	PDB/SOP #2	OUCTP ROD
FO-29	Q		Sampling Port/SOP #4	OUCTP ROD
FO-30	Q		Sampling Port/SOP #4	OUCTP ROD
FO-31	Q		Sampling Port/SOP #4	OUCTP ROD
Mini-storage	A		Sampling Port/SOP #4	OUCTP ROD
MP-BW-31-292	A	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-41-318	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-41-353	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-42-345	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-49-287	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-49-316	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-49-368	Q	Q	Westbay Port/SOP #1	OUCTP ROD
MP-BW-49-400	Q	Q	Westbay Port /SOP #1	OUCTP ROD
MP-BW-50-339	Q	Q	Westbay Port /SOP #1	OUCTP ROD
MP-BW-50-384	Q	Q	Westbay Port /SOP #1	OUCTP ROD
MP-BW-51-405	Q	Q	Westbay Port /SOP #1	OUCTP ROD
MW-BW-04-180	A	Q	PDB/SOP #2	OUCTP ROD
MW-BW-59-180	Q	Q	PDB/SOP #2	Well Install Completion Report (Ahtna, 2019f)
MW-OU2-66-180	Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-69-180	Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-72-180	Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-78-180	Q	Q	PDB/SOP #2	OU2 ESD
MW-OU2-82-180	Q	Q	PDB/SOP #2	OU2 ESD
The Following Wells Are Measured for Groundwater Elevation Data Only:				
MCWD-08A		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-30-317		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis

Well Name	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MP-BW-30-342		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-30-397		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-30-467		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-30-537		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-31-332		Q	Westbay Port/SOP #1	Groundwater elevation trend analysis
MP-BW-31-362		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-31-407		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-31-457		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-31-522		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-332		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-366		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-412		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-472		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-32-522		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-33-317		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-33-352		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-33-397		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-34-292		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-34-357		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-34-422		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-34-492		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-34-537		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-312		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-366		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-402		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-467		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-527		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-35-562		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis

Well Name	VOCs (8260-SIM)	Water Levels	Sampling Methods/SOP	Rationale[1]
MP-BW-37-328		Q	Westbay Port/SOP #1	Groundwater elevation trend analysis
MP-BW-37-303		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-37-368		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-37-398		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-37-460		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-38-327		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-38-341		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-38-353		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-38-368		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-38-418		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-39-310		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-39-330		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-39-350		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-39-395		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-40-333		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-40-353		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-40-375		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-40-400		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-41-286		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-41-396		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-295		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-314		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-42-400		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-49-336		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-50-289		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-50-309		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-50-359		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-51-315		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis

Well Name	**VOCs (8260-SIM)**	**Water Levels**	**Sampling Methods/SOP**	**Rationale[1]**
MP-BW-51-340		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-51-370		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-52-323		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-52-338		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-52-363		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-52-388		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MP-BW-52-408		Q	Westbay Port /SOP #1	Groundwater elevation trend analysis
MW-BW-03-400		Q	SOP #7	Groundwater elevation trend analysis
MW-OU2-07-400		Q	SOP #7	Groundwater elevation trend analysis
MW-OU2-28-400		Q	SOP #7	Groundwater elevation trend analysis
MW-OU2-68-180		Q	SOP #7	Groundwater elevation trend analysis
MW-OU2-71-180		Q	SOP #7	Groundwater elevation trend analysis
Test 2		Q	SOP #7	Groundwater elevation trend analysis

Notes:

A: sampled on an annual basis
PDB: passive diffusion bag
PTM: post-treatment monitoring
Q: sampled on a quarterly basis
ROD: Record of Decision
SIM: selected ion monitoring
SOP: standard operating procedures

[1] The rationale for sampling locations and frequency is based on the applicable program RODs, ESDs, program history and precedent established by the BCT, which includes the Army, USACE, EPA, DTSC, and CCRWQCB.

4.2 Worksheet #18: Sampling Locations and Methods

This Worksheet was not used. Information that would be included in this worksheet is incorporated into Worksheets #17a through #17c.

5.0 Sampling Requirements

5.1 Worksheets #19 and #30: Sample Container, Preservation, and Hold Times

Laboratory: SGS

Florida:
4405 Vineland Rd, Suite C-15
Orlando, FL 32811

Telephone: 407-425-6700
Point of Contact: Svetlana Izosimova
E-mail: Svetlana.Izosimova@sgs.com

Sample Delivery Method: Courier to San Jose, CA distribution center or FedEx overnight shipment to Florida

Matrix	Analytical Group	Preparation/Analytical Method	Sample Volume	Containers	Preservation	Holding Time[1]	SGS Laboratory
Water	VOCs	EPA 5030/8260-SIM	120 mL	Three 40-mL Teflon-lined® VOA Vials	HCl to pH < 2 Sample temp > 0°C ≤ 6°C	14 days	Florida
	Dissolved Metals	EPA 3010A/6010D	500 mL	Two 250-mL HDPE bottles	HNO_3 to pH < 2 after field filtering Sample temp > 0°C ≤ 6°C	6 months	
	Chloride	EPA 9056A	100 mL	One 100-mL HDPE bottle	Sample temp > 0°C ≤ 6°C	28 days	

Notes:
°C: degrees Celsius
HCl: hydrochloric acid
HDPE: high-density polyethylene
HNO_3: nitric acid
mL: milliliter
VOA: volatile organic analysis
VOCs: volatile organic compounds
[1] Data package TAT is 15 business days

5.2 Worksheet #20: Field Quality Control Summary

Matrix	Analytical Group (Method)	Frequency of Field Duplicate Samples	Frequency of Trip Blanks	Frequency of Field Blanks	Frequency of Equip Blanks	Frequency of MS/MSD
Water	VOCs (8260-SIM)	10% of field samples collected	1 set per cooler /day	1 per sampling day	1 per sampling event (Westbay sampling only[1])	5% of field samples collected
	Metals (6010D)	10% of field samples collected	N/A	N/A	N/A	5% of field samples collected
	Cl (9056A)	10% of field samples collected	N/A	N/A	N/A	5% of field samples collected

Notes:

Cl: chloride

MS/MSD: matrix spike/matrix spike duplicate

N/A: not applicable

VOCs: volatile organic compounds

[1] Sampling at Westbay wells requires reuse and decontamination of sampling equipment. Sampling with PDBs, HydraSleeves and from sampling ports is performed with non-reusable sampling equipment, and no decontamination of field equipment is required. Westbay sample locations are identified as “Westbay Port” in the “Sampling Method” column of Worksheet #17c.

5.3 Worksheet #21: Field SOPs/Methods

SOP Reference Number	Title	Organization	Revision Date	Equipment Type	Modified for Project Work?	Comments
SOP #1	Westbay MOSDAX Sampler Probe – Model 2531 Operations Manual	Schlumberger	Oct. 20, 2006	Westbay Multi-port Wells	No	
SOP #2	PDB Sampling Protocol	Wood/U.S. Geological Survey (USGS)	2001	PDBs	Yes	Project-specific procedures are appended to USGS User's Guide
SOP #3	HydraSleeve Field Manual	GeoInsight	2006	HydraSleeve	No	
SOP #4	Supply and Irrigation Well Sampling Protocol	Wood/Ahtna	2016	Sampling Ports	Yes	GWMP project-specific procedures
SOP #5	OU2 and Sites 2/12 GWTSs and OUCTP EISB Extraction Well Sample Handling and Custody Requirements	Ahtna	2016	Sampling Ports	Yes	GWTS project-specific procedures
SOP #6	Low Flow Groundwater Quality Parameter Collection	Ahtna	2016	Horiba Multi-Meter and Low Flow Pump	Yes	OUCTP GWMP project-specific procedures
SOP #7	Downhole Meter Groundwater Quality Parameter Collection	Ahtna	2016	YSI Sonde Downhole Meter	Yes	OUCTP GWMP project-specific procedures

Note: SOPs are provided in Attachment A.

5.4 Worksheet #22: Field Equipment Calibration, Maintenance, Testing, and Inspection

Field Equipment	Calibration Activity	Maintenance Activity	Testing Activity	Inspection Activity	Frequency	Acceptance Criteria	Corrective Action	Responsible Person	SOP Reference
Electric Water Level Sounder	Calibrated against steel tape	Maintain in proper working order, store in a secure location, decon after each use	Check battery and sensitivity daily prior to use	Inspect tape for damage prior to use	Quarterly prior to use	Calibrates with steel tape to within 0.05 ft/100 feet depth to water	Send into factory for repair	Field Supervisor	SOPs #2 & #5
YSI Sonde Downhole Meter	Calibrated with solutions	Decon after each use, store according to manufacturer directions	Check battery prior to use	Inspect for damage prior to use	Quarterly prior to use	According to manufacturer instructions	Check manual or send into factory for repair	Field Supervisor	SOP #7
Digital Thermometer	Factory calibrated, ice-point method per HACCP-based SOP	Store in a secure location, avoid excessive heat	Check battery prior to use	Inspect for damage prior to use	Annually	Factory calibration, temperature reading = 0°C ± 1°C	Replace with new unit	Field Supervisor	SOPs #2 & #5

Notes:

°C: degrees Celsius
HACCP: Hazard Analysis & Critical Control Points (Title 9 Code of Federal Regulations Part 417)
N/A: not applicable
SOP: standard operating procedures

6.0 Analytical Requirements

6.1 Worksheet #23: Analytical SOPs

The SOPs referenced below are the laboratory-specific procedures for the tests for which the laboratory is certified under DoD Environmental Laboratory Accreditation Program (ELAP). Laboratories with the DoD ELAP certificate undergo annual audits by the independent accrediting bodies responsible for the DoD ELAP certification. Copies certifications including the specifically referenced methods are included in Attachment F.

Data will be evaluated based on the guidance provided in the DoD QSM Version 5.1, the published methods, and the laboratory Quality Assurance Manual.

SOP Reference Number	Title	Organization	Revision Date	Equipment Type	Modified for Project Work?	Comments
SGS SOP# MS010.7	Analysis of Volatile Organics by GC/MS Select Ion Monitoring (SIM) (VOCs by 8260 SIM)	SGS	Aug 30, 2017	Analytical Instruments	No	
SGS SOP# MET108.03	Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP) (Metals by 6010D)	SGS	Feb 22, 2018	Analytical Instruments	No	
SGS SOP# GN228.9	Determination of Inorganic Anions by Ion Chromatography (Chloride by 9056A)	SGS	April 4, 2018	Analytical Instruments	No	
SGS SOP# SAM101.19	Sample Receipt and Storage	SGS	Oct 29, 2018	None	No	
SGS SOP# SAM108.10	Sample and Laboratory Waste Disposal	SGS	Jan 21, 2016	None	No	

6.2 Worksheet #24: Analytical Instrument Calibration

Instrument/ Analysis	Calibration Requirements	Frequency of Calibration	Acceptance Criteria	Corrective Action	Responsible Person
GC/MS – VOCs by EPA Method 8260-SIM	Check of instrument tuning using BFB	Prior to ICAL and every 12 hours	Refer to method for specific ion criteria	Re-tune instrument Re-analyze affected	GC/MS Analyst
	Multipoint calibration (minimum of five points), lowest point at or below LOQ	Initially and as required	Minimum RF per method. Each analyte must meet one of the three options below: Option 1: RSD for each analyte ≤ 15% Option 2: linear least squares regression $r^2 \geq 0.99$ Option 3: non-linear regression – coefficient of determination (COD) $r^2 \geq 0.99$ (six points shall be used for second order, seven for third order)	Correct problem, then repeat ICAL	GC/MS Analyst
	Second Source - ICV Standard	Once after each ICAL	Analytes within ± 20% of true value	Correct problem and verify second source standard. Re-run second source verification. If that fails, correct the problem and repeat ICAL.	GC/MS Analyst
	Instrument blanks and method blanks	After initial calibration and daily, prior to sample analysis (instrument blank) and with each	No analytes detected > ½ LOQ or > ⅒ the amount measured in any sample or ⅒ the regulatory limit, whichever is greater.	Re-analyze blank Clean system Re-analyze affected samples	GC/MS Analyst

Instrument/ Analysis	Calibration Requirements	Frequency of Calibration	Acceptance Criteria	Corrective Action	Responsible Person
		batch of samples (method blank)	Common contaminants must not be detected > LOQ.		
GC/MS – VOCs by EPA Method 8260-SIM (continued)	Continuing calibration verification (CCV) standard	Daily before sample analysis and every 12 hours of analysis time, and at the end of the analytical run	RF criteria per method. All reported analytes and surrogates within ± 20% of true value All reported analytes and surrogates within ± 50% for end of analytical batch CCV	Correct problem, then re-run the CCV. If that fails, repeat ICAL. Re-analyze samples run since last successful CCV.	GC/MS Analyst
ICP Metals by EPA Method 6010D	ICAL: Single or multipoint calibration. Minimum one high standard and a calibration blank	Daily ICAL prior to sample analysis	If more than one calibration standard is used, $r^2 \geq 0.99$	Correct problem, then repeat ICAL	ICP Analyst
	Second Source (ICV) Standard	Once after each ICAL, prior to sample analysis	Value of second standard source for target analytes within ± 10% of true value	Correct the problem and verify second source standard. Re-run ICV. If that fails, correct problem and repeat ICAL.	ICP Analyst
	CCV	After analysis of every 10 samples and at the end of the analytical sequence	Within ± 10% of true value	Correct problem, then re-run the CCV. If that fails, repeat ICAL. Re-analyze samples run since last successful CCV.	ICP Analyst
	Low-level calibration check standard (LOQ low point standard from calibration)	Daily, following one point ICAL	Within ± 20% of true value	Correct problem, then re-analyze.	ICP Analyst

Instrument/ Analysis	Calibration Requirements	Frequency of Calibration	Acceptance Criteria	Corrective Action	Responsible Person
	ICS (Interference check sample)	After ICAL and prior to sample analysis	ICS-A: Absolute value of concentration for all non-spiked project analytes < ½ LOQ (unless they are a verified trace impurity from one of the spiked analytes)	Terminate analysis. Locate and correct problem. Re-analyze ICS and samples.	ICP Analyst
ICP Metals by EPA Method 6010D (continued)	Calibration blanks	Immediately after the ICV and Immediately after every CCV.	The absolute values of all analytes must be < ½ LOQ or < ⅒ the amount measured in any sample.	Calibration blanks: Correct the problem. Re-prep and re-analyze calibration blank. Samples following the last acceptable calibration blank must be re-analyzed.	ICP Analyst
Ion Chromatography – Chloride by EPA Method 9056A	Initial Calibration (minimum three standards and one calibration blank)	ICAL prior to sample analysis	$r^2 \geq 0.99$	Correct problem, then repeat ICAL.	IC Analyst
	ICV	After each ICAL and prior to sample analysis	Analytes within ± 10% of true values and retention times within appropriate windows	Correct problem and verify second source standard. Re-run ICV. If that fails, correct the problem and repeat ICAL.	IC Analyst
	Retention time window position establishment	Once per multipoint calibration	Retention time width is set using the midpoint standard of the ICAL for each analyte when ICAL is performed. On days when ICAL is not performed, the initial CCV is used	If the retention time shifts by more than 10%, a new ICAL is performed.	IC Analyst

Instrument/ Analysis	Calibration Requirements	Frequency of Calibration	Acceptance Criteria	Corrective Action	Responsible Person
Ion Chromatography – Chloride by EPA Method 9056A (continued)	CCV	After ICAL, after every ten samples, and at end of run	Analytes within established retention time windows and within ± 10% of true value	Correct problem, then re-run the CCV. If that fails, repeat ICAL. Re-analyze samples run since last successful CCV.	Wet Chemistry Analyst

Notes:

%D: percent difference / percent drift
BFB: 4-bromofluorobenzene
CCC: continuing calibration check compounds
CCV: continuing calibration verification
COD: coefficient of determination
GC/MS: gas chromatography / mass spectrometry
ICAL: initial calibration
ICP: inductively coupled plasma atomic emission spectroscopy
ICS: interference check sample
ICS-A: interference check standard A
ICS-AB: interference check standard AB
ICV: initial calibration verification
LOD: limit of detection
LOQ: limit of quantitation
N/A: not applicable
RF: response factor
RSD: relative standard deviation
SIM: selected ion monitoring
VOCs: volatile organic compounds

[1] Normal balance and thermometer calibration applies (Worksheet #25).

6.3 Worksheet #25: Analytical Instrument and Equipment Maintenance, Testing and Inspection

Analytical instruments used for this project will be maintained in accordance with the requirements presented in the SGS QA Manual and the individual analytical method SOPs. The SGS QA Manual also presents the documentation requirements for maintenance activities.

Instrument/Equipment	Maintenance/Inspection Activity	Frequency	Person Responsible for Corrective Action
GC/MS	Inspect/replace column Clean ion source Inspect, clean concentrator trap Change electron multiplier Backflush purge and trap Change rough oil pump	As required. Refer to Analytical Method and instrument manufacturer.	GC/MS Analyst
ICP	Inspect/replace tubing and pump Inspect/replace windings Inspect/replace torch and injector	As required. Refer to Analytical Method and instrument manufacturer.	ICP Analyst
IC	Inspect/perform column cleanup	As required. Refer to Analytical Method and instrument manufacturer.	IC Analyst

Notes:

GC/MS: gas chromatography/mass spectrometry
IC: ion chromatography
ICP: inductively coupled plasma

6.4 Worksheets #26 and #27: Sample Handling, Custody, and Disposal

Groundwater samples will be collected in laboratory-provided bottles using methods described in Worksheets #17a through #17c and #19, and SOPs #1 through #5. Samples will be received and logged into the laboratory information management system for analysis as described in the DoD QSM Version 5.1. Chain of custody procedures will be performed in accordance with Worksheet #29.

Sample organization: Ahtna/ Wood

Laboratory: SGS

Method of sample delivery (shipper/carrier): SGS courier or FedEx overnight shipping

Number of days from reporting until sample disposal: No less than 30 days after final report sent to the client

Activity	**Organization and Title or Position of Person Responsible for the Activity**	**SOP Reference**
Sample Labeling	Ahtna/ Wood Field Technicians	SOP #5
Chain of custody form completion	Ahtna/ Wood Field Technicians	SOP #5
Packaging	Ahtna/ Wood Field Technicians	SOP #5
Shipping coordination	Ahtna/ Wood Field Technicians	SOP #5
Sample receipt, inspection, & log-in	SGS Sample Management Supervisor	SOP #SAM101.19
Sample custody and storage	SGS Sample Management Supervisor	SOP #SAM101.19
Sample disposal	SGS Sample Management Supervisor	SOP #SAM108.10

Notes:
N/A: not applicable
O&M: operation and maintenance

6.5 Worksheet #28: Analytical Quality Control and Corrective Action

6.5.1 Worksheet #28a: VOCs

Matrix: Groundwater (µg/L)

Analytical Group/Test Method: VOCs by EPA Method 8260-SIM

QC Sample	Frequency	Acceptance Limits	Source of Acceptance Limits	Corrective Action	Responsible Person	Data Quality Indicator
Method Blank	1 per analytical batch	No analytes detected > ½ LOQ or > ⅒ the amount measured in any sample or ⅒ the regulatory limit, whichever is greater. Common contaminants must not be detected > LOQ.	DoD QSM 5.1 App B Table 4	Re-analyze method blank. If fails, clean system and re-analyze blank and affected samples.	GC/MS Analyst	Accuracy/ Bias Contamination
Laboratory Control Sample (LCS)/ LCSD	1 set per analytical batch. Spike target compounds. VC to be spiked at DL of 0.1 µg/L.	<u>Analyte</u> <u>Recovery</u> <u>RPD</u> 1,1-DCA 81-122% ≤ 15% 1,1-DCE 78-137% ≤ 18% 1,2-DCA 75-125% ≤ 14% 1,2-DCE (total) 76-127% ≤ 17% 1,2-DCPA 76-124% ≤ 14% 1,3-DCPE (total) 75-120% ≤ 23% Benzene 81-122% ≤ 14% CT 76-136% ≤ 23% Chloroform 80-124% ≤ 15% cis-1,2-DCE 78-120% ≤ 15% MC 69-135% ≤ 16% PCE 76-135% ≤ 16% TCE 81-126% ≤ 15% VC 69-159% ≤ 18%	Lab-derived	Re-prep and re-analyze LCS/LCSD and associated batch samples	GC/MS Analyst	Bias Accuracy/ Precision

QC Sample	Frequency	Acceptance Limits	Source of Acceptance Limits	Corrective Action	Responsible Person	Data Quality Indicator
MS/MSD	1 per analytical batch spike target compounds. VC to be spiked at DL of 0.1 µg/L.	Same as LS/LCSD acceptance limits for 8260-SIM.	Lab-derived	If MS results are outside the LCS limits, the data shall be evaluated to determine the source of difference and to determine if there is a matrix effect or analytical error. If the concentration in parent sample is > 4x the spiked amount, include in case narrative. No CA required.	GC/MS Analyst	Bias/Precision
Surrogates	Field samples and laboratory QC	1,2-Dichloroethane-$_{d4}$ 74-125% Toluene-$_{d8}$ 88-111%	Lab-derived	Re-prep and re-analyze affected samples unless matrix interference is present.	GC/MS Analyst	Bias
Internal Standards	Field samples, standards, and laboratory QC	Retention time ±10 seconds from retention time of the midpoint standard in the ICAL; extracted ion current profile area within -50% to +100% of ICAL midpoint standard. On days when ICAL is not performed, the daily initial CCV can be used.	DoD QSM 5.1 App B Table 4	Inspect mass spectrometer and GC for malfunction. Re-analysis of samples analyzed while system was malfunctioning is mandatory.	GC/MS Analyst	Bias/Precision

Notes on next page.

Notes:
%: percent
µg/L: micrograms per liter
cis-1,2-DCE: cis-1,2-dichloroethene
CT: carbon tetrachloride
1,1-DCA: 1,1-dichloroethane
1,1-DCE: 1,1-dichloroethene
1,2-DCA: 1,2-dichloroethane
1,2-DCE (total): total 1,2-dichloroethene
1,2-DCPA: 1,2-dichloropropane
1,3-DCPE (total): total 1,3-dichloropropene
DL: detection limit
DoD: Department of Defense
GC/MS: gas chromatography/mass spectrometry
ICAL: initial calibration
LCS: laboratory control sample
LCSD: laboratory control sample duplicate
LOQ: limit of quantitation
MC: methylene chloride
MS: matrix spike
MSD: matrix spike duplicate
N/A: not applicable
PCE: tetrachloroethene
QC: quality control
QSM: Quality Systems Manual
RPD: relative percent difference
TCE: trichloroethene
VC: vinyl chloride

6.5.2 Worksheet #28b: Metals

Matrix: Groundwater (µg/L)

Analytical Group/Test Method: Metals by EPA Method 6010D

QC Sample	Frequency	Acceptance Limits	Source of Acceptance Limits	Corrective Action	Responsible Person	Data Quality Indicator
Method Blank	1 per analytical batch	Absolute values of analytes detected < ½ LOQ or < ⅒ the amount measured in any sample or ⅒ the regulatory limit, whichever is greater.	DoD QSM 5.1 App B Table 8	Correct problem. Re-prep and re-analyze method blank and affected samples.	ICP Analyst	Accuracy/Bias Contamination
Laboratory Control Sample (LCS)	1 per analytical batch. Spike target compounds.	Analyte Recovery Antimony 80-120% Copper 80-120% Lead 80-120%	DoD QSM 5.1 App B Table 8 and App C Table 4	Re-prep and re-analyze LCS and associated batch samples	ICP Analyst	Bias Accuracy/ Precision
Laboratory Duplicate Sample	1 per analytical batch	≤ 20%	DoD QSM 5.1 App B Table 8	Narrate outliers in case narrative. No CA	ICP Analyst	Precision
MS/MSD	1 per analytical batch	Analyte Recovery RPD Antimony 80-120% ≤20% Copper 80-120% ≤20% Lead 80-120% ≤20%	DoD QSM 5.1 App C Table 4	Perform additional QC test (dilution test and/or post-digestion spike [PDS]) unless concentrations in parent sample are > 4x the spiked amount (no corrective action required). Perform PDS.	ICP Analyst	Bias/Precision
Dilution Test	1 per prep batch	5-fold dilution must agree within ± 10% of the original measurement	DoD QSM 5.1 App B Table 8	Perform post-digestion spike	ICP Analyst	Bias/Precision

QC Sample	Frequency	Acceptance Limits	Source of Acceptance Limits	Corrective Action	Responsible Person	Data Quality Indicator
Post-Digestion Spike (PDS)	Perform if MS/MSD fails, 1 per analytical batch	Recovery within 80-120%	DoD QSM 5.1 App B Table 8	Run associated samples by method of standard addition or flag data	ICP Analyst	Bias/Precision

Notes:

µg/L: micrograms per liter
ICP: inductively coupled plasma
LOQ: limit of quantitation
PDS: post-digestion spike
RPD: relative percent difference

6.5.3 Worksheet #28c: Wet Chemistry

Matrix: Groundwater (mg/L)

Analytical Group/Test Method: Chloride by EPA Method 9056A

QC Sample	Frequency	Acceptance Limits	Source of Acceptance Limits	Corrective Action	Person Responsible for Corrective Action	Data Quality Indicator
Method Blank	1 per analytical batch	No analytes detected > ½ the LOQ or > ⅒ the amount measured in any sample or ⅒ the regulatory limit	Laboratory limits	Correct problem. Re-prep and re-analyze method blank and affected samples.	Wet Chemistry Analyst	Accuracy/Bias Contamination
Laboratory Control Sample (LCS)	1 per analytical batch.	EPA 9056A: 90-110%	Laboratory performance-based limits	Re-prep and re-analyze LCS and associated batch samples.	Wet Chemistry Analyst	Bias Accuracy/ Precision
MS/MSD	1 set per analytical batch.	90-110% and RPD ±20%	Lab performance-based limit	Re-prep and re-analyze MS/MSD samples and report both sets of data. If concentration in parent sample is > 4x the spiked amount, include in case narrative. No CA required.	Wet Chemistry Analyst	Bias/Precision

Notes:

%: percent

LCS: laboratory control sample

mg/L: milligrams per liter

MS/MSD: matrix spike/ matrix spike duplicate

N/A: not applicable

RPD: relative percent difference

7.0 Data Management and Data Review

7.1 Worksheet #29: Project Documentation and Records

Project data and information will be documented, tracked, and managed in a manner to ensure data integrity, defensibility, and retrievability. Project records will be generated from various aspects of the project, including 1) Sample Collection and Field Measurement Records, 2) Analytical Records, and 3) Data Assessment Records. Project data and information are stored in the Fort Ord Administrative Record located at Building 4463, Room 101, Gigling Road, Seaside, California. The Administrative Record is managed by the Army and will be maintained until site closure, at which time disposition of site records will be determined by the Army.

7.1.1 Sample Collection and Field Measurement Records

At a minimum, the following documentation will be used for sample collection and field measurement activities. Examples of field forms are presented in Attachment C.

- Field Activity Daily Logbook – A bound, Field Activity Daily Logbook (FADL), with sequentially numbered pages will be used for field documentation of key sampling and analytical activities associated with the Sites 2/12 and OU2 GWTS and the Sites 2/12, OU2, and OUCTP GWMP. The FADL will contain information to include:
    - Name and company of sampling technician
    - Date, time, and location of sample collection
    - Site observations and remarks related to sampling activities
    - Field equipment calibration documentation
- Groundwater Level Field Data Sheets – are used to record depth to groundwater measurements, and include the following information:
    - Sampling station name, date, and time of measurement
    - Depth to water (DTW) sounder serial number and documented calibration differential from steel tape
    - Samplers initials
    - Measured depth to water
    - Historical average DTW and total depth of well which are used to verify the measured reading in the field
- Groundwater Sampling Forms – are used to record collection of groundwater samples. Groundwater samples from the Sites 2/12, OU2 and OUCTP GWMP are collected via PDBs, Westbay multi-port wells, and sampling ports, while samples from the Sites 2/12 and OU2 GWTS are primarily collected via sampling ports. Each of these sampling systems has a designated groundwater sampling form, specific to the data needed for each sampling method; however, each groundwater sampling form will contain the same essential information:

  - Name of sampling technician
  - Date and time of sample collection
  - Depth to water (where applicable)
  - Depth of sample collection (or port number, or bag number)
  - Method of sample collection
  - Volume of sample collected
  - Preservation of samples (if any)
  - Analysis requested
  - QC samples collected at the sampling station

- Sample Labels – Sample labels will be affixed to each sample container upon collection and prior to transfer to the laboratory. Each sample will be assigned a unique sample identification number. The sample label will include the following information:
  - Project name, number, and location
  - Site name
  - Name of collector
  - Date and time of collection
  - Sample identification number
  - Sample preservation
- Chain of Custody Forms - A chain of custody form will be completed for every sample collected and submitted to the analytical laboratory to document custody of the sample from the time of collection to receipt at the laboratory. Chain of custody forms will be completed in triplicate (at a minimum) so one copy is kept at the field site, one copy is sent to the Project Manager or designee, and one copy accompanies the samples submitted to the analytical laboratory. The laboratory will send the project chemist, or designee, a copy of the completed chain of custody along with a completed Cooler Receipt Form (CRF) and completed log-in information within 24 hours of sample receipt and log-in. The chain of custody will include the following information:
  - Name, number, and location of project
  - Project Manager or “Report to” contact
  - Name and signature of sample collector, sampler, or recorder
  - Date and time of sample collection
  - Sample type/matrix
  - Number of containers submitted and preservative used (if any)
  - Analyses requested and TAT requirements
  - Signature trail of persons relinquishing and receiving samples
  - Receiving laboratory address and contact information
  - Date and time of sample receipt

7.1.2 Analytical Records

The analytical laboratory will maintain and submit the following records as part of the data deliverable for each sample. These records together make up the Comprehensive Certificate of Analysis, which is a required deliverable to report results and is used in the data validation process.

- Chain of custody records
- Sample/Cooler Receipt Forms (SRFs/CRFs) documenting the general condition of the samples upon receipt including temperature, sample preservation, and number of containers received as well as any discrepancies or issues
- Sample tracking forms
- Sample preparation and analysis forms/logbooks
- Tabulated data summary forms and raw data for field samples, QC samples, and standards. If manual integration is performed on project samples, raw data to include chromatographs from before and after manual integration is applied. The case narrative will also address the reason manual integration was performed on each affected sample
- Case narrative
- Date and times of sample receipt, extraction, and analysis
- QC sample results
- Communication logs
- Corrective action reports
- Definitions of laboratory qualifiers
- Instrument calibration data and summary reports
- Signatures for laboratory sign-off

7.1.3 Project Data Assessment Records

Project data assessment records will be generated and submitted as part of the quarterly or annual reporting requirements for the Sites 2/12, OU2, OUCTP GWMP and the Sites 2/12 and OU2 GWTS as necessary. Project Data Assessment reports may be created at any time throughout the project, and typically consist of the following:

- Field Sampling Audit Report (if applicable)
- Laboratory Audit Report (if applicable)
- Data Validation Summary Report

7.2 Worksheets #31, #32, and #33: Assessments and Corrective Action

Planned project assessments will be completed for the Sites 2/12 and OU2 GWTS and Sites 2/12, OU2, and OUCTP GWMP through the Three Phase Quality Control Process, as follows:

- Preparatory Phase: Activities and assessments conducted during the preparatory phase are conducted prior to the start of a feature of work to ensure technical requirements and work prerequisites have been completed. Discrepancies will be resolved and corrective actions implemented and verified prior to the start of work.
- Initial Phase: Activities and assessments conducted during the initial phase are performed during the first day of the feature of work to verify compliance with the specifications and requirements described in this QAPP and approved project plans and procedures. Discrepancies will be resolved and corrective actions implemented and verified prior to work proceeding.
- Follow-Up and Reporting Phase: Activities and assessments performed during the follow-up and reporting phase are conducted to verify continued compliance with project requirements and to verify project reports meet client and regulatory requirements.

An overview of the Three Phase Quality Control Process and related forms used to document the process are provided in Attachment D. The activities and assessments conducted during each phase of the Three Phase Quality Control Process are described below.

7.2.1 Assessments and Corrective Action

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Organization)	Timeframe for Response
Phase I - Preparatory Phase						
Planning Document review	Internal Memo	Document Author	Prior to the start of field activities	Response to comments documentation and USACE approval of document as applicable	Derek Lieberman, PM, Ahtna Jeff Fenton, PM, Wood	One week
Planning document (QAPP) sign-off by field and laboratory	Memo	Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna Elvin Kumar, PM, SGS	Prior to the start of field activities	Obtain sign-off that document has been read and understood by field and lab personnel	Christopher Ohland, Program Chemist, Ahtna Kevin Garrett, Project Chemist, Wood	One week
Review of lab and field personnel readiness	Memo	Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna Elvin Kumar, PM, SGS	Prior to the start of field activities	Provide kickoff meeting notes from field and lab meetings	Christopher Ohland, Program Chemist, Ahtna Kevin Garrett, Project Chemist, Wood	One week
Review of field equipment	Memo	Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna	Prior to the start of field activities	Provide checklist documenting field equipment is available and in good working order	Christopher Ohland, Program Chemist, Ahtna Kevin Garrett, Project Chemist, Wood	Prior to the start of field activities

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Organization)	Timeframe for Response
Phase II – Initial Phase						
Field and laboratory audit	Field and lab audit report	Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna Elvin Kumar, PM, SGS Eric Schmidt, Project Chemist, Ahtna Jeff Fenton, PM, Wood Derek Lieberman, PM, Ahtna	Within 48 hours of audits	Field and laboratory to issue formal response to audit findings requiring corrective action	Christopher Ohland, Program Chemist, Ahtna Kevin Garrett, Project Chemist, Wood	One week
Review of Contractor QC Reports	Memo	Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna Sylvester Kosowski, QC Manager, Ahtna	Within 48 hours of review	Revision of Contractor Quality Control Reports (CQCRs) as needed	Derek Lieberman, PM, Ahtna Jeff Fenton, PM, Wood	One week

Assessment Type	Nature of Deficiencies Documentation	Individual(s) Notified of Findings (Name, Title, Organization)	Timeframe of Notification	Nature of Corrective Action Response Documentation	Individual(s) Receiving Corrective Action Response (Name, Title, Organization)	Timeframe for Response
Review of project plans to reflect current site or lab activities	Memo	Holly Dillon, Task Lead, Ahtna Scott Graham, Field Task Manager, Wood Mark Fisler, O&M Manager, Ahtna Elvin Kumar, PM SGS	Within 10 days of observations	Update project plans to reflect current conditions (may be addendum to existing document) or documentation of changes to field or lab protocol to be in accordance with project plans	Derek Lieberman, PM, Ahtna Jeff Fenton, PM, Wood	Prior to next scheduled sampling event
Phase III – Follow-Up and Reporting Phase						
Review of Data Reports	Internal comments from staff and external comments from client and regulatory agencies	Document Author Derek Lieberman, PM, Ahtna Jeff Fenton, PM, Wood	Internal = prior to issuance of report External = within 30 days of receipt of report	Provide response to comments and revise report as needed	Commenting client and/or agencies Alex Kan, Technical Lead, USACE	30 days

7.2.2 QA Management

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Sites 2/12 GWMP and GWTS O&M Reports	Quarterly	Final 60 days after end of quarterly sampling event	Derek Lieberman, PM, Ahtna Holly Dillon, Task Lead, Ahtna	USACE: Dana Gentry – PM, Jonathan Whipple – Project Chemist, Alex Kan – Technical Lead Fort Ord BRAC: William Collins – BEC Chenega: Tom Ghigliotto – Field Oversight Inspector Fort Ord Administrative Record EPA: Maeve Clancy – PM TechLaw: Robert Young CCRWQCB: Amber Sellinger – PM DTSC: Min Wu – PM
	Annually	Preliminary Draft 75 days after end of annual sampling event		
OU2 GWMP and GWTS O&M Reports	Quarterly	Final 60 days after end of quarterly sampling event	Derek Lieberman, PM, Ahtna Holly Dillon, Task Lead, Ahtna	
	Annually	Preliminary Draft 75 days after end of annual sampling event		
OUCTP GWMP Reports	Quarterly	Final 60 days after end of quarterly sampling event	Derek Lieberman, PM, Ahtna Holly Dillon, Task Lead, Ahtna	
	Annually	Preliminary Draft 75 days after end of annual sampling event		
CQCR	Quarterly, following each sampling event	Within 60 days of completion of field sampling event	Jeff Fenton, Project Manager, Wood	USACE: Dana Gentry – PM, Jonathan Whipple – Project Chemist, Alex Kan– Technical Lead Chenega: Tom Ghigliotto – Field Oversight Inspector Ahtna: Derek Lieberman, Project Manager

Type of Report	Frequency (daily, weekly monthly, quarterly, annually, etc.)	Projected Delivery Date(s)	Person(s) Responsible for Report Preparation (Title and Organizational Affiliation)	Report Recipient(s) (Title and Organizational Affiliation)
Non-Routine Occurrences Report	As needed	Within 48 hours of a Non-Routine Occurrence in the field or laboratory. A copy of this report will also be included in the CQCR	Kevin Garrett, Project Chemist, Wood	USACE: Dana Gentry – PM, Jonathan Whipple – Project Chemist, Alex Kan– Technical Lead Chenega: Tom Ghigliotto – Field Oversight Inspector Ahtna: Christopher Ohland, Program Chemist Wood: Jeff Fenton, PM
Field Work Variance Report	As needed	Prior to implementation of proposed change or immediately following a variance implemented in the field. A copy of the Field Work Variance will also be included in the CQCR	Scott Graham, Field Task Manager, Wood	USACE: Dana Gentry – PM, Jonathan Whipple – Project Chemist, Alex Kan-Technical Lead Ahtna: Derek Lieberman - PM, Christopher Ohland - Program Chemist Wood: Jeff Fenton - PM, Kevin Garrett - Project Chemist Chenega: Tom Ghigliotto – Field Oversight Inspector
Validation Summary Report	Quarterly, following each sampling event	Produced as part of the Quarterly Monitoring Report	Kevin Garrett, Project Chemist, Wood	USACE: Dana Gentry – PM, Jonathan Whipple – Project Chemist, Alex Kan– Technical Lead Fort Ord BRAC: William Collins – BEC Fort Ord Administrative Record EPA: Maeve Clancy – PM TechLaw: Robert Young CCRWQCB: Amber Sellinger – PM DTSC: Min Wu – PM

7.3 Worksheet #34: Data Verification and Validation Inputs

Verification Input	**Description**	**Internal / External**	**Responsible for Verification (Name, Organization)**
Chain of custody and shipping forms	Chain of custody forms will be reviewed internally upon their completion and verified against the packed sample coolers they represent. When everything is verified, the shipper's signature on the chain of custody form will be initialed by the reviewer. A copy of the form will be retained in the site file, and the original and remaining copies will be taped inside the cooler for shipment. Refer to Attachment A for SOPs #4 and #7 for further detail.	I	Sites 2/12 and OU2 GWTS: Mark Fisler, O&M Manager, Ahtna
			Sites 2/12, OU2, OUCTP GWMP: Scott Graham, Field Task Manager, Wood
	Receiving laboratory will verify chain of custody forms with contents of coolers. Wood project chemist will be notified of any discrepancies or issues within 24 hours of sample receipt. Resolution will be documented in writing and submitted with final data package.	E	Elvin Kumar, Project Manager, SGS Laboratory
	Laboratory receipt/log-in report will be reviewed against chain of custody internally.	I	Sites 2/12 and OU2 GWTS: Holly Dillon, Data Manager, Ahtna Sites 2/12, OU2, OUCTP GWMP Zack Carroll, Data Validator, Wood
Field Notes	Field notes will be reviewed internally by the field supervisor for consistency with the chain of custody forms and SOPs. One copy of the field notes will be retained in the onsite project file, and originals will be forwarded to the Project Manager for review.	I	Sites 2/12, OU2 GWTS: Mark Fisler, O&M Manager, Ahtna Sites 2/12, OU2, OUCTP GWMP: Scott Graham, Field Task Manager, Wood

Verification Input	Description	Internal / External	Responsible for Verification (Name, Organization)
Laboratory Data	Analytical data packages will be verified by the laboratory performing the work for completeness prior to submittal.	I	Svetlana Izosimova, Quality Assurance Officer, SGS
	Received data packages will be verified according to the data validation procedures specified in Worksheet #35. Laboratory electronic deliverables will be verified against the data package hard copy reports.	I	Sites 2/12, OU2 GWTS: Christopher Ohland, Program Chemist, Ahtna Sites 2/12, OU2, OUCTP GWMP: Zack Carroll, Project Database Analyst, Wood

7.4 Worksheet #35: Data Verification Procedures

Stage 2A/2B	Validation Input	Description	Responsible for Verification – GWTS	Responsible for Verification – GWMP
2A	Methods used for sample collection	Field data notes will be reviewed for compliance with published methods and SOPs. Deviations from SOPs and methods described in this QAPP will be summarized and provided to the Project Manager in writing.	Mark Fisler, O&M Manager, Ahtna	Scott Graham, Field Task Manager, Wood
2A	Methods used for analysis	Laboratory data packages will be reviewed to verify the methods specified in this QAPP were followed. Deviations shall be documented in writing.	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2A	Sampling SOPs and Analytical Compliance	Review field notes for compliance with SOPs. Review laboratory data deliverables for compliance with QAPP and published methods.	Mark Fisler, O&M Manager, Ahtna Eric Schmidt, Project Chemist, Ahtna	Scott Graham, Field Task Manager, Wood Zack Carroll, Project Database Analyst, Wood
2A	Documentation of method QC results	Review laboratory data packages to determine if QC parameters required by the referenced methods were performed and reported. The QC forms will be reviewed to determine if method acceptance criteria were met. Method QC outliers will be identified by the laboratory in the case narrative. Reviewer will determine if data will require qualification due to outliers.	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	Documentation of QAPP QC sample results	Verify QC samples specified in this QAPP were analyzed and reported. Reviewer will identify QAPP QC sample results in the data validation report.	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood

Stage 2A/2B	Validation Input	Description	Responsible for Verification – GWTS	Responsible for Verification – GWMP
2B	Laboratory data package documentation	Laboratory data packages will be reviewed to ensure documentation requirements specified in the QAPP have been met. If deficiencies are found, the Data Reviewer will document the issue in a memorandum to the laboratory. The laboratory will address deficiencies in writing or submit a revised data package correcting the deficiencies.	Christopher Ohland, Program Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	Target analyte list	Laboratory report summary forms will be reviewed to verify the target compounds and parameters specified in the QAPP were reported.	Christopher Ohland, Program Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	LOQs	Determine quantitation limits were achieved, as outlined in the QAPP. Verify the laboratory analyzed a low standard at the quantitation limit in the initial calibration.	Christopher Ohland, Program Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2A	Raw data and laboratory transcription errors	Ten percent (10%) of raw data will be reviewed to confirm laboratory calculations and that there are no transcription errors. Chromatographs containing manual integrations, if any, will be evaluated as part of the raw data review.	Christopher Ohland, Program Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2A and 2B	Data Validation Report	Summarize deviations from the referenced methods, SOPS, and QAPP-specific requirements. Include qualified data and explanations of all data qualifiers.	Christopher Ohland, Program Chemist, Ahtna	Zack Carroll, Wood
2A and 2B	Data Validation Report Review	Review validation reports and Validation Summary Report.	Christopher Ohland, Program Chemist, Ahtna	Kevin Garrett Project Chemist, Wood

7.5 Worksheet #36: Data Validation Procedures

Stage 2A/2B	Matrix	Analytical Group	Validation Criteria	GWTS Validator	GWMP Validator
2A	Aqueous	VOCs	EM-200-1-10. *Guidance for Evaluating Performance-based Chemical Data* (USACE, June 2005) and SW-846 Method 8260-SIM	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	Aqueous	VOCs	QAPP Worksheets and ADR Library	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2A	Aqueous	Dissolved metals	EM-200-1-10 and SW-846 Method 6010D	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	Aqueous	Dissolved Metals	QAPP Worksheets and ADR Library	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2A	Aqueous	Wet Chemistry	EM-200-1-10, EPA Method 9056A (chloride)	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood
2B	Aqueous	Wet Chemistry	QAPP Worksheets and ADR Library	Eric Schmidt, Project Chemist, Ahtna	Zack Carroll, Project Database Analyst, Wood

Notes:

ADR: Automated Data Review program

7.5.1 Stage 1 Validation

Stage 1 validation of the laboratory analytical data package consists of verification and validation checks for the compliance of sample receipt conditions, sample characteristics (e.g., percent moisture), and analytical results (with associated information). The following minimum baseline checks (as relevant) will be performed on the laboratory analytical data package received for a Stage 1 validation:

1) Documentation identifies the laboratory receiving and conducting analyses and includes documentation for all samples submitted by the project or requester for analyses.
2) Requested analytical methods were performed and the analysis dates are present.
3) Requested target analyte results are reported along with the original laboratory data qualifiers and data qualifier definitions for each reported result.
4) Requested target analyte result units are reported.
5) Requested LOQs for all samples are present and results at and below the requested (required) LOQs are clearly identified (including sample DLs if required).
6) Sampling dates (including times if needed), date and time of laboratory receipt of samples, and sample conditions upon receipt at the laboratory (including preservation, pH, and temperature) are documented.
7) Sample results are evaluated by comparing sample conditions upon receipt at the laboratory (e.g., preservation checks) and sample characteristics (e.g., percent moisture) to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract.

7.5.2 Stage 2A Validation

Stage 2A validation builds on the validation conducted in Stage 1. Stage 2A validation of the laboratory analytical data package consists of the Stage 1 validation plus the verification and validation checks for the compliance of sample-related QC. The following additional minimum baseline checks (as relevant) will be performed on the laboratory analytical data package received for a Stage 2A validation:

1) Requested methods (handling, preparation, cleanup, and analytical) are performed.
2) Method dates (including dates, times and duration of analysis for radiation counting measurements and other methods, if needed) for handling (e.g., Toxicity Characteristic Leaching Procedure), preparation, cleanup, and analysis are present, as appropriate.
3) Sample-related QC data and QC acceptance criteria (e.g., method blanks, surrogate recoveries, laboratory control sample (LCS) recoveries, duplicate analyses, matrix spike and matrix spike duplicate recoveries, serial dilutions, post-digestion spikes, standard reference materials) are provided and linked to the reported field samples (including the field QC samples such as trip and equipment blanks).
4) Requested spike analytes or compounds (e.g., surrogate, LCS spikes, post-digestion spikes) have been added, as appropriate.
5) Sample holding times (from sampling date to preparation and preparation to analysis) are evaluated.

6) The frequency of QC samples is checked for appropriateness (e.g., one LCS per 20 samples in a preparation batch).
7) Sample results are evaluated by comparing holding times and sample-related QC data to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract.

7.5.3 Stage 2B Validation

Stage 2B validation builds on the validation conducted in Stage 2A. Stage 2B validation of the laboratory analytical data package consists of the Stage 2A validation plus the verification and validation checks for the compliance of instrument-related QC. The following additional minimum baseline checks (as relevant) will be performed on the laboratory analytical data package received for a Stage 2B validation:

1) Initial calibration data (e.g., initial calibration standards, initial calibration verification [ICV] standards, initial calibration blanks [ICBs]) are provided for all requested analytes and linked to field samples reported. For each initial calibration, the calibration type used is present along with the initial calibration equation used including any weighting factor(s) applied and the associated correlation coefficients, as appropriate. Recalculations of the standard concentrations using the initial calibration curve are present, along with their associated percent recoveries, as appropriate (e.g., if required by the project, method, or contract). For the ICV standard, the associated percent recovery (or percent difference, as appropriate) is present.
2) Appropriate number and concentration of initial calibration standards are present.
3) Continuing calibration data (e.g., continuing calibration verification [CCV] standards and continuing calibration blanks [CCBs]) are provided for all requested analytes and linked to field samples reported, as appropriate. For the CCV standard(s), the associated percent recoveries (or percent differences, as appropriate) are present.
4) Reported samples are bracketed by CCV standards and CCBs standards as appropriate.
5) Method specific instrument performance checks are present as appropriate (e.g., tunes for mass spectrometry methods, instrument blanks and interference checks for ICP methods).
6) The frequency of instrument QC samples is checked for appropriateness (e.g., gas chromatography-mass spectroscopy [GC-MS] tunes have been run every 12 hours).
7) Sample results are evaluated by comparing instrument-related QC data to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract.

Metals and Wet Chemistry analyses are also reviewed under Stage 2B validation using a combination of criteria from the DoD QSM (where provided) and laboratory performance-based in-house acceptance criteria.

VOC data are used to evaluate compliance with the relevant ROD and ACLs for each of the GWTS. As a result, the VOC data are subject to a rigorous 100% EPA Stage 2B data review (EPA, 2009) to verify data are of a known quality in compliance with this QAPP, the *Department of Defense Quality Systems*

Manual for Environmental Laboratories, Final Version 5.1, the published analytical methods, and are capable of supporting project decisions.

Stage 2B review is performed using the automated data review software program ADR.NET. Flagging conventions for the test methods included in the QAPP are incorporated with the ADR program's reference library (Attachment E) to assess compliance with project requirements. The ADR program is used as an electronic validation tool for the following Stage 2B elements:

- Holding Times
- Instrument Performance Checks
- Method Blank Contamination
- Surrogates
- Laboratory Duplicates
- Laboratory Control Samples
- Matrix Spike Samples
- Field Blank Contamination
- Field Duplicates
- Initial and Continuing Calibration Data

Initial and continuing calibration files for each test method may need to be validated manually if the contract library is unable to provide electronic validation files.

The Data Reviewer checks the ADR-generated Non-Conformance Report, identifying items that do not conform to the ADR Project Library requirements, and the results are incorporated into the assessment of the data.

The Data Reviewer proceeds with the review of the ADR files in the ADR Data Review module. The ADR Data Review module identifies outliers and applies validation qualifiers to the data based on the ADR Project Library data review requirements. The ADR Library qualification scheme files are provided as Attachment E.

The Data Reviewer then reviews the ADR output, comparing the ADR findings with the lab reports to ensure the automated validation process is working accurately. The Data Reviewer may manually edit the validation qualifiers based on his or her professional judgment, which will be described in the Validation Summary Report. Flagging conventions used for data qualification are presented in Attachment E.

7.5.4 Stage 3 Validation

Stage 3 validation builds on the validation conducted in Stage 2B. Stage 3 validation of the laboratory analytical data package consists of the Stage 2B validation plus the recalculation of instrument and sample results from the laboratory instrument responses, and comparison of recalculated results to laboratory reported results. The following additional minimum baseline checks (as relevant) will be performed on the laboratory analytical data package received for a Stage 3 validation:

1) Instrument response data (e.g., GC peak areas, ICP corrected intensities) are reported for requested analytes, surrogates, internal standards, and deuterated monitoring compounds for all requested field samples, matrix spikes, matrix spike duplicates, LCS, and method blanks as well as calibration data and instrument QC checks (e.g., tunes, DDT/Endrin breakdowns, interelement correction factors, and Florisil cartridge checks).
2) Reported target analyte instrument responses are associated with appropriate internal standard analyte(s) for each (or selected) analyte(s) (for methods using internal standard for calibration).
3) Fit and appropriateness of the initial calibration curve used or required (e.g., mean calibration factor, regression analysis [linear or non-linear, with or without weighting factors, with or without forcing]) is checked with recalculation of the initial calibration curve for each (or selected) analyte(s) from the instrument response.
4) Comparison of instrument response to the minimum response requirements for each (or selected) analyte(s).
5) Recalculation of each (or selected) opening and closing CCV (and CCB) response from the peak data reported for each (or selected) analyte(s) from the instrument response, as appropriate.
6) A compliance check of recalculated opening and/or closing CCV (and CCB) response to recalculated initial calibration response for each (or selected) analyte(s).
7) Recalculation of percent ratios for each (or selected) tune from the instrument response, as appropriate.
8) A compliance check of recalculated percent ratio for each (or selected) tune from the instrument response.
9) Recalculation of each (or selected) instrument performance check (e.g., DDT/Endrin breakdown for pesticide analysis, instrument blanks, interference checks) from the instrument response.
10) Recalculation and compliance check of retention time windows (for chromatographic methods) for each (or selected) analyte(s) from the laboratory reported retention times.
11) Recalculation of reported results for each reported (or selected) target analyte(s) from the instrument response.
12) Recalculation of each (or selected) reported spike recovery (surrogate recoveries, deuterated monitoring compound recoveries, LCS recoveries, duplicate analyses, MS/MSD recoveries, serial dilutions, post-digestion spikes, standard reference materials etc.) from the instrument response.
13) Each (or selected) sample result(s) and spike recovery(ies) are evaluated by comparing the recalculated numbers to the laboratory reported numbers according to the requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract.

Selection of analytes, spikes, and performance evaluation checks for the Stage 3 validation checks for a laboratory analytical data package being verified and validated generally will depend on many factors including (but not limited to) the type of verification and validation being performed (manual or electronic), requirements and guidelines present in national or regional data validation documents, analytical method(s) or contract, the number of laboratories reporting the data, the number and type of analytical methods reported, the number of analytes reported in each method, and the number of detected analytes.

7.5.5 Stage 4 Validation

10% of the data are subject to Stage 4 data review, which builds on the validation conducted in Stage 3. Stage 4 validation of the laboratory analytical data package consists of the Stage 3 validation plus the evaluation of instrument outputs. It is recommended that the following additional minimum baseline checks (as relevant) be performed on the laboratory analytical data package received for a Stage 4 validation:

1) All required instrument outputs (e.g., chromatograms, mass spectra, atomic emission spectra, instrument background corrections, and interference corrections) for evaluating sample and instrument performance are present.
2) Sample results are evaluated by checking each (or selected) instrument output (e.g., chromatograms, mass spectra, atomic emission spectra data, instrument background corrections, interference corrections) for correct identification and quantitation of analytes (e.g., peak integrations, use of appropriate internal standards for quantitation, elution order of analytes, and interferences).
3) Each (or selected) instrument's output(s) is evaluated for confirmation of non-detected or tentatively identified analytes.

In the event the findings of the Stage 4 validation indicate the potential for other reported results to be impacted by quality related issues, the Stage 4 validation may be expanded to include additional samples.

7.6 Worksheet #37: Data Usability Assessment

The suitability of the environmental data collected from both the Sites 2/12 and OU2 GWTS and the Sites 2/12, OU2, and OUCTP GWMP will be assessed by the Ahtna Project Chemist and the Wood Project Chemist, respectively. Data usability will comprise an evaluation of the quantity, type, and overall quality of the generated data against the project DQOs as presented in Worksheet #11 and the MPC presented in Worksheet #12. The usability of data associated with QC results outside of the established acceptance criteria is dependent on the degree of the exceedance, whether the potential bias is high or low, and whether the uncertainty implied by the exceedance is significant relative to project decisions and DQOs. Data usability will be assessed in accordance with the guidance provided in the DoD QSM Version 5.1 and additional applicable USACE and EPA guidance as well as the professional experience of the decision maker during data validation. The following items will be assessed and conclusions are drawn based on their results:

- **Precision** – Duplicate field and laboratory samples will be evaluated for precision based on relative percent difference (RPD). RPD will be calculated for each detectable result between the two samples. RPDs exceeding MPC in Worksheet #12 will be identified in the Validation Summary Report and any limitations on the use of the data will be noted. RPDs within the MPC will demonstrate the data have acceptable precision and the data are usable.
- **Accuracy** – Laboratory Control Samples (LCS), Laboratory Control Sample Duplicate (LCSD), MS/MSD sample results will be evaluated by comparing spike recovery results with MPC in Worksheet #12.
- **Sensitivity** – Data sensitivity will be verified by comparing method blank results with MPC in Worksheet #12 and cross checking analyte data with limits of quantitation (LOQs) and ACLs presented in Worksheet #15a.
- **Bias** – Laboratory surrogate compound recovery will be evaluated for bias by comparing results with MPC in Worksheet #12.
- **Contamination** – Field blank, trip blank and method blank data will be used to determine whether there are contamination issues based upon MPC in Worksheet#12.
- **Representativeness** – Sampling procedures will be implemented in accordance with SOPs to eliminate or minimize sources of error. Compliance with SOPs will be confirmed through QC field audits. Analytical procedures will be implemented in accordance with laboratory SOPs, QC acceptance limits, and the laboratory Quality Assurance Manual. Laboratories used for sample analysis will maintain DoD ELAP certification and undergo annual audits by the independent accrediting bodies responsible for the DoD ELAP certification.
- **Completeness** – The completeness of the sample event will be determined based upon the number of field samples collected compared to the number of samples planned and the number of unqualified laboratory results compared to the total number of results.[20] This information will be compared to MPC in Worksheet #12.

---

[20] Results qualified as estimated due to detected quantities between the LOQ and LOD will not be counted in the analytical completeness quantity assessment.

- **Comparability** – The data from each sampling event are comparable to past and future events as long as the same or similar sampling and analytical SOPs located in Attachment A are utilized.
- **Reconciliation** – Each of the DQOs presented in Worksheet #11 will be examined to determine whether the objectives were met. This examination will include a combined overall assessment of the results of each analysis pertinent to an objective. Each analysis will be first evaluated separately in terms of the major impacts observed from the data validation, DQIs, and MPC assessments. Based on the results of these assessments, the quality of the data will be determined. Based on the quality, data usability for each analysis will be determined. Based on the combined data usability from all analyses for an objective, it will be determined whether the DQO was met and whether action limits were exceeded.

In the event the data quantity or quality prove to be inadequate to meet project objectives, re-analysis or re-sampling may be required. Replacement samples may be collected when existing data are insufficient or inadequate to support project objectives. The decision to take replacement samples will be made in coordination with the project team and may include USACE, Ahtna or Wood Project Managers, and the Ahtna Program Chemist or Wood Project Chemist.

Usability of the data will be presented in the Validation Summary Report, included with each Quarterly Monitoring Report. Copies of the associated data validation reports will be presented as an attachment to the Validation Summary Report. The Validation Summary Report will contain the following information:

- Basic summary of validation results, including a summary of data qualified with validation flags as listed in Attachment E
- Summary of deviations from the QAPP
- Summary of rejected data that resulted in a data gap
- Summary of points that went into the reconciliation of each objective
- Comments on recovery issues with the MS/MSDs
- Comments on limitations on the data usability
- Comments on corrective action needed and/or taken
- Conclusions and recommendations

8.0 References[21]

AES, 2009. *Final Operations and Maintenance Manual Volume II, Sites 2 and 12 Groundwater Remedy, Former Fort Ord, California* (Sites 2/12 GWTS O&M Manual). August. AR# BW-2479G.

AES, 2014. *Final Operable Unit Carbon Tetrachloride Plume Remedial Action Work Plan, Former Fort Ord, California; Appendix A Operable Unit Carbon Tetrachloride Plume A-Aquifer Remedial Design Addendum*. April. AR# OUCTP-0062A.

AES, 2015. *Final Remedial Investigation/Feasibility Study Addendum at Sites 2 and 12, Former Fort Ord, California*. February 27. AR# BW-2721B.

Ahtna, 2019a. *Draft Sites 2 and 12 Fourth Quarter 2017 through Third Quarter 2018 Groundwater and Soil Gas Monitoring and Treatment System Report, Former Fort Ord, California.* February 8. AR# BW-2861.

Ahtna, 2019b. *Draft Operable Unit Carbon Tetrachloride Plume Fourth Quarter 2017 through Third Quarter 2018 Groundwater Monitoring and Treatment System Report, Former Fort Ord, California.* February 11. AR# OUCTP-0085.

Ahtna, 2019c. *Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix C, Final Revision 4, Soil Gas Monitoring at Sites 2 and* 12. February 15. AR# BW-2792G.

Ahtna, 2019d. *Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix D, Draft Final Revision 3, Operable Unit 2 Landfills*. February 19. AR# OU2-702G.

Ahtna, 2019e. *Draft Operable Unit 2 Fourth Quarter 2017 through Third Quarter 2018 Groundwater Monitoring and Treatment System Report, Former Fort Ord, California.* June. AR# TBD.

Ahtna, 2019f. *Draft Monitoring Well Installation Completion Report, Former Fort Ord, California*. June. AR# TBD.

Ahtna, 2019g. *Draft 2019 Monitoring Well and Soil Gas Probe Decommissioning Completion Report, Former Fort Ord, California*. June. AR# TBD.

Dames & Moore, 1993. *Baseline Risk Assessment, Remedial Investigation/Feasibility Study, Site 2 Landfills, Fort Ord, California*. June 7. AR# OU2-218.

Department of Defense (DoD), 2017. *Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, Version 5.1.* https://www.denix.osd.mil/edqw/documents/documents/qsm-version-5-1-final/

Fort Ord Reuse Authority (FORA), 1997. *Fort Ord Reuse Plan, Volume I: Context and Framework*. June. http://www.fora.org/Reports/BRP/BRP_v1_ContextAndFramework_1997.pdf

---

[21] At the end of references included in the Fort Ord Administrative Record are the Administrative Record Numbers (AR#s) (e.g. BW-1234). To find the referenced document, this number may be typed into the online search tool at: http://www.fortordcleanup.com/documents/search/. Please note the referenced documents were available in the Fort Ord Administrative Record at the time this document was issued; however, some may have been superseded by more current versions and were subsequently withdrawn. TBD: to be determined.

Harding ESE, 2001. *Technical Memorandum, Passive Diffusion Bag Pilot Study Results and Recommendations.* July 25. AR# BW-2099.

Harding Lawson Associates (HLA), 1995. *Final Basewide Remedial Investigation/Feasibility Study, Fort Ord, California, Volume II – Remedial Investigation, Basewide Hydrogeologic Characterization.* October 19. AR# BW-1283A.

HLA, 1999. *Draft Final Revised Treatment System Plan, OU2 Groundwater Remedy, Fort Ord, California.* January 29. AR# OU2-584.

Intergovernmental Data Quality Task Force (IDQTF), 2005. *Uniform Federal Policy for Quality Assurance Project Plans*, *Part 1: UFP-QAPP Manual, Final Version 1*. March. https://www.epa.gov/fedfac/assuring-quality-federal-cleanups#ufp-qapp

IDQTF, 2012. *Uniform Federal Policy for Quality Assurance Project Plans, Part 2a, Revision 1: Optimized UFP-QAPP Worksheets*. March. https://www.epa.gov/fedfac/assuring-quality-federal-cleanups#ufp-qapp

MACTEC Engineering and Consulting, Inc. (MACTEC), 2009. *Final Technical Memorandum, Groundwater Remediation Exit Strategy, Sites 2 and 12 and OU2, Former Fort Ord, California*. July 20. AR# BW-2485H.

Monterey County Water Resources Agency (MCWRA), 2017. *Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin*. October. http://www.co.monterey.ca.us/home/showdocument?id=57432

RORE Innovative Solutions Joint Venture (JV), 2018. *Operations and Maintenance Manual, Operable Unit 2 (OU 2) Groundwater Treatment Plant, Former Fort Ord* (OU2 O&M Manual). October. AR# OU2-TBD.

U.S. Department of the Army (Army), 1994. *Record of Decision, Operable Unit 2, Fort Ord Landfills, Fort Ord, California*. July 15. AR# OU2-480.

Army, 1995. *Explanation of Significant Differences, Operable Unit 2, Fort Ord Landfills, Fort Ord, California.* August 3. AR# OU2-406.

Army, 1997. *Record of Decision, Basewide Remedial Investigation Sites, Fort Ord, California*. January 13. AR# RI-025.

Army, 2008. *Record of Decision, Operable Unit Carbon Tetrachloride Plume, Former Fort Ord, California*. February 6. AR# OUCTP-0021D.

Army, 2016. *Explanation of Significant Differences No. 1, Basewide Remedial Investigation Sites 2 and 12, Former Fort Ord, California*. February 1. AR# BW-2794.

U.S. Army Corps of Engineers (USACE), 2005. *EM-200-1-10, Guidance for Evaluating Performance Based Chemical Data.* June. http://www.publications.usace.army.mil/Portals/76/Publications/EngineerManuals/EM_200-1-10.pdf?ver=2013-09-04-070852-230

U.S. Environmental Protection Agency (EPA), 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4. February. https://www.epa.gov/fedfac/guidance-systematic-planning-using-data-quality-objectives-process

EPA, 2008. *Final Regulatory Determinations for Priority Contaminants on the Second Drinking Water Contaminant Candidate List.* July. https://www.epa.gov/ccl/regulatory-determination-2-contaminants-second-drinking-water-contaminant-candidate-list

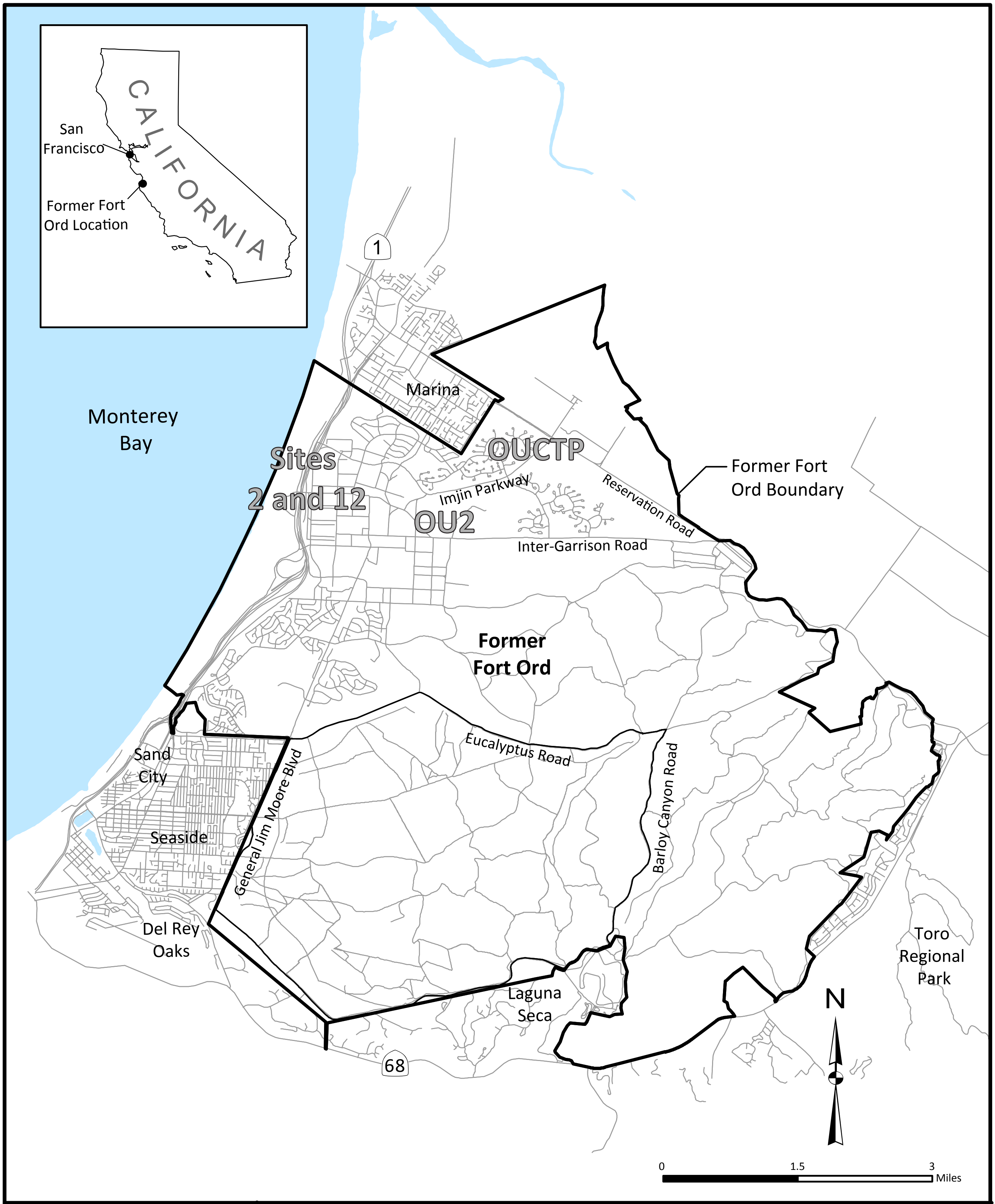
EPA, 2009. *Guidance for Labeling Externally Validated Laboratory Analytical Data for Superfund Use.* January. OSWER No. 9200.1-85, EPA 540-R-08-005.

EPA, 2013. *Guidance for Evaluating Completion of Groundwater Restoration Remedial Actions*. November. OSWER 9355.0-129.

EPA, 2014a. *Groundwater Remedy Completion Strategy, Moving Forward with the End in Mind*. May. OSWER 9200.2-144.

EPA, 2014b. *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*. August. OSWER 9283.1-44.

FIGURES



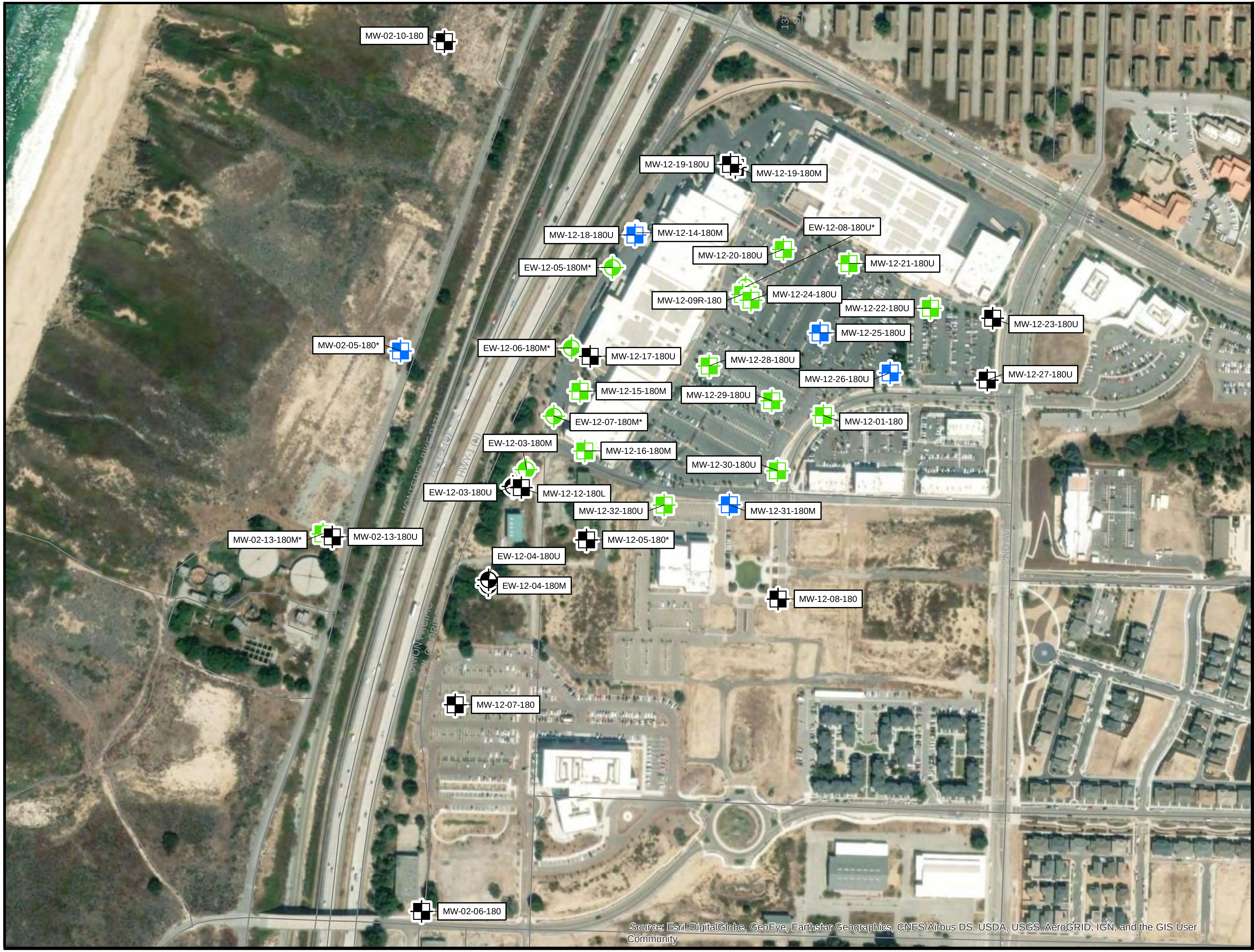
Ahtna

Former Fort Ord Location Map

Quality Assurance Project Plan, Former Fort Ord, California, Volume 1, Appendix A
Revision 7, Groundwater Remedies and Monitoring at Operable Unit 2,
Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume

Figure:

1



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

— Roads

Sites 2/12 Wells 2019-2Q

Well Type and Sample Schedule

- Extraction Well - Quarterly VOCs
- Monitoring Well - Quarterly VOCs
- Monitoring Well - Annual VOCs
- Extraction Well - Water Levels
- Monitoring Well - Water Levels

*Annual chloride sample collected

N

0 100 200 400
Feet

Sites 2/12 Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
2

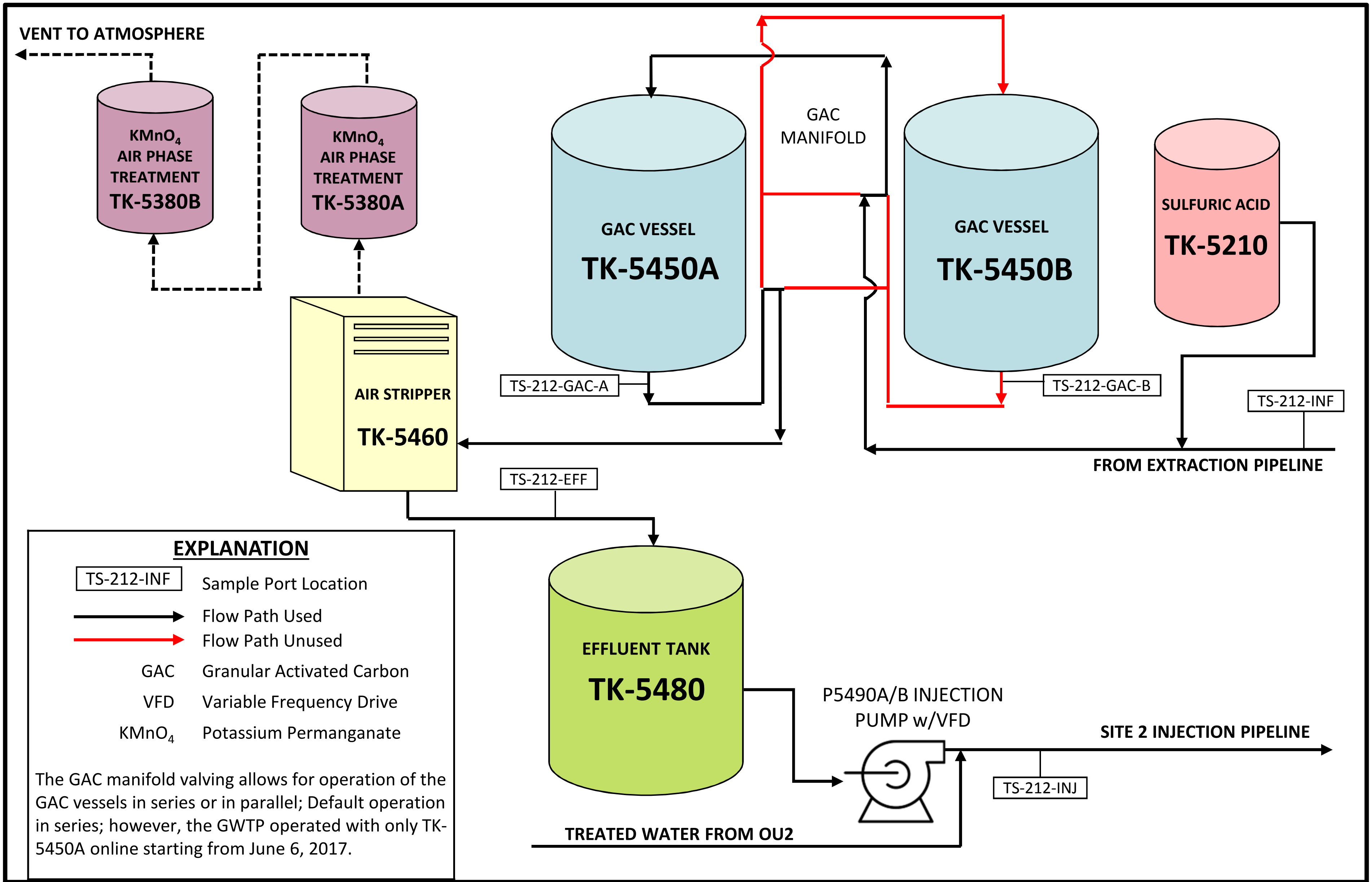
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Sites 2/12 Groundwater Remedy Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
3



EXPLANATION

TS-212-INF	Sample Port Location
→	Flow Path Used
→	Flow Path Unused
GAC	Granular Activated Carbon
VFD	Variable Frequency Drive
$KMnO_4$	Potassium Permanganate

The GAC manifold valving allows for operation of the GAC vessels in series or in parallel; Default operation in series; however, the GWTP operated with only TK-5450A online starting from June 6, 2017.

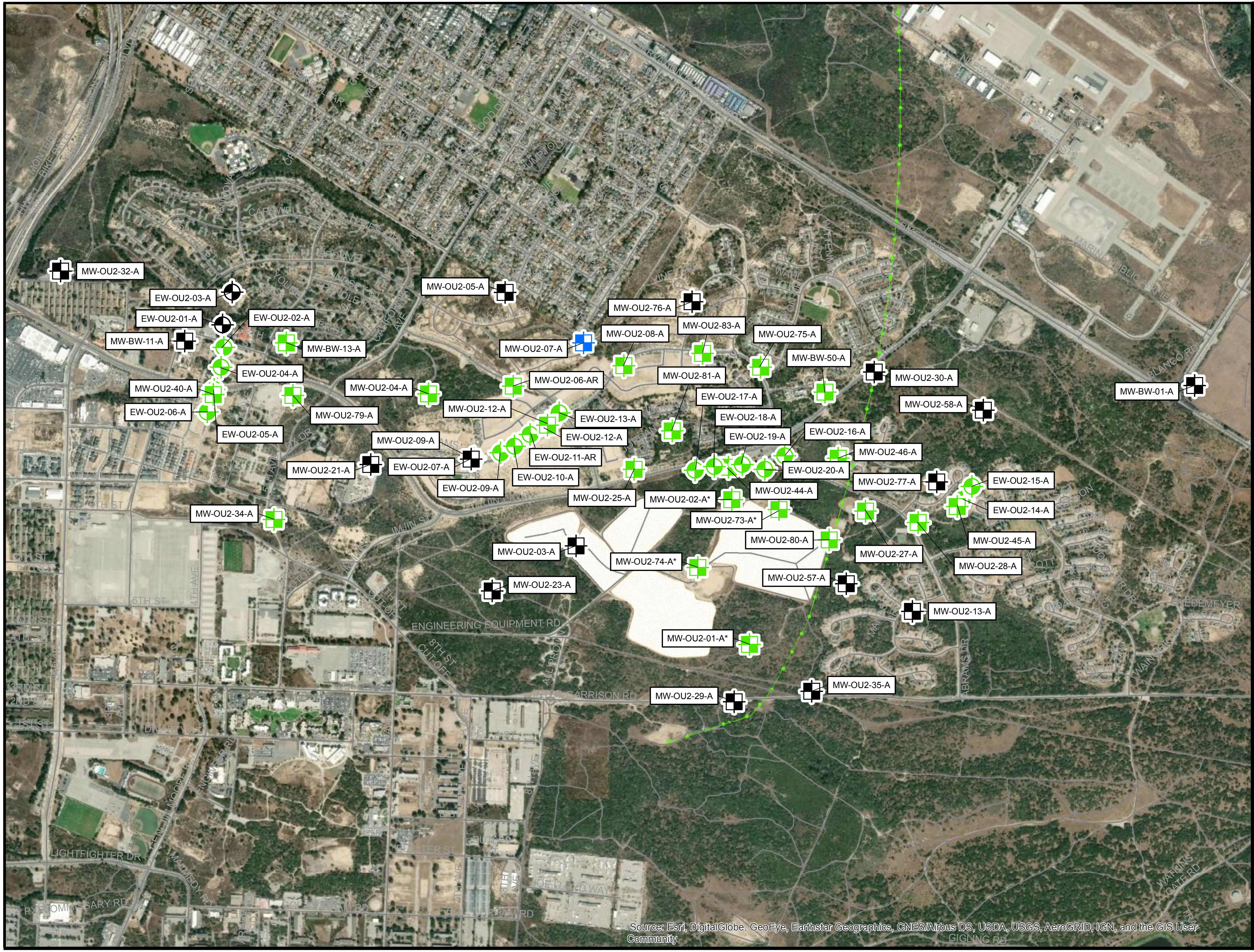
Ahtna

Sites 2/12 Groundwater Treatment Plant Schematic

Quality Assurance Project Plan, Former Fort Ord, California, Volume I, Appendix A, Revision 7
Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and
Operable Unit Carbon Tetrachloride Plume

Figure:

4



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

Roads

Groundwater Divide

Fort Ord Landfills

OU2-A Wells 2018-3Q

Well Type and Sample Schedule

Extraction Well - Quarterly VOCs

Monitoring Well - Quarterly VOCs

Monitoring Well - Annual VOCs

Extraction Well - Water Levels

Monitoring Well - Water Levels

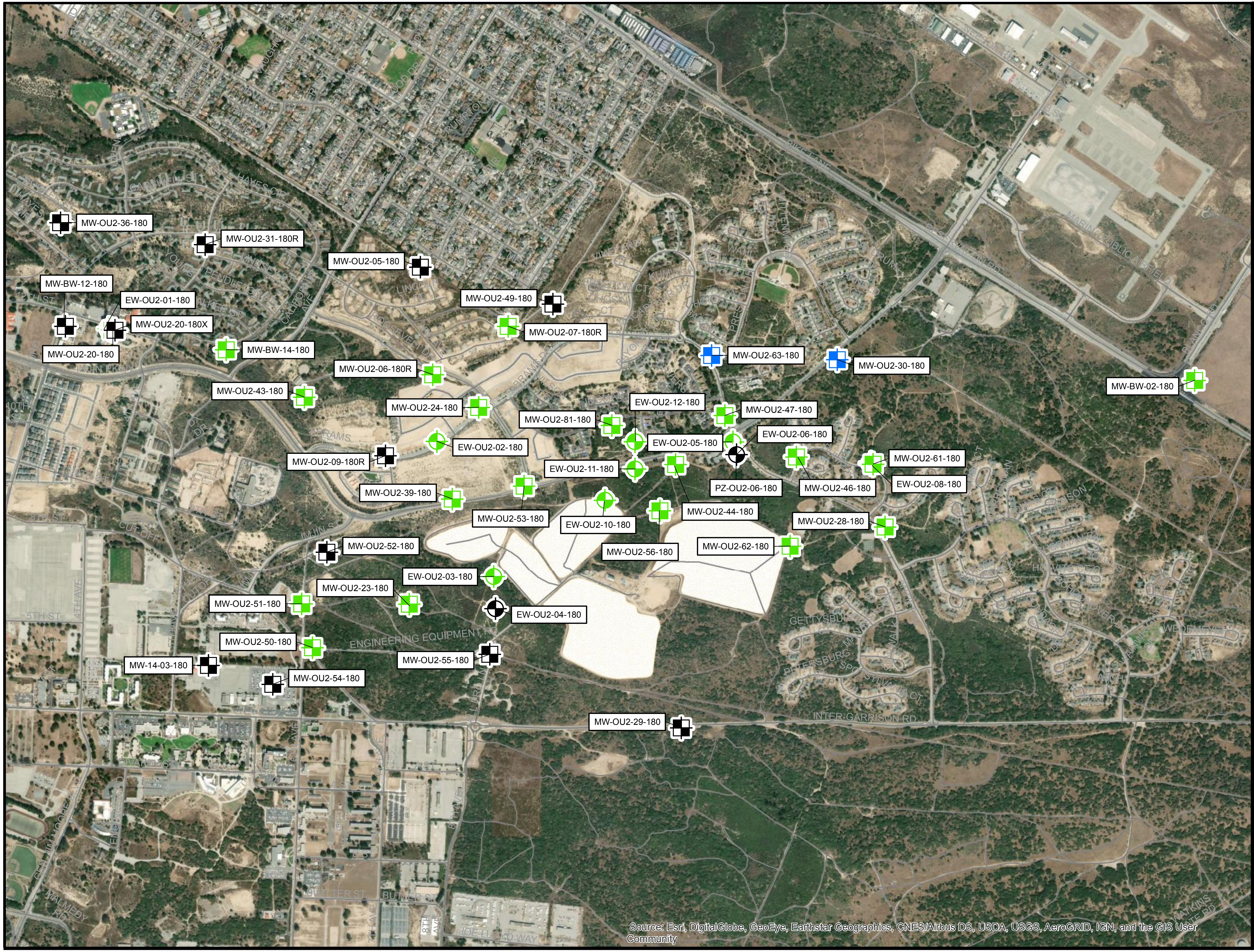
*Annual metals (antimony, copper, and lead) sample collected.

OU2 A-Aquifer Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
5A



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

— Roads

▨ Fort Ord Landfills

OU2-Upper Wells 2018-3Q

Well Type and Sample Schedule

⊕ Extraction Well - Quarterly VOCs

🟩 Monitoring Well - Quarterly VOCs

🟦 Monitoring Well - Annual VOCs

⊕ Extraction Well - Water Levels

⬛ Monitoring Well - Water Levels

N

0 450 900 1,800 Feet

OU2 Upper 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

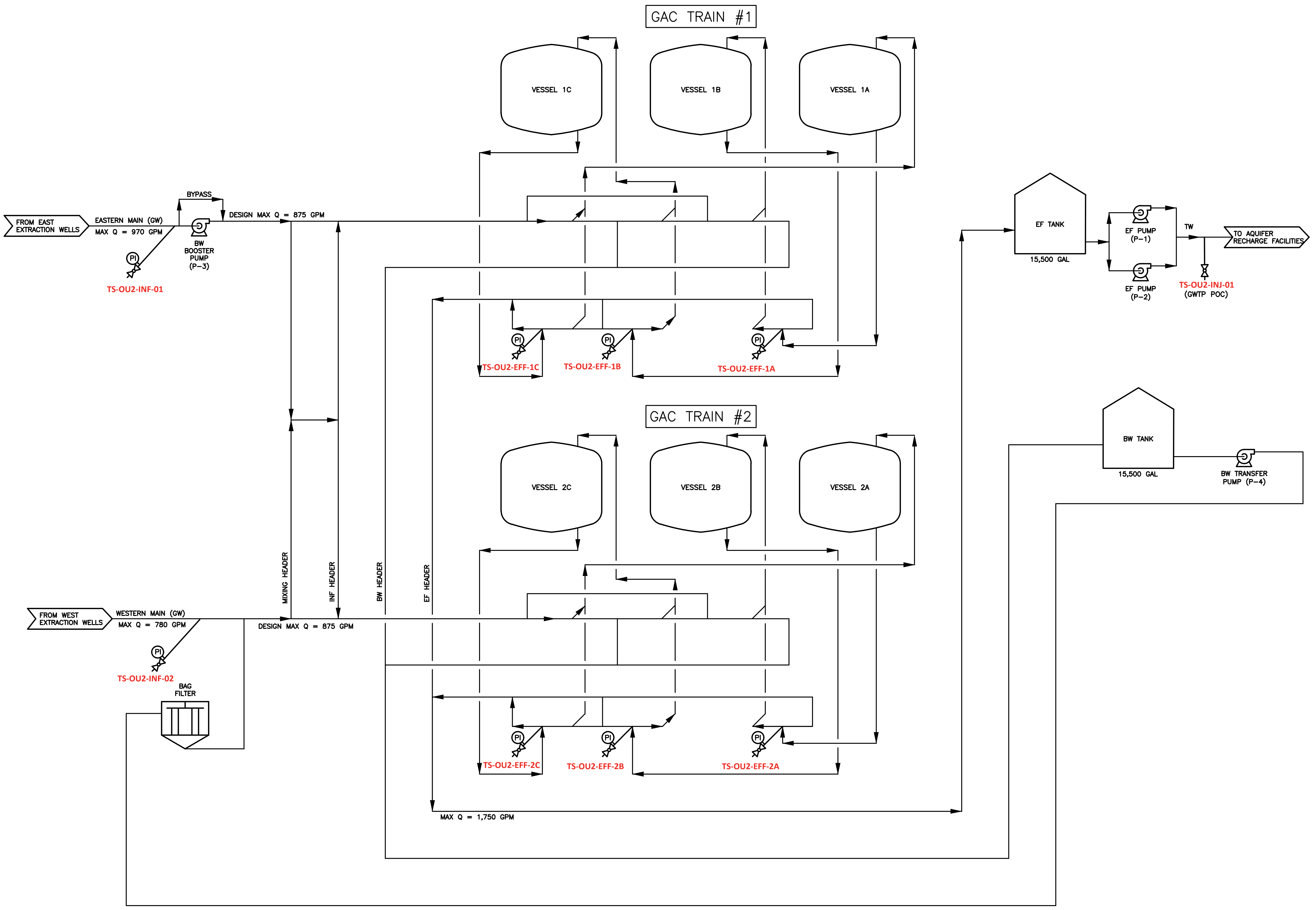
Figure:
5B

OU2 and OUCTP
Upper 180-Foot Aquifer
Groundwater Remedies Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
6



Legend

ABBREVIATIONS

BW	BACKWASH
EF	EFFLUENT
GAC	GRANULAR ACTIVATED C
GAL	GALLONS
GPM	GALLONS PER MINUTE
GW	GROUNDWATER (UNTREA
GWTP	GROUNDWATER TREATME
MAX	MAXIMUM
PI	PRESSURE INDICATOR
POC	POINT OF COMPLIANCE
Q	FLOW RATE
SP	SAMPLE PORT
TW	TREATED WATER

NOTES

1. VALVES ARE NOT INDICATED.
2. FLOW ARROWS INDICATE NORI OPERATION, WITH VESSEL SEC A–B–C IN EACH GAC TRAIN.

Locations in red font are sample locations

Note: The lead GAC vessel effluent will be sampled at the time of the sampling event

OU2 Groundwater Treatment Plant Schematic

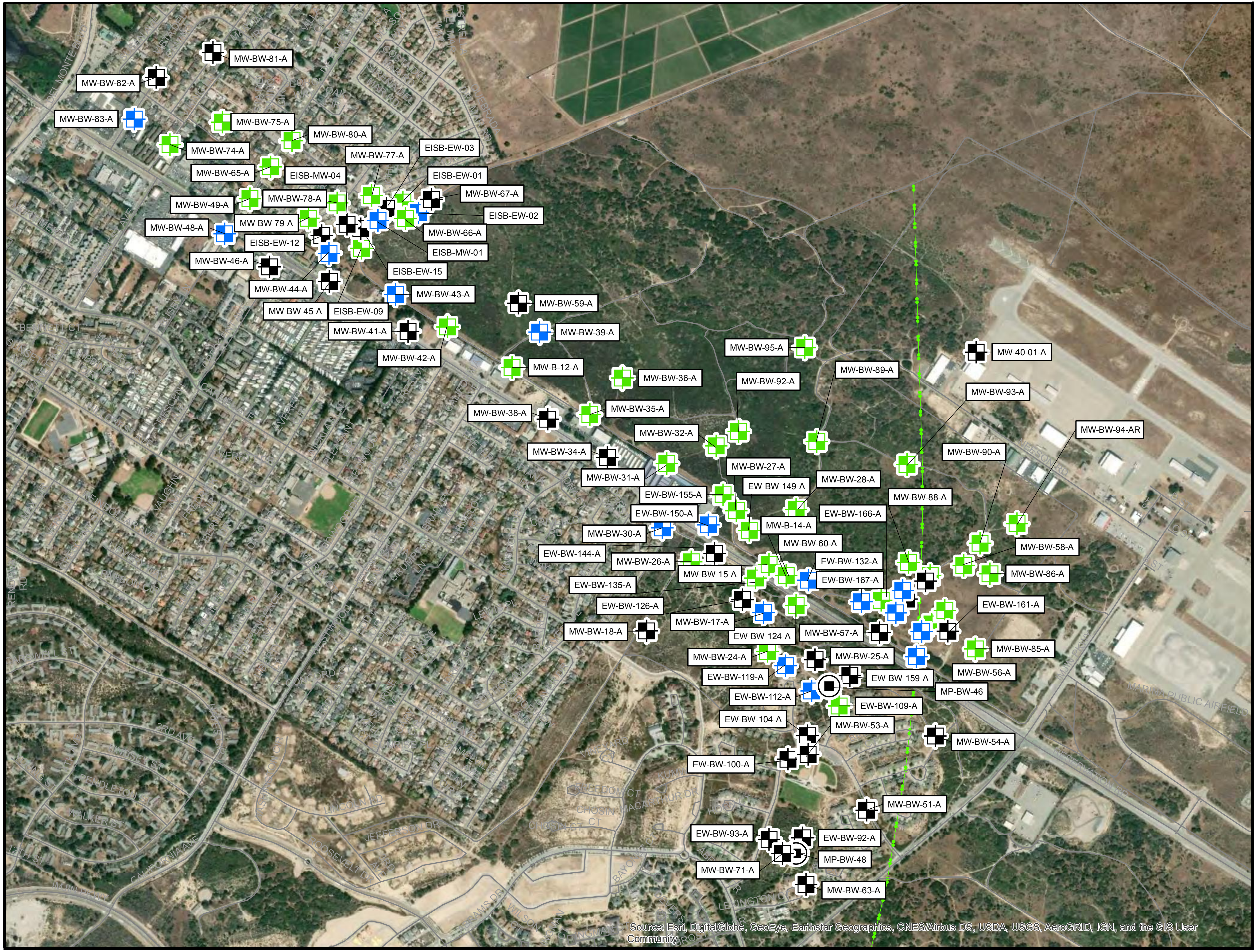
Quality Assurance Project Plan
Former Fort Ord, California
Volume I, Appendix A
Revision 7, Groundwater Remedies and Monitoring at Operable Unit 2, Sites 2 and 12, and Operable Unit Carbon Tetrachloride Plume

Ahtna
RORE ITSI

Figure
7

FILENAME:P:\Projects\JRGF JV0001RDRE JV GWTP Fort Ord\10.0 CADD\400_CADD Current Drawins\26.0 DandM _Figures\Fig 2-5.dwg

SAVED: Monday, 26 February 2018 - 9:54AM PRINTED: 26-FEB-2018



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

— Roads

•–•–• Groundwater Divide

OUCTP-A Wells 2019-2Q

Well Type and Sample Schedule

🟩 Monitoring Well - Quarterly VOCs

🟢 Multi-Port Well - Quarterly VOCs

🟦 Monitoring Well - Annual VOCs

■ Monitoring Well - Water Levels

● Multi-Port Well - Water Levels

0 300 600 1,200 Feet

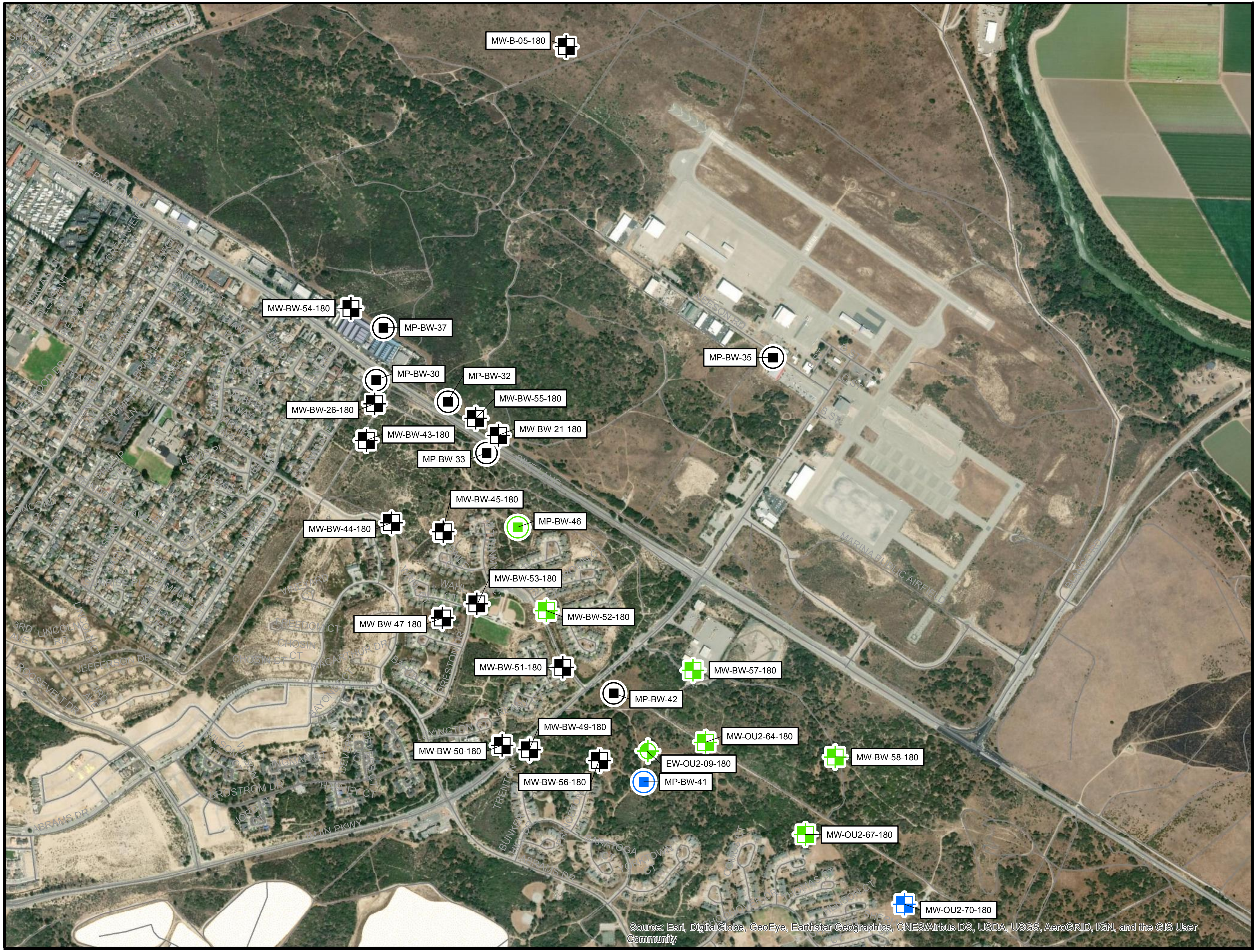
N

OUCTP A-Aquifer Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
8A



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

— Roads

▨ Fort Ord Landfills

OUCTP-Upper Wells 2018-3Q

Well Type and Sample Schedule

- Extraction Well - Quarterly VOCs
- Monitoring Well - Quarterly VOCs
- Multi-Port Wells - Quarterly VOCs
- Monitoring Well - Annual VOCs
- Multi-Port Well - Annual VOCs
- Monitoring Well - Water Levels
- Multi-Port Well - Water Levels

N

0 375 750 1,500 Feet

OUCTP Upper 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

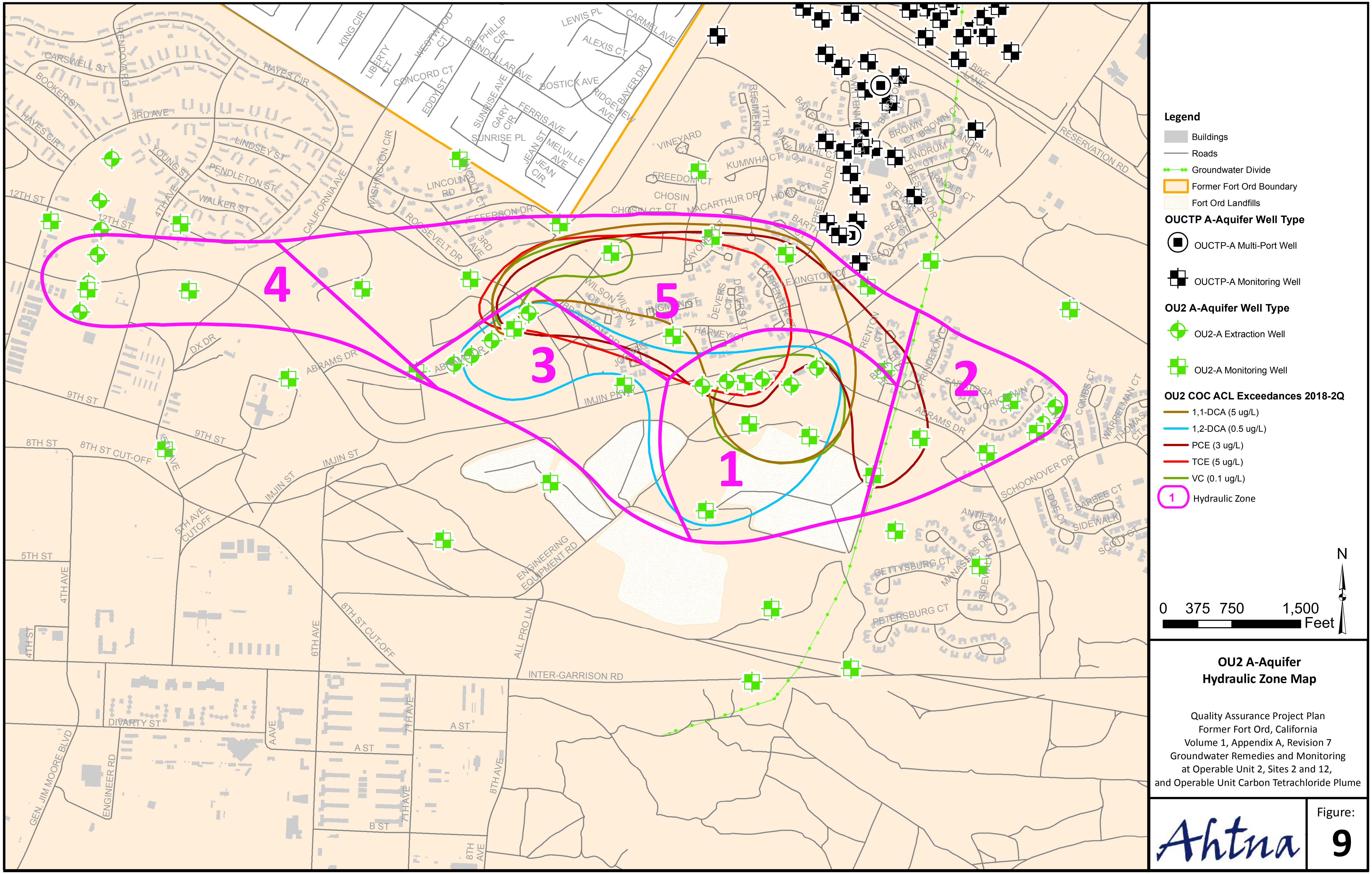
Figure:
8B

OUCTP Lower 180-Foot Aquifer Groundwater Monitoring Program Sampling Locations

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
8C

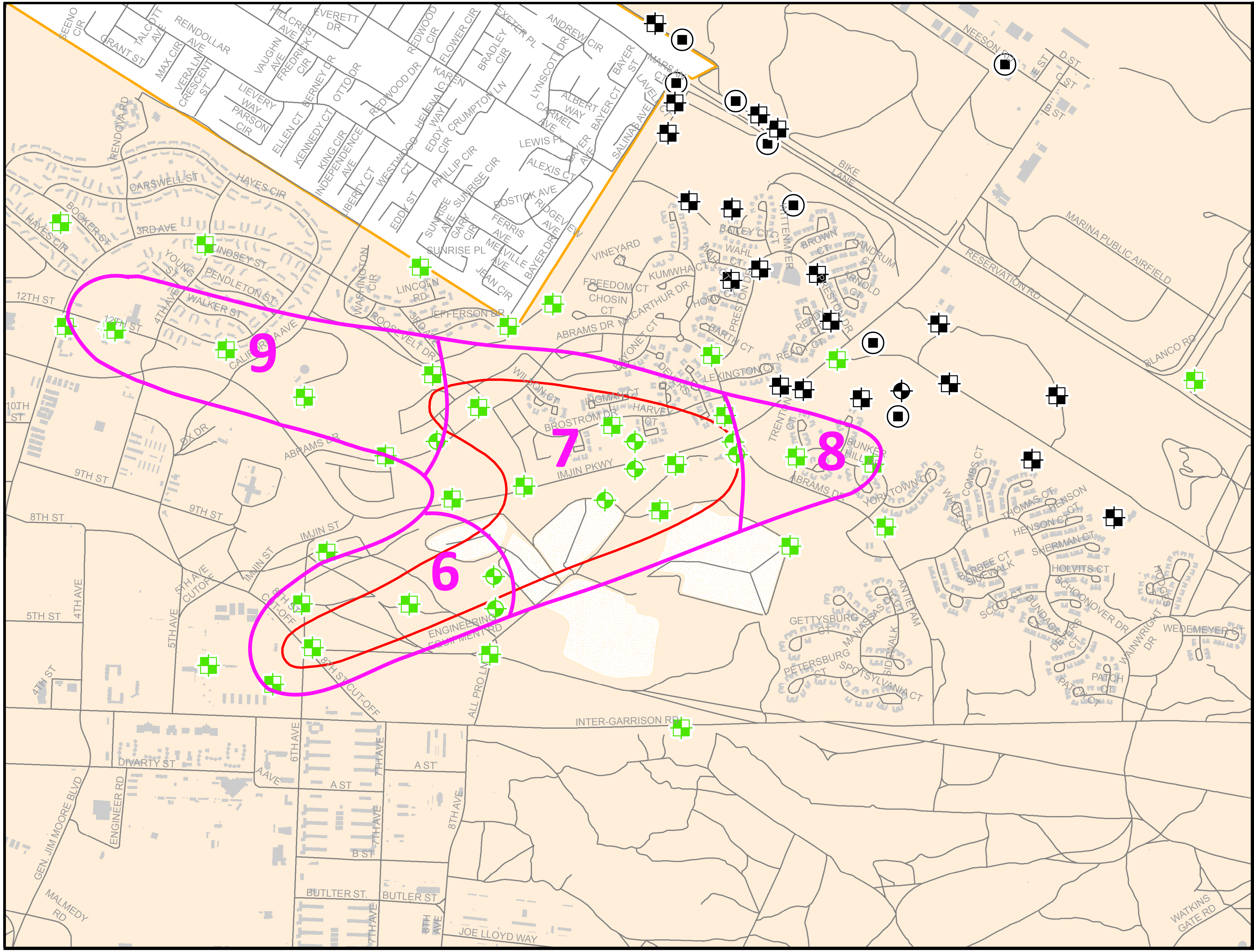


OU2 A-Aquifer
Hydraulic Zone Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
9



Legend

OUCTP Upper Well Type

- ⊕ OUCTP-U Extraction Well
- ⊙ OUCTP-U Multi-Port Well
- ▣ OUCTP-U Monitoring Well

OU2 Upper Well Type

- ⊕ OU2-U Extraction Well
- ▣ OU2-U Monitoring Well

OU2 COC ACL Exceedance 2018-2Q

- — TCE (5 ug/L)
- ▨ Buildings
- — Roads
- ▨ Fort Ord Landfills
- ▭ Former Fort Ord Boundary
- ⓵ Hydraulic Zone

0 375 750 1,500 Feet

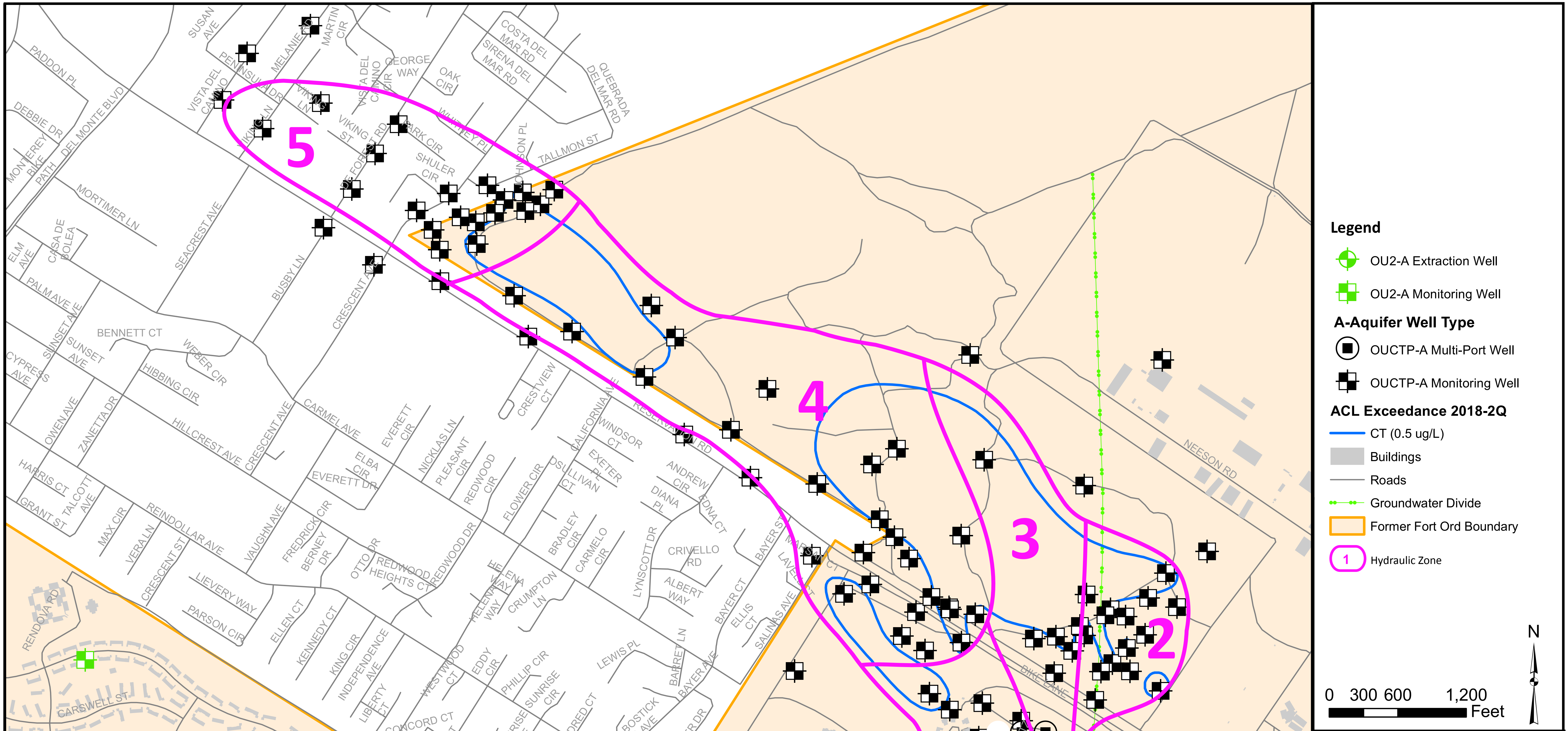
N

OU2 Upper 180-Foot Aquifer Hydraulic Zone Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
10

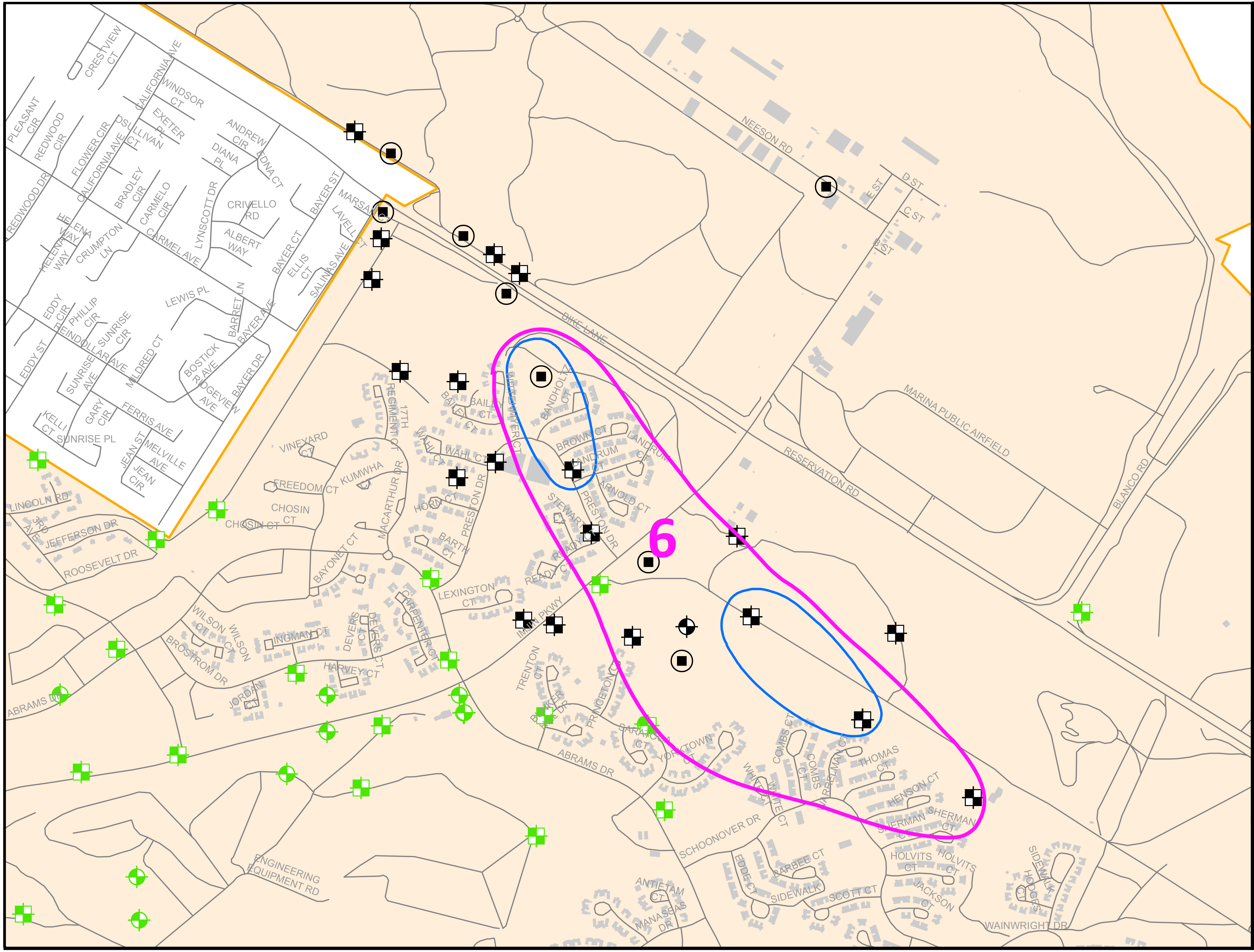


OUCTP A-Aquifer Hydraulic Zone Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
11



Legend

⊕ OU2-U Extraction Well

▣ OU2-U Monitoring Well

⊕ OUCTP-U Extraction Well

◉ OUCTP-U Multi-Port Well

▣ OUCTP-U Monitoring Well

ACL Exceedance 2018-2Q

― CT (0.5 ug/L)

▬ Buildings

― Roads

▭ Former Fort Ord Boundary

① Hydraulic Zone

N

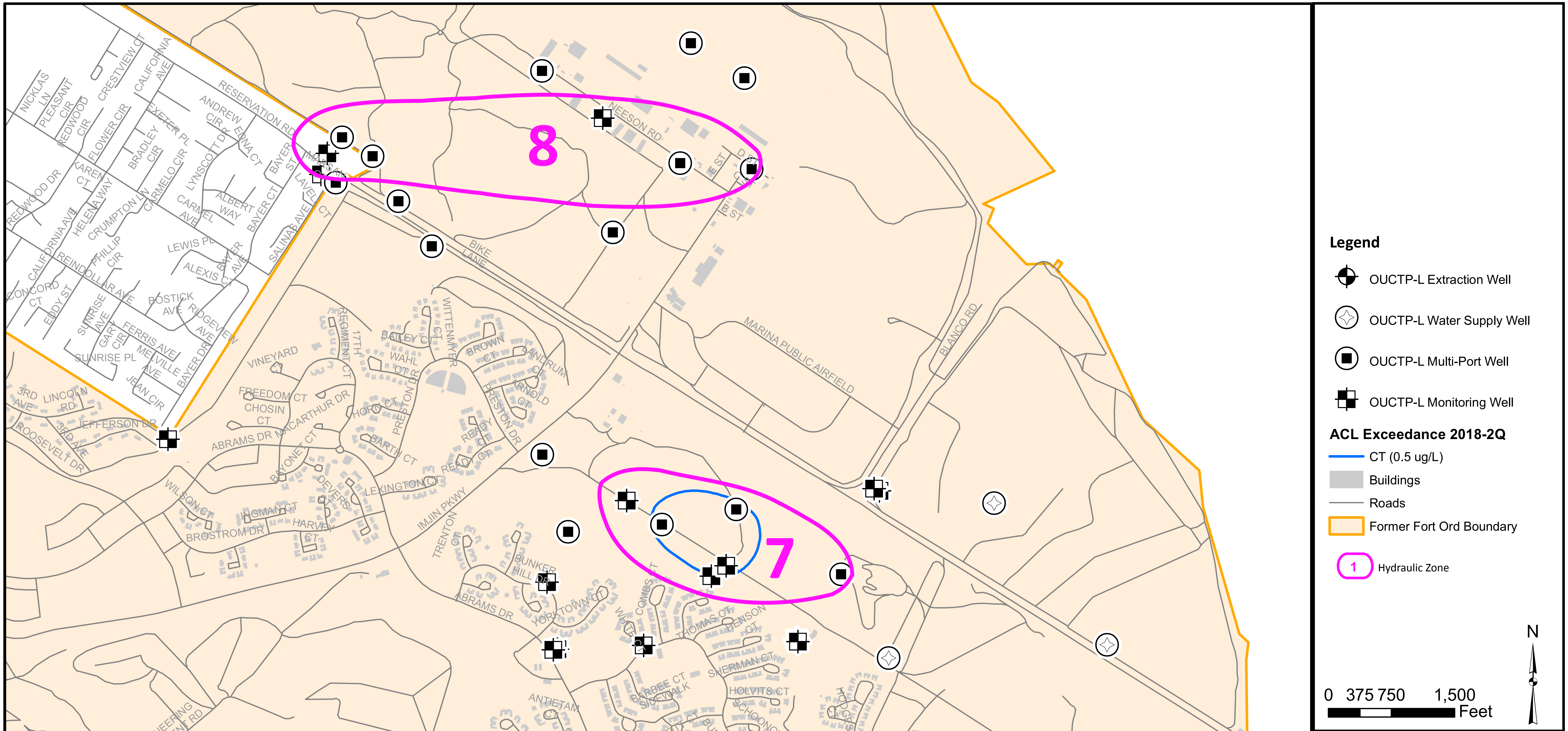
0 300 600 1,200 Feet

OUCTP Upper 180-Foot Aquifer Hydraulic Zone Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
12



Legend

- OUCTP-L Extraction Well
- OUCTP-L Water Supply Well
- OUCTP-L Multi-Port Well
- OUCTP-L Monitoring Well

ACL Exceedance 2018-2Q

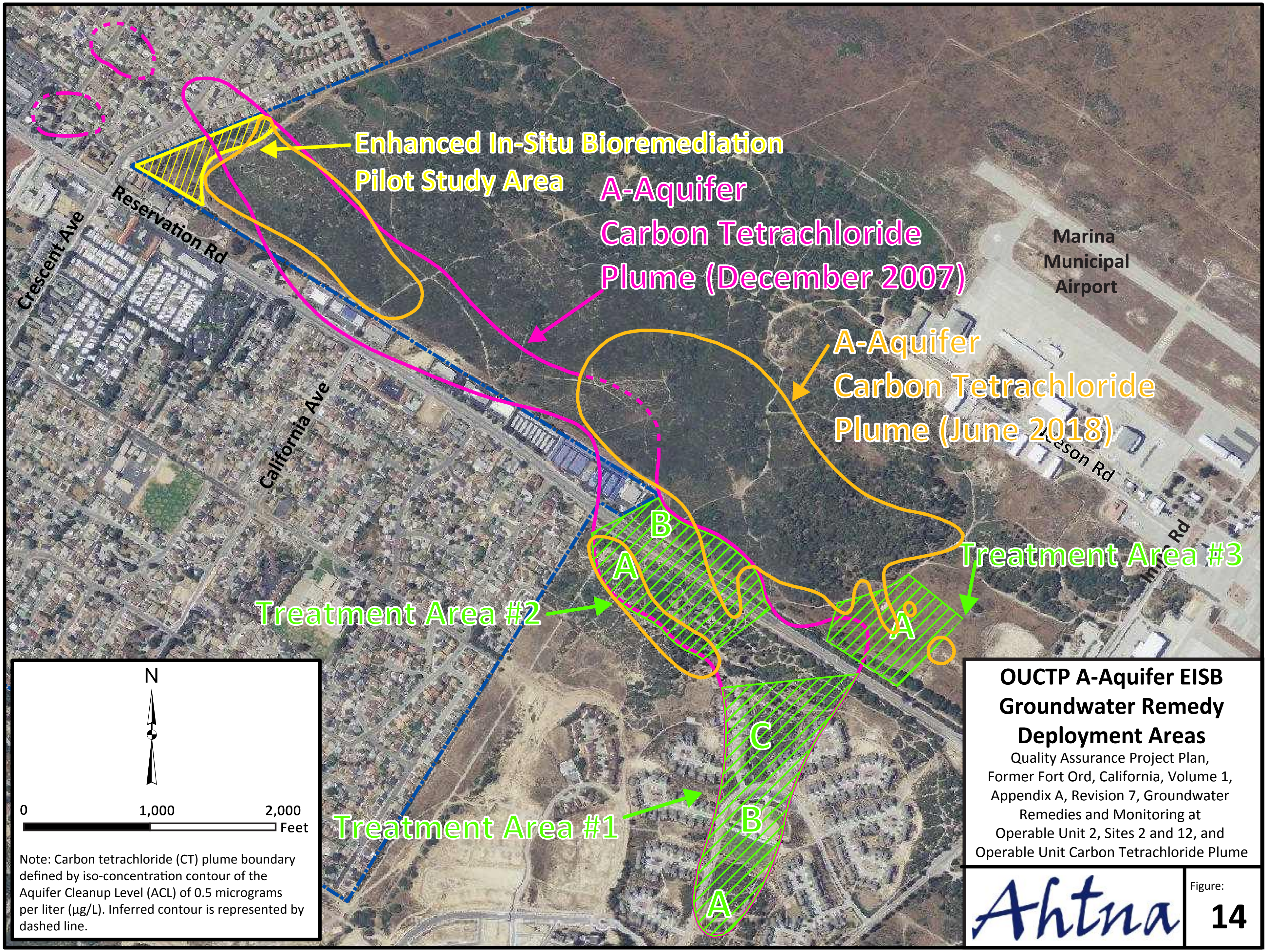
- CT (0.5 ug/L)
- Buildings
- Roads
- Former Fort Ord Boundary
- 1 Hydraulic Zone

OUCTP Lower 180-Foot Aquifer Hydraulic Zone Map

Quality Assurance Project Plan
Former Fort Ord, California
Volume 1, Appendix A, Revision 7
Groundwater Remedies and Monitoring
at Operable Unit 2, Sites 2 and 12,
and Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
13



Note: Carbon tetrachloride (CT) plume boundary defined by iso-concentration contour of the Aquifer Cleanup Level (ACL) of 0.5 micrograms per liter (µg/L). Inferred contour is represented by dashed line.

OUCTP A-Aquifer EISB Groundwater Remedy Deployment Areas

Quality Assurance Project Plan,
Former Fort Ord, California, Volume 1,
Appendix A, Revision 7, Groundwater
Remedies and Monitoring at
Operable Unit 2, Sites 2 and 12, and
Operable Unit Carbon Tetrachloride Plume

Ahtna

Figure:
14

TABLE

Table 1: Summary of Existing Monitoring Wells and Samples Collected Annually

Site	Aquifer	Total Number[1] of Wells Per Aquifer	Number of Army-Owned Wells	Total Number of Sample Ports Currently Sampled	Number of Well/Ports Sampled Quarterly	Number of Wells/Ports Sampled Annually	Number of Wells Not Sampled (water level only)	Number of Samples Collected Annually[2]
Sites 2 and 12	A	0	0	0	0	0	0	0
	Upper 180	38	38	24	19	5	14	89
	Lower 180	1	1	0	0	0	1	0
	Subtotal	**39**	**39**	**24**	**19**	**5**	**15**	**89**
Operable Unit 2	A	59	59	40	39	1	19	173
	Upper 180	45	45	31	29	2	14	130
	Lower 180	0	0	0	0	0	0	0
	Subtotal	**104**	**104**	**71**	**68**	**3**	**33**	**303**
Operable Unit Carbon Tetrachloride Plume	A	95	95	62	43	19	33	210
	Upper 180	37	37	9	7	2	28	33
	Lower 180	95	89	24	21	3	71	96
	Subtotal	**227**	**221**	**95**	**71**	**24**	**132**	**339**
Total Number of Samples Collected Annually								**730**

Notes:

[1] Number of wells in the groundwater monitoring program (not including wells not measured for depth to water and to be decommissioned at a later date).

[2] Includes duplicate samples collected during groundwater monitoring at a frequency of 10 percent (%) per quarterly event.

ATTACHMENTS

ATTACHMENT A

Standard Operating Procedures (SOPs)

Sampling SOPs

1. Westbay MOSDAX Sampler Probe – Model 2531 Operations Manual
2. Passive Diffusion Bag (PDB) Sampling Protocol
3. HydraSleeve Field Manual
4. Supply and Irrigation Well Sampling Protocol
5. OU2 and Sites 2/12 GWTSs and OUCTP EISB Extraction Well Sample Handling and Custody Requirements
6. Low Flow Groundwater Quality Parameter Collection
7. Downhole Meter Groundwater Quality Parameter Collection

OPERATIONS MANUAL

Westbay MOSDAX Sampler Probe - Model 2531

Schlumberger
WATER SERVICES

NOTICE

Operation of Westbay System equipment should only be undertaken by qualified instrument technicians who have been trained by Westbay authorized personnel.

This document contains proprietary information. No part of this document may be photocopied, reproduced or translated to another language without the prior written consent of Westbay Instruments Inc. The information contained in this document is subject to change without notice.

DO NOT OPEN THE SAMPLER

All warranties expressed or implied will be void if, after examination by Westbay Instruments Inc. personnel, it is established that any of the instrument housings have been opened without prior authorization from Westbay Instruments Inc.

DO NOT LET THE SAMPLER FREEZE

Extreme care should be taken to avoid freezing the MOSDAX Sampler probe. Permanent transducer damage may result from freezing.

Manual Revision: 1.13 20 October 2006

Issued for Serial No.: ____________________

Date: ____________________

Signature: ____________________

Contents

1. DESCRIPTION 1

  1.1 MOSDAX Sampler Probe, Model 2531 1

  1.2 MOSDAX Automated Groundwater Interface (MAGI), Model 2536 1

  1.3 Cable Reels 1

  1.4 Sample Containers 1

2. PRESSURE PROFILING 2

  2.1 Items Required 2

  2.2 Surface Checks 2

  2.3 Pressure Measurement Procedures 3

3. FLUID SAMPLING 4

  3.1 Items Required 4

  3.2 Surface Checks and Preparation 4

  3.3 Drillhole Sampling 5

  3.4 Rinsing Instructions 5

4. CARE AND MAINTENANCE 6

  4.1 MPCI 6

  4.2 Cable Reels and Control Cable 6

  4.3 MOSDAX Sampler Probe 6

    4.3.1 Face Seal 6

    4.3.2 Location Arm 6

    4.3.3 Button Shoe Replacement 7

    4.3.4 Actuator Nut 7

5. CALIBRATION 7

6. SPARE PARTS LIST 8

1. DESCRIPTION

1.1 MOSDAX Sampler Probe, Model 2531

The MOSDAX Sampler is a downhole probe designed to collect fluid pressure information and fluid samples from Westbay System monitoring wells. Each MOSDAX pressure sensor is calibrated over its full pressure range for nonlinearity and temperature variation. MOSDAX Sampler probes are available in a variety of pressure ranges to permit operation to various depths. The shoe and valve motors can be operated from the surface. The power for the shoe and valve motors is supplied from the surface.

1.2 MOSDAX Automated Groundwater Interface (MAGI), Model 2536

The MOSDAX Sampler can be operated directly by the keypad on the MOSDAX Automated Groundwater Interface (MAGI), or by a Hand Held Controller (HHC) connected to the MAGI, or with a computer running Microsoft Windows (2000 or higher) and Westbay software connected to the MAGI. The MAGI translates the signals between the computer or HHC and the MOSDAX Sampler. The MAGI requires 12 volt DC power to operate.

Older versions of MOSDAX sampling equipment may incorporate a Model 2522 MOSDAX PC Interface (MPCI) and HHC rather than a MAGI. For such systems, reference to the MAGI in this document can be considered as reference to the MPCI and HHC.

1.3 Cable Reels

The manual cable reel can operate all Westbay probes and tools to a depth of 300m (1,000 ft) on a single-conductor cable. The manual reel is hand operated with an internal brake to control the speed of descent of the probe in the well. The two-pin cable connects the MAGI to the reel and the signals pass through a slipring located in the hub of the reel into the control cable. For maintenance information, see the appropriate cable reel manual.

Motorized cable reels are available for deeper applications.

1.4 Sample Containers

Sample containers can be used with the MOSDAX Sampler. The nonvented stainless steel sample containers maintain samples under formation pressure while the sampler and container are brought to the surface.

2. PRESSURE PROFILING

2.1 Items Required

- MOSDAX Sampler Probe, Model 2531
- MAGI, Model 2536 with:
  - one two-pin data cable
  - one three-pin power cable
  - hand held controller with cable and user’s guide (optional)
  - computer running Windows 2000 or higher with one nine-pin computer cable and MProfile software (optional)
- MOSDAX-compatible winch with cable
- Sheave with counter and tripod
- 12 VDC, 2 Amp power source (Battery pack, car/truck battery, or transformer)
- Water level measuring tape
- MProfile User's Guide for computer or the Handheld Controller Operations Manual
- Westbay Casing Log showing depths to ports and couplings in hole to be tested.

2.2 Surface Checks

1. Remove the MOSDAX Sampler from its storage case. Inspect the probe housing and body for any damage. Please contact Westbay for advice on any cover tube damage.
2. Assemble the tripod and counter over the well. Run the cable over the counter.
3. Connect the probe to the cable. Before attaching, inspect the O-ring at the top of the probe and lubricate with silicon. The O-ring should be clean and intact. Tighten the nut hand tight only.
4. Connect the two-pin cable from the MPCI to the cable reel. With the MPCI OFF connect the three-pin cable from the MPCI to the 12 v power supply.
5. Connect the 9 pin cable from computer or HHC to the MPCI and turn the MPCI ON.
6. Perform the following surface checks to ensure that the location arm and the shoe mechanisms are operating normally: Release the location arm. The location arm should extend smoothly. The number of revolutions used to release the location arm is displayed and should be 15 to 16 revolutions. If a smaller number of revolutions is reported, retract the arm and repeat. Place the probe in a piece of Westbay casing or coupling. Activate the shoe. The shoe should extend and hold the probe firmly in the coupling or casing. The display should indicate 16 to 19 revolutions. A reading of 23 revolutions indicates the probe is activated in open air. Retract the backing shoe.

7. Check that the face plate for sampling and the plastic plunger are installed on the sampler.
8. The probe is now ready to be lowered down the well.

2.3 Pressure Measurement Procedures

1. Obtain the completed Westbay Casing Log.
2. With the location arm retracted, lower the probe into the Westbay casing to immediately below the lowest measurement port coupling to be monitored. If magnetic collars have been installed on the well, the Collar Detect Command can be used to detect the collars. The Collar Detect Command is cancelled by pressing any key.
3. Release the location arm. The display should update and beep after the arm is released.
4. Raise the probe about 0.5 m (1.5 ft) above this measurement port. If the probe is accidentally lifted above the next higher coupling, it will be necessary to retract the location arm and lower the probe to below the measurement port and release the arm.
5. Lower the probe gently until the location arm rests in the measurement port.
6. Record the pressure and temperature inside the Westbay casing.
7. Optional: If a water level tape is available, measure and record the depth to water in the Westbay casing.
8. Activate the shoe. The pressure on the display should change to the formation pressure.
9. When the reading has stabilized, record the formation pressure.
10. Once the pressure has been recorded, retract the shoe.
11. Record the pressure of the fluid in the Westbay casing. This reading should be similar to that recorded in Step 6. If a large difference is noted between the readings, record the water level inside the Westbay casing again using the water level tape.
12. The three pressure readings plus the time and water level constitute a complete set of readings at a measurement port coupling.
13. Continue up the Westbay casing to obtain the pressure data from other measurement ports.
14. Take one last set of pressure and temperature readings at the surface. These readings should be similar to those recorded in Step 2.

CAUTION: If a water level tape was used, remove the water level tape from the Westbay casing before removing the sampler probe from the well to prevent them from becoming jammed.

3. FLUID SAMPLING

3.1 Items Required

- MOSDAX Sampler, Model 2531
- MAGI, Model 2536 with:
  - one two-pin data cable
  - one three-pin power cable
  - hand held controller with cable and user's guide (optional)
  - computer running Windows 2000 or higher with one nine-pin computer cable and MProfile software (optional)
- MOSDAX-compatible winch with cable
- Sample containers and connecting tubes
- Westbay Casing Log
- Groundwater Sampling Field Data Sheet
- 12 VDC, 2 amp power source (battery pack, car/truck, or transformer)
- Counter and tripod
- Westbay Sampling Kit including vacuum pump

3.2 Surface Checks and Preparation

1. Set up the MOSDAX Sampler probe following Steps 1 through 8 of Section 2.2.
2. Attach the sample containers.
3. Release the location arm. Locate the probe in the vacuum coupling.
4. Activate the shoe in the vacuum coupling.
5. Close the sampler valve. The motor should run about 5 seconds. The display should indicate one revolution.
6. Use the vacuum pump to apply a vacuum through the vacuum coupling. The vacuum should remain constant. If the vacuum is not maintained, inspect for leaks at the face seal of the probe, the connection to the pump and at the probe sampling valve.
7. Once a vacuum has been maintained, open the sampler valve. Apply a vacuum again to check that all connections are sealed.
8. Close the sampler valve. A vacuum has now been applied to the sample bottles.
9. Retract the shoe.

3.3 Drillhole Sampling

1. Check recent pressure logs of the hole and ensure that the head inside the Westbay casing is lower than the head outside the measurement port to be sampled.
2. After completing the surface checks, follow Steps 1 to 5 of Section 2.3 to locate the sampler at the measurement port in the monitoring zone to be sampled.
3. Record the pressure reading.
4. Activate the probe and record the formation pressure.
5. Open the sampler valve. The pressure should drop and then slowly increase as the bottles fill. When the pressure in the bottle equals the zone pressure from Step 4, the bottle is full. Wait a maximum of two minutes per sample bottle even if the pressures are not equal.
6. Close the sampler valve and retract the shoe.
7. Record the pressure reading. A reading the same as in Step 3 indicates that the sample is OK.
8. Reel the sampler to the surface and remove it from the Westbay casing.
9. **Do not open the sampler valve as damage to the probe or injury to the operator could occur.**
10. Remove the cap from the bottom sample bottle and open the valve on the bottle to release the pressure and to transfer the sample.
11. Open the sampler valve to allow the sample to flow from the bottles. Once the pressure in the sampler and bottles has decreased to atmospheric, the bottles may be disconnected to speed the process.
12. Take particular care in handling pressurized samples.

3.4 Rinsing Instructions

Rinse the sampler around the face seal and the bottom connector. With the sampler valve open, flush the interior of the sampler from the bottom connector. Rinse the sample bottles and connectors.

Note: Project specific procedures for decontaminating the sampler and sample bottles are the responsibility of the project manager and are not covered in this manual.

4. Care and Maintenance

The MOSDAX Sampler System must be routinely maintained for optimum performance. The procedures outlined here are required to keep the instrument operating properly. For any additional information or advice, please contact Westbay Instruments Inc.

4.1 MAGI

The MAGI should be cleaned to remove dirt and dust and inspected for damage or wear. If any part requires replacement, contact Westbay for information.

4.2 Cable Reels and Control Cable

The cable reels should be kept clean and protected from damage. The cable and cable head should be inspected for kinks and corrosion. Rehead the cable if necessary. For more information concerning cable reels and the control cable, refer to the appropriate reel manual.

4.3 MOSDAX Sampler Probe

1. Never allow the probe to freeze or the pressure transducer may be damaged.
2. Clean and inspect the probe for dents and scratches on the cover tube. Clean the threads with a nylon brush, such as a toothbrush. DO NOT use a wire brush. Protect the O-rings from damage and dirt.

4.3.1 Face Seal

Inspect the face seal and replace if damaged or worn.

1. Remove the two screws holding the face plate to the probe body and lift the face plate off.
2. Remove the face seal and plunger. Set the location arm assembly aside. Clean the plunger and probe body.
3. When reinstalling the face plate hold the face seal, plunger and location arm assembly in place. Replace the two screws the hold the face plate on the probe.

4.3.2 Location Arm

Release the location arm. Check that the arm moves smoothly and freely and check for damage and sharp edges due to wear. Replace the location arm if necessary.

1. Release the location arm. Remove the two screws and face plate (Section 4.3.1).
2. Remove the location arm with its spring and pivot pin. Clean and inspect all parts and replace if needed.
3. Insert the spring and pivot in the location arm and place the assembly in the probe body. Place the face plate over the face seal and location arm and tighten the two screws.

SECTION 4.3.2 SUPPLEMENT

WESTBAY Probe Location Arm replacement

a) It is easier when the arm is first extended to the "out" position (Fig. A). Do this before powering down and disconnecting the probe.

b) Remove the face seal slowly and stabilize the arm as it is under tension from the spring (Section 4.3.2.2) and may suddenly pop out. Observe the position and orientation of the parts as they are removed (Fig. B).

c) Insert the hook of bent leg of the spring into the tiny hole on the neck of the new arm and align the spring coil opening alongside the larger hole in the arm with the spring leg positioned directly against the arm and over the pivot facing out (Fig. C-1). The metal pivot pin goes through the hole in the arm and through the spring coil (Fig. C-2). The straight leg of the spring leads under the pivot into the smaller side slot on the side of the main arm aperture, parallel with the probe. Place the assembly into its space in the probe body (Fig. C-3). <u>The arm assembly has to be held in place while replacing the face seal</u> to counter the force of the slightly compacted spring (Fig.C-4).

d) Replace the face seal by sliding it toward the top of the probe and sliding the top edge into the slot while at the same time allowing the arm to protrude through the face seal. The arm should remain in the extended position while screwing down the face seal.

e) Check to see that the arm can be freely, manually pushed in and that it pops back out when released. Attach the probe to the cable and mechanically retract the arm using the MAGI commands.

Parsons, 11/21/07

Figure **A** - Arm is extended out at start of replacement operation.

Figure **B** - Disassembled face seal and location arm.

Figure **C-1 -** Orientation of spring relative to arm.

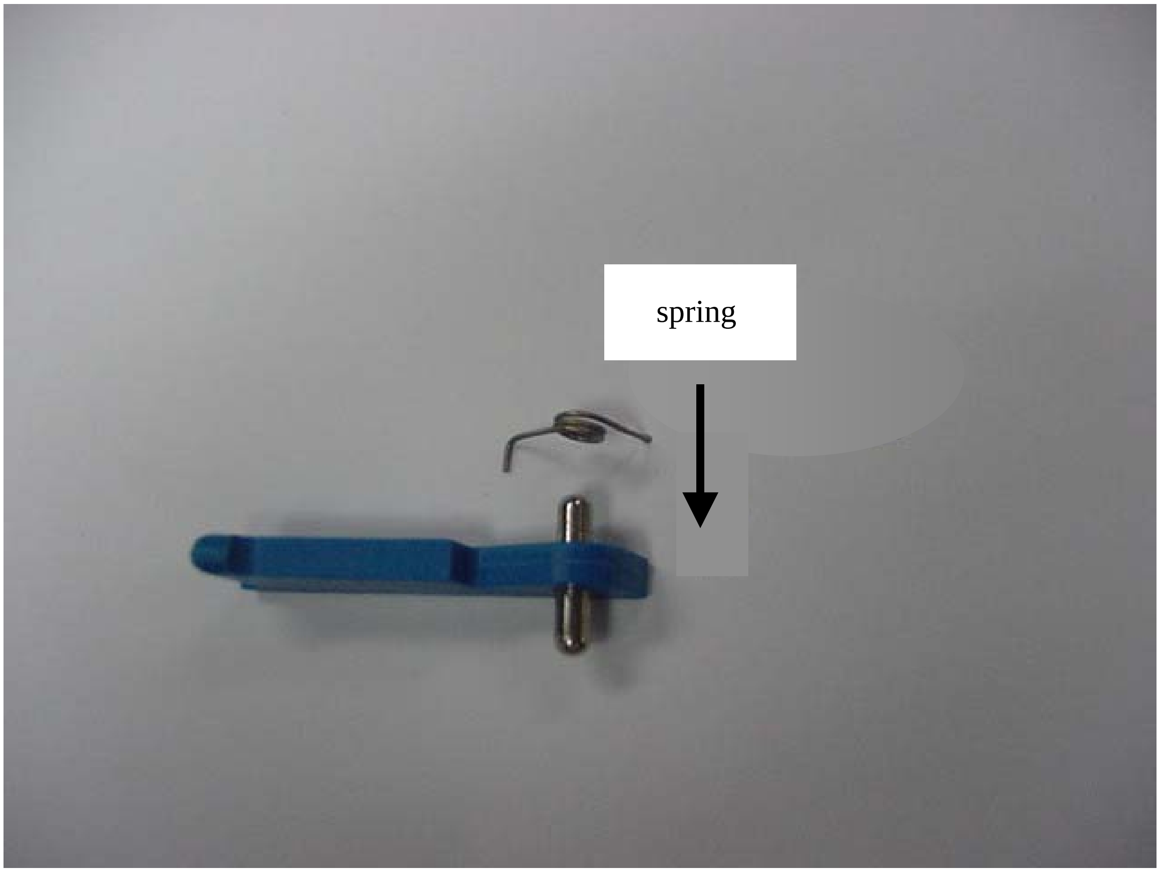


Figure **C-2 -** Position of spring and pivot in the arm.

Figure **C-3 -** Placement of arm assembly.

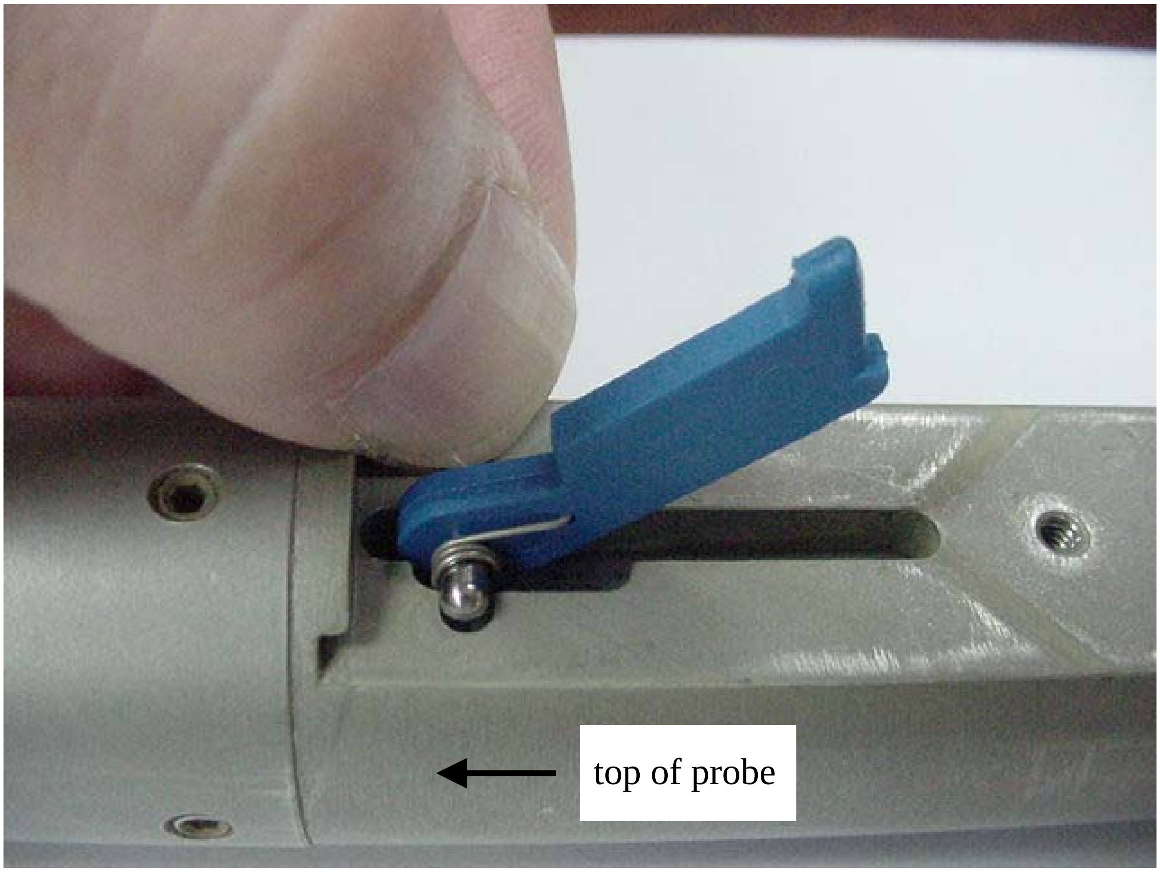
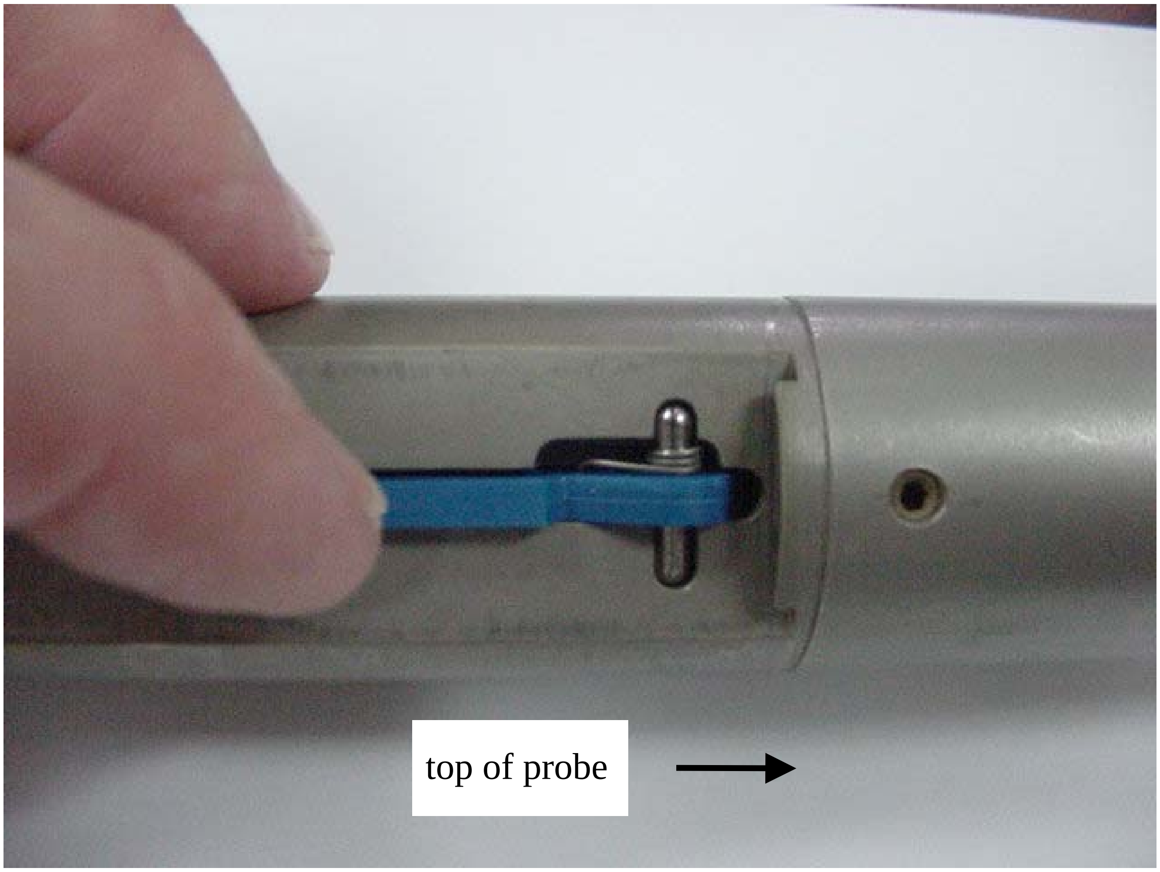


Figure **C-4 -** Top view of arm and spring placement.



Check that the arm is moving freely and the face seal insert and plunger are held securely in place.

4.3.3 Shoe Replacement

Activate the shoe and inspect for damage or wear. The shoe should rotate freely about the pivot pin. When the shoe is retracted it should retract quickly and smoothly back into the probe. The shoe may be replaced in the following manner:

1. Release the location arm and extend the shoe to expose the pivot pin.
2. Unscrew the shoe pivot pin from the lever arm and remove the shoe.
3. Place a new shoe in the lever arm and install the shoe pivot pin.

4.3.4 Actuator Nut

The actuator nut needs to be routinely cleaned to remove particles of grit which can interfere with its movement. Remove the actuator nut in the following manner:

1. Remove the two set screws that hold in the lever arm pivot pin. Using the Allen key, push the lever pivot pin out of the probe body.
2. Remove the set screws on the side of the probe body that holds the plastic support block.
3. Remove the screw closest to the top of the probe.
4. Lift out the lever arm, guide plate, shoe, spring and plastic support block as one unit.
5. Use the Clean Nut Command to remove the actuator nut from the actuator screw. Turn off the MPCI and remove the nut from the probe.
6. Clean the actuator nut with the cleaning tap. Use the Clean Nut Command and clean the actuator screw with a nylon brush. DO NOT use a wire brush.
7. Apply a thin coating of silicone lubricant to the actuator screw. Place the actuator nut in the probe body against the actuator screw and retract the arm to thread the nut onto the actuator screw. Allow the nut to travel along the full length of the screw. YOU MAY HAVE TO REPEAT THIS OPERATION.
8. Install the single unit from Step 4 in the probe body. Install the lever arm pin through the probe body, lever arm, and spring. Lock the pin in position with two set screws.
9. Install the top screw into the guide plate and install the set screws to secure the support block.

5. CALIBRATION

The Westbay System permits frequent or periodic calibration of the transducers used for pressure measurement. Contact Westbay for details.

6. SPARE PARTS LIST

Item	Part No. or Size	Qty
Face Seal Insert	200302	5
Plunger	(see Note 1)	5
Location Arm	252112	5
Shoe	252313	5
Pin 3 (Location Arm)	252320	2
Spring 2 (Location Arm)	252319	2
Pin 1 (Shoe)	252316	2
Spring 1 (Shoe Lever)	252318	2
Pan Head Screw	# 4-40 x 1/4 - inch	2
Pan Head Screw	# 6-32 x 3/16 - inch	2
Pan Head Screw	# 6-32 x 1/2 - inch	2
Hex Socket Head Screw	# 8-32 x 1/8 - inch	4
Hex Socket Head Screw	# 10-32 x 3/16 - inch	4
Hex Socket Set Screw	# 8-32 x 5/16 - inch	2
Allen Key	5/64 - inch	1
Allen Key	3/32 - inch	1
Actuator Nut Tap	208001	1
Cablehead Parts:		
O-ring	# 111 B	2
Termination Sleeve	251805	1
Termination Insert	251806	1
Feedthru Connector	251814	1
Bushing 1	251812	1
Bushing 2	251813	1
O-Ring	# 108 V	1
O-Ring	# 010 V	1
O-Ring	# 004 V	1
Boot	JF0602CF	1
Contact	JF0603CF	1
Cable Heading Tool	208100	1

1. Plunger appropriate to type of measurement port to be accessed.

Schlumberger
WATER SERVICES

Groundwater Sampling

Field Data Sheet

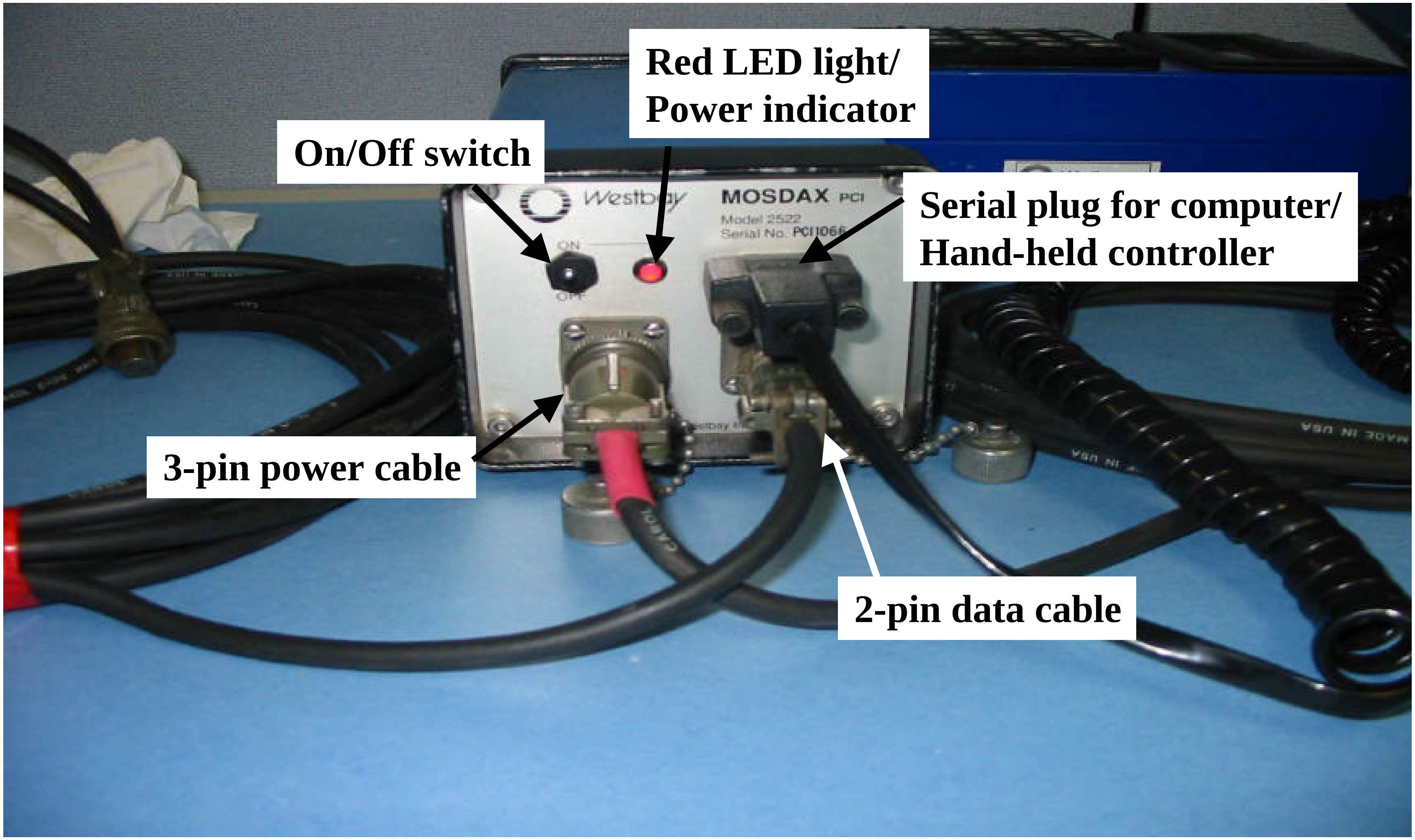
Project: ______________________
Monitoring Well No.: ______________________
Sampling Zone No(s).: ______________________

Date: ______________________
Start Time: __________ Atm. Rdg: __________
End Time: __________ Atm. Rdg: __________
Operators: ______________________

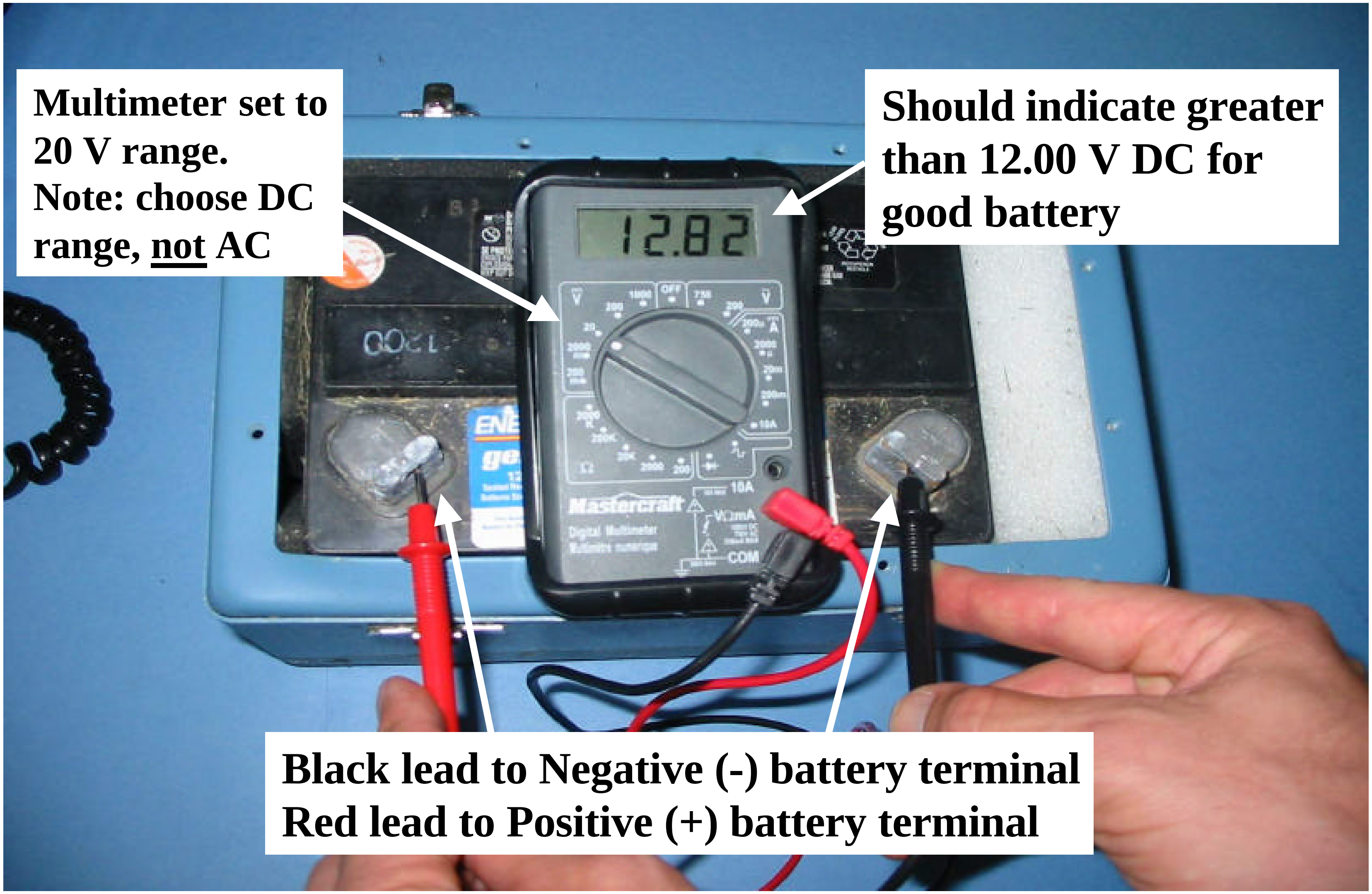
Port No.	Run No.	Surface Function Tests (probe in flushing collar)						Position Sampler			Sample Collection Checks (probe located at sampling zone in Westbay casing)								Comments (volume recovered)
		Shoe Out	Close Valve	Check Vacuum	Open Valve	Apply Vacuum	Close Valve	Locate Port	Arm Out	Land Probe	Pressure in Westbay ( )	Shoe Out	Zone Pressure ( )	Open Valve	Zone Pressure ( )	Close Valve	Shoe In	Pressure in Westbay ( )	

Additional Comments: (pH, turbidity, S.C., etc.)

Pic.1 Computer Interface Units, old and new:
MPCI model 2522 (left) and MAGI model 2536 (right)



Pic.2 MPCI unit showing typical set-up configuration

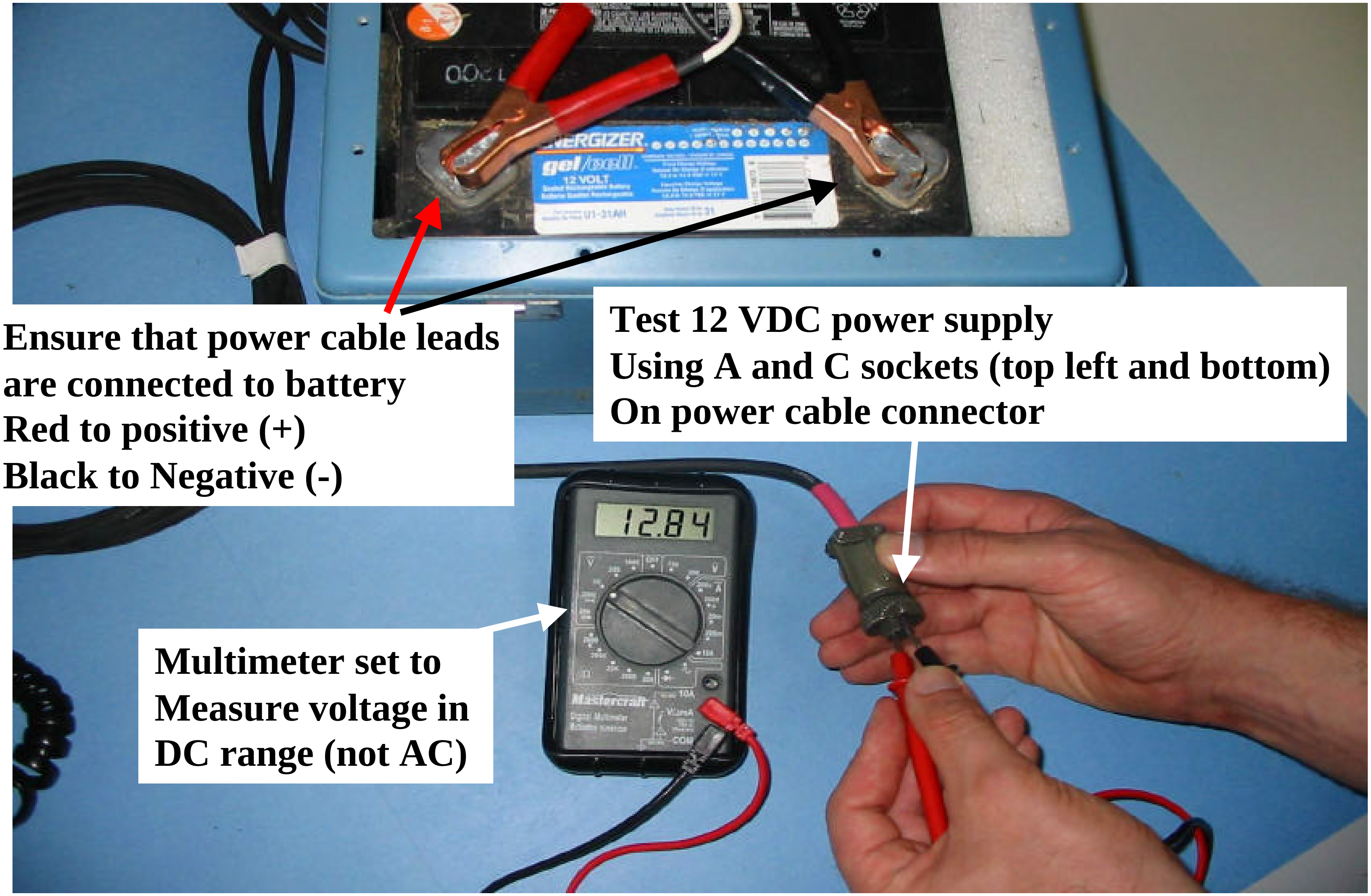


Multimeter set to 20 V range.
Note: choose DC range, not AC

Should indicate greater than 12.00 V DC for good battery

Black lead to Negative (-) battery terminal
Red lead to Positive (+) battery terminal

Pic.3 Testing 12 VDC Power Supply using Multimeter

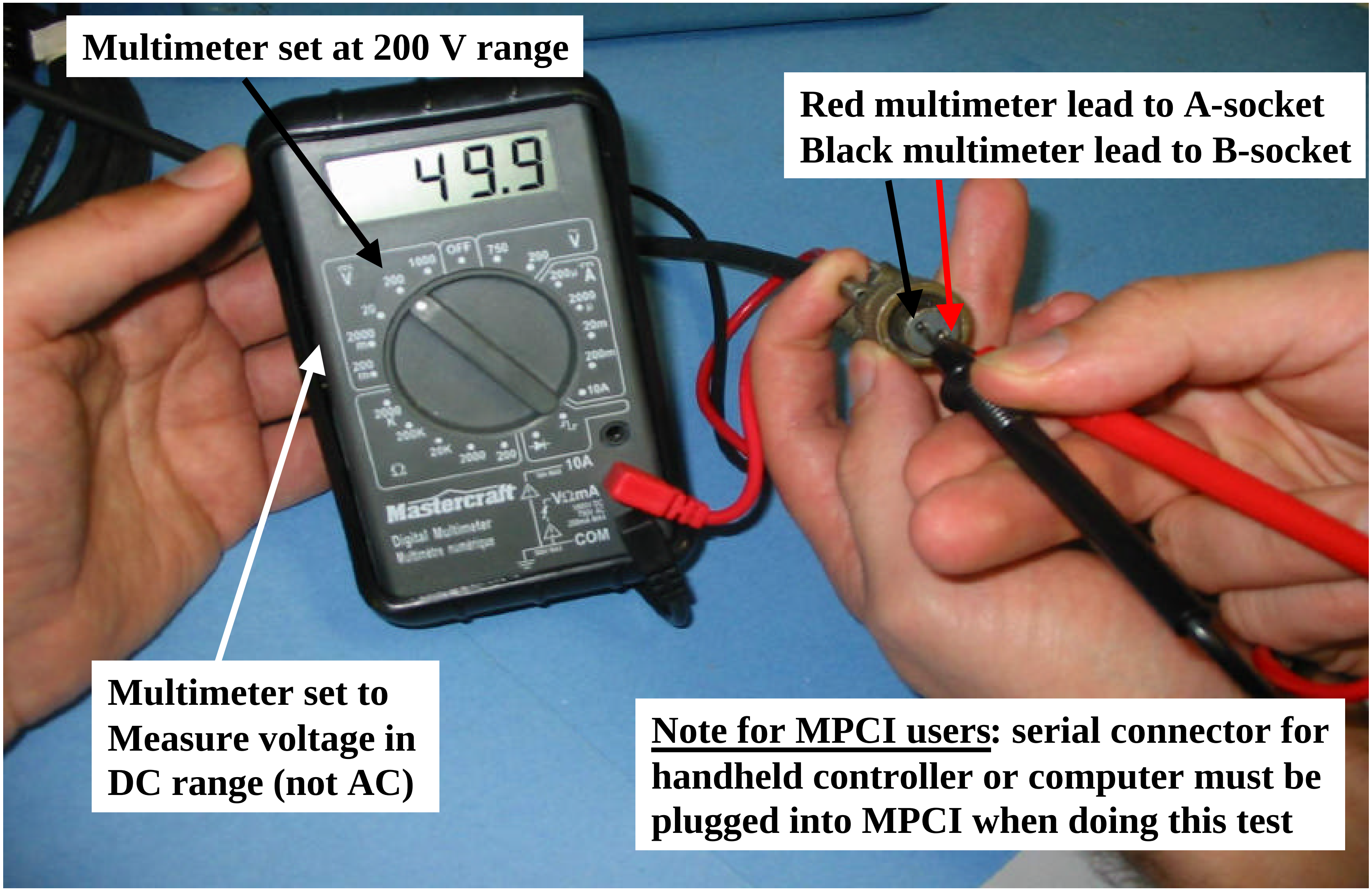


Ensure that power cable leads
are connected to battery
Red to positive (+)
Black to Negative (-)

Test 12 VDC power supply
Using A and C sockets (top left and bottom)
On power cable connector

Multimeter set to
Measure voltage in
DC range (not AC)

Pic.4 Testing Power Cable Voltage
(should indicate greater than 12.00 V DC for good battery and cable)



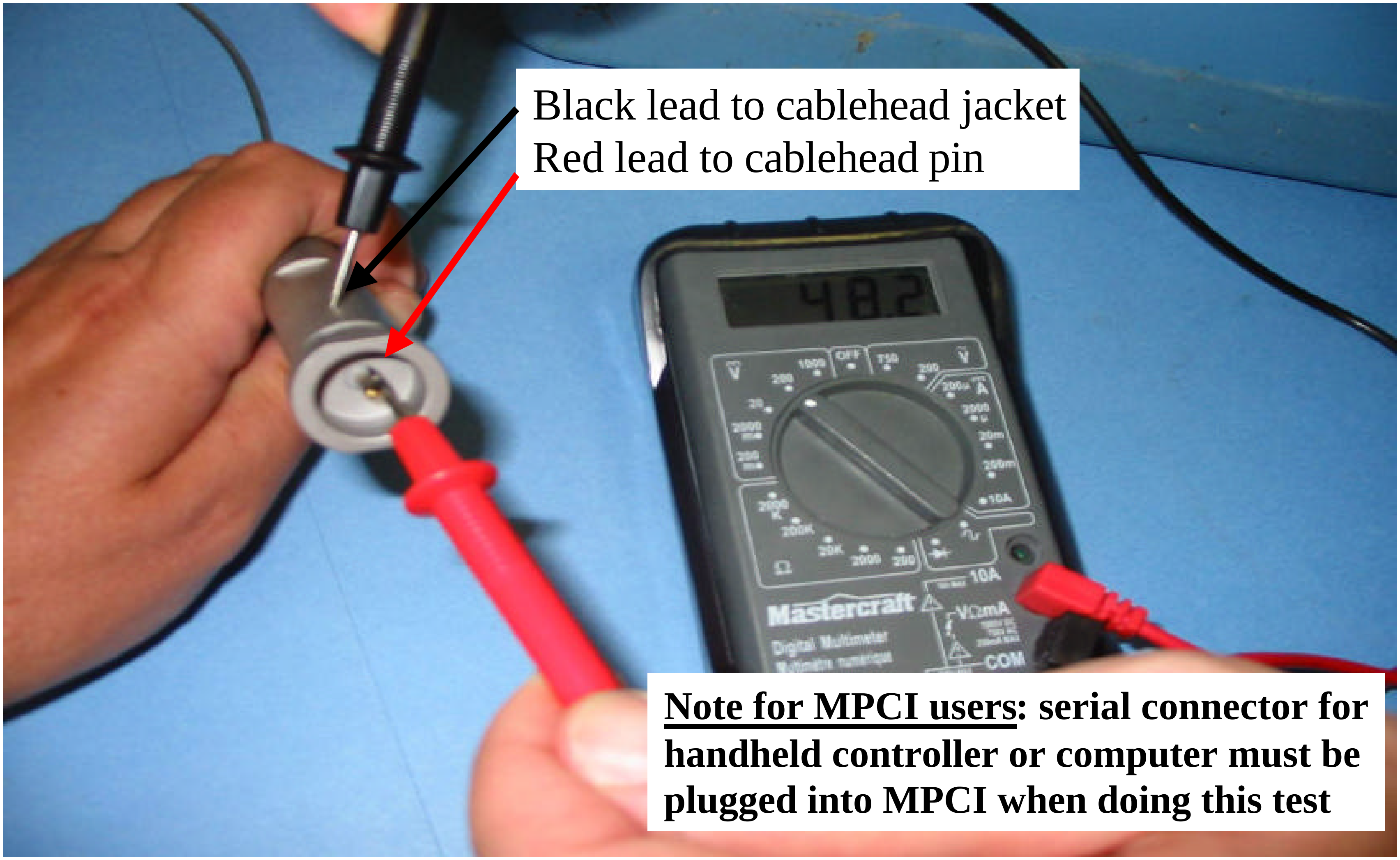
Multimeter set at 200 V range

Red multimeter lead to A-socket
Black multimeter lead to B-socket

Multimeter set to Measure voltage in DC range (not AC)

<u>Note for MPCI users</u>: serial connector for handheld controller or computer must be plugged into MPCI when doing this test

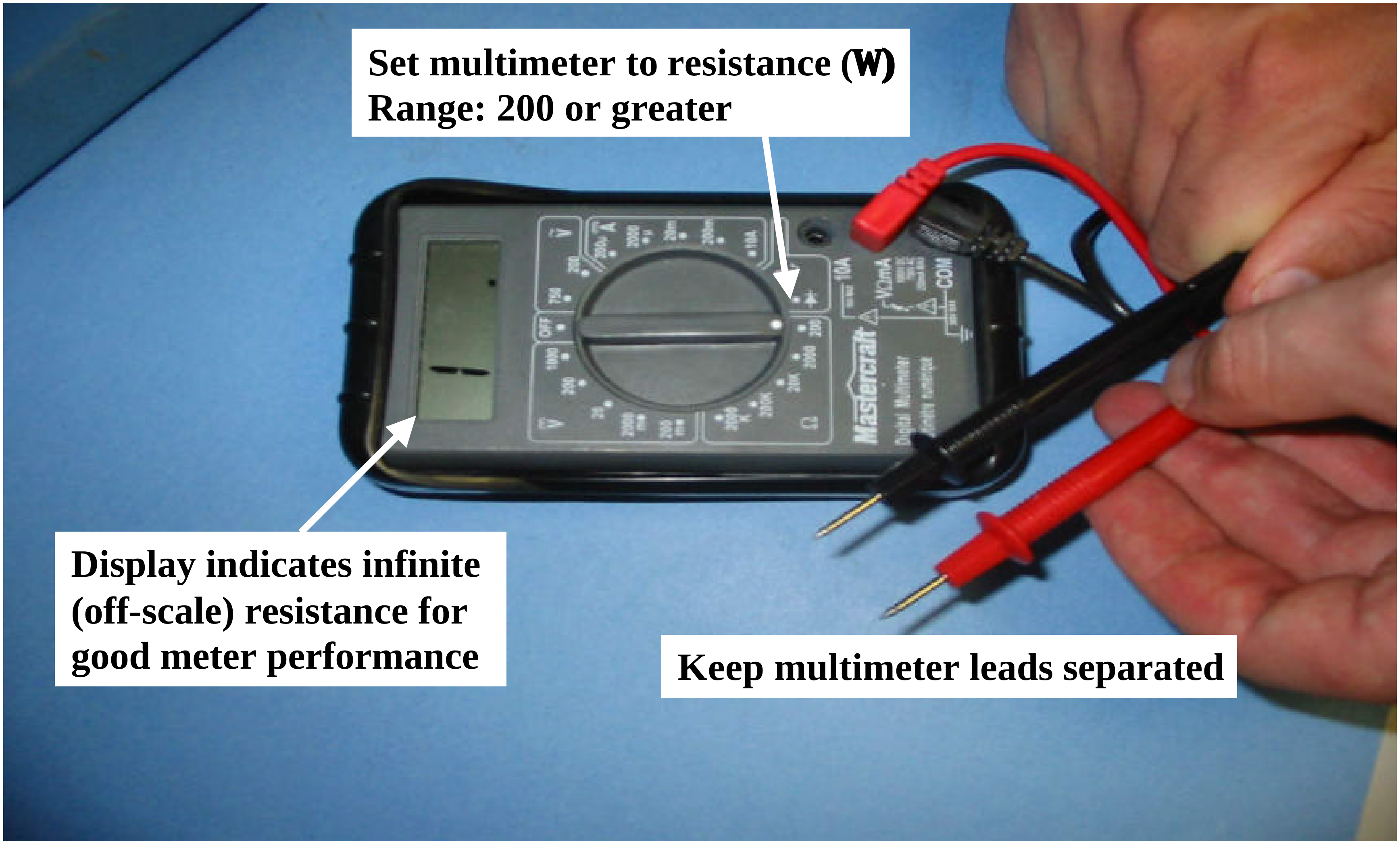
Pic.5 Testing Power output from MPCI or MAGI using data cable (should be greater than 48 V) *Note: MPCI/MAGI must have power ‘on’ and be connected to power supply.*



Black lead to cablehead jacket
Red lead to cablehead pin

<u>Note for MPCI users</u>: serial connector for handheld controller or computer must be plugged into MPCI when doing this test

Pic.6 Checking power output at cablehead (should be greater than 48 V)
Note: MPCI/MAGI must have power 'on' and be connected to power supply.

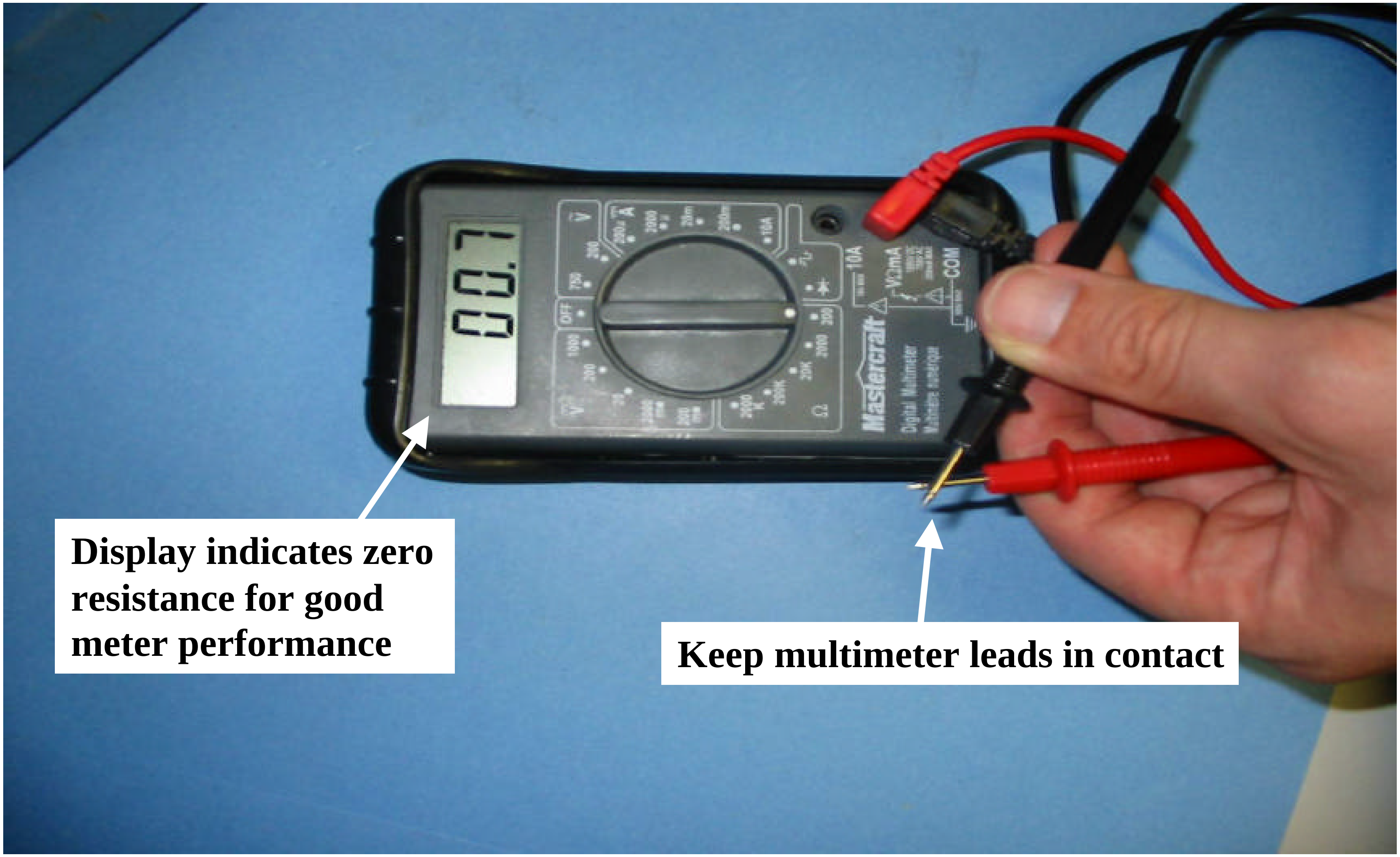


Set multimeter to resistance (W)
Range: 200 or greater

Display indicates infinite (off-scale) resistance for good meter performance

Keep multimeter leads separated

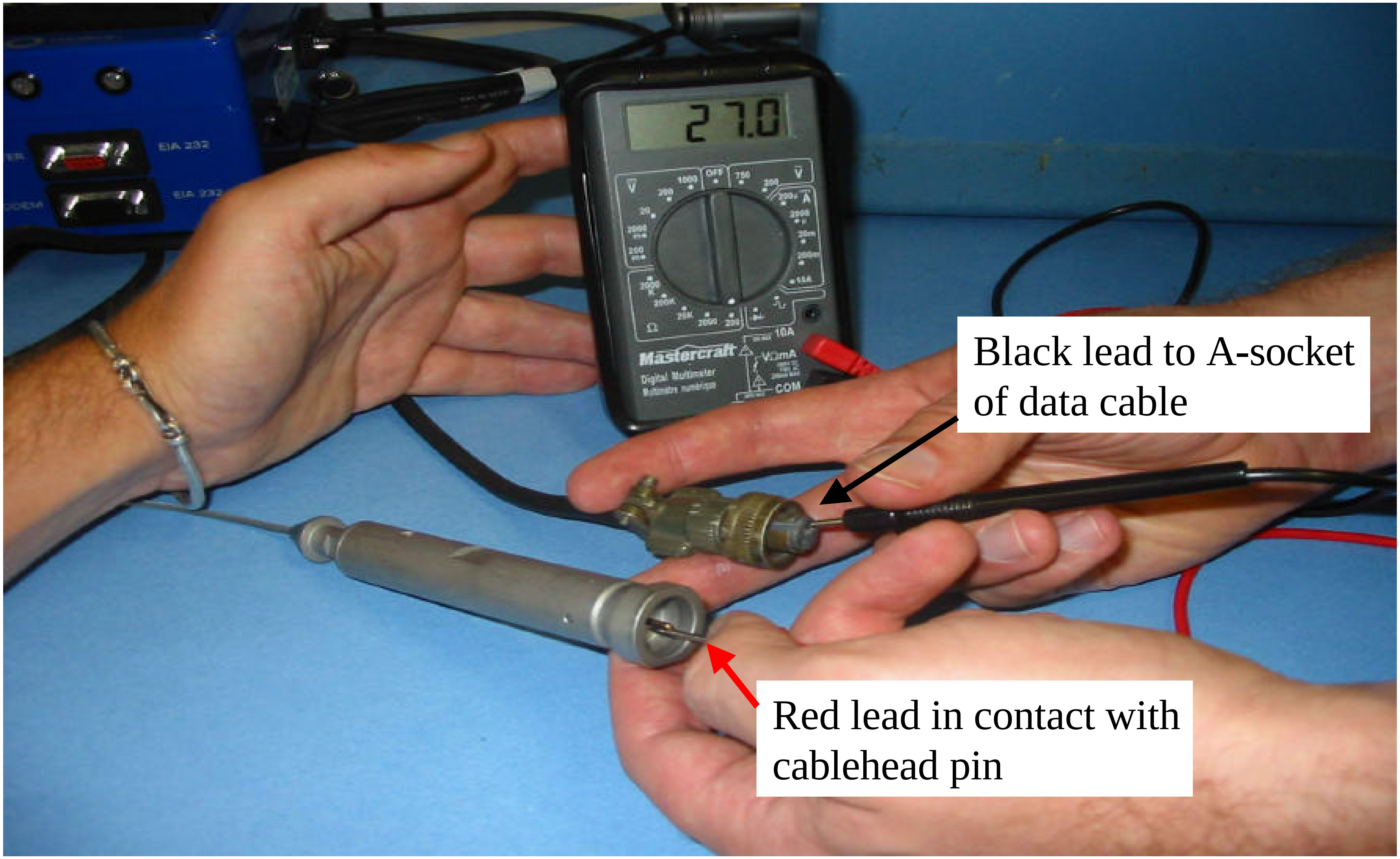
Pic.7 Test multimeter “open” resistence



Display indicates zero resistance for good meter performance

Keep multimeter leads in contact

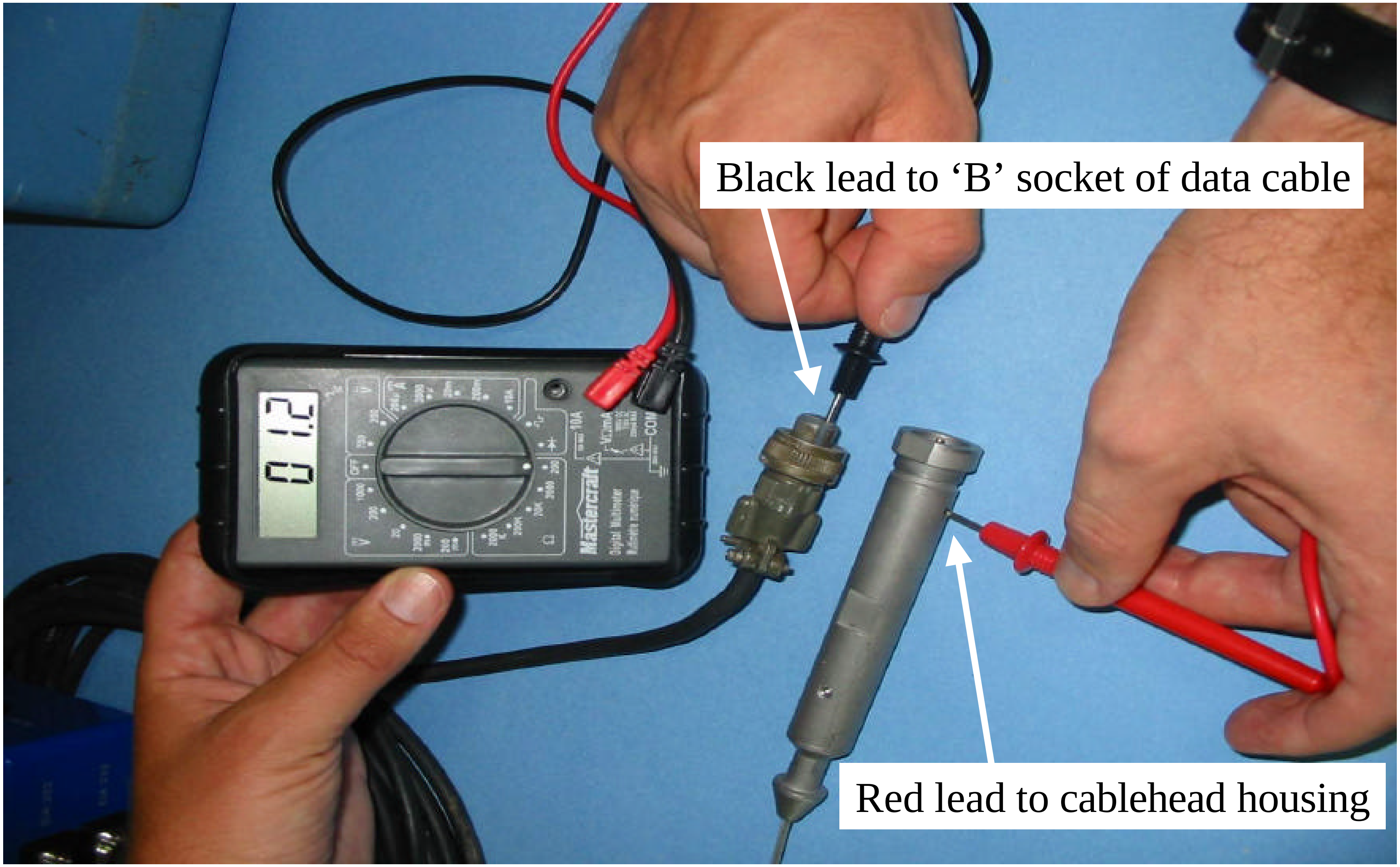
Pic.8 Test multimeter “closed” resistence



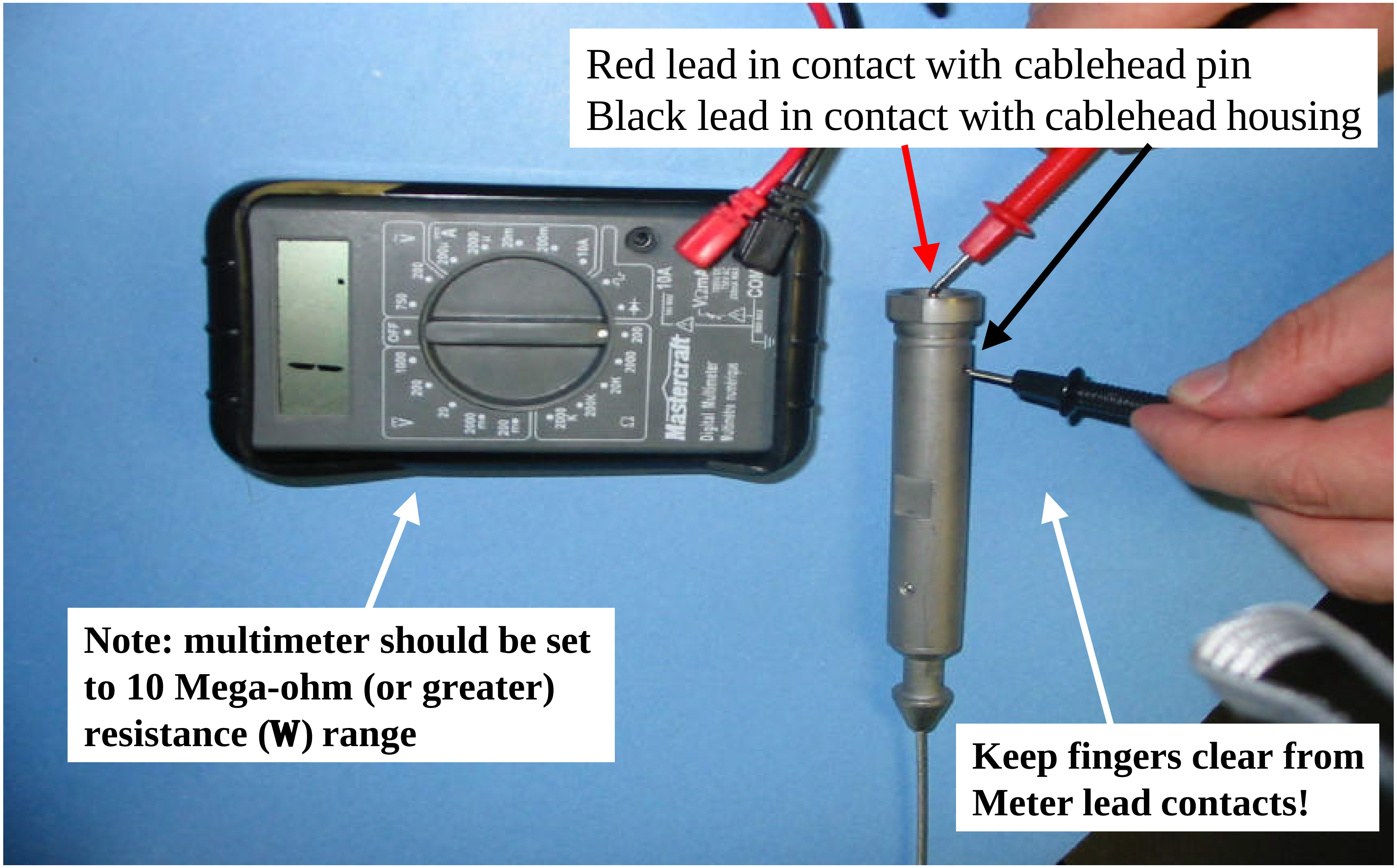
Black lead to A-socket of data cable

Red lead in contact with cablehead pin

Pic.9 Test wireline ‘A-A’ resistance (approx. 27 W/1000 ft)



Pic.10 Test wireline 'B-B' resistance (should be less than 'A-A')

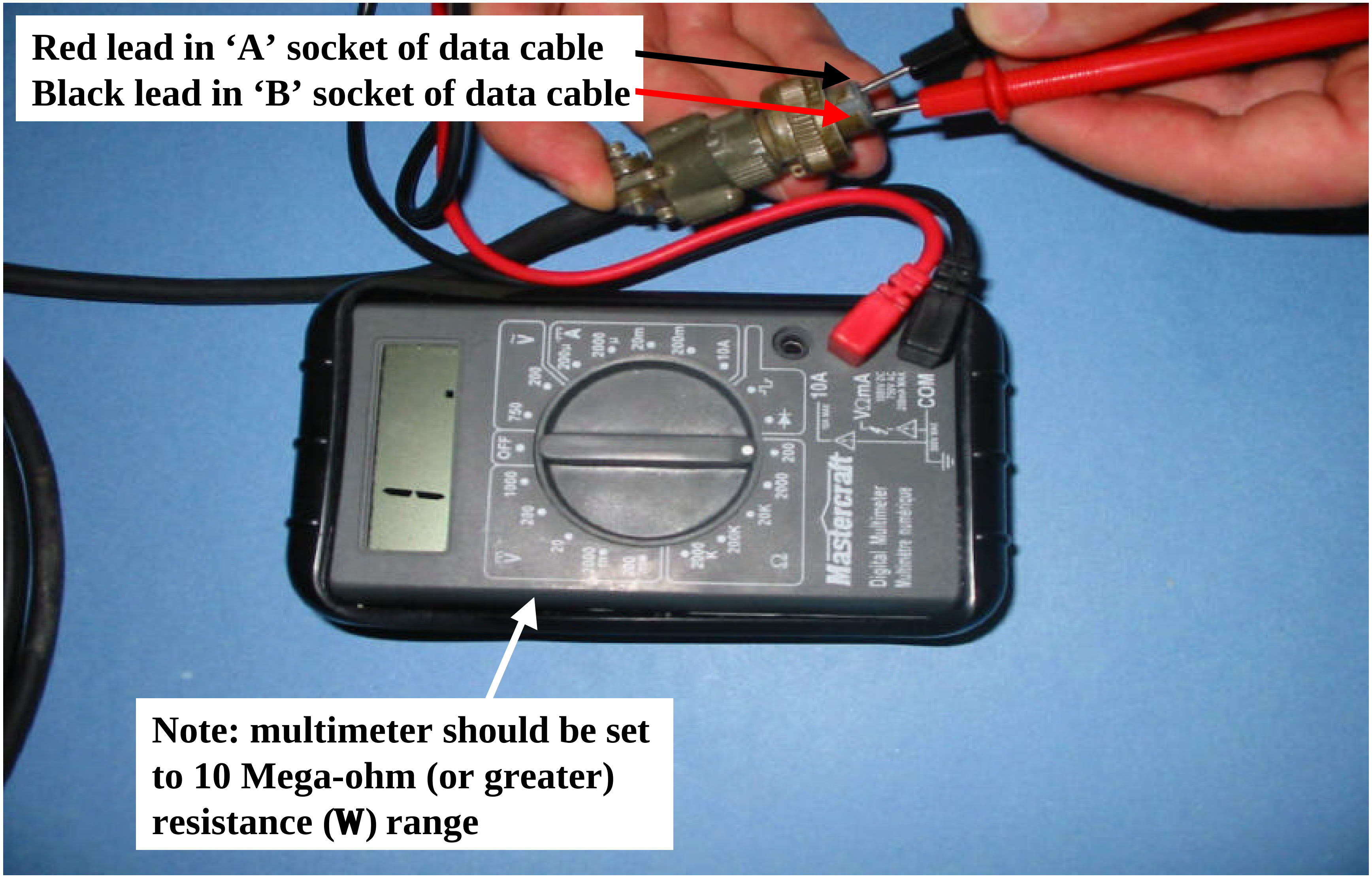


Red lead in contact with cablehead pin
Black lead in contact with cablehead housing

Note: multimeter should be set to 10 Mega-ohm (or greater) resistance (W) range

Keep fingers clear from Meter lead contacts!

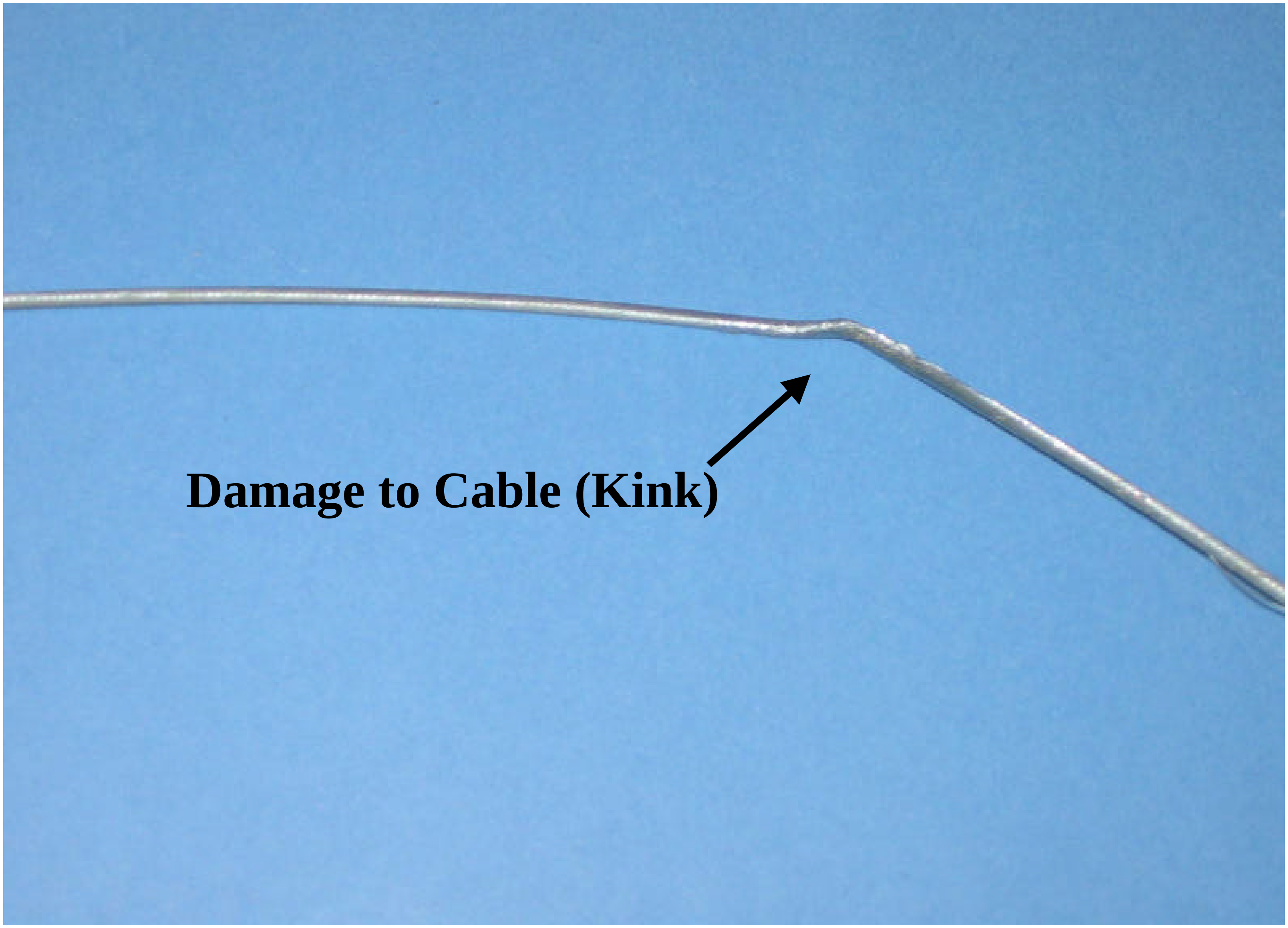
Pic.11 Test wireline ‘A-B’ resistance at cablehead (should be off-scale)



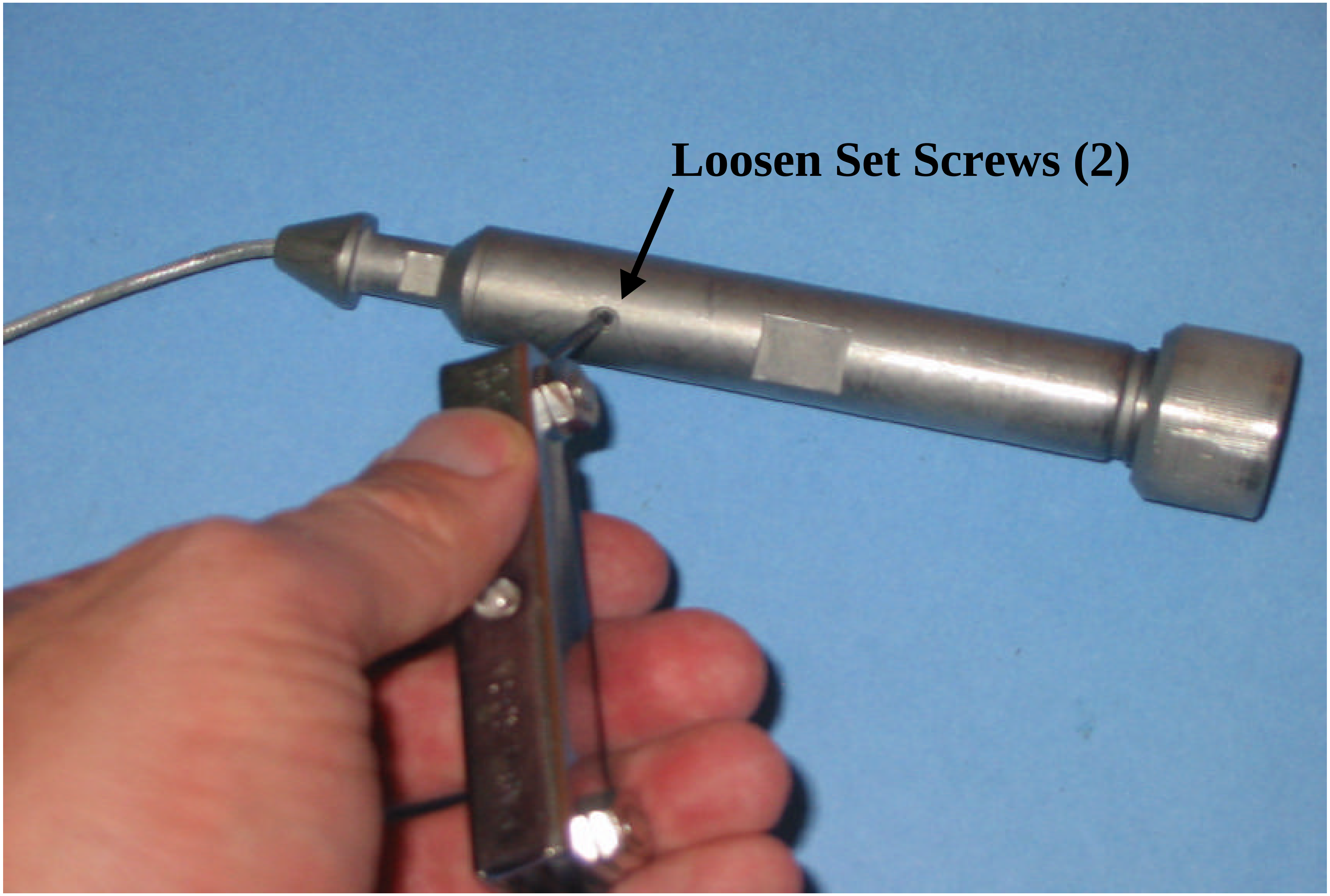
Red lead in ‘A’ socket of data cable
Black lead in ‘B’ socket of data cable

Note: multimeter should be set to 10 Mega-ohm (or greater) resistance (W) range

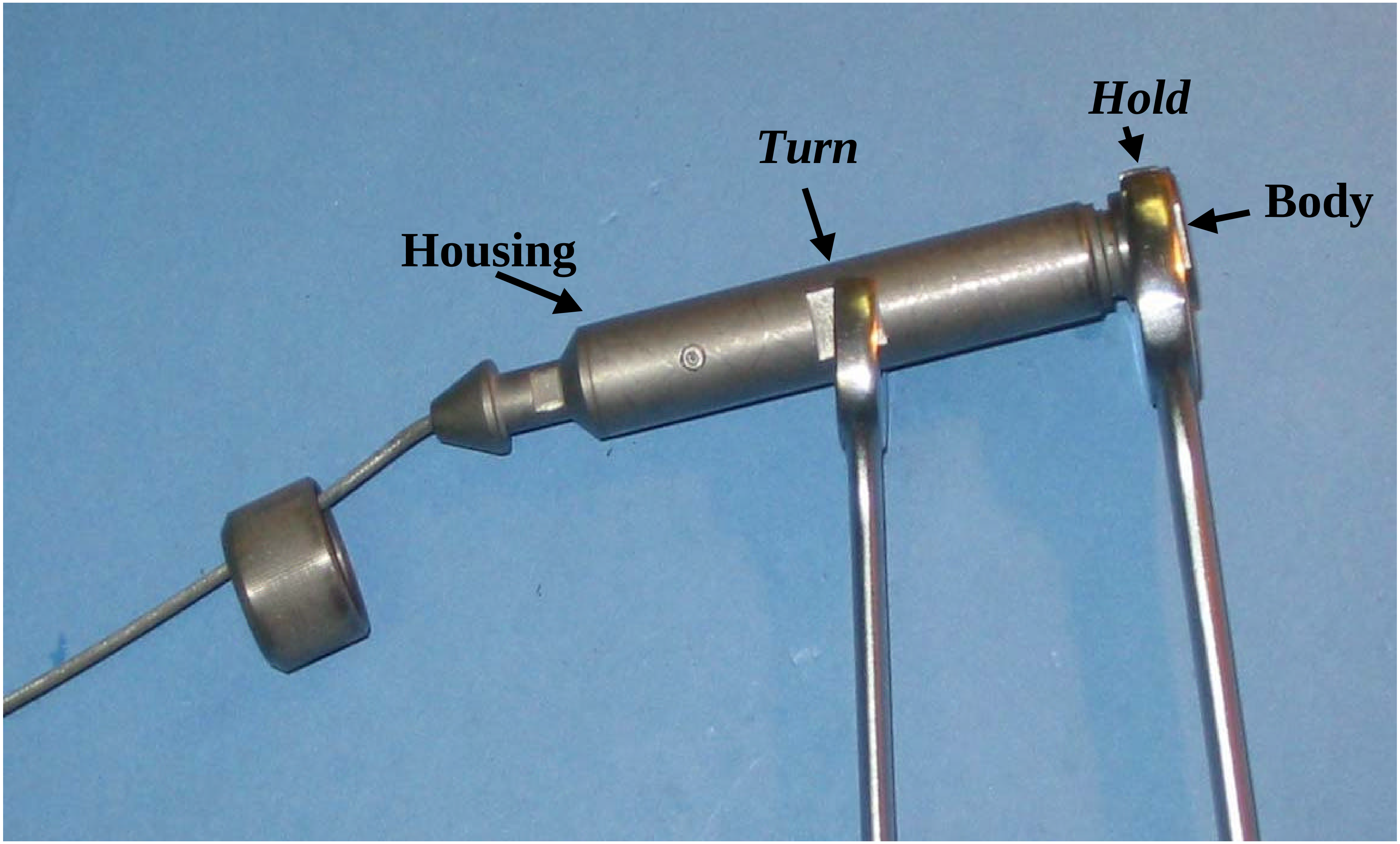
Pic.11 Test wireline ‘A-B’ resistance at data cable (should be off-scale)



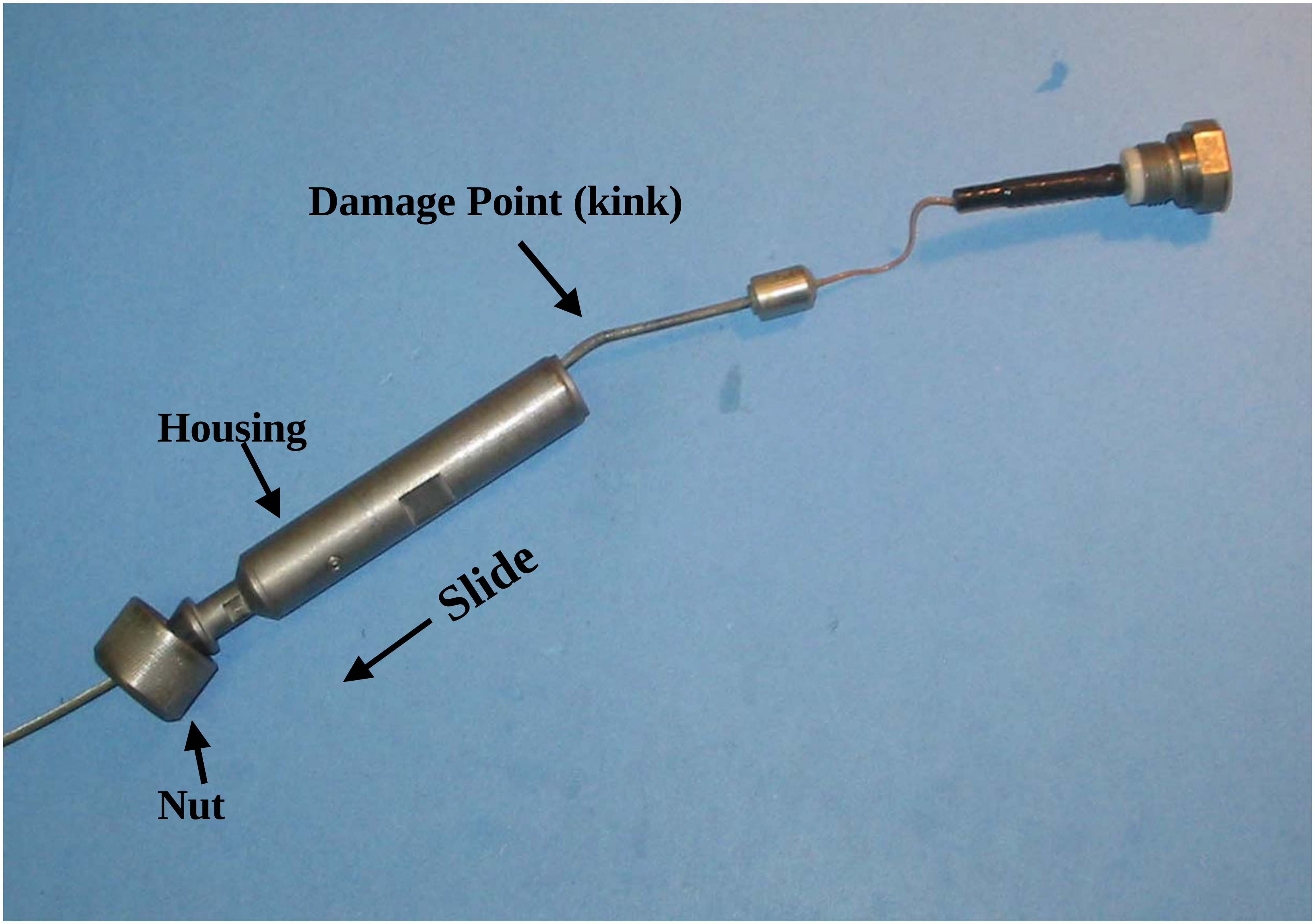
Pic.1 **Identification of Cable Damage**



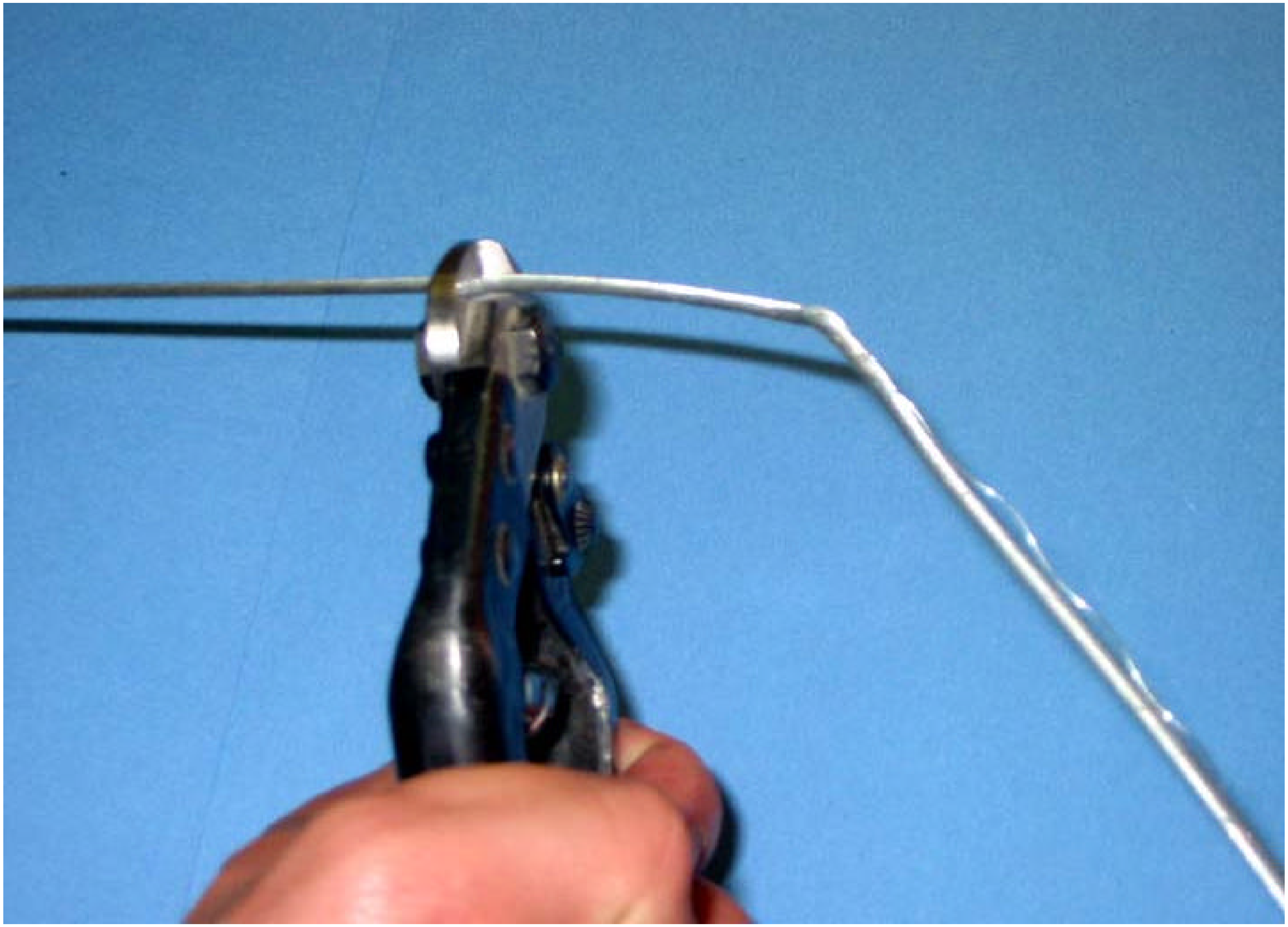
Pic.2 Cablehead Disassembly (1): Loosen set Screws



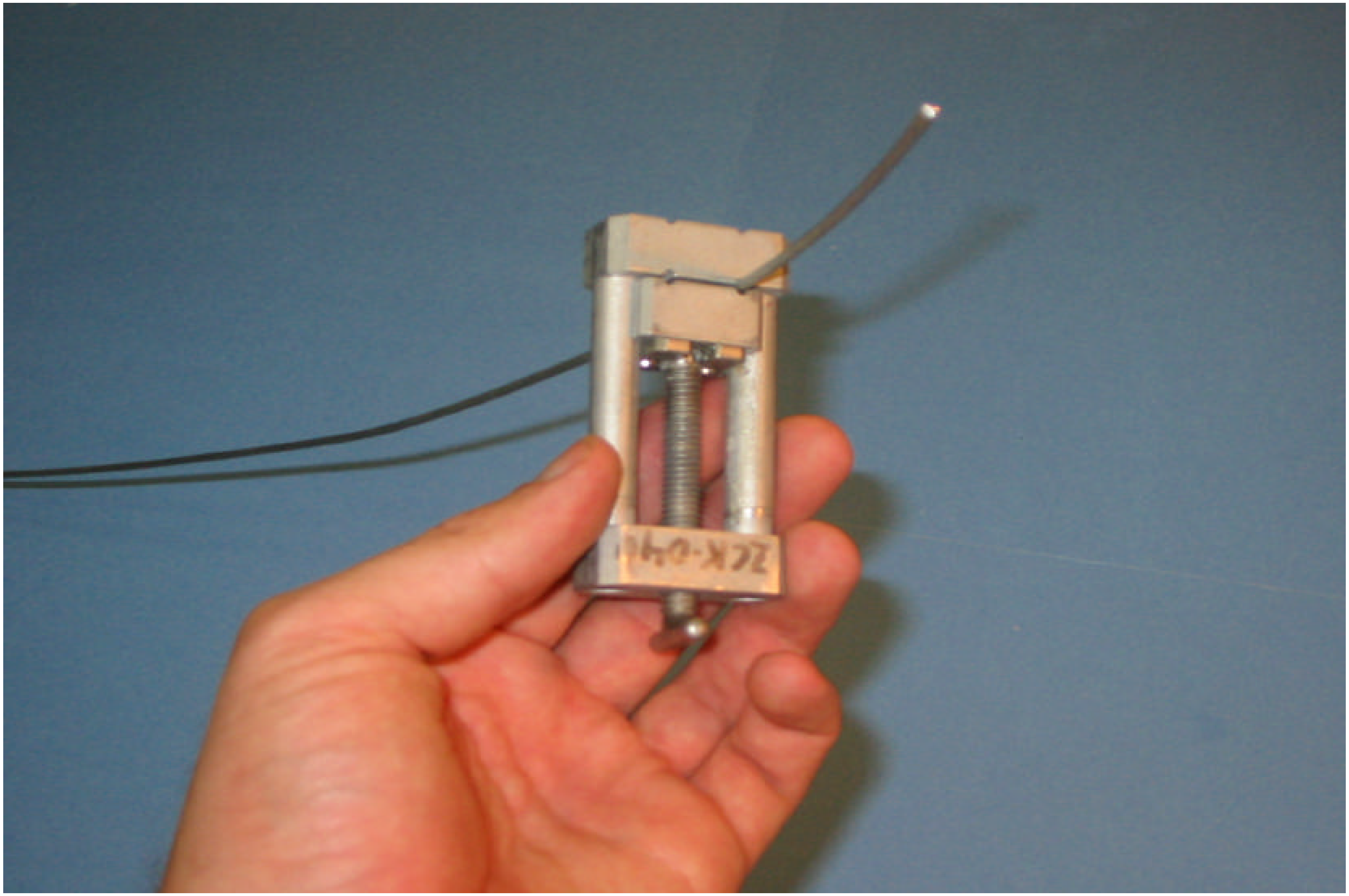
Pic.3 Cablehead Disassembly(2): Unscrew Housing From Body



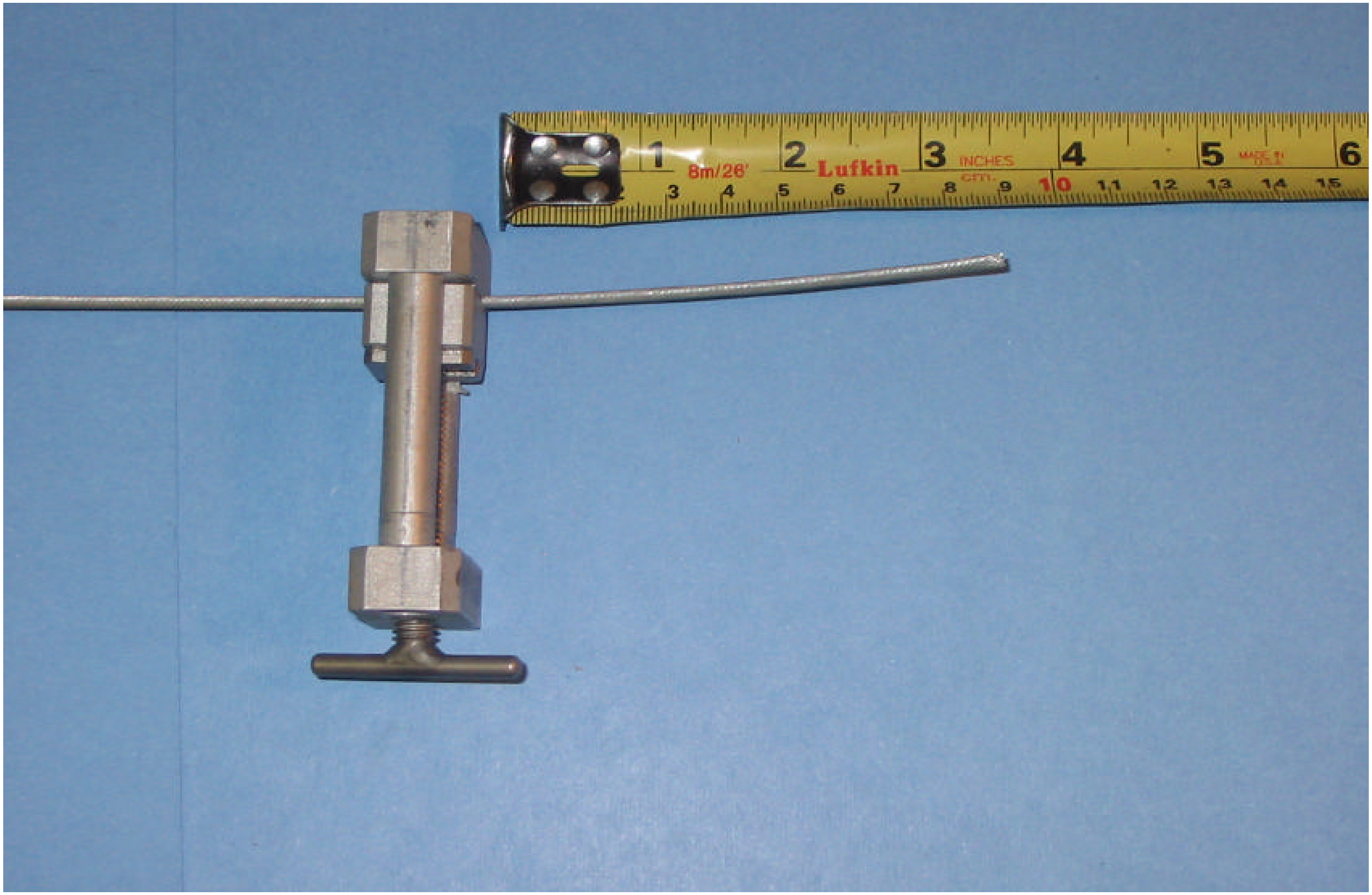
Pic.4 Cablehead Disassembly(3):
Slide Housing and Cablehead Nut Past Damage Point



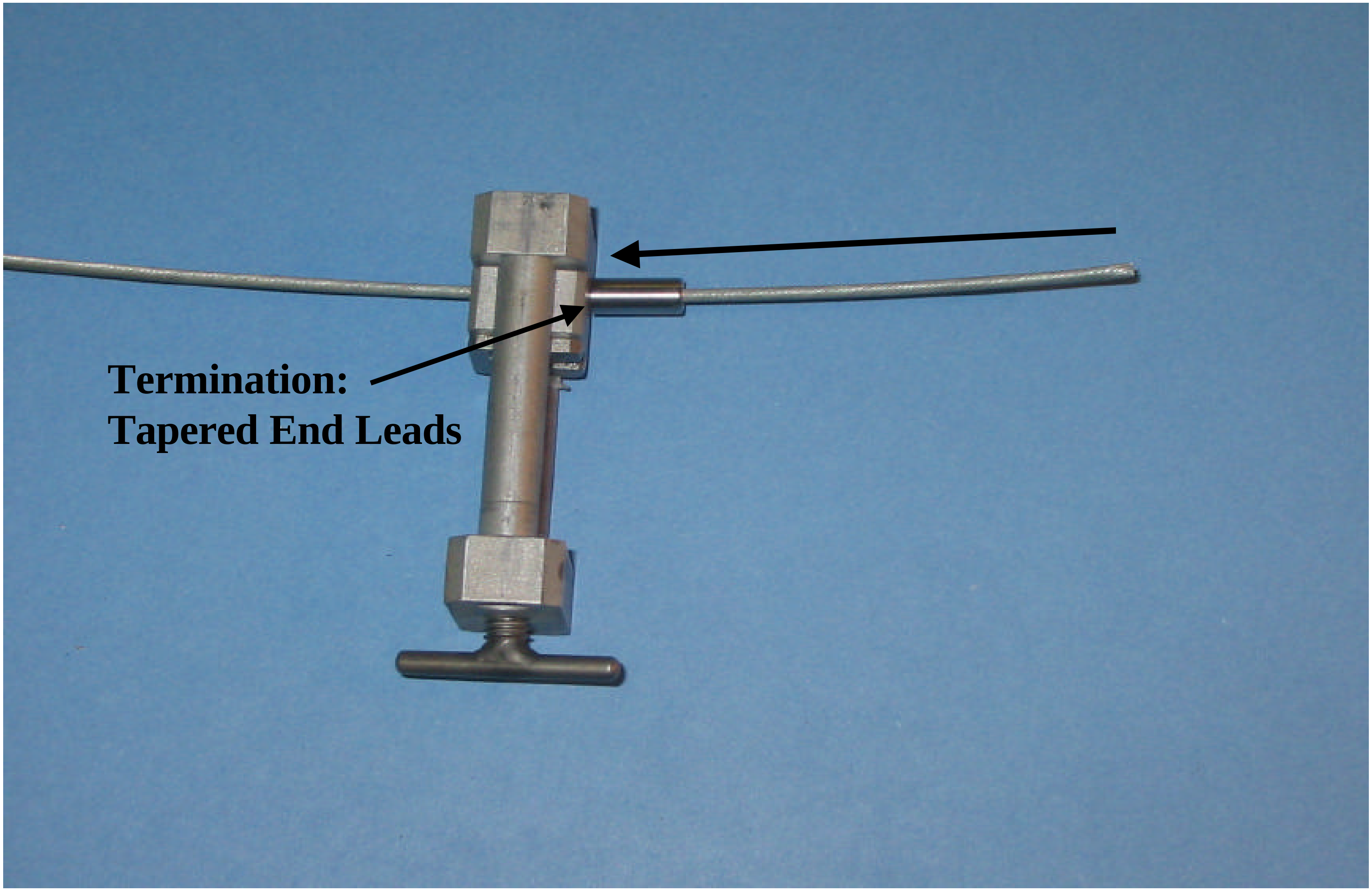
Pic.5 Cut Cable above Damage Point



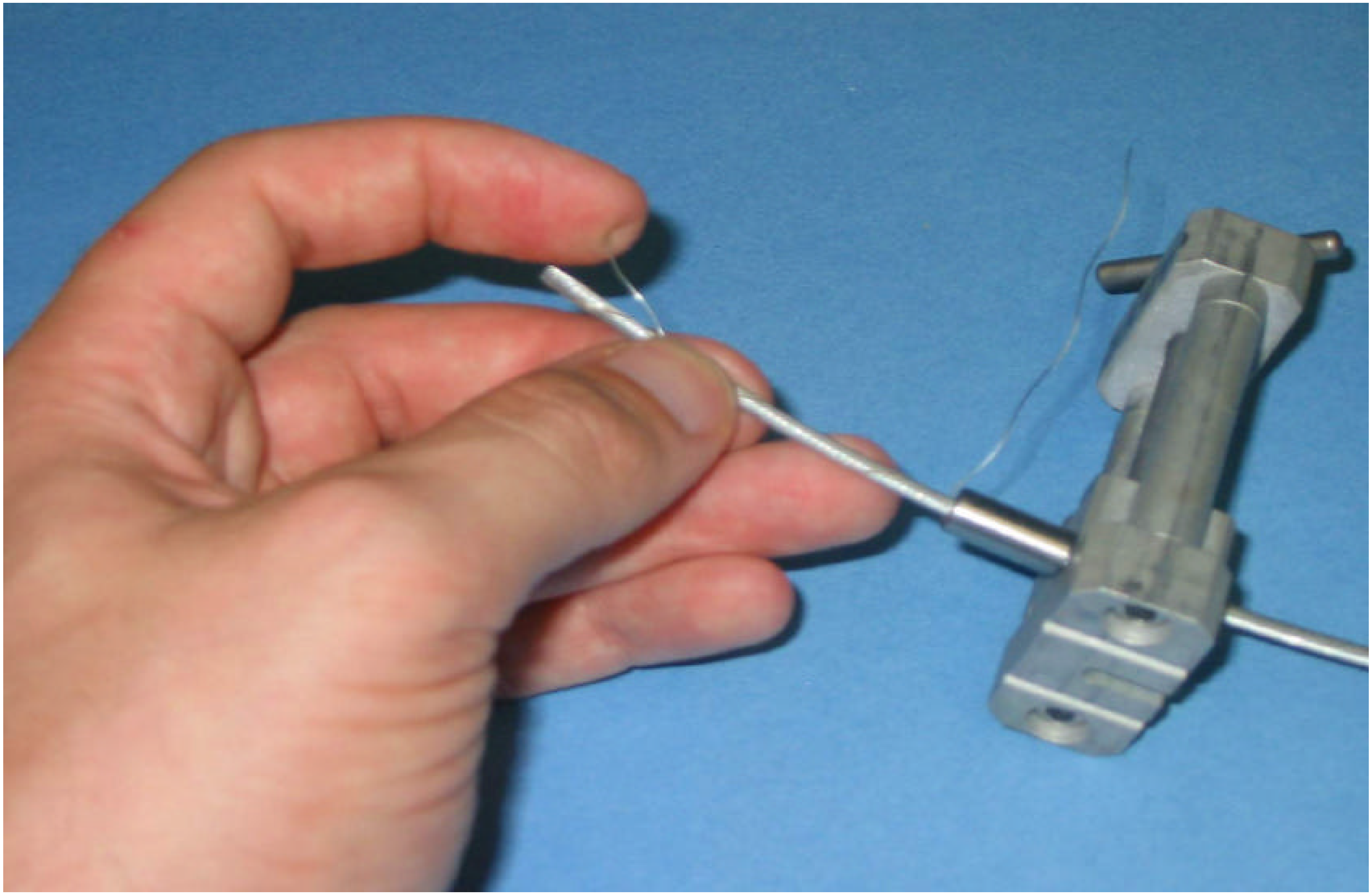
Pic.6a Clamp Cable in Termination Jig



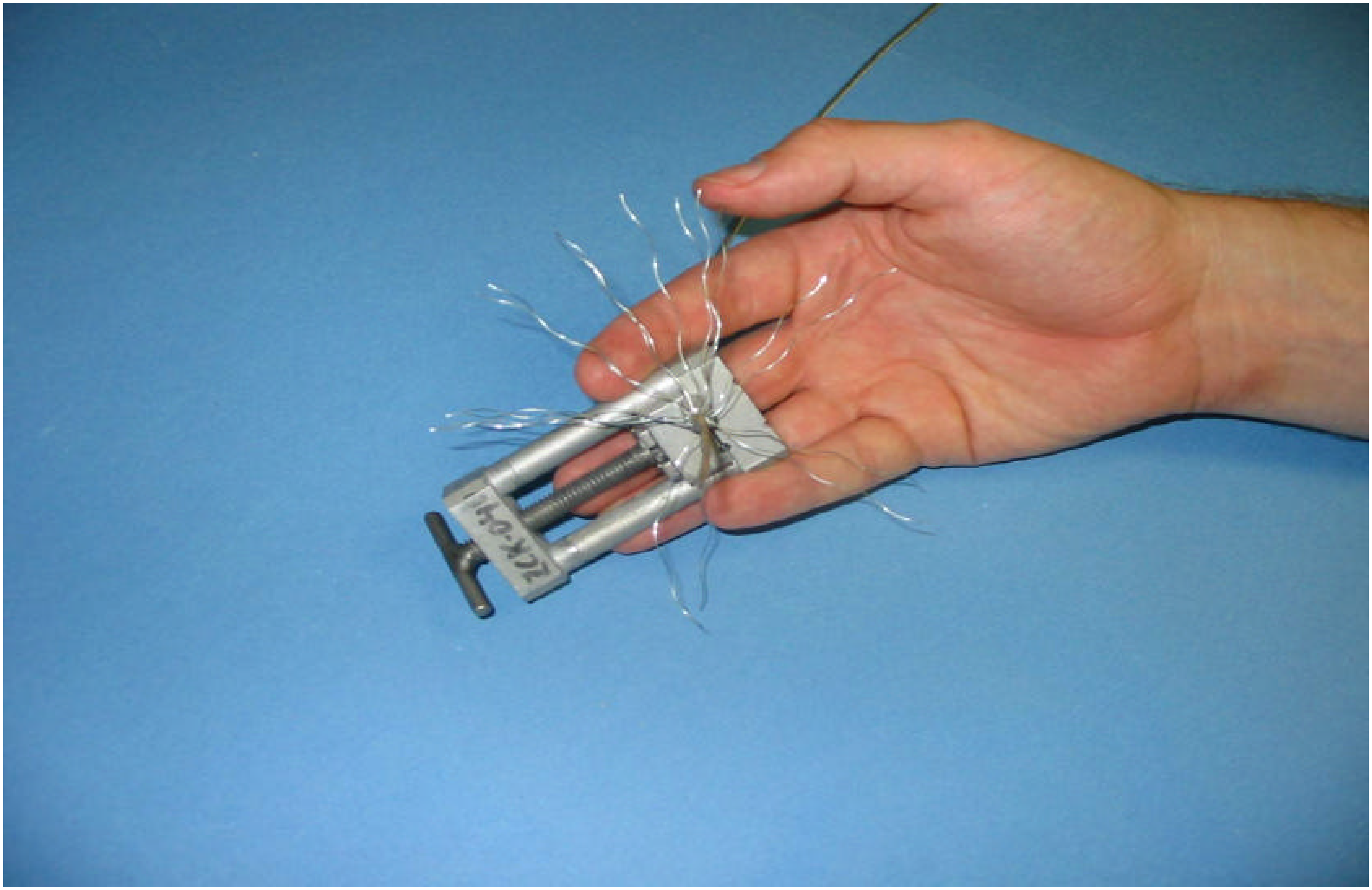
Pic.6b Leave 3.5 inches Cable Exposed



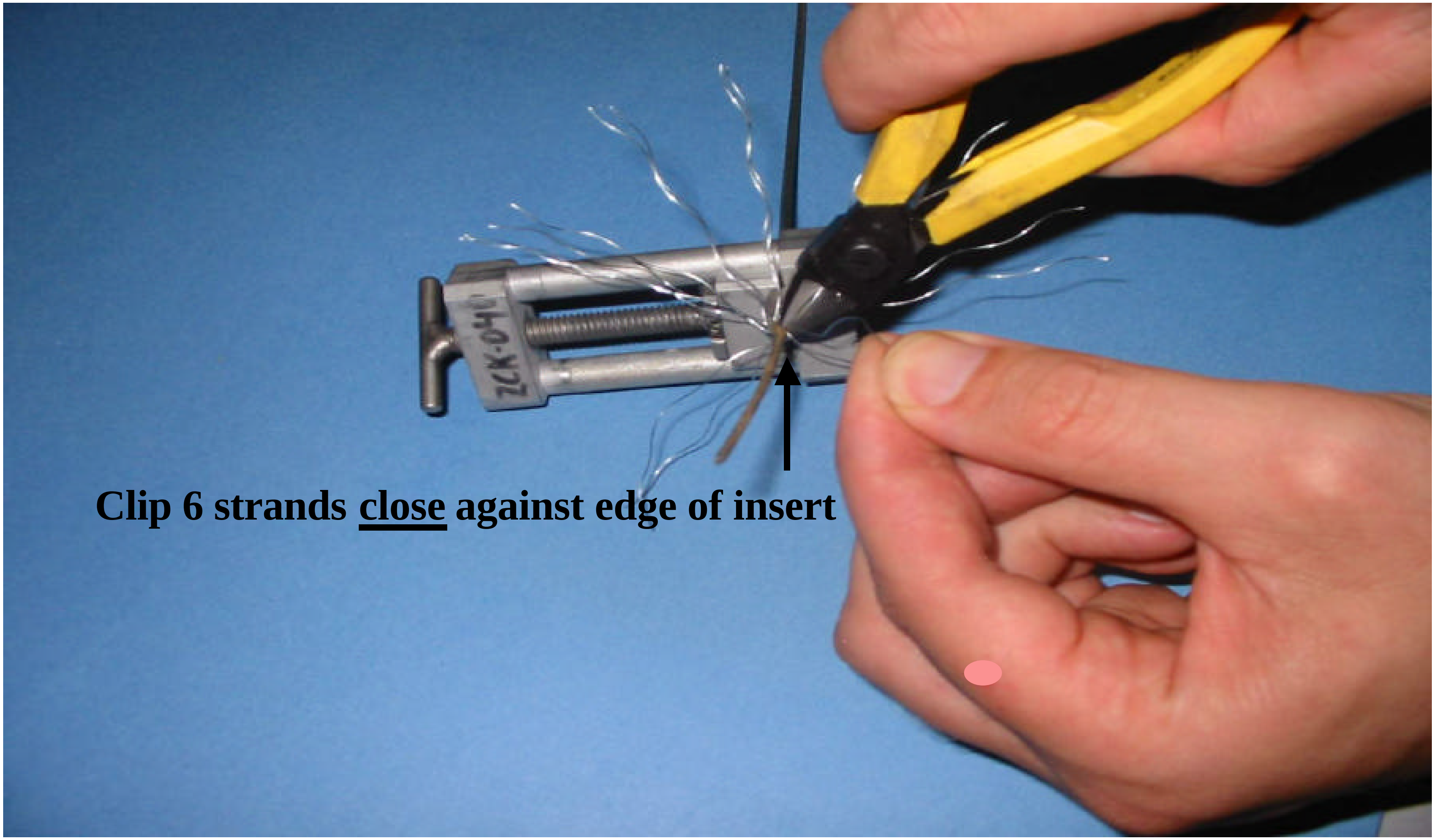
Pic.6c Slide Termination Insert Over Cable



Pic.7a Unwind Outer-layer Strands (start)

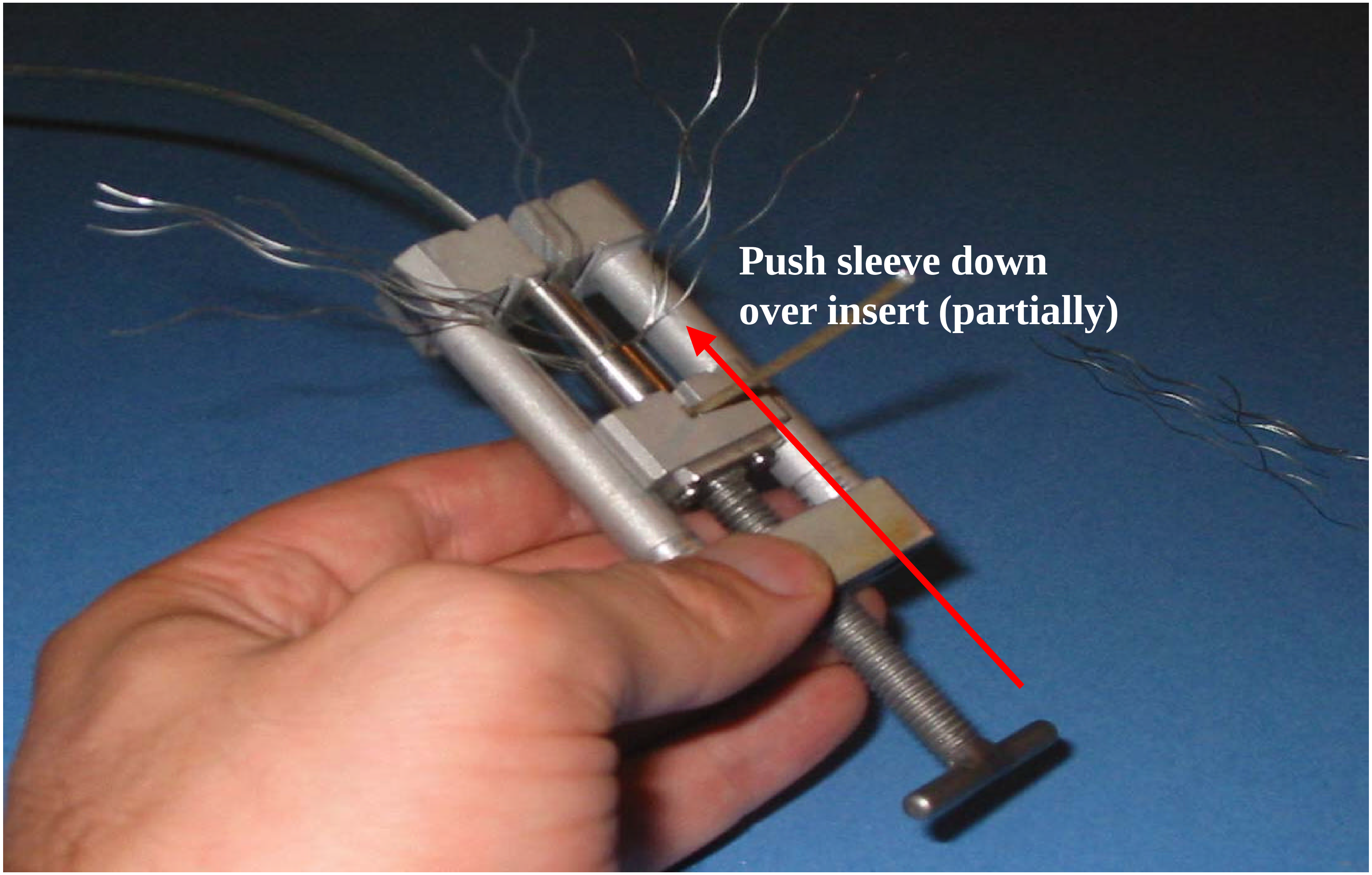


Pic.7b Unwind Outer Layer Strands (finish)

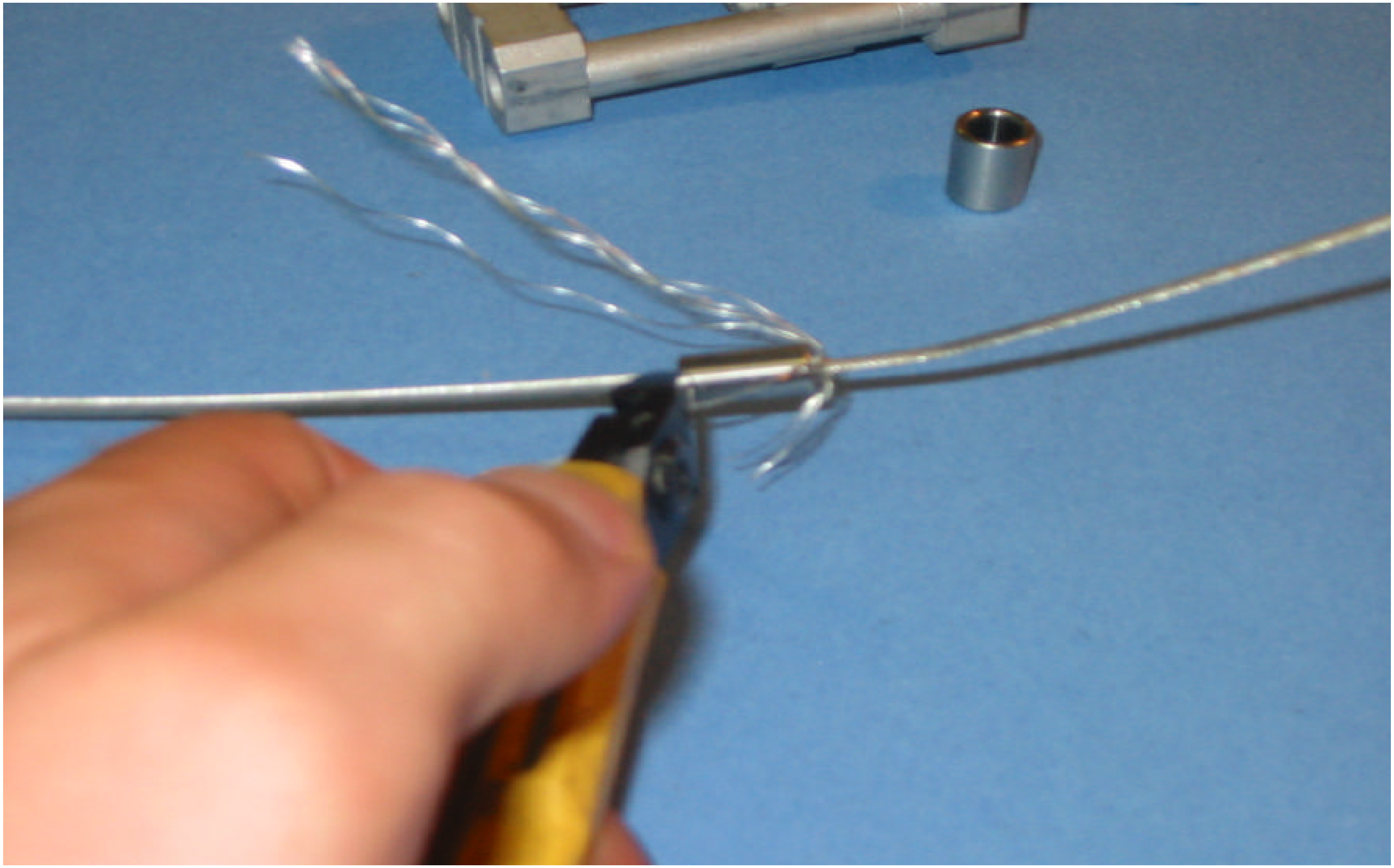


Clip 6 strands close against edge of insert

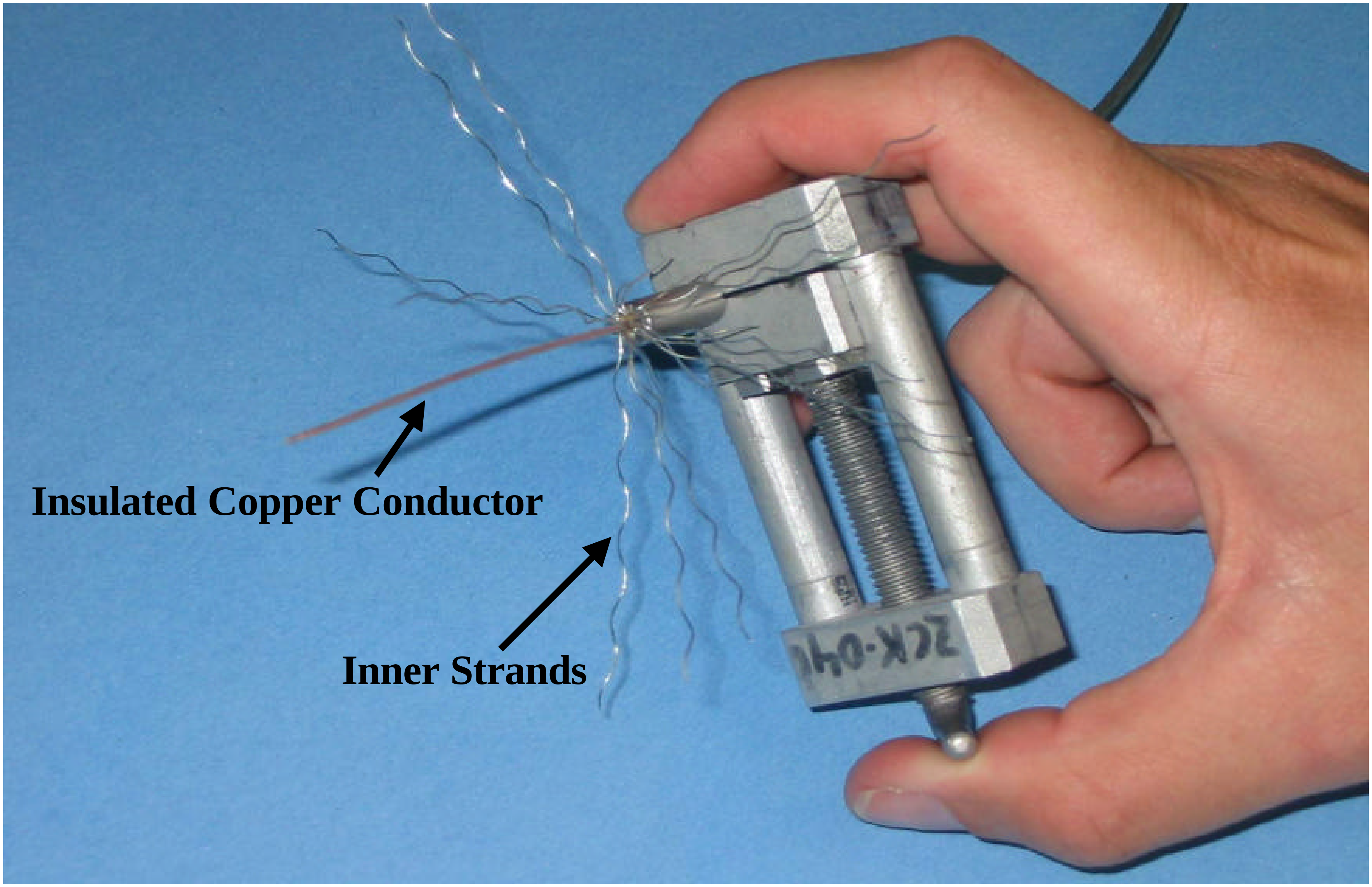
Pic.8 Clipping Outer Wire Strands (6 strands out of 18)



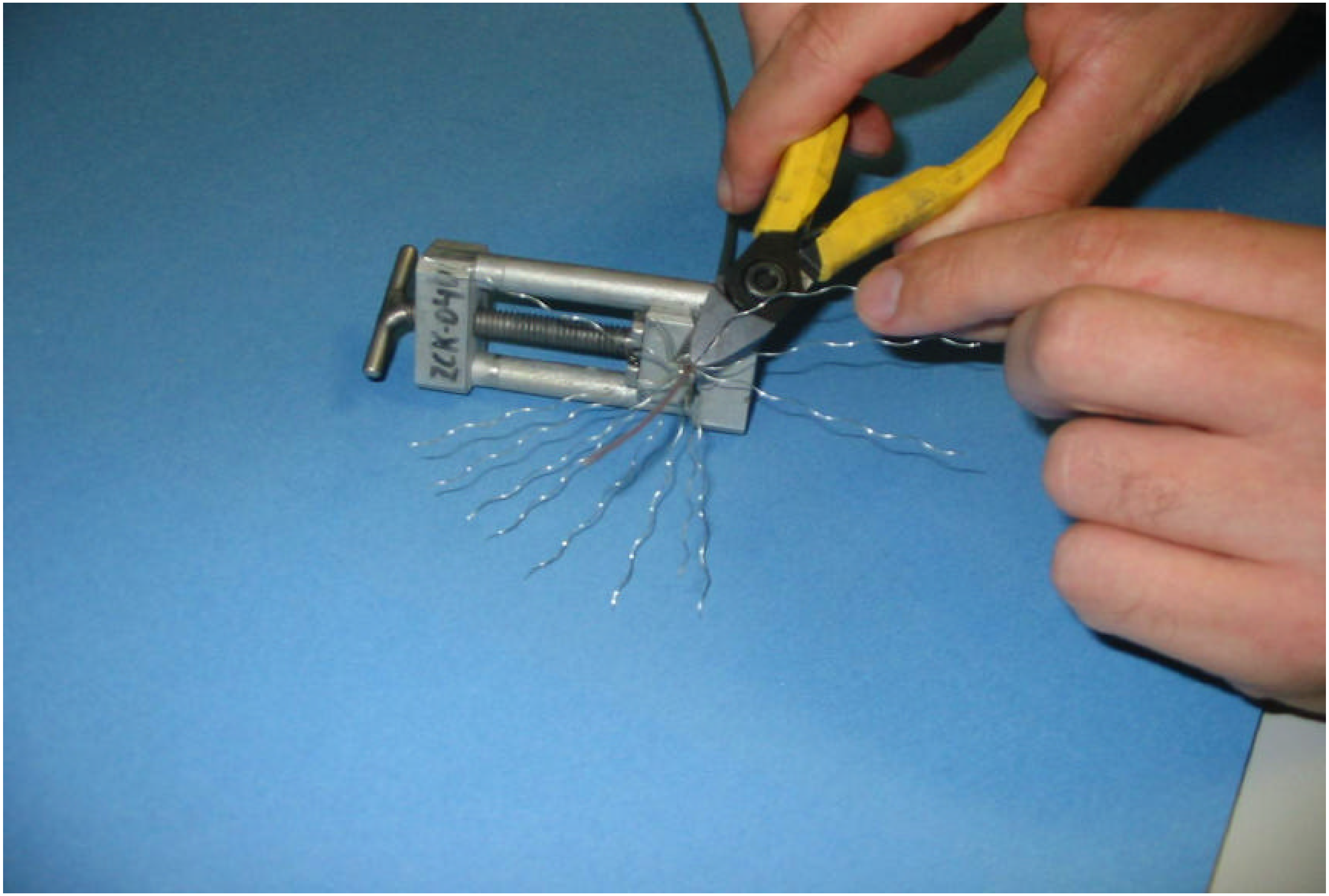
Pic.9 **Partially Push Sleeve Down on Insert Using Jig**
(enough to bend strands down along insert)



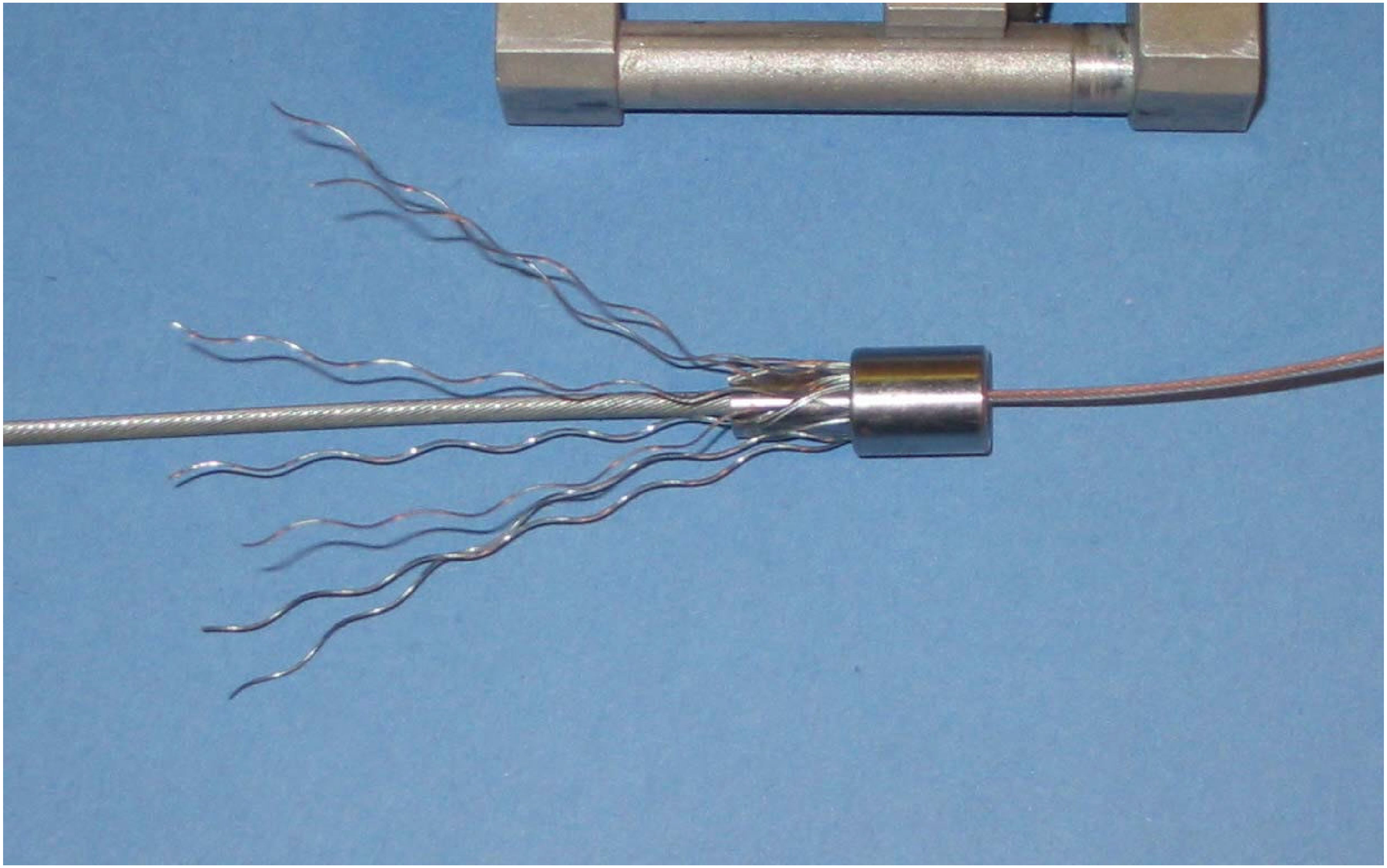
Pic.10 Trim Outer Wire Strands to Base of Insert.



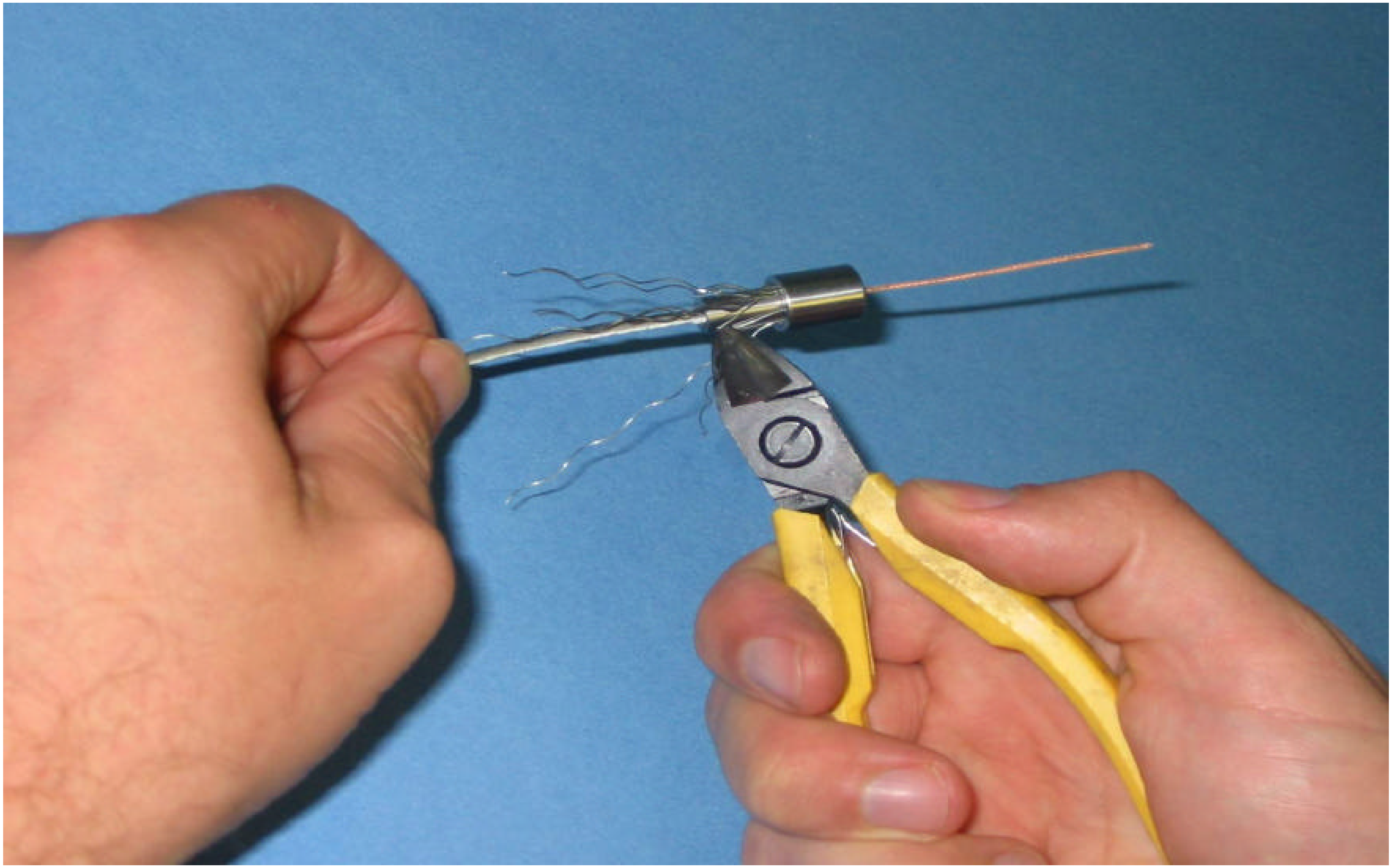
Pic.11 Unwind inner-layer strands of armor
(exposing the insulated conductor wire)



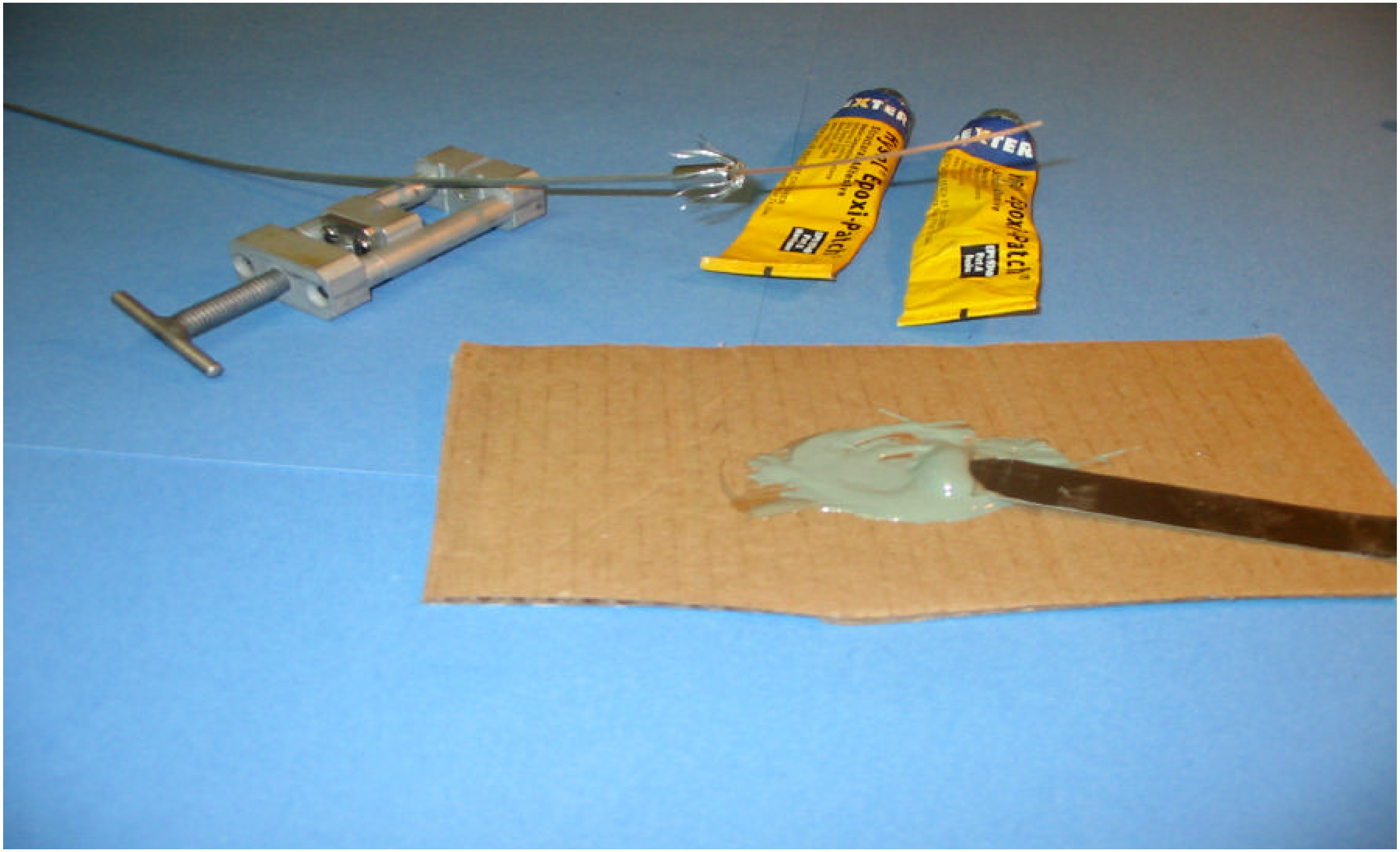
Pic.12 Clip 5 of the 12 inner armor strands close to the top of the insert



Pic.13 Bend down Remaining Inner Wire Strands
(Use jig and termination sleeve)

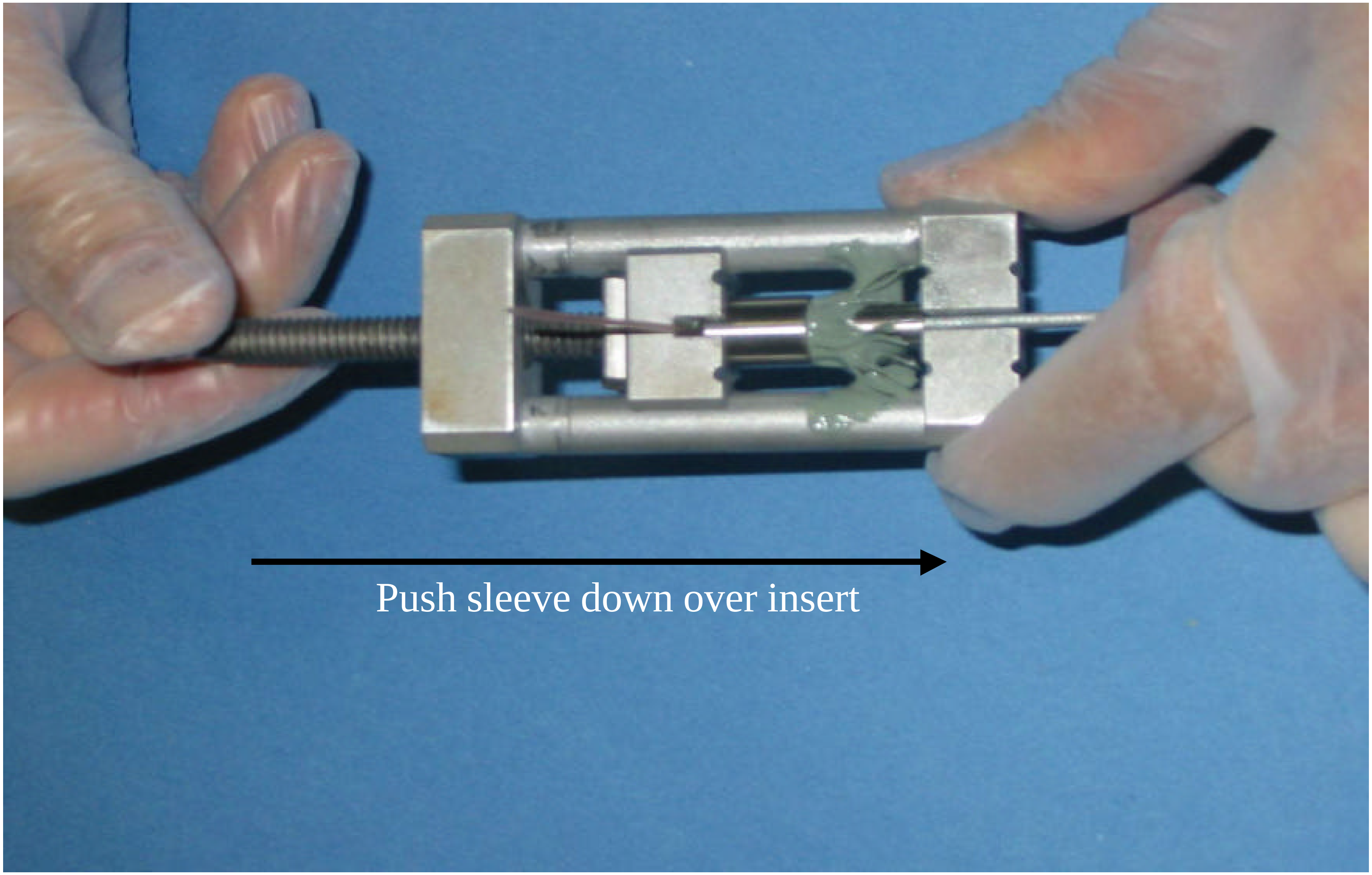


Pic.13 Trim Inner Wire Strands to Base of Insert

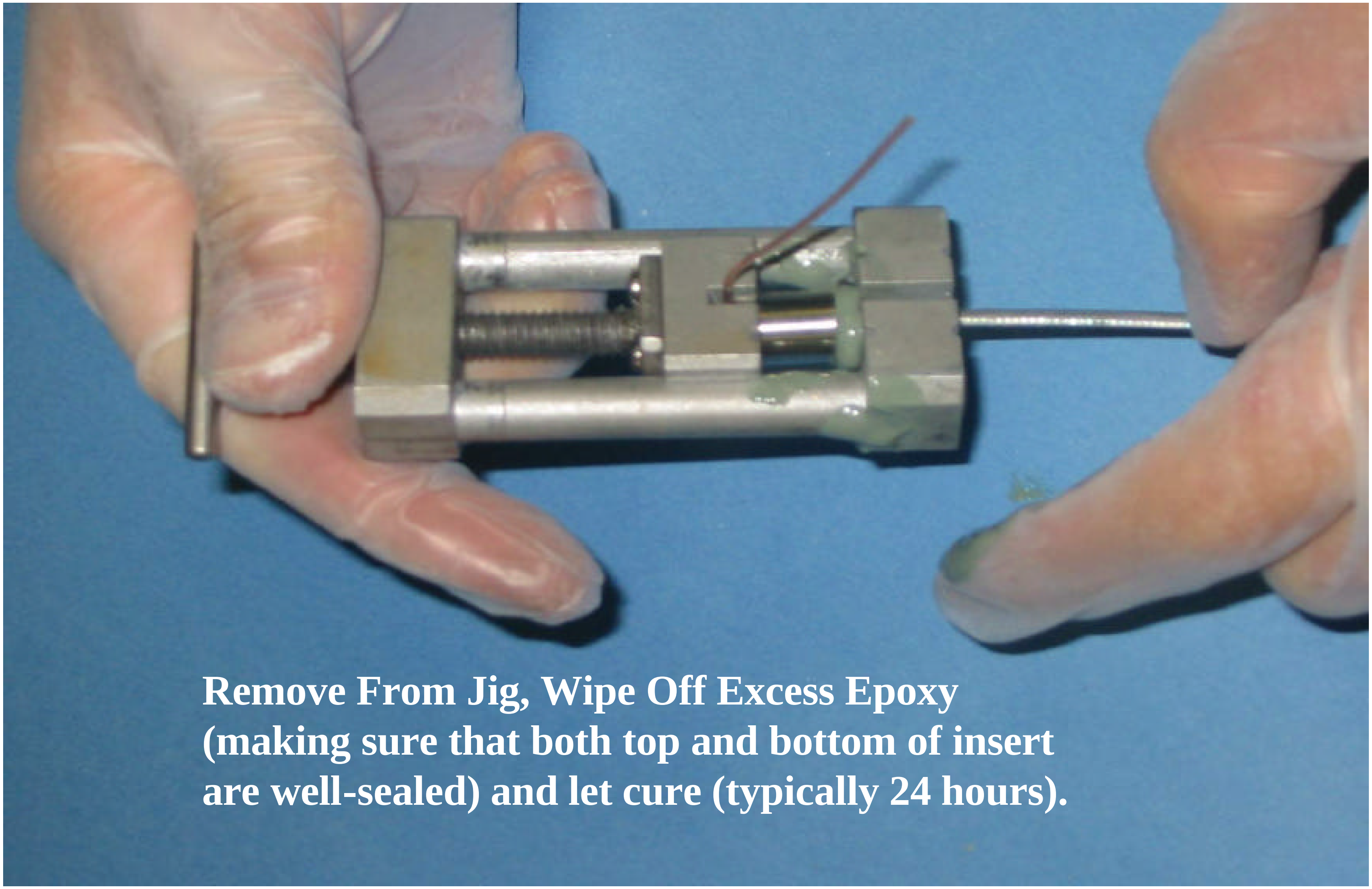


Pic.14 Mix epoxy

Pic.15 Apply epoxy. Cover the trimmed armor strands with epoxy



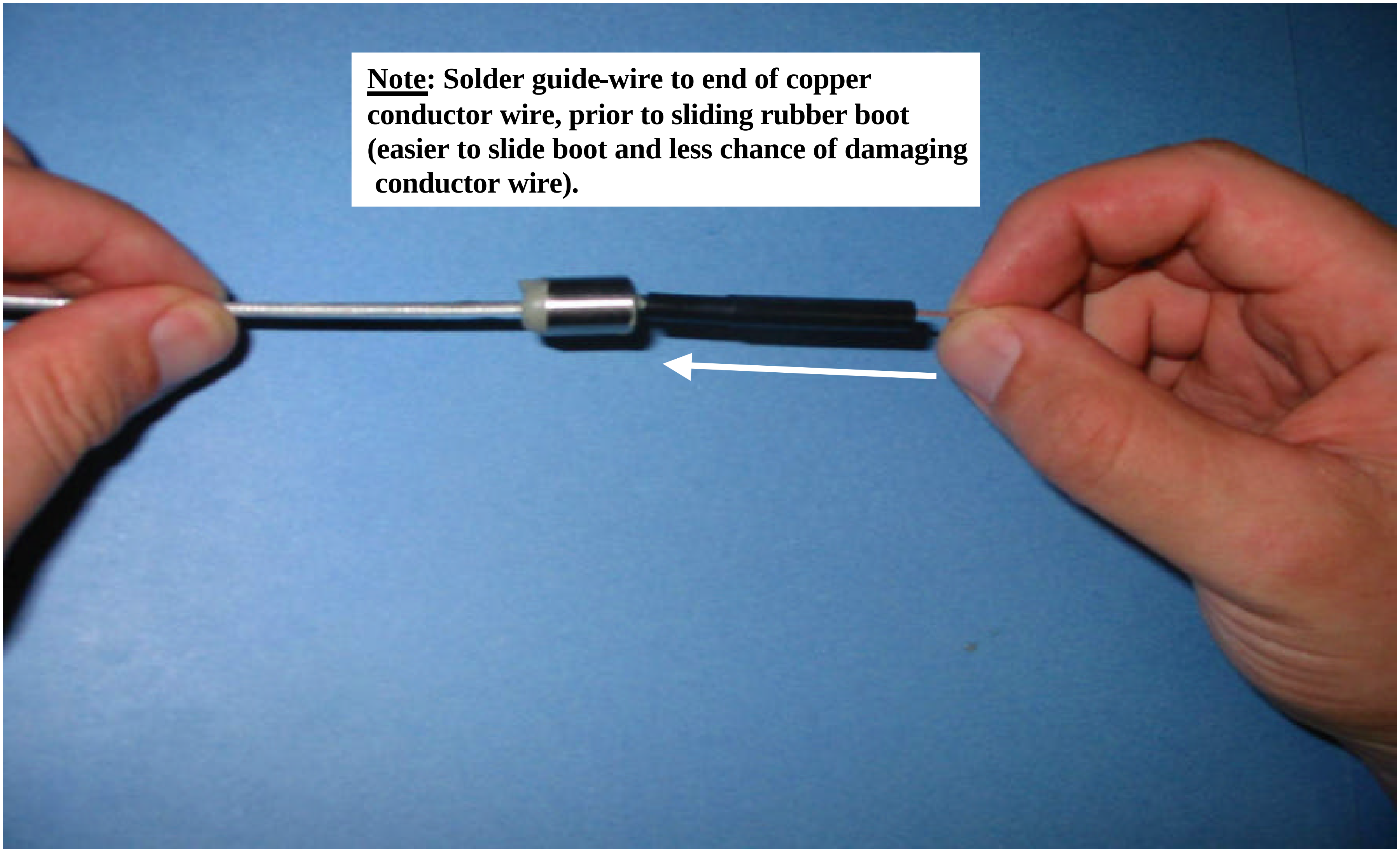
Pic.16 Using the termination jig, push the termination sleeve completely down over the insert



Remove From Jig, Wipe Off Excess Epoxy (making sure that both top and bottom of insert are well-sealed) and let cure (typically 24 hours).

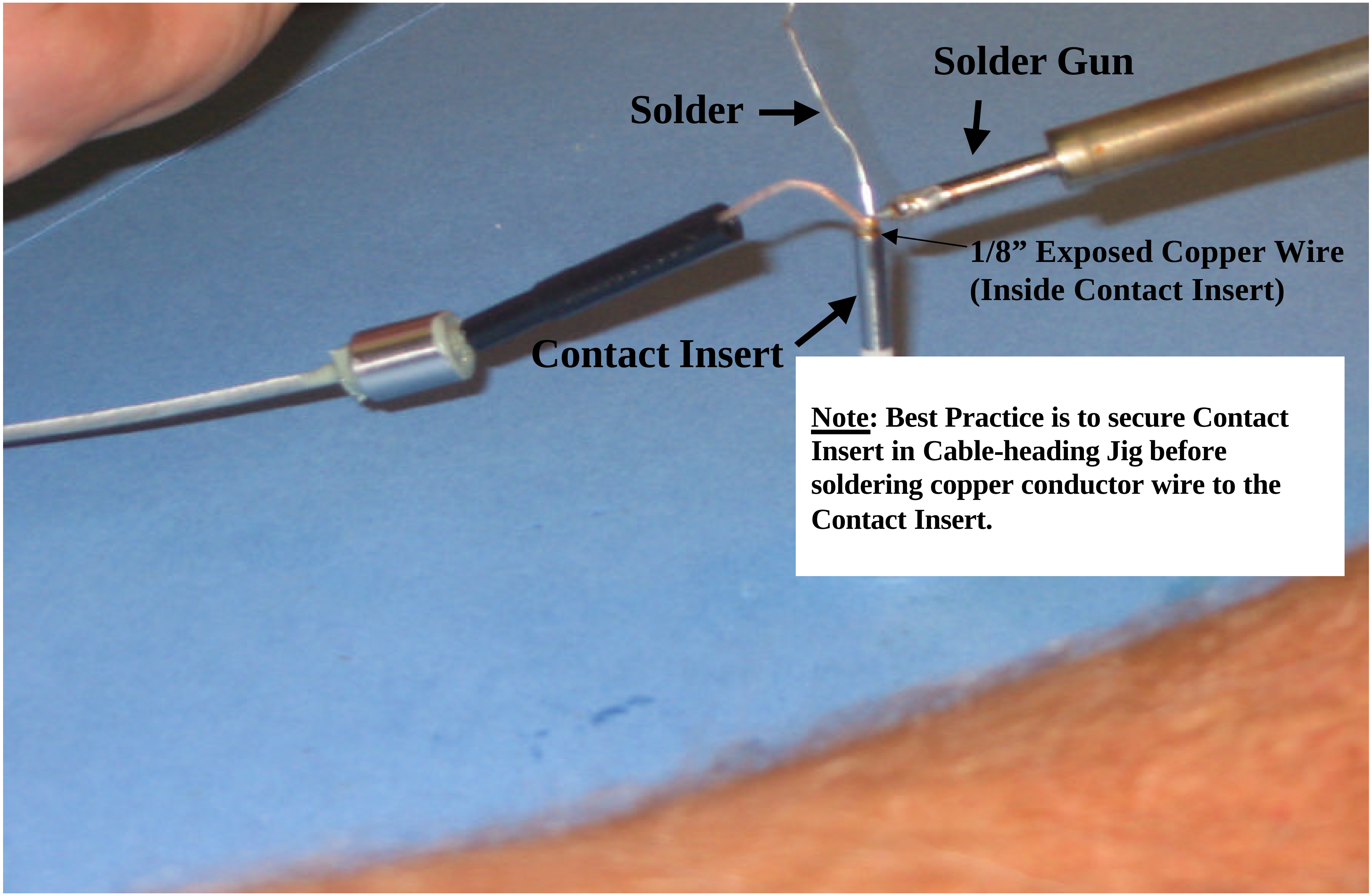
Pic.17 Termination Sleeve completely pushed down over insert

Pic.18 Apply silicon lubricant to the insulated conductor wire



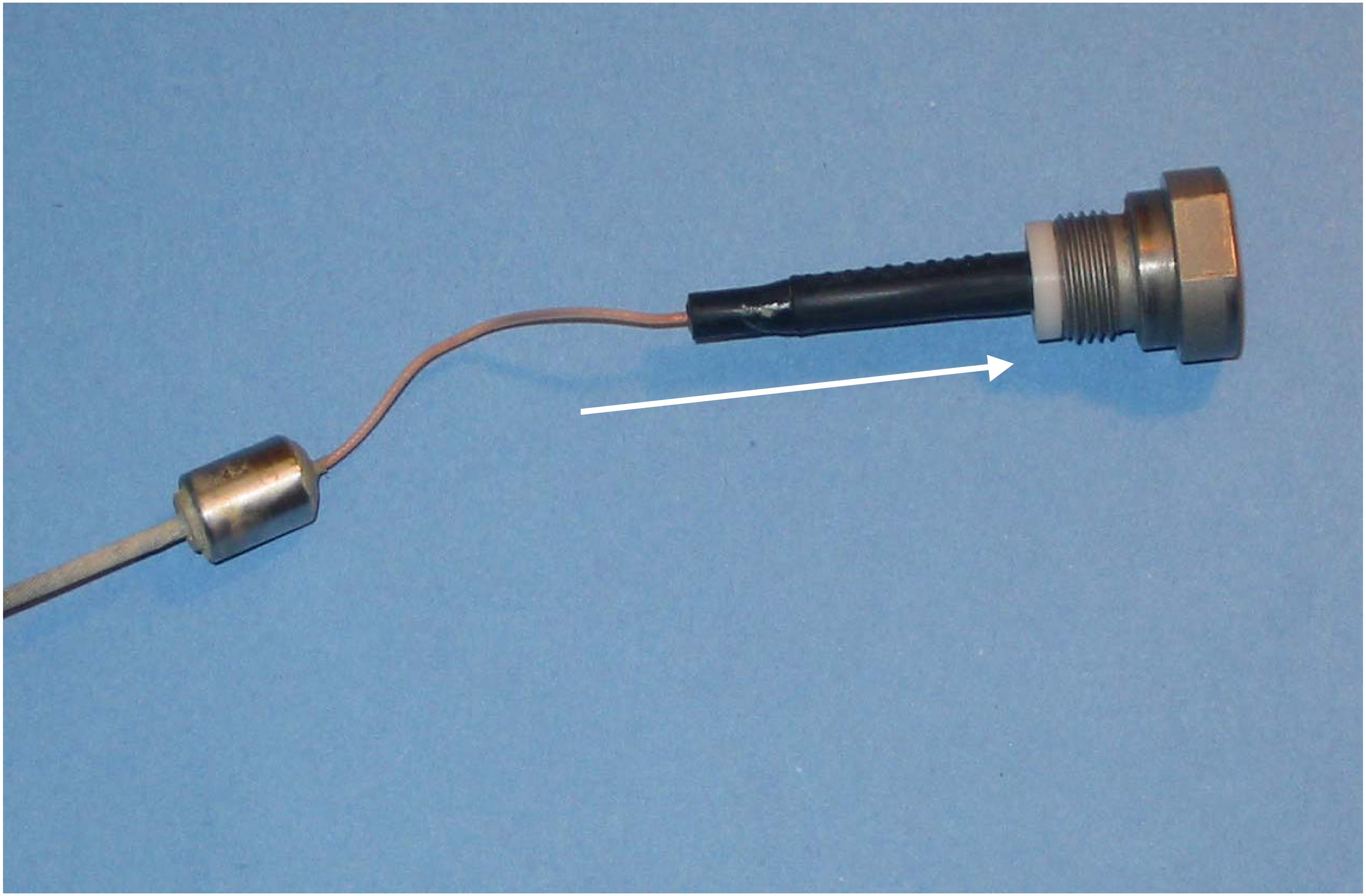
Note: Solder guide-wire to end of copper conductor wire, prior to sliding rubber boot (easier to slide boot and less chance of damaging conductor wire).

Pic.20 Slide the rubber boot towards the cablehead termination (final position)

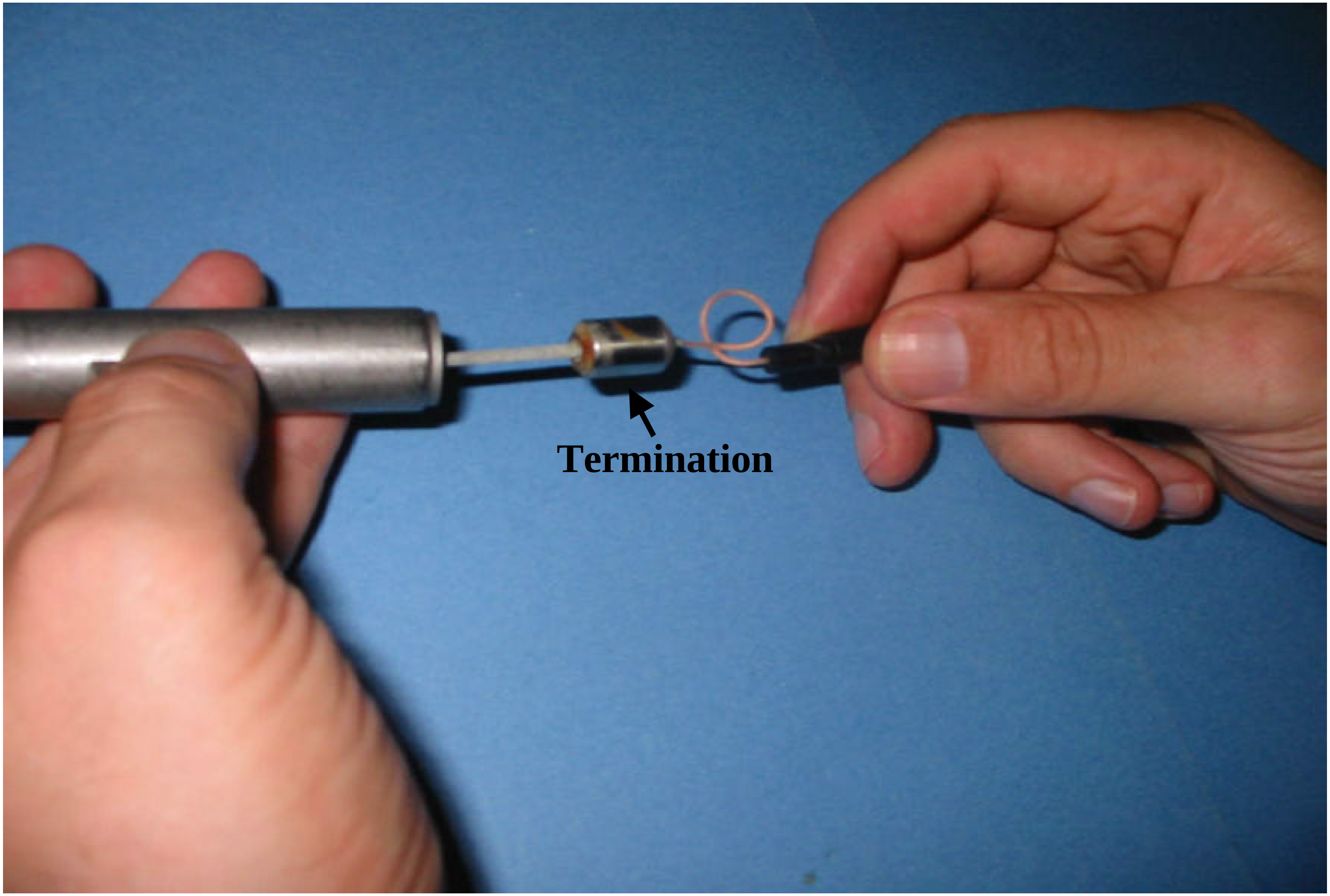


Note: Best Practice is to secure Contact Insert in Cable-heading Jig before soldering copper conductor wire to the Contact Insert.

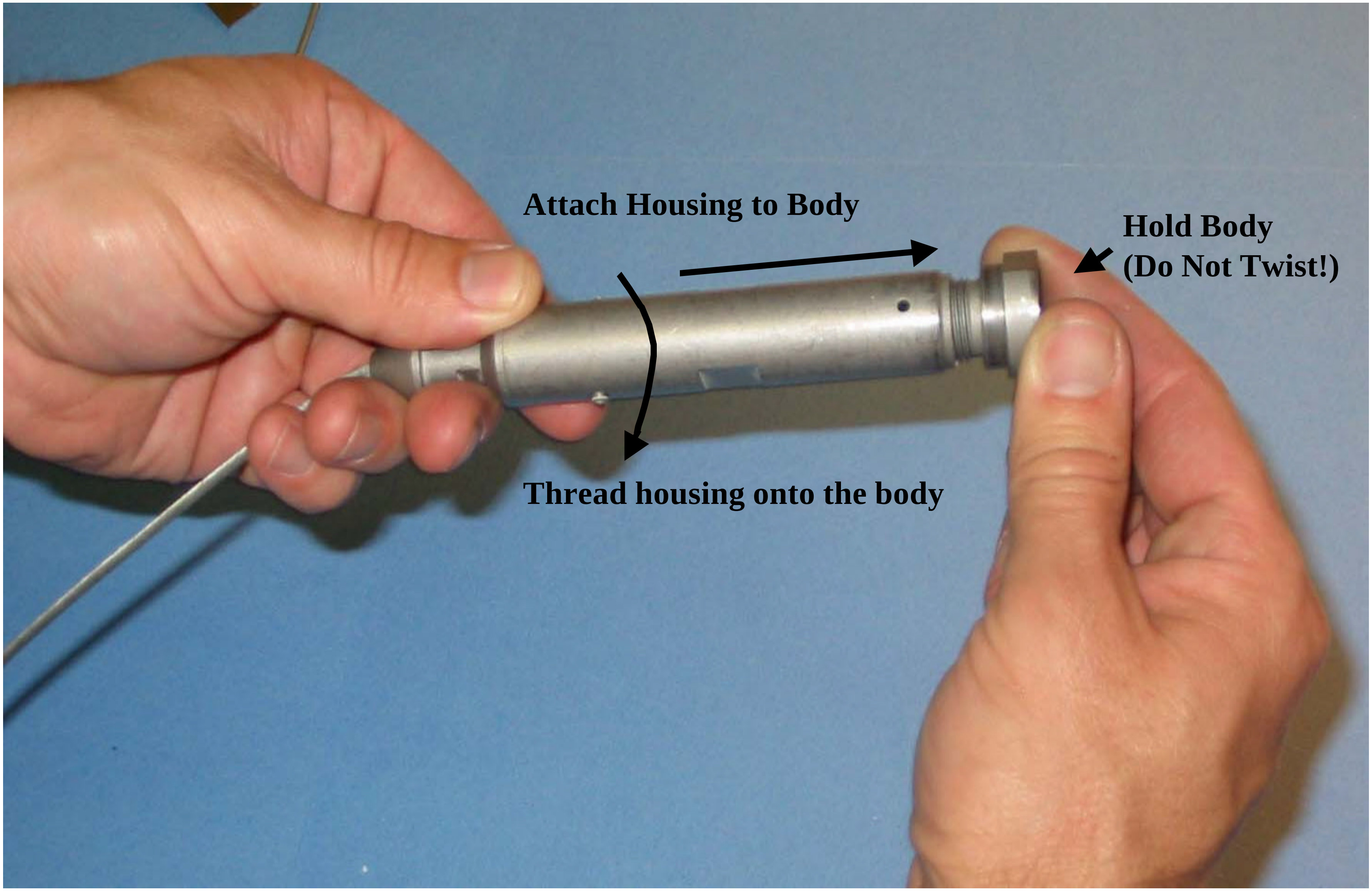
Pic.21 Solder 1/8 inch exposed copper wire (use wire strippers) into contact insert



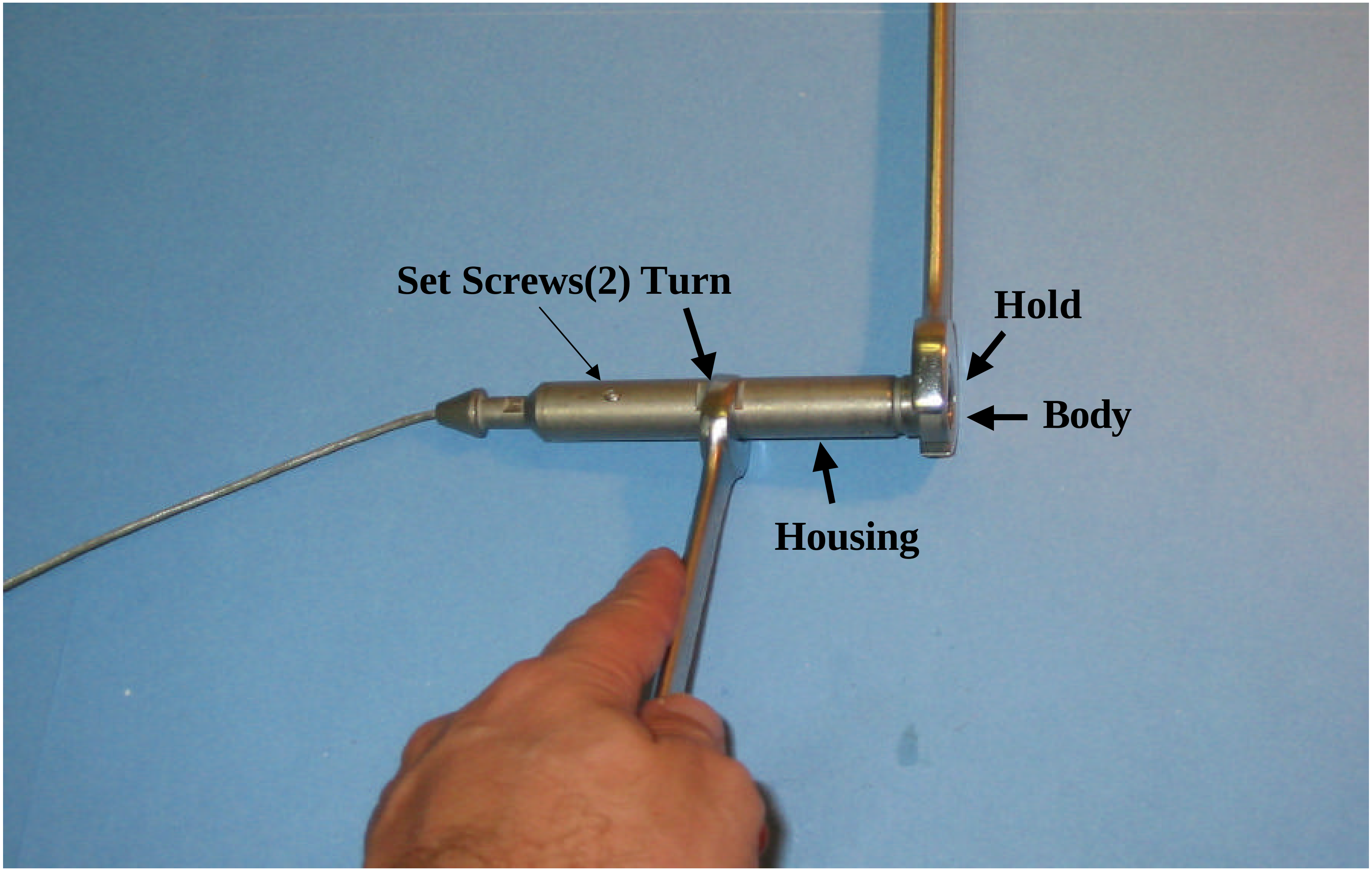
Pic.22 Slide the rubber boot down over the contact insert (when the solder has cooled)



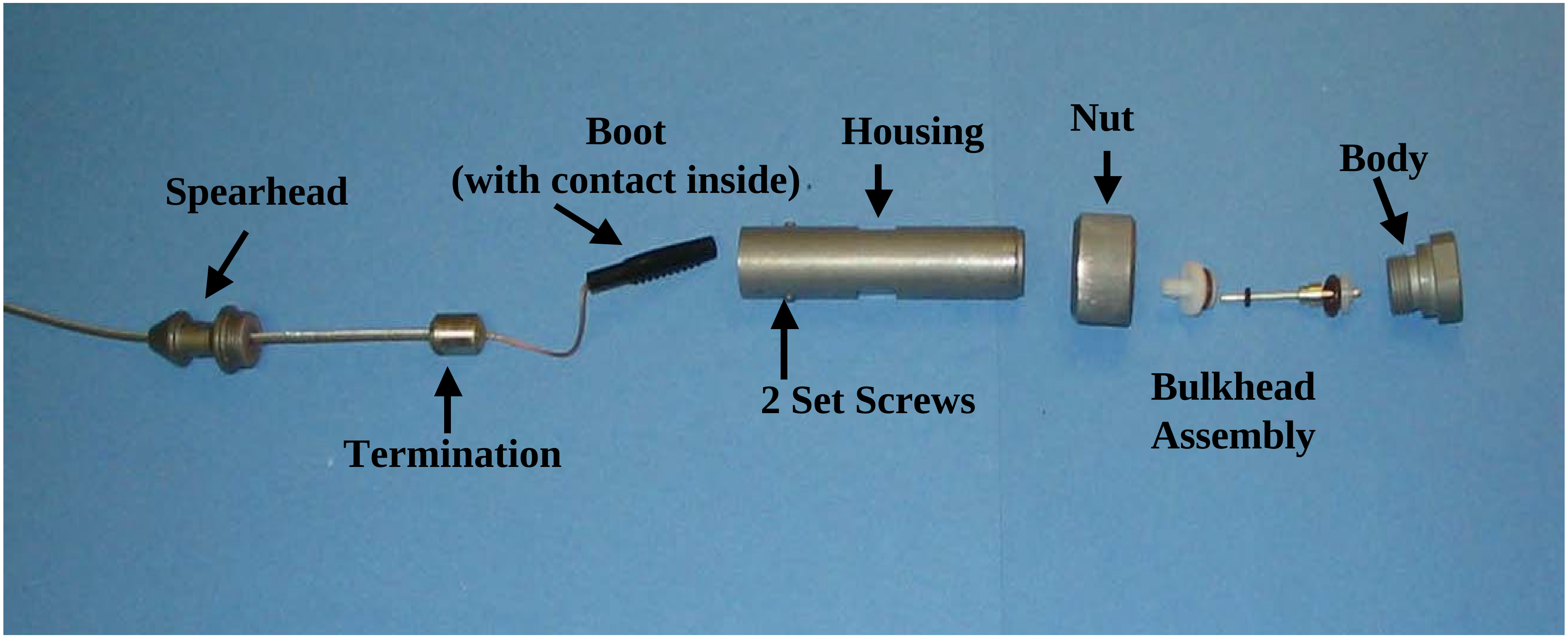
Pic.23 Create a loop in the conductor wire before sliding the cablehead housing down over the termination



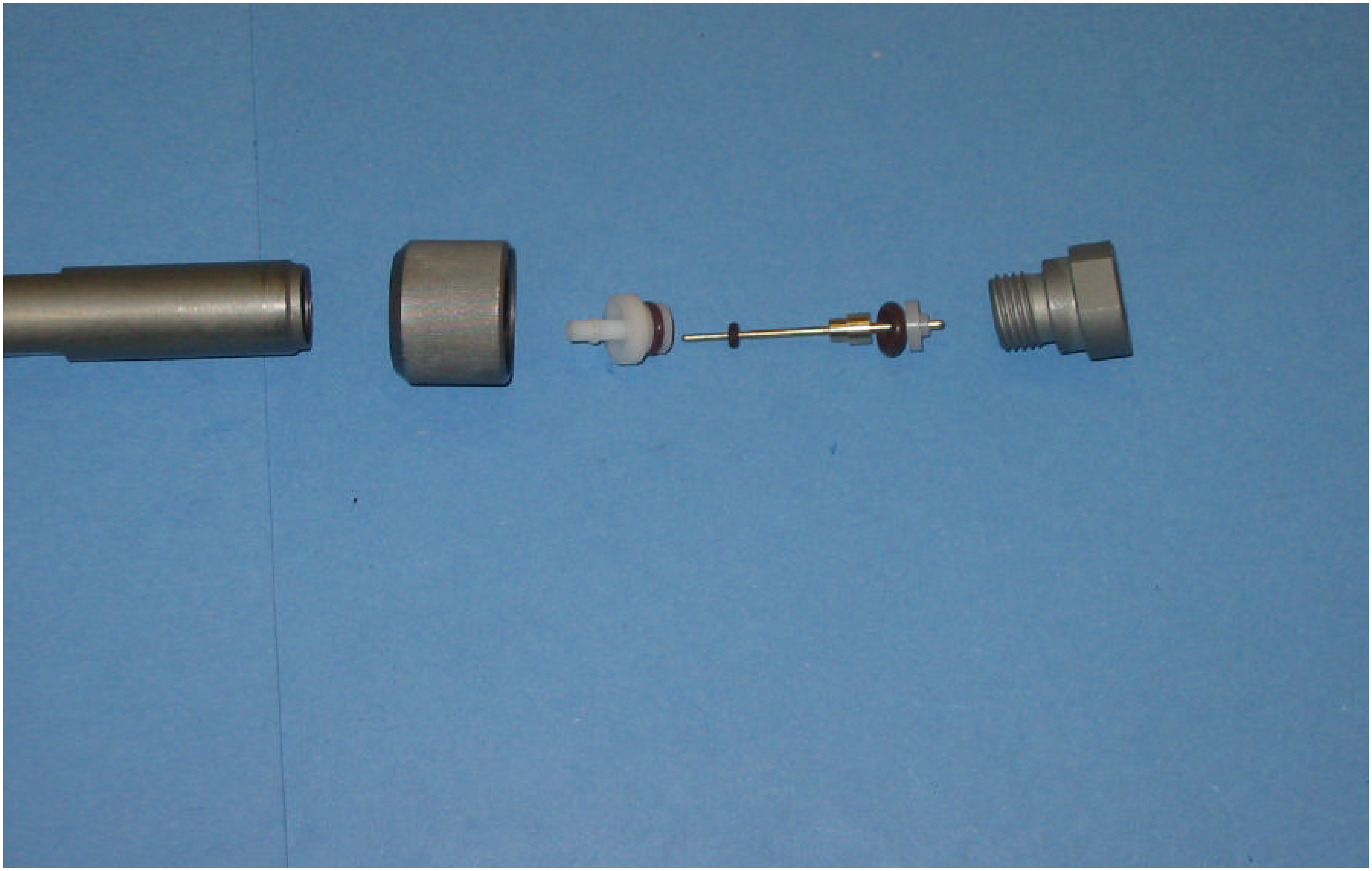
Pic.24 Thread the cablehead housing onto the body
(Do not twist the body! –this can damage the conductor wire)



Pic.25 Tighten the housing to the body
Tighten the set screws to complete re-assembly of the cablehead



Pic.26 Exploded view of cablehead assembly



Pic.27   Exploded view of bulkhead assembly

Attachment A: Standard Operating Procedure (SOP) #2

Passive Diffusion Bag (PDB) Sampling Protocol

1.0 Obtain PDB Sampler Hardware

- The hardware for each well in the sampling program will be custom-made by the PDB manufacturer (EON Products, Inc.) or by field sampling personnel, prior to the initiation of the field program.
- Each hardware kit is labeled for each well, and should closely match the dimensions submitted to the kit manufacturer.
- Open the hardware kit bag and carefully unwind the first few feet of cable or rope, to expose the first PDB station (colored zip ties or metal clips) from which the PDB samplers will hang.

2.0 Install PDB Sampler Hardware (Page 6, USGS, 2001)

- Unseal the appropriate PDB sampler hardware kit (match label to well name) and carefully retrieve hardware.
- Clip the first (bottom) PDB sampler onto the top and bottom PDB station using the available zip ties.
- Record time and bag position in the well.
- If this well is to be profiled, continue attaching PDB samplers to remaining PDB stations for this monitoring well.
- Otherwise, if this well is not scheduled to be profiled and has not yet been profiled, continue unwinding the hardware kit until the uppermost set of plastic disks is exposed and then attach the second PDB sampler.
- Once a well has been profiled and a specific depth has been selected from which to monitor groundwater quality, only one PDB sampler will be installed on the hardware kit – the depth interval will be noted on the field instruction form.
- Once the necessary PDB samplers have been installed, carefully lower the hardware kit until the stainless steel weight touches the well bottom.
- Confirm that the top clip (marker) roughly equals the top of casing and adjust as necessary to ensure a snug fit (slightly taught line) when the well cap is closed.
- Attach the end of the hardware line to the well head hanging device – make sure that the PDB sampler kit does not sag when well cap is closed.
- Secure the well.

3.0 Sample Naming/Recording

- Sample numbers will be generated as specified in the QAPP.
- Field personnel must include a depth for each sampler on the chain-of-custody.

- Record the relative position of each bag – they will be numbered in the order they will be retrieved (i.e., top → #1... #2... #n... → bottom) – in other words, the first PDB sampler to be installed will have the highest number and the last PDB sampler will have the lowest number.

4.0 PDB Sampler Retrieval (Page 9, USGS, 2001)

- Collect the appropriate number of VOA vials for the required number of VOC samples.
- Measure and record the corrected depth to water from the top of casing to ensure PDB are completely submerged below the water level.
- Note the time and begin reeling the PDB sampler hardware line.
- Field personnel must include a depth for each sampler on the chain-of-custody in the form of station number as recorded during bag placement.
- Important - the contents of each bag must be transferred to the VOA vials immediately after PDBs are removed from the well and before addressing any other sampling-related issues to avoid losing volatile compounds to atmosphere. Once the first bag leaves the water, the time limit starts at the same time for all exposed bags. All samples shall be contained in the VOA vials within 15 minutes of the PDB leaving the water.
- Extract the PDB sampler(s) from the well, remove the sampler cap and carefully empty the contents into VOA vials (preferably set up in a bottle holder), taking care not to over agitate the bag or water.
- Apply completed label to each VOA vial to ensure that they are not confused later.
- Repeat until all PDB samplers have been removed and contents transferred.
- QC duplicate samples consist of two separate sets of VOA vials filled from the same diffusion sampler.
- Store all filled VOA vials in Ziploc bags inside a properly cooled container.
- Follow above guidelines to re-install new PDB samplers as scheduled (profile or single-bag scenario).
- Dispose of all used passive diffusion sample bags and components appropriately as either IDW or recyclable material.
- Decontaminate all reusable equipment with clean water and ALCONOX.

5.0 User's Guide for Polyethylene-based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells

(See following pages)

science for a changing world

USER'S GUIDE FOR POLYETHYLENE-BASED PASSIVE DIFFUSION BAG SAMPLERS TO OBTAIN VOLATILE ORGANIC COMPOUND CONCENTRATIONS IN WELLS

PART 1:
DEPLOYMENT, RECOVERY, DATA INTERPRETATION, AND QUALITY CONTROL AND ASSURANCE

Water-Resources Investigations Report 01-4060

Prepared in cooperation with the

U.S. AIR FORCE
U.S. NAVAL FACILITIES ENGINEERING COMMAND
U.S. ENVIRONMENTAL PROTECTION AGENCY
FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE
DEFENSE LOGISTICS AGENCY
U.S. ARMY CORPS OF ENGINEERS and
INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION WORK GROUP

U.S. Department of the Interior
U.S. Geological Survey

Acknowledgments

Technical Advisory Board

U.S. Air Force Base Conversion Agency (AFBCA)
U.S. Air Force Center For Environmental Excellence (AFCEE)
Maj. Jeff Cornell (AFCEE)
Mario Ierardi (AFBCA)
Dr. Javier Santillan (AFCEE)

Defense Logistics Agency (DLA)
Lt. Col. Daniel L. Welch

U.S. Environmental Protection Agency (EPA)
Steve Schmelling, Office of Research and Development (ORD)
Dick Willey, EPA Region 1
Kathy Davies, EPA Region 3
Richard Steimle, Technology Innovation Office (TIO)

U.S. Naval Facilities Engineering Command (NAVFAC)
Cliff C. Casey (Southern Division)
Dennis Howe (Engineering Service Center)
Richard G. Mach, Jr. (Southwest Division)
Nick Ta (Engineering Service Center)

U.S. Army Corps of Engineers (USACE)
Johnette Shockley

Federal Remediation Technologies Roundtable

Interstate Technology and Regulatory Cooperation Work Group (ITRC)
George H. Nicholas (New Jersey) Team Lead
Paul M. Bergstrand (South Carolina)
Chris A. Guerre (California)
David Randolph (Tennessee)

Funding for this Guide was provided by the U.S. AIR FORCE and NAVFAC (Southern and Southwest Divisions). Additionally, the following persons are recognized for their leadership and support to this project: Marty Faile, Joe Dunkle, Kay Wishkaemper, Vince Malott, and the Passive Diffusion Bag Sampler (PDBS) Work Group.

User’s Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells

Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance

By Don A. Vroblesky

U.S. Geological Survey

Water-Resources Investigations Report 01–4060

Prepared in cooperation with the
U.S. AIR FORCE
U.S. NAVAL FACILITIES ENGINEERING COMMAND
U.S. ENVIRONMENTAL PROTECTION AGENCY
FEDERAL REMEDIATION TECHNOLOGIES ROUNDTABLE
DEFENSE LOGISTICS AGENCY
U.S. ARMY CORPS OF ENGINEERS and
INTERSTATE TECHNOLOGY AND REGULATORY COOPERATION WORK GROUP

Columbia, South Carolina
2001

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

Copies of this report can be obtained from:

U.S. Environmental Protection Agency
(USEPA)/National Service Center for
Environmental Publications (NSCEP)
Box 42419
Cincinnati, OH 45242-0419

and

U.S. Geological Survey
Branch of Information Services
Box 25286
Denver, CO 80225
Phone: 888-ASK-USGS

For additional information, write to:

District Chief
U.S. Geological Survey
Stephenson Center–Suite 129
720 Gracern Road
Columbia, SC 29210-7651

Additional information about water resources in South Carolina is available on the World Wide Web at **http://sc.water.usgs.gov**

CONTENTS

Executive Summary 1
Introduction 3
  Summary of Passive Diffusion Bag Sampler Advantages and Limitations 5
    Advantages 5
    Limitations 5
Passive Diffusion Bag Sampler Deployment 6
Passive Diffusion Bag Sampler and Sample Recovery 9
Determining Applicability of Passive Diffusion Bag Samplers and Interpretation of Data 11
  Influences of Hydraulic and Chemical Heterogeneity on Sample Quality in Long-Screened Wells 12
  Comparison of Passive Diffusion Bag Sampling Methodology to Conventional Methodologies 12
Quality Control and Assurance 14
Summary 14
References 16

Figures

1. Photo showing typical water-filled passive diffusion bag samplers used in wells, including diffusion bag with polyethylene mesh, diffusion bag without mesh, and bag and mesh attached to bailer bottom 4
2. Photo showing example of multiple passive diffusion bag samplers prepared for deployment 8

Table

1. Compounds tested under laboratory conditions for use with passive diffusion bag samplers 4

Conversion Factors, Vertical Datum, Acronyms, and Abbreviations

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square mile (mi^2)	2.590	square kilometer
	Flow	
foot per day (ft/d)	0.3048	meter per day
foot squared per day (ft^2/d)	0.09294	meter squared per day
gallon per minute (gal/min)	0.06308	liter per second
gallon per day (gal/d)	0.003785	cubic meter per day
inch per year (in/yr)	25.4	millimeter per year
	Volume	
gallon (gal)	3.785	liter

Temperature is given in degrees Celsius (°C), which can converted to degrees Fahrenheit (°F) by the following equation: °F = 9/5 (°C) + 32

Sea level refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration in water is expressed in metric units as milligrams per liter (mg/L) or micrograms per liter (µg/L).

Additional Abbreviations	
EDB	1,2-Dibromomethane
AFCEE	Air Force Center for Environmental Excellence
*c*DCE	*cis*-1,2-Dibromoethene
ft^3/d	cubic feet per day
ft^3/mg	cubic feet per milligram
°C	degrees Celsius
g	gram
ITRC	Interstate Technology Regulatory Cooperation
LDPE	low-density polyethylene
L	liter
µg	microgram
µm	micrometer
µL	microliter
mg	milligram
mL	milliliter
mL/min	milliliter per minute
MTBE	Methyl-*tert*-butyl ether
NAVFAC	Naval Facilities Engineering Command
NAPL	non-aqueous phase liquid
PDB	passive diffusion bag
PCE	Tetrachloroethene
TCE	Trichloroethene
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
VOA	Volatile organic analysis
VOC	Volatile organic compound

User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells

Part 1: Deployment, Recovery, Data Interpretation, and Quality Control and Assurance

By Don A. Vroblesky

EXECUTIVE SUMMARY

Water-filled passive diffusion bag (PDB) samplers described in this report are suitable for obtaining concentrations of a variety of volatile organic compounds (VOCs) in ground water at monitoring wells. The suggested application of the method is for long-term monitoring of VOCs in ground-water wells at well-characterized sites.

The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water is representative of the ground water in the aquifer directly adjacent to the screen. If there are vertical components of intra-bore-hole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then a multiple deployment of PDB samplers within a well may be more appropriate for sampling the well.

A typical PDB sampler consists of a low-density polyethylene (LDPE) lay-flat tube closed at both ends and containing deionized water. The sampler is positioned at the target horizon of the well by attachment to a weighted line or fixed pipe.

The amount of time that the sampler should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for the environmental disturbance caused by sampler deployment to return to ambient conditions. The rate that the water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. The concentrations of benzene, *cis*-1,2-dichloroethene, tetrachlorethene, trichloroethene, toluene, naphthalene, 1,2-dibromoethane, and total xylenes within the PDB samplers equilibrated with the concentrations in an aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 degrees Celsius (°C). A subsequent laboratory study of mixed VOCs at 10 °C showed that tetrachloroethene and trichloroethene were equilibrated by about 52 hours, but other compounds required longer equilabration times. Chloroethane, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and 1,1-dichloroethene were not equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours, but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed VOC solutions have not yet been thoroughly examined.

The samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. Laboratory and field data suggest that 2 weeks of equilibration probably is adequate for many applications; therefore, a minimum equilibration time of 2 weeks is suggested. In less permeable formations, longer equilibration times may be required. When applying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating data, a side-by-side comparison with conventional methodology is advisable to justify the field equilibration time.

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified time for sampler recovery after initial equilibration. PDB samplers routinely have been left in ground waters having concentrations of greater than 500 parts per million (ppm) of trichloroethene for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers have been left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity. The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations, however. Moreover, in some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices (SPMDs) have shown that the transfer of some compounds across a heavily biofouled polyethylene membrane may be reduced, but not stopped. If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparison to a conventional sampling method before continuing to use PDB samplers for long-term deployment in that well.

Recovery consists of removing the samplers from the well and immediately transferring the enclosed water to 40-milliliter sampling vials for analysis. The resulting concentrations represent an integration of chemical changes over the most recent portion of the equilibration period (approximately 48 to 166 hours, depending on the water temperature and the type of compound).

The method has both advantages and limitations when compared to other sampling methods. Advantages include the potential for PDB samplers to eliminate or substantially reduce the amount of purge water associated with sampling. The samplers are relatively inexpensive and easy to deploy and recover. Because PDB samplers are disposable, there is no downhole equipment to be decontaminated between wells, and there is a minimum amount of field equipment required. The samplers also have the potential to delineate contaminant stratification in the formation across the open or screened intervals of monitoring wells where vertical hydraulic gradients are not present. In addition, the samplers integrate concentrations over time, which may range between about 48 to 166 hours depending on the compound of interest. Because the pore size of LDPE is only about 10 angstroms or less, sediment does not pass through the membrane into the bag. Thus, PDB samplers are not subject to interferences from turbidity. In addition, none of the data collected suggest that VOCs leach from the LDPE material, or that there is a detrimental effect on the VOC sample from the PDB material.

Water-filled polyethylene PDB samplers are not appropriate for all compounds. The samplers are not suitable for inorganic ions and have a limited applicability for non-VOCs and for some VOCs. For example, although methyl-*tert*-butyl ether and acetone and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. A variety of factors influence the ability of compounds to diffuse through the polyethylene. These factors include the molecular size and shape and the hydrophobic nature of the compound. Unpublished laboratory test data of semivolatile compounds in contact with PDB samplers showed a higher concentration of phthalates inside the PDB sampler than outside the PDB sampler, suggesting that the polyethylene may contribute phthalates to the enclosed water. Thus, the samplers should not be used to sample for phthalates.

VOC concentrations in PDB samplers represent concentrations in the vicinity of the sampler within the well screen or open interval. This may be a limitation for PDB samplers and some other types of sampling, such as low-flow sampling, if the ground-water contamination is above or below the screen or not in the sample intervals providing water movement to the PDB samplers. If there is a vertical hydraulic gradient in the well, then the concentrations in the sampler may represent the concentrations in the water flowing vertically past the sampler rather than in the formation directly adjacent to the sampler. Vertically spaced multiple PDB samplers may be needed in chemically stratified wells or where flow patterns through the screen change as a result of ground-water pumping or seasonal water-level fluctuations.

The purposes of this document are to present methods for PDB sampler deployment, and recovery; to discuss approaches to determine the applicability of passive diffusion samplers; and to discuss various factors influencing interpretation of the data. The intended audience for the methodology sections of this report is managers and field personnel involved in using PDB samplers. The discussion of passive diffusion sampler applicability and interpretation of the data is suited for project managers, technical personnel, and the regulatory community. Part 2 of this report presents case studies of PDB sampler field applications.

INTRODUCTION

The use of PDB samplers for collecting ground-water samples from wells offers a cost-effective approach to long-term monitoring of VOCs at well-characterized sites (Vroblesky and Hyde, 1997; Gefell and others, 1999). The effectiveness of the use of a single PDB sampler in a well is dependent on the assumption that there is horizontal flow through the well screen and that the quality of the water is representative of the ground water in the aquifer directly adjacent to the screen. If there are vertical components of intra-borehole flow, multiple intervals of the formation contributing to flow, or varying concentrations of VOCs vertically within the screened or open interval, then deployment of multiple PDB samplers within a well may be more appropriate for sampling the well.

The samplers consist of deionized water enclosed in a LDPE sleeve (fig. 1) and are deployed adjacent to a target horizon within a screened or open interval of a well. The suggested application is for long-term monitoring of VOCs in ground-water wells. Where the screened interval is greater than 10 feet (ft), the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than 10 ft. It is important that the vertical distribution of contaminants be determined in wells having 10-ft-long well screens, and that both the vertical distribution of contaminants and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft. For many VOCs of environmental interest (table 1), the VOC concentration in water within the sampler approaches the VOC concentration in water outside of the PDB sampler over an equilibration period. The resulting concentrations represent an integration of chemical changes over the most recent part of the equilibration period (approximately 48 to 166 hours, depending on the water temperature and the type of compound being sampled). The approach is inexpensive and has the potential to eliminate or substantially reduce the amount of purge water removed from the well.

A variety of PDB samplers have been utilized in well applications (fig. 1). Although the samplers vary in specific construction details, a typical PDB sampler consists of a 1- to 2-ft-long LDPE tube closed at both ends and containing laboratory-grade deionized water (fig. 1). The typical diameter for PDB samplers used in a 2-inch-diameter well is approximately 1.2 inches; however, other dimensions may be used to match the well diameter. Equilibration times may be longer for larger diameter PDB samplers. On the outside of the PDB sampler, a low-density polyethylene-mesh sometimes is used for protection against abrasion in open boreholes and as a means of attachment at the prescribed depth. The PDB sampler can be positioned at the target horizon by attachment to a weighted line or by attachment to a fixed pipe.

PDB samplers for use in wells are available commercially. Authorized distributors as of March 2001 are Columbia Analytical Services (800-695-7222; www@caslab.com) and Eon Products (800-474-2490; www.eonpro.com). A current list of vendors and PDB-sampler construction details can be obtained from the U.S. Geological Survey Technology Transfer Enterprise Office, Mail Stop 211, National Center, 12201 Sunrise Valley Drive, Reston, Virginia 20192 (telephone 703-648-4344; fax 703-648-4408). PDB samplers employ patented technology (U.S. patent number 5,804,743), and therefore, require that the user purchase commercially produced samplers from a licensed manufacturer or purchase a nonexclusive license for sampler construction from the U.S. Geological Survey Technology Enterprise Office at the above address.

The purposes of this document are to present methods for PDB sampler deployment, and recovery; to discuss approaches for determining the applicability of passive diffusion samplers; and to discuss various factors influencing interpretation of the data. The intended audience for the methodology sections of this report is managers and field personnel involved in using PDB samplers. The discussion of PDB sampler applicability and interpretation of the data is suited for project managers, technical personnel, and the regulatory community. Part 2 of this report presents case studies of PDB-sampler field applications.

Figure 1. Typical water-filled passive diffusion bag samplers used in wells, including (A) diffusion bag with polyethylene mesh, (B) diffusion bag without mesh, and (C) bag and mesh attached to bailer bottom.

Table 1. Compounds tested under laboratory conditions for use with passive diffusion bag samplers

[From Vroblesky and Campbell, 2001]

Tested compounds showing good correlation (average differences in concentration of 11 percent or less between diffusion-sampler water and test-vessel water) in laboratory tests			
Benzene	2 Chlorovinyl ether	*cis*-1,2-Dichloroethene	1,1,1-Trichloroethane
Bromodichloromethane	Dibromochloromethane	*trans*-1,2-Dichloroethene	1,1,2-Trichloroethane
Bromoform	Dibromomethane	1,2-Dichloropropane	Trichloroethene
Chlorobenzene	1,2-Dichlorobenzene	*cis*-Dichloropropene	Trichlorofluoromethane
Carbon tetrachloride	1,3-Dichlorobenzene	1,2-Dibromoethane	1,2,3-Trichloropropane
Chloroethane	1,4-Dichlorobenzene	*trans*-1,3-Dichloropropene	1,1,2,2-Tetrachloroethane
Chloroform	Dichlorodifluoromethane	Ethyl benzene	Tetrachloroethene
Chloromethane	1,2-Dichloroethane	Naphthalene	Vinyl chloride
	1,1-Dichloroethene	Toluene	Total xylenes
Tested compounds showing poor correlation (average differences in concentration greater than 20 percent between diffusion-sampler water and test-vessel water) in laboratory tests			
Acetone*	Methyl-*tert*-butyl ether	Styrene	

*T.M Sivavec and S.S. Baghel, General Electric Company, written commun., 2000

Summary of Passive Diffusion Bag Sampler Advantages and Limitations

Advantages

1. PDB samplers have the potential to eliminate or substantially reduce the amount of purge water associated with sampling.

2. PDB samplers are inexpensive.

3. The samplers are easy to deploy and recover.

4. Because PDB samplers are disposable, there is no downhole equipment to be decontaminated between wells.

5. A minimal amount of field equipment is required.

6. Sampler recovery is rapid. Because of the small amount of time and equipment required for the sampling event, the method is practical for use where access is a problem or where discretion is desirable (that is, residential communities, business districts, or busy streets where vehicle traffic control is a concern).

7. Multiple PDB samplers, distributed vertically along the screened or open interval, may be used in conjunction with borehole flow meter testing to gain insight on the movement of contaminants into and out of the well screen or open interval or to locate the zone of highest concentration in the well. Analytical costs when using multiple PDB samplers sometimes can be reduced by selecting a limited number of the samplers for laboratory analysis based on screening by using field gas chromatography at the time of sample collection.

8. Because the pore size of LDPE is only about 10 angstroms or less, sediment does not pass through the membrane into the bag. Thus, PDB samplers are not subject to interferences from turbidity. In addition, none of the data collected suggest that VOCs leach from the LDPE material or that there is a detrimental effect from the PDB material on the VOC sample.

Limitations

1. PDB samplers integrate concentrations over time. This may be a limitation if the goal of sampling is to collect a representative sample at a point in time in an aquifer where VOC-concentrations substantially change more rapidly than the samplers equilibrate. Laboratory results obtained indicate that a variety of compounds equilibrated within 48 hours at 21 °C (Vroblesky and Campbell, 2001). Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane may require between 93 and 166 hours to equilibrate at 10 °C (T.M. Sivavec and S.S. Baghel, General Electric Company, written commun., 2000). The initial equilibration under field conditions may be longer to allow well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment.

2. Water-filled polyethylene PDB samplers are not appropriate for all compounds. For example, although methyl-*tert*-butyl ether and acetone (Vroblesky, 2000; Paul Hare, General Electric Company, oral commun., 2000) and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. A variety of factors influence the ability of compounds to diffuse through the polyethylene membrane. These factors include the molecular size and shape and the hydrophobic nature of the compound. Compounds having a cross-sectional diameter of about 10 angstroms or larger (such as humic acids) do not pass through the polyethylene because the largest (transient) pores in polyethylene do not exceed about 10 angstroms in diameter (Flynn and Yalkowsky, 1972; Hwang and Kammermeyer, 1975; Comyn, 1985). The samplers are not appropriate for hydrophilic polar molecules, such as inorganic ions. A detailed discussion of the relation between hydrophobicity and compound transport through polyethylene can be found in Gale (1998). Unpublished laboratory test data (D.A. Vroblesky, U.S. Geological Survey, written commun., 1998) of semivolatile compounds in contact with PDB samplers showed a higher concentration of phthalates inside the PDB sampler than outside the PDB sampler, suggesting that the polyethylene may contribute phthalates to the enclosed water. Thus, the samplers should not be used to sample for phthalates.

3. PDB samplers rely on the free movement of water through the well screen. In situations where ground water flows horizontally through the well screen, the VOC concentrations in the open interval of the well probably are representative of the aquifer water in the adjacent formation (Gillham and others, 1985; Robin and Gillham, 1987; Kearl and others, 1992; Powell and Puls, 1993; Vroblesky and Hyde, 1997). In these situations, the VOC concentration of the water in contact with the PDB samplers, and therefore, the water within the diffusion samplers, probably represents local conditions in the adjacent aquifer. However, if the well screen is less permeable than the aquifer or the sandpack, then under ambient conditions, flowlines may be diverted around the screen. Such a situation may arise from inadequate well development or from iron bacterial fouling of the well screen. In this case, the VOC concentrations in the PDB samplers may not represent concentrations in

the formation water because of inadequate exchange across the well screen. PDB samplers have not yet been adequately tested to determine their response under such conditions.

4. VOC concentrations in PDB samplers represent ground-water concentrations in the vicinity of the screened or open well interval that move to the sampler under ambient flow conditions. This is a limitation if the ground-water contamination lies above or below the well screen or open interval, and requires the operation of a pump to conduct contaminants into the well for sampling.

5. In cases where the well screen or open interval transects zones of differing hydraulic head and variable contaminant concentrations, VOC concentrations obtained using a PDB sampler may not reflect the concentrations in the aquifer directly adjacent to the sampler because of vertical transport in the well. However, a vertical array of PDB samplers, used in conjunction with borehole flow meter testing, can provide insight on the movement of contaminants into or out of the well. This information then can be used to help determine if the use of PDB samplers is appropriate for the well, and to select the optimal vertical location(s) for the sampler deployment.

6. In wells with screens or open intervals with stratified chemical concentrations, the use of a single PDB sampler set at an arbitrary (by convention) depth may not provide accurate concentration values for the most contaminated zone. However, multiple PDB samplers distributed vertically along the screened or open interval, in conjunction with pump sampling (as appropriate), can be used to locate zone(s) of highest concentration in the well. Multiple PDB samplers also may be needed to track the zone of maximum concentration in wells where flow patterns through the screened interval change as a result of ground-water pumping or seasonal water-table fluctuations.

PASSIVE DIFFUSION BAG SAMPLER DEPLOYMENT

A variety of approaches can be used to deploy the PDB samplers in wells. A typical deployment approach, described in this section, is to attach the PDB samplers to a weighted line. It also is acceptable to attach the weights directly to the PDB sampler if the attachment point is of sufficient strength to support the weight. The weights attached to the bottom of the line are stainless steel and can be reused, but must be thoroughly decontaminated with a detergent before the first use or before using in a different well. Rope, such as 90 pound, 3/16 inch braided polyester, can be used as the line for single-use applications if it is of sufficient strength to support the weight and sampler, is nonbuoyant, and is subject to minimal stretch; however, the rope should not be reused because of the high potential for cross contamination. Stainless-steel or Teflon-coated stainless-steel wire is preferable. The weighted lines should not be reused in different wells to prevent carryover of contaminants. A possible exception is coated stainless-steel wire, which can be reused after sufficient decontamination. An alternative deployment approach, not discussed in this section, is to attach the PDB samplers to a fixed pipe in the well (Vroblesky and Peters, 2000, p. 3; also included in Part 2 of this publication). The PDB samplers should not contact non-aqueous phase liquid (NAPL) during deployment or retrieval to prevent cross contamination. An approach that can be utilized to deploy diffusion samplers through a layer of floating NAPL is described in the field test at Naval Station North Island, California (Vroblesky and Peters, 2000, p. 3-4; also included in Part 2 of this publication).

If the PDB sampler is to be compared with a conventional pumping approach to sampling, then it is suggested that both the pump and the PDB sampler be deployed at the same time, with the sampler attached near (such as directly below) the pump inlet. This approach eliminates potential concentration differences between the two methods that may result from well disturbance during equipment removal and deployment at the time of sampling. An alternative method is to deploy the PDB samplers independently of the pumps and recover the samplers immediately prior to placing the pump down the well.

PDB samplers are available either prefilled (field ready) with laboratory-grade deionized water or unfilled. The unfilled samplers are equipped with a plug and funnel to allow for field filling and sample recovery. To fill these samplers, remove the plug from the sampler bottom, insert the short funnel into the sampler, and pour laboratory-grade deionized water into the sampler. The sampler should be filled until water rises and stands at least half way into the funnel. Remove excess bubbles from the sampler. Remove the funnel and reattach the plug. A small air bubble from the plug is of no concern.

The following steps should be used for deploying PDB samplers in wells:

1. Measure the well depth and compare the measured depth with the reported depth to the bottom of the well screen from well-construction records. This is to check on whether sediment has accumulated in the bottom of the well, whether there is a nonscreened section of pipe (sediment sump) below the well screen, and on the accuracy of well-construction records. If there is an uncertainty regarding length or placement of the well screen, then an independent method, such as video imaging of the well bore, is strongly suggested.

2. Attach a stainless-steel weight to the end of the line. Sufficient weight should be added to counterbalance the buoyancy of the PDB samplers. This is particularly important when multiple PDB samplers are deployed. One approach, discussed in the following paragraphs, is to have the weight resting on the bottom of the well, with the line taut above the weight. Alternatively, the PDB sampler and weight may be suspended above the bottom, but caution should be exercised to ensure that the sampler does not shift location. Such shifting can result from stretching or slipping of the line or, if multiple samplers are attached end-to-end rather than to a weighted line, stretching of the samplers.

3. Calculate the distance from the bottom of the well, or top of the sediment in the well, up to the point where the PDB sampler is to be placed. A variety of approaches can be used to attach the PDB sampler to the weight or weighted line at the target horizon. The field-fillable type of PDB sampler is equipped with a hanger assembly and weight that can be slid over the sampler body until it rests securely near the bottom of the sampler. When this approach is used with multiple PDB samplers down the same borehole, the weight should only be attached to the lowermost sampler. An additional option is to use coated stainless-steel wire as a weighted line, making loops at appropriate points to attach the upper and lower ends of PDB samplers. Where the PDB sampler position varies between sampling events, movable clamps with rings can be used. When using rope as a weighted line, a simple approach is to tie knots or attach clasps at the appropriate depths. Nylon cable ties or stainless-steel clips inserted through the knots can be used to attach the PDB samplers. An approach using rope as a weighted line with knots tied at the appropriate sampler-attachment points is discussed below.

(a) For 5-ft-long or shorter well screens, the center point of the PDB sampler should be the vertical midpoint of the saturated well-screen length. For example, if the well screen is at a depth of 55 to 60 ft below the top of casing, and the measured depth of the well is 59 ft, then the bottom of the well probably has filled with sediment. In this case, the midpoint of the sampler between the attachment points on the line will be midway between 55 and 59 ft, or at 57 ft. Thus, for a 1.5-ft-long sampler, the attachment points on a weighted line should be tied at distances of 1.25 ft (2 ft – 0.75 ft) and 2.75 ft (2 ft + 0.75 ft) from the top of the sediment in the well, or the bottom of the well, making adjustments for the length of the attached weight. When the PDB sampler is attached to the line and installed in the well, the center of the sampler will be at 57-ft depth. If, however, independent evidence is available showing that the highest concentration of contaminants enters the well from a specific zone within the screened interval, then the PDB sampler should be positioned at that interval.

(b) For 5- to 10-ft-long well screens, it is advisable to utilize multiple PDB samplers vertically along the length of the well screen for at least the initial sampling (fig. 2). The purposes of the multiple PDB samplers are to determine whether contaminant stratification is present and to locate the zone of highest concentration. The midpoint of each sampler should be positioned at the midpoint of the interval to be sampled. For 1.5-ft-long samplers, at each sampling depth in the screened interval, make two attachment points on the weighted line at a distance of about 1.5 ft apart. The attachment points should be positioned along the weighted line at a distance from the bottom end of the weight such that the midpoint between the knots will be at the desired sampling depth along the well screen. Sampler intervals are variable, but a simple approach is to use the top knot/loop of one sampler interval as the bottom knot/loop for the overlying sampler interval.

Figure 2. Example of multiple PDB samplers prepared for deployment.

(c) PDB samplers should not be used in wells having screened or open intervals longer than 10 ft unless used in conjunction with borehole flow meters or other techniques to characterize vertical variability in hydraulic conductivity and contaminant distribution or used strictly for qualitative reconnaissance purposes. This is because of the increased potential for cross contamination of water-bearing zones and hydraulically driven mixing effects that may cause the contaminant stratification in the well to differ from the contaminant stratification in the adjacent aquifer material. If it is necessary to sample such wells, then multiple PDB samplers should be installed vertically across the screened or open interval to determine the zone of highest concentration and whether contaminant stratification is present.

4. The samplers should be attached to the weights or weighted line at the time of deployment. For samplers utilizing the hanger and weight assembly, the line can be attached directly to the top of the sampler. PDB samplers utilizing an outer protective mesh can be attached to a weighted line by using the following procedure:

(a) Insert cable ties through the attachment points in the weighted line.

(b) At each end of the PDB sampler, weave the ends of the cable ties or clamp through the LPDE mesh surrounding the sampler and tighten the cable ties. Thus, each end of the PDB sampler will be attached to a knot/loop in the weighted line by means of a cable tie or clamp. The cable ties or clamps should be positioned through the polyethylene mesh in a way that prevents the PDB sampler from sliding out of the mesh.

(c) Trim the excess from the cable tie before placing the sampler down the well. Caution should be exercised to prevent sharp edges on the trimmed cable ties that may puncture the LDPE.

5. When using PDB samplers without the protective outer mesh, the holes punched at the ends of the bag, outside the sealed portion, can be used to attach the samplers to the weighted line. Stainless-steel spring clips have been found to be more reliable than cable ties in this instance, but cable ties also work well.

6. Lower the weight and weighted line down the well until the weight rests on the bottom of the well and the line above the weight is taut. The PDB samplers should now be positioned at the expected depth. A check on the depth can be done by placing a knot or mark on the line at the correct distance from the top knot/loop of the PDB sampler to the top of the well casing and checking to make sure that the mark aligns with the lip of the casing after deployment.

7. Secure the assembly in this position. A suggested method is to attach the weighted line to a hook on the inside of the well cap. Reattach the well cap. The well should be sealed in such a way as to prevent surface-water invasion. This is particularly important in flush-mounted well vaults that are prone to flooding.

8. Allow the system to remain undisturbed as the PDB samplers equilibrate.

PASSIVE DIFFUSION BAG SAMPLER AND SAMPLE RECOVERY

The amount of time that the samplers should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for environmental disturbances caused by sampler deployment to return to ambient conditions. The rate that the water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. The concentrations of benzene, *cis*-1,2-dichloroethene (*c*DCE), tetrachlorethene (PCE), trichloroethene (TCE), toluene, naphthalene, 1,2-dibromoethane (EDB), and total xylenes within the PDB samplers equilibrated with the concentrations in an aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 °C (Vroblesky and Campbell, 2001). A subsequent laboratory study of mixed VOCs at 10 °C showed that PCE and TCE were equilibrated by about 52 hours, but other compounds required longer equilibration times (T.M. Sivavec and S.S. Baghel, General Electric Company, written commun., 2000). Chloroethane, *c*DCE, *trans*-1,2-dichloroethene, and 1,1-dichloroethene were not equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours, but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed-VOC solutions have not yet been thoroughly examined.

Under field conditions, the samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. The results of borehole dilution studies show that wells can recover to 90 percent of the predisturbance conditions within minutes to several hours for permeable to highly permeable geologic formations, but may require 100 to 1,000 hours (4 to 40 days) in muds, very fine-grained loamy sands, and fractured rock, and may take even longer in fractured shales, recent loams, clays, and slightly fractured solid igneous rocks (Halevy and others, 1967).

In general, where the rate of ground-water movement past a diffusion sampler is high, equilibration times through various membranes commonly range from a few hours to a few days (Mayer, 1976; Harrington and others, 2000). One field investigation showed adequate equilibration of PDB samplers to aquifer trichloroethene (TCE) and carbon tetrachloride (CT) concentrations within 2 days in a highly permeable aquifer (Vroblesky and others, 1999). In other investigations, PDB samplers recovered after 14 days were found to be adequately equilibrated to chlorinated VOCs (Obrien & Gere Engineers, Inc., 1997a, 1997b; Hare, 2000); therefore, the equilibration period was less than or equal to 14 days for those field conditions. Because it appears that 2 weeks of equilibration probably is adequate for many applications, a minimum equilibration time of 2 weeks is suggested. When applying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating field data, a side-by-side comparison with conventional sampling methodology is advisable to justify the field equilibration time.

In less permeable formations, longer equilibration times may be required. It is probable that water in the well bore eventually will equilibrate with the pore-water chemistry; however, if the rate of chemical change or volatilization loss in the well bore exceeds the rate of exchange between the pore water and the well-bore water, then the PDB samplers may underestimate pore-water concentrations. Guidelines for equilibration times and applicability of PDB samplers in low-permeability formations have not yet been established. Therefore, in such situations, a side-by-side comparison of PDB samplers and conventional sampling methodology is advisable to ensure that the PDB samplers do not underestimate concentrations obtained by the conventional method. A detailed discussion of diffusion rates relevant to diffusion sampler equilibrium in slow-moving ground-water systems can be found in Harrington and others (2000).

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified maximum time for sampler recovery. PDB samplers have routinely been left in ground waters having concentrations of greater than 500 ppm of TCE for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers have been left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity (Paul Hare, General Electric Company, oral commun., 2000). The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations. Moreover, in some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices (SPMDs) have shown that the transfer of some compounds may be reduced, but not stopped, across a heavily biofouled polyethylene membrane (Ellis and others, 1995; Huckins and others, 1996; Huckins and others, in press). If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparing contaminant concentrations from the PDB sampler to concentrations from a conventional sampling method before continuing to use PDB samplers for long-term deployment in that well.

Recovery of PDB samplers is accomplished by using the following approach:

1. Remove the PDB samplers from the well by using the attached line. The PDB samplers should not be exposed to heat or agitated.

2. Examine the surface of the PDB sampler for evidence of algae, iron or other coatings, and for tears in the membrane. Note the observations in a sampling field book. If there are tears in the membrane, the sample should be rejected. If there is evidence that the PDB sampler exhibits a coating, then this should be noted in the validated concentration data.

3. Detach and remove the PDB sampler from the weighted line. Remove the excess liquid from the exterior of the bag to minimize the potential for cross contamination.

4. A variety of approaches may be used to transfer the water from the PDB samplers to 40-mL volatile organic analysis (VOA) vials. One type of commercially available PDB sampler provides a discharge device that can be inserted into the sampler. If discharge devices are used, the diameter of the opening should be kept to less than about 0.15 inches to reduce volatilization loss. Two options are presently available to recover water from the sample using discharge devices. One option involves removing the hanger and weight assembly from the sampler, inverting the sampler so that the fill plug is pointed upward, and removing the plug. The water can be recovered by directly pouring in a manner that minimizes agitation or by pouring through a VOC-discharge accessory inserted in place of the plug. The second approach involves piercing the sampler near the bottom with a small-diameter discharge tube and allowing water to flow through the tube into the VOA vials. In each case, flow rates can be controlled by tilting or manipulating the sampler. Alternatively, the PDB sampler can be cut open at one end using scissors or other cutting devices which have been decontaminated between use for different wells. Water can then be transferred to 40-ml VOA vials by gently pouring in a manner that minimizes water agitation. Acceptable duplication has been obtained using each method. Preserve the samples according to the analytical method. The sampling vials should be stored at approximately 4 °C in accordance with standard sampling protocol. Laboratory testing suggests that there is no substantial change in the VOC concentrations in PDB samplers over the first several minutes after recovery; however, the water should be transferred from the water-filled samplers to the sample bottles immediately upon recovery.

5. A cost-effective alternative when using multiple PDB samplers in a single well is to field screen water from each sampler using gas chromatography. These results can be used to decide which of the multiple PDB samplers should be sent to an EPA-approved laboratory for standard analysis. Typically, at least the sample containing the highest concentration should be analyzed by a laboratory.

6. If a comparison is being made between concentrations obtained using PDB samplers and concentrations obtained using a conventional sampling approach, then the well should be sampled by the conventional approach soon after (preferably on the same day) recovery of the PDB sampler. The water samples obtained using PDB samplers should be sent in the same shipment, as the samples collected by the conventional approach for the respective wells. Utilizing the same laboratory may reduce analytical variability.

7. Any unused water from the PDB sampler and water used to decontaminate cutting devices should be disposed in accordance with local, state, and Federal regulations.

DETERMINING APPLICABILITY OF PASSIVE DIFFUSION BAG SAMPLERS AND INTERPRETATION OF DATA

When attempting to determine whether the use of PDB samplers is appropriate at a particular well, a common approach is to do a side-by-side comparison with a conventional sampling method during the same sampling event. This approach is strongly suggested in wells having temporal concentration variability. In a well having relatively low temporal concentration variability, comparison of the PDB-sampler results to historical concentrations may provide enough information to determine whether the PDB samplers are appropriate for the well. In general, if both PDB and conventional sampling produce concentrations that agree within a range deemed acceptable by local, state, and Federal regulatory agencies and meet the site-specific data-quality objectives, then a PDB sampler may be approved for use in that well to monitor ambient VOC concentrations. If concentrations from the PDB sampler are higher than concentrations from the conventional method, it is probable that concentrations from the PDB sampler adequately represent ambient conditions because there usually is a greater potential for dilution from mixing during sampling using conventional methods than during sampling using PDB samplers.

If, however, the conventional method produces concentrations that are significantly higher than those obtained using the PDB sampler, then it is uncertain whether the PDB-sampler concentrations represent local ambient conditions. In this case, further testing can be done to determine whether contaminant stratification and/or intra-borehole flow is present. Multiple sampling devices can be used to determine the presence of contaminant stratification, and borehole flowmeters can be used to determine whether intra-borehole flow is present. When using flowmeters to measure vertical flow in screened boreholes, however, the data should be considered qualitative because of the potential for water movement through the sand pack. Borehole dilution tests (Halevy and others, 1967; Drost and others, 1968; Grisak and others, 1977; Palmer, 1993) can be used to determine whether water is freely exchanged between the aquifer and the well screen.

Once the source of the difference between the two methods is determined, a decision can be made regarding the well-specific utility of the PDB samplers. Tests may show that VOC concentrations from the PDB samplers adequately represent local ambient conditions within the screened interval despite the higher VOC concentration obtained from the conventional method. This may be because the pumped samples incorporated water containing higher concentrations either from other water-bearing zones induced along inadequate well seals or through fractured clay (Vroblesky and others, 2000), from other water-bearing zones not directly adjacent to the well screen as a result of well purging prior to sampling (Vroblesky and Petkewich; 2000), or from mixing of chemically stratified zones in the vicinity of the screened interval (Vroblesky and Peters, 2000).

The mixing of waters from chemically stratified zones adjacent to the screened interval during pumping probably is one of the more important sources of apparent differences between the results obtained from PDB sampling and conventional sampling because such stratification probably is common. Vertical stratification of VOCs over distances of a few feet has been observed in aquifer sediments by using multilevel sampling devices (Dean and others, 1999; Pitkin and others, 1999), and considerable variation in hydraulic conductivity and water chemistry has been observed in an aquifer in Cape Cod, Massachusetts, on the scale of centimeters (Wolf and others, 1991; Smith and others 1991; Hess and others, 1992). Multiple PDB samplers have been used to show a change in TCE concentration of 1,130 (μg/L over a 6-ft vertical screened interval in Minnesota (Vroblesky and Petkewich, 2000). Tests using PDB samplers in screened intervals containing VOC stratification showed that the PDB-sampler data appeared to be point-specific, whereas the pumped sample integrated water over a larger interval (Vroblesky and Peters, 2000).

The decision on whether to use PDB samplers in such situations depends on the data-quality objectives for the particular site. If the goal is to determine and monitor higher concentrations or to examine contaminant stratification within the screened interval, then the PDB samplers may meet this objective. If the goal is to determine the average concentrations for the entire screened interval, then a pumped sample or an average from multiple diffusion samplers may be appropriate.

As an aid in the decision-making process, the following section examines the influences that hydraulic and chemical heterogeneity of an aquifer can have on sample quality in long-screened wells. Because VOC concentrations from PDB samplers commonly are compared to VOC concentrations from other sampling methodologies, the second section examines the differences in sample quality between these methodologies in situations of hydraulic and chemical heterogeneity.

Influences of Hydraulic and Chemical Heterogeneity on Sample Quality in Long-Screened Wells

Sampling biases and chemical variability in long-screened wells, which can be loosely defined as wells having significant physical and chemical heterogeneity within the screened interval and in the adjacent aquifer (Reilly and Leblanc, 1998), have been the subject of numerous investigations. Sources of chemical variability in such wells include non-uniform flow into wells (Robbins and Martin-Hayden, 1991; Reilly and Gibs, 1993; Chiang and others, 1995; Church and Granato, 1996; Reilly and LeBlanc, 1998), lithologic heterogeneity (Reilly and others, 1989; Robbins, 1989; Martin-Hayden and others, 1991; Gibs and others, 1993; Reilly and Gibs, 1993), and in-well mixing. In a well open across a chemically or hydraulically heterogeneous section of the aquifer, differences in the sampling methodology can produce significant differences in the sampling results.

Long-screened wells have the potential to redistribute chemical constituents in the aquifer where there are vertical hydraulic gradients within the screened interval. Water can move into the well from one horizon and exit the well at a different horizon (Church and Granato, 1996; Reilly and LeBlanc 1998). If there is vertical flow in the screened or open interval, and the zone of low hydraulic head (outflow from the well) is within the contaminated horizon, then the PDB samplers (or any standard sampling methodology) can underestimate or not detect the contamination. The reason is that, in this case, the contaminated horizon does not contribute water to the well under static conditions. Instead, water from other horizons with higher hydraulic head will invade the contaminated horizon by way of the well screen. Under pumped conditions, the majority of the extracted water will be from the most permeable interval, which may not be the contaminated zone. Even when pumping induces inflow from the contaminated interval, much of that inflow will be a reflection of the residual invaded water from other horizons. In this situation, a substantial amount of purging would be required before water representative of the aquifer could be obtained (Jones and Lerner, 1995). Such sampling is not likely to reflect a significant contribution from the contaminated zone, and concentrations in the contaminated zone probably will be underestimated.

Similarly, if VOC-contaminated water is flowing into the well and is exiting the well at a different horizon, then VOCs will be present along the screened interval between the two horizons. In this case, VOC concentrations in the screened interval may be representative of aquifer concentrations at the inflow horizon, but may not be representative of aquifer concentrations near the outflow horizon.

In areas where vertical stratification of VOC concentrations is anticipated, using multiple PDB samplers may more fully characterize the contaminated horizon than using a single PDB sampler. This is particularly true in wells having screens 10 ft or longer; however, significant VOC stratification has been observed over intervals of less than 5 ft (Vroblesky and Peters, 2000). Because of the increased probability of vertical concentration or hydraulic gradients within the open interval of long-screened (greater than 10 ft) wells, it is advisable to determine the zones of inflow and outflow within the screened or open interval of these wells using borehole flowmeter analysis (Hess, 1982; 1984; 1986; 1990; Young and others, 1998).

Comparison of Passive Diffusion Bag Sampling Methodology to Conventional Methodologies

Traditional sampling methodologies, such as the purge-and-sample (or conventional purging method), low-flow or low-volume sampling, and using straddle packers and multilevel samplers, produce VOC concentrations that may differ from VOC concentrations obtained from PDB samplers because the methodologies sometimes are influenced in different ways by aquifer hydraulic and chemical heterogeneity. This section examines potential sources of concentration differences between traditional methodologies and the PDB methodology.

The purge-and-sample approach to ground-water monitoring differs from the diffusion-sampler approach primarily because the area of the screened or open interval that contributes water to the purged sample typically is greater than for the PDB sampler, and the potential for mixing of stratified layers is higher. When pumping three or more casing volumes of water prior to collecting a sample, chemical concentrations in the discharging water typically change as the well is pumped (Keely and Boateng, 1987; Cohen and Rabold, 1988; Martin-Hayden and others, 1991; Robbins and Martin-Hayden, 1991; Reilly and Gibs, 1993; Barcelona and others, 1994; Martin-Hayden, 2000), due to mixing during pumping and other factors, such as the removal of stagnant water in the casing and changing patterns of inflow and outflow under ambient and pumping conditions (Church and Granato, 1996). The induction of lateral chemical heterogeneity during pumping also may produce variations in the sampled concentrations. The amount of mixing during purging can be highly variable (Barber and Davis, 1987; Church and Granato, 1996; Reilly and LeBlanc, 1998; Martin-Hayden, 2000), and may result in concentrations that are not locally representative (Reilly and Gibs, 1993). Substantial vertical hydraulic gradients, even in shallow homogeneous aquifers, have been observed to bias sampling using conventional purging because the majority of the pumped water may come from a particular horizon not related to the contaminated zone and because the intra-well flow that intruded the aquifer may not be adequately removed during purging (Hutchins and Acree, 2000). Thus, differences may be observed between concentrations obtained from a pumped sample and from a PDB sample in a chemically stratified interval if the pumped sample represents an integration of water collected from multiple horizons and the PDB sampler represents water collected from a single horizon.

Low-flow purging and sampling (Barcelona and others, 1994; Shanklin and others, 1995) disturbs the local ground water less than conventional purge-and-sample methods. Thus, samples obtained by PDB samplers are likely to be more similar to samples obtained by using low-flow purging than to those obtained by using conventional purge-and-sample methods. Even under low-flow conditions, however, purging still can integrate water within the radius of pumping influence, potentially resulting in a deviation from VOC concentrations obtained by PDB sampling. One investigation found that in low hydraulic conductivity formations, low-flow sampling methodology caused excessive drawdown, which dewatered the screened interval, increased local ground-water velocities, and caused unwanted colloid and soil transport into the ground-water samples (Sevee and others, 2000). The authors suggest that in such cases, a more appropriate sampling methodology may be to collect a slug or passive sample from the well screen under the assumption that the water in the well screen is in equilibrium with the surrounding aquifer.

Isolating a particular contributing fracture zone with straddle packers in an uncased borehole allows depth-discrete samples to be collected from the target horizon (Hsieh and others, 1993; Kaminsky and Wylie, 1995). Strategically placed straddle packers often can minimize or eliminate the impact of vertical gradients in the sampled interval. However, even within a packed interval isolating inflowing fracture zones, deviations between VOC concentrations in water from PDB samplers and water sampled by conventional methods still may occur if the conventional method mixes chemically stratified water outside the borehole or if the packed interval straddles chemically heterogeneous zones.

The use of multilevel PDB samplers and other types of multilevel samplers (Ronen and others, 1987; Kaplan and others, 1991; Schirmer and others, 1995; Gefell and others, 1999; Jones and others, 1999) potentially can delineate some of the chemical stratification. Diffusion sampling and other sampling methodologies, however, can be influenced by vertical hydraulic gradients within the well screen or the sand pack. When vertical hydraulic gradients are present within the well, water contacting the PDB sampler may not be from a horizon adjacent to the PDB sampler. Rather, the water may represent a mixing of water from other contributing intervals within the borehole. In a screened well, even multilevel samplers with baffles to limit vertical flow in the well cannot prevent influences from vertical flow in the gravel pack outside the well screen. Such vertical flow can result from small vertical differences in head with depth. A field test conducted by Church and Granato (1996) found that vertical head differences ranging from undetectable to 0.49 ft were sufficient to cause substantial flows (as much as 0.5 liters/minute) in the well bore.

QUALITY CONTROL AND ASSURANCE

The sources of variability and bias introduced during sample collection can affect the interpretation of the results. To reduce data variability caused during sampling, a series of quality-control samples should be utilized.

Replicate samples are important for the quality control of diffusion-sampler data. Sample replicates provide information needed to estimate the precision of concentration values determined from the combined sample-processing and analytical method and to evaluate the consistency of quantifying target VOCs. A replicate sample for water-filled diffusion samplers consists of two separate sets of VOC vials filled from the same diffusion sampler. Each set of VOC vials should be analyzed for comparison. Approximately 10 percent of the samplers should be replicated.

The length of the PDB sampler can be adjusted to accommodate the data-quality objectives for the sampling event. The length can be increased if additional volume is required for collection of replicate and matrix spike/matrix spike duplicate samples.

Trip blanks are used to determine whether external VOCs are contaminating the sample due to bottle handling and/or analytical processes not associated with field processing. Trip blanks are water-filled VOA vials prepared offsite, stored and transported with the other bottles used for collecting the environmental sample, and then submitted for analysis with the environmental sample. Consideration also should be given to the collection of a predeployment PDB trip blank to determine if the PDB samplers are exposed to extraneous VOCs prior to deployment. The predeployment trip blank should be a PDB sampler that is stored and transported with the field PDB samplers from the time of sampler construction to the time of deployment in the wells. An aliquot of the predeployment blank water should be collected from the PDB sampler in a VOA vial and submitted for analysis at the time of sampler deployment.

Water used to construct the diffusion samplers should be analyzed to determine the presence of background VOCs. Although many VOCs accidentally introduced into the diffusion-sampler water probably will reequilibrate with surrounding water once the diffusion samplers are deployed, some VOCs may become trapped within the diffusion-sampler water. For example, acetone, which is a common laboratory contaminant, does not easily move through the polyethylene diffusion samplers (Paul Hare, General Electric Company, oral commun., 1999). Thus, acetone inadvertently introduced into the diffusion-sample water during sampler construction may persist in the samplers, resulting in a false positive for acetone after sampler recovery and analysis.

SUMMARY

Water-filled passive diffusion bag (PDB) samplers described in this report are suitable for obtaining a variety of VOCs in ground water at monitoring wells. The suggested application for PDB samplers is for long-term monitoring of VOCs in ground-water wells at well-characterized sites. Where the screened interval is greater than 10 ft, the potential for contaminant stratification and/or intra-borehole flow within the screened interval is greater than in screened intervals shorter than 10 ft. It is suggested that the vertical distribution of contaminants be determined in wells having 10-ft-long well screens, and that both the vertical distribution of contaminants and the potential for intra-borehole flow be determined in wells having screens longer than 10 ft. A typical PDB sampler consists of a 1- to 2-ft-long low-density polyethylene lay-flat tube closed at both ends and containing deionized water. The sampler is positioned at the target horizon by attachment to a weighted line or fixed pipe.

The amount of time that the samplers should be left in the well prior to recovery depends on the time required by the PDB sampler to equilibrate with ambient water and the time required for environmental disturbances caused by sampler deployment to return to ambient conditions. The rate that water within the PDB sampler equilibrates with ambient water depends on multiple factors, including the type of compound being sampled and the water temperature. Concentrations of benzene, *cis*-1,2-dichloroethene, tetrachlorethene, trichloroethene, toluene, naphthalene, 1,2-dibromoethane, and total xylenes within the PDB samplers equilibrated with the concentrations in an aqueous mixture of those compounds surrounding the samplers under laboratory conditions within approximately 48 hours at 21 °C. A subsequent laboratory study of mixed VOCs at 10 °C showed that tetrachloroethene and trichloroethene were equilibrated by about 52 hours, but other compounds required longer equilabration times. Chloroethane, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, and 1,1-dichloroethene were not equilibrated at 52 hours, but appeared to be equilibrated by the next sampling point at 93 hours. Vinyl chloride, 1,1,1-trichloroethane, 1,2-dichloroethane, and 1,1-dichloroethane were not equilibrated at 93 hours but were equilibrated by the next sampling point at 166 hours. Different equilibration times may exist for other compounds. Differences in equilibration times, if any, between single-solute or mixed-VOC solutions have not yet been thoroughly examined.

The samplers should be left in place long enough for the well water, contaminant distribution, and flow dynamics to restabilize following sampler deployment. Laboratory and field data suggest that 2 weeks of equilibration probably is adequate for many applications. Therefore, a minimum equilibration time of 2 weeks is suggested. In less permeable formations, longer equilibration times may be required. When deploying PDB samplers in waters colder than previously tested (10 °C) or for compounds without sufficient corroborating data, a side-by-side comparison with conventional methodology is advisable to justify the field equilibration time.

Following the initial equilibration period, the samplers maintain equilibrium concentrations with the ambient water until recovery. Thus, there is no specified maximum time for sampler recovery after initial equilibration. PDB samplers have routinely been left in ground waters having concentrations of greater than 500 ppm of TCE for 3 months at a time with no loss of bag integrity, and at one site, the PDB samplers were left in place in VOC-contaminated ground water for 1 year with no reported loss of sampler integrity. The effects of long-term (greater than 1 month) PDB-sampler deployment on sampler and sample integrity have not yet been thoroughly tested for a broad range of compounds and concentrations. In some environments, development of a biofilm on the polyethylene may be a consequence of long-term deployment. Investigations of semipermeable membrane devices (SPMDs) have shown that the transfer of some compounds across a heavily biofouled polyethylene membrane may be reduced, but not stopped. If a heavy organic coating is observed on a PDB sampler, it is advisable to determine the integrity of the sample by comparing sampler results to a conventional sampling method concentrations before continuing to use PDB samplers for long-term deployment in that well.

PDB methodology is suitable for a broad variety of VOCs, including chlorinated aliphatic compounds and petroleum hydrocarbons. The samplers, however, are not suitable for inorganic ions and have a limited applicability for non-VOCs and for some VOCs. For example, although methyl-*tert*-butyl ether and acetone and most semivolatile compounds are transmitted through the polyethylene bag, laboratory tests have shown that the resulting concentrations were lower than in ambient water. The samplers should not be used to sample for phthalates because of the potential for the LDPE to contribute phthalates to the water sample.

When attempting to determine whether the use of PDB samplers is appropriate at a particular well, a common approach is to do a side-by-side comparison with a conventional sampling method. This approach is strongly suggested in wells having temporal concentration variability. In a well having relatively low temporal concentration variability, comparison of the PDB-sampler results to historical concentrations may provide enough information to determine whether the PDB samplers are appropriate for the well. In general, if the two approaches produce concentrations that agree within a range deemed acceptable by the local, state, and Federal regulatory agencies, then use of a PDB sampler in that well will provide VOC concentrations consistent with the historical record. If concentrations from the PDB sampler are higher than concentrations from the conventional method, then it is probable that the concentrations from the PDB sampler are an adequate representation of ambient conditions. If, however, the conventional method produces concentrations that are substantially higher than the concentrations found by using the PDB sampler, then the PDB sampler may or may not adequately represent local ambient conditions. In this case, the difference may be due to a variety of factors, including mixing or translocation due to hydraulic and chemical heterogeneity of the aquifer within the screened or open interval of the well and the relative permeability of the well screen.

REFERENCES

Barber, C., and Davis, G.B., 1987, Representative sampling of ground water from short screened boreholes: Ground Water, v. 25, no. 5, p. 581-587.

Barcelona, M., Wehrmann, H.A., and Varljen,. M.D., 1994, Reproducible well-purging procedures and VOC stabilization criteria for ground-water sampling: Ground Water, v. 32, p. 12-22.

Chiang, C.C., Raven, Gary, and Dawson, Clint, 1995, The relationship between monitoring well and aquifer solute concentrations: Ground Water, v. 32, no. 5, p. 718-126.

Church, P.E., and Granato, G.E., 1996, Effects of well design and sampling methods on bias of water-quality samples: Ground Water, v. 34, no. 2, p. 262-273.

Cohen, R.M., and Rabold, R.R., 1988, Simulation of sampling and hydraulic tests to assess a hybrid monitoring well design: Ground Water Monitoring Review, v. 8, no. 1, p. 55-59.

Comyn, J., 1985, Polymer Permeability: New York, Elsevier Applied Science Publishers Ltd, 383 p.

Dean, S.M., Lendvay, J.M., Barcelona, M.J., Adriaens, P., and Katopodes, N.D., 1999, Installing multilevel sampling arrays to monitor ground water and contaminant discharge to a surface-water body: Ground Water Monitoring and Remediation, Fall 1999, p. 90-96.

Drost, W., Klotz, D., Koch, A., Moser, H., Neurnaier, F., and Rauert, W., 1968, Point dilutions methods of investigating ground water flow by means of radioisotopes: Water Resources Research, v. 4, no. 1, p. 125-146.

Ellis, G.S., Huckins, J.N., Rostad, C.E., Schmitt, C.J., Petty, J.D., and MacCarthy, Patrick, 1995, Evaluation of lipid-containing semipermeable membrane devices for monitoring organochlorine contaminants in the upper Mississippi River: Environmental Science and Technology, v. 14, no. 11, p. 1875-1884.

Flynn, G.L., and Yalkowsky, S.H., 1972, Correlation and prediction of mass transport across membrane I: Influence of alkyl chain length on flux determining properties of barrier and diffusant: Journal of Pharmaceutical Science, v. 61, p. 838-852.

Gale, R.W., 1998, Three-compartment model for contaminant accumulation by semipermeable membrane devices: Environmental Science and Technology, v. 32, p. 2292-2300.

Gefell, M.J., Hamilton, L.A., and Stout, D.J., 1999, A comparison between low-flow and passive-diffusion bag sampling results for dissolved volatile organics in fractured sedimentary bedrock, *in* Proceedings of the Petroleum and Organic Chemicals in Ground Water--Prevention, Detection, and Remediation Conference, November 17-19, 1999, Houston, Texas, p. 304-315.

Gibs, Jacob, Brown, G.A., Turner, K.S., MacLeod, C.L., Jelinski, J.C., and Koehnlein, S.A., 1993, Effects of small-scale vertical variations in well-screen inflow rates and concentrations of organic compounds on the collection of representative ground water quality samples: Ground Water, v. 35, no. 2, p. 201-208.

Gillham R.W., II, Robin, M.J.L., Barker, J.F., and Cherry, J.A., 1985, Field evaluation of well flushing procedures: Washington, D.C., American Petroleum Institute Publication 4405.

Grisak, G.E., Merritt, W.F., and Williams, D.W., 1977, A fluoride borehole dilution apparatus for ground water velocity measurements: Canadian Geotechnical Journal, v. 14, p. 554-561.

Halevy, E., Moser, H., Zellhofer, O, and Zuber, A., 1967, Borehole dilution techniques: A critical review, Isotopes in Hydrology: Vienna, Austria, International Atomic Energy Agency, p. 531-564.

Hare, P.W., 2000, Passive diffusion bag samplers for monitoring chlorinated solvents in ground water: The Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, Battelle, May 22-25, 2000, Monterey, California.

Harrington, G.A., Cook, P.G., and Robinson, N.I., 2000, Equilibration times of gas-filled diffusion samplers in slow-moving ground-water systems: Ground Water Monitoring and Remediation, Spring 2000, p. 60-65.

Hess, A.E., 1982, A heat-pulse flowmeter for measuring low velocities in boreholes: U.S. Geological Survey Open-File Report 82-699, 44 p.

_____ 1984, Use of a low-velocity flowmeter in the study of hydraulic conductivity of fractured rock: Proceedings of National Water Well Association Conference on Surface and Borehole Geophysics, San Antonio, Texas, p. 812-831.

_____ 1986, Identifying hydraulically conductive fractures with a slow-velocity borehole flowmeter: Canadian Geotechnical Journal, v. 23, no. 1, p. 69-78.

_____ 1990, A thermal flowmeter for the measurement of slow velocities in boreholes: U.S. Geological Survey Open-File Report 87-121.

Hess, K.M., Wolf, S.H., and Celia, M.A., 1992, Large-scale natural gradient tracer test in sand and gravel, Cape Cod, Massachusetts, 3. Hydraulic conductivity variability and calculated macrodispersivities. Water Resources Research, v. 28, no. 8, p. 2011-2027.

Hsieh, P.A., Shapiro, A.M., Barton, C.C., Haeni, F.P., Johnson, C.D., Martin, C.W., Paillet, F.L., Winter, T.C., and Wright, D.L., 1993, Methods of characterizing fluid movement and chemical transport in fractured rocks, *in* Field Trip Guidebook for the Northeastern United States: 1993 Boston GSA, Cheney, J.T., and Hepburn, J.C., eds., RI-R30. Amherst: University of Massachusetts, Department of Geology and Geography.

Huckins, J.N., Petty, J.D., Lebo, J.A., Orazio, C.E., Prest, H.F., Tillitt, D.E., Ellis, G.S., Johnson, B.T., and Manuweera, G.K., 1996, Semipermeable membrane devices (SPMDs) for the concentration and assessment of bioavailable organic contaminants in aquatic environments, *in* Ostander, G.K., ed., Techniques in Aquatic Toxicology: Boca Raton, Fla., CRC-Lewis Publishers, p. 625-655.

Huckins, J.N, Petty, J.D., Prest, H.F., Clark, R.C., Alverez, D.A., Orazio, C.E., Lebo, J.A., Cranor, W.L., and Johnson, B.T., in press, A guide for the use of semipermeable membrane devices (SPMDs) as samplers of waterborne hydrophobic organic contaminants: Report for the American Petroleum Institute (API), Washington, DC., API publication number 4690.

Hutchins, S.R., and Acree, S.D., 2000, Ground water sampling bias observed in shallow, conventional wells: Ground Water Monitoring and Remediation, Winter 2000, p. 86-93.

Hwang, S.T., and Kammermeyer, K., 1975, Membranes in Separations: Malabar, Fla., Robert E. Krieger Publishing Company, Inc., 559 p.

Jones, Ian, and Lerner, D.N., 1995, Level-determined sampling in an uncased borehole: Journal of Hydrology, v. 171, p. 291-317.

Jones, Ian, Lerner, D.N., and Baines, O.P., 1999, Multiport sock samplers: Alow cost technology for effective multilevel ground water sampling: Ground Water Monitoring and Remediation, v. 19, no. 1, p. 134-142.

Kaminsky, J.F., and Wylie, A.H., 1995, Vertical contaminant profiling of volatile organics in a deep fractured basalt aquifer: Ground Water Monitoring and Remediation, v. 15, no. 2, p. 97-103.

Kaplan, Edward; Banerjee, Sujit; Ronen, Daniel; Margaritz, Mordeckai; Machlin, Alber; Sosnow, Michael; and Koglin, Eric, 1991, Multilayer sampling in the water-table region of a sandy aquifer: Ground Water, v. 29, no. 2, p. 191-198.

Kearl, P., Korte, N., and Cronk, T., 1992, Suggested modifications to ground water sampling procedures based on observations from the colloidal borescope: Ground Water Monitoring Review, v. 12, no. 2, p. 155-166.

Keely, J.F., and Boateng, K., 1987, Monitoring well installation, purging, and sampling techniques - Part 1: Conceptualizations: Ground Water, v. 25, no. 3, p. 3300-313.

Martin-Hayden, J.M, 2000, Sample concentration response to laminar wellbore flow: Implications to ground water data variability: Ground Water, v. 38, no. 1, p. 12-19.

Martin-Hayden, J.M., Robbins, G.A., and Bristol, R.D., 1991, Mass balance evaluation of monitoring well purging. Part II: Field tests at a gasoline contamination site: Journal of Contaminant Hydrology, v. 8, no. 3/4, p. 225-241.

Mayer, L.M., 1976, Chemical water sampling in lakes and sediments with dialysis bags, Limnology and Oceanography: v. 21, p. 909-912.

Obrien & Gere Engineers, Inc, 1997a, Passive bag sampling results, JMT Facility, Brockport, New York: Consultant's report to General Electric Company, Albany, New York, October 10, 1997, 10 p.

_____ 1997b, Passive bag sampling results, JMT Facility, Brockport, New York: Consultant's report to General Electric Company, Albany, New York, December 12, 1997, 10 p.

Palmer, C.D., 1993, Borehole dilution tests in the vicinity of an extraction well: Journal of Hydrology, v. 146, p. 245-266.

Pitkin, S.E., Ingleton, R.A., and Cherry, J.A., 1999, Field demonstrations using the Waterloo Ground Water Profiler: Ground Water Monitoring and Remediation, v. 19, no. 2, Spring 1999, p. 122-131.

Powell, R.M., and Puls, R.W., 1993, Passive sampling of ground water monitoring wells without purging: Multilevel well chemistry and tracer disappearance: Journal of Contaminant Hydrology, v. 12, p. 51-77.

Reilly, T.E., Frank, O.L., and Bennet, G.D., 1989, Bias in ground water samples caused by wellbore flow: ASCE, Journal of Hydraulic Engineering, v. 115, p. 270-276.

Reilly, T.E., and Gibs, J., 1993, Effects of physical and chemical heterogeneity of water-quality samples obtained from wells: Ground Water, v. 31, no. 5, p. 805-813.

Reilly, T.E., and LeBlanc, D.R., 1998, Experimental evaluation of factors affecting temporal variability of water samples obtained from long-screened wells: Ground Water , v. 36, no. 4, p. 566-576.

Robin, M.J.L., and Gillham, R.W., 1987, Field evaluation on well purging procedures: Ground Water Monitoring Review, v. 7, no. 4, p. 85-93.

Robbins, G.A., 1989, Influence of using purged and partially penetrating monitoring wells on contaminant detection, mapping and modeling: Ground Water, v. 27, no. 2, p. 155-162.

Robbins, G.A., and Martin-Hayden, J.M., 1991, Mass balance evaluation of monitoring well purging. Part I: Theoretical models and implications for representative sampling: Journal of Contaminant Hydrology, v. 8, no. 3/4, p. 203-224.

Ronen, Daniel, Magaritz, Mordeckai, and Levy, Itzhak, 1987, An *in situ* multilevel sampler for preventive monitoring and study of hydrochemical profiles in aquifers: Ground Water Monitoring and Remediation, Fall, p. 69-74.

Schirmer, M., Jones, I., Teutsch, G., and Lerner, D.N., 1995, Development and testing of multiport sock samplers for ground water: Journal of Hydrology, v. 171, p. 239-257.

Shanklin, D.E., Sidle, W.C., and Ferguson, M.E., 1995, Micro-purge low-flow sampling of uranium-contaminated ground water at the Fernald Environmental Management Project: Ground Water Monitoring and Remediation, v. 15, no. 3, p. 168-176.

Sevee, J.E., White, C.A., and Maher, D.J., 2000, An analysis of low-flow ground water sampling methodology: Ground Water Monitoring and Remediation, Spring 2000, v. 20, no. 2, p. 87-93.

Smith, R.L., Harvey, R.W., and LeBlanc, D.R., 1991, Importance of closely spaced vertical sampling in delineating chemical and microbial gradients in ground water studies: Journal of Contaminant Hydrology, v. 7, p. 285-300.

Vroblesky, D.A., 2000, Simple, inexpensive diffusion samplers for monitoring VOCs in ground water: The Second International Conference on Remediation of Chlorinated and Recalcitrant Compounds, May 22-25, 2000, Monterey, California.

Vroblesky, D.A., and Campbell, T.R., 2001, Equilibration times, stability, and compound selectivity of diffusion samplers for collection of ground-water VOC concentrations: Advances in Environmental Research, v. 5, no. 1, p. 1-12.

Vroblesky, D.A., and Hyde, W.T., 1997, Diffusion samplers as an inexpensive approach to monitoring VOCs in ground water: Ground Water Monitoring and Remediation, v. 17, no. 3, p. 177-184.

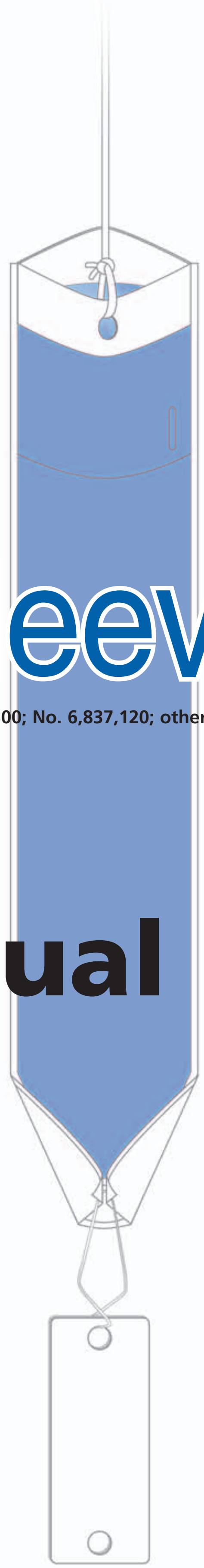
Vroblesky, D.A., Nietch, C.T., Robertson, J.F., Bradley, P.M., Coates, John, and Morris, J.T., 1999, Natural attenuation potential of chlorinated volatile organic compounds in ground water, TNX flood plain, Savannah River Site, South Carolina: U.S. Geological Survey Water-Resources Investigations Report 99-4071, 43 p.

Vroblesky, D.A., and Peters, B.C., 2000, Diffusion sampler testing at Naval Air Station North Island, San Diego County, California, November 1999 to January 2000: U.S. Geological Survey Water-Resources Investigations Report 00-4812, 27 p.

Vroblesky, D.A., and Petkewich, M.D., 2000, Field testing of passive diffusion bag samplers for volatile organic compound concentrations in ground water, Naval Industrial Reserve Ordnance Plant, Fridley, Minnesota, November 1999 and May 2000: U.S. Geological Survey Water-Resources Investigations Report 00-4246, 10 p.

Wolf, S.H., Celia, M.A., and Hess, K.M., 1991, Evaluation of hydraulic conductivities calculated from multiport permeameter measurements: Ground Water, v. 29, no. 4, p. 516-552.

Young, S.C., Julian, H.E., Pearson, H.S., Molz, F.J., and Boman, G.K, 1998, Application of the electromagnetic borehole flowmeter: U.S. Environmental Protection EPA/600/R-98/058, 56 p.



HYDRASleeve

Simple by Design

US Patents No. 6,481,300; No. 6,837,120; others pending

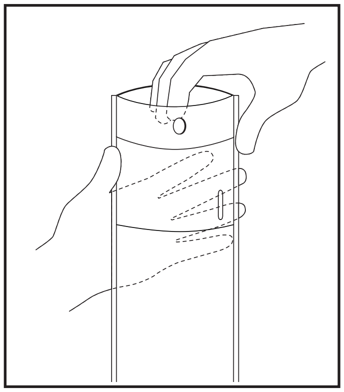
Field Manual

Introduction

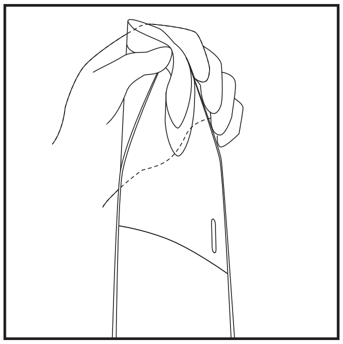
The HydraSleeve groundwater sampler can be used to collect a representative sample for most physical and chemical parameters without purging the well. It collects a whole water sample from a user-defined interval (typically within the well screen), without mixing fluid from other intervals. One or more HydraSleeves are placed within the screened interval of the monitoring well, and a period of time is allocated for the well to re-equilibrate. Hours to months later, the sealed HydraSleeve can be activated for sample collection. When activated, HydraSleeve collects a sample with no drawdown and minimal agitation or displacement of the water column. Once the sampler is full, the one-way reed valve collapses, preventing mixing of extraneous, non-representative fluid during recovery.

Assembly

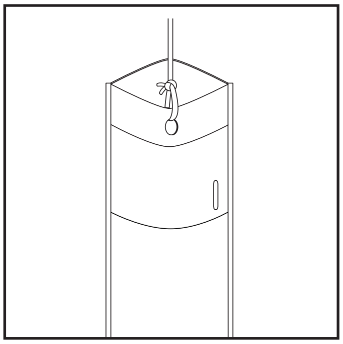
Assembling the HydraSleeve is simple, and can be done by one person in the field, taking only a minute or two.



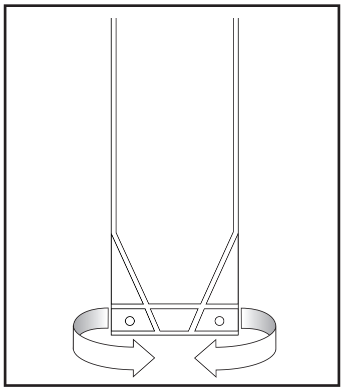
1 Remove HydraSleeve from package and grasp top to “pop” open.



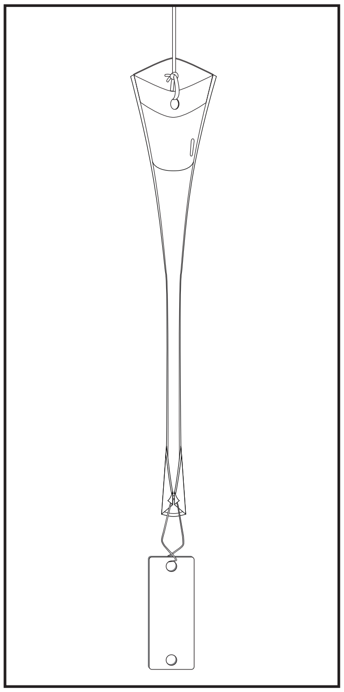
2 Squeeze side fins together at top to bend reinforcing strips outward.



3 Attach line to hole at top of HydraSleeve.



4 Fold the two holes at bottom of HydraSleeve together and attach weight



5 Sampler is ready to insert into the well.

Placing the HydraSleeve(s)

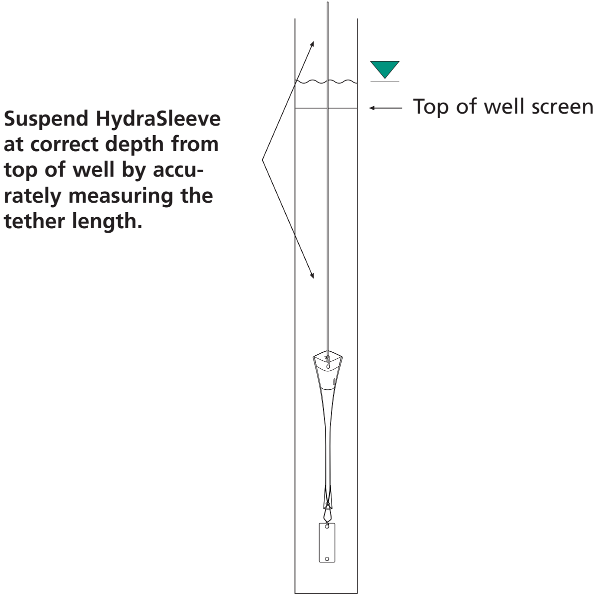
To collect a representative groundwater sample without purging, the well must be allowed time to re-equilibrate after placement of the sampler. When any device is lowered into a well, some mixing of the water column occurs. The diameter of the device and its shape greatly affect the degree of mixing. The flat cross-section of the empty HydraSleeve minimizes the disturbance to the water column as the sampler is lowered into position, reducing the time needed for the well to return to equilibrium.

There are three basic methods for holding a HydraSleeve in position as the well equilibrates.

TOP DOWN DEPLOYMENT (Figure 1)
Measure the correct amount of suspension line needed to "hang" the top of the HydraSleeve(s) at the desired sampling depth (in most cases, this will be at the bottom of the sampling zone). The upper end of the tether can be connected to the well cap to suspend the HydraSleeve at the correct depth until activated for sampling.

Note: For deep settings, it may be difficult to accurately measure long segments of suspension line in the field. Factory prepared, custom suspension line and attachment points can be provided.

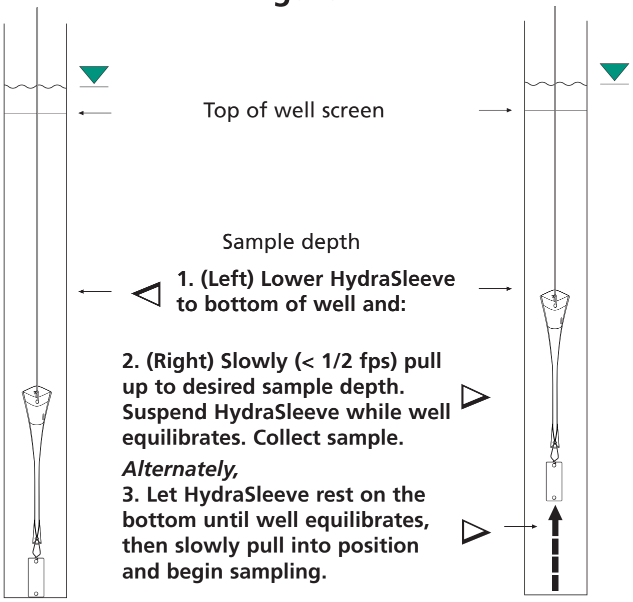
Figure 1



BOTTOM DEPLOYMENT (Figure 2)
Sound the well to determine the exact depth. Lower the weighted HydraSleeve into the well and let it touch the bottom. <u>Very slowly</u> (less than 1/2 foot per second) raise the sampler to the point where the check valve is at the depth the sample is to be collected. Attach the suspension line to the top of the well to suspend it at this depth. (It is often easier to measure a few feet from the bottom of the well up to the sample point, than it is to measure many feet from the top of the well down.)

Alternately, the sampler can be left on the bottom until the well re-equilibrates. For sampling, it can be very slowly pulled (< 1/2 fps) to sampling depth, then activated (see "Sample Collection," p. 6) to collect the sample, and retrieved to the surface.

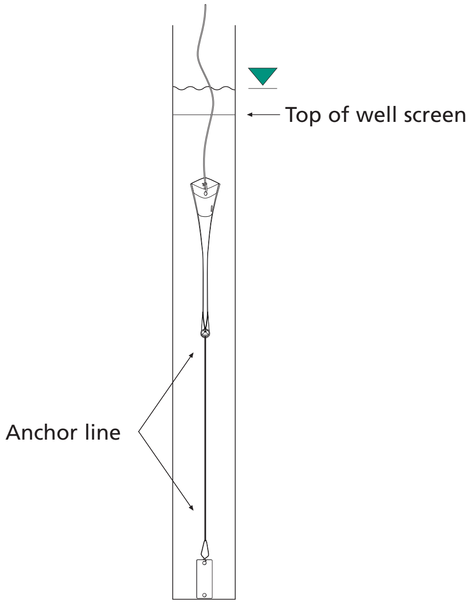
Figure 2



BOTTOM ANCHOR (Figure 3)

Determine the exact depth of the well. Calculate the distance from the bottom of the well to the desired sampling depth. Attach an appropriate length anchor line between the weight and the bottom of the sampler and lower the assembly until the weight rests on the bottom of the well, allowing the top of the sampler to float at the correct sampling depth.

Figure 3



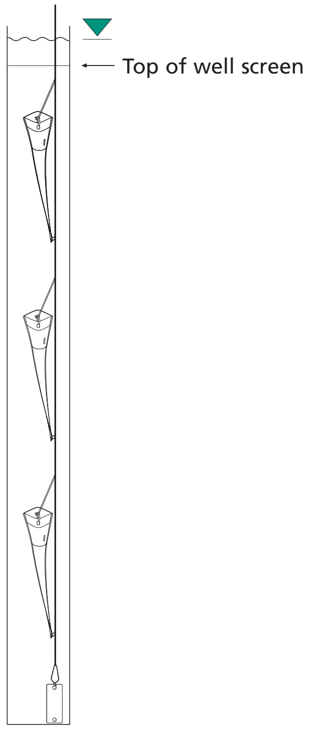
Multiple Interval Deployment

There are two basic methods for placing multiple HydraSleeves in a well to collect samples from different levels simultaneously.

ATTACHED TO A SINGLE TETHER (Figure 4)

To use 3 or more samplers simultaneously, we recommend attaching them all to a tether for support to prevent the sampling string from pulling apart. The weight is attached to a single length of suspension line and allowed to rest on the bottom of the well. The top and bottom of each HydraSleeve are attached to the tether at the desired sample intervals. Cable tie or stainless steel clips (supplied) work well for attaching the HydraSleeves to the line. Simply push one end of the clip between strands of the rope at the desired point before attaching the clip to the HydraSleeve.

Figure 4

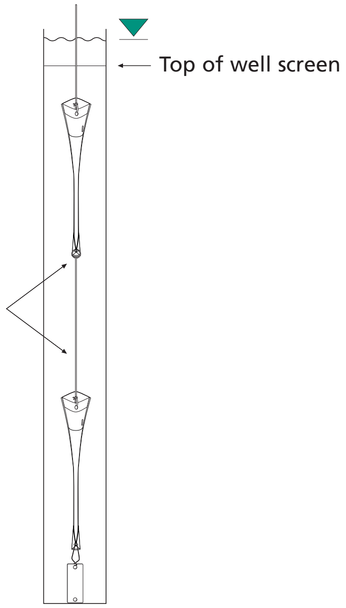


Separate HydraSleeves to the desired spacing by measuring along the tether when attaching samplers.

ATTACHED END TO END (Figure 5)

To place 2 or 3 stacked HydraSleeves for vertical profiling, use one of the methods described above to locate the bottom sampler. Attach the bottom of the top sampler to the top of the following HydraSleeve(s) with a carefully measured length of suspension cable. Connect the weight to the bottom sampler. Note: if many HydraSleeves are attached to a tether, more weight may be required than with a single sampler.

Figure 5



Separate HydraSleeves to the desired spacing by measuring tether between samplers.

Sample Collection

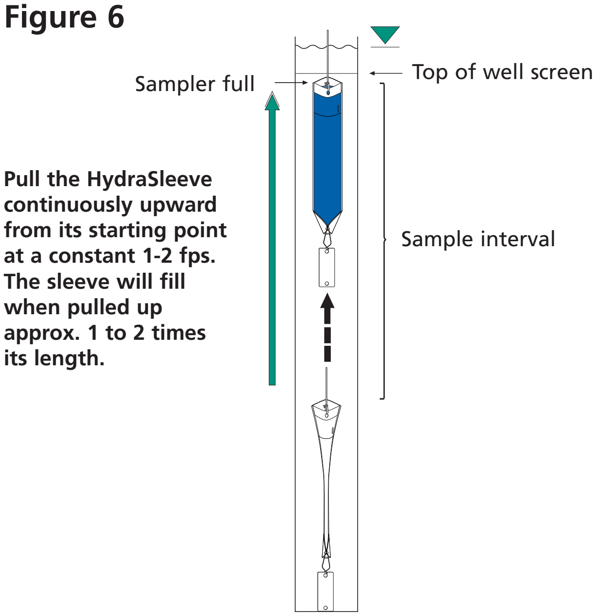
The HydraSleeve must move upward at a rate of one foot per second or faster (about the speed a bailer is usually pulled upward) for water to pass through the check valve into the sample sleeve. The total upward distance the check valve must travel to fill the sample sleeve is about 1 to 2 times the length of the sampler. For example, a 24-inch HydraSleeve needs a total upward movement of 24 to no more than 48 inches to fill. The upward motion can be accomplished using one long continuous pull, several short strokes, or any combination that moves the check valve the required distance in the open position. A special technique is used for sampling low-yield wells.

CONTINUOUS PULL (Figure 6)

Pull the HydraSleeve continuously upward from its starting point at a constant 1 to 2 feet per second until full. This method usually provides the least turbid samples and is analogous to coring the water column from the bottom up.

Note: When using this method, the screen interval should be long enough so the sampler fills before exiting the top of the screen.

Figure 6



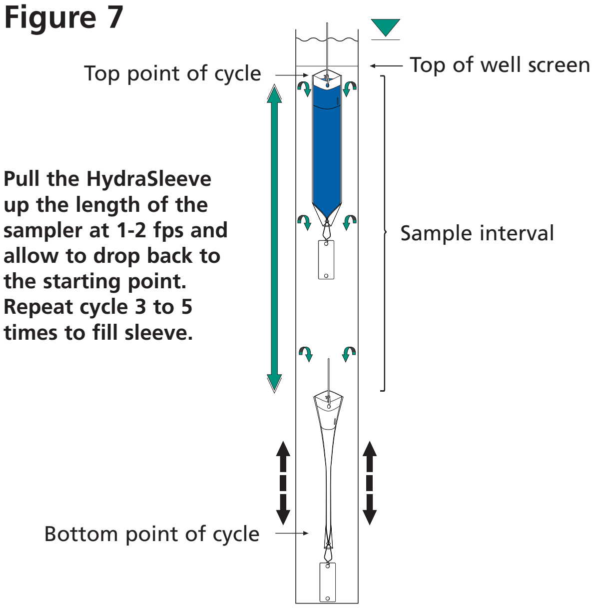
Pull the HydraSleeve continuously upward from its starting point at a constant 1-2 fps. The sleeve will fill when pulled up approx. 1 to 2 times its length.

SHORT STROKES (Figure 7)

Pull the sampler upward at about 1 to 2 feet per second for the length of the sampler and let it drop back to the starting point. Repeat the cycle 3 to 5 times.

This method provides a shorter sampling interval than the continuous pull method (above), and usually reduces the turbidity levels of the sample below that of numerous rapid, short cycles (below). The sample comes from between the top of the cycle and the bottom of the sampler at its lowest point.

Figure 7

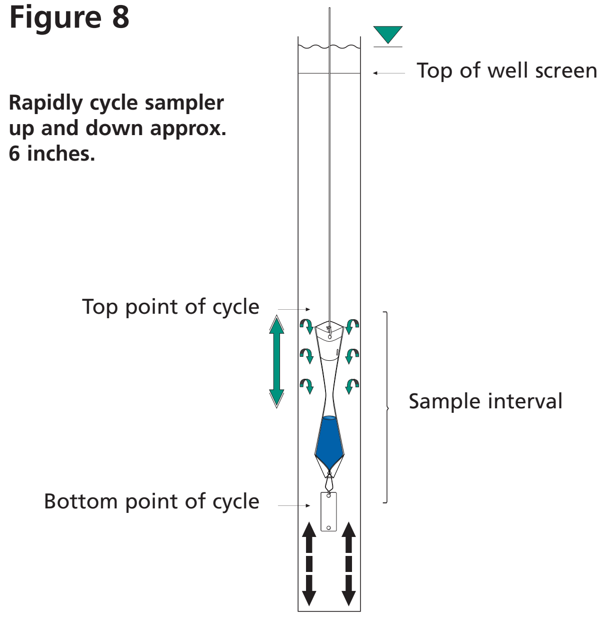


Pull the HydraSleeve up the length of the sampler at 1-2 fps and allow to drop back to the starting point. Repeat cycle 3 to 5 times to fill sleeve.

RAPID, SHORT CYCLES (Figure 8)

Cycle the HydraSleeve up and down using rapid, short strokes (6-inch cycle at a minimum of 1 cycle per second) 5 to 8 times. This method provides the shortest sampling interval. Dye studies have shown that when using this method the sample flows into the check valve from along the length of the sampler and immediately above the check valve. The sample interval is from the bottom the sampler at its lowest point in the cycle to the top of the check valve at the peak of the cycle.

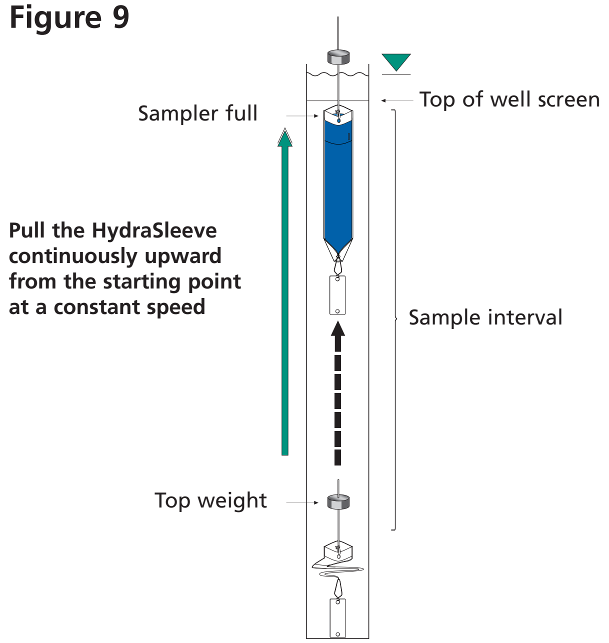
Figure 8



SAMPLING LOW-YIELD WELLS (Figure 9)

HydraSleeve provides the best available technology for sampling low yield wells. When pulled upward after the well re-equilibrates, the HydraSleeve will collect a water core from the top of the sampler to about its own length above that point. The sample is collected with no drawdown in the well and minimal sample agitation. An optional top weight can be attached to compress the sampler in the bottom of the well if needed for an extremely short water column. With a top weight, the check valve is pushed down to within a foot of the bottom of the well.

Figure 9



Sample Discharge

The best way to remove a sample from the HydraSleeve with the least amount of aeration and agitation is with the short plastic discharge tube (included).

1

2

3

First, squeeze the full sampler just below the top to expel water resting above the flexible check valve. (Photo 1, top left)

Then, push the pointed discharge tube through the outer polyethylene sleeve about 3-4 inches below the white reinforcing strips. (Photo 2, middle left)

Discharge the sample into the desired container. (Photo 3, bottom left)

Raising and lowering the bottom of the sampler or pinching the sample sleeve just below the discharge tube will control the flow of the sample. The sample sleeve can also be squeezed, forcing fluid up through the discharge tube, similar to squeezing a tube of toothpaste. With a little practice, and using a flat surface to set the sample containers on, HydraSleeve sampling becomes a one-person operation.

GeoInsight

1680 Hickory Loop, Suite B • Las Cruces, NM 88005
Phone: 1.800.996.2225 • 1.505.523.5799 • Fax: 1.505.523.0789
www.geoinsightonline.com • KentCordry@aol.com

Attachment A: Standard Operating Procedure (SOP) #4
Supply and Irrigation Well Sampling Protocol

1.0 Sample Collection

Samples are collected from three former Fort Ord supply wells (Well 29(A), 30 (B), and 31 (C)[1]) operated by the Marina Coast Water District (MCWD), and on private off post irrigation well (Mini-Storage). Samples from these wells are analyzed for VOCs by EPA Test Method 8260 SIM (selected ion monitoring) OUCTP A-Aquifer COC list on a quarterly basis[2]. Samples are collected in three 40 milliliter (mL) VOA vials pre-preserved with hydrochloric acid (HCl). The water from these wells is collected prior to treatment or chlorination; therefore, the addition of sodium thiosulfate as a preservative is not needed.

2.0 Sample Techniques

Upon arriving at the supply well, the MCWD field technician will inform the sampler if the well is on (pumping) or off. If the pump is off, the sampler should remain outside the building until the MCWD field technician has started the pump due to noise associated with the pump's initial start-up. Once the pump is running, the sampler must open the sampling port, a small Teflon or copper tube coming from the main water flow pipe. The MCWD filed technician can help locate the sampling port if the sampler is unable to identify it. Let the spigot run approximately one minute at high flow to flush the sampling port tube. A drain located in the floor near the spigot collects the discharge water. Adjust the flow rate downward until you are able to fill the 40mL VOA vials with no splashing or bubbling, letting the water flow down the side of the container. Do not overfill or rinse the container or the preservative will be lost. The 40m: VOA vials should be completely filled to the point where the water's meniscus forms a convex shape above the lip of the container. Replace the container's cap and secure snugly making sure not to over tighten, and check for headspace or bubbles. VOA vials are zero headspace and therefore if a bubble appears inside the bottle after capping, a new sample must be collected. The sample bottles are to be labeled, stored in a Ziploc bag, and placed on ice in a sample cooler immediately. The chain of custody (COC) and daily field logbook shall be filled out completely prior to moving on to the next well.

The Mini-Storage well is located in the Marina Mini-Storage yard on the north side of Reservation Road in Marina. The pump head is located just north of the parking area in the main lot. Two spigots are on the top of the pump head just outside a small garden box container. A hose may be attached to one or both spigots. The spigot where the sample will be collected should be turned on and the water allowed to flow for at least a minute. A pressure gauge is located on the pipe and will indicate when the pump has been activated. After the pump has turned on, allow the water to run for another one to one and a half minutes. Remove any hoses attached to the spigot, adjust the flow as low as reasonable, and collect the sample in the same fashion as described for the Supply Wells. When finished replace any hoses that have been removed from the spigots. The sample bottles are to be labeled, stored in Ziploc bags, and placed on ice in a sample cooler immediately. The COC and daily field logbook shall be filled out completely prior to moving on to the next well.

---

[1] These wells are identified as FO-29, FO-30, and FO-31, respectively.

[2] Unless a well is inoperable.

Attachment A: Standard Operating Procedure (SOP) #5

OU2 and Sites 2/12 GWTSs and OUCTP EISB Extraction Well Sample Handling and Custody Requirements

Table of Contents

1.0 Sample Types ... A-5: 1
  1.1 Extraction Well Samples ... A-5: 1
  1.2 GWTP Process Samples ... A-5: 1
  1.3 Quality Control (QC) ... A-5: 1
    1.3.1 Trip Blanks ... A-5: 1
    1.3.2 Field Duplicate Samples ... A-5: 1
2.0 Field Documentation ... A-5: 2
  2.1 Field Logbooks ... A-5: 2
  2.2 Sample Identification and Labels ... A-5: 3
    2.2.1 Sample Identification ... A-5: 3
    2.2.2 Sample Label ... A-5: 5
  2.3 Chain of Custody Record ... A-5: 5
  2.4 Transfer and Review of Field Documentation ... A-5: 6
3.0 Groundwater Sampling ... A-5: 6
  3.1 Sampling Preparation ... A-5: 6
  3.2 Sampling Procedures ... A-5: 7
  3.3 Water-Level Measurement ... A-5: 7
  3.4 Sampling Equipment Calibration Procedures ... A-5: 8
  3.5 Decontamination Procedures ... A-5: 8
4.0 Sample Handling Procedures ... A-5: 9
  4.1 Field Sample Custody ... A-5: 9
  4.2 Sample Containers and Preservation ... A-5: 9
  4.3 Sample Transfer and Shipment ... A-5: 9
  4.4 Laboratory Custody ... A-5: 10

1.0 Sample Types

Project samples may be extraction well groundwater samples, Groundwater Treatment Plant (GWTP) process water samples, or quality control/quality assurance samples. Standard operating procedures for the collection of these water samples are described in this document.

1.1 Extraction Well Samples

Extraction well samples (standard field samples) will be generated to evaluate the effectiveness of the remedial action in containing the groundwater contamination plume, removing contaminant mass from the groundwater, and achieving remedial action objectives. Data generated will be applied to decision rules identified in the QAPP to determine operational status and sampling frequency for individual extraction wells.

1.2 GWTP Process Samples

GWTP process samples (standard field samples) will be generated to evaluate the effectiveness and efficiency of GWTP components in removing chemicals of concern (COCs) from extracted groundwater, determining the timing for replacing granular activated carbon (GAC) in the GAC vessels, and maintaining discharge limits for COCs in treated water.

1.3 Quality Control (QC)

Field QC samples will be generated to evaluate the precision, accuracy, and integrity of field sampling and laboratory analytical procedures. Quality control samples are introduced into the sample analysis stream along with environmental samples. The frequency of field QC sample generation is based on project Data Quality Objectives (DQOs), as well as the total number of samples submitted and the nature and intensity of the investigative process that is being monitored or evaluated. The following QC samples will be employed during the field program.

1.3.1 Trip Blanks

Trip blanks are prepared by the laboratory using contaminant-free water (e.g., nitrogen purged deionized water) which is poured into Volatile Organic Analysis (VOA) vials and shipped to Ahtna Environmental Inc. (Ahtna) by the laboratory. The laboratory also provides pre-cleaned and hydrochloric acid (HCl) acid-preserved sample containers for collecting water samples for Volatile Organic Compound (VOC) analysis. Trip blanks will accompany sample containers into the field and will be shipped back to the laboratory with every cooler that contains samples for VOC analyses. Trip blanks will be analyzed for all VOC analytes specified for environmental samples in the corresponding cooler.

1.3.2 Field Duplicate Samples

Duplicate samples are submitted to the contract laboratory for the purpose of assessing the effect of the sample matrix on analytical measurement precision.

The laboratory will not be informed as to the identity of duplicate samples and no special sample handling protocol will be employed during collection, shipment, or analysis of these samples. These “blind” duplicate samples will be submitted and analyzed on a frequency of one in ten of the total environmental sampling effort for each matrix sampled. Areas of known contamination or critical sampling points may be preferentially selected for submittal as blind duplicates. Duplicate samples will be analyzed for the same parameters as the corresponding primary sample.

2.0 Field Documentation

Field activities and sample collection will be documented using the following forms and information as appropriate: sample label, chain of custody form, groundwater sampling form, well completion details, well development form, cooler receipt form, waste management label, and hazardous waste label. The purpose of standardized field documentation and sampling procedures is to maintain integrity of field documentation and field samples throughout the remediation process. Each field sample will be labeled and sealed immediately after collection. Sample identification documents will be carefully prepared to maintain control of sample disposition. Field sample custody procedures are described in Section 4.1. Standard procedures for documentation of field activities are presented below.

2.1 Field Logbooks

Field procedures relevant to sample collection and field activities will be recorded daily in permanently bound notebooks. Each individual in the field will maintain a bound field logbook with serially numbered pages. The logbook is signed and dated prior to daily initiation of field work. If logbook duties are transferred, the individuals relinquishing and receiving will both sign and date the logbook and record the transfer time. Logbook corrections are made by a single line strikeout of the incorrect entry and entering the correct information that is initialed by the person making the entry. If the correction is made at a later time or date, the correction date is also entered. Unused partial or whole logbook pages are crossed out and unused pages signed and dated at the end of each workday. All entries must be legible, in ink, and primarily factual in content. Hypothetical information can be entered but should be noted accordingly. Logbook entries may include the following information as necessary:

- Project name and number.
- Site name and location.
- Arrival and departure date/time.
- Name and affiliation of personnel onsite (including site visitors), and personnel contacted.
- Author name and date.
- Field instrument calibration methods and identification number.
- Chronology and location of activities.
- Sampling locations.
- Sample identification numbers, amount collected, sampling method and container (size/type) for each sample collected, including QC samples. Sample processing techniques such as filtration, compositing, and preservation techniques should be noted. Alternatively, this information may be contained on the COC form, groundwater sampling form, or other field form. The logbook will then contain a unique identifier linking the field log book entry to the field form.
- Date and time of sample collection, name of sampler.
- Field observations including weather conditions and applicable comments.

- Number of shipping coolers packaged and sent.
- Name and address of all receiving laboratories.
- Any modifications or deviations from quality assurance project plan.

Written reports of all significant non-routine events for field and laboratory work will be sent to the USACE Contracting Officer within 48 hours of occurrence. These reports will identify the problem, corrective action, and verbal written instructions from the USACE Project Manager (PM) to Ahtna regarding corrective action. Significant non-routine events are occurrences that impact cost of work, work schedule, work quality, and analytical data quality.

2.2 Sample Identification and Labels

2.2.1 Sample Identification

Two sample identifiers, the sample number and the station number, will be used to designate samples and sampling locations. Sample numbers will be used for coding, tracking, and reporting chemical data. Station numbers will encode sample type, site identification, and boring number or monitoring well sequence. Conventions for generating sample and station numbers are presented below.

The sample number is a coded identification designed to satisfy project and database criteria. Each sample number:

- Will contain up to 12 characters.
- Will be unique.
- Will be traceable to a specific sampling event.
- Will be traceable to a specific sampler.
- Will incorporate a specific site designation.
- Will not obviously indicate to the laboratory the sample depth, station number, or type of sample (i.e., original sample and duplicate).

All chemical data produced by the contract laboratory will be reported using the sample number. Samples will be numbered as follows (no spaces in actual sample numbers):

YR WK X SSS 000 Z

Where:

YR = Calendar year

WK = Week of the year

X = One-letter ID code assigned to each field sampler

SSS = Three-character site identification code: “OU2” or “212”

000 = Three-digit sequence number for each sample

Z = Assigned QC sample code

Assigned sample QC codes are as follows:

- A = Trip blank

- B = Not used for groundwater treatment system (GWTS) sampling
- C = Not used for GWTS sampling
- D = Field duplicate
- E = Not used for GWTS sampling
- F = Standard field sample

For example, sample number 1704M212015A represents the fifteenth sample collected by sampler "M" and is a trip blank (QC code A) collected at Sites 2/12 during Week 4 of 2017. Each sample collector will start with sequence number 001 and continue consecutively through 999. Field personnel are responsible for keeping track of their own sequence in the field logbook. Field audits will include checks of this sample numbering system to ensure that correct procedures are being followed.

Week numbers are assigned to week-long periods ending on Friday. For example, Week 4 of 2017 is the week ending January 27, 2017. Week numbers below 9 must contain a zero (i.e., 01 through 08). For aqueous samples, multiple sample containers for each discrete sample may be required to fulfill analytical requirements. In these instances, the same sample number will be used on all sample containers.

The station description is a sequence of characters designed to identify site-specific samples. Station descriptions will not be included on the laboratory copy of the chain of custody form. The station description field on the chain of custody form will be used to record the site, sample type, sequence number, and other relevant sample characteristics.

The convention for station description naming is as follows:

ST-SSS-000-XXX

Where:

ST = Sample type

SSS = Three-character site identification code (same as for sample numbering scheme)

000 = Station number unique to each station

XXX = Sample depth or aquifer

Station description names will not include spaces. Example sample type codes are as follows:

- EW = Extraction well
- MP = Multi-port well
- MW = Monitoring well
- SG = Soil gas
- SL = Sludge
- PZ = Piezometer
- TS = Treatment system
- WW = Wastewater
- VE = Vapor extraction

Sample depth may indicate the actual depth the sample was collected relative to ground surface or top of well casing (e.g. the pump intake depth), the port the sample was collected from in a multi-port well, or the aquifer the sample was collected from. Example sample depth codes for aquifers at the former Fort Ord are as follows:

- A = A-Aquifer
- 180 = Upper or Lower 180-Foot Aquifer

For example, station name EW-OU2-13-A represents an extraction well station 13 at the OU2 site with a sample depth in the A-Aquifer.

2.2.2 Sample Label

All samples will be properly labeled to prevent misidentification of samples. Preprinted sample labels will be provided. The label will be affixed to the sample container prior to transportation to the laboratory and will contain the following information:

- Project name, number, and location
- Site name
- Name of collector
- Date and time of collection
- Sample identification number
- Preservative, if any
- Requested test methods or analyses

2.3 Chain of Custody Record

A chain of custody (COC) record will be filled out for and will accompany every sample to the analytical laboratory for documentation of sample possession from the time of collection to sample receipt. A carbonless copy of the chain of custody form will be retained in the investigation files according to project number. The primary laboratory will upload copies of the cooler receipt forms and associated chain of custody forms to its LabLink website for review by the Project Chemist within 24 hours of sample receipt. The forms will contain the following information:

- Sample number or identification
- Name and signature of collector, sampler, or recorder
- Name, number, and location of project
- Project manager's name
- Date of collection
- Place of collection (station description)
- Sample type
- Analyses requested
- Dates and times of possession changes

- Signature of persons relinquishing and receiving sample
- Laboratory sample number, where applicable
- Date and time of laboratory sample receipt

2.4 Transfer and Review of Field Documentation

During site-specific field operations, copies of each field logbook page will be telefaxed or hand delivered to the Task Manager on a daily basis. In the absence of a facsimile, field staff will be in contact with the Task Manager, via mobile telephones.

At the end of each week of field operations, all field documentation will be copied, and originals sent to the Task Manager or Project Manager for review and verification. Original field documents will be kept in the project files. Verification and review of field documentation will include at a minimum, the following checks:

- Consistency of dates and times of activities; among the various field records and forms
- Consistency of sample location and identification documentation among the various field records and forms
- Accuracy and correctness of well completion details
- Correctness of sample preservation techniques

Errors or inconsistencies identified during the review process will trigger a nonconformance investigation to be conducted by the Project Chemist or Quality Control System Manager (QCSM). Appropriate corrective action will be implemented and documented if systemic errors are identified.

3.0 Groundwater Sampling

This section describes groundwater sampling procedures to be followed prior to, during, and after groundwater sample collection from monitoring wells. Procedures for collecting grab groundwater samples are described at the end of this section.

3.1 Sampling Preparation

Prior to sampling, the well vault or GWTS process sampling port will be examined for signs of tampering or deterioration and observations noted. After a well vault is opened, the Activity Hazard Analysis (AHA) may call for the air in the wellhead vicinity to be tested for organic vapors with the Photo Ionization Detector (PID) or Flame Ionization Detector (FID) and/or for explosive atmospheres with an oxygen/combustible gas indicator (see Appendix E of the Site Safety and Health Plan). Results will be recorded in the field notebook. (Note: well vault air testing is not required for routine groundwater sampling as long as previous results indicate that organic vapors or explosive atmosphere are not present). All measuring and sampling equipment will be decontaminated prior to use in any well (see Section 3.5).

Extraction wells that are not normally operated will be run to purge a minimum of three well volumes prior to sample collection. Pumped purge volumes will be estimated using the flow meter in the well vault. The volume of water purged and the withdrawal rates will be recorded. Purge rates will be sustainable and executed at a rate that minimizes drawdown to prevent water from cascading into the well. Prior to sample collection, ports for extraction well and process sampling will be purged with the port valve completely open for a minimum of 1 minute to ensure stagnant water and any foreign matter or debris are discharged so a representative sample may be collected.

If a well is purged dry before three casing volumes have been removed, VOC samples will be collected immediately. Other samples will be taken after the well has recovered to within 80 percent of the static water level prior to purging, or after 4 hours, or when sufficient water volume is available to meet analytical requirements, whichever occurs first.

Pre-cleaned sample containers will be provided by the laboratory. The containers for each sample will be labeled in advance of the sampling event with the date, sample number, project name, sampler's name or initials, parameters for analysis (method numbers where possible), and preservation.

3.2 Sampling Procedures

After purging, samples will be collected using designated sampling ports in extraction well vaults or designated GWTS process sampling ports. Water samples will be collected carefully by discharging directly from the sample port to the appropriate sample containers.

Water samples for VOC analysis will be collected in VOA vials, which will be filled by inserting the sample port spout to the bottom of the VOA vial and keeping the spout beneath the surface of the liquid as it fills the vial until there is a convex meniscus over the neck of the bottle. The Teflon side of the septum (in the cap) will be positioned against the meniscus, and the cap screwed on tightly; the sample will be inverted, and the vial tapped lightly. The absence of an air bubble indicates a successful seal; if a bubble is evident, the sample will be discarded and the process repeated.

All sample bottles and equipment will be kept away from fuels and solvents. Gasoline (used in generators) will be transported in a different vehicle from the vehicle containing sampling equipment, sample bottles, etc. If possible, one person should be designated to handle samples and another person should operate the generators and refuel equipment, if required. Disposable gloves will be worn for each separate activity and then properly disposed. Care will be taken to avoid fuel spillage.

All samples will be packaged and transported appropriately, as described in Section 4.3.

3.3 Water-Level Measurement

The methods presented below are intended to produce water-level measurements that are consistent over multiple measurement events. Calibration and precision requirements for water-level measurements are summarized in Section 3.4.

Groundwater levels may be measured using an electrical sounder, a steel tape, or a pressure transducer. All water-level measurements will be taken from an obvious survey mark at the top edge of the well casing. Water levels will be measured using the following procedures.

Electrical Sounder

The standard equipment for making individual water-level measurements will be a battery-powered sounder. The sounder must have firmly affixed or permanent marks on the sounder line at regular intervals (minimum interval of 0.01 foot).

Calibration checks on the electrical sounder will be made periodically. The sounder markings will first be checked for the proper spacing by physically comparing the spacing with a graduated steel tape. Accuracy rechecks will be made after any incident that might alter the measuring capability of the instrument, such as cable stretching, entanglement, or sensor tip replacement.

Portions of the cable that are inserted in wells will be decontaminated after use according to the procedure described in Section 3.5. Sounders will be maintained in a clean and functional condition.

Steel Tape

A graduated steel tape (with 0.01-foot graduations) can be used for water-level measurements in conjunction with other methods and, when required, for a quality control check of other methods. The steel tape will be periodically checked for kinks, and if kinked tapes are found, the tape will be labeled as unusable and taken out of service. Portions of the tape that are inserted in wells will be cleaned after use according to the procedure described in Section 3.5. Tapes will be maintained in a clean and functional condition.

3.4 Sampling Equipment Calibration Procedures

Included is a description of the procedure or a reference to an applicable standard operating procedure, the calibration frequency, and the calibration standards used. All instruments and manufacturers' instructions and specifications are maintained in the project files. All instruments are calibrated prior to being sent to the field. Field calibration procedures will be documented in the Field Logbook.

Water-Level Measurement Instruments

Electrical sounder: Checked against steel surveyor's tape prior to initial use. Battery and sensitivity checked daily.

Graduated steel tape: Referred to new steel tape; manufacturer-supplied temperature correction is applied if appropriate for field conditions.

Pressure transducer: Factory calibrated once, in-house calibration checked with water columns prior to aquifer tests, and weekly field checks made against steel tape or electrical sounder.

3.5 Decontamination Procedures

All reusable equipment that may come in contact with potentially contaminated soil, sediment, or water will be decontaminated prior to use to reduce the potential for cross-contamination during field activities. Decontamination will consist of steam cleaning (high pressure, hot water washing); non-phosphate detergent wash; solvent rinse; distilled, deionized (DI), or clean water rinse; pesticide-grade methanol rinse; and final rinse with DI water, as appropriate.

The procedures for decontaminating sampling equipment are described below:

- Wash steel tapes, well sounders, transducers, and water quality probes in a non-phosphate detergent solution, and rinse in distilled or DI water, or wipe clean after each use, depending upon site conditions. Clean the portion of these devices inserted into wells with a mild non-phosphate detergent solution.

4.0 Sample Handling Procedures

Appropriate sample handling techniques are necessary to protect the samples and maintain sample custody protocol requirements following collection. Sample handling includes custody, container/preservative type, transfer, storage, and disposal.

4.1 Field Sample Custody

Standardized sample custody procedures will be followed through sample collection, transfer, storage, analysis, and ultimate disposal. Sample custody begins with shipment of the empty sample container sent to the office or site. All sample containers are shipped from the laboratory in sealed containers or cartons with appropriate seals and custody information. Sample quantities, types, and locations will be specified before the actual field work commences.

A sample is considered under custody if one or more of the following criteria are met:

- The sample is in the sampler's possession
- The sample is in the sampler's view
- The sample is in a designated secure area after being in the sampler's possession

4.2 Sample Containers and Preservation

Samples should be collected and containerized in order of the analyte volatilization sensitivity. A preferred collection order is listed below:

- Volatile organic compounds
- Sulfate and chloride

Methods of sample preservation are intended to retard biological action, retard hydrolysis, and reduce sorption effects. Preservation methods are generally limited to pH control, chemical addition, refrigeration, and protection from light.

All sample containers will be properly labeled (see Section 2.2) and monitored for temperature control in the field and during laboratory transport and storage. Temperature blanks will be used in all coolers containing samples requiring preservation at reduced temperature (4°C).

4.3 Sample Transfer and Shipment

Samples will always be accompanied by a chain of custody record. When transferring samples, both the individuals relinquishing and receiving the samples will sign, date, and note the transference time on the chain of custody record. Samples will be packaged properly for shipment, including isolation of samples suspected of high chemical concentrations, and dispatched to the appropriate laboratory for analysis. Custody seals will be used when samples are shipped via courier service, and must be placed on the container so that the seals have to be broken before the container can be opened. The seal must be signed and dated by the field personnel. Custody seals are not deemed necessary when the samples will be in the continuous possession of project, field, or laboratory personnel. The chain of custody record(s) will accompany each sample shipment. Samples will be packaged for shipment as follows:

- Print the following information clearly in waterproof ink on the label; the test methods requested, the preservative(s) used (if any), the sample number, the project number, the initials of the sample collector, and the date and time the sample was collected.

- Fill out field sample log and chain of custody record as described in Sections 1.2.1 and 1.2.3, respectively.
- Place each sample bottle or set of VOA vials in a separate plastic bag and seal the bag. Squeeze air from the bag before sealing.
- If using a plastic cooler as a shipping container, tape shut the drain plug from the inside and outside, and line the cooler with a large plastic bag. If sample containers are glass, place approximately 3 inches of inert packing material, such as asbestos-free vermiculite, perlite, or Styrofoam beads in the bottom of the container or wrap the sample containers in other appropriate protective packing material (e.g., bubble wrap. Other commercial shipping containers (cardboard or fiber boxes complete with separators and preservatives) may be used but should be preapproved by the USACE.
- Place the bottles upright in the lined plastic cooler and position to avoid contact during shipment. Cardboard separators may be placed between the bottles at the discretion of the shipper.
- Transport all samples to the laboratory on ice chilled to 4°C ± 2°C.
- Place additional inert packing material in the cooler to partially cover the sample bottles (more than halfway). If samples are required to be shipped to the laboratory with ice, place ice in double bags around, among, and on top of the sample bottles, fill the cooler with inert packing material, and tape the liner shut.
- Place paperwork going to the lab inside a plastic bag. Seal the bag and tape to the inside of the cooler lid. Include the original of the COC form in the paperwork sent to the laboratory. The last block on the COC form should indicate the over-night carrier and air bill number, if applicable. Fill out the air bill before the samples are handed over to the carrier. Notify the laboratory if the shipper suspects that the sample contains any other substance that would require laboratory personnel to take additional safety precautions.
- Close the cooler and tape it securely shut.
- Place at least two signed custody seals on the cooler, one on the front and one on the side. Additional seals may be used if the sampler or shipper deems necessary. Affix "fragile" and "this end up" labels on coolers, as appropriate.
- Samples may be hand delivered to the laboratory, transported by commercial or laboratory couriers, or shipped to the laboratory using an overnight shipper.

4.4 Laboratory Custody

A designated laboratory sample custodian will accept custody of the samples and verify that the information on the sample label matches that on the chain of custody form(s). Pertinent information as to sample condition, shipment, pickup, and courier will also be checked on the chain of custody form(s). In addition, a Cooler Receipt Form (e.g., cooler receipt form) will also be completed by the custodian and copies will be sent to the project chemist within 24 hours of sample receipt. On receiving samples at the laboratory, the temperature inside the cooler and of the temperature blank will be measured immediately after opening the cooler and the results recorded on the cooler receipt form. Information on the date and time of receipt, method of shipment, and sample condition also will be recorded on this form. The custodian will then enter the appropriate data into the laboratory sample tracking system. The laboratory custodian will use the sample number on the sample label as well as assign a unique laboratory number to each sample. The custodian will then transfer the sample(s) to the proper analyst(s) or store the sample(s) in the appropriate secure area.

Laboratory personnel are responsible for the care and custody of samples from the time they are received through sample disposal. Data sheets and laboratory records will be retained by the laboratory as part of the permanent documentation for a period of at least 3 years.

Attachment A: Standard Operating Procedure (SOP) #6
Low Flow Groundwater Quality Parameter Collection

1.0 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for calibrating and operating the field equipment necessary for collecting groundwater stabilization parameters by low flow. Groundwater stabilization parameters are obtained by using electronic equipment and are required to meet calibration standards.

2.0 Equipment List

- Decontamination equipment including soap, de-ionized and tap water
- Health and safety equipment including safety glasses and nitrile/latex exam gloves
- Field logbook, indelible ink pens and field forms
- Tools to open wells
- Horiba U-50 Series multi-meter or equivalent
- Electronic water level meter such as the Solinst Model 101 or equivalent
- Rinse water receptacle and disposal area
- Horiba pH4 multi-calibration solution or equivalent
- Horiba oxygen-reduction potential (ORP) standard powder No. 160-22 or No. 160-51 or equivalent.
- Flow-through-cell/chamber for Horiba
- Dedicated or non-dedicated submersible low flow 12 volt Geosquirt pump or equivalent
- Vehicle battery to power pump with pump controller
- Sample tubing (dedicated or non-dedicated) 3/8 inch (”) or ½” inner diameter (ID) Polyethylene

3.0 Procedures

3.1 Multi-Meter Calibration

Water parameters are primarily recorded with the **Horiba U-50 Series** (Horiba) multi-meter (or equivalent). A wide variety of measurements can be obtained, but for groundwater stabilization parameter purposes only temperature, specific conductivity, dissolved oxygen (DO), pH, ORP, and turbidity are needed. All these parameters require calibration with the exception of temperature. According to the Horiba manual utilize approximately 200 milliliters (mL) of calibration fluid in the calibration cup. While calibrating turbidity, the lower fill line in the calibration cup is used. Remember to remove any protective caps from the sensors prior to calibration and use of the meter.

The Horiba instrument utilizes simultaneous Auto Calibration of **DO, pH, conductivity, and turbidity** with the standard pH 4 calibration solution. At a standard temperature of 25 degrees Celsius (°C); pH is calibrated to 4.01, conductivity is calibrated to 4.49 milliSiemens per centimeter (mS/cm), DO is calibrated to 8.92 milligrams per liter (mg/L), and turbidity calibrated to 0 nephelometric turbidity units (NTU). Be sure the calibration solution is approximately the same temperature as the ambient air, if this cannot be confirmed, allow a one hour equilibration time. To perform auto calibration of the parameters listed above, follow the steps below:

1. Turn the Horiba unit on and let it warm up for approximately 20 minutes.
2. Remove the sensor guard and wash the sensor probe two to three times with deionized (DI) water.
3. Remove the transparent calibration cup.
4. Fill the transparent calibration cup to the “With TURB” labeled lower line with pH 4 standard solution.
5. Press the Horiba’s “CAL” key or navigate to the Calibration menu to set the calibration mode.
6. Select “Auto Calibration”.
7. Immerse the sensor probe in the transparent calibration cup.
8. Check that there are no air bubbles and the appropriate sensors are submerged.
9. Place the transparent cup with probe into the black calibration cup.
10. When all the sensor values have stabilized, press the “ENTER” key to start calibration.
11. Calibration is finished when the message “Cal complete. MEAS to measure” appears.
12. Press “MEAS” to begin reading parameters.
13. Finally, remove the calibration cup and rinse sensors and cup with DI water.

ORP is calibrated with another set of steps and materials as described below. ORP standard solution is not stable for more than an hour and therefore cannot be stored. For measuring low concentrations measurements may not be repeatable, start the measurement immediately after submersion.

1. Fill a clean beaker with one bag of ORP standard powder No. 160-22 or No. 160-51.
2. Add 250 mL of DI water and agitate the solution thoroughly (there will be some excess quinhydrone [a black powder] that floats on the surface when agitating the solution).
3. Fill the transparent calibration cup to the reference line (the upper line “Without TURB”) with this ORP solution.
4. Wash the sensor probe two to three times with DI water then submerge probe into the transparent calibration cup.
5. Press the Horiba’s “CAL” key or navigate to the Calibration menu to set the calibration mode.
6. Select “Manual Calibration”.
7. Select “ORP”.
8. Set the millivolts (mV) value of the ORP standard solution appropriate for specific temperature conditions as specified in the table below.

Temperature (°C)	**ORP Powder 160-22**	**ORP Powder 160-51**
5	+274	+112
10	+271	+107
15	+267	+101
20	+263	+95
25	+258	+89
30	+254	+83
35	+249	+76
40	+244	+69

9. Once the value has stabilized, press "ENTER" to start calibration.
10. Calibration is finished when the message "Cal complete. ENT to manual cal menu" appears.
11. Press "ENT" and then "MEAS" to begin reading parameters.
12. Finally, remove the calibration cup and rinse sensors and cup with DI water.

The auto multi-calibration and the ORP calibration of the Horiba should be performed daily. Record the auto multi-calibration and ORP calibrations were performed in the daily field logbook and other paperwork as necessary. Remember to replace any protective caps on the sensors following calibration or use of the meter and decontamination.

3.2 Site Control

- Upon arrival at groundwater monitoring well or sample station, position field vehicle in location convenient to access well as necessary for use of pump and field equipment while collecting parameters. Consider using the field vehicle to provide safety from traffic or shade from the sun.
- Establish a work area as needed. Lay out equipment in an orderly manner so as to avoid creating trip hazards. This is an important consideration in regards to cords and tubing. If necessary, use traffic cones or caution tape to define a work area and do not allow the public or subcontractors to enter your work area. Control activities in the sample collection work area so as to preserve the quality and integrity of the parameters being collected.

3.3 Water Level Measurement

Water level indicators (sounders) need to be calibrated and checked for accuracy. If more than one instrument is to be used, they should be checked by measuring a single well using both instruments to assure that measurements are consistent. A single water level meter can be checked against another tape (i.e. 100 foot reel measuring tape). Turn on unit and test the audible detector by depressing button on the site of unit before use.

Prior to leaving field office or before beginning water level measurements, decontaminate the probe and cable. Inspect well casing and locking cap for tampering, damage, maintenance needs or rust and make note of the conditions on the appropriate *Well Maintenance Form* and in the field logbook.

Use care when removing the well cap or J-plug and observe if there is a pressure difference between the closed well and atmospheric pressure. If project groundwater wells tend to build pressure attach a lanyard to well cap to eliminate the potential for injury from rapid pressure release. Never place body, face or head directly over a well while opening the well cap. Each well shall be marked with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed. In the event a marking is not visible or well is not yet surveyed, take the water level reading from the north-side top of casing.

Don disposable silicone or nitrile exam gloves before lowering well sounder probe and measuring tape into the well. After decontaminating the sounder following water level measurement, properly dispose of exam gloves. A fresh pair of exam gloves should be used for each well or monitoring station.

Slowly lower probe into the monitoring well until contact with the water surface. An audible alarm on the water level meter will occur when the probe touches the water. Gently lift and lower the probe until an accurate measurement can be determined. Adjust well sounder sensitivity as necessary to get a good reading. Obtain the reading from the established mark on the well casing and measure to the nearest 0.01 foot. Record water level on the appropriate field forms.

After a water level measurement is collected at a groundwater monitoring well, decontaminate the measuring tape and reel. After decontamination is completed, properly secure the sounder in the sampling vehicle before moving on to the next location.

3.4 Equipment Setup

- Lie out and connect electric cords to vehicle battery from the pump. Lie out and connect pump discharge tubing from pump to flow-through-cell and from flow-through-cell to purge water storage tank. Keep tubing and equipment in shade whenever possible.
- Check the specifications for the well and place the pump at the specified depth after collecting a depth to water measurement, collecting any necessary analytical samples, and removing any hardware in the well. Make sure the pump is decontaminated accordingly with deionized water and soap between locations. Discharge tubing should be securely attached to the pump head and decontaminated or replaced between locations. Secure the pump electrical line and discharge tubing to the top of the well in a manner to avoid kinking once the desired depth has been reached. Record depth to water and depth to pump in the field log.
- Attach the end of the discharge tubing to the flow through cell that has been setup with the calibrated Horiba multi-meter. Attach the discharge of the flow through cell to a bucket for collecting purge water.
- Attach the end of the pump's electrical connector to the controller and connect the controller to the battery. The pump should start running once the controller is on and hooked up but it may

take a few minutes for water to come up to the surface. Adjust the flow accordingly if no water is being produced. Allow the flow through cell to fill before taking the first reading.

- Measure and monitor the flow rate with a graduated cylinder and record it as milliliters per minute (mL/min). Also record the cumulative volume purged as liters (L) and the water quality parameters temperature, pH, conductivity, dissolved oxygen, oxidation reduction potential, and turbidity.

Low-flow dedicated pump purging and sampling will consist of low flow 12 volt Geosquirt, or equivalent, low flow type pump to purge wells. This pump type is meant to pull water from approximately 120 feet below ground surface or shallower. If the well is too deep to pump adequately, lift the pump in the water column and record the pump depth on the field log.

The pumping rate will be maintained within the range of 0.25 to 1.0 liters per minute, limited to minimize the drawdown of the water table. Water level measurements will be collected before purging and after purging to ensure that drawdown in the well is not causing the well to go “dry”. Any well that should go “dry” during the course of sampling will be noted in the field notebook as well as on the appropriate field monitoring data sheet. After recharge time is allowed purging may be reattempted at a slower rate.

3.5 Groundwater Quality Parameter Collection

Parameters are measured from the wells by low-flow dedicated or non-dedicated pumping with a Horiba multi-meter or equivalent. Begin well documentation by filling out the top half of the water sampling log as needed.

The Horiba will be connected to a flow through cell. Parameter measurements are recorded on the sample log as follows:

- Time of measurement
- Pump intake depth (feet below top of casing)
- Flow rate (mL/min)
- Cumulative volume (L)
- Temperature (°C)
- Conductivity (mS/cm)
- DO (mg/L)
- pH (unitless)
- ORP (mV)
- Turbidity (NTU)
- Additional comments, if any

Each successive measurement will be recorded within 3-5 minutes. At least three measurements will be taken but there must be three successive readings stabilized according to the requirements below:

- pH: ± 0.1 units
- Electrical conductivity: ± 3% mS/cm

- ORP: ± 10 mV
- Dissolved oxygen: ± 10 percent mg/L
- Temperature: ± 1.0 °C
- Turbidity: ± 10% or less than 10.0 NTU

Well purging will be continued until the field parameters meet the criteria above, or until a maximum of three well volumes have been purged. An additional water level measurement should also be taken after monitoring is completed to assure the drop in water level is not excessive. Complete paperwork as needed.

3.6 Demobilization and Equipment Decontamination

- Stop purging the well, remove pump if non-dedicated and tubing and electrical line from the well. Re-install hardware and deploy passive diffusion bag (PDB) for next sampling event as necessary.
- Install the well cap or J-plug. Store dedicated discharge tubing in well or contain on vehicle as applicable. Decontaminate non-dedicated pump and tubing with water and soap, purging tubing by operating the pump.
- If possible, purge wells in order of lowest to highest contaminant of concern (COC) concentrations to reduce the chance of carryover from non-dedicated equipment.
- For wells located in a busy street, once all sampling equipment is packed, travel to the next scheduled location before decontaminating field equipment.
- Pumps should not be stored in an area where volatile sources (e.g., household cleaning chemicals, fuels, oils) are present; pumps shall not be stored without appropriate decontamination. Prior to use, the outside of the pump and tubing should be thoroughly rinsed with reagent grade water. Decontaminate all other equipment that contacted the well discharge water, including the water level sounder and the field meter flow-through-cell and probes.
- Collect all cords, tubing, tools and equipment and store in field vehicle in an orderly manner. Police site for trash and investigative derived waste and place in a trash bag.
- Collect any traffic control equipment while paying attention to potential traffic hazards. Never turn your back to oncoming traffic while on the street or when de-mobilizing traffic control from your work area.

3.7 Waste Management

Purged groundwater will be collected in temporary storage tanks, buckets or drums and transferred to proper storage tank for disposal at the Sites 2 and 12 groundwater treatment plant (2/12 GWTP). Non-hazardous solid wastes such as latex and nitrile gloves, plastic bags and paper towels will be collected and discarded to an approved municipal solid waste collection container.

Attachment A: Standard Operating Procedure (SOP) #7 Downhole Meter Groundwater Quality Parameter Collection

1.0 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures for calibrating and operating the field equipment necessary for collecting groundwater quality parameters by downhole meter.

2.0 Equipment List

- Decontamination equipment including soap, de-ionized and tap water
- Health and safety equipment including safety glasses and nitrile/latex exam gloves
- Field logbook, indelible ink pens and field forms
- Rinse water receptacle and disposal area
- Water level meter
- Tools to open wells
- YSI 6-Series (6920) Multi-parameter Water Quality Sonde or equivalent downhole multi-parameter probe
- Calibration cup
- Probe guard
- Battery if required
- Ruler
- Barometer recommended
- Calibration solutions:
    - Conductivity: 10 milliSiemen per centimeter (mS/cm) YSI 3163 or 1 mS/cm YSI 3165 or equivalent
    - pH: pH 7 and pH 10 buffer solutions or pH 4 and pH 7 buffer solutions
    - Oxygen-reduction potential (ORP): Zobell standard recommended
    - Turbidity: two standards 0 nephelometric turbidity unit (NTU) and 100 NTU of formazin prepared by YSI, Hach, or other approved vendor.
    - Water for dissolved oxygen (DO)
- Ring stand recommended
- YSI 200 foot Sonde cable (for deeper wells)
- YSI 100 foot Sonde cable (for shallower wells)

3.0 Procedures

3.1 Downhole Meter Calibration

If the Sonde did not come with the sensors installed, install and activate the appropriate sensors per manufacturer's instructions. Remove protective caps on the sensors before calibration or use of the meter. If the meter is rented, calibration has already been performed by the vendor and field calibration is not necessary during field events lasting less than 1 month. If the meter is rented, it is assumed that, unless warranted by erroneous field data, the meter will not require any maintenance.

To perform calibration of the Sonde, follow the general procedures below or specific manufacturer directions.

1. If installed, remove the Sonde probe guard.
2. Use the calibration cup supplied with the Sonde for all calibrations.
3. Rinse the Sonde probe and calibration cup with water and shake off excess.
4. Rinse the Sonde probe and calibration cup with a small amount of calibration solution if there is sufficient volume.
5. While calibrating the Sonde can be upright or inverted, but the sensors should be fully submerged.
6. Turn on the YSI meter and select Calibrate on the menu.

The following approximate volumes of calibration solution are to be used (check calibration solution and meter directions).

- Conductivity: 320 milliliters (mL) upright (150 mL inverted)
- Dissolved Oxygen: 1/8 inch (") water vented to air
- pH/ORP: 200 mL upright (150 mL inverted)
- Optical sensors (turbidity): 225 mL upright (do not calibrate inverted)

7. Fill the calibration cup with the appropriate amount and type of calibration standard.
    a. For conductivity, be sure the probe is dry prior to immersing and no salt deposits. Make sure the sensor is completely immersed past the vent hole. Rotate the Sonde to remove air bubbles from sensor. Allow the temperature to equilibrate for approximately one minute after submersion.
    b. When calibrating dissolved oxygen, place 3 millimeters (mm) or 1/8" of water in the calibration cup. Engage only one or two threads of the calibration cup to vent to air. Loosen the bottom cap if the probe is inverted. Do not immerse DO or temperature sensors in the water. Wait approximately 10 minutes for the air in the calibration cup to become water saturated and for temperature equilibration.
    c. For pH, allow approximately one minute for temperature stabilization.
8. Screw the cup onto the probe. It is recommended to use a ring stand to prevent the probe from falling over.
9. In the Sonde Menu select "Calibrate".
10. Input the calibration type you are performing (i.e., conductivity, Dissolved Oxygen, pH, ORP, Turbidity).
    a. Select Specific Conductivity for Conductivity calibration.
    b. Calibrating for percent (%) DO will also calibrate for milligrams per liter (mg/L) DO.
    c. For pH, enter 2-point calibration for two buffer solutions.
    d. For turbidity, enter 2-point calibration.

11. Once a parameter is selected, some will have a number that appears in parenthesis, which is the default value to be used for calibration.
12. Check the number is correct on the calibration standard being used, and press Enter or change the calibration value accordingly.
    a. For pH you must enter the calibration value, which is usually temperature dependent.
    b. For DO, you must enter the current barometric pressure. If you do not have a barometer, check the local weather station and calculate according to actual elevation. Barometric pressure must be entered in mm Hg. If given in in Hg, multiply by 25.4. To calculate for elevation take the barometric pressure at sea level in your area and subtract the following; divide your location's altitude in feet above sea level by 100 and multiply by 2.5.
    c. For turbidity, the 0 NTU standard must be calibrated first.
13. A real time value will display, with all enabled sensors reading values, not just the sensor currently being calibrated.
    a. For turbidity activate the wiper function to remove any bubbles if necessary.
14. Observe the stabilization of the sensor value being calibrated. When the reading stabilizes for approximately 30 seconds, press Enter to accept calibration.
15. Press Enter to return to the Calibration menu, and proceed to the next calibration. Repeat steps 3-13 for each calibration standard. For pH and turbidity 2-point calibrations, the Sonde will prompt you for the second calibration solution. Dry the Sonde between readings.
16. Once completed rinse and dry the Sonde.

The Sonde is now ready to be used for readings throughout the day. Recalibrate as necessary if field conditions present erroneous data or the Sonde experiences mechanical issues. Record the calibrations were performed in the daily field logbook and other paperwork as necessary. Remember to replace any protective caps on the sensors following calibration or use of the meter and decontamination.

3.2 Site Control

- Upon arrival at groundwater monitoring well or sample station, position field vehicle in location convenient to access well as necessary for use of pump and field equipment while collecting parameters. Consider using the field vehicle to provide safety from traffic or shade from the sun.
- Establish a work area as needed. Lay out equipment in an orderly manner so as to avoid creating trip hazards. This is an important consideration in regards to cords and tubing. If necessary, use traffic cones or caution tape to define a work area and do not allow the public or subcontractors to enter your work area. Control activities in the sample collection work area so as to preserve the quality and integrity of the parameters being collected.

3.3 Water Level Measurement

Water level indicators (sounders) need to be calibrated and checked for accuracy. If more than one instrument is to be used, they should be checked by measuring a single well using both instruments to assure that measurements are consistent. A single water level meter can be checked against another tape (i.e. 100 foot reel measuring tape). Turn on unit and test the audible detector by depressing button on the site of unit before use.

Prior to leaving field office or before beginning water level measurements, decontaminate the probe and cable. Inspect well casing and locking cap for tampering, damage, maintenance needs or rust and make note of the conditions on the appropriate *Well Maintenance Form* and in the field logbook.

Use care when removing the well cap or J-plug and observe if there is a pressure difference between the closed well and atmospheric pressure. If project groundwater wells tend to build pressure attach a lanyard to well cap to eliminate the potential for injury from rapid pressure release. Never place body, face or head directly over a well while opening the well cap. Each well shall be marked with a permanent, easily identified reference point for water level measurements whose location and elevation have been surveyed. In the event a marking is not visible or well is not yet surveyed, take the water level reading from the north-side top of casing.

Don disposable silicone or nitrile exam gloves before lowering well sounder probe and measuring tape into the well. After decontaminating the sounder following water level measurement, properly dispose of exam gloves. A fresh pair of exam gloves should be used for each well or monitoring station.

Slowly lower probe into the monitoring well until contact with the water surface. An audible alarm on the water level meter will occur when the probe touches the water. Gently lift and lower the probe until an accurate measurement can be determined. Adjust well sounder sensitivity as necessary to get a good reading. Obtain the reading from the established mark on the well casing and measure to the nearest 0.01 foot. Record water level on the appropriate field forms.

After a water level measurement is collected at a groundwater monitoring well, decontaminate the measuring tape and reel. After decontamination is completed, properly secure the sounder in the sampling vehicle before moving on to the next location.

3.4 Equipment Setup

Remove any sample or hardware from the well and allow settling time before deployment of the downhole meter, approximately five minutes. Remove hardware and take water level readings in a manner to minimize disturbance of the water column in the monitoring well, lower and remove equipment slowly.

Be sure the Sonde and cables have been decontaminated prior to deployment in the monitoring well. Connect the Sonde to the power source if needed and connect communication cable from the Sonde to the probe.

Remove the probe guard and any protective sensor caps before using the Sonde. After calibration of the meter, confirm the sensors and parameters that are needed (turbidity, temperature, DO, ORP, and conductivity) are all reading on the instrument display. Replace the probe guard and keep in place during deployment. Check the pump intake depth for the current monitoring well and attach the correct length of Sonde cable to the meter (100 foot or 200 foot cable available).

Deploy the meter into the monitoring well and secure at the top of the well once the appropriate depth has been reached as to avoid kinking. Attempt to not disturb the water column too much while deploying by lowering the meter slowly. Allow settling time before collecting parameters, approximately two minutes.

3.5 Groundwater Quality Parameter Collection

On the YSI meter menu, Select Run. Choose Discrete Sampling on the meter's menu. Discrete sampling is used for spot sampling and short term sampling. In the Discrete Sampling Menu, set the appropriate sample interval sample time length. The default sample interval is four seconds and is appropriate for most discrete sampling. Optionally, identify the location by entering a filename and site name. Then select Start Sampling. Once the sample interval time has passed (4 seconds), the data will be displayed and it can be saved by selecting Log Last Sample.

When using the downhole meter, place the meter at the specified pump depth and record one measurement on the field paperwork once stabilized. If no other readings are required, remove the Sonde and cable from the monitoring well. Replace the hardware and deploy a passive diffusion bag (PDB) as necessary for the next sampling event. Replace the well cap and secure well.

3.6 Equipment Decontamination and Waste Disposal

Decontaminate the Sonde, meter cables, and all sensor probes with deionized water and a mild detergent. A small brush may be used on the sensors if necessary. The cable connector port must always be covered to prevent moisture from entering. If the cable is not connected cover the port with the pressure cap.

For short term storage place approximately 0.5 inches of water in the calibration or storage cup and place it on the Sonde. The use of a moist sponge is also acceptable instead of water. Do not immerse the sensors. The purpose is to keep the air in the cup at 100% humidity. Any type of water may be used such as tap water, distilled water, or deionized water. Make sure the cup is on tight to prevent evaporation. Check periodically to make sure there is still water/moisture present. For Sondes with level sensors, keep the tube sealed and dry.

Containerize any decontaminate water and dispose at the Sites 2 and 12 groundwater treatment plant (2/12 GWTP). Bag up any non-hazardous solid wastes, such as disposable gloves and paper towels, for disposal in a garbage receptacle.

Analytical SOPs

MS010.7	Analysis of Volatile Organics by GC/MS Select Ion Monitoring (SIM) (VOCs by 8260 SIM)
MET108.03	Metals by Inductively Coupled Plasma Atomic Emission Spectrometry (ICP) (Metals by 6010D)
GN228.9	Determination of Inorganic Anions by Ion Chromatography (Chloride by 9056A)
SAM101.19	Sample Receipt and Storage
SAM108.10	Sample and Laboratory Waste Disposal

ANALYSIS OF VOLATILE ORGANICS BY GC/MS SELECT ION MONITORING (SIM)

Prepared by: Norm Farmer Date: 08/28/17

Approved by: Juan Garcia Date: 08/30/17

Annual Review

Reviewed by: ____________________ Date: __________

Reviewed by: ____________________ Date: __________

Reviewed by: ____________________ Date: __________

Document Control

Issued to: QA Department Date: 09/01/17

Issued to: MS Volatile Department Date: * 09/01/17

Issued to: MS Volatile Soil Lab Date: 09/01/17

Issued to: ____________________ Date: __________

Issued to: ____________________ Date: __________

Issued to: ____________________ Date: __________

Effective 7 days after "*" date

CONTROLLED COPY
DO NOT DUPLICATE

TITLE: ANALYSIS OF VOLATILE ORGANICS BY GC/MS SELECT ION MONITORING (SIM)

REFERENCES: SW846 8260B

REVISED SECTIONS: 1.1.8, 4.6, 7.5.2.2-7.5.2.4 and 11.1

1.0 SCOPE AND APPLICATION, SUMMARY

1.1 Scope and Application

1.1.1 This method is used to determine the concentrations of various volatile organic compounds in water utilizing a gas chromatograph equipped with a mass spectrometer detector. This SOP was written primarily for the analysis of 1,4-dioxane but the analytes listed in Table 1 have also been validated by this method.

1.1.2 Unlike conventional full scan 8260, this method utilizes the instrument’s selected ion monitoring (SIM) capabilities. By monitoring for a few specific ions the sensitivity can be increased 10 to 20 fold.

1.1.3 Utilizing a heated purge greatly improves the purge efficiency of 1,4-dioxane from water.

1.1.4 The Lower Limit of Quantitation (LLOQ) or Reporting limits (RL) are based on the sample amount and the lowest calibration standard. LLOQs may vary depending on matrix complications and sample volumes. The LLOQ for 1,4-dioxane by this method are 1.0 ug/l for aqueous samples and 5.0 ug/kg for solid samples. The LLOQs for the additional analytes listed in Table 1 are 0.1 to 0.5ug/l for aqueous samples and 5 to 25ug/kg for methanol soils. Solid matrices are reported on a dry weight basis.

1.1.5 The Method Detection Limit (MDL) for each analyte is evaluated on an annual basis for each matrix and instrument. MDLs are pooled for each matrix, and the final pooled MDLs are verified. The verified MDLs are stored in the LIMS and should be at least 2 to 3 times lower than the LLOQ. Exceptions may be made on a case by case basis; however, at no point shall the MDL be higher than the reported LLOQ.

1.1.6 The LLOQ for each analyte is evaluated on an annual basis for each matrix and instrument. The LLOQ verifications are prepared by spiking a clean matrix at 0.5 to 2 times the current LLOQ level. This LLOQ verification is carried through the same preparation and analytical procedures as the samples. Recovery of the analytes should be within the established limits. The DOD QSM requirements for Limit of Detection (LOD) and Limit of Quantitation (LOQ) verifications are different. See SOP QA020 for complete requirements for MDL, LOD, LOQ, and LLOQ.

1.1.7 Compounds detected at concentrations between the LLOQ and MDL are quantitated and qualified as estimated values and reported with either a “J” or “I” qualifier. Some program or project specifications may require that no values below the LLOQ be reported.

1.1.8 For DOD projects refer to QSM 4.2, Table F4; QSM 5.0, Table 4; or QSM 5.1, Table B-4 for additional method requirements and data qualifying guidance.

1.2 Summary

1.2.1 This method is adapted from SW846 method 8260B.

1.2.2 Samples are received, stored, and analyzed within the appropriate holding times.

1.2.3 Sample preparation is performed in accordance with SGS Accutest - Orlando SOP OP020 and OP021.

1.2.4 The samples are analyzed on a gas chromatograph equipped with mass spectrometer detector.

1.2.5 The peaks detected are identified by comparison to characteristic ions and retention times specific to the known target list of compounds.

1.2.6 Library searches cannot be performed on data acquired in SIM mode because data was only acquired for selected ions.

1.2.7 Manual integrations are performed in accordance with SOP QA029.

2.0 PRESERVATION AND HOLDING TIME

2.1 Preservation

Aqueous Samples:

2.1.1 Samples should be preserved to a pH < 2. The pH should be checked and recorded immediately after the sample analysis. If the sample is not preserved to a pH < 2, it must be noted on the report.

2.1.2 The samples must be stored in capped vials, with minimum headspace, at ≤ 6 °C in an area free of solvent fumes. The size of any bubble caused by degassing upon cooling should not exceed 5-6mm.

Solid Samples:

2.1.3 Special 40ml vials for purge-and-trap of solid samples, as well as the collection and preservation options are described in OP020.

2.1.4 Low level soil samples are preserved by storing them in sealed VOA vials at temperatures between –10 °C to –20 °C. High level soil samples are preserved by storing them in methanol at a ratio of 1 gram of soil to 1ml of methanol.

2.2 Holding Time

2.2.1 Aqueous samples are to be analyzed within 14 days of collection, unless otherwise specified by the contract. Samples that are not preserved should be analyzed within 7 days of collection; however, the preservation deficiency must be noted in the report.

2.2.2 Solid and waste samples must be analyzed within 14 days of collection.

3.0 INTERFERENCES

3.1 Data from all blanks, samples, and spikes must be evaluated for interferences.

3.2 Impurities in the purge gas, organic compounds out-gassing from the plumbing ahead of the trap, and solvent vapors in the laboratory account for the majority of contamination problems. The analytical system must be demonstrated to be free from contamination under the conditions of the analysis by running laboratory blanks. The use of non-TFE tubing, non-TFE thread sealants, or flow controllers with rubber components in the purging device should be avoided.

3.3 Samples can be contaminated by diffusion of volatile organics (particularly methylene chloride and fluorocarbons) through the septum seal into the sample during shipment and storage. A trip blank can serve as a check on such contamination.

3.4 Contamination by carry-over can occur whenever high level and low-level samples are sequentially analyzed. Whenever an unusually concentrated sample is encountered, it should be followed by an analysis of reagent water to check for carry-over.

3.5 SIM may provide a lesser degree of confidence in compound identification unless multiple ions are monitored for each compound. In general, SGS Accutest monitors 3 ions per compound.

3.6 Historically 1,4-dioxane was used as a stabilizer for various chlorinated solvents such as trichlorethene and tetrachloroethene. Samples that contain 1,4-dioxane often contain trichloroethene and/or tetrachloroethene at orders of magnitude higher concentrations. Because of this, it is best to analyze samples for 1,4-dioxane on a system dedicated to only the analysis of 1,4-dioxane.

4.0 DEFINITIONS

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or samples loaded on an instrument within the same 12-hour shift, whichever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Continuing Calibration Verification (CCV): A check standard used to verify instrument calibration throughout an analytical run. For all MS methods, a CCV must be analyzed at the beginning of each analytical run. For DoD QSM 5 and 5.1 projects, an additional CCV must be analyzed at the end of the run.

4.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still be considered valid.

4.5 Internal Standards: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Internal standards for mass spec methods are often deuterated forms of target analytes. Internal standards are used to compensate for retention time and response shifts during an analytical run.

4.6 Initial Calibration (ICAL): A series of standards used to establish the working range of a particular instrument and detector. The low point should be at a level equal to or below the LLOQ.

4.7 Initial Calibration Verification (ICV): A standard from a source different than that used for the initial calibration. A different vendor should be used whenever possible. The ICV is used to verify the validity of an Initial Calibration. This may also be called a QC check standard.

4.8 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.9 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.10 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.11 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.12 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

4.13 Surrogate: An organic compound which is similar to the target analyte(s) in chemical composition and behavior, but which is not normally found in environmental samples. Surrogates are used to measure the purge efficiency.

4.14 Trip Blank: A sample of analyte-free matrix taken from the laboratory to the sampling site and returned to the laboratory unopened. A trip blank is used to document contamination attributable to shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organic samples.

5.0 REAGENTS

5.1 Reagent water – distilled or deionized water free of interferences

5.2 Methanol – purge-and-trap grade or equivalent

5.3 Hydrochloric acid (HCl) – ACS reagent grade or equivalent

5.4 Inert Gas – UHP Helium or UHP Nitrogen

5.5 1,4-Dioxane stock standards – traceable to Certificate of Analysis

5.6 4-Bromofluorobenzene (BFB) – instrument tuning mix

5.7 Surrogate standards – (varies based on analytes being reported)

Dibromofluoromethane
1,2-Dichloroethane-d_4
Toluene-d_8

5.8 Internal standards – (varies based on analytes being reported)

Fluorobenzene
Chlorobenzene-d_5
1,4-Dioxane-d_8

6.0 APPARATUS

6.1 Gas Chromatograph – Agilent Technologies 6890 or 7890

6.1.1 Gas Chromatograph

The analytical system that is complete with a temperature programmable gas chromatograph and all required accessories, analytical columns, and gases.

6.1.2 The injection port is designed for split-splitless injection with capillary columns. The injection port must have an appropriate interface for sample introduction.

6.2 Mass Spectrometer– Agilent Technologies 5973 or 5975

The mass spectrometer must be capable of scanning from 35-300 amu every second or less, utilizing 70-volt (nominal) electron energy in the electron impact ionization mode. It must also be capable of producing a mass spectrum that meets all the criteria in section 7.5.1.1 when injecting 50 ng of bromofluorobenzene (BFB).

6.3 Purge and Trap – OI Analytical 4560 or 4660 with OI Analytical 4552 or 4551

6.3.1 The following autosampler models are used for purging, trapping and desorbing the sample onto GC column.

- O.I. Model 4560 sample concentrator with 4552 Water/Soil multisampler
- O.I. Model 4660 sample concentrator with 4552 Water/Soil multisampler
- O.I. Model 4660 sample concentrator with 4551 Water multisampler

6.3.2 The sample purge vessel must be designed to accept 5 ml samples with a water column at least 3 cm deep.

6.3.3 The multisampler or concentrator is equipped with a heater capable of maintaining the purge chamber at 60 °C to improve purging efficiency.

6.3.4 The desorber should be capable of rapidly heating the trap to the manufacturer recommended desorb temperature.

6.4 Data System – Agilent Technologies MS Chemstation rev. DA 02.0x, DA 03.0x or EA 02.0x.

6.4.1 A computer system interfaced to the mass spectrometer that allows for the continuous acquisition and storage of all mass spectral data obtained throughout the duration of the chromatographic program.

6.4.2 The computer utilizes software that allows searching any GC/MS data file for ions of a specific mass and that can plot such ion abundances versus time or scan number. This type of plot is defined as an Extracted Ion Current Profile (EICP).

6.4.3 The software should allow for integrating the abundances in any EICP between specific time or scan number limits. See Table 2.

6.4.4 Data is archived to a backup server for long term storage.

6.5 Trap – OI #10 or equivalent: Tenax, Silica Gel, and Carbon Molecular Sieve. The trap should be conditioned according to the manufacturer's recommendations.

6.6 Columns – RTX-624 or equivalent: 60m X 0.25mm 1.4um.
– RTX-VMS or equivalent: 40m X 0.18mm 1.0um

6.7 Gas-tight syringes and class "A" volumetric glassware for dilutions of standards and samples.

7.0 PROCEDURE

7.1 Standards Preparation

Standards are prepared from commercially available certified reference standards. All standards must be logged in the Volatile Standards Logbook. All standards shall be traceable to their original source. The standards should be stored at temperatures between –10 °C and –20 °C, or as recommended by the manufacturer. Calibration levels, spike and surrogate concentrations, preparation information, and vendor part numbers can be found in the MSVOA STD Summary in the Active SOP directory.

7.1.1 Stock Standard Solutions

Stock standards are available from several commercial vendors. All vendors must supply a "Certificate of Analysis" with the standard. The certificate will be retained by the lab. Hold time for unopened stock standards is until the vendor's expiration date. Once opened, the hold time is reduced to six months (one month for gases) or the vendor's expiration date (whichever is shorter).

7.1.2 Intermediate Standard Solutions

Intermediate standards are prepared by quantitative dilution of the stock standard with methanol. The hold time for intermediate standards is one month (one week for gases) or the vendor's expiration date (whichever is shorter). Intermediate standards may need to be remade if comparison to other standards indicates analyte degradation or concentration changes.

7.1.3 Calibration Standards

Calibration standards for the volatile organics are prepared at a minimum of five concentration levels through quantitative dilutions of the intermediate standard. The low standard concentration is at or below the LLOQ, and the remaining standards define the working range of the detector.

Calibration standard concentrations are verified by the analysis of an initial calibration verification (ICV) standard.

7.2 Instrument Conditions

<u>Gas Chromatograph/ Mass Spectrometer</u>

Carrier gas flow	1.0-1.3 ml/min
Transfer line temperature	220 - 280 °C
Analyzer temperature	150 °C

Oven program – 45 °C for 2.5 minutes (RTX-VMS 40m)
10 °C/min to 80 °C for 0 minutes
15 °C/min to 185 °C for 0 minutes
30 °C/min to 240 °C for 2.5 minutes

Oven program – 35 °C for 2.5 minutes (RTX-VMS 40m)
4 °C/min to 60 °C for 0 minutes
25 °C/min to 220 °C for 0 minutes
30 °C/min to 240 °C for 1.2 minutes

Oven program – 45 °C for 2.0 minutes (RTX-624)
10 °C/min to 80 °C for 0 minutes
14 °C/min to 210 °C for 0 minutes
16 °C/min to 240 °C for 4.2 minutes

GC conditions are optimized for each instrument. Actual conditions may vary slightly from those listed above.

MS Descriptors – Monitor 3 characteristic ions for each target analyte, and 2 characteristic ions for each surrogate and internal standard. Each descriptor may have up to 30 ions; however, the more ions in a descriptor, the less the sensitivity. Therefore, it is beneficial to use multiple descriptors for longer analytes lists. Refer to the specific instrument methods for actual descriptors.

7.3 Purge and Trap Device conditions

Purge Gas:	Helium or Nitrogen at 30-45 ml/min
Sample Temp:	Aqueous (60°C) Soils (40°C)
Trap Temp:	<25°C
Purge Time:	6 or 11 min
Desorb:	1 min. at 190°C
Bake:	5 min. at 210°C

Purge and Trap conditions are optimized for each instrument. Actual conditions may vary slightly from those listed above.

NOTE: Due to the poor purge efficiency of 1,4-dioxane, purge times of less than 11 minutes should not be used when analyzing for 1,4-dioxane.

7.4 Sample Preparation

7.4.1 Water Samples

A 5ml aliquot of sample is loaded onto the purge-and-trap device and purged for 6 or 11 minutes at 60°C. Detailed procedures are described in SOP OP021.

7.4.2 Solid Samples

A 5-gram aliquot of sample is loaded onto the purge-and-trap device. 5mls of reagent water is added along with internal standards and surrogates. The sample is then purged for 6 or 11 minutes while heated to 40°C and mechanically agitated. Detailed procedures are described in SOP OP020.

Alternatively a methanol aliquot from the sample is loaded onto the purge-and-trap device. 5mls of reagent water is added along with internal standards and surrogates. The sample is then purged for 6 or 11 minutes. Detailed procedures are described in SOP OP020 and OP021.

7.5 Gas Chromatographic Analysis

Instrument calibration consists of two major sections:

Initial Calibration Procedures
Continuing Calibration Verification

7.5.1 Initial Calibration Procedures

Before samples can be run, the GC/MS system must be tuned, the injection port inertness must be verified, and the instrument must be calibrated.

7.5.1.1 Tune Verification (BFB)

The instrument should be hardware tuned per manufacturer's instructions. Verify the instrument tune by injecting 50ng of BFB solution onto the instrument. The BFB standard may also be purged. The resulting BFB spectra should meet the criteria in the following table.

BFB KEY IONS AND ION ABUNDANCE CRITERIA

Mass	Ion Abundance Criteria
50	15-40% of mass 95
75	30-60% of mass 95
95	Base peak, 100% relative abundance
96	5-9% of mass 95
173	<2% of mass 174
174	>50% of mass 95
175	5-9 % of mass 174
176	>95% and <101% of mass 174
177	5-9% of mass 176

Evaluate the tune spectrum using three mass scans from the chromatographic peak and a subtraction of instrument background. This procedure is performed automatically by the MS Chemstation software by running "autofind" on the BFB peak.

Select the scans at the peak apex and one to each side of the apex. Calculate an average of the mass abundances from the three scans.

Background subtraction is required. Select a single scan in the chromatogram that is absent of any interfering compound peak and no more than 20 scans prior to the elution of BFB. The background subtraction should be designed only to eliminate column bleed or instrument background ions. Do not subtract part of the tuning compound peak.

Alternatively, the average spectra over the entire peak may be used. **All subsequent tune evaluations must use the same procedure that was used for the Initial Calibration.**

If the criteria are not achieved, the analyst must retune the mass spectrometer and repeat the test until all criteria are met.

Analysis must not begin until the tuning criteria are met. The injection time of the acceptable tune analysis is considered the start of the 12-hour clock. The same mass spec settings must be used for the calibration standards and samples that were used for the tune evaluation standard. The exception being that the tune evaluation standard must be acquired in full scan mode and all others in SIM mode.

7.5.1.2 Internal Standard Calibration

A minimum 5-point calibration curve is created for the volatile organic compounds and surrogates using an internal standard technique. SGS Accutest Laboratories routinely performs a 6-point calibration to maximize the calibration range.

Historically, many analytical methods have relied on linear models of the calibration relationship, where the instrument response is directly proportional to the amount of a target compound. The linear model has many advantages including simplicity and ease of use. However, given the advent of new detection techniques and because many methods cannot be optimized for all the analytes to which they may be applied, the analyst is increasingly likely to encounter situations where the linear model neither applies nor is appropriate. The option of using non-linear calibration may be necessary to address specific instrumental techniques. However, it is not EPA's intent to allow non-linear calibration to compensate for detector saturation or avoid proper instrument maintenance.

NOTE: Because of this concern, select programs including SC DHEC do not support the use of non-linear regressions.

The low point may be omitted from the calibration table for any compound with an LLOQ set at the level two standard. Additionally, the high point may be omitted for any compound that exhibits poor linearity at the upper end of the calibration range.

An entire level may be omitted provided that a minimum of 5 points remain. There must be technical justification to omit an entire level. This should be documented in the run log.

Response factors (RF) for each analyte are determined as follows:

$$RF = (A_{analyte} \mathbf{X} C_{istd})/(A_{istd} \mathbf{X} C_{analyte})$$

$A_{analyte}$ = area of the analyte
A_{istd} = area of the internal standard
$C_{analyte}$ = concentration of the analyte
C_{istd} = concentration of the internal standard.

The mean RF and standard deviation of the RF are determined for each analyte. The percent relative standard deviation (%RSD) of the response factors is calculated for each analyte as follows:

%RSD = (Standard Deviation of RF X 100) / Mean RF

If the %RSD $\leq$ 15%, linearity through the origin can be assumed and the mean RF can be used to quantitate target analytes in the samples. Alternatively, a calibration curve of response vs. amount can be plotted. This method allows for the use of average response factors, linear regressions, and non-linear regressions. Linear regressions may be unweighted or weighted as 1/x or $1/x^2$. If the correlation coefficient (r) is $\geq$0.995 (r^2 $\geq$0.990) then the curve can be used to quantitate target analytes in the samples. Regardless of which calibration model is chosen, the laboratory should visually inspect the curve plots to see how the individual calibration points compare to the plot.

Alternatively, either of the two techniques described below may be used to determine whether the calibration function meets acceptable criteria. These involve refitting the calibration data back to the model. Both % Error and Relative Standard Error (RSE) evaluate the difference between the measured and the true amounts or concentrations used to create the model.

Calculation of the % Error

% ERR = (xi-x'i) / xi * 100

x'i = Measured amount of analyte at calibration level i, in mass or concentration units.

xi = True amount of analyte at calibration level i, in mass or concentration units.

Percent error between the calculated and expected amounts of an analyte should be ≤ 30% for all standards. For some data uses, ≤50% may be acceptable for the lowest calibration point.

Calculation of Relative Standard Error (%RSE)

$$RSE = 100 \times \sqrt{\sum_{i=1}^{n} \left[\frac{x'_i - x_i}{x_i}\right]^2 \Big/ (n-p)}$$

x'i = Measured amount of analyte at calibration level i, in mass or concentration units.

xi = True amount of analyte at calibration level i, in mass or concentration units.

p = Number of terms in the fitting equation.
(average = 1, linear = 2, quadratic = 3)

n = Number of calibration points.

The %RSE acceptance limit criterion is ≤15% for good performing compounds and ≤30% for poor performing (PP) compounds.

7.5.1.3 Initial Calibration Verification (ICV)

The validity of the initial calibration curve must be verified through the analysis of an initial calibration verification (ICV) standard. The ICV should be prepared from a second source at a mid-range concentration.

The %D for all analytes of interest should be ≤ 20%. If the %D > 20%, the analysis of samples may still proceed if the analyte failed high and the analyte is not expected to be present in the samples. However, if a reportable analyte is detected in a sample and the %D for that analyte was greater than 20% in the ICV, the sample will need to be reanalyzed on a system with a passing ICV for that analyte.

NOTE: For any DoD QSM project, the %D for all target compounds should be ≤ 20%. If samples must be analyzed with an analyte of interest having a %D > 20%, then the data must be qualified accordingly.

If the ICV does not meet this criteria, a second standard should be prepared. If the ICV still does not meet criteria, analyze an ICV prepared from a third source. If this ICV meets criteria, proceed with sample analysis. If the ICV still does not meet criteria, determine which two standards agree. Make fresh calibration standards and an ICV from the two sources that agree. Recalibrate the instrument.

7.5.2 Continuing Calibration Verification (CCV)

7.5.2.1 Inject 2ul of the tune evaluation mix at the beginning of each 12-hour shift. Evaluate the resultant peaks against the criteria in section 7.5.1.1. The injection time of this standard starts the 12-hour window.

When the analyst is running an unattended second 12-hour window, they may opt to purge the BFB standard. This can be performed by purging an additional blank (which contains BFB) just prior to the second CCV.

7.5.2.2 Analyze a continuing calibration check standard. The CCV should be at or below the mid-point of the calibration curve.

The percent difference (%D) for each analyte of interest will be monitored. The |%D| should be ≤ 20% for each analyte.

If the first continuing calibration verification does not meet criteria, a second standard may be injected. If the second standard does not meet criteria, the system must be recalibrated. If the second standard meets criteria then the system is considered in control and results may be reported.

Rationale for second standard such as instrument maintenance, clipped column, remade standard, etc should be documented in the run log or maintenance log. Reanalysis of second standard without valid rationale may require the analysis of a third standard (in which case both the second and third standard would have to pass).

NOTE: For any DoD QSM project, if the second standard meets criteria, then a third standard must be analyzed. If the third standard also meets criteria then the system is considered in control and results may be reported.

If the |%D| is greater than 20%, then documented corrective action is necessary. This may include recalibrating the instrument and reanalyzing the samples, performing instrument maintenance to correct the problem and reanalyzing the samples, or qualifying the data. Under certain circumstances, the data may be reported, i.e., the CCV failed high, the associated QC passed, and the samples were ND.

NOTE: For any DoD QSM project, if samples must be reported with a target analyte having a %D > 20%, then the data must be qualified accordingly, regardless of whether the analyte was detected or not.

NOTE: Any target analytes that are detected in the samples must be bracketed by an acceptable initial calibration curve and acceptable CCV standards; otherwise, the samples must be reanalyzed or the data must be qualified.

7.5.2.3 For DoD QSM 5.0 and 5.1 compliance, an additional CCV must be analyzed at the end of each run. The closing CCV should be within the 12-hour Tune window.

The %D for all target compounds in this CCV should be ≤ 50%. If the %D > %50 for any target compound, then the samples should be reanalyzed at least once at the appropriate dilution. If the %D > %50 for the analytes in the reanalysis, the department supervisor shall review the data and determine what further action is necessary. This may include reanalyzing the samples at a higher dilution or qualifying the data.

NOTE: If samples are ND and an analyte in the CCV fails high, then the sample does not need to be reanalyzed.

7.5.2.4 If any of the internal standard area change by a factor of two (-50% to +100%) or retention time changes by more than 30 seconds (10 seconds for DOD QSM 5.1 compliance) from the midpoint standard of the last initial calibration or from the daily CCV, the mass spectrometer must be inspected for malfunctions and corrections made, as appropriate. Corrective action may include re-calibration (initial Calibration) of the instrument.

7.5.3 Sample Analysis

7.5.3.1 Samples are analyzed in a set referred to as an analysis sequence or batch. A batch consists of the following:

Tune Evaluation Mix
Initial Calibration Standards (or CCV)
QC Samples
Samples

7.5.3.2 One microliter of internal standard/surrogate solution is added to every 5ml of sample in the sparge vessel. Generally, 5ml of sample are transferred to the sparge vessel.

7.5.3.3 After purging, the system will automatically reverse flow and rapidly heat the trap to desorb the sample analytes onto the GC column.

7.5.3.4 Qualitative identification

The target compounds shall be identified by analysts with competent knowledge in the interpretation of mass spectra by comparison of the sample mass spectrum to the mass spectrum of a standard of the suspected compound. The criteria required for a positive identification are:

The intensities of the characteristic ions of a compound maximize in the same scan or within one scan of each other. Selection of a peak by a data system target compound search routine where the search is based on the presence of a target chromatographic peak containing ions specific for the target compound at a compound-specific retention time will be accepted as meeting this criterion.

The sample component must elute at the same relative retention time (RRT) as the daily standard. The RRT of sample component must be within ± 0.06 RRT units of the standard.

All ions monitored in the standard mass spectra should be present in the sample spectrum.

The relative intensities of these ions must agree within ± 30% between the daily standard and sample spectra, (e.g., for an ion with an abundance of 50% in the standard spectra, the corresponding sample abundance must be between 20 and 80%).

Structural isomers that produce very similar mass spectra should be identified as individual isomers if they have sufficiently different GC retention times. Sufficient GC resolution is achieved if the height of the valley between two isomer peaks is less than 25% of sum of the two peak heights. Otherwise, structural isomers are identified as isomeric pairs.

If peak identification is prevented by the presence of interferences, the sample must be diluted so that the interference does not mask any analytes.

7.5.3.5 Quantitative analysis

When a target compound has been identified, concentration will be based on the integrated area of the quantitation ion, which is normally the base peak.

The sample matrix may produce an interference with the primary ion. This may be characterized by an excessive background signal of the same ion, which distorts the peak shape beyond a definitive integration. The interference could also, severely inhibit the response of the internal standard ion.

If the analyte response exceeds the linear range of the system, the extract must be diluted and reanalyzed. It is recommended that samples be diluted so that the response falls into the middle of the calibration curve.

7.6 Maintenance and Trouble Shooting

7.6.4 Refer to SOP GC001 for routine instrument maintenance and trouble shooting.

7.6.5 All instrument maintenance must be documented in the appropriate “Instrument Repair and Maintenance” log. The log will include such items as problem, action taken, correction verification, date, and analyst.

7.6.6 Repairs performed by outside vendors must also be documented in the log. The analyst or Department Supervisor responsible for the instrument must complete the log if the repair technician does not.

7.6.7 PC and software changes must be documented in the “Instrument Repair and Maintenance” log. Software changes may require additional validation.

8.0 METHOD PERFORMANCE

Method performance is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), matrix spikes (MS), and matrix spike duplicates (MSD). The MB and BS are used to monitor overall method performance, while the MS and MSD are used to evaluate the method performance in a specific sample matrix.

Blank spike, matrix spike, and matrix spike duplicate samples are compared to statistically generated control limits. These control limits are reviewed and updated annually. Control limits are stored in the LIMS. Additionally, blank spike accuracy is regularly evaluated for statistical trends that may be indicative of systematic analytical errors.

9.0 QUALITY ASSURANCE / QUALITY CONTROL

Accuracy and matrix bias are monitored by the use of surrogates and by the analysis of a QC set that is prepared with each batch (maximum of 20 samples) of samples. The QC set consists of a method blank (MB), blank spike (BS), matrix spike (MS), and matrix spike duplicate (MSD).

9.1 Internal Standards

9.1.1 Fluorobenzene, Cclorobenzene-d_5, and 1,4-dioxane-d_8 may be used as the internal standards for this method. The response of the internal standard in all subsequent runs should be within a factor of two (-50% to +100%) of the internal standard response in the opening CCV for each sequence. On days that an initial calibration is performed, the internal standard response should be compared to the internal standard response for the mid-point standard.

9.1.2 If the internal standard response is not within limits, the following are required.

9.1.2.1 Check to be sure that there are no errors in calculations, integrations, or internal standards solutions. If errors are found, recalculate the data accordingly.

9.1.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.1.1.3 If no problem is found, prepare a second aliquot of sample and reanalyze the sample. If there is insufficient sample for reanalysis, footnote this on the report.

9.1.1.4 If upon reanalysis, the responses are still not within limits, the problem is considered matrix interference. The sample may need to be diluted or the results qualified.

9.2 Surrogates

9.2.1 Dibromofluoromethane, 1,2-dichloroethane-d_4 and toluene-d_8 may be used as the surrogate standards to monitor the efficiency of the purge-and-trap system.

A known amount of surrogate standard is added to each sample including the QC set prior to purging. The percent recovery for each surrogate is calculated as follows:

% Recovery = (Sample Amount / Amount Spiked) X 100

The percent recovery must fall within the established control limits for all surrogates for the results to be acceptable.

9.2.2 If any surrogate recovery is not within the established control limits, the following are required.

9.2.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, surrogate solutions or internal standard solutions. If errors are found, recalculate the data accordingly.

9.2.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.2.2.3 If no problem is found, reanalyze the sample. **NOTE:** If the recoveries are high and the sample is non-detect, then reanalysis may not be necessary. For any DoD QSM projects, the resulting data must be qualified accordingly. If there is insufficient sample for reanalysis, footnote this on the report.

9.2.2.4 If upon reanalysis, the recovery is still not within control limits, the problem is considered matrix interference. Surrogates from both sets of analysis should be reported on the final report.

9.3 Method Blank

9.3.1 The method blank is de-ionized water or de-ionized water with 5 grams of Teflon chips (depending upon sample matrix) to which the surrogate standard has been added. An appropriate aliquot of methanol should also be added. The method blank is then purged along with the other samples to determine any contamination from the system or ambient sources. The method blank must be free of any analytes of interest or interferences at ½ the required LLOQ level to be acceptable. Common laboratory contaminants such as methylene chloride must be below the LLOQ if present. Samples associated with a contaminated method blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples or qualifying the results with a “B” or “V” qualifier.

9.3.2 If the MB is contaminated but the samples are non-detect, then the source of contamination should be investigated and documented. The sample results can be reported without qualification.

9.3.3 If the MB is contaminated but the samples results are > 10 times the contamination level, the source of the contamination should be investigated and documented. The samples results may be reported with the appropriate “B” or “V” qualifier. This must be approved by the department supervisor.

9.3.4 If the MB is contaminated but the samples results are < 10 times the contamination level, the source of the contamination should be investigated and documented. The samples should be reanalyzed for confirmation. If there is insufficient sample to reanalyze, or if the sample is reanalyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.4 Blank Spike

9.4.1 The blank spike is de-ionized water or de-ionized water with 5 grams of Teflon chips (depending upon sample matrix) to which the surrogate standard and spike standard have been added. An appropriate aliquot of methanol should also be added. The blank spike is then processed along with the other samples to monitor the efficiency of the purge-and-trap procedure. The percent recovery for each analyte is calculated as follows:

$$\% \text{ Recovery} = (\text{Blank Spike Amount} / \text{Amount Spiked}) \times 100$$

The percent recovery for each analyte of interest should fall within the established control limits for the results to be acceptable.

NOTE: A secondary check against 70-130% limits should be performed for all analytes reported to SC DHEC.

9.4.2 If the blank spike recoveries are not within the established control limits, the following are required.

9.4.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, spike solutions, or internal standard solutions. If errors are found, recalculate the data accordingly.

9.4.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample.

9.4.2.3 If the recovery of an analyte in the BS is high and the associated sample is non-detect, the data may be reportable. For any DoD QSM projects, the resulting data must be qualified accordingly.

9.4.2.4 If no problem is found, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples or qualifying the results as estimated.

9.4.2.5 If there is insufficient sample to reanalyze, or if the sample is reanalyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. This must be approved by the department supervisor.

9.5 Matrix Spike and Matrix Spike Duplicate

9.5.1 Matrix spike and spike duplicates are replicate sample aliquots to which the surrogate standard and spike standard have been added. The matrix spike and spike duplicate are then processed along with the other samples to monitor the precision and accuracy of the purge-and-trap procedure. The percent recovery for each analyte is calculated as follows:

% Recovery = ([Spike Amount – Sample Amount] / Amount Spiked) X 100

The percent recovery for each analyte of interest must fall within the established control limits for the results to be acceptable.

9.5.2 If the matrix spike recoveries are not within the established control limits, the following are required.

9.5.2.1 Check to be sure that there are no errors in calculations, dilutions, integrations, spike solutions, or internal standard solutions. If errors are found, recalculate the data accordingly.

9.5.2.2 Check instrument performance. If an instrument performance problem is identified, correct the problem and reanalyze the sample. If the recovery is high due to interfering peaks, it may be possible to get a more accurate recovery by analyzing the sample on a different column type.

9.5.2.3 If no problem is found, compare the recoveries to those of the blank spike. If the blank spike recoveries indicate that the problem is sample related, document this on the run narrative. Matrix spike recovery failures are not grounds for reanalysis, but are an indication of the sample matrix effects.

9.5.3 Precision

Matrix spike and spike duplicate recoveries for each analyte are used to calculate the relative percent difference (RPD) for each compound.

$$\text{RPD} = (|\text{ MS Result} - \text{MSD Result }| \ / \text{ Average Result}) \times 100$$

The RPD for each analyte should fall within the established control limits. If the RPDs fall outside of the established control limits, the department supervisor shall review the data and determine if any corrective action is necessary. RPD failures are generally not grounds for batch reanalysis.

10.0 CALCULATIONS

The concentration of each target compound in the original sample is calculated as follows:

Water (ug/l) = $(\text{CONC}_{\text{inst}}) \times \text{DF}$

Soil (ug/kg) = $[(\text{CONC}_{\text{inst}}) \times (5 / W_I)] / \%\text{solids}$ (*low level soils)*

Soil (ug/kg) = $[(\text{CONC}_{\text{inst}}) \times (V_F / V_A) \times (5 / W_I) \times \text{DF}] / \%\text{solids}$ (*high level soils)*

$\text{CONC}_{\text{inst}}$ = Instrument concentration calculated from the initial calibration using mean RF or curve fit.
DF = Dilution Factor
V_F = Volume of methanol extract (ul)
V_A = Volume of methanol aliquot (ul)
W_I = Weight of sample (g)
%solids = Dry weight determination in decimal form

For high level soils, V_F is calculated as follows:

$V_F = \{\text{ml of solvent } + [(\%\text{moisture} \times W_I) / 100]\} \times 1000$ ul/ml

11.0 SAFETY AND POLLUTION PREVENTION

11.1 Safety

The analyst should follow normal safety procedures as outlined in the SGS Health and Safety Program, which includes the use of safety glasses, gloves, and lab coats.

The toxicity of each reagent and target analyte has not been precisely defined; however, each reagent and sample should be treated as a potential health hazard. Material Safety Data Sheets (MSDS) or Safety Data Sheets (SDS) are available for all reagents and many of the target analytes. Exposure must be reduced to the lowest possible level. Personal protective equipment should be used by all analysts.

11.2 Pollution Prevention

Waste solvents from the sample analysis, methanol extraction, and standards preparation are collected in waste storage bottles and are eventually transferred to the non-chlorinated waste drum.

Old stock standards are disposed of in the waste vial drum.

Samples are archived and stored for 30 days after analysis. After the storage time has elapsed, the remaining aqueous and soil samples are transferred to the appropriate drums for disposal.

12.0 REFERENCES

SW846 Method 8000D Revision 4, July 2014

SW846 Method 8260B Revision 2, December 1996

TABLE 1

Routine Target Analytes

Benzene	cis-1,3-Dichloropropene
Carbon Tetrachloride	trans-1,3-Dichloropropene
Chloroform	1,4-Dioxane
1,1-Dichloroethane	Methyl Chloride
1,2-Dichloroethane	Methylene Chloride
1,1-Dichloroethylene	Tetrachloroethylene
cis-1,2-Dichloroethylene	1,1,1-Trichloroethane
trans-1,2-Dichloroethylene	Trichloroethylene
1,2-Dichloropropane	Vinyl Chloride

TABLE 2

Characteristic Ions

Analyte	Quant. Ion	Q1	Q2	Q3
Fluorobenzene IS	96	70		
Methyl Chloride	50	52		
Vinyl Chloride	62	64		
1,1-Dichloroethene	61	96	98	63
Methylene Chloride	49	84	86	51
trans-1,2-Dichloroethene	61	96	98	63
1,1-Dichloroethane	63	65		
cis-1,2-Dichloroethene	96	61	98	63
Chloroform	83	85	47	
Dibromofluoromethane Surr	113	111	192	
Carbon Tetrachloride	117	119	121	82
1,1,1-Trichloroethane	97	99	61	
Benzene	78	51		
1,2-Dichloroethane-d4 Surr	65	67	102	
1,2-Dichloroethane	62	49	64	
Trichloroethene	95	130	97	132
1,2-Dichloropropane	63	62	41	76
cis-1,3-Dichloropropene	75	77	39	
Chlorobenzene-d_5 IS	117	82		
Toluene-d_8 Surr	98	100		
trans-1,3-Dichloropropene	75	77	39	49
Tetrachloroethene	166	164	129	131
1,1,2-Trichloroethane	83	97	61	99
1,4-Dioxane-d_8 IS	96	64		
1,4-Dioxane	88	58	43	

METALS BY INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY (ICP)

Prepared by: David Metzgar III Date: 02/22/2018

Approved by: Svetlana Izosimova Date: 02/22/2018

Annual Review

Reviewed by: ______________________ Date: __________

Reviewed by: ______________________ Date: __________

Reviewed by: ______________________ Date: __________

Document Control

Issued to: QA Department Date: 02/22/2018

Issued to: Metals Date: * 02/22/2018

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Effective 7 days after "*" date

CONTROLLED COPY
DO NOT DUPLICATE

TITLE: METALS BY INDUCTIVELY COUPLED PLASMA ATOMIC EMISSION SPECTROMETRY (ICP)

REFERENCES: SW846 6010D, 2014

INSTRUMENT: THERMO 6500, SERIAL # 20100903 SSTRACE 1
INSTRUMENT: THERMO 6500, SERIAL # 20103825 SSTRACE 2
AUTOSAMPLER: CETAC 240 POSITION, SERIAL # 031038A520 SSTRACE 1
AUTOSAMPLER: CETAC 240 POSITION, SERIAL # 041048A520 SSTRACE 2

SUGGESTED WAVELENGTH (S): TABLE 2

REVISED SECTIONS: removed all references to Accutest

1.0 SCOPE AND APPLICATION SUMMARY

SW-846 methods, with the exception of required method use for the analysis of method-defined parameters, are intended to be guidance methods which contain general information on how to perform an analytical procedure or technique which a laboratory can use as a basic starting point for generating its own detailed Standard Operating Procedure (SOP), either for its own general use or for a specific project application. The performance data included in this method are for guidance purposes only, and are not intended to be and must not be used as absolute QC acceptance criteria for purposes of laboratory accreditation.

1.1 This method is applicable for the determination of metals in water, sludges, sediments, and soils. Elements that can be reported by this method include: Aluminum, Antimony, Arsenic, Barium, Beryllium, Cadmium, Calcium, Chromium, Cobalt, Copper, Iron, Lead, Magnesium, Manganese, Molybdenum, Nickel, Potassium, Selenium, Silver, Sodium, Strontium, Titanium, Thallium, Tin, Vanadium, and Zinc.

1.2 Sample matrices are pretreated following SW846 and EPA methods for digestion of soil, sediment, sludge or water samples. Refer to specific metals department digestion SOP's for more information on digestion techniques.

1.3 This inductively coupled argon plasma optical emission spectrometer (s) (ICP-OES) uses an Echelle optical design and a Charge Injection Device (CID) solid-state detector to provide elemental analysis. Control of the spectrometer is provided by PC based iTEVA software. In the instrument, digested samples are introduced into the Thermo 6500 ICP, passed through a nebulizer and transported to a plasma torch. The element-specific emission spectra are produced by a radio frequency inductively coupled plasma. The spectra are dispersed by a spectrometer, and the intensities of the emission lines are monitored with the solid state detector.

1.4 Reporting limits (RL)(LLOQ) are based on the extraction procedure. Reporting limits may vary depending on matrix complications, volumes and by client needs, but the reporting limits must always be verified with a low check which meets the criteria outlined in this SOP. Solid matrices are reported on a dry weight basis. Refer to table 1 of this SOP for SGS - Orlando typical reporting limits. Refer to scheduling sheets and/or project specific QAPP for further information regarding client specific reporting limits.

1.5 MDLs must be established for all analytes, using a solution spiked at approximately 3 to 5 times the estimated detection limit. To determine the MDL values, take seven replicate aliquots of the spiked sample and process through the entire analytical method. The MDL is calculated by multiplying the standard deviation of the replicate analyses by 3.14, which is the student's t value for a 99% confidence level. MDLs must be determined approximately once per year for each matrix and instrument. Please refer to SGS - Orlando QA SOP QA020, current version for further information regarding method performance criteria and experimental method detection limits.

MDLs are generated for each matrix on both ICP instruments. The higher of the two statistically calculated MDL's is entered into LIMS as the MDL. The verified MDLs are stored in the LIMS and must be at least 2 to 3 times lower than the RL. Exceptions may be made on a case by case basis; however, at no point shall the MDL be higher than the reported RL.

1.6 LLOQ verification. LLOQ is the lowest point of quantitation. The LLOQ is initially verified by the analysis of 7 replicate samples, spiked at the LLOQ and processed through all preparation and analysis steps of the method. The mean recovery should be within +/- 35 percent of the true value with an RSD $\leq$ 20 percent.

1.7 Ongoing Lower limit of quantitation (LLOQ) check sample. The lower limit of quantitation check sample should be analyzed on a quarterly basis to demonstrate the desired detection capability. The LLOQ sample is carried through the entire preparation and analytical procedure. The mean recovery should be within +/- 35 percent of the true value with an RSD $\leq$ 20 percent.

1.8 Compounds detected at concentrations between the RL and MDL are quantitated and qualified as estimated values and reported with either a "J" or "I" qualifier. Some program or project specifications may require that no values below the RL be reported.

1.9 Instrument Detection Limits (IDL). It is suggested that IDL's be completed upon initial instrument installation, whenever instrument conditions have significantly changed, or at a minimum annually. Instrument detection limits can be estimated as the mean of the blank results plus 3 times the standard deviation of 10 replicate analyses of the reagent blank solution. (use zero for the mean if the mean is negative) Each IDL measurement shall be performed as though it were a separate analytical sample. IDLs shall be determined and reported for each wavelength used in the analysis of the samples.

2.0 PRESERVATION AND BOTTLEWARE

All samples should be preserved with nitric acid to a pH of <2 at the time of collection. All sample pH are checked in sample receiving and within the metals department. Samples that are received with a pH >2 must be preserved to pH <2 and held for 24 hours prior to metals digestion to dissolve any metals that absorb to the container walls. Refer to SOP SAM101, current revision for further instruction. Final pH of TCLP extracts are checked and recorded in SGS - Orlando Extractions Department. Please refer to TCLP (1311) fluid determination logbook and SPLP (1312) fluid determination logbook for further information. TCLP extracts received from SGS - Orlando Extractions Department are prepared as soon as possible, no longer than 24 hours from time of receipt. If precipitation is observed during the sample preparation process the sample(s) are immediately re-prepped on dilution until no precipitation is observed. Samples received for dissolved metals analysis should be filtered and preserved to pH<2 as soon as possible and held for 24 hours prior to digestion. Refer to SGS - Orlando Sample Filtration Logbook for further information.

All soil samples must be stored in a refrigerator at ≤ 6ºC upon receipt. Refer to SOP SAM101, current revision for further instruction.

All bottleware used by SGS - Orlando is tested for cleanliness prior to shipping to clients. Analysis results must be less than one half the reporting limit (LLOQ) to be acceptable. Refer to SOP SAM104, current revision for further instruction.

3.0 HOLDING TIME AND BATCH SIZE

All samples must be prepared and analyzed within 6 months of the date of collection. Refer to appropriate SGS - Orlando digestion SOP, current revision for batch size criteria.

4.0 INTERFERENCES

Several types of interferences can cause inaccuracies in trace metals determinations by ICP. These interferences are discussed below.

4.1 Spectral interferences are caused by overlap of a spectral line from another element, unresolved overlap of molecular band spectra, background contribution from continuous or recombination phenomena, and background contribution from stray light from the line emission of high concentration elements. Corrections for these interferences can be made by using interfering element corrections, by choosing an alternate analytical line, and/or by applying background correction points. The locations selected for the measurement of background intensity will be determined by the complexity of the spectrum adjacent to the wavelength peak. The locations used for routine measurement must be free of off-line spectral interference or adequately corrected to reflect the same change in background intensity as occurs at the wavelength peak.

Note: Refer to section 17.0 of this SOP for further instruction regarding interfering element correction factor generation.

4.2 Physical interferences can be caused by changes in sample viscosity or surface tension, by high acid content in a sample, or by high dissolved solids in a sample. These interferences can be reduced by making sample dilutions.

4.3 Matrix interferences in high solid samples can be overcome by using an internal standard. Yttrium/Indium mix is used for the Thermo 6500 ICP. The concentration must be sufficient for optimum precision but not so high as to alter the salt concentration of the matrix. The element intensity is used by the instrument as an internal standard to ratio the analyte intensity signals for both calibration and quantitation.

4.4 Chemical interferences are not pronounced with ICP due to the high temperature of the plasma, however if they are present, they can be reduced by optimizing the analytical conditions (i.e. power level, torch height, etc.).

5.0 APPARATUS

5.1 Currently there are two solid state ICPs available for use in the lab. Both are Thermo 6500 ICP units. These units have been optimized to obtain lower detection limits for a wide range of elements. Since they are solid state systems, different lines may be included for elements to obtain the best analytical results. However, the lines which are normally included in the normal analysis program are shown in Table 2.

5.2 Instrument auto samplers. For random access during sample analysis.

5.3 Class A volumetric glassware and pipettes.

5.4 Polypropylene auto sampler tubes.

5.5 Eppendorf Pipette (s) - Pipette (s) are checked daily for accuracy and to ensure they are in good working condition prior to use. Volumes are checked at 100% of maximum volume (nominal volume). Pipettes are checked within the metals department and results are stored electronically in the “Pipette Calibration Log”. Refer to SOP QA006, current revision for further information regarding pipette calibration. BIAS: mean must be within 2% of nominal volume. Precision: RSD must be $\leq$ 1% of nominal volume based on three replicates.

5.6 Fisher Brand 0.45 micron (um) filter or equivalent. Filter lots are checked for cleanliness through the Method Blank process. All Method Blank analytical results must be less than one half the reporting limit(LLOQ) to be acceptable, if not, the contaminated lot must be identified and removed from laboratory use. Samples filtered through the contaminated filters must be re-filtered through acceptable filters.

5.7 Fisher Brand disposable 10 ml syringes or equivalent. Syringe lots are checked for cleanliness through the Method Blank process. All Method Blank results must be less than one half the reporting limit (LLOQ)to be acceptable, if not, the contaminated lot must be identified and removed from laboratory use. Samples filtered through the contaminated syringes must be re-filtered through acceptable syringes.

5.8 Data System

Microsoft Windows XP Professional Version 2002
Instrument software SST1 – Thermo iTEVA version 2.8.0.89

Instrument software SST2 – Thermo iTEVA version 2.7.0.87

5.8.1 A computer system interfaced to the Thermo 6500 ICP that allows for the continuous acquisition and storage of all data obtained throughout the duration of the analytical run sequence.

5.8.2 Data is archived to a backup server for long term storage.

6.0 REAGENTS

All chemicals listed below are trace metal grade unless otherwise specified. Refer to Acid Certificate of Analysis logbook for Certificates of Analysis and compliance with the specifications of the grade listed. SGS - Orlando produces DI water to the specifications for the ASTM Type II standard designation based on the system manufacturer's performance specifications. The DI water is used exclusively for laboratory purposes. De-ionized (DI) water should be used whenever water is required. Refer to SOP QA037, current revision for more information regarding testing and monitoring. Refer to the Metals Department Standard Prep Logbook for the make-up and concentrations of standards and stock solutions being used within this SOP. Some of the information included in the logbook is as follows: standard name, elements in mix, manufacturer, lot number, parent expiration date, acid matrix, stock concentration, volume of standard added, total volume, final prepared concentration, prep date, initials, MET number, and prepared standard expiration date. Standards and prepared reagents must be prepared every 6 months or before stock standard expiration date, whichever comes first**.** Refer to tables 3 through 7 of this SOP for concentration levels of standards used. Unless otherwise approved, the calibration curve must contain 3 points determined by a blank and a series of standards representing the elements of interest.

6.1 2.5 ppm Yttrium and 10 ppm Indium internal standard, made from ICP quality standard.

6.2 Hydrochloric acid, trace metals grade.

6.3 Nitric Acid, trace metals grade.

6.4 ICP quality standard stock solutions are available from Inorganic Ventures, Spex, Plasma Pure, Ultra, Environmental Express, or equivalent.

6.5 Calibration Standards. These can be made up by diluting the stock solutions to the appropriate concentrations. The calibration standards should be prepared using the same type of acid (s) and at approximately the same concentration as will result in the samples following sample preparation.

6.5.1 For calibration and quantitation an internal standard (Yttrium/Indium) is used to limit nebulization problems. If it is known that the samples contain a significantly different acid matrix, the samples must be diluted so that they are in a similar matrix to the curve. All sample results are referenced to the initial calibration blank (ICB) Internal Standard counts. The criteria is 60-125 percent of the initial calibration blank (ICB) counts. If the internal standard counts fall outside these criteria matrix effects must be suspected and the sample diluted until it meets the criteria or footnoted in LIMS as suspected matrix interference.

6.5.2 Standards must be prepared so that there is minimal spectral interference between analytes.

Note: All Ag stock and intermediate solutions must be stored away from direct sunlight.

6.6 Analytical Quality Control Solutions.

All of the solutions below are prepared by adding either mixed or single element metals solutions to a solution prepared using the same type of acid (s) and at approximately the same concentration as will result in the samples following sample preparation.

6.6.1 Blank (Calibration, ICB, CCB)

This reagent blank contains Nitric Acid at 3 percent and Hydrochloric Acid at 5 percent.

6.6.2 Initial Calibration Verification solution.

This standard solution must be made from a different source than the calibration curve. The concentrations for each element must be within the range of the calibration curve and should be approximately at the midpoint of the curve. This solution is used to verify the accuracy of the initial calibration. Levels for the ICV standard are shown in Table 4.

6.6.3 Continuing Calibration Verification solution.

The metals concentrations for this standard should be at approximately the mid-point of the calibration curve for each element. This standard should be prepared from the same source that is used for the calibration curve. Levels for the CCV standard are shown in Table 5.

6.6.4 Spectral Interference Checks (SIC). Two types of SIC checks are used. Individual element SIC are performed when the instrument is initially set up, and every six months thereafter. The mixed element SIC solution is used daily to check that the instrument is free from interference from elements typically observed in high concentration and to check that interference corrections (IEC) are still valid.

6.6.4.1 Single element interference checks – At a minimum, single element SIC checks should be performed for the following elements: Aluminum 500 mg/l; Barium 4 mg/l; Calcium 500 mg/l; Copper 4 mg/l; Iron 500 mg/l; Magnesium 500 mg/l; Manganese 4 mg/l; Molybdenum 4 mg/l; Sodium 1000 mg/l; Nickel 4 mg/l; Selenium 4 mg/l; Silicon 50 mg/l; Tin 4 mg/l; Vanadium 4 mg/l and Zn 4 mg/l.

Mixed element SIC solution – The mixed element SIC solution is used as an ongoing daily check of freedom from spectral interferences. The mixed element SIC contains the following elements: Aluminum 500 mg/l; Calcium 500 mg/l; Iron 200 mg/l; Magnesium 500 mg/l.

The absolute value of the concentration observed for any unspiked analyte in the single element SIC checks must be less than 2 times the analytes LLOQ. The concentration of the SIC checks are suggested, but become the highest reportable concentration in the sample analysis and cannot be higher than the highest established linear range. Samples with concentrations of elements higher than the SIC check must be diluted until the concentration is less than the SIC check solution. Reanalysis of a diluted sample is required even if the high concentration element is not required to be reported for the specific sample, since the function of the SIC check is to evaluate spectral interferences on other elements. The daily mixed element SIC solution is analyzed daily after calibration. The concentration measured for any target analytes must be less than +/- the LLOQ. For spiked elements, the analyzed results must be within 20 percent of the true value for SIC check and within 10 percent for linear range check. If this criterion cannot be met then sample analysis may not proceed until the problem is corrected, or the LLOQ is raised to twice the concentration observed in the SIC solution. The only exceptions are those elements that have been demonstrated and documented as contaminants in the SIC solutions. Levels for the SIC and mixed SIC can be found on tables 9 and 10.

6.7 CRIA Standard Solution (Also referred to as LLCCV)

The CRIA standard contains the elements of interest at levels equal to SGS - Orlando quantitation limits (RL). Please refer to Table 6 for list of elements of interest and concentration levels for the CRIA. If special client reporting limits are requested, then low checks corresponding to those reporting limits must also be analyzed.

6.8 Matrix Spike, Matrix Spike duplicate, and Spike Blank Solution.

This solution is prepared by adding either mixed or single element metals solutions to a solution containing 3 percent nitric acid and 5 percent hydrochloric acid and diluting to a fixed final volume with this acid mixture. Spiking solution (s) must be added to the spike blank, matrix spike, and the matrix spike duplicate prior to digestion. Levels for the MS and MSD and Spike Blank standard are shown in Table 7.

6.9 Liquid Argon or Argon Gas. (99.999% purity)

7.0 ANALYTICAL PROCEDURE

Note: Please refer to section 8 of this SOP for further detail on quality control standards. Please refer to scheduling sheets and/or project specific QAPP for further information regarding client specific QC requirements.

7.1 General procedure on how to operate the Thermo 6500 is described below. Refer to the Thermo 6500 operation manual for further details.

7.2 Before starting up the instrument, make sure that the pump tubing is in good condition, the torch assembly, the nebulizer, and the spray chamber are clean, the dehumidifier (if used) is filled with DI water up to the level between Minimum and Maximum, and that there are no leaks in the torch area.

7.3 Turn on the recirculating cooler. Verify that the argon is turned on and there is enough for the entire days analytical run.

7.4 Tighten the pump platens and engage the peristaltic pump. Make sure sample and internal standard solutions are flowing smoothly.

7.5 Put a new solution of acid rinse into the rinse reservoir. The composition of the rinse solution may be periodically changed to minimize sample introduction problems and sample carryover. If internal standard is being used, make sure that sufficient amount of internal standard is prepared for the entire analytical run.

7.6 Start up the instrument following the sequence show below.

7.6.1 Double click the **iTEVA Control Center** Icon on the desktop. Type ***admin*** in User Name field, and then click **OK**.

7.6.2 Once the iTEVA Control Center window is opened, click on **Plasma** Icon at status bar area. Then click on **Instrument Status** to check the interlock indicators (torch compartment, purge gas supply, plasma gas supply, water flow and exhaust should be in green; drain flow and busy should be in gray) and the Optics Temperature. (It should be around 38°C.) Click on the Close box.

7.6.3 Click **Plasma On**. When the plasma is on, click close. Let the instrument warm up for 15 to 20 minutes before starting the analysis. New tubing may take an hour to stabilize.

7.7 Torch Alignment and Auto Peak

7.7.1 If the torch has been cleaned, then the torch alignment procedure must be performed.

7.7.2 Open the method and then click on **Sequence** tab, then click on **List View** Icon until you reach rack display.

7.7.3 Go to S-6 position (you can assign any position in the rack for torch alignment), then right click to select **Go** to empty sample S:6. (Now, the auto sampler tip moves from Rinse to this position).

7.7.4 Click on **Analysis** tab, then select **Torch Alignment** from Instrument drop down menu. There will be a pop up dialog box present. Click **Run**. Then there will be another dialog pop up box (This is a reminder for Torch Alignment Solution (2 ppm Zn)), click **Ok**. Now, the instrument is initializing an automated torch alignment. It takes about 7 minutes to complete this step. Progress is indicated in the progress bar.

7.7.5 After torch alignment is complete, click **Close**. Click on **Sequence** tab, then followed by **List View** Icon.

7.7.6 Go to Rinse position at rack display, right click to select Go to rinse and let it rinse for approximately 5 minutes.

7.7.7 Perform Auto Peak

7.7.8 It is recommended that the Auto Peak Adjust procedure be performed daily prior to calibration. A standard that contains all of the lines of interest is used and the system automatically makes the appropriate fine adjustments. (High standard solution should be used for this process.)

7.7.9 Click **Sequence** tab, then click on **List View** Icon until the rack is displayed.

7.7.10 Go to S-5 position (you can assign any position in the rack for auto peak adjust), then right click to select **Go** to empty sample S:5. (Now, the auto sampler tip moves from the Rinse position to this position). Click on **Analysis** tab. All elements result is shown in the display area. From Instrument drop down menu, select **Perform Auto Peak**. There will be a pop up dialog box present. Highlight “All Elements”, and then click **Run**. Then there will another pop up dialog box (This is a reminder for Auto Peak Solution), click **Ok**. Now, the instrument is performing auto peak adjust. It takes about 5 minutes to complete this process. The Auto Peak dialog box will show a green check mark in front of “All Elements”, which indicates Auto Peak is complete.

7.8 Open the method and start up the run.

7.8.1 Click on **Analyst** Icon at the workspace. Go to the method and choose Open from the drop down menu. Select the method with the latest revision number.

7.8.2 Go to **Method** tab at the bottom of left hand corner to click on **Automated Output** at the workspace area. Type a filename in Filename field in the data display area (i.e. : SA101010M1, starts with SA, then followed by MM-DD-YY, then M1; M1 indicates the first analytical run for that day, then followed by M2, M3 and so on for the second and third runs.) Click on **Apply To All Sample Types**.

7.8.3 Click on **Sequence** tab at the bottom of left hand corner. From Auto Session drop down menu bar, click on **New Auto sampler** to create a sequence. This will pop up a dialog box, then click on **New** and fill in number of samples (i.e.: 100) in the Number of Samples field and the sample I.D. (leave this field empty) in Sample Name field. Type a sequence name (i.e. : SEQ101010M1, starts with SEQ, then MM-DD-YY, then M1; M1 indicates the first analytical run for that day, then followed by M2, M3 and so on for the second and third runs) in the Sequence Name field. Click Ok, then put in “0” as settle time between sequences, and click **Ok**.

7.8.4 Right click on **Untitled** (Cetac ASX-520 Enviro 5 Named Rack is the rack that is currently used) at the workspace area, click on **Auto-Locate All** to locate all sample positions.

7.8.5 Double click on **Untitled** again, then click on the sequence name (i.e. : SEQ101010M1), on the data display area, type the sequence in Samplename column, dilution factor (if needed) in CorrFact column, check the box in front of Check column, and select an appropriate check table.

7.8.6 Once done with creating sequence, go to **Method** drop down menu and save all changes as **Save As**. There will be a Save a Method dialog box present, go to the save option to check on “Overwrite Method and bump revision number” box, and then click **Ok**.

7.8.7 Go to Sequence tab, click on List View Icon from tool bar, then click on Connect Autosampler to PC and Initialize Icon.

7.8.8 See table 8 for a typical run sequence.

7.9 Calibrate the instrument as outlined below. See table 3 for calibration standards concentrations. This calibration procedure is done a minimum of once every 24 hours. The calibration standards may be included in the auto sampler program or they may be run manually from the **Calibrate Instrument (graduated cylinder)** icon located on the Analyst tab. The instrument may be calibrated using a single point standard and a calibration blank or a multipoint calibration. If a multipoint calibration is used a minimum of three standards are required. All curves must be determined from a linear calibration prepared in the normal manner using the established analytical procedure for the instrument. Refer to instrument manual for further detail. Three exposures will be used with a percent relative standard deviation of less than 5 percent. The resulting correlation coefficient must be $\geq$0.995. If the calibration curves do not meet these criteria, analysis must be terminated, the problem corrected, and instrument re-calibrated. Correlation coefficients, slopes, and y-intercepts for each wavelength are printed and included in each analytical data package.

7.10 Initial Calibration Verification Standard (ICV).

After each calibration, a standard from a different source than the calibration standard shall be analyzed. For the ICV, all elements to be reported must be within 10 percent of the true value for 6010D. If the ICV is outside these criteria then the analysis must be terminated, problem corrected, and the instrument re-calibrated.

7.11 After analyzing the ICV, the ICB must be analyzed. The results of the ICB must be less than one half the reporting limit (LLOQ). The instrument blank may be failing the criteria due to contamination or instrument drift. Samples associated with the failing blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples bracketed by the failing blank, qualifying the results with a “B” or “V” qualifier, or raising the reporting limit (LLOQ) for all samples to greater than two times the background concentration.

7.12 Before analyzing any real world samples the CRIA (also referred to as LLCCV) must be analyzed. The CRIA contains elements of interest at the reporting limit. The CRIA will be analyzed at the beginning and end of each analytical run. For all elements the results must be within 20 percent of the true value. Refer to scheduling sheets and/or project specific QAPP for further information regarding client specific reporting limits (CRIA Requirement). If the initial CRIA fails no samples associated with the failing CRIA can be reported, and the CRIA should be reanalyzed for the failing elements. If the closing CRIA fails the criteria, the samples associated with the CRIA shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples associated with the CRIA, or qualifying the results in LIMS.

7.13 Before analyzing any real world samples, the Mixed element SIC solution must be analyzed. The mixed element SIC solution is used as an ongoing daily check of freedom from spectral interferences. The mixed element SIC contains the following elements: Aluminum 500 mg/l; Calcium 500 mg/l; Iron 500 mg/l; Magnesium 500 mg/l.

The daily mixed element SIC solution is analyzed daily after calibration. The concentration measured for any target analytes must be less than +/- the LLOQ. For spiked elements, the analyzed results must be within 20 percent of the true value for SIC check and within 10 percent for linear range check. If this criterion cannot be met then sample analysis may not proceed until the problem is corrected, or the LLOQ is raised to twice the concentration observed in the SIC solution. The only exceptions are those elements that have been demonstrated and documented as contaminants in the SIC solutions. Refer to section 17.0 of this SOP for Interfering Element Correction (IEC) procedure.

7.14 After the initial analytical quality control has been analyzed, the samples and the preparation batch matrix quality control shall be analyzed. Each sample analysis must be a minimum of 3 readings using at least a 5 second integration time. Between each sample, flush the nebulizer and the solution uptake system with a blank rinse solution for at least 60 seconds or for the required period of time to ensure that analyte memory effects are not occurring.

7.15 Analyze the continuing calibration verification solution and the continuing calibration blank after every tenth sample and at the end of the sample run. If the CCV solution is not within 10 percent of the true value for method 6010D, the CCV shall be reanalyzed to confirm the initial value. If the CCV is not within criteria after the reanalysis, no samples can be reported in the area bracketed by the failing CCV. Immediately following the analysis of the CCV the CCB shall be analyzed. The results of the CCB must be less than one half the reporting limit (LLOQ) for all elements. The instrument blank may be failing the criteria due to contamination or instrument drift. Samples associated with the failing blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples bracketed by the failing blank, qualifying the results with a “B” or “V” qualifier, or raising the reporting limit (LLOQ) for all samples to greater than two times the background concentration.

7.16 One sample per preparation batch, or whenever matrix interferences are suspected for a batch of samples, a serial dilution (SDL) must be prepared. For the serial dilution, a 1:5

dilution must be made on the sample. The results of the 1:5 dilution shall agree within 20 percent of the true value as long as the analyte concentration is within the linear range of the instrument and sufficiently high (minimally, a factor of 25 times greater than the LLOQ). If the results are outside these criteria then matrix interference should be suspected and the proper footnote entered into LIMS. A post digestion spike (PDS) must be performed if the SDL fails. The PDS must recover within ± 25 percent for method SW846-6010D. If the PDS is outside these limits then matrix interference must be suspected and the proper footnote entered into LIMS.

7.17 The upper limit of quantitation may exceed the highest concentration calibration point and can be defined as the “linear range”. Sample results above the linear range shall be diluted under the linear range and reanalyzed. Following calibration, the laboratory may choose to analyze a standard (or mixed standard solution) at a higher concentration than the high standard used in the calibration curve. The standard must recover within 10 percent of the true value, and if successful, establishes the linear range. The linear range standards must be analyzed in the same instrument run as the calibration they are associated with, but may be analyzed anywhere in the run. Samples following a sample with high concentrations of analyte (s) must be examined for possible carryover. Verification may be done by rinsing the lines with an acid solution and then reanalyzing the sample. A limit check table is built into the autosampler file so that samples exceeding the standardization range are flagged on the raw data.

7.18 After the instrument is optimized and all initial QC has been run, click on **Run Auto-Session** Icon to start the analytical run sequence.

7.18.1 If you need to add or delete samples once the run is started, follow the steps shown below.

7.18.2 Click on **Sequence** tab, then click on **List View** Icon at the tool bar. There is the sequence table shown on the display area.

7.18.3 Click on **Add Samples** Icon. This will pop up a dialog box, and then fill in number of samples that need to be added. Click **Ok**. By doing this, samples will be added to the end of the current sequence without a rack location.

7.18.4 On the Samplename column type in the sample I.D., correction factors, and check tables. **Click on Auto Locate All.**

7.18.5 The added samples will be analyzed at the end of the original sequence run order unless they are assigned a different run order.

7.18.6 Deleting Samples

7.18.7 Click on **Sequence** tab, and then click on **List View** Icon under the sequence display area.

7.18.8 Highlight all samples that need to be deleted and then click on the **Delete Samples** icon.

7.19 When the analysis is completed export the data to LIMS following the procedure outlined below.

7.19.1 Double click on **ePrint** Icon on desktop. There will be a **LEADTOOLS ePRINT** pop up box, click on **Finish Jobs** and **OK** boxes.

7.19.2 Double click the **PDF** Icon on the desktop; the PDF file will be present as Document_#. Right click on that file, select **rename** to change the filename to an assigned analytical run I.D. (i.e.: MA9000). This is the raw data file for MA9000.

7.19.3 Drop the raw data to the **LIMS Data Drop** icon located on the desktop.

7.19.4 By completing the above steps, the raw data (i.e.: MA9000) can be viewed and/or printed from the Raw Data Search function.

7.19.5 Go to **Analysis** tab, right click on sample header, and select export all samples. A pop up dialog box will come up, type in the analytical run I.D. (i.e.: SA101010M1) and click **Ok**. Go to **Lims Export** folder located on the desktop, right click on analytical run and change extension from .TXT to .ICP. Open the analytical file and make any necessary changes, such as deleting any samples that need to be re-run on dilution. **Save** the file. Drop the data file to the **LIMS Data Drop** icon located on the desktop. This will then send the export file to LIMS for review.

7.20 The data can be evaluated by running an automated data evaluation program, which will help to generate quality control summary pages. Each run must be evaluated as quickly as possible to make sure that all required quality control has been analyzed. With each data package include: cover sheet, copies of all prep sheets, autosampler run sequence, dilution sheets, and raw data. Label each folder with MA#, instrument run I.D., instrument used, and date.

7.21 At the end of the analysis day the ICP must be shutdown using the following sequence.

7.21.1 Place the auto sampler tip in the rinse cup and rinse in a mixed solution of approximately 5 percent nitric acid and 5 percent hydrochloric acid for 10 minutes and then in DI water for 20 minutes.

7.21.2 Turn off the plasma by clicking on the **Plasma** Icon and then by clicking **Plasma Off.**

7.21.3 Close all iTeva programs/windows.

7.21.4 Release the tension on the sample pump platens.

7.21.5 Turn off recirculating chiller.

8.0 QUALITY CONTROL

This section outlines the QA/QC operations necessary to satisfy the analytical requirements for method SW846 6010D. Please refer to scheduling sheets and/or project specific QAPP for further information regarding client specific QC requirements. Check with the area supervisor or lab manager for any non-compliant quality control for further information.

8.1 Initial Calibration Verification Standard (ICV).

After each calibration, a standard from a different source than the calibration standard shall be analyzed. For the ICV, all elements to be reported must be within 10 percent of the true value for 6010D. If the ICV is outside these criteria then the analysis must be terminated, problem corrected, and the instrument re-calibrated.

8.2 Continuing Calibration Blank/Initial Calibration Blank.

Analyze the Initial calibration blank solution at the beginning of each run and the continuing calibration blank after every tenth sample and at the end of the sample run. The ICB/CCB must be less than one half the reporting limit (LLOQ) for each element. The instrument blank may be failing the criteria due to contamination or instrument drift. Samples associated with the failing blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples bracketed by the failing blank, qualifying the results with a “B” or “V” qualifier, or raising the reporting limit (LLOQ) for all samples to greater than two times the background concentration.

8.3 Low Standard Check (CRIA or LLCCV).

Before analyzing any real world samples the CRIA (also referred to as LLCCV) must be analyzed. The CRIA contains elements of interest at the reporting limit. The CRIA will be analyzed at the beginning and end of each analytical run. For all elements the results must be within 20 percent of the true value. Refer to scheduling sheets and/or project specific QAPP for further information regarding client specific reporting limits (CRIA Requirement). If the initial CRIA fails no samples associated with the failing CRIA can be reported, and the CRIA should be reanalyzed for the failing elements. If the closing CRIA fails the criteria, the samples associated with the CRIA shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples associated with the CRIA, or qualifying the results in LIMS.

8.4 ICSA (Mixed SIC Solution)

Before analyzing any real world samples, the Mixed element SIC solution must be analyzed. The mixed element SIC solution is used as an ongoing daily check of freedom from spectral interferences. The mixed element SIC contains the following elements: Aluminum 500 mg/l; Calcium 500 mg/l; Iron 500 mg/l; Magnesium 500 mg/l.

The daily mixed element SIC solution is analyzed daily after calibration. The concentration measured for any target analytes must be less than +/- the LLOQ. For spiked elements, the analyzed results must be within 20 percent of the true value for SIC check and within 10 percent for linear range check. If this criterion cannot be met then sample analysis may not proceed until the problem is corrected, or the LLOQ is raised to twice the concentration observed in the SIC solution. The only exceptions are those elements that have been demonstrated and documented as contaminants in the SIC solutions. Refer to section 17.0 of this SOP for Interfering Element Correction (IEC) procedure.

8.5 Continuing Calibration Verification.

Analyze the continuing calibration verification solution and the continuing calibration blank after every tenth sample and at the end of the sample run. If the CCV solution is not within 10 percent of the true value for method 6010D the CCV must be reanalyzed to confirm the initial value. If the CCV is not within criteria after reanalysis no samples can be reported in the area bracketed by the failing CCV.

8.6 Method Blank.

The laboratory must digest and analyze a method blank with each batch of samples. The method blank must contain elements at less than one half the reporting limit (LLOQ) for each element. The exception to this rule is when the samples to be reported contain greater than 10 times the method blank level. In addition, if all the samples are less than a client required limit and the method blank is also less than that limit, then the results can be reported as less than that limit. Samples associated with the contaminated blank shall be evaluated as to the best corrective action for each particular sample. This may include reanalyzing the samples, re-digesting and reanalyzing the samples, qualifying the results with a “B” or “V” qualifier, or raising the reporting limit (LLOQ) to greater than two times the background concentration,

8.7 Blank Spike Sample.

The laboratory must digest and analyze a spike blank sample with each batch of samples. Blank Spikes must be within 20 percent of the true value for method SW846-6010D. If the lab control is outside of the control limits for a reportable element, all samples must be re-digested and reanalyzed for that element. The exception is if the lab control recovery is high and the results of the samples to be reported are less than the reporting limit (LLOQ). In that case, the sample results may be reported with no flag. For solid standard reference materials (SRMs) ± 20 percent accuracy may not be achievable and the manufacturer’s established acceptance criterion should be used for all soil SRMs.

8.8 Matrix Spike and Matrix Spike Duplicate Recovery.

The laboratory must digest and analyze a matrix spike and matrix spike duplicate with each batch of samples. The matrix spike recovery is calculated as shown below and must be within 20 percent of the true value for method SW846-6010D. If a matrix spike is out of control, then the results must be flagged with the appropriate footnote. If the matrix spike amount is less than one fourth of the sample amount, then the sample cannot be assessed against the control limits and must be footnoted to that effect.

Note: Both the matrix spike amount and the sample amount are calculated to the IDL for any given element. Any value less than the IDL is treated as zero.

$$\frac{\textbf{(Spiked Sample Result - Sample Result)}}{\textbf{Amount Spiked}} \textbf{ x 100 = matrix spike recovery}$$

8.9 Matrix Duplicate/Matrix Spike Duplicate Relative Percent Difference.

The laboratory must digest a duplicate with each batch of samples. The relative percent difference (RPD) between the duplicate and the sample must be assessed and must be ≤ 20 percent for sample results at or above the reporting limit (LLOQ). If the RPD is outside the 20 percent criteria the results must be qualified in LIMS. RPD’s are also calculated in LIMS for sample results below the reporting limit (LLOQ). RPD’s outside the 20 percent criteria are not considered failing and LIMS automatically footnotes these as “RPD acceptable due to low duplicate and sample concentrations.”

Note: Both the duplicate amount and the sample amount are calculated to the IDL for any given element. Any value less than the IDL is treated as zero.

$$\frac{(|\text{Sample Result - Duplicate Result}|) \text{ x } 100}{(\text{Sample Result + Duplicate Result})/2} = \text{Duplicate RPD}$$

8.10 Serial Dilution Analysis and Post Digestion Spike.

One sample per preparation batch, or whenever matrix interferences are suspected for a batch of samples, a serial dilution (SDL) must be prepared. For the serial dilution, a 1:5 dilution must be made on the sample. The results of the 1:5 dilution shall agree within 20 percent of the true value as long as the analyte concentration is within the linear range of the instrument and sufficiently high (minimally, a factor of 25 times greater than the LLOQ). If the results are outside these criteria then matrix interference should be suspected and the proper footnote entered into LIMS. A post digestion spike (PDS) must be performed if the SDL fails. The PDS must recover within ± 25 percent for method SW846-6010D. If the PDS is outside these limits then matrix interference must be suspected and the proper footnote entered into LIMS.

$$\frac{(\text{Sample Result - Serial Dil. Result})}{\text{Sample Result}} \text{ x } 100 = \text{Serial Dilution RPD}$$

8.11 Linear Calibration ranges.

The upper limit of quantitation may exceed the highest concentration calibration point and can be defined as the “linear range”. Sample results above the linear range shall be diluted under the linear range and reanalyzed. Following calibration, the laboratory may choose to analyze a standard (or mixed standard solution) at a higher concentration than the high standard used in the calibration curve. The standard must recover within 10 percent of the true value, and if successful, establishes the linear range. The linear range standards must be analyzed in the same instrument run as the calibration they are associated with, but may be analyzed anywhere in the run. Samples following a sample with high concentrations of analyte (s) must be examined for possible carryover. Verification may be done by rinsing the lines with an acid solution and then reanalyzing the sample. A limit check table is built into the autosampler file so that samples exceeding the standardization range are flagged on the raw data.

8.12 Sample RSD

For samples containing levels of elements greater than five times the reporting limits (LLOQ), the relative standard deviation for the replicates should be less than 5%. If not, reanalyze the sample. If upon reanalysis, the RSD's are acceptable then report the data from the reanalysis. If RSD's are not acceptable upon reanalysis, then the results for that element should be footnoted that there are possible analytical problems and/or matrix interference indicated by a high RSD between replicates.

8.13 Interelement Spectral Interference Correction Validity

For the interelement spectral interference corrections to remain valid during sample analysis, the interferent concentration must not exceed its linear range. If the interferent concentration exceeds its linear range or its correction factor is big enough to affect the element of interest even at lower concentrations, sample dilution with reagent blank and reanalysis is required. In these circumstances, analyte dilution limits are raised by an amount equivalent to the dilution factor.

8.14 Internal Standard (Yttrium/Indium)

For any readings where the internal standard is outside of the range 60-125 percent of the internal standard level in the reference standard (Initial Calibration Blank), then the sample must be diluted until the internal standard is within range and all sample results must be footnoted in LIMS.

8.15 MSA (Method of Standard Additions)

SGS - Orlando uses the internal standard technique as an alternative to the MSA per SW846-6010D section 4.4.2. However, in certain circumstances MSA may be needed by some project specific requirements. SGS - Orlando may perform an MSA when sample matrix interference is confirmed through the post digestion spike process or may qualify the results in LIMS. SGS - Orlando will use a single addition method as described in SW846-7000B.

9.0 GLASSWARE CLEANING

All glassware must be washed with soap and tap water and then rinsed with 5 percent nitric acid. It must then be rinsed at least 3 times with DI water. Refer to SOP GN196, current revision for further information regarding glassware cleaning.

10.0 DOCUMENTATION REQUIREMENTS

Refer to the Laboratory Quality Assurance Manual for documentation requirements. All raw data is printed to .PDF format and archived to a backup server for long term storage.

11.0 SAFETY

The analyst must follow normal safety procedures as outlined in the SGS - Orlando Safety Manual which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and must be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor. Follow proper safety precautions when working with gas cylinders.

12.0 CALCULATIONS

For water samples, the following calculations must be used. Refer to the QC section for the calculations to be used for the QC samples.

Original sample concentration of metal (ug/l) =

$$\frac{\textbf{(conc. in the digestate (ug/l)) x (final digestate volume (ml))}}{\textbf{(initial sample volume (ml))}}$$

For soil samples, the following calculations must be used.

Concentration of the metal in the dry sample (mg/kg) =

$$\frac{\textbf{(conc. in the digestate (mg/l) x final digestate volume(L))}}{\textbf{(sample wt. (kg)) x (\% solids/100)}}$$

13.0 INSTRUMENT MAINTENANCE

Recommended periodic maintenance includes the items outlined below. All maintenance must be recorded in the instrument maintenance log.

13.1 Change the pump tubing as needed.

13.2 Clean the filter on the recirculating pump approximately once a month and dust off the power supply vents as needed.

13.3 Clean or replace the nebulizer, torch assembly, and injector tube as needed.

13.4 Change the sampler tip as needed.

13.5 Clean the recirculating pump lines and internal sock filter every 3 months or as needed.

13.6 Clean the radial view quartz surface weekly or more often if needed.

14.0 POLLUTION PREVENTION AND WASTE MANAGEMENT

14.1 Pollution Prevention

Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids must be followed. All method users must be familiar with the waste management practices described in Section 14.2.

14.2 Waste Management

Individuals performing this method must follow established waste management procedures as described in the Sample and Laboratory Waste Disposal SOP SAM108, current revision. This document describes the proper disposal of all waste materials generated during the testing of samples.

15.0 GENERIC DEFINITIONS

15.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or 24 hours whichever comes first.

15.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

15.3 Continuing Calibration Verification (CCV): A check standard used to verify instrument calibration throughout an analytical run. A CCV must be analyzed at the beginning of the analytical run, after every 10 samples, and at the end of the run.

15.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still be considered valid.

15.5 Initial Calibration (ICAL): A series of standards used to establish the working range of a particular instrument and detector. The low point must be at a level equal to or below the reporting level.

15.6 Initial Calibration Verification (ICV): A standard from a source different than that used for the initial calibration. A different vendor must be used whenever possible. The ICV is used to verify the validity of an Initial Calibration. This may also be called a QC check standard.

15.7 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the performance of a method in a given sample matrix.

15.8 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the precision and performance of a method in a given sample matrix.

15.9 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

15.10 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

15.11 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

16.0 METHOD PERFORMANCE

Method performance is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), matrix spikes (MS), and matrix spike duplicates (MSD). The MB and BS are used to monitor overall method performance, while the MS and MSD are used to evaluate the method performance in a specific sample matrix.

Blank spike, matrix spike, and matrix spike duplicate samples are compared to method defined control limits. Statistical control limits are stored in the LIMS for QA purposes only. Additionally, blank spike accuracy is regularly evaluated for statistical trends that may be indicative of systematic analytical errors.

17.0 GENERATION OF INTERFERING ELEMENT CORRECTION FACTORS

17.1 It is recommended that all IEC’s be verified and updated approximately every 6 months or whenever instrument conditions change significantly. It is also recommended that elements with frequent high concentrations or with large IEC’s should be checked more frequently.

17.2 Calculate the IEC correction factors and enter them into the method (refer to Thermo 6500 instrument manual). Calculate the correction factor using the equation shown below. This correction factor must be added to the correction factor already in place in the method for a given element.

$$\text{IEC} = \frac{\text{Concentration Result of the element with the interference}}{\text{Concentration result of the interfering element}}$$

17.3 Verify the new correction factors by reanalyzing the ICSA/ICSAB solutions and/or the SIC solutions or by reloading and recalculating the previously stored results. If the reanalysis is not within QC limits, make additional changes to the IEC factors and then re-verify both the individual and combined solution values.

17.4 Save and update the method.

17.5 Interfering element correction factors are saved as raw data along with the run printouts on a daily basis so that the IEC's for a given run are traceable.

TABLE 1: REPORTING LIMIT BY ELEMENT

Analyte	Water Reporting Limit(LLOQ) (ug/L)	Soil Reporting Limit(LLOQ)(mg/kg)	TCLP Reporting Limit(LLOQ) (mg/L)/MCL
Tin	50	5	
Aluminum	200	20	
Antimony	5	1	
Arsenic	10	0.5	0.10 / 5.0
Barium	200	20	10 / 100
Beryllium	4	0.5	
Cadmium	5	0.4	0.05 / 1.0
Calcium	1000	500	
Chromium	10	1	0.10 / 5.0
Cobalt	50	5	
Copper	25	2.5	
Iron	300	10	
Lead	5	1	0.5 / 5.0
Magnesium	5000	500	
Manganese	15	1.5	
Nickel	40	4.0	
Potassium	5000	500	
Selenium	10	1	0.5 / 1.0
Silver	10	1	0.10 / 5.0
Sodium	5000	500	
Thallium	10	1	
Vanadium	50	5	
Zinc	20	2	
Molybdenum	50	2.5	
Strontium	10	0.5	
Titanium	10	0.5	

TABLE 2. THERMO 6500 ANALYSIS LINES

Element	Wavelength
Al	396.1
As	189.042
Ca	317.933
Fe	259.9
Mg	279.078
Mn	257.610
Pb	220.353
Se	196.026
Tl	190.864
V	292.402
Ag	328.068
Ba	455.4
Be	313.042
Cd	226.502
Co	228.616
Cr	267.716
Cu	324.753
K	766.491
Na	589.5
Ni	231.604
Sb	206.838
Zn	206.2
Mo	202.030
Sn	189.900
Sr	407.7
Ti	334.9

TABLE 3: LOW, MID AND HIGH STANDARD LEVELS
Single Point Calibration (blank and high standard) may be used

Element	Low	Mid	High
	ug/l	**ug/l**	**ug/l**
Al	10000	40000	80000
As	500	2000	4000
Ca	10000	40000	80000
Fe	10000	40000	80000
Mg	10000	40000	80000
Mn	500	2000	4000
Pb	500	2000	4000
Se	500	2000	4000
Tl	500	2000	4000
V	500	2000	4000
Ag	62.5	250	500
Ba	500	2000	4000
Be	500	2000	4000
Cd	500	2000	4000
Co	500	2000	4000
Cr	500	2000	4000
Cu	500	2000	4000
K	10000	40000	80000
Na	10000	40000	80000
Ni	500	2000	4000
Sb	500	2000	4000
Zn	500	2000	4000
Mo	500	2000	4000
Sn	500	2000	4000
Sr	500	2000	4000
Ti	500	2000	4000

TABLE 4: ICV STANDARD LEVELS

Element	Concentration ug/l
Al	40000
As	2000
Ca	40000
Fe	40000
Mg	40000
Mn	2000
Pb	2000
Se	2000
Tl	2000
V	2000
Ag	250
Ba	2000
Be	2000
Cd	2000
Co	2000
Cr	2000
Cu	2000
K	40000
Na	40000
Ni	2000
Sb	2000
Zn	2000
Mo	2000
Sn	2000
Sr	2000
Ti	2000

TABLE 5: CCV STANDARD LEVELS

Element	Concentration ug/l
Al	40000
As	2000
Ca	40000
Fe	40000
Mg	40000
Mn	2000
Pb	2000
Se	2000
Tl	2000
V	2000
Ag	250
Ba	2000
Be	2000
Cd	2000
Co	2000
Cr	2000
Cu	2000
K	40000
Na	40000
Ni	2000
Sb	2000
Zn	2000
Mo	2000
Sn	2000
Sr	2000
Ti	2000

TABLE 6: CRIA(LLCCV) STANDARD LEVELS

Element	CRIA
	ug/l
Al	200
As	10
Ca	1000
Fe	300
Mg	5000
Mn	15
Pb	5
Se	5
Tl	10
V	50
Ag	10
Ba	200
Be	5
Cd	5
Co	50
Cr	10
Cu	25
K	5000
Na	5000
Ni	40
Sb	5
Zn	20
Mo	50
Sn	50
Sr	10
Ti	10

TABLE 7: BLANK SPIKE, MATRIX SPIKE AND MATRIX SPIKE DUPLICATE LEVELS

Element	Concentration
	ug/l
Al	27000
As	2000
Ca	25000
Fe	26000
Mg	25000
Mn	500
Pb	500
Se	2000
Tl	2000
V	500
Ag	50
Ba	2000
Be	50
Cd	50
Co	500
Cr	200
Cu	250
K	25000
Na	25000
Ni	500
Sb	500
Zn	500
Mo	500
Sn	500
Sr	500
Ti	500

TABLE 8: TYPICAL RUN SEQUENCE

BLANK
LOW
MID
HIGH
HIGH STD
ICV
ICB
CRIA
ICSA
ICSAB
CCV
CCB
MB
SB
SAMPLE1
DUPLICATE
SERIAL DILUTION
MATRIX SPIKE
MATRIX SPIKE DUPLICATE
POST DIGESTION SPIKE
SAMPLE2
SAMPLE3
CCV
CCB
SAMPLE4
SAMPLE5
SAMPLE6
SAMPLE7
SAMPLE8
SAMPLE9
SAMPLE10
SAMPLE11
SAMPLE12
SAMPLE13
CRIA CLOSING
ICSA CLOSING
ICSAB CLOSING
CCV
CCB

TABLE 9: ICSA (Mixed SIC) SOLUTION LEVELS

Element	**Concentration**
	mg/l
Al	500
As	0
Ca	500
Fe	500
Mg	500
Mn	0
Pb	0
Se	0
Tl	0
V	0
Ag	0
Ba	0
Be	0
Cd	0
Co	0
Cr	0
Cu	0
K	0
Na	0
Ni	0
Sb	0
Zn	0
Mo	0
Sn	0
Sr	0
Ti	0

TABLE 10: SINGLE ELEMENT INTERFERENCE CHECK SOLUTION (SIC) LEVELS

Element	Concentration
	mg/l
Al	500
As	0
Ca	500
Fe	500
Mg	500
Mn	4
Pb	0
Se	4
Tl	0
V	4
Ag	0
Ba	4
Be	0
Cd	0
Co	0
Cr	0
Cu	4
K	0
Na	1000
Ni	4
Sb	0
Zn	4
Mo	4
Sn	4
Si	50
Sr	0
Ti	0

DETERMINATION OF INORGANIC ANIONS BY ION CHROMATOGRAPHY

Prepared by: Jenna Kravitz Date: 11/28/2017

Approved by: Svetlana Izosimova Date: 04/04/2018

Annual Review

Reviewed by: ________ Date: ________

Reviewed by: ________ Date: ________

Reviewed by: ________ Date: ________

Document Control

Issued to: QA Department Date: 04/04/2018

Issued to: General Chemistry Department Date: * 04/04/2018

Issued to: ________ Date: ________

Issued to: ________ Date: ________

Issued to: ________ Date: ________

Issued to: ________ Date: ________

Effective 7 days after "*" date

CONTROLLED COPY
DO NOT DUPLICATE

TITLE: DETERMINATION OF INORGANIC ANIONS BY ION CHROMATOGRAPHY

REFERENCES: EPA 300.0, Revision 2.1, 1993; SW846 9056A;
40CFR, part 136, App. B – MDL procedure

REVISED SECTIONS: Apparatus and Reagents sections 7 and 8 are revised to accommodate transition to carbonate-bicarbonate eluent; updated references sec. 17.

1.0 SCOPE AND APPLICATION

1.1 This method is for the measurement of anions such as bromide, chloride, fluoride, nitrate, nitrite and sulfate by ion chromatography. The method is applicable to potable and non-potable water, solids after extractions, and neutral leachates.

2.0 SUMMARY OF METHOD

2.1 A small volume of sample is introduced into an ion chromatograph. The anions of interest are separated and measured, using a system comprised of a guard column, and analytical column, a suppressor, and a conductivity detector.

2.2 Detection limits vary with the instrument conditions and calibration levels used.

REPORTING LIMIT AND METHOD DETECTION LIMIT

3.1 Reporting Limit. The normal reporting limit for this method is normally established at or above the lowest non-zero concentration standard in the calibration curve. Detected concentrations below this concentration are not reported unless MDL reporting is being done. Reporting limits were set as follows:

ANALYTE	REPORTING LIMIT
Bromide	0.50 mg/l
Chloride	2.00 mg/l
Fluoride	0.20 mg/l
Nitrate	0.10 mg/l
Nitrite	0.10 mg/l
Sulfate	2.00 mg/l

3.2 Method Detection Limit. Experimentally determine MDLs using the procedure specified in 40 CFR, Part 136, Appendix B. This value represents the lowest reportable concentration of an individual compound that meets the method qualitative identification criteria.

Experimental MDLs must be determined semiannually for this method, as outlined in EPA 300.0. Refer to SOP QA020, current revision, for further details.

4.0 DEFINITIONS

4.1 Batch: A group of samples which are similar with respect to matrix and the testing procedures being employed and which are processed as a unit. A sample batch is limited to a maximum of 20 samples or samples loaded on an instrument within the same 12-hour shift, whichever comes first.

4.2 Blank Spike (BS): An analyte-free matrix spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. Blank Spike Recoveries are used to document laboratory performance for a given method. This may also be called a Laboratory Control Sample (LCS).

4.3 Continuing Calibration Verification (CCV): A check standard used to verify instrument calibration throughout an analytical run. CCV must be analyzed at the beginning of the analytical run, after every 10 samples, and at the end of the run.

4.4 Holding Time: The maximum times that samples may be held prior to preparation and/or analysis and still be considered valid.

4.5 Initial Calibration (ICAL): A series of standards used to establish the working range of a particular instrument and detector. The low point should be at a level equal to or below the reporting level.

4.6 Initial Calibration Verification (ICV): A standard from a source different than that used for the initial calibration. A different vendor should be used whenever possible. The ICV is used to verify the validity of an Initial Calibration. This may also be called a QC check standard.

4.7 Matrix Spike (MS): A sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike recoveries are used to document the bias of a method in a given sample matrix.

4.8 Matrix Spike Duplicate (MSD): A replicate sample aliquot spiked with a known amount of analyte(s), processed simultaneously with the samples through all the steps of the analytical procedure. The matrix spike duplicate recoveries are used to document the precision and bias of a method in a given sample matrix.

4.9 Method Blank (MB): An analyte-free matrix to which all reagents are added in the same volumes or proportions as used in sample processing. The method blank is processed simultaneously with the samples through all the steps of the analytical procedure. The method blank is used to document contamination resulting from the analytical process.

4.10 Method Detection Limits (MDLs) MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero and is determined from analysis of a sample in a given matrix containing the analyte. This definition is qualitative in nature and does not evaluate an acceptable quantitative limit for method performance. MDLs should be determined semiannually for every matrix in this method. Refer to SOP QA020, current revision.

4.11 Reagent Blank: The reagent blank is a blank that has the same matrix as the samples, i.e., all added reagents, but did not go through sample preparation procedures. The reagent blank is an indicator for contamination introduced during the analytical procedure. For methods requiring no preparation step, the reagent blank is equivalent to the method blank.

4.12 Reagent Grade: Analytical reagent (AR) grade, ACS reagent grade, and reagent grade are synonymous terms for reagents, which conform to the current specifications of the Committee on Analytical Reagents of the American Chemical Society.

4.13 Reagent Water: Water that has been generated by any method, which would achieve the performance specifications for ASTM Type II water.

4.14 Reference Material: A material containing known quantities of target analytes in solution or in a homogeneous matrix. It is used to document the bias of the analytical process.

4.15 Sample Duplicate (DUP): A replicate sample which is used to document the precision of a method in a given sample matrix.

4.16 Preservation: Refrigeration and/or reagents added at the time of sample collection (or later) to maintain the chemical integrity of the sample.

5.0 HEALTH & SAFETY

5.1 The analyst should follow normal safety procedures as outlined in the SGS Accutest Health and Safety Program which includes the use of safety glasses and lab coats. In addition, all acids are corrosive and should be handled with care. Flush spills with plenty of water. If acids contact any part of the body, flush with water and contact the supervisor.

5.2 The toxicity or carcinogenicity of each reagent used in this method has not been precisely determined; however, each chemical should be treated as a potential health hazard. Exposure to these reagents should be reduced to the lowest possible level. The laboratory is responsible for maintaining a current awareness file of OSHA regulations regarding the safe handling of the chemicals specified in this method. A reference file of data handling sheets should be made available to all personnel involved in these analyses.

6.0 COLLECTION, PRESERVATION, AND HOLDING TIME

6.1 Samples must be cooled to <6°C at the time of collection.

6.2 Bromide, chloride, fluoride, and sulfate must all be analyzed within 28 days. Nitrite and nitrate must be analyzed within 48 hours for aqueous samples. For solids, the same hold time applies, after the samples are prepared (see section 10.1.)

Note: State of West Virginia requires 48 hours from collection to completion for NO2/NO3, regardless of matrix.

7.0 APPARATUS AND MATERIALS

7.1 Ion Chromatograph with a guard column, an analytical column, a suppressor column, and a conductivity detector. This SOP is written for the use with the Dionex ICS-2000 or ICS-2100 instrument. The ICS-2000 is run using prepared eluent. The columns used are listed below. Alternate columns may be used if all method requirements can be met.

Maintenance and troubleshooting procedures are described in detail in operation manual. Most basic procedures include checking connections for leaks, cleaning and/or replacing tubing, monitoring and recording the pressure. See Sec.12.0.

7.1.1 Suppressor, AERS 500 Carbonate 4mm. Dionex part number 085029

7.1.2 Guard Column, IONPAC AG22 4 mm. Dionex part number 064139

7.1.3 Analytical Column, IONPAC AS22. Dionex part number 064141

7.1.4 Data System **Chromeleon 6.80 SR 10, build 2818**. Data system's revisions will be updated during annual SOP revisions. Data system changes prior to the date of revision are to be recorded in Maintenance log.

7.2 Top loading balance, capable of weighing to 0.01g. Calibrated and serviced annually by outside vendor and verified daily with Class 1 weights.

7.3 Analytical balance capable of accurately weighing to the nearest 0.0001 g.

7.4 Centrifuge Centra CL2, or equivalent

7.5 Class 1 weights

7.6 Volumetric glassware, class A.

7.7 IC vials and caps

7.8 Volumetric pipettes, class A or autopipetters. Note: If autopipetters are used, make sure that the calibration is checked before use as specified in the autopipetter SOP QA006, current revision.

7.9 Helium tank and regulator. On the ICS-2000 and ICS-2100 instruments, helium is used only for head pressure on the water reservoirs. The pressure should be set at approximately 6 psi.

7.10 Nylon 0.45µm membrane filters or equivalent.

7.11 Disposable syringes, for sample filtering.

7.12 Conductivity meter to pre-determine dilutions for possible interferences.

8.0 REAGENTS

All chemicals listed below are reagent grade unless otherwise specified. Deionized water must be used whenever water is required.

8.1 Stock Standard Solutions, custom mix standards that contain all target anions with a concentration range from 500mg/L to 10000mg/L: This custom standard can be purchased from various manufacturers such as High Purity Standard cat. # SM-205-001 and Inorganic Ventures cat.# acuttest-19.

Note: Levels shown below are suggested levels and may be changed to meet different reporting limit requirements.

8.1.1 The final concentrations of suggested standards are shown in the table below. All units are in mg/L.

Anion	**STD A**	**STD B**	**STD C**	**STD D**	**STD E**	**STD F**	**STD G**
F	.1	.5	1.5	2.5	5	7.5	10
CHL	2	10	30	50	100	150	200
NO2	.1	.5	1.5	2.5	5	7.5	10
BRO	.5	2.5	7.5	12.5	25	37.5	50
SO4	2	10	30	50	100	150	200
NO3	.1	.5	1.5	2.5	50	7.5	10

8.1.2 The volume of stock added to 100mL volumetric flask are shown in the table below. All volume units are in mL.

Anion	**STD A**	**STD B**	**STD C**	**STD D**	**STD E**	**STD F**	**STD G**
Custom mix	0.02	0.10	0.30	0.50	1.00	1.50	2.00

8.2 CCV. Same concentration as standard D.

8.3 ICV (External Check Solution.) The ICV can be made in the same manner as the standard D from a separate source than the ICAL standards. It must be within the range of the curve. Alternatively, it can be purchased from an outside supplier.

8.4 Stock Eluent (450mM Na2CO3, 140mM NaHCO3): In a 1000mL flask, add approximately 300mL of DI H20. Using oven dried reagent, dried at 105˚C, (temperature should not exceed 110 ˚C) weigh 47.6955g of Na2CO3 and 11.7614g of NaHCO3, and add to flask. Bring this solution to volume. This solution is stable for 6 months stored refrigerated.

8.5 Eluent Solution (4.5mM Na2CO3, 1.4mM NaHCO3): Dilute Stock Eluent –Sec. 8.4 using 20mL of stock in a 2000mL flask and bring up to volume. This solution is stable for a week stored refrigerated.

8.6 0.2N H_2SO_4 for suppressor regeneration: Pipet 1.0 mL of concentrated H_2SO_4 into 100 mL DI and dilute to final volume of 200mL with DI.

8.7 0.1M Oxalic Acid for metals column clean-up: Dissolve 6.3g of oxalic acid into approx. 300mL of DI water. Bring to final volume of 500mL with DI water.

8.8 10X eluent concentrate for hydrophilic ionic contamination clean-up.

8.9 Acetonitrile, reagent grade

8.10 1M HCl: Add 8.3 mL of concentrated hydrochloric acid to approximately 70 mL of deionized water. Dilute to a final volume of 100 mL and mix well.

9.0 INTERFERENCES

9.1 Interferences can be caused by substances with retention times that are similar to and overlap those of the anion of interest. This interference is especially important at low concentrations.

9.2 The acetate anion elutes early during the chromatographic run and can cause elution times of other anions to vary when large amounts of acetate are present. High levels of acetate also can cause interference with the fluoride peak. Therefore, this method is not recommended for leachates containing acetic acid.

9.3 Large amounts of an anion can interfere with the peak resolution of an adjacent anion. High concentrations of an anion can also cause the peak to be misidentified on the chromatograph due to the large width of the peak. Sample dilution and fortification can be used to correct most interference problems connected with peak resolution.

9.4 Samples that contain particles greater than 0.45μm and reagents with particles larger than 0.2μm must be filtered to prevent damage to instrument columns and flow systems.

10.0 SAMPLE PREPARATION PROCEDURE

10.1 For soil samples, follow the preparation outlined below.

10.1.1 Mix the sample well and remove any artifacts as discussed in SOP QA034, current revision. Weigh approximately 5g of sample and add 50mL of DI water. Mix or shake the resulting slurry for 10 minutes. Record the weight to the nearest 0.01g on preparation log.

10.1.2 For matrix spikes, make sure to spike the aliquot of the sample directly and then add the volume of DI water needed to make the volume of liquid being added to the soil sample equal to 50 mL including the volume of the spike solutions. In most cases this will be 49.75 mL of DI.

10.1.3 Prepare blank QC (Method Blank and Blank Spike) using a clean solid matrix, using approximately 5g aliquot and 50mL of DI water. Record the weight to nearest 0.01g.

10.1.4 Check with the lab supervisor if there is insufficient sample to use a 5g aliquot. Smaller aliquots may be used if a homogeneous portion of the sample can be obtained. The sample must always be extracted with 10 times the sample weight of DI water.

10.1.5 Centrifuge samples and QC for 10 minutes at 2000 RPM, then pre-filter through 0.45µm filters before analysis.

10.2 For aqueous samples, pre-filter water samples through 0.45µm filters only if they contain sediment or appear cloudy before analysis. Matrix spikes must be spiked before filtration. Pre-filter method blanks and blank spikes to act as QC check of the filters, only if there are samples in the batch that have been filtered. Record which samples have been filtered and the lot number of the filters in the run log. An unfiltered Method Blank and unfiltered Blank Spike are required for every batch of samples.

11.0 ION CHROMATOGRAPHY ANALYSIS PROCEDURE

11.1 Check to make sure that the helium tank pressure is > 100 PSI and the pressure gauge by the eluent bottles is set at 6 PSI.

11.2 Fill the eluent generation bottle(s) that are to be used with Eluent Solution- Sec. 8.5, making sure that they are pressurized with helium. On the instrument panel (or in the software) set the water volume at the level in the bottles and adjust the flow rate up to 1.0 mL/min.

11.3 Check the lines coming out of the suppressor for air bubbles. Bubbles should be present. If not, then check to make sure the current is on and the suppressor is working properly.

11.4 Check the pump waste line and see if bubbles are present. If they are present, then prime the pump using the procedure described below.

11.4.1 Verify that the priming valve on the primary pump head (right side) is closed. Hit the prime button on the front panel.

11.4.2 Follow the screen prompts. When prompted, open the waste valve by turning the knob ¼ to ½ turn counter-clockwise.

11.4.3 Check for air bubbles on the pump waste line. Continue priming until no air bubbles are exiting the waste line. Turn the pump off and then close the waste valve.

11.4.4 Allow the instrument conditions to settle and then check the pressure and check for air bubbles. If there is still a problem, the priming procedure may be repeated.

11.5 In the software, go to the browser and go to the correct instrument panel (1 or 2). Then connect the instrument. Monitor the baseline until it is stable.

11.6 Go to the template sequences and edit a sequence for the samples in the run. If a calibration is being used from an earlier run, make sure to copy the calibration into the front of the sequence. After the sequence is generated, then save it using the file name (instrument, date, run). Refer to the instrument manuals or help screens in the program for help in using the software. A summary of the instrument conditions required for the analysis of anions is shown below. Note: the retention time for each anion must not exceed ±10% of that anions retention time from the calibration. Refer to section 14.7 for more discussion of the proper application of retention time.

Column: IonPac AG22, AS22
Eluent: 4.5mM Na2CO3, 1.4mM NaHCO3
Suppressor setting: approximately 30mAmps. This setting will be autogenerated.
Flow Rate: 1.0mL/min
Inj. Volume: 12.5µl
Pump pressure – should be around 1600 psi
Detection: Suppressed conductivity, SRS Ultra II, external water mode

11.7 Check sample conductivity with a conductivity meter to determine if dilutions are needed. Refer to spreadsheet of possible dilutions stored on LAN in GenChem directory.

11.8 Load the autosampler and turn it on. The autosampler should then move to the first sample. A print-out of the autosampler table should be generated showing the order that the samples are loaded into the autosampler.

11.9 Start the run. Monitor the results as the run is going to make sure that problems are identified quickly. Note: the initial demonstration of capability, including instrument MDL's and linear calibration ranges, must be completed before samples can be run.

11.9.1 Data files should be saved using the naming scheme of instrument, year (last 2 digits), month, day, run number followed by the extension of .txt. For example, the first IC run on instrument 2 on May 20, 2005 would be named 205052001.txt. This name should always be used in the workgroup description in the LIMS system.

11.9.2 It is recommended that a new calibration be run a minimum of once per month. (It is required that a calibration be run once per quarter.) Calibrations standards may be varied from the one stated in this SOP depending on the levels of each anion that are to be reported. A minimum of 5 standards and a blank are required and a low standard must be at or below the reporting limit for each anion. A correlation coefficient of 0.995 or greater is required. If this correlation coefficient is not met, than the instrument must be recalibrated. Force to Origin (aka Force to Zero) is not permitted.

11.9.2.1 Using weighed regression 1/concentration is also acceptable. Same correlation coefficient of 0.995 or better is required for this calibration model. *For greater details refer to SOP QA042, current revision.*

11.9.3 After the calibration, a low check at the reporting limit must be run. This low check must have the levels in standard A or at the reporting limit for the calibration outlined in this SOP and recoveries must be in the range of 50–150%. On a daily basis, it is recommended that an external check is analyzed and recoveries must be within a range of 90-110%. (This check must be analyzed at a minimum with each new calibration.) Continuing calibration checks and continuing calibration blanks must be run every 10 samples. The continuing calibration checks must have recoveries in the range of 90-110%. Refer to the quality control section of this SOP for more detail on these quality control samples.

11.10 After the run is completed, review all of the chromatograms and check for overlapping peaks, dilutions, etc.

11.10.1 If the retention time of any anion in the ICV or CCV check standards has shifted more than 10% from the original calibration curve retention time, then no results can be reported for that anion. The column should be reconditioned, if necessary, and the instrument recalibrated before any more samples are reported for that anion. Affected samples are reanalyzed after the problem has been corrected.

11.10.2 If a sample peak has shifted significantly from the original retention time (and the ICV and CCV check standards are within the 10% retention time window), then verify the reported result using post-digest spike on that sample. Do not report results from peaks where the retention time has shifted more than 10 percent unless the peak can be verified using a post-digest spike.

11.10.3 For large or overlapping peaks, make dilutions. If at all possible, make dilutions and reruns on the same run as the original sample.

11.10.4 Refer to section 14.7 for information on how to determine the appropriate retention time window.

11.11 Review all data and update the appropriate tests in the LIMS system. A write-up including a run log, a calibration summary, batch quality control summary, and copies of all chromatograms should be turned into the area supervisor for each batch.

11.11.1 If edits are needed in the calibration after the data has been calculated, the run can be reprocessed using the batch function in the software. Refer to the instrument manuals or on-screen help for addition information.

12.0 INSTRUMENT MAINTENANCE

12.1 Whenever a new suppressor is put in place or when the baseline is unstable or very high, the suppressor should be regenerated. The procedure below is for the Ultra 4mm suppressor.

12.1.1 Using a disposable plastic syringe, push approximately 3mL if 0.2(200mN) H_2SO_4 through the ELUENT OUT port and 5mL of 0.2N H_2SO_4 through the REGIN IN port respectively.

12.1.2 Allow the suppressor to sit for approximately 20 minutes to fully hydrate the suppressor screens and membranes.

12.1.3 Re-connect the suppressor to the system in the recycle mode.

12.2 Periodically, due to the matrix of samples, both guard and analytical columns become degraded and cleaning them becomes necessary. This is evidenced in changing retention times, round-shaped peaks, tailing peaks and overall poor integration. The metals cleanup should be done a minimum of once per month, while the others should be done a minimum of once per quarter.

12.2.1 There are 3 recommended cleanup solutions for the AS22 and AG22 columns.

12.2.2 Metal contamination column clean-up: Use 500mL of 0.2M oxalic acid solution.

12.2.3 Low valency hydrophilic ionic contamination column clean-up. Use 500mL of 10X eluent concentrate (300 mM KOH).

12.2.4 High valency hydrophobic ion 200mM HCl in 80% acetonitrile: The acetonitrile solution is stored in a separate eluent bottle because acetonitrile slowly breaks down in acidic aqueous solutions. Prepare 2 bottles (E1 and E2) with the following 500-mL solutions: E1: 100% Acetonitrile and E2: 1M HCl using DI water.

12.3 Column Clean-up Procedure.

12.3.1 Prepare 500mL solution of the appropriate cleanup solution from 12.2.1

12.3.2 Disconnect the suppressor from the IonPac AS22 Analytical column. **Make sure to reverse the order of the guard and analytical column in the eluent flow path.** Contaminants that have accumulated on the guard column can be eluted onto the analytical column and irreversibly damage it. Cleaning each column separately is recommended. Double check that the eluent flows in the direction designated on each of the column labels.

12.3.3 Set the pump flow rate to 1.0mL/min for an AS22 4-mm analytical or guard column.

12.3.4 Rinse the column for 15 minutes with DI water before pumping the chosen cleanup solution over the columns.

12.3.5 Pump the cleanup solution through the column for at least 60 minutes.

12.3.6 Rinse the column for 15 minutes with DI water before pumping eluent over the column.

12.3.7 Equilibrate the columns with eluent before resuming normal operation for at least 30 minutes.

12.3.8 Reconnect the suppressor and place the guard column in line between the injection valve and the analytical column.

13.0 METHOD PERFORMANCE

Method performance (accuracy and precision) is monitored through the routine analysis of negative and positive control samples. These control samples include method blanks (MB), blank spikes (BS), matrix spikes (MS), and matrix spike duplicates (MSD). The MB and BS are used to monitor overall method performance, while the MS and MSD are used to evaluate the method performance in a specific sample matrix.

Blank spike, matrix spike, and matrix spike duplicate samples are compared to method defined control limits. Control limits are stored in the LIMS. Additionally, blank spike accuracy is regularly evaluated for statistical trends that may be indicative of systematic analytical errors.

Filtered method blanks and blank spikes to act as QC check of the filters. Unfiltered method blanks and blank spikes are used to monitor overall method performance.

14.0 QC REQUIREMENTS

14.1 A method detection limit study must be done semiannually, or when new operator begins work, or whenever there is a significant change in the background or instrument response. The MDL study is done following the procedure outlined in the SGS Accutest - Orlando SOP QA020, current revision. A minimum of seven replicates spiked at 3 to 5 times the MDL must be taken through the procedure for each anion. If instrument conditions (columns, etc.) are modified, then a new MDL must be done.

14.2 A method blank and a spike blank are required to be run with every batch of 20 samples. Additionally a matrix spike and a matrix duplicate are required for every 10 samples. In some cases a matrix spike duplicate may be required in place of a duplicate.

14.2.1 The method blank must contain <½ RL of each anion that is reported and this sample must be run with each set of samples in a batch. If the blank contains more than the reporting level, then all samples must be reanalyzed. If no sample volume remains to be reanalyzed, then the data must be flagged. (The exception is if the sample results are less than the reporting limit.)

Note: West Virginia state specific requirement for method blank must contain analyte at <MDL

14.2.1.1 Although the method states that values greater than the MDL should be suspect, this is not appropriate for the concentration levels being applied for this analysis. MDL's are generally up to 10 times lower than reporting limits for all analytes and values over the MDL do not impact data usability.

14.2.2 The recovery of the spike blank must be within the limits of 90-110% recovery for each anion that is reported and this sample must be run with each set of samples in a batch. If the recoveries are outside of this range, then all associated samples must be reanalyzed. If no sample volume remains to be reanalyzed, then the data must be flagged.

14.2.3 The matrix spike is spiked with all anions of interest. Method limits of 90 -110 % recovery must be applied. Control limits must be generated from laboratory data to support method limits. If the recoveries are outside of this range, and all other method quality control is within limits, then matrix interference should be suspected.

14.2.4 For matrix duplicates control limits of 10% RPD must be applied for all sample values within the calibration range (up to 10 times the reporting limit). If the RPD values are outside of this range, and all other method quality control is within limits, then sample non-homogeneity should be suspected.

14.3 An external source standard (ICV) must be analyzed after every new calibration and its recovery must be within 10% of the true value. If the ICV is not within ±10%, a second ICV should be prepared and analyzed. If the ICV is still outside of the limits, sample analysis must be discontinued and the cause determined (preparation of ICV from third source, instrument recalibration, etc)

14.4 It is recommended that a new calibration be run a minimum of once per month. (It is required that a calibration be run once per quarter.) Calibrations standards may be varied from the one stated in this SOP depending on the levels of each anion that are to be reported. A minimum of 5 standards and a blank are required and a low standard must be at or below the reporting limit for each anion. A correlation coefficient of 0.995 is required.

14.4.1 A new calibration is required when standard retention times shift by more than 10% from the original calibration.

14.5 A low check at the reporting limit (CCV2) for each anion must be run after each calibration. Acceptance criteria is 50–150%.

14.6 Continuing Calibration Verification (CCV) Checks at or near the mid-level of the curve must be run at the beginning and the end of the run and after every 10 samples throughout the run. Every CCV must be followed by a continuing calibration blank (CCB). The CCV must have results within 90-110% of the true value. If the CCV results are outside of the acceptance criteria range, analyst must demonstrate acceptable performance with two CCVs analyzed immediately (started within 1 hour), with no samples between failing CCV and the two additional CCVs. The results for the CCB must be <1/2 RL for an analyte. If they are not, then all bracketed samples for that analyte must be reanalyzed.

14.7 Retention time windows must be established whenever a new column/guard column is installed in an instrument or whenever a major change has been made to an instrument. Retention time shift is checked weekly with a CCV to ensure it does not exceed 10%, and the data is stored on LAN in GenChem directory.

Retention time windows are established by injecting standard mix three times over the course of 24 hours and calculating the standard deviation of the retention times of each analyte. Plus or minus three times the standard deviation of the retention times is defined as the retention time window of that compound.

Peak identification is based on the retention time of an analyte in the standard (initial or continuing) being used as the mid-point of the retention time window. The retention time windows should be used as a guide for identifying compounds; however, the experience of the analyst should weigh heavily in the interpretation of the chromatograms. The analyst should monitor the retention times of known standard peaks throughout an instrument run as an indication of instrument performance.

Because calculated retention time windows are generally very tight (less than ± 0.10 minutes), the retention time windows for the data processing method are generally set wider than the calculated window. This is done to ensure that the software does not miss any potential “hits”. The analyst will then review these “hits” and determine if the retention times are close enough to the retention time of the target analyte to positively identify the peak or to require confirmation.

14.8 The Linear Calibration Range (LCR) is the concentration range the instrument response is linear and must be initially determined and verified every 6 months or whenever a significant change in the instrument is observed or expected. Initially, enough standards must be used to insure the curve is linear. The linearity verification must use at a minimum, a blank and 3 standards. The verification data must be within ±10% of the assigned values. If the data falls outside of this range, then the linearity of the instrument must be reestablished. If any portion of the curve is nonlinear, then sufficient standards must be used to clearly delineate the nonlinear portion of the curve.

NOTE: Samples with detections within 10% of highest calibration standard must be diluted.

14.9 ***Contingencies for handling out-of-control QC***. Upon certain circumstances data can be reported from batches with QC non-conformances. Such samples are to be qualified accordingly. Examples include:

- If the MB is contaminated but the samples are non-detect, then the source of contamination should be investigated and documented. The sample results reported with appropriate qualifiers and footnotes. If the MB is contaminated but the samples results are > 10 times the contamination level, the source of the contamination should be investigated and documented. The samples results may be reported with the appropriate “B” or “V” qualifier. *This must be approved by the department supervisor.* Samples with hits <10 times contamination are reprepped and reanalyzed. If there is insufficient sample to reanalyze, or if the sample is re-analyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. *This must be approved by the department supervisor*
- Similarly, if the recovery of LCS or CCV is high and the associated sample is non-detect, the data may be reportable with appropriate qualifiers and footnotes. If the recovery of LCS or CCV is below lower acceptance limit, the department supervisor shall review the data and determine what further corrective action is best for each particular sample. That may include reanalyzing the samples, reprepping and/or reanalyzing the samples, or qualifying the results as estimated. *This must be approved by the department supervisor.* If there is insufficient sample to reanalyze, or if the sample is re-analyzed beyond hold time, the appropriate footnote and qualifiers should be added to the results. *This must be approved by the department supervisor.*

If the matrix spike recoveries are not within the established control limits, compare the recoveries to those of the LCS to assess method performance in clean QC matrix. Matrix spike recovery failures are not grounds for reanalysis but are an indication of the sample matrix effects

15.0 DOCUMENTATION REQUIREMENTS

15.1 All reagents must be recorded in a reagent logbook with manufacturers, lot numbers, and expiration dates. All reagent information must be cross referenced on the sample worksheet.

15.2 All instrument data must be exported to the LIMS system and a copy of the run log must be included in the logbook by the instrument.

15.3 A data package consisting of a manual run log, a LIMS run log, a calibration summary, batch quality control summary, and copies of all chromatograms must be turned into the area supervisor for each batch. The analyst should also complete the preliminary review in the LIMS system.

15.4 Refer to SOP QA029, current revision, for procedures and documentation that must be followed when peaks are manually integrated.

16.0 POLLUTION PREVENTION & WASTE MANAGEMENT

16.1 Users of this method must perform all procedural steps in a manner that controls the creation and/or escape of wastes or hazardous materials to the environment. The amounts of standards, reagents, and solvents must be limited to the amounts specified in this SOP. All safety practices designed to limit the escape of vapors, liquids or solids to the environment must be followed. All method users must be familiar with the waste management practices described in section 16.2.

16.2 Waste Management. Individuals performing this method must follow established waste management procedures as described in the waste management SOP, SAM108, current revision. This document describes the proper disposal of all waste materials generated during the testing of samples.

17.0 ADDITIONAL REFERENCES

17.1 Dionex Instrument and column manuals

17.2 QA020 Method performance SOP, current revision

17.3 QA029 Manual Integration SOP, current revision.

17.4 QA042, General Chemistry Calculations, current revision

17.5 TNI 2009 standards.

17.6 DoD QSM, Rev. 5.1, 2017

Table 1 QC Criteria

Quality Control	Frequency	Acceptance Criteria	Corrective Action
Initial Calibration: r = coefficient of correlation	At least quarterly	≥0.995	Rerun calibration standards, and/or prepare new calibration standards and recalibrate the instrument, or document why the data are acceptable. See 11.9.2.
Initial Calibration Verification standard (ICV)	One per calibration	90-110% of the standard's true value	Rerun standard, and/or prepare new standard, and/or recalibrate instrument, or document why the data are acceptable. See 14.3
Continuing Calibration Verification standard (CCV)	Every tenth sample	90-110% of the standard's true value	Rerun standard, and/or recalibrate instrument and reanalyze all samples run since the last acceptable CCV, or document why the data are acceptable. See 14.6
Low-level Standard	One per calibration	50-150% of the standard's true value	Rerun standards, and/or recalibrate instrument and reanalyze all samples run since the last acceptable CCV, or document why the data are acceptable.
Method blank (MB) and Calibration Blank (CCB)	MB: One per batch CCB: Every tenth sample	< ½ RL **Note**: West Virginia state specific requirement for method blank must contain analyte at <MDL	Reanalyze, and/or stop the run and determine the source of contamination, or document why the data are acceptable.
Retention time	Checked weekly	90-110% of the standard's true value	Rerun standard, and/or recalibrate instrument and reanalyze all samples run since the last acceptable CCV, or document why the data are acceptable.
Blank Spike (BS or LCS)	One per batch	90-110%	Determine and correct the problem, reanalyze samples, if necessary, or document why data are acceptable.
MS/MSD	10% of matrix	90-110%	Determine and correct the problem, reanalyze samples and MS/MSD, or document why data are acceptable
Linear Calibration Range (LCR)	Bi-annually	± 10% of the standard's true value	Rerun and/or prepare new series of standard, and/or recalibrate instrument

SAMPLE RECEIPT AND STORAGE

Prepared by: Svetlana Izosimova Date: 10/25/2018

Approved by: Heather Wandrey Date: 10/29/2018

Annual Review

Reviewed by: ______________________ Date: __________

Reviewed by: ______________________ Date: __________

Reviewed by: ______________________ Date: __________

Document Control

Issued to: QA Department Date: 10/29/2018

Issued to: Sample Management Date: * 10/30/2018

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Issued to: ______________________ Date: __________

Effective 7 days after "*" date

CONTROLLED COPY
DO NOT DUPLICATE

TITLE: SAMPLE RECEIPT AND STORAGE

REFERENCES: TNI Standards 2009 and 2016, State of Florida DEP SOPs, 40 CFR Part 136, DoD QSM 5.1 and 5.1.1

REVISED SECTIONS: Removed Accutest references throughout the document; Added Access Receipt program throughout the document; added verification of correction factors to 2.2.2; discussed recording temperature to first decimal place in 2.2.3; added section 2.4.8; added green labels to 2.11.2; removed 2.5 as redundant to 2.2.4; edited 2.10;

1.0 SCOPE AND APPLICATION

To maintain documentation of custody of all bottle sets, samples (domestic and foreign), digestates, distillates, and extracts that fall under the responsibility of SGS North America, Inc. - Orlando.

2.0 EXTERNAL CHAIN-OF-CUSTODY PROCEDURE

2.1 Samples are received via commercial carrier, client delivery, or are picked up by SGS - Orlando employees. Upon receipt, sample management inspects the outside of the container for signs of tampering, such as a torn or missing custody seal. The staff reviews Chain Of Custody (CoC) document for the following information:

2.1.1 Client Information- Name / Address, Phone and Fax contact numbers

2.1.2 Facility Information- Project name, Location, Project Number.

2.1.3 Field ID / Point of Collection- Date- Time- (HOLD TIMES) Samplers Initials- # of containers Shipped, Preservative types.

2.1.4 Matrix of samples: WW- water, GW-ground water, SW-surface water, DW-drinking water, SO-Soil, SOL-other solid, LIQ-other liquid, OI- Oil, AIR-air, WP- Wipe, FB-field blank, TB-trip blank.

2.1.5 Analytical Information- Samples with hold times of 72 hrs or less remaining on analyses upon receipt are considered Short Hold Samples and are listed on Short Hold Notification form in order of hold times, from ASAP to 7 days with less than 3 days left. These samples are processed immediately. Job Numbers are assigned, and the samples are given directly to the appropriate lab. Copy of CoC and completed Short Hold Notification Form are relinquished to the appropriate lab by the sample receiving technician. Laboratory personnel accept the samples, time of transfer is recorded, both parties sign SHNF and a copy of the SHNF is attached to CoC. (See Attachment I, Short Hold Notification Form)

2.1.5.1 VOC soil sample vials must be frozen within 48 hours of collection. Receiving technicians review sample times and deliver samples with a

SHNF if sufficient hold-time remains to process the samples. If samples are close to expiring the samples are immediately placed in the freezer with a card notating the time they were placed in the freezer.

2.1.6 TURN AROUND TIME- Samples with a 6 day or less TAT are processed as soon as possible, depending on samples with short hold status.

2.1.7 Sample custody documentation signatures – relinquished/received in Client – Carrier – Laboratory sequence. Per FL DEP SOPs signature shall consist of full signature – no initials allowed – and business affiliation.

2.1.8 Special Requirements and or comments - Compositing, filtering or preservation of samples, Extended sample storage etc.

2.2 Samples are processed by a two-technician team, The sample custodian(s) accepts sample custody upon receipt of samples and verifies that the custody document is correct. Sample conditions, sample temperature, and other observations, including custody seal condition, are documented in detail on the electronic Sample Receipt Confirmation form (p-note).

2.2.1 Temperature is measured using IR thermometer against white label on temperature blank, or on the sample container, if temperature blank is absent. **NOTE: For jobs originated in West Virginia every sample container must be checked.** This thermometer is calibrated measuring the temperature off of white sample label against NIST-traceable liquid-in-glass thermometer – see SOP QA002, current revision. When recording the cooler temperature with the use of an IR gun the following needs to be documented on Sample Receipt Confirmation Form:

2.2.1.1 IR gun used.
2.2.1.2 Correction factor.
2.2.1.3 Observed cooler temperature.
2.2.1.4 Corrected cooler temperature.

2.2.2 Verify IR thermometer correction factor gains Correction factor recorded in Receipt utility to make sure it is correct in both locations. Notify QA/Department Manager if these values are not the same. Apply temperature correction factor for a face value – positive number to be added to direct reading temperature, negative correction factor to be subtracted.

2.2.3 **Samples must remain in coolers full of ice until it is time to process the job for login. Coolers received out of temperature range have initial temperature recorded and are then placed into a Walk-In cooler until resolution from client is received.** 40 CFR part 136, TNI Standards 2009, 2016 revision and DoD QSM 5.1 all designate acceptable temperature as “above freezing and below 6°C”. Temperature is measured and recorded to first decimal place due to state-specific and client-specific requirements.

2.2.4 Any discrepancies or non-compliant situations are documented on the Sample Receipt Confirmation Form (p-note) which is automatically e-mailed to the SGS - Orlando Project Manager (PM) team. PM assigned to the particular client contacts the client for resolution. Major issues require the client to be contacted before the samples can be logged in, such as but not limited to missing COC's, samples being out of hold, insufficient sample volume, bottles received not on COC or out of temperature range. If resolution of the problem is taking time, the samples are labeled as is and placed into refrigerated storage until the problems are resolved. Samples are then removed and processed according to client's instructions. Minor issues identify discrepancies that do not interfere with log-in and/or analysis of the samples, such as 1 of 2 PAH bottles received broken or supplied. The resolution is documented and communicated to sample management for execution.

2.2.5 Once the sample custodian(s) is (are) satisfied with the information on the chain of custody document, the job number is generated from Receipt access-based utility with the next available SGS - Orlando sequential job ID in FXXXXXX convention.

2.2.6 First technician arranges samples on the counter in the order of CoC. Every different point of collection must have a different fraction number, i.e. -1, -2, etc. The assigned fraction number must be written on the chain of custody, to the left of the line identifying the point of collection (Client ID) unless there is insufficient space. The custodian then assigns a unique sample identifier to each sample container, i.e. FAXXXXX-1.4, where 4 is a unique container designation.

2.2.7 The same technician enters samples in the sample location database and prints the labels for the samples. A second technician then attaches the labels to the samples and re-verifies sample client ID and Lab fraction number against CoC. After all the steps in Sec. 3 are completed, first technician closes the Sample Receipt Confirmation Form and second technician reviews it for completeness and accuracy of recorded information.

2.2.7.1 Wherever samples are designated to be put on hold by the client, labels on these samples are highlighted in bright pink and additional bright pink **"HOLD – Do Not Dispose"** label is attached to the individual containers

2.2.8 **After Hours Delivery Procedure**. Upon return to the lab SGS - Orlando-employed couriers will visually inspect the coolers and add ice if needed. Coolers will then be placed into Refrigerated storage until Sample Receiving Technicians can process the coolers. Sample Receiving technicians will arrive first thing in the morning to verify Short Holds, Rushes etc as per sec. 3.1.5 and 3.1.6.

2.3 When assigning a job number, the following information from the chain of custody is entered in the Access Receipt utility:

2.3.1 SGS - Orlando Assigned Job #
2.3.2 Client Name
2.3.3 Project Name
2.3.4 Date and Time Samples Received.
2.3.5 # of coolers Received.

2.3.6 Courier Information
2.3.7 Skif # (Sample Kit Information Sheet)
2.3.8 Technician Initials

2.4 The sample custodian then checks the samples' preservation, except for the volatile samples, which are checked by the analyst after the sample is analyzed. Should a sample be received preserved incorrectly the following actions are taken:

2.4.1 pH and residual chlorine: For samples requiring preservation (HNO3, H2SO4, NAOH and NAOH/Zn Acetate) each container is tested by applying the sample with disposable capillary to narrow-range pH paper. Residual chlorine presence/absence is measured using potassium iodide/starch paper in samples for all EPA 600 series and samples originated in North Carolina (one bottle per well). 45-ml VOC vials are exempt from this procedure and are being tested in the lab after the requested tests are completed (purge-and-trap GC and GC/MS, TOC/TC and EPA 504/8011).

2.4.2 Organochlorine pesticides and PCBs by EPA 608 - samples that are not extracted within 72 hours of collection need to have pH checked and adjusted, if necessary, to a pH within 5.0-9.0 using H2SO4 or NaOH. Coordinate with Extraction department.

2.4.3 Pesticides/PCB's/Semivolatile Organic aqueous samples with residual chlorine present: Add 1 ml of 8% sodium thiosulfate solution per 1liter (0.008%) to all containers except VOA. Record event on Sample Receipt Confirmation Form and in preservative adjustment log.

2.4.4 Cyanide is preserved to pH ≥ 12 using 10N NaOH, prepared by WetChem personnel.

2.4.5 Sulfide is preserved to pH ≥ 9 using 10N NaOH and Zn acetate, prepared by WetChem personnel.

2.4.6 Aqueous samples for metals are preserved to pH ≤ 2 with nitric acid, prepared by WetChem Personnel. These samples are marked with colored label "**Metals Sample Received Unpreserved. Preserved Date_____Time_____ Analyze after 24 hours".** For correctly preserved aqueous metals sampling date and time from COC is recorded as date and time of preservation.

2.4.7 Aqueous samples for TRPH and some WetChem parameters are preserved to a pH of ≤2 with H2SO4, prepared by WetChem Personnel.

2.4.8 To avoid using expired preservatives, in the beginning of the calendar month obtain no more than 100 ml of currently used preservative reagents from Shipping area, appropriately label the container with reagent identity and expiration date and discontinue its use at the end of the month. Turn unused portion to the Waste room for further disposal.

2.5 .

2.6 Incorrectly preserved samples have the proper amount of preservative added, upon confirmation from PM or client, volume added is recorded on the Sample Receipt Confirmation form and in preservative adjustment log. The same volume and type of preservative is then added to the Equipment Blank and/or Field Blank, regardless of pH reading. Volume added is recorded on the Sample Receipt Confirmation form and in the preservative adjustment log. Also see Sec. 3.4.5.

Job Number, Sample ID, Bottle Number, Parameter, Preservative Type, Preservative Lot, and Amount of Preservative Added, Date/Time Added and the technician's initials.

2.7 All bottles must be labeled. Each bottle will be labeled both on the cap and on the bottle. VOA vials have the label wrapped around the top of the vial, just below the cap. The labels are generated by the electronic sample receipt log. The following information is entered into the electronic log:

2.7.1 Job #:
2.7.2 Client Name and Project
2.7.3 Date and time samples were received.
2.7.4 The number of coolers received
2.7.5 The temperature of each cooler
2.7.6 Initials of custodian logging in the job
2.7.7 Number of samples
2.7.8 Number of bottles
2.7.9 Bottle type
2.7.10 Preservative by code. Preservatives codes are:

"1" = preservative is checked by analyst
"2" = not applicable
"3" = correctly preserved for the analysis requested

2.7.11 Bottle storage location
2.7.12 Department to do the analysis
2.7.13 The information is saved and labels can be printed.

2.8 The following information must be on the bottle:

2.8.1 The sample number and bottle number
2.8.2 Storage location
2.8.3 The preservative used during sampling as indicated on the chain
2.8.4 Any hazard the Sample Custodian may be aware of

2.9 The samples must be placed in their assigned locations and kept at above freezing and below 6.0°C until preparation and/or analysis. Water samples preserved with HNO_3 for metals analyses are stored at room temperature. Access to the area is limited.

2.10 The original chain of custody and any additional documented information relative to the job is handed to Log-in technician for further processing as described in SOP QA048, current revision, for entry in LIMS.

2.11 **Foreign samples** are referred to samples originated outside of continental United States. These samples must be segregated from domestic samples in storage, processing and disposal. Objective of such segregation is to keep agricultural pests and pathogens from entering continental US territory and interfering with animal and plant health.

2.11.1 Foreign Samples shall be shipped in securely closed watertight containers and free of debris and macro organisms (insects, mollusks, worms, ticks and mites).

2.11.2 Foreign samples are stored in lockable cage in WI#3 to prevent accidental disposal. This cage is clearly marked *for foreign samples only*. Sample labels are colored green to stand out in the lab departments.

2.11.3 Keep lids tightly closed while in storage.

2.11.4 All unconsumed samples and containers must be separately collected for disposal. SGS - Orlando employs outside contractor to sterilize and dispose of foreign samples – see SOPs SAM108 and SAM109, current revision.

3.0 SAMPLE STORAGE TEMPERATURE AND CROSS-CONTAMINATION MONITORING

3.1 While in the laboratory, samples shall be stored in limited-access, temperature –controlled areas. Refrigerators shall be monitored for temperature daily. Acceptance criteria for the temperature of refrigerator is 0.5 to 6.0 °C * and is listed in the refrigerator log. Thermometers that have been calibrated with a NIST traceable thermometer monitor all cold storage areas. As indicated by the finding of the calibration, a correction factor is applied to each thermometer for a face value. Records that include acceptance criteria shall be maintained.

*According to TNI 2009 and 2016, V1M2, sec. 5.8.9.a.i) temperature should be above freezing point and below 6.0°C, when specified storage temperature is 4°C. Lowest temperature that can be practically read above freezing point is 0.5°C.

3.2 Samples for volatile organics determination shall be stored separately from other samples, standards, and sample extracts. Acceptance criteria for the temperature of a volatile refrigerator is 0.5 to 6.0 °C and is listed in the refrigerator's log. VOC Soil freezers are maintained between –10.0°C and -20.0°C per SW-846 5035A. For further details refer to SOP QA004, current revision.

3.3 Sample storage area for volatile organics shall be monitored for cross contamination using refrigerator blanks. Refrigerator blanks shall be analyzed every other week.

3.3.1 If contamination of the refrigerator is confirmed, the samples must be removed from the refrigerator and placed in coolers with ice, or in alternate refrigerated storage.

3.3.2 All samples received after the date of the last clean refrigerator blank must be checked for the same contaminants. If present, they must be reported and flagged with a qualifier indicating possible lab contamination.

3.3.3 The source of the contamination must be located and removed.

3.3.4 A new refrigerator blank is then placed in the refrigerator and analyzed after 24 hours.

3.3.5 Samples may be returned to the refrigerator when all contaminants are removed as indicated by the analysis of a refrigerator blank without contamination.

4.0 DOCUMENTATION

All samples received by SGS - Orlando must come with a chain-of-custody (COC). Special attention shall be paid to client-specific COCs.

SGS - Orlando personnel MUST record dates and time in **mm/dd/yy 24:00** format, and both observed and corrected temperatures.

Current revisions of forms and label templates used in sample receipt process are maintained as controlled documents in limited access directory on LAN.

Attachment I

SHORT HOLD NOTIFICATION FORM JOB #________________

HOLD TIME	ANALYTE	CHECK COC	COMMENTS
ASAP	RedOx		
	Bacteria- Total Coliform/Fecal Coliform		
24 hrs	XCr / Hexachrome / Cr +6		
	Dissolved/Filtered Metals		
	Odor		
	Salinity (SCON+ Field Temp & Presure)		
48 hrs	BOD		
	CBOD		
	MBAS		
	Turbidity		
	Color		
	Nitrate (NO3)		
	Nitrite (NO2)		
	TN (NO2/NO3)		
	OPO4 / Orthophos		
	SS (Settleable Solids)		
	Chlorophyl A (Subcontract)		
72 hrs	Acrolein/Acrylonitrile (VOA from Alaska)		
	Formaldehyde (Subcontract)		
7 days Only for samples received after 5 days	Unpreserved Voa Vials		
	TDS/TSS/TS		
	Sulfide		
	8141 pesticides in soil		
	All the Water extractables		
	Soils		
48 Hours	5035 Field Kit (DI vials)		
	Encore Sampler VOA/VPH/GRO		
	Soil Jar (Bulk Sample) VOA/VPH/GRO		
	NO2/NO3 from WV (IC analysis)		

Relinquished by:______________________**Date/Time relinquished:**_______________

Received by:__________________________**Date/Time received:**__________________

SAMPLE AND LABORATORY WASTE DISPOSAL

Prepared by:	Svetlana Izosimova	Date:	12/30/2015
Approved by:	Randy Shields	Date:	01/21/2016

Annual Review

Reviewed by:		Date:	
Reviewed by:		Date:	
Reviewed by:		Date:	

Document Control

Issued to:	QA Department	Date:	01/21/2016
Issued to:	Sample Management (Shipping)	Date: *	01/21/2016
Issued to:		Date:	
Issued to:		Date:	
Issued to:		Date:	
Issued to:		Date:	

Effective 7 days after "*" date

CONTROLLED COPY
DO NOT DUPLICATE

TITLE: SAMPLE AND LABORATORY WASTE DISPOSAL

REFERENCES: Florida DEP Hazardous Waste; 40 CFR, Part 261

REVISED SECTIONS: Segregation of Foreign soils – see 4.2.6; Storage and Disposal of samples in "HOLD" status – sec. 4.7 (new), corrected facility name throughout the document.

1.0 SCOPE AND APPLICATION

The disposal of samples and lab waste adhering to Florida State and Federal Regulations.

2.0 SUMMARY

This SOP describes the procedures used by SGS Accutest - Orlando to properly and safely dispose of samples and laboratory wastes; hazardous and non-hazardous; domestic and foreign.

3.0 DEFINITIONS

3.1 Foreign sample: Samples from sites that are outside the continental United States.

3.2 Hazardous Sample or Waste: A material is considered hazardous if it is listed in the Code of Federal Regulations, 40 CFR, Part 261 or it demonstrates any of the hazardous characteristics including, ignitability, corrosivity, reactivity, or has demonstrated toxicity.

4.0 PROCEDURE

Sample Disposal: Samples are kept in appropriate storage for a minimum of 30 days after the report is sent to the client unless otherwise specified by client. The samples are divided into three categories: Aqueous, Soil, and Non-aqueous liquid.

4.1 Aqueous Samples

4.1.1 A disposal list is generated by computer, based on either reporting dates or sample number range (see attached).

4.1.2 Samples are then removed from the refrigerators and/or cabinets, and are separated as non-hazardous (non-detected or normal) and hazardous (positive result) samples.

4.1.3 Non-hazardous samples are emptied into a drum. Once full, the drum is sampled and screened for metals. If screening results are within TCLP limits, the drum is then pumped into a large holding tank. If TCLP limits are exceeded, the drum should be disposed of via the contracted waste disposal company. Once the large holding tank is full, the contracted waste disposal is contacted to arrange for an on-site transfer. The contents are profiled annually unless a major change to the waste stream occurs.

4.1.4 VOA vials are processed through a glass crusher and into an open-top drum. The solid material (glass, plastic, and septa) is separated from the liquid and is drummed separately. The liquid drum, when full, is then handled in the same way as described in section 4.1.3. The crushed glass drum is handled as described in section 4.2.2.

4.1.5 SGS Accutest - Orlando contract Disposal Company segregates hazardous aqueous samples into the appropriate waste drums for disposal.

4.1.6 Samples containing PCB in excess of 50 ppm are automatically flagged by LIMS on disposal list. These samples are labeled with distinct PCB label and segregated from the rest of waste samples to be disposed of in LabPak.

4.1.7 Some samples, on a case by case basis, are returned to the client for disposal.

4.2 Soil Samples

4.2.1 Domestic Soil Samples (DSS) are placed in drums after the storage period, either in a hazardous or non-hazardous drum per the samples' status on the disposal sheets.

4.2.2 When the drums are full, they are then sampled and analyzed to determine their hazardous constituents (Full TCLP, RCI, and PCBs).

4.2.3 Based on the results of analysis, the drums are then either disposed of as hazardous or non-hazardous by our contract disposal company.

4.2.4 Samples containing PCB in excess of 50 ppm are automatically flagged by LIMS on disposal list. These samples are labeled with distinct PCB label and segregated from the rest of waste samples to be disposed of in LabPak.

4.2.5 Some samples, on a case by case basis, will be returned to the client for disposal.

4.2.6 Foreign soil samples (FSS) come in vials (volatile organic analysis) or jars. These soils are segregated in WI#3 in lockable cage (see also SAM101 and SAM109, current revisions)

4.2.7 After minimum 60-day hold period, but not to exceed 6 months, these FSS are disposed of in the following manner.

4.2.7.1 FSS vials: Vial samples are preserved either with methanol or DI water. Vials with water are uncapped and placed into a drum labeled specifically for foreign soils. No more than six months may elapse form the accumulation start date on the drum before the drum must be disposed. The contracted disposal company must be certified to handle and dispose of foreign soils. Vials with methanol must be filtered. The filtrate (methanol) is disposed of in the non-chlorinated solvent waste drum. The soil is then drummed per the hazard status on the disposal sheets.

4.2.7.2 FSS Solids: FSS in jars are emptied into drum labeled specifically for foreign soils. Once full, the drum is disposed of via the contracted disposal company. No more than six months may elapse from the accumulation start date on the drum to disposal.

4.3 Non-aqueous liquid samples

4.3.1 Non-aqueous samples are placed in drums after the hold period.

4.3.2 When the drums are full, they are then sampled and analyzed to determine their hazardous constituents (PCBs). Drums have a 6 month expiration time. If the drum is not full by then it is analyzed and picked up by our contract disposal company.

4.3.3 Based on the results of analysis, the drums are then either disposed of as hazardous or non-hazardous by our contract disposal company.

4.3.4 Samples, on a case by case basis, will be returned to the client for disposal.

4.4 Sample Containers

4.4.1 Containers from samples deemed Non-Hazardous are immediately disposed of into a waste container provided by waste management services specifically for SGS Accutest - Orlando direct use. A lock and key has been installed to keep the containers use limited to Accutest only.

4.4.2 Containers from samples deemed hazardous are disposed of into the Hazardous waste solids drum.

4.4.3 Waste Management services picks the container up on a weekly basis and brings to the local sort facility where contents are destroyed -recycled.

4.5 Laboratory Waste Disposal:

4.5.1 All materials determined to be hazardous are containerized in appropriate vessels (i.e. drums). A waste is considered hazardous if it is listed in the Code of Federal Regulations, 40 CFR, Part 261 or it demonstrates any of the hazardous characteristics including, ignitability, corrosivity, reactivity, or has demonstrated toxicity. Our contract disposal company disposes of the drums.

4.5.2 WASTE DRUMS are separated by type:

Chlorinated Waste (Closed Top Steel) - Methylene Chloride

Non-Chlorinated Waste (Closed Top Steel) - Hexane, Methanol, and mixed solvents

Sodium Sulfate/Used Charcoal (Open Top Steel) - Charcoal and paper filters used in the filtering of samples.

Non Hazardous Aqueous Vials (Open Top Poly) - Primarily Acid Vials.

Hazardous Flammable Vials (Open Top Poly) - Methylene Chloride, Hexane.

Hazardous Aqueous waste (Closed Top Poly) - High Odor Samples, Lachat Waste.

Non Hazardous Soil (Open Top Steel)- Soils.

Hazardous Solid Waste - (Open Top Steel).

Non-Aqueous/Oil Samples- (Closed Top Steel)

Difference between Open and Closed type of drums is whether it is possible to remove entire lid or just threaded stopper. Drums are closed at all times while in storage.

4.5.3 Disposal is done as conscientiously as possible following guidelines set forth by both the State of Florida and our contract disposal company. Management and proper handling is necessary to avoid any violation. The guidelines change depending on how much waste is generated on a monthly basis:

4.5.3.1 Less than 220 pounds (100 kilograms or about half a drum) is a “Conditionally Exempt Small Quantity Generator”.

4.5.3.2 A “Small Quantity Generator” generates 220-2,200 pounds (100-1,000 kilograms or about half a drum to 5 drums)

4.5.3.3 More than 2,200 pounds (100-1,000 kilograms or more than about 5 drums) is a “Large quantity Generator”.

4.5.3.4 SGS Accutest - Orlando is considered a “Small Quantity Generator”.

4.6 Waste Containers and Storage

4.6.1 Containers must be maintained in good condition at all times. Care must be taken to prevent leaks, ruptures, and the accumulation of rainwater on tops of the drums.

4.6.2 Waste containers must be kept closed at all times, except when waste is being transferred to drum.

4.6.3 The containers must be compatible with the waste being stored (i.e. acids should not be stored in metal drums). Never store incompatible wastes in the same container (i.e. acids and bases). Containers must be stored in such a way to accommodate inspection for leaks and damage from all sides

4.6.4 Each waste container must be labeled with the following information.

4.6.4.1 Type and nature of waste (soil, oil, hazardous, non-hazardous)

4.6.4.2 Waste generator’s name and address

4.6.4.3 Manifest document number

4.6.4.4 Proper DOT shipping name and identification number

4.6.4.5 Accumulation start date (change to storage date when container is full)

4.6.4.6 In addition, a hazardous waste must have the words “HAZARDOUS WASTE. FEDERAL LAW PROHIBITS IMPROPER DISPOSAL. IF FOUND, PLEASE CONTACT THE NEAREST POLICE OR PUBLIC SAFETY AUTHORITY OR THE U.S. ENVIRONMENTAL PROTECTION AGENCY” prominently displayed on the container.

4.6.5 Inspection and Records

4.6.5.1 Containers must be inspected weekly. All records must be kept on file for three years. The records, which must be kept on file, include:

4.6.5.1.1 A written log of the inspections
4.6.5.1.2 Manifests and shipping receipts
4.6.5.1.3 Results of laboratory analyses of the wastes
4.6.5.1.4 Land Disposal Restriction form

4.7 Samples in “HOLD” status

4.7.1 Wherever samples are designated to be put on hold by the client, labels on these samples are highlighted in bright pink and additional bright pink **“HOLD – Do Not Dispose”** label is attached to the individual containers.

4.7.2 Additionally, all Foreign Soils are kept in lockable cage in WI#3 regardless of status (see 4.2.6).

4.7.3 When samples are removed from the temperature controlled storage and boxed for extended storage these boxes also receive same bright pink label as individual containers.

4.7.4 Samples are segregated into a designated quarantine area with clear signs to the nature of the stored samples.

4.7.5 Prior to removal and disposal from this area, written permission should be obtained from the Project Manager, addressed to Sample Management Supervisor and CC’d to the Laboratory Director.

4.7.5.1 Due to 6-months storage restriction on Foreign soils samples (see 4.2.7.1) Project Manager’s input must be requested by Sample Management department in a timely manner.

5.0 HEALTH AND SAFETY

5.1 All employees who handle waste materials should wear full protective clothing including safety glasses &/or face shield, gloves, boots, lab coat or a Tyvek suit, and air-purifying respirator. Direct skin contact with waste materials should be avoided.

5.2 If an employee has accidentally been exposed to a hazardous waste, the individual should rinse the affected areas thoroughly under a safety shower for at least 15 minutes. If the individual begins to exhibit any adverse effects from the exposure, he should be immediately transported to the nearest hospital emergency room. Employees are referred to the Material Safety Data Sheets for specific instructions on exposure to hazardous substances.

ATTACHMENT B

Resumes

Ahtna

Holly Dillon

Environmental Scientist/SSHO

EDUCATION

MS, Coastal and Watershed Science and Policy (watershed emphasis), 2010, California State University

BA, Environmental Science (Public Policy Minor), 2005, Mills College

CERTIFICATIONS, LICENSES, TRAINING

Safety, Health, and Environmental Program (SHEP), 2015

Leading Cultural Change, 2014

Management Conference, 2014

Biennial American Red Cross CPR / First Aid

Confined Spaces for Construction, 2009 / Respiratory Protection, 2009

HAZWOPER 40-Hour, 2005 / Annual 8-Hour Refresher

Hazardous Waste Management, 2004 / Hazard Communication, 2005

OSHA 30-Hour Construction Safety, 2009

HAZWOPER Supervisor, 2009 / Health and Safety Leadership, 2009

DOT Hazmat, 2013

Laboratory, 2008 / Compressed Gas, 2008 / Fire Extinguisher, 2010 / Defensive Driving Safety, 2014

U.S. Army Corps of Engineers Construction Quality Management for Contractors, 2011

US Army AKO READ and ERIS, 2013

Incident Management and Reporting Procedures, 2012

EXPERIENCE SUMMARY

- Over 11 years of experience as an Environmental Scientist supporting federal/DoD environmental remediation projects through data management, sampling and analysis, site safety and quality control, and the development of work plans and reports
- Over 6 years of SSHO experience and specialized safety training in field and office workplace environments including USACE environmental remediation projects throughout California; ensure quality health and safety reporting, safety training; develop APPs and AHAs, perform safety inspections, conduct daily toolbox meetings and administer best safety practices; experience at sites where EPA Level C PPE was required
- Over 8 years of quality control (QC) experience including QC inspections and reporting of field and office work performance, equipment, and reports
- 2 years of experience implementing Stormwater Pollution Prevention Plan (SWPPP) Best Management Practices

PROJECT EXPERIENCE

Environmental Scientist and SSHO, Ahtna, 2009-Present

Maintain safety training records and schedule training. Assist with production of safety plans including Business Response Plans, Site Specific Health and Safety Plans (SSHPs), Activity Hazard Analyses (AHAs), Accident Prevention Plans (APPs), Emergency Action Plan (EAP), and Hazard Communication Program (HCP). Provide training to coworkers and subcontractors for safety related topics and conduct safety meetings. Maintain Safety Data Sheets (SDSs) for all onsite hazardous substances, inventories of materials, and update site plans and maps accordingly. Support the development of quarterly and annual monitoring reports, work plans, construction completion reports, and project-specific reports. Manage environmental data for various projects including tracking sample information, data validation, and data upload to project specific databases. Analyze environmental data by creating and updating site maps, plume and water elevation contours, tracking data trends, creating data tables, and assisting with project decisions based on data analyses. Completed all work to date with zero lost-time safety incidents.

Environmental Scientist/SSHO, Groundwater Treatment Plant O&M – Former Fort Ord, USACE Sacramento, Marina, CA, 2008-present, $10M

Prepare Quarterly and Annual Groundwater Treatment System and Groundwater Monitoring reports, and project APP and AHAs as well as Quality Assurance Project Plans (QAPPs). Provide technical support, handouts, and minutes for client and agency monthly and semi-annual meetings. Perform groundwater treatment plant sampling, data management, data analysis, and data validation in support of O&M of two GWTPs consisting of a network of 28 extraction and 6 injection wells and infiltration galleries. Provide field supervision and support, oversee QC, and health and safety during the quarterly sampling of over 200 groundwater monitoring wells, as well as water level measurements at over 300 wells. Support project optimization

Behavior Based Safety, 2012

Terrorism Awareness, 2013

Annual Medical Clearance and Respirator Fit Test

Globally Harmonized System, 2013

Munitions Response, 2012

Qualified SWPPP Practitioner (QSP) training, 2012 (not licensed)

WORK HISTORY

Ahtna Environmental Inc., Environmental Scientist/Site Safety & Health Officer, 2015-present

Ahtna Engineering Services, LLC, Environmental Scientist/Site Safety & Health Officer, 2009-2015

Volt Workforce Inc. (California American Water), Laboratory Technician, 2008-2009

Student Intern, California State University Monterey Bay, 2007-2010

MACTEC Engineering & Consulting, Environmental Scientist, 2005-2007

City of Menlo Park, Engineering Intern, 2004-2005

Yoh Scientific/ICF Consulting (USEPA Contractor), Laboratory Assistant, 2002-2004

PTRL West, Laboratory Assistant, 2001

and expansion strategies for remedial systems at three sites in six groundwater aquifers.

Environmental Scientist/SSHO, Operable Unit Carbon Tetrachloride Plume (OUCTP) Evaluation, Injection, and Bioremediation, Former Fort Ord, USACE Sacramento, Marina, CA, 2014-present, $2.5M

Write APP and AHAs and provide SSHO support for field work involving the evaluation and remediation of the OUCTP A-Aquifer CT groundwater plume, including installation and sampling of eight new groundwater monitoring wells, and installation and operation of an injection and bioremediation system (summer 2016).

Environmental Scientist/SSHO, Sites 2/12 Remedial Investigation/Feasibility Study (RI/FS) Addendum, Former Fort Ord, USACE Sacramento, Marina, CA, 2013-2015, $1.2M

Executed fieldwork as part of a four-person team to perform drilling and sampling work to investigate plume delineation of groundwater and soil gas, as well as potential for soil vapor intrusion in commercial buildings. Directed the installation and sampling of 167 soil gas probes and 17 monitoring wells, and provided support for 25 sub-slab soil gas samples and 25 indoor air samples. Provided technical input into the RI/FS Work Plan and Addendum report. Prepared Cinema Work Plan and SSHP. Provided technical support for client, agency, and land owner meetings. Performed data management and analyses. Performed onsite field QC inspections, safety meetings. Oversaw field activities including monitoring well and soil boring drilling, overnight drilling, soil gas probe and monitoring well installation, geologic logging, soil gas sampling, soil sampling, groundwater sampling, laboratory and subcontractor oversight. Completed the installation and operation of a Soil Vapor Extraction Pilot Study. Produced the RI/FS report and additional Indoor Investigation Technical Memorandum. Supported preparation to expand the groundwater remedy to include additional groundwater extraction and a full-scale soil vapor extraction treatment system at Sites 2/12.

Environmental Scientist/SSHO, Multiple Environmental Government Acquisition (MEGA) ID/IQ Environmental Services, USACE Sacramento, Hawthorne Army Depot, NV, 2014-2015, $97.7K

Prepared APP in support of groundwater assessment work at three solid waste management units. Provided safety support during field execution. Implemented corrective actions as needed to maximize safe execution of work.

Environmental Scientist/SSHO, Greely Hall, East Range Mine Shaft and South Range Landfill, Fort Huachuca, USACE Los Angeles, Fort Huachuca, AZ, 2013-2014, $1.3M

Prepared APP for all three sites that involve environmental services to achieve site closure including the installation of groundwater monitoring wells, groundwater monitoring, and development of a Response Complete Decision Document. Provided safety support during field execution. Implemented corrective actions as needed to maximize safe execution of work.

Environmental Scientist/SSHO, POM/OMC Stormwater Compliance,

USACE Sacramento, Former Fort Ord, CA, 2013-2014, $21K

Prepared the SWPPP Implementation Plan to guide the Presidio of Monterey/Ord Military Community in ensuring compliance with the new municipal storm water permit by researching new permit requirements, organizing requirements into an annual list of requirements, and researching available resources of nearby storm water organizations.

Environmental Scientist, Building 258 Source Area Remediation (SAR) Excavation, USACE Los Angeles, Fort Hunter Liggett, CA, 2012-2013, $5M

Prepared a SWPPP for the Building 258 Source Area Remediation (SAR) land farm. Implemented and provided staff training for the SWPPP including land farm BMP inspections, daily weather reports, Rain Event Action Plans, reporting on SMARTS including annual reports and the Notice of Termination (site closeout). Created gINT boring logs for the new monitoring wells installed.

Environmental Scientist/SSHO, O&M - Riverbank Army Ammunition Plant, USACE Sacramento, Riverbank, CA, 2009-present, $1.2M

Perform QC document editing of monthly and quarterly progress reports, SDS records, training records, safety oversight of site personnel in support of the O&M of the GWTP.

Environmental Scientist/SSHO, Building 258 Monitoring Well Installation, UVOST, MIP, HPT profiling, USACE Sacramento, Fort Hunter Liggett, CA, 2011-2012, $5.8M

Supported the installation of new monitoring wells at Building 258. Drilled soil borings to perform Ultraviolet Optical Screening Tool (UVOST), Membrane Interface Probe (MIP), and Hydro Punch Tool (HPT) subsurface vertical profiling for site plume and remediation analysis. Performed HPT profiling, monitoring well installation. Prepared Work Plan and Construction Completion reports. Conducted data management and analyses. Created gINT boring logs for the new monitoring wells. Observed MIPS and UVOST field work. Presented HPT results to the Army. Provided safety oversight and QC inspections of field work.

Environmental Scientist/SSHO, FAA Anchorage, FAA Release Investigation, McGrath, AK, 2011, $760K

Provided field support during a UVOST subsurface investigation of 13 former Federal Aviation Administration (FAA) underground storage tank (UST) and aboveground storage tank (AST) and conveyance pipeline sites in remote McGrath, Alaska. Performed Geoprobe direct-push drilling oversight, UVOST data analysis, monitoring well installation oversight, soil sampling, geologic logging, monitoring well development with pump and bailer, groundwater sampling with micro-purge, shipping and receiving samples, created gINT boring logs, and survey monitoring wells. Performed QC and safety oversight of subcontractors.

Environmental Scientist/SSHO, Fort Hunter Liggett Building 194 Chemical Injections, USACE Sacramento, Fort Hunter Liggett, CA, 2011-2012, $360K

Provided oversight of fieldwork and technical support during in situ chemical injections at the Building 194 area using direct push technology as well as groundwater sampling and analysis to monitor the groundwater post-injection. Ensured all field work was executed in accordance with approved work plans and schedule. Conducted safety vapor monitoring of worker breathing zone. Coordinated sampling and laboratory work. Prepared Chemical Injection Completion Report. Performed safety oversight and QC inspections of field work.

Environmental Scientist/SSHO, Building 258 Groundwater Monitoring and Reporting, USACE Sacramento, Fort Hunter Liggett, CA, 2010-2013, $750K

Provided technical expertise for groundwater monitoring and reporting of the monitoring well network at Building 258. Conducted groundwater sampling, safety oversight and QC inspections of field work. Prepared quarterly and annual progress reports, and data management and analysis.

Environmental Scientist/SSHO, OUCTP Monitoring Well Installation, USACE Sacramento, Former Fort Ord, CA, 2010-2011, $1.6M

Conducted safety meetings and safety oversight of field activities, and QC inspections during the installation of monitoring wells. Prepared Work Plan and Construction Completion report. Monitored well drilling and installation executed by a four-person crew, including geologic logging, well development, well surveying, groundwater sampling, Westbay multi-port well installation, and overnight drilling operations. Created gINT boring logs for the installed wells.

Environmental Scientist/SSHO, Landfill Post-Closure Monitoring, USACE Sacramento, Fort Hunter Liggett, CA, 2010-2011, $750K

Provided technical guidance during the inspection and monitoring of the closed FHL Landfill. The FHL Landfill includes 32 landfill gas vents, 7 landfill gas probes, and 28 wells. Prepared semi-annual reports, and performed data management, safety and QC oversight of field activities, landfill inspections, and micro-purge groundwater sampling.

Environmental Scientist/SSHO, Building 258 Soil Vapor Extraction System (SVE) Operation and Maintenance, USACE Sacramento, Fort Hunter Liggett, CA, 2009-2011, $750K

Provided technical expertise during the construction and operation of an SVE treatment system including five SVE wells. Installed, maintained and sampled the SVE system. Performed micro-purge groundwater sampling and data management. Oversaw safety and QC for field activities. Prepared monthly and quarterly progress reports.

Environmental Scientist/SSHO, Building 194 Groundwater Monitoring and Reporting, USACE Sacramento, Fort Hunter Liggett, CA, 2009-2011, $207K

Supported groundwater monitoring and reporting of the monitoring well network at Building 194. Completed groundwater sampling with a bladder pump and micro-purge, and oversaw safety and QC inspections of field work. Prepared quarterly and annual monitoring reports, and performed data management and analyses.

Environmental Scientist/SSHO, Del Monte Shopping Center Groundwater Monitoring, USACE Sacramento, Monterey, CA, 2009-2010, $6.7K

Performed groundwater monitoring and reporting of the monitoring well network of approximately 15 wells at the Del Monte Shopping Center in Monterey, CA. Recorded groundwater elevation measurements. Completed groundwater sampling of monitoring wells, pump station, and creek surface water sampling. Communicated with shopping center personnel to coordinate sampling. Oversaw safety and QC inspections of field work.

Environmental Scientist/SSHO, Fort Hunter Liggett Building 194 Well Repair, USACE Sacramento, Fort Hunter Liggett, CA, 2009, $7.5K

Conducted safety tailgate meeting and safety oversight of field activities during the relocation of seven monitoring wells in the Building 194 area. Oversaw 2-person field crew.

Other Relevant Work Experience 2001-2009

Laboratory Technician, Volt Workforce Inc. (California American Water), CA, 2008-2009

Performed drinking water sampling at customer homes, businesses, reservoirs, treatment pump stations, and wells. Analyzed drinking water samples and Moss Landing pilot desalination plant samples in a bacteriological laboratory for coliform, total heterotrophic plate count, alkalinity, and general water quality parameters. Operated an autoclave for sterilization of bacteriological waste. Maintained laboratory and prepared biological media. Investigated customer drinking water complaints.

Student Intern, California State University Monterey Bay, CA, 2007-2010

Conducted field and laboratory tests and analyzed data with computer modeling simulation software to predict environmental data with various agricultural settings. Developed predictions of greenhouse gas emissions from application of fertilizer on agricultural fields. Performed stream and watershed analyses of steelhead fish population, diurnal invertebrate cataloging, urea contamination distribution, and impacts of wildfire and rain on stream erosion and meandering.

Environmental Scientist, MACTEC Engineering and Consulting, CA, 2005-2007

Prepared and implemented several phases of remedial investigation to delineate lateral and vertical extent of perchlorate in soil and groundwater for design of an onsite remediation system at the site of a former flare manufacturing facility. Perchlorate was detected in onsite soil and onsite and offsite groundwater extending 10 miles from the site and to depths in excess of 600 feet below ground surface. Supported the identification and implementation of innovative monitoring well installation techniques, in situ aquifer testing procedures, groundwater sampling methods, as well as several monitoring and evaluation programs to save the client additional future costs. Collected drinking water samples for perchlorate analysis at customer homes, businesses, agricultural pumps, and municipal wells. Sampled groundwater from monitoring wells with micro-purge, barcade, bailer, airlift, bladder pump, snap sampler, and waterra hydrolift. Measured water elevation with water level meter and transducer. Inspected and sampled ion-exchange (IX) perchlorate groundwater treatment systems. Received HAZWOPER safety training and supervised QC and safety during field activities including monitoring well drilling, sampling, and surveying activities.

Engineering Intern, City of Menlo Park, CA, 2004-2005

Sampled drinking water at customer residences, water wells, pumps, and reservoirs. Analyzed drinking water for chemical disinfectant and byproducts with a colorimeter and performed data entry and analyses. Identified system maintenance and upgrades to increase water quality within the distribution system. Performed hazardous waste disposal per applicable regulations utilizing the Uniform Hazardous Waste Manifest. Prepared a Hazard Communication Program and an Emergency Preparedness Plan for the office.

Laboratory Assistant, Yoh Scientific/ICF Consulting (USEPA), 2002-2004

Performed laboratory analyses including Total Organic Carbon (TOC), percent moisture, and alkalinity. Performed safety and QC inspections of laboratory equipment, emergency equipment, personnel, and mobile laboratory vehicle. Cleaned laboratory equipment utilizing ovens and acid washers in accordance with SOPs. Maintained SDS records and disposed of and treated hazardous waste IAW laws and regulations. Produced laboratory spiral locked notebooks. Maintained laboratory scales, thermometers, pH meters, refrigerators, and freezers. Prepared an SOP report for calibrating thermometers.

Laboratory Assistant, PTRL West, 2001

Performed laboratory analyses, sample preparation, shipping and receiving including radioactive and biological materials, and hazardous waste operations.

Mark Fisler

Field Supervisor

EDUCATION

BS, Biology, George Mason University

CERTIFICATIONS, LICENSES, TRAINING

40-Hour HAZWOPER and annual 8-Hour refresher

CA. Dept. of Health Services Water Distribution 2 and Water Treatment 2 certifications

USACE Construction Quality Management for Contractors

OSHA Construction and Safety Health

OSHA 30-Hour Construction Safety

First Aid/CPR

WORK HISTORY

Ahtna Environmental, Inc., Field Supervisor, 2015-present

Ahtna Engineering Services, Field Supervisor, 2002-2006, and 2006-2015

Harding Lawson Associates, Plant Operator, 2001-2002

Advanced Biological Testing, VP and Field Manager, 1993-2001

EXPERIENCE SUMMARY

- Environmental: 15+ years of experience on Army/DoD environmental restoration projects with expertise in the O&M of groundwater treatment plants; 3+ years of experience in the O&M of soil vapor extraction systems
- Field Supervisor: 8 years of experience directing field teams during the execution of groundwater monitoring, upgrades and repairs to GWTS at three DoD/Army installations in CA

PROJECT EXPERIENCE

Senior Plant Operator/Field Supervisor, Groundwater Treatment System Operation and Maintenance, USACE Albuquerque and Sacramento, Former Fort Ord, Marina, CA, 2002-present, $16M

Manage daily O&M of OU2 and Sites 2/12 GWTPs consisting of 27 extraction wells, four injection wells, and five infiltration galleries. Perform weekly inspections of mechanical and electrical systems, repairs and preventive maintenance, routine housekeeping, GAC change-outs, GWTS monitoring, flow regulation, and process sampling. Direct the execution of system upgrades in support of optimization. Ensure the effective management of hazardous materials resulting from a 1,000-gal tank of sulphuric acid stored at Sites 2/12. Develop daily reports.

- To-date, maintained a total maximum flow rate of 1,200-gpm for both GWTS, for an average of 95% operability since 2002
- Consistently complete work on schedule and within budget in accordance with contract requirements

Field Supervisor, Groundwater Monitoring, USACE Albuquerque, Former Fort Ord, Marina, CA, 2010-present, $10M

Oversee quarterly groundwater sampling at over 200 wells across 5,000 acres using passive diffusion bag samplers, the Westbay sampling system, and HydraSleeves. Perform routine maintenance on monitoring wells, including replacing broken or worn locks on well covers, repainting and labeling well completions, checking and recording total depth.

Senior Plant Operator, Groundwater Treatment System Operation and Maintenance, sub to Geosyntec Consultants, Hollister, CA, 2013-present, $50K

Perform operations and maintenance of a groundwater extraction system with seven extraction wells at a former explosives facility utilizing a combination of bio-reaction, sand filtration, and granular activated carbon to remove perchlorate, chromium 6+, arsenic, and volatile organic carbons. Perform sampling of all plant constituents to comply with NPDES requirements for discharge. Provide daily reports to the client within 24 hours to confirm work completed in accordance with the task list provided by the prime contractor.

- Recommended and completed four upgrades and optimization strategies within the first three months to increase productivity and reduce long-term O&M costs

- Successfully resolved an unanticipated system shutdown within a few hours of discovery, avoiding significant impact to system functionality

Field Supervisor, Groundwater Treatment System Operation and Maintenance, Riverbank Army Ammunition Plant, USACE Sacramento, Riverbank, CA, 2004-present, $8M

Oversee the operations and maintenance of the GWTP at the former Riverbank Army Ammunition Plant. Perform three phase inspection processes. Review daily field activity reports and monthly O&M reports. Manage hazardous waste streams, including treatment, handling and temporary storage, documentation, transport and disposal. Support the Project Manager in resolving any operation and maintenance issues.

- Successfully completed upgrades to an existing extraction well to increase the extraction capacity to three times the previous rate
- To-date, performed all work with zero safety incidents

Field Supervisor, Site 12 Remedial Investigation/Feasibility Study Addendum, Former Fort Ord, USACE Sacramento, Marina, CA, 2012-present, $1.2M

Manage field team performing soil gas sampling at Site 12 on the Former Fort Ord as part of the RI/FS addendum. Perform USACE three phase inspections. Work with chemistry labs to ensure the timely procurement of supplies. Support the field team in completing fieldwork in accordance with budget and schedule. Develop daily reports.

Senior Plant Operator/Field Supervisor, Soil Vapor Extraction System Operation and Maintenance, USACE Albuquerque and Sacramento, Former Fort Ord, Marina, CA, 2015-present

Manage daily O&M of Site 12 SVE System consisting of 10 vapor extraction wells. Perform daily and weekly inspections of mechanical and electrical systems, repairs and preventive maintenance, routine housekeeping, vapor extraction monitoring, flow regulation, and process sampling. Direct the execution of system upgrades in support of optimization. Develop daily reports.

- To-date, maintained a total maximum flow rate of approximately 800 cfm, for an average of 99% operability since 2015
- Consistently complete work on schedule and within budget in accordance with contract requirements
- Ensure cost efficiencies and productivity by evaluating the chemistry and identifying which of the 10 wells to run at any given time, and reducing sampling events from weekly to monthly to quarterly as appropriate
- Saved money by eliminating ambient air sampling after demonstrating through historical data collected from years working at the site, that the ambient air samples had been non-detect during the entire sampling period.

Field Supervisor, Monitoring Well Installation and Development, USACE Sacramento, Former Fort Ord, Marina, CA, 2010-2011, $1.6M

Executed fieldwork for the installation of 11 monitoring wells including lithologic logging and soil classification during drilling, and groundwater sampling and analysis. Managed IDW, including disposal of drill cuttings/soil core, in accordance with applicable laws and regulations.

- Successfully completed the work three months ahead of schedule and within budget, despite the challenges of working in and around an active airport and residential areas, and habitat reserve

Charles Holman

Vice President, Southwest Environmental Operations

EDUCATION

Graduate, Structural Design, Heald Institute of Engineering, 1978

CERTIFICATIONS, LICENSES, TRAINING

NQA-1 Certified Lead Auditor

40-Hour HAZWOPER and 8-Hour Refresher

USACE Construction Quality Management for Contractors

DOT Certification

WORK HISTORY

Ahtna Environmental, Inc., Environmental Program Manager, 2016-present

Ahtna Engineering Services, LLC, Environmental Program Manager, 2009-2015

Ahtna Government Services Corporation, Environmental Program Manager, 2006-2009

TN&A, Inc., Senior Technical Manager, 2003-2006

Shaw Environmental IT Corporation, Construction and QC Management, 1996-2003

Parsons Brinckerhoff, Nuclear Quality Services, 1986-1996

Kaiser Engineers, Construction Management, 1977-1986

EXPERIENCE SUMMARY

- 38 years of experience including 28 years working for the DoD and DOE on environmental engineering and construction projects located nationwide
- 15 years of program management experience on DoD/Army environmental contracts; managed multiple contracts valued at over $100M to-date; successfully procured $16M in DoD/Army sole source awards in 2013 as a result of outstanding performance and strong client relationships; maintained 100% repeat business with the AEC and USACE SPD, consistently performing quality work at individual sites for over 10 years
- 15 years of project management experience overseeing all technical execution of environmental restoration projects, QA/QC, project controls, and personnel management; managed projects/task orders exceeding $1B in total value
- Received multiple letters of recognition for outstanding work and client service for work performed at the Former Fort Ord and Riverbank Army Ammunition Plant: "…Without exception, Ahtna has provided the Fort Ord BRAC office with the highest degree of expertise and professionalism."
- More than doubled the growth of SWE operations from one office with five employees to three offices and 30 employees, with cumulative revenues of over $150 million

PROJECT EXPERIENCE

Vice President, Southwest Environmental Operations, Pleasant Hill, CA, 2015-present

Direct a team of 30 staff in the development and execution of USACE and USAEC programs across the southwest U.S. (CA, NV, NM, AZ) with an annual budget of $25M. Oversee the development of cost bids for negotiated and sole source contracts. Develop and maintain client relationships within the USACE SPD and USAEC, achieving 100% repeat business rate to-date. Manage staff resources in multiple locations to maintain an average of 89% utilization.

Program Manager, Two MESA IDIQs, USACE Los Angeles, AZ and CA, 9/2013-present, $20M

Direct the planning and execution of 12 environmental and engineering support services task orders (to-date) varying in size and complexity from a $30K geophysical survey to a $4.5M major auger excavation and a $5.8M soil removal at a high profile FUDS. Manage client relations. Review and approve work plans. Identify and allocate resources to meet project requirements. Ensure contractual, safety, and quality requirements and expectations are exceeded on all task orders.

Program Manager, Environmental Remediation Services IDIQ, USACE Sacramento, Multiple Locations, CA, 2006-present, $23M

Oversaw 40 TOs under four consecutive contracts to provide environmental services at multiple Army installations including O&M/optimization of GWTPs, groundwater sampling and analysis/monitoring, and the development of SWMPs. Direct the development of project estimates. Perform resource allocation and client communications. Oversee project teams for the timely and cost-effective completion of all work including project reports in accordance with plans. Develop and maintain relationships with regulators and ensure compliance with all requirements.

- Commended by Robert Smith, BRAC Environmental Coordinator: "I would like to congratulate and thank you for the exceptional professionalism and customer service I have received from Ahtna for the last three years…[I] look forward to working with [Ahtna] in the future."

Program Manager, Environmental Services IDIQ – Former Fort Ord, USACE Albuquerque, Marina, CA, 2010-present, $10M

Oversee the execution of FFP environmental quality and restoration projects at the Former Fort Ord, including development of hazardous materials management storage plans at the GWTP, O&M, remedial system construction, and document production. Manage government client and stakeholder relations with the USAEC, USACE, and US Army/FFO. Ensure the delivery of all work in accordance with quality, safety, and performance standards and expectations.

- Consistently complete work on schedule and within budget and in accordance with contract requirements
- Performed all work to-date with zero recordable or reportable injuries to-date

Ahtna Government Services Corporation/Ahtna Engineering Services, LLC (Ahtna), Environmental Program Manager

As the senior cost center manager for nationwide environmental operations, managed identification of opportunities, evaluated teaming options, developed proposals, and managed program start up through reporting and turnover. Achieved significant departmental growth, development of an employee mentoring plan, and consistent high evaluations from clients. Worked as an integral part of the company senior management team helping to keep this small disadvantaged business on the leading edge of technological and managerial excellence. Projects include the development and implementation of SWPPPs, groundwater treatment systems, construction, operations and maintenance (O&M), demolition, soil removal actions, and groundwater monitoring, reporting, and analysis. Specific Ahtna projects include the following:

Program/Project Manager, Pacific Gas and Electric Company Storm Water Pollution Prevention Services and Support, Various Locations, CA, 2009-2011, $2.6M

Directed multiple T&M, not-to-exceed projects to prepare, install, monitor and inspect a variety of SWPPPs. Managed 14-person team to perform full services from determination of BMPs, SWPPP development/approval, BMP implementation, and preparation and processing of NOTs. Interfaced daily with client. Monitored cost/schedule. Executed 29 projects at sites across California, with an average of 10 projects managed concurrently.

- Completed all work in compliance with 1 and 2 Risk/Type Levels for General Construction and Linear Underground/Aboveground Projects in accordance with permitting requirements

BMPs have included erosion control, sediment control, tracking control, wind erosion control, non-storm water management, and materials and waste management controls. The SWPPPs also featured appropriate BMP "cut-sheets" identifying installation, inspection, and maintenance requirements. Provided water pollution control drawings showing the recommended temporary BMPs. The SWPPPs included sampling and analysis plans for construction storm water monitoring for non-visible pollutants, sediment, siltation, and/or turbidity pollutants.

Program/Project Manager, Performance-Based Multiple Award Contract (PERMAC) for Environmental Remediation Services at Naval and Marine Corps Installations in California, Arizona, Nevada, New Mexico, and Utah, NAVFAC Southwest (Sub to AMEC), 2008-2009, $13M

- Camp Pendleton, Pesticides Soil Treatment/Removal, 400,000 cy, 370-acre soil removal. Mobilization and startup had to be accomplished in a very short time frame to support federal reconstruction funding requirements. Successfully mobilized including 14 pieces of heavy equipment and all operators and engineers and began operations within 2 weeks of NTP
- Moffett Naval Air Station, Hangar 1 Demolition Engineering Support, PCB contaminated Hangar Demolition
- Alameda Naval Air Station, Sites 1 and 2 Soil Remediation, landfill excavation, waste management and backfill immediately adjacent to the SF Bay

Nuclear Quality Services Director, Parsons Brinckerhoff, California

As Quality Services Director for the nuclear services division on DOE Projects, planned, budgeted, staffed, and assessed performance of QA/QC functions for all 4 high-level nuclear waste programs. Performed contract reviews, developed QA and PM procedures, completed audits and surveillance, and kept senior management advised of project performance. Developed and ensured implementation of all NQA-1 based quality programs, companywide.

- Successfully procured $500M project to perform QA/QC and engineering support for the exploratory tunnel construction at Yucca Mountain including repository design and exploratory studies facilities construction, construction of all radioactive waste conveyance systems and facilities, and ensuring that the disposal facilities met regulatory requirements
- Basalt waste isolation project, exploratory studies facilities (ESF), and repository design, including the assessment of radiological waste migration prevention measures and background surveys for naturally occurring radioactive constituents
- Salt project, ESF design, including designs for all radioactive waste isolation systems
- Waste isolation pilot project, sealing systems design, including performance monitoring of the test sealing and containment systems for radioactive leaks

Senior Technical Manager, TN and Associates Inc.,

Senior Technical Manager, Hunters Point Shipyard, Tetra Tech ECI, San Francisco, CA, $4M

Managed radiological remediation project including the production of high quality planning documents responsive to radiological and environmental regulatory standards, construction of SWPPP and BMPs for the excavation, regrading, and site restoration for $70M of cleanup activities.

- Successfully obtained approvals for HPS documents involving a complex set of regulations, working collaboratively and proactively with the EPA, DTSC, Water Board, Fish and Wildlife
- Completed all work on time and on budget

Shaw (IT) Environmental

Site Manager, Environmental Compliance, Alameda Naval Air Station, Alameda, CA

Manage environmental compliance and restoration work. Developed work plans, including SWPPP, QC, and Health & Safety Plans. Ensured NPDES SWPPP field compliance, and managed field construction, subcontractors, sampling, QC, Health and Safety, T&D of the soil and groundwater. Obtained Navy and regulatory (EPA, DTSC, and Water Board) approval of the plans governing construction and remediation operations for the groundwater analysis, design, and construction of dual-vapor extraction systems for removal of free hydrocarbon products.

- Successfully led the completion of more than $23M in remedial actions at Alameda and received commendations from the Navy

Construction Manager, Sulphur Bank Mercury Mine Superfund Site, USEPA, Clear Lake, CA

Managed the construction of a 36” diameter, mile-long storm water diversion pipeline at an abandoned mercury mine. The construction was completed in hazardous conditions on time and within budget.

Senior QC Manager, Fort Ord, Monterey, CA, $50M

Managed a support staff of more than 20 people during the execution of a $50M project. Oversaw SWPPP compliance inspection, chemistry, sampling, and document control. Worked extensively with client, regulators (EPA and DTSC), and responsible parties to facilitate cost-effective land transfer. Completed base-wide SWPPP compliance; installation, testing, and startup of a base-wide groundwater pump and treat system; consolidation of existing US Army landfills into a single facility; completion of a 28-acre landfill cap; removal, transportation, screening, and recycling of more than 285,000 cy of lead soils from the beach ranges.

- Successfully addressed all management and technical concerns of the client and was commended by the USACE Program Manager, Mr. Steve Lightner, for contributions to the successful turnaround of this major environmental undertaking

QC Manager, Presidio of San Francisco, San Francisco, CA

Managed the development and implementation of plans for both field and technical activities, ensuring balance between client needs and regulators (DHS, EPA and DTSC) in a highly charged political atmosphere. Managed the field technical staff, technicians, document control staff, and sampling groups. This project involved planning, field activities, and preparation of closure reports necessary to receive regulatory approval for turnover of multiple properties including the Crissy Field soil remediation, the fuel distribution systems pipeline removal and soil remediation, the Nike Missile Silos lead abatement and water treatment, and the Fill Site 7 soil and groundwater remediation.

- Successfully completed the remedial actions to allow the base to be turned over to the Presidio Trust

QC Manager, Hamilton Army Airfield, Novato, CA

Managed the review and approval of site closure documents including Work Plans, Sampling and Analysis Plans, Risk Assessment Reports, and Closure Reports.

Field Supervisor, Kaiser Engineers, CA

Supervised mechanical systems design, construction supervision, and QA/QC. Successfully performed the following:

- Basalt nuclear waste isolation project, ESF design/construction, including all natural and engineered high-level radioactive waste barriers
- ICBM basing research, construction
- VALCO aluminum smelter, construction and capital improvements
- Mechanical design, various industrial facilities

Ahtna

Sylvester Kosowski

Project Manager/Senior Environmental Scientist

EDUCATION

MS, Civil & Environmental Engineering, University of Wroclaw Poland

MS, Hydrogeology, University of Wroclaw Poland

BS, Geotechnical Engineering, University of Wroclaw Poland

CERTIFICATIONS, LICENSES, TRAINING

24-Hour Hazardous Waste Generator Training and 8-Hour Annual Refresher Training

40-Hour HAZWOPER & 8-Hour Refresher

OSHA 30-Hr Construction Safety Training

WORK HISTORY

Ahtna Environmental, Inc. Project Manager/Senior Environmental Scientist, 2016-present

T3W Business Solutions, Inc., Senior Project Manager, 2011-2016

Jacobs Technology, Inc./Jacobs Engineering, Inc. Senior Project Manager, 2008-2011

General Dynamics Information Technology (GDIT)

Remedial project Manager, 2006-2008

Tybrin Corporation, Senior Remediation Project Manager, 2000-2006

Laidlaw Environmental/Safety-Kleen, (California), Inc.

Project Manager, 1997-2000

Remedial Management Corporation,

Vice President Engineering

EXPERIENCE SUMMARY

- 30 years in environmental consulting including 16 years in program management with expertise in all phases of the environmental assessment and remediation in the United States within different EPA regions.
- Well-qualified Environmental Program and Project Management Leader with extensive experience in the development and execution of domestic and international remediation and compliance programs and projects that have significantly improved productivity and environmental quality while reducing operating costs for major domestic and international private companies and government agencies.
- Assists in negotiating cleanup and remediation strategies and technical approaches with regulators to secure cost-effective remediation and accelerated, risk based site remediation and closures.
- Oversees field teams including multiple subcontractors conducting soil/groundwater assessments, groundwater monitoring/sampling, SVE O&M, groundwater extraction system O&M, post-closure landfill O&M, in situ chemical injection, demolition, bioremediation, bio augmentation, land farming, and remedial landfill cap installations.
- Manages CERCLA remediation program and project-specific activities and oversees performance of the remediation project and program specific activities including technical document deliverables. Reviews remedy specific operations and monitoring to optimize remedies performances.

PROJECT EXPERIENCE

Project Manager/Senior Environmental Scientist, Sharp Army Depot Groundwater and Soil Remediation, USACE Sacramento, Lathrop, CA 5/2016-present, $ 10 M

Manages CERCLA remediation program and project-specific activities and oversees performance of the remediation project and program specific activities including technical document deliverables.

- Reviews remedy specific operations and monitoring to optimize remedies performances. Manages and supervises program and project specific staff and contractor personnel.

- Assists in negotiating cleanup and remediation strategies and technical approaches with regulators to secure cost-effective remediation and accelerated, 1993-1997

Canonie Environmental Corporation

Project Engineer/Project Manager 1989-1993

International Technology Corporation (IT)

Staff Engineer/Hydrogeologist 1986-1989

risk based site remediation and closures.

- Ensures remediation and remedy performance and monitoring activities are performed in accordance with applicable laws, guidelines and regulations. Recommends optimization approaches to remedial process and remedy operations and long term monitoring.
- Performs business development activities and assists in proposal preparations.
- Oversees personnel during field remediation and monitoring activities.

Senior Project Manager, RCRA Hazardous Waste Facility Management and IRP Program Support, NAF El Centro CA, NAVFAC SW San Diego, CA, 2011–2016,
$ 6.0 M

Directed program and project-specific activities and oversaw performance of the compliance and restoration program activities. Oversaw and participated in business development activities, including meetings, presentations and proposal preparation and oversight. Managed and supervised program and project staff and contractor personnel. Negotiated cleanup and remediation strategies and technical approaches with regulators to secure cost-effective remediation and accelerated, risk based site closures. Ensured compliance and remediation activities are performed in accordance with applicable laws, guidelines and regulations.

- Prepared and implemented Environmental Assessment, Remediation, Compliance, Solid and Hazardous Waste Management Plans, and Storm Water Pollution Prevention and Spill Prevention, Control and Countermeasure (SPPCC) Plans. Prepared water quality, surface water and treated groundwater discharge monitoring plans. Ensured compliance with all Federal (US EPA), State and Local environmental regulations pertaining to soil, storm water, air emissions and water quality.
- Provided support to project management, field remediation, compliance and construction personnel. Ensured storm water is managed and discharged in accordance with the General Permit to Discharge under the National Pollutant Discharge Elimination System (NPDES), State Pollutant Discharge Elimination System, and County

requirements.

- Ensured compliance and remediation systems at installations are managed with state and county specific air emissions permits and discharge requirements. Interacted with regulatory agencies to negotiate cleanup strategies based on risk based and cost-effective cleanup goals and objectives. Supported the client(s) at the meetings with regulatory agencies negotiations. Advised clients and supporting contractors on changes to compliance and restoration program approaches and strategies in order to optimize programs performance. Provided recommendations on how to implement new approaches, strategies, and technological advances to minimize waste generation activities at the installations.

Senior Project Manager, Site 25 OU8 and Multiple Sites in OU5, OU 10 and OU 8 RI/FS, PP, ROD, IRAs RD, RA, RAO and LTM, AFCEE/AFCEC San Antonio, TX, Edwards Air Force Base, Edwards, CA, 2008-2011,

$ 10 M

Maintained client relationships, directed and oversaw environmental remediation program and project work to maintain high technical and high quality control standards. Managed, mentored and supervised program and project specific personnel. Participated in business development activities, including meetings, presentations, proposal preparation, and oversight. Directed and oversaw preparation of budgets, and monthly status reports. Conducted due diligence activities, contaminated site investigation, remediation, regulatory compliance, permitting, and storm water management. Directed, performed and oversaw work in regulatory compliance for landfills and other solid waste projects.

- At Edwards Air Force Base (EAFB) in California, worked with Environmental Restoration operations, including program and project specific components. Performed the Environmental Restoration Program, Planning, Budgeting and Execution. Assisted in developing cleanup strategies and participated in cleanup strategies negotiations with regulatory agencies. Developed engineering cost estimates and scope of works (SOW).

- Provided program and project management, engineering support, and technical assistance for the Operable Units (OUs), on complex, Comprehensive

Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation Recovery Act (RCRA), Military Munitions Response Program (MMRP), Underground Storage Tank (UST) investigation, assessment, and remediation projects. Oversaw and performed technical reviews of Environmental Restoration documents.

- Reviewed new restoration and compliance mitigation technologies, and provided recommendations on how to implement restoration Research and Development (R&D) activities at Edwards AFB. Provided sub-consultants and subcontractors management and oversaw their performance via field surveillance activities. Served as a senior remedial project manager for OUs 5, 10 and OU8.

Remedial Project Manager, Multiple Sites in Multiple OUs RI/FS, PP, ROD, IRAs RD, RA, IRAs, RAO and LTM, NAVFAC SW and BRAC PMO West San Diego, CA, NWS Seal Beach Detachment Concord, CA, 2006-2008, $ 10 M

Served as client manager to direct and oversee environmental services program and project work to maintain high technical and high quality control standards. Participated in business development activities, including meetings, presentations, proposal preparation, and oversight. Managed and supervised program and project-specific staff personnel. Directed and oversaw preparation of budgets, and monthly status reports. Managed and mentored contract and task specific personnel and client(s). Interacted with regulators and clients to negotiate cleanup strategies and associated cleanup goals and objectives. Conducted due diligence assessments, contaminated site investigation, remediation, regulatory compliance, permitting, and storm water management. Directed, performed and oversaw work in regulatory compliance for landfills and other solid waste projects.

- Provided vision and direction as the Remedial Project Manager (RPM) at Naval Weapons Station Seal Beach Detachment Concord (NWSSB) Tidal and Inland Areas, in Concord, California.

- Assisted at Base Realignment and Closure Program Management Office (BRAC PMO West) in San Diego with the Installation Restoration Program/Environmental Restoration Program (IRP/ERP) Division operations by providing program and project management, engineering advisory support, and technical assistance on complex Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation Recovery Act (RCRA), Military Munitions Response Program (MMRP), and Underground Storage Tank (UST) investigation, assessment and remediation projects.

- Directed, oversaw, and performed technical reviews of IRP/ERP Remedial Investigation (RI), Feasibility Study (FS), Proposed Plan (PP), Record of Decision (ROD), Remedial Design (RD), Remedial Action (RA), Operations and Maintenance (O&M), Remedial Process Optimization (RPO), and Long Term Monitoring/Management (LTM) documents. Managed and provided oversight of the IRP/ERP contractors during the performance of field investigations, treatability and/or feasibility studies, remediation design and system optimization, remedial action, and long term management activities under CERCLA, RCRA, MMRP, and LUFT programs.

- Interacted with the regulatory Remedial Project Managers (RPMs), Restoration Advisory Board (RAB) members and other stakeholders during the program and project management planning and execution meetings and activities. Developed engineering cost estimates and scope of works (SOW).

Senior Remediation Project Manager, OU4 and OU 9 AFRL RI/FS, PP, ROD, IRAs RD, RA, RAO and LTM, AFCEE/AFCEC San, AFCCE San Antonio, TX, Edwards AFB, Edwards, CA, 2000-2006, $ 30 M

Worked with Environmental Restoration Division (ERD) operations by providing program and project management, engineering support, and technical assistance for the Operable Units (OUs 4 & 9), on complex Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation Recovery Act (RCRA), Munitions Response Program (MRP), and Underground Storage Tank (UST) investigation and remediation projects. Reviewed new restoration technologies, and provided recommendations on how to implement restoration Research and Development (R & D) at Edwards AFB. Developed engineering scope of works and cost estimates.

- Advised ERD on changes to technical documents to avoid receiving similar comments from the regulatory agencies and other reviewers. Provided surveillance of ERP contractors during the performance of field investigations, treatability and/or feasibility studies, remediation systems implementation, maintenance, operation, remedial systems optimization, and long term monitoring activities.

- Assisted ERD team in developing multiple risk based cleanup strategies leading to multi million dollars in remediation cost avoidance. Maintained and assimilated detailed technical information for tracking progress and efficiency of ERP projects. Performed remedial action (RACER) cost estimates. Prepared OU4 and 9 project funding narratives and associated cost estimates.

Project Manager, Multiple Private and Government Clients, Los Angeles, CA, 1997 – 2000, $ 12 M

Responsible for project management, client relations, and interaction with Federal, State, and local regulatory agencies to meet all requirements associated with hazardous waste removal, treatment, and remediation. Assisted with business development activities, proposal preparation, estimates, bids and maintained cost controls, community and client relations. Won multiple bids and contributed to a company gross revenue increase. Served as project manager and task (TO) and/or DO manager on a variety of private and government projects. Met with clients on a regular basis to provide updates regarding status of the projects and discuss scope of work of the projects.

- Directed, oversaw and performed technical review of documents that involved site investigations (RI/FS), remedial design and implementation (RD/RA), and Long Term Operation/Long Term Monitoring (LTO/LTM) associated with soil and groundwater remediation systems. Managed and oversaw development of work plans, remedial investigations, engineering design and remediation to comply with CERCLA, RCRA and LUFT laws, guidelines and regulations. Supervised, trained and mentored staff geologists, engineers and technicians.

Vice President Engineering, Multiple Private and Government Clients and Projects, Schaumburg IL, and Newport Beach, CA, 1993-1997, $ 10 M

Acted in charge of P&L and overall financial performance of the RMC

Schaumburg, Illinois office. Involved in development and implementation of strategic plans to establish and grow the business in Midwest and Europe. Directed and conducted marketing and business development activities to identify new domestic and international opportunities. Oversaw and participated in domestic and international contract, teaming and joint venture partnering activities and negotiations. Established an office for the environmental services consulting company in Midwest.

- Managed, mentored and supervised program and project specific RMC personnel in Schaumburg, Illinois office. Participated in business development activities. Acted as program account manager and client(s) representative/liaison during program and project execution activities, and negotiations with regulatory agencies.
- Managed and prepared business development proposals and cost estimates for the removal and treatment of contaminated soil and groundwater. Managed and oversaw the assessment of contaminant extent and design of soil and groundwater remediation systems. Directed and oversaw preparation of hydrogeological and engineering reports to ensure technical quality and thoroughness.

Project Engineer/Project Manager, Multiple Private and Government Clients and Projects San Mateo, CA, 1989 – 1993,

$ 5.0 M

Served as project engineer and project manager and worked on private sector NPL, CERCLA and RCRA investigation and remediation projects such as industrial and landfill facilities. Prepared hydrogeological, design and remediation engineering reports. Reviewed and prepared applications for the NPDES permits. Planned and performed hazardous waste investigations, design and remediation under CERCLA, RCRA and LUFT regulations. Prepared landfill cap and liner design, closure and post closure reports. Participated and assisted in business development activities including meetings, presentations and proposal preparation. Evaluated NPL site investigation and remediation decision documents (RI/FS) to identify data gaps relating to selection, design and implementation of future potential remedies.

- Directed and prepared conceptual remedial and corrective action plans (RAPs and CAPs), engineering design, and construction plans and specifications. Investigated, selected and implemented RCRA corrective action programs associated with hazardous waste management facilities.

- Investigated and designed Class I surface impoundments and landfills meeting RCRA minimum standards. Developed surface impoundments and landfill cap and liner design and implemented closure and post closure plans.

Staff Engineer/Hydrogeologist, NPL Site Former Firestone Plant Salinas, CA, 1986-1989, $ 2.0 M

Worked as staff engineer and hydrogeologist on a National Priority List (NPL) site in Salinas, CA. The site was a former Firestone Site (Superfund Project). The project included additional site assessment, remedial design, remediation construction and site remediation, O&M, and LTO/LTM associated with a large full scale pump and treat system (800 gpm).

- Conducted pump tests for different types of aquifers, data analysis due to pumping tests and evaluation of hydrogeological characteristics for shallow and deep aquifers. Prepared technical hydrogeological and engineering reports.

- Performed data analysis of hydrological, hydrogeological and geotechnical parameters of the aquifers affecting groundwater and well hydraulics, their planning, design and construction. Evaluated groundwater flow directions, shallow and deep aquifers contour maps. Performed soil, treatment plant, surface and groundwater sampling.

Ahtna

Derek Lieberman, PE

Senior Project Manager/Regulatory Specialist

EDUCATION

MA, Science, Technology, and Public Policy, The George Washington University Elliott School of International Affairs, 2002

Master of Environmental Management, Yale University, School of Forestry and Environmental Studies, 2000

BS, Engineering (Geological Engineering), Purdue University, 1989

REGISTRATIONS

Professional Engineer, Civil Engineering, California #C57417

Qualified SWPPP Developer/Practitioner (QSD/QSP) CA#20527

CERTIFICATIONS, LICENSES, TRAINING

40-Hour HAZWOPER

8-Hour HAZWOPER Refresher

Supervisory Hazardous Substances/Waste Health and Safety, 1994

Health and Safety Training and Field Experience for Hazardous Materials Operations, 1994

U.S. Army CHPPM Advanced Health Risk Communication Training, 2004

Defensive Driving Techniques, 2010

Confined Spaces, 1992

OSHA 30-hour Construction Safety, 2013

DOT Hazmat Employee, 2013

USACE Construction Quality Management for Contractors, 2011

WORK HISTORY

Ahtna Environmental Inc., Senior Project Manager, 2015 – present

Ahtna Engineering Services, LLC, Senior Project Manager,

EXPERIENCE SUMMARY

- 23 years of engineering experience in environmental remediation services (ERS), including soil, soil gas and groundwater remediation, CERCLA (as amended by SARA)/RCRA/BRAC sites, and geotechnical investigation, design and construction oversight
- 13 years of experience managing the preparation of analytical and descriptive reports and property transfer documentation
- 12 years of experience in Community Relations, delivering presentations on behalf of the U.S. Army regarding the status of the groundwater remediation program at the former Fort Ord at the U.S. Army's Community Involvement Workshops, Technical Review Committee meetings, Open House events
- 10 years of experience managing operations and maintenance (O&M) of full scale groundwater treatment systems (GWTS) and soil vapor extraction and treatment systems (SVETS), including system optimization and QC oversight of construction, documentation and environmental sampling
- In-depth experience with the CERCLA process, including development of Decision Documents and use of EPA's Guide to Preparing Superfund Proposed Plans, Records of Decision, and Other Remedy Selection Decision Documents
- Commended by Gail Youngblood, BRAC Environmental Coordinator: "No listing of Ahtna's personnel would be complete without Derek Lieberman, whose breadth of knowledge about remediation systems, Fort Ord history, and the ins-and-outs of transferring property have helped Fort Ord reach the point of having transferred the vast majority of property available for redevelopment."

PROJECT EXPERIENCE

Director, Environmental Services, Former Fort Ord, Multiple Consecutive USACE Sacramento and Albuquerque Districts, Marina, CA, 2008-present, $10M

Manage seven environmental technical onsite staff performing FFP ERS, including development of hazardous materials business plans (HMBP), remedial system construction and O&M, reporting, preparation of CERCLA documents and UFP-QAPPs. Provide expertise on CERCLA/RCRA issues. Update the HMBP describing procedures for emergency response for hazardous materials (sulfuric acid and compressed helium) stored at the groundwater treatment plants (GWTP) in accordance with the requirements of the local California Certified Unified Program Agency. Maintain hazmat storage facilities in compliance with laws/regulations and received no notices of violation (NOVs). Participate in regular meetings with the U.S. Army Environmental Command (AEC), USACE, regulatory agencies and the public to provide technical and regulatory expertise on ERS in accordance with CERCLA/RCRA.

Project Manager, O&M of GWTS and SVETS, Former Fort Ord, Multiple Consecutive USACE Sacramento, Marina, CA, 2007-present, $20M (multiple consecutive awards)

2007 – 2015

J.M. Waller Associates, Inc., Senior Environmental Compliance Specialist, 2003 – 2007

U.S. Department of Agriculture, Economist, 2001 – 2003

The Tahoe-Baikal Institute, Environmental Exchange Participant, 2000

Harding Lawson Associates (now Amec Foster Wheeler), Project Engineer, 1991 – 1999

Herzog Associates (now defunct), Assistant Engineer, 1989 – 1991

Direct O&M of two GWTS, which include 32 extraction wells, 4 injection wells and 4 infiltration galleries, and one SVETS, which includes 10 extraction wells. All three systems use granular activated carbon (GAC) as the primary treatment technology for VOCs. Prepare and review programmatic documents, including project management plan, O&M manuals, project schedule, UFP-QAPPs, and site-specific Accident Prevention Plan (APP). Directed construction and commissioning of automated sampling and analytical platforms, including integration w/SCADA system to allow real-time automated decision-making for GWTS operations. Develop all work plans, QC/safety plans. Monitor productivity, cost/schedule and provide progress reports. Oversee implementation of USACE three-phase inspection process for ERS and remedial system construction. Perform data validation, database management, and reporting, which includes quarterly O&M status and monitoring summary reports, and an annual effectiveness evaluation report. Manage accumulation, manifesting and shipment of wastes in the form of spent GAC.

- Successfully operated both GWTS at over 99% cumulative operability since 2007
- As of December 2015, treated over 8.5 billion gallons of contaminated groundwater while maintaining plume capture; discharged treated water per CWA requirements with no NOVs
- Successfully operated the SVETS at over 99% cumulative operability since startup in September 2015
- Discharged treated air per CAA requirements with no NOVs

Project Manager, O&M of Landfills and Landfill Gas Extraction and Treatment System, Former Fort Ord, USACE Sacramento, Marina, CA, 2015-present

Direct O&M of five landfill areas and a landfill gas (LFG) extraction and treatment system, which includes 35 extraction wells, LFG collector pipes, and a thermal treatment unit (TTU) as the primary treatment technology for methane and VOCs. Prepare and review programmatic documents, including O&M manual, project schedule, UFP-QAPP, and site-specific APP. Develop all work plans, QC/safety plans. Monitor productivity, cost/schedule and provide progress reports. Oversee implementation of USACE three-phase inspection process for O&M activities. Perform data validation, database management, and reporting, which includes monthly O&M status and LFG monitoring reports, and an annual O&M and regulatory compliance monitoring report.

- Successfully operated the TTU at over 99% cumulative operability since September 2015
- Discharged treated LFG per CAA requirements with no NOVs
- Successfully managed LFG in compliance with California Code of Regulations Title 27

Senior Environmental Engineer, Optimization of GWTS and SVETS, Former Fort Ord, Multiple Consecutive USACE Sacramento Environmental Services Contracts, Marina, CA, 2007-present

Provide engineering and regulatory expertise to identify cost-saving measures to be implemented at the GWTS (e.g., waste minimization and waste management). Evaluate quarterly analytical and operational data and modify GWTS and SVETS operational parameters accordingly (e.g., extraction wells were operated based on specific decision rule criteria). Employ groundwater modeling to evaluate GWTS effectiveness and capture analysis to optimize the operation of extraction and injection wells. Evaluate new technologies for potential application to the GWTS and SVETS. Present optimization recommendations to the USACE for implementation with regulatory agency approval.

- Optimized GWTS operations through decision rules that maximize GAC lifecycle, confirm plume capture and remediation progress, and significantly reduce sampling frequency
- When an air stripper was installed as a polishing step after GAC treatment at the Sites 2 and 12 (2/12) GWTP, determined the air stripper effectively treated specific contaminants that were not efficiently treated by GAC. This allows for continuous operation until the GAC capacity is maximized for trichloroethene (TCE), the primary chemical of concern at Sites 2/12, reducing the need for GAC change-outs from once every 8-12 weeks to once every 19-23 months; decision rules were approved by regulatory agencies and subsequently modified and applied by other contractors at the former Fort Ord
- Performed a cost benefit analysis to determine the feasibility of relocating the Operable Unit 2 (OU2) GWTP to an area with the highest concentrations of contaminants in groundwater; determined that moving the GWTP in combination with installing new extraction wells and groundwater recharge structures would reduce the time to achieve remedial action objectives by 10 years, thereby reducing costs by almost 50% over the life of the project; based on these findings, the Army is proceeding with the project

Project Manager/Environmental Engineer, Installation of Monitoring Wells, Former Fort Ord, USACE Sacramento, Marina, CA, 2010-2011, $1.6M

Designed and executed the installation of 11 monitoring wells up to 450 feet deep in support of a monitored natural attenuation groundwater remedy in a deep aquifer. Developed a well installation work plan that included a SAP and an Environmental Protection Plan to address well installation in protected habitat areas that include several federally listed species and species of concern. Implemented a high level of quality control through all phases of well construction, including determining well locations, borehole logging, well design by a registered professional hydrogeologist, well casing and screen installation, well development, and installation of the Westbay sampling system. Coordinated all work with multiple stakeholders including: the Fort Ord BRAC Office Biologist to minimize impact to protected habitat; the Army to avoid impact to residential neighborhoods, and the municipality, airport staff, and the Federal Aviation Administration to avoid impact to airport operations.

- Completed the project three months ahead of schedule, and with no impact to residents, airport operations, or critical habitat

(of the 11 wells, two are located in the habitat area, four in residential areas, and one at an airport)

- Successfully worked with the Army, regulatory agencies and University of California (habitat reserve managers) to complete the work plans and obtain the necessary permits to allow work to start the first week of December, complying with the Army's request to start drilling no later than December to avoid impact to protected plant species (the growing season for sand gilia and Monterey spine flower is approximately December through May)

Project Manager, Groundwater Monitoring Program, Former Fort Ord, USACE Sacramento, Marina, CA, 2010-present, $900K

Manage quarterly groundwater sampling at over 150 wells on the former Fort Ord using passive diffusion bag samplers (PDS), the Westbay sampling system, and HydraSleeves. Analyze groundwater samples for organic and inorganic compounds in accordance with the approved Quality Assurance Project Plan (QAPP). Measure and record water level elevations with respect to established survey control points. Use data to optimize GWTS operations.

Project Manager, Soil Gas Investigation and Vapor Intrusion Analysis, Former Fort Ord, USACE Sacramento, Marina, CA, 2008-2009, $30K

Developed a work plan, SAP, and Activity Hazard Analysis to conduct a soil gas investigation within an area proposed for residential development at the former Fort Ord. Used the investigation data to perform a screening level assessment of the vapor intrusion pathway using DoD guidance documents (Tri-Services Handbook for the Assessment of the Vapor Intrusion Pathway) and the DTSC Human and Ecological Risk Division (HERD) version of the EPA Vapor Intrusion (Johnson and Ettinger [J&E]) Model (HERD Model), which contains the toxicity criteria acceptable to the DTSC. Based on the analytical and HERD Model results, the site passed a site-specific J&E evaluation; therefore, no further consideration for indoor air risk was necessary and the site continues to meet No Action conditions.

Community Relations Specialist, Former Fort Ord, USACE Sacramento, Marina, CA, 2004-present, $250K (multiple awards)

As a recognized subject matter expert with effective communication skills, provide community relations representation on behalf of the U.S. Army for environmental work at former Fort Ord. Deliver presentations regarding the status of the groundwater remediation program at the former Fort Ord to the public at the Army's Community Involvement Workshops (CIW), Technical Review Committee (TRC) meetings, and Open House events.

Environmental Compliance Manager, Property Transfer, Former Fort Ord, USACE Sacramento, Marina, CA, 2003-present, $450K (multiple awards)

Provide technical support to U.S. Army BRAC Fort Ord Office for property transfer documentation including producing reports and documents, and responding to regulatory agency and public comments concerning property transfer and real estate issues as they relate to the environmental remediation program. Draft deeds for transfer of former Fort Ord property in accordance with the Army's Model Deed and the Department of Defense Instruction Number 4165.72. Provide technical support for USACE legal review of the deeds including preparing or reviewing draft deed revisions and memorandums, coordinating receipt of legal descriptions and other deed exhibits, responding to comments and questions from USACE and property recipients regarding environmental and technical components of the deed, and tracking the progress of deed execution and recordation. With expertise in institutional controls for real estate transactions, prepare and coordinate Covenants to Restrict Use of Property (CRUPs) to be executed by the Army and the State of California for application and enforcement of land use controls on former Fort Ord property. Prepare documentation required to obtain RCRA Corrective Action Complete Determination (CACD) from DTSC for all transferred property where remedial action is complete.

- Completed Findings of Suitability to Transfer (FOST) in accordance with the Army's Model FOST for former Fort Ord property impacted by munitions and explosives of concern (MEC)
- Due to the policy complexities associated with MEC at CERCLA sites, participated in successful negotiations between the Army's Environmental Law Division and Office of General Counsel, EPA and DTSC to resolve issues pertaining to the environmental condition of the property and the appropriate section of CERCLA under which the transfer should occur
- Reviewed and commented on land use control implementation plans (LUCIPs) for munitions response areas (MRAs) at the former Fort Ord, which ensured conformity between the LUCIP and the requirements of the deed under CERCLA
- Established the procedure for issuing the CERCLA Warranty for early transfer property where CERCLA remedial actions are complete

Environmental Compliance Manager, CERCLA Decision Documents, Former Fort Ord, USACE Sacramento, Marina, CA, 2006-2010

Completed two Explanations of Significant Differences (ESDs) to the Operable Unit 1 (OU1) ROD and the OU2 ROD at the former Fort Ord. Successfully coordinated with the regulatory agencies and obtained signatures from all the parties on behalf of the Army. The OU2 ESD was particularly complex and addressed several areas of concern, including MEC, mitigation of landfill gas, Corrective Action Management Unit (CAMU) requirements for a landfill, and use of treated groundwater for construction purposes. Participated in the review process for several RODs and ROD Amendments.

Project Manager, Remedial Investigation/Feasibility Study (RI/FS) Addendum at Sites 2/12, Former Fort Ord, USACE Sacramento, Marina, CA, $1.2M, 2013-2014

Manage $1.2M project to determine the magnitude and extent of PCE and TCE contamination in soil, soil gas, groundwater, and indoor air. Developed and implemented detailed RI/FS work plan to meet the client's aggressive schedule, which included a significant community relations effort to address the concerns of the property owners and 11 retailers located within the project site (Target, Kohl's, Old Navy, Recreational Equipment, Inc., etc.), and to coordinate field work to ensure minimal impact to daily retail operations. Designed and implemented remedial investigation; designed and constructed a soil vapor extraction (SVE) and air sparge (AS) pilot treatability study, and developed a RI/FS Addendum report.

- Eliminated offsite disposal of waste – solid IDW transferred to onsite OU2 Landfills for reuse as landfill cover, liquid IDW treated at the onsite GWTS
- Scheduled the SVE/AS pilot study as "proveout" study ahead of the RI/FS report, based on 10+ years of experience at the former Fort Ord including previous use of SVE at other former Fort Ord locations, thereby completing the project four months ahead of schedule
- Completed extensive indoor air and sub-slab sampling program without disruption to retail operations; received no complaints from property owners, retail managers or customers
- Based on RI results, determined there was no unacceptable risk to human health due to vapor intrusion, but additional remedial action was appropriate to protect groundwater from contaminants found in soil gas

Project Manager, Groundwater Remedy Addendum at Sites 2/12, Former Fort Ord, USACE Sacramento, Marina, CA, 2015, $1.2M

Based on the results of the RI/FS Addendum, prepared an ESD to the Remedial Investigation Sites ROD to include soil vapor extraction and treatment as part of the Sites 2/12 groundwater remedy to prevent partitioning of contaminants between soil gas and groundwater. Managed $1.2M project to construct and operate the SVETS and one additional groundwater extraction well. Developed and implemented detailed remedial action work plan to meet the client's aggressive schedule, which included a significant community relations effort to address the concerns of the property owners and 11 retailers located within the project site (Target, Kohl's, Old Navy, Recreational Equipment, Inc., etc.), and to coordinate field work to ensure minimal impact to daily retail operations. Developed an O&M manual based on construction and start-up/shakedown activities.

Qualified SWPPP Developer (QSD), Multiple federal and commercial clients, Marina, CA

In compliance with CWA requirements, develop storm water pollution prevention plans (SWPPPs) for federal facilities and private utility sites throughout California. QSD of record for over a dozen projects. Select and design Best Management Practices (BMPs). Developed an implementation plan and related cost estimate for the execution of the new storm water management program at the Presidio of Monterey (POM) and Ord Military Community (OMC) in accordance with the Phase II Small Municipal Separate Storm Sewer Systems (MS4) General Permit (California State Water Resources Control Board [SWRCB] Order No. 2013-0001 DWQ) and applicable SWRCB guidance.

Quality Control Engineer, Fort Hunter Liggett Building 194 Groundwater Monitoring and Reporting, USACE Sacramento, Fort

Hunter Liggett, CA, $285K (multiple task orders)

Provide senior level quality control review for quarterly groundwater sampling and analysis, data validation, waste management, well maintenance, quarterly groundwater monitoring reports, and annual groundwater monitoring report. Ensure regulatory compliance and technical accuracy.

Quality Control Engineer, Fort Hunter Liggett Building 258 Soil Vapor Extraction System Operations and Maintenance, USACE Sacramento, Fort Hunter Liggett, CA, 2010-2011, $478K

Provide senior level quality control review, ensuring regulatory compliance and technical accuracy of all documents for a project involving vadose zone hydro-carbon remediation at the Building 258 Area using SVE technology. Reviewed Remedial Action Work Plan detailing the SVE system requirements for installation, start-up, and shakedown, and semi-annual treatment system monitoring reports.

Quality Control Engineer, Operations and Maintenance of Fort Hunter Liggett Landfill, USACE Sacramento, Fort Hunter Liggett, CA, 2010-2012, $109K

Provide senior level quality control review, ensuring regulatory compliance and technical accuracy of all documents for a project involving the O&M of Landfill #1, including semiannual groundwater monitoring, landfill gas monitoring, laboratory analysis, data validation, waste management, reporting, well maintenance, and landfill cover inspections.

Quality Control Engineer, O&M of Riverbank Army Ammunition Plant, USACE Sacramento, Riverbank, CA, 2007-2012, $4M

Support the O&M for the RBAAP GWTP and quarterly groundwater monitoring. Provide QC and technical and regulatory compliance oversight for O&M of groundwater treatment facilities, a closed landfill, and associated reporting and documentation.

Quality Control Engineer and Regulatory Specialist, RCRA Hazardous Waste Facility Permit Closure, Riverbank Army Ammunition Plant, USACE Sacramento, Riverbank, CA, 2011-2013, $4M

Provide QC and technical and regulatory compliance oversight during preparation of closure plans, QAPP, and closure certification reports, and decommissioning activities for 13 hazardous waste management units.

Senior Environmental Compliance Specialist, Fort Ord Office, U.S. Army Base Realignment and Closure, J.M. Waller Associates, Inc., College Park, GA, 2003-2006

Worked with the BRAC Environmental Coordinator (BEC), USACE, contractors, and regulatory agencies to ensure requirements were met for environmental cleanup actions for contaminated soil and groundwater at the former Fort Ord. Monitored and modified project schedules and ensured specifications of the Federal Facility Agreement, CERCLA, RCRA, and applicable or relevant and appropriate requirements (ARARs) were met. Ensured actions were cost-effective and efficient, as well as protective of human health and the environment. Met with and presented information to community groups, local government officials, and others as requested by the BEC.

- Successfully completed and obtained regulatory approval of four FOSTs, two Findings of Suitability for Early Transfer (FOSETs), two Findings of Suitability to Lease (FOSLs), and 24 CRUPs leading to the transfer of more than 8,000 acres of property
- Coordinated with USACE to support production of deeds for transfer of property; reviewed and commented on draft deeds and provided technical support
- Initiated request and compiled all documentation for DTSC RCRA corrective action complete determinations
- Provided technical support for completion of a Covenant Deferral Request (CDR) for early transfer of property
- Initiated development of a land use control (LUC) database for LUCs for use in drafting LUC Implementation Plans
- Coordinated with property recipients to resolve post-transfer issues related to the environmental condition of the property
- Achieved regulatory closure of RCRA hazardous waste facility

Economist, U.S. Department of Agriculture, Foreign Agricultural Service, Commodity and Marketing Programs, Forest and Fishery Products Division, Washington, DC , 2001 - 2003

Assisted industry associations to develop and maintain export markets for U.S. forest and fishery products via a Unified Export Strategy. Analyzed markets for U.S. forest products in North America, Europe, and Oceania. Assessed impact of trade agreements and environmental reviews on U.S. forest products exports. Assessed causes and consequences of illegal logging and timber trade. Analyzed market trends for exports of U.S. forest and fishery products for development of a Global Marketing Strategy. Wrote briefing papers for each of the top 15 states in seafood industry production for use in presentations and speeches by USDA personnel.

Environmental Exchange Participant, Lake Baikal, Russia and Lake Tahoe, United States, Tahoe-Baikal Institute, South Lake Tahoe, CA, 2000

Studied natural and cultural histories and current environmental problems and policies related to the respective limnological systems through contact with government agencies, non-government organizations, and citizens. Performed volunteer work for multiple water quality improvement projects at both lakes:

- Site Restoration in the village of Khuzhir on Olkhon Island in Lake Baikal: Worked on the U.S. Agency for International Development (USAID)-funded restoration of Shaman’s Cape, a Buryat sacred site. Work focused on an area once encompassed by a Soviet-era petroleum fueling and storage facility. Provided manual labor and made recommendations to project leaders for site restoration. Utilized engineering experience to plan and implement interim erosion control measures to mitigate shoreline degradation and migration of contaminated silt and storm runoff to the lake.
- Land-use Planning -- Environmental Assessments on Olkhon

Island: Worked with researcher from the Institute of Geography of Irkutsk, Siberian Branch of the Russian Academy of Sciences to assess anthropogenic impact on wildlife areas. Proposed policies for future land use, management of wildlife protection, recreational activities, and waste disposal to be incorporated into national park zoning plan.

- Stream Restoration: Worked with California Tahoe Conservancy on stream restoration project for Cold Creek, a tributary to Lake Tahoe. Native vegetation was transplanted into areas degraded by livestock activity along a one-mile section of stream.
- Environmental Policy and Natural Resource Management: Evaluated impact of wild horses and domestic livestock grazing in the South Lake Tahoe watershed and Great Basin by observing wild horses and range areas, interviewing experts, including Bureau of Land Management (BLM) officials and ranchers, and performing research regarding wild horses. Completed a report, including policy recommendations, for the Animal Legal Defense Fund, BLM, U.S. Forest Service, and members of U.S. Congress.

Project Engineer, Harding Lawson Associates (now AMEC), Petaluma, CA, 1991 - 1999

Managed field offices, coordinated and supervised trainees, engineering technicians, staff engineers, and scientists in environmental sampling and investigation work. Developed and implemented health & safety and work plans. Conducted QA/QC programs for hazardous materials/waste investigations. Performed feasibility studies and remedial actions on civilian, military and Superfund projects, including: lead abatement in former military small arms ranges in coastal sand dunes; hexavalent chromium abatement in former military pickling and plating facility; decommissioning of sewage treatment plants and tank farms; sampling and analysis of discharge from shoreline storm drain outfalls; monitoring and remediation of contaminated groundwater; sampling and remediation of contaminated dredge material. Performed O&M of remedial systems, including soil vapor extraction, bioremediation, and groundwater treatment facilities utilizing granular activated carbon and ultraviolet light oxidation/reduction. Supervised trainees, engineering technicians, staff engineers, and scientists in the same. Successfully operated systems with minimal down time. Devised and proposed expansion of groundwater treatment system. Supervised general laborers and heavy equipment operators in construction of remedial systems. Consistently completed projects on time and within budget. As site project manager, acted as liaison to clients, regulatory agencies, the public, and the media; interpreted data and wrote project status reports and proposals; and gave presentations to prospective clients. Conducted Phase I and Phase II site assessments; supervised drilling crews for installation of exploratory borings and monitoring and extraction wells; logged and sampled borings; conducted soil gas surveys; developed and sampled wells; and performed construction and remedial action oversight.

Assistant Engineer, Herzog Associates, Petaluma, CA, 1989 - 1991

Observed and tested geotechnical related construction, including earthwork, grading, paving, and foundation installations for commercial and residential projects to confirm conformance to plans and specifications. Wrote proposals, reports, and plan reviews; drafted site plans and detailed specifications; and designed street and parking lot pavements and building foundations. As Radiation Safety Officer, devised and implemented state compliant program for and oversaw use of nuclear testing equipment.

Ahtna

Christopher Ohland

Senior Program Chemist

EDUCATION

BS, Water Chemistry, University of Wisconsin, 1985

CERTIFICATIONS, LICENSES, TRAINING

40-hour HAZWOPER, 1988

8-Hour HAZWOPER Refresher, 2015

Blood-borne Pathogens, 1998

Confined Spaces, 1996

DOT Hazmat Employee, 2013

RCRA Statistics, 1992

Supervisory Hazardous Substances/Waste Health and Safety, 1988

USACE Construction Quality Management for Contractors, 2015

WORK HISTORY

Ahtna Environmental, Inc.
Senior Program Chemist, 2015 – Present

E-Data, Inc.

Technical Director, 2009 – 2015

Sullivan International, Inc.
Project Manager / Program Chemist, 2007 – 2009

OTIE, Inc.
Project Manager / Program Chemist, 1998 – 2007

Katalyst Analytical Technologies, Inc.
Operations Director, 1996 – 1998

CH2M Hill, Inc.
Senior Project Scientist, 1988 – 1996

Hazleton Laboratory America
Senior Project Scientist, 1985 – 1988

EXPERIENCE SUMMARY

- Over 27 years of experience in environmental investigation and remediation programs for government/DoD, state, and commercial clients
- 19 years of experience as Project Manager directing site assessments; remedial investigations; feasibility studies; risk assessments; long-term operations and management; remedial actions; regulatory agency interaction and negotiations; community involvement programs
- Technical expertise in environmental chemistry, data management, meteorological and perimeter air quality, natural attenuation, soil vapor and indoor air monitoring, multi-media sampling methods, quality assurance, and quality control

WORK EXPERIENCE

Ahtna Environmental Inc. – Pleasant Hill, CA Senior Program Chemist

Oversight of corporate laboratory programs, third-party quality assurance/quality control (QA/QC) reviews, and analytical chemistry consulting services to industrial clients and environmental science and engineering firms.

E-Data Inc. – San Francisco, CA Technical Director

Oversight of corporate laboratory programs, third-party quality assurance/quality control (QA/QC) reviews, and analytical chemistry consulting services to industrial clients and environmental science and engineering firms.

Typical tasks include: develop chemistry programs, perform laboratory data validation, define data quality objectives, complete QA/QC project plans, write SOPs, train employees in proper field sampling protocol and documentation, and perform ongoing QC audits of sample collection and handling activities and contracted laboratory vendors. Used MS Access to import various electronic data (SEDDs, ERPIMS, EQuIS, others), evaluate, report, and export large datasets.

Sullivan – San Francisco, CA Project Manager / Program Chemist
Served as USACE and Navy Program Chemist with firm-wide oversight of task-level associates that wrote sampling and analysis plans, quality assurance plans (UFP-QAPP), performed sampling and chemical testing, managed laboratory vendors, reviewed chemical data, and validated data with ADR.net.

Managed 16 ongoing environmental projects valued at $2.4M that were completed on time and profitable. Projects included: fuel spills investigations, hotspots assessments, sediment/soil/groundwater investigations, skeet debris removal, and soil gas and vapor intrusion studies.

Proposal and deputy program manager for USEPA Region 9 and USACE Sacramento District direct awards. Successful as proposal manager and interim program manager for awards with USEPA

Region 9 ($1M direct award and $3.5M small biz award), USACE-Omaha ($1M MATOC task order); and USEPA Region 2 ($10M Small Business RAC IDIQ). Developed project scope through carefully written specification statements to limit contract liability and establish a fair price. Developed cost and schedule estimates, managed risk registers, wrote technical specifications, and assigned staff resources for projects.

OTIE, Inc. – Project Manager / Program Chemist

Technical lead for environmental chemistry programs and data management using in-house database management tools. Responsible for growing the environmental chemistry practice, maintaining high quality standards and efficient work processes, training and mentoring the team, providing senior technical support, working to create external visibility, while building the client portfolio.

Extensive experience in preparation and peer review of field sampling plans and data quality objectives to ensure effective and appropriate data collection along with other quality-related tasks, including field and laboratory auditing and training, writing technical specifications and standard operating procedures (SOPs), providing QA/QC and health and safety orientation, document preparation, data quality assessments, data validation of analytical laboratory data, data management, technical support, and senior document review. Identified innovative solutions to streamline work flow processes resulting in reduced levels of labor effort, budget and schedule improvements, and increased access to innovative technology.

Project management of more than 30 projects valued between $25K and $1M. In this role, collaborated with project stakeholders, developed scope of work, wrote work plans, established budgets and schedule, staffing plans, QA/QC plans, and risk management plans; monitoring progress of project and providing technical direction and resources to project team, and managing project scope.

Brief list of extraordinary personal accomplishments:

- Knowledge of USEPA terminology and requirements for environmental chemistry programs was a key advantage to winning the firm’s first USEPA Region 9 contract
- Expert testimony led to two successful subcontractor litigations
- Grew the environmental chemistry team from a single office to a nationwide team of highly qualified chemists and data managers
- Collected, chemically tested, and managed data for 900 multimedia samples for off-site chemical analysis and 3,000 soil samples for onsite analysis during a 3 month remedial action
- Developed a perimeter air monitoring program with real-time data acquisition and reporting that allowed sediment remediation work to proceed without a single fence line non-compliance

- Designed a soil bio-pile treatability study resulting in remediation of fuel contaminated soil and onsite reuse at base landfill; successfully eliminating all offsite transportation and disposal costs
- Performed a PA/SA for 91 listed areas at Dare County Bombing Range and successfully negotiated 86 no action determinations and reducing remediation cost by 85%

Katalyst Analytical Laboratory, Inc. - Laboratory Operations Director

Manage the overall financial and technical aspects of the laboratory operations while maintaining corporate profit goals. Responsibilities include all data reported by the laboratory, personnel management, environmental consulting, public relations and financial support and management. Review the operations of each reporting function on a regular basis and support the development and implementation of the quality control program to maintain an excellent reputation in the environmental field.

CH2M Hill, Inc. - Sr. Project Scientist.

Skilled in the sampling of multimedia environmental samples (air, water, soil, waste, unknown material), chain-of-custody documentation, packing and shipping hazardous materials, data interpretation and reporting, and regulatory agency notification. Authored various documents and work plans including activities memorandums, field sampling and analysis plans, quality assurance project plans, health and safety plans, spill containment plans, and sections of investigation reports. Setup and operated mobile laboratories for general chemistry, GC, HPLC, and XRF instrumentation.

Hazleton Laboratory America, Inc. – ***Project Scientist***

As a project scientist in the Environmental Fate, Metabolism, and Transport department responsible for laboratory procedures used to quantify pesticide degradation using various pathways such as soil metabolism, soil and aqueous photolysis, hydrolysis, column leaching, and volatility. Trained in the safe use of radiological isotopes.

Ahtna

Eric Schmidt

Chemist

EDUCATION

M.S., Environmental Science and Engineering, Contaminant Hydrology Focus, Oregon Graduate Institute, 1993

B.S., Biochemistry, University of California, Davis, 1986

TRAINING

40-Hour HAZWOPER

ERPIMS Training course, 2013

QSP/QSD Training course, 2012

Microsoft elearning SQL Server 2005 coursework, 2010

Geographic Information Systems, San Francisco State University, 2002

Stream Habitat Restoration Course, CDFG, 1995

Database: MS Access, SSMS, Oracle

Programming: VBA, C, FORTRAN, Javascript, HTML

WORK HISTORY

Ahtna Environmental, Marina, CA, Senior Environmental Project Manager, 2015-Present

Chicago, Bridge, and Iron Federal Services, IMS Analyst III, 2013 – 2015

Shaw Environmental, Scientist III, 2003 – 2013

International Technologies Corporation, Project Chemist, 1997 – 2003

Woodward Clyde Consultants, Project Chemist, 1995 – 1997

Law Crandall Associates, Project Chemist, 1994-1995

Kuparuk Industrial Center Laboratory, Chemist, 1990 – 1992

Chemical and Geological Laboratories of Alaska,

EXPERIENCE SUMMARY

- 21 years of experience as a Project Chemist for multiple environmental investigation and remediation DoD/Army CERCLA sites
- 20 years of experience performing environmental data management, and programming
- 27 years of field sampling of multiple media including soil, ambient air, indoor air, landfill gas, soil vapor, surface water, vernal pools, groundwater, and landfill leachate.
- Document Development: Primary or co-author in documents that include Quality Control Summary Reports, Work Plans, Technical Memorandums and Reports, Quarterly and Annual Reports, Closure Reports, Uniform Federal Policy Quality Assurance Project Plans (UFP-QAPP), Sampling and Analysis Plans, Chemical Data Quality Management Plans, and Environmental Protection Plans

PROJECT EXPERIENCE

Project Chemist/Senior Scientist, Former Fort Ord, Presidio of Monterey, CA, 9/97 - present

Management of subcontracted laboratories and third party data validation using Automated Data Review (ADR) software; Development of project specific ADR libraries; Gas/Soil/Groundwater/Surface water sampling; Familiar with standard test methods, SW846, and other analytical methods in sample analysis; Incorporation of the latest DoD QSM requirements and EPA data quality objectives process in the development of UFP-QAPPs; Implementation of data validation per EPA guidance; Production of Quality Control Summary Reports, Contractor Quality Assurance Reports, and Data Quality Assessments.

Optimization, monitoring of landfill gas (LFG) thermal treatment unit; field measurement of LFG for compliance, LFG Annual reporting, assistance in annual source testing to determine compliance with regulations; groundwater velocity calculations and plume determinations, creation of Environmental Protection Plan which involved detailed review of Fort Ord Wetlands Restoration Plan, and USFWS Biological Opinions.

Programmer, Treasure Island, San Francisco, CA, 2013 – 2014

Performed needs assessment and worked with radiological technicians and program manager in the development of a customized Excel VBA application for radiological field work.

GIS/Database Manager, Former Fort Ord, Presidio of Monterey, CA, 8/2006 – 8/2009

Managed www.fortordcleanup.com and www.fodis.net, and associated databases (MS Access and SQL Server); designed web-based chemistry data loading tool, managed subcontractors performing work for Sacramento Total Environmental Restoration Contract (TERC) I and II project site; and provided cost estimates, schedule updates, accruals, and budget information on a monthly basis.

Supervisor/Chemist, 1988 – 1990

Sebastiani Vineyards, Laboratory Technician, 1987 - 1988

Data Management/Programming, 8/2006 – 8/2009

Creation of customized MS Access databases for data management of chemistry and landfill data; Development of custom MS Excel VBA macros for data conversion, loading, and presentation; Optimization and improvement of existing programming, utilization of data in a multitude of formats (delimited, fixed length); Querying, and updating of SQL and oracle databases; Tortoise SVN SOP development; Development of Migration Plan and QC Test Plan for migration and merger of multiple databases; Google API map development: http://199.255.250.170/parcelmap/; and troubleshooting and QC of applications, and training.

Task Manager, Former Fort Ord, Presidio of Monterey, CA, 2006 – 2007

Task management for offsite drilling operations, and fence construction; Liaison with local land owners to address their concerns and provide information; installed passive diffusion bags, and profiled aquifer for TCE contamination; provided technical evaluations of data to the client and to the agencies, wrote statements of work and procured subcontractors; and tracked costs/invoices and performed monthly accruals.

MEC Removal Database Manager, Former Fort Ord, Presidio of Monterey, CA, 8/2005 – 9/2008

Data management for MEC removal action; imported data into an offsite SQL server database that was collected using handheld PDAs, resolved data issues with field staff, queried SQL server database (using MS Access as a front end) for daily reporting, presented updates at weekly meetings with USACE, made grid assignments working with task management and UXO supervisors, worked with UXO QC, lead Geophysicist;

Senior Staff Scientist, Hamilton Army Airbase, Novato, CA, 8/1995 – 9/1997

Applied statistical analysis on analytical data to characterize remediation stockpiled soils; created SAPs, QAPPs, work plans, and Data Quality Assessment reports for the USACE; developed database for analytical data; generated data quality assessment for inclusion in Remedial Investigation report; and directed preparatory phase inspections.

Supervisor/Chemist, AK, 10/1988 – 8/1992

Worked at two laboratories, one of which was on remote camp in the Arctic; Developed and produced Standard Operating Procedures to ensure uniformity in sample analysis; implemented QA/QC procedures for inorganic sample analysis and field work done at Kuparuk Field, Alaska; gathered soil samples at petroleum spill site; Supervised Inorganic Chemical Analysis section; and developed extraction procedure for soil petroleum hydrocarbons analyses.

Field work: Kenai, Alaska, screened for petroleum hydrocarbons at oil company cleanup site; Kodiak, Alaska, screened for petroleum hydrocarbons on bore samples, to determine location of leaking underground fuel tank; and Soldotna, Alaska, samples monitoring wells at Kenai and Soldotna landfills.

Zachary T. Carroll - ***Staff Database Analyst II***
13 total years of experience

EDUCATION

Bachelor of Art, History (Social Science Program), 1999, California State University, Sonoma

BIOSKETCH

Mr. Carroll is a Data Management Specialist and Data Validation Technician who has been maintaining data integrity and production of scheduled reports in a timely manner since 2000. He has reviewed all aspects of program databases for accuracy, advised on future database design needs, performed data validation, wrote and presented reports, and answered questions regarding analysis.

PROJECT EXPERIENCE

Data Validation Technician: Casmalia Resources Superfund Site Maintenance, Remedial Investigation/Feasibility Study (RI/FS), Groundwater Monitoring, Casmalia, California. Responsible for providing quality assurance (QA) and quality control (QC) review relative to analytical laboratory data. Performed Level III and Level IV data review in accordance with the project work plan, the project field sampling plan, and the principals presented in the *USEPA National Functional Guidelines for Superfund Organics Data Review* and the *USEPA National Functional Guidelines for Laboratory Data Review, Inorganics*. Scope: Work performed in support of site maintenance and management, RI/FS, regulatory compliance and support of investigation at a 252-acre, former Class I Superfund, Hazardous Waste Management Facility comprising five separate landfills and which included approximately 40,000 tons of industrial waste on site (with acids, caustics, solvents, pesticides, and metals). Implemented 24-hour operating leachate collection and contaminated groundwater treatment system, and over 300 monitoring wells.

Data Validation Technician: Universal Paragon Corporation / BP PLT-1, LLC Former Schlage Lock and Southern Pacific Brisbane Rail Yard Operable Units (OUs) Brownfield Soil and Groundwater Remediation Services, San Francisco, California. Responsible for providing data review summary reports describing analytical performance expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS). Scope: Engineering efforts in development of a strategic roadmap to help close the real estate deal and transfer of environmental liability to BP/MACTEC Team for redevelopment. Brownfield site is scheduled to be redeveloped into a $450 million mixed-use development, including 1,200 residential homes and public open space. Conducted remedial investigation (RI) and feasibility studies (FSs) to identify final remedies for volatile organic compound- (VOC) impacted soil and groundwater and metal-impacted soils. The selected remedial action will entail in-situ bioremediation of VOC-impacted groundwater using enhanced reductive de-chlorination by injecting soybean oil into the subsurface to enhance natural microbial activities.

Database Specialist/Data Validation Technician: U.S. Army Corps of Engineers - Sacramento District, Fort Ord Groundwater Sampling, Analysis and Reporting, Fort Ord Site (Seaside), California. Responsible for providing data review in accordance with the *Uniform Federal Policy for Quality Assurance Project Plans*; generating quarterly output and maintaining the project libraries for the project's Automated Data Review (ADR) software; writing of the Quality Control Summary Report for inclusion in the Quarterly Report; and conducting ongoing data loading in SQL and Access databases. Scope: Continuation of ongoing groundwater sampling, analysis, and reporting program at Fort Ord site. Quarterly sampling and analysis conducted at more than 300 stations along with evaluation of treatment systems operation.

Database Technician/Data Validation Technician: Former Chemical Manufacturing Facility Perchlorate Investigation, Remediation, Morgan Hill, California. Responsible for providing Level III and Level IV data review in accordance with the *USEPA National Functional Guidelines for Laboratory Data Review, Inorganics*; troubleshooting data validation issues with laboratory personnel; MAROS Mann-Kendall Analysis for determining trends in analyte concentration levels; performing quarterly reporting of QA/QC findings; regulatory uploading of data packages and written reports to Geo-Tracker online website; and data loading and QC tracking in SQL and Access databases. Work is being done in support of a Remedial Investigation to delineate lateral and vertical extent of perchlorate in soil and groundwater at the site of a former flare manufacturing facility. Perchlorate has been detected in onsite soil and onsite and offsite groundwater.

Database Specialist/Data Validation Technician: Confidential Client, Former Manufacturing Facility, Groundwater Investigation and Remediation, Northern California. Responsible for ongoing uploading of chemistry data to SQL database and providing database support in implementation of SQL database relating both historical and incoming chemistry data in support of regulatory review and environmental support services for a former industrial building products manufacturer; Level II and Level III data validation performed in accordance with the project's Quality Assurance Project Plan and the *USEPA National Functional Guidelines for Superfund Organics Data Review* and writing of quarterly data review summary. Services provided include groundwater testing and sampling pertaining to nearby groundwater plume impacted by solvents (PCE and TCE).

Database Specialist/Data Validation Technician: Groundwater Monitoring Program, Los Angeles, California. Responsible for reviewing data for compliance with laboratory control limits and method compliance in accordance with USEPA Level II review; quarterly reporting of validation summary for groundwater data to assist client with making project decisions; MAROS Mann-Kendall analysis to determine trends in chemicals of concern on a quarterly basis. Work is being done in support of O&M of Soil Vapor Extraction (SVE) system and vapor enhanced recovery (VER) system and semi-annual groundwater monitoring program. Site occupies several acres on property converted from manufacturing operation (including buildings) to present day asphalt-covered commercial parking lot.

Database Specialist/Data Validation Technician: Site A Environmental Site Assessment and Remediation, Torrance, California. Responsible for quarterly reporting of validation summary for groundwater data to assist client with making project decisions; review of data for compliance with laboratory control limits and method compliance, in accordance with USEPA Level II review. Work being done in support of soil and groundwater contamination remediation at a 3.2 million square feet industrial complex site comprised of numerous manufacturing buildings. Services included indoor air monitoring for VOCs.

Database Technician: IBM Corporation Phase I Environmental Site Assessments, Groundwater Treatment System O&M and Monitoring, San Jose, California. Provided database support, including data loading, QC, reporting, and archiving. Created and delivered to the client a data extract from SQL database in EQuIS data format. Scope: Phase I Environmental Site Assessments and other environmental services for leased properties at end of lease, prior to being returned to owner. Sites have included offices and manufacturing facilities. Activities included well installation and abandonment; O&M of groundwater extraction system; management of Self-Monitoring Program; and various on-call services to support client's environmental program. MACTEC services saved IBM an average of $40,000-$50,000 a year over a four-year period in monitoring and O&M costs by negotiating closure of over 150 monitoring wells.

Jeffery J. Fenton - ***Senior Geologist***
27 total years of experience

EDUCATION

Bachelor of Science, Geology, 1981, Oregon State University, Corvallis

CERTIFICATIONS

HAZWOPER 40 Hour
HAZWOPER 8 Hour Refresher
HAZWOPER 8 Hour Supervisor
OSHA Confined Space Entry

BIOSKETCH

Mr. Fenton is a Senior Geologist and Project Manager with over 27 years of experience. He is responsible for designing and managing programs, developing work plans, performing record searches and evaluation of storage and handling of hazardous wastes, supervising field work and data reduction, and participating in agency and public meetings. He has managed numerous large and small HTRW projects, including the evaluation and characterization of sites with hydrocarbon, solvent, metals, pesticide, PCB, explosive compound, and low-level radioactive wastes. His responsibilities have included preparing RI/FS and site characterization reports, confirmation reports, IA Approval Memos, Environmental Baseline Surveys, FOSTs, FOSLs, FOSETs, environmental compliance reports, BRAC Cleanup Plans, site safety plans, and confirmation reports in compliance with BRAC, DoD, CERCLA, RCRA, USACE, EPA and State and local guidance. He has managed tasks involving industrial facilities, landfills, munitions response sites, service stations, food processing plants, and agricultural facilities for federal DoD agencies (e.g., USACE, Army, and Navy) and private sector clients.

PROJECT EXPERIENCE

Project Manager: Ahtna Engineering Services, Fort Ord Groundwater Monitoring Program, Sites 2 and 12, OU2 and OUCTP. Responsible for the monitoring and characterization of three groundwater plumes at the former Fort Ord, CERCLA site. Manage the collection of groundwater elevations and the chemical sampling of a network of over 300 monitoring wells on a quarterly basis. Samples are analyzed for a variety of inorganic and organic compounds. Groundwater elevation and chemistry data are compiled for inclusion into quarterly and annual monitoring reports that include groundwater elevation contour maps and iso-concentration plots of the data collected for each plume and for each aquifer affected. Responsible for overall project quality control, validation of analytical data and submittal of the quarterly and annual reports to the client, regulatory agencies and the public.

Project Manager: Ageiss, Inc., Data Validation Support, Semi-Annual Groundwater Sampling, Dodge Hill Landfill, Fort Sill Oklahoma. Provide validation and statistical analysis of all groundwater data collected during semi-annual groundwater sampling at the Dodge Hill Landfill, fort Sill Oklahoma. Validation includes Level III review on 100% of the data and Level IV review on 10% of the data with qualifiers applied to the electronic deliverable file (EDD). Data review is presented in a Data Validation Summary Report. Perform statistical analysis on all groundwater analytical data for each sampling event. The statistical analysis is presented in a report which is appended to the client’s semi-annual groundwater report for submittal to the US Army Corps of Engineers (Ageiss client) and the Oklahoma Department of Environmental Quality.

Project Manager: Hydrogeologic Inc. (HGL), Treatment Plant Decommissioning, Fort Ord, California. Provided technical review of the Work Plan and Completion Report prepared by HGL and provided field oversight of well destruction activities to ensure well destruction was completed as per the permit requirements and HGLs Work Plan. Work performed for HL under Huntsville Small Business Worldwide Environmental Services (WERS) contract.

Project Manager: Innovative Technical Solutions, Inc. (ITSI), A Gilbane Company, Groundwater Modeling and Technical Memorandum Revision, Fort Ord, California. Provided updates to the fort Ord groundwater model to support the design element of the relocation of the Operable Unit 2 (OU2) groundwater treatment plant. Completed a groundwater model run with existing and proposed extraction and injection wells, including a cost benefit analysis used to support the design basis for the new location of the OU2 groundwater treatment plant. Included revision/finalization of the draft groundwater technical memorandum. The technical memorandum included the proposed locations of new extraction wells to supplement and optimize the existing groundwater extraction well network.

Task Manager: Lennar / BVHP, LLC Hunters Point Naval Shipyard Parcel A Environmental Consulting Services, San Francisco California. Environmental consulting services to support client's legal counsel, address special requests for information from project stakeholders, and present information at planning and technical meetings as part of ongoing effort to redevelop Parcel A of area formerly occupied by U.S. Naval shipyard. Provided review of and recommendations on existing documents. ***Lennar achieved compliance with regulatory requirements with MACTEC's assistance.*** Responsible for preparing a Finding of Suitability to Lease document for 8 buildings and 2 open spaces.

Geologist: The Presidio Trust Site Closure Environmental Services, San Francisco California. Environmental services associated with site closure, including site investigation, risk assessment, feasibility study (FS), engineering design, data management, ecological risk assessment, remediation, and reporting at historic 1,416-acre former military base at the south end of the Golden Gate Bridge. Responsible for preparing a Supplemental Health and Safety Plan for Munitions and Explosives of Concern.

Task Manager: U.S. Army Corps of Engineers - Huntsville District, Fort Ord Operable Unit (OU) Habitat Remedial Investigation / Feasibility Study (RI/FS), Monterey California. Since 2004, MACTEC has been conducting full remediation investigation / feasibility study (RI/FS) to address munitions and explosives of concern (MEC) at the Impact Area Munitions Response Area (MRA) for 6,500 acres of a 8,000-acre former U.S. Army training range complex (small arms to artillery fire). Activities included planning, site characterization, archival (historic) search, risk assessment (human health), feasibility study, and community relations support. Responsible for conducting site characterization efforts.

Task Manager: U.S. Army Corps of Engineers - Huntsville and Sacramento Districts, Fort Ord Site RI/FS Reports Track 0&1 Approval Memorandum, Parker Flats ROD and Public Meeting, Monterey California. Under an additional delivery order, completed the development and submittal of additional Track 0 and 1 approval memoranda and ROD for multiple reuse parcels throughout site of former Fort Ord. Activities support remedial investigation efforts as part of Military Munitions Response Program. ***Analysis performed by MACTEC resulted in No Further Action determination for 21 of 24 Track 1 sites.*** Responsible for participating as one of the authors of the Remedial Investigation / Feasibility Studies document.

Task Manager: U.S. Army Corps of Engineers - Huntsville and Sacramento District, Environmental Baseline Survey for Transfer (EBST) Documentation Services, Monterey California. Preparation of documents and associated evaluations relating to broad range of environmental issues (e.g., asbestos and lead-based paint) at Fort Ord as part of work for Environmental Baseline Survey for Transfer (EBST). In support of property transfer MACTEC prepared Findings of Suitability to Transfer (FOST), Findings of Suitability to Lease (FOSL), and Findings of Suitability for Early Transfer (FOSET). ***Early transfer was approved saving $1 million in infrastructure and maintenance cost.*** Responsible for writing the FOST documents for 30 parcels and the FOSET documents for 64 parcels.

Task Manager: U.S. Army Corps of Engineers - Huntsville and Sacramento Districts, Fort Ord Site Investigation and Documentation for FOST, Monterey California. Investigative and documentation activities performed as part of development of environmental basewide survey for transfer (EBST) and findings of suitability for transfer (FOST) at former Fort Ord site. In support of property transfer MACTEC prepared Findings of

Suitability to Transfer (FOST), Findings of Suitability to Lease (FOSL), and Findings of Suitability for Early Transfer (FOSET). ***Early transfer was approved saving $1 million in infrastructure and maintenance cost.*** Responsible for writing the FOST document for one parcel.

Project Manager: U.S. Army Corps of Engineers - Sacramento District, Fort Ord Groundwater Sampling, Analysis and Reporting 2008-2009, Fort Ord Site (Seaside) California. Continuation of ongoing groundwater sampling, analysis and reporting program at Fort Ord site for 2008-2009 (Option Year 3). Quarterly sampling and analysis conducted at more than 300 stations along with evaluation of treatment systems operation. Responsible for data management, data evaluation, and reporting.

Task Leader: U.S. Army Corps of Engineers - Sacramento District, Fort Ord Site Electronic Data Integration and Management, Monterey California. Electronic data integration and management of various environmental databases, administrative records, facilities management information and GIS applications developed for site characterization, OE investigation, and remediation activities at former Fort Ord site. Work is continuation of services under ongoing BRAC and IRP programs. The database contains over one million records. Contract Compliance Screening (CCS), Automated Data Review (ADR), and Environmental Management System software programs were developed and resulted in ***cost savings of up to 50% in labor reduction ($250K) and improvements in the data management process for numerous task orders.*** Responsible for contributing information regarding property transfer-related documents that needed to be integrated into the overall Fort Ord database.

Environmental Task Manager: U.S. Army Corps of Engineers, Sacramento District, Fort Ord Complex Site BRAC Related Environmental Services, Monterey California. Environmental and engineering services under BRAC Program since 1985 for Fort Ord Complex (28,000-acre former Fort Ord, the Presidio of Monterey, and Fort Hunter Liggett, Fritzsche Army Airfield), a National Priorities List (NPL) site. Completed several hundred multidisciplinary, multitask delivery orders, with dozens more in progress. Services have included site investigations, risk assessments, feasibility studies, including ordnance/explosives remedial investigation, remedial designs, remedial actions, environmental compliance, utilities/roads, parcel descriptions, endangered species and habitat assessments, underground storage tank investigations, asbestos assessments, groundwater remediation, planning for base reuse, and community relations. Services have been conducted under CERCLA; RCRA; NEPA/CEQA; California landfill regulations; Monterey County underground storage tank (UST) regulations; air toxics regulations; and other federal, state, and local environmental laws and regulations. ***Successful completion of RI/FS documentation as part of 40+ site RI/FS allowed the Army to meet the congressionally mandated 36 month RI/FS schedule.*** To track the status of the property transfer and to provide the most up-to-date information to community stakeholders on the environmental cleanup, MACTEC developed a public website (www.fortordcleanup.com). This allowed interested parties to view information online. ***This reduced the time needed for onsite staff to manage the paper administrative record by approximately 50%.*** Responsible for serving as the BRAC task manager, preparing appropriate documentation, including Environmental Baseline Surveys (EBSs), Findings of Suitability to Transfer (FOSTs), Findings of Suitability for Early Transfer (FOSETs), Findings of Suitability to Lease (FOSLs), and Notices of Intent (NOIs), under the Comprehensive Environmental Response, Compensation, and Recovery Act (CERCLA) guidance, which accelerated real-property transfers in accordance with the Defense BRAC Act (BRAC Program). Worked closely with the U.S. Department of the Army, U.S. Army Corps of Engineers (USACE), EPA, and State of California to develop approaches that met the requirements of CERCLA 120(h) and satisfied regulatory concern for documenting the environmental condition of the property at the time of transfer. Also responsible for RCRA closure activities.

Technical Consultant: U.S. Army Corps of Engineers - Sacramento District, Fort Ord Wetlands Habitat Monitoring 2003, Monterey California. Continuation of habitat monitoring work as part of the BRAC and IRP activities at site of former Fort Ord. Monitoring activities at wetland sites on property include vegetation sampling, wildlife surveys, and collecting and analyzing physical and hydrological data. ***Results of the habitat monitoring showed that the habitat had recovered in four years and thus eliminated the fifth year of monitoring saving $85,000.*** Responsible for review of property transfer documents related to habitat monitoring activities.

Task Manager: U.S. Army Corps of Engineers - Sacramento District, Fort Ord and Fort Hunter Liggett Groundwater Monitoring Program, Forts Ord, Hunter Liggett California. Groundwater investigations and provided quarterly monitoring; prepared property transfer documents; performed habitat monitoring and groundwater remediation system evaluation; and conducted Small Arms Range remediation pilot study evaluation at site of two former U.S. Army installations under BRAC program. ***The project has been completed and consisted of twelve sites requiring remediation that have been closed with regulatory approval resulting in a reduction in long-term O&M for the client.*** Responsible for data evaluation and management, preparation of reports and cost proposals, and review of invoices.

Task Manager: USACE, Sacramento District, Military Munitions Response Program (MMRP), FortOrd, Monterey County, California. Currently serving as Task Manager responsible for the completion of a RI/FS, Proposed Plan, and Record of Decision at former munitions response sites. Conducted and evaluation of the possible use of military munitions at 24 former military munitions sites. The evaluation included researching the history of each site (PA/SI) and completing a review of the available data to develop conceptual site model(s) for each potential site. Data gaps were identified and the potential risk remaining at each site was also evaluated. Worked directly with federal and state regulatory agencies and community stakeholders throughout the review and approval process. The RI/FS is being conducted following EPA, DoD, and CERLA guidance. Other documentation prepared in support of the Fort Ord MMRP include IA Approval Memorandums, and Notices of Intent (NOI) for Removal Actions and Land disposal Site Plans prepared in support of the Army's Time-Critical Removal Action (TCRA) program. The NOI complies with 40 CFR, Part 300, Section 415 and notifies the regulatory agencies and the public of upcoming removal actions, intended to mitigate or eliminate the threat to public safety presented by the presence of munitions and explosives of concern (MEC).

Task Manager: USACE, Sacramento District, Closure of RCRA Solid Waste Management Units, Former Fort Ord, Monterey County, California. Implementing the closure of two solid waste management units under the Fort Ord RCRA program. Closure involves the site investigation and characterization of a former PCB storage facility and a former Open Burning/Open Detonation (OB/OD) munitions disposal unit. Investigation involved conducting a field investigation including the sampling and analysis for chemicals of concern, and completion of a closure certification report following RCRA guidance.

Task Manager: USACE, Sacramento District, Investigation of Solid Waste Management Units, Former Fort Ord, Monterey County, California. Task manager for the evaluation of former hazardous waste storage units. Evaluation involves physical inspection of the units including a review of the cleanliness and integrity, waste handling and storage practices, determining whether a release has occurred and making sampling recommendations if necessary. Information including any recommendations made to state and federal regulatory agencies through a status report. Wastes stored and evaluated include waste oil, fuel, solvents and paint, PCBs, pesticides, asbestos, used ethylene glycol, adhesives and polymers. Created a detailed historic account of the solid waste management units which has been instrumental in the regulatory approval of the transfer of property containing the units.

Project Geologist: Confidential Client, Regulatory Compliance Audits, Processing and Distribution Facilities, Western U.S. Served on audit teams performing regulatory compliance audits for a major food production, processing and distribution company. The project entailed the completion of audits in a 5-month period at 37 facilities in California, and several other facilities in four states. The audit protocol prepared by HLA addressed facility compliance with regulations for hazardous waste, hazardous materials, air quality, water quality, drinking water and transportation. The protocol further provided for the completion of a preliminary screening evaluation that involves the local facility management in targeting relevant operations and matters of concern for the audit, prior to proceeding with the on-site phase of the program.

Task Manager: USACE, Site Investigations, Fort Ord, Monterey, California. Served as task manager for the investigation of several UST sites. Was responsible for determination of MACTEC and subcontractors scope of work, calculation of excavation volumes, oversight of subcontractors, collection of samples, review of analytical data, preparation of clearance and characterization reports, and budget tracking.

Task Manager: USACE, Remedial Investigation/Feasibility Study, Fort Ord, Monterey, California. Served as task manager for the remedial investigation/feasibility study (RI/FS) of two IRP sites at Fort Ord. Was responsible for the interpretation of chemical and hydrogeologic data, oversight of chemical and geologic database, coordination with risk assessment and engineering personnel, determination of contaminant fate and transport, coordination and production of final RI/FS report, and budget tracking.

Task Manager: Alameda County Department of Public Works, Landfill Investigation, Winton Avenue Landfill, Hayward, California. Served as task manager for landfill investigation under the state Solid Waste Assessment Test (SWAT) program. Was responsible for the preparation of work plan, installation and quarterly sampling of groundwater and leachate monitoring wells, aquifer testing, data evaluation, assessment of impact of leachate on waters of the state, and preparation of SWAT report.

Task Manager: U.S. Navy/PRC, Utilities Investigation, Hunters Point Naval Shipyard, San Francisco, California. Was task manager for a cross-base underground utilities investigation. Study involved the review of as-built drawings of sanitary sewer, storm drain, steam pipelines, and fuel lines, and the collection of soil and water samples adjacent to and within utility systems. Was responsible for the review and interpretation of analytical data, recommendations on remediation and mitigation measures, and the presentation of the results at a series of client and agency meetings.

Task Manager: U.S. Navy/PRC, Remedial Investigation, Hunters Point Naval Shipyard, San Francisco, California. Served as task manager for RI of five sites for contaminants including petroleum hydrocarbons, PNAs, pesticides, and metals. Completed interim-action evaluation in accordance with the EPA Superfund Accelerated Cleanup Model. Was responsible for budget and schedule tracking, chemical and hydrogeologic data interpretation, report preparation, and client representation at regulatory agency meetings.

Field Manager: U.S. Navy/PRC, Field Coordination, Hunters Point Naval Shipyard, San Francisco, California. Managed all aspects of field work, including the development, implementation and tracking of field schedules; coordination with client, subcontractors, and regulatory agencies; scheduling field personnel and reviewing all field documentation; and calculating and ordering all field supplies.

Task Manager: U.S. Navy/PRC, Aquifer Testing, San Francisco, California. Developed and implemented site-wide aquifer characterization program. Work included the development of the scope of work assessment of well construction and suitability, performing step-tests, and constant rate discharge tests.

Project Manager: Confidential Client, Product Removal Investigation, Hunters Point Naval Shipyard, San Francisco, California. As project manager, supervised the field investigation involving the removal of free-phase floating hydrocarbons from monitoring wells. Calculated and tracked the volume of product removed to determine the feasibility of installing a pumping system.

Task Manager: Confidential Client, Monitoring Well Network Installation, Longview, Washington. Installed, developed, and sampled network of groundwater monitoring wells in bedrock to investigate the impacts of a long-term release of mercury.

Task Manager: Montecito Heights Landfill, Monitoring Well Installation, Napa County, California. Installed monitoring well in deep aquifer using air rotary drilling method.

Task Manager: Former Fuel Storage and Dispensing Facility, Contra Costa County, California. Supervised and directed excavation of hydrocarbon-contaminated soil at former oil tank farm.

Task Manager: Site Assessment and Remediation, Richmond, California. Installed and developed monitoring wells and collected soil and groundwater samples. Supervised and directed contractor's removal of lead-, hydrocarbon-, and lime-contaminated soils at former shipyard site.

Field Manager: Well Installation, Morgan Hill, California. Installed double-cased well in deep aquifer using mud rotary drilling methods.

Field Manager: Well Installation, Vorhees, New Jersey. Installed monitoring well nests in shallow and deep aquifers using mud rotary and hollow stem auger methods.

Well Site Geologist: Exploration Logging Geothermal Division, Geothermal Exploration, California, Nevada, and Japan. Experienced in mud rotary, air rotary, and aerated mud drilling systems. Performed geologic logging of deep exploration geothermal boreholes. Responsibilities included descriptive lithologic sample analysis, monitoring of borehole temperature, borehole pressure and borehole gas levels; collection of borehole gas samples for chemical analysis; geothermal well production testing and reservoir analysis. Health and safety monitoring of carbon dioxide, methane and hydrogen sulfide gas levels around the drill site. Field experience in the Geysers California, Steamboat Nevada, Takigami and Fushime Fields, Kyushu Japan.

Kevin E. Garrett Ph.D., P.E., PMP – *Senior Principal*
21 Years Experience

EDUCATION

Doctor of Philosophy, The Pennsylvania State University Chemistry, 1990
Bachelor of Science, Colorado State University Chemistry, 1986

REGISTRATIONS

Colorado Licensed Professional Engineer (License number 43243)
Project Management Institute Project Management Professional (PMP)

BIOSKETCH

Dr. Garrett has a Ph.D. in Chemistry and is a Colorado licensed professional engineer with extensive experience in groundwater and soil remediation, site investigation, and the application of environmental chemistry. Dr. Garrett has managed RCRA facility investigation projects (RFIs) and remediation projects that have included developing innovative regulatory approaches resulting in significant cost savings for associated site remediation. Dr. Garrett has managed projects and applied innovative approaches to remediate groundwater, including monitored natural attenuation (MNA), enhanced reductive dechlorination (ERD), in situ biological remediation, in situ chemical oxidation (ISCO), soil vapor extraction (SVE), and neutralization remediation strategies.

Dr. Garrett has designed a full-scale in situ treatment system to remove chlorinated solvents such as methylene chloride, trichloroethene (TCE), tetrachloroethene (PCE), 1,1,1-trichloroethane (1,1,1-TCA), petroleum products, and inorganic constituents such as nitrate and perchlorate from groundwater. The remediation designs utilizes innovative strategies that that has minimized system complexity with reduced set up, operating and maintenance costs and achieve client and regulatory agency remediation goals in the shortest time possible.

Dr. Garrett has managed projects under a variety of regulatory programs including Resource Conservation and Recovery Act (RCRA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and State Voluntary Cleanup Programs. During these projected, Dr. Garrett has aided clients in negotiating site closure, points of compliance, and remediation criteria with regulatory agencies. . These negotiations have aided AMEC clients to close and/or redevelop sites for other uses while meeting the environmental and human health protection goals of the regulatory agency.

In addition, Dr. Garrett has assisted clients with implementation of client’s environmental compliance programs including monitoring. Activities include requirements hazardous waste, waste water and storm water compliance, spill prevention plans, and emergency response planning. Dr. Garrett has extensive experience with Phase I and II environmental site assessments (Phase I and Phase II ESA).

As Project Manager and Senior Principal, Dr. Garrett manages technically difficult projects. Dr Garrett is responsible for all aspects of a project, including compliance with company policies, definition of scope of work, establishment of budgets and schedules, control of project costs, compliance with schedule, timely payment for the work, and assurance of overall client satisfaction. In addition, as project manager, Dr. Garrett ensures project quality control activities are in place and adhered to. Selects and supervises project team members; ensures that team members are assigned appropriate roles. Provides leadership to project team; maintains a positive environment and high morale. As Senior Principal, Dr. Garrett provides senior-level technical expertise for project teams. Acts as primary interface with clients for assigned projects; communicates with clients on an ongoing basis; responds effectively to meets clients' needs.

Dr. Garrett is the Chief Engineer of AMEC’s Golden, Colorado office. As Chief Engineer, Dr. Garrett provides leadership role for marketing to major clients, service areas, and technically unusual projects; responsible for selected key clients. Serves as primary quality assurance officer for assigned office(s); verifies implementation of quality programs and initiatives.

In the area of quality assurance, Dr. Garrett has extensive experience in development of project-specific QA / QC programs and writing of quality assurance project plans (QAPPs). He has developed appropriate analytical and QA/QC criteria, selected appropriate methods, and developed appropriate reporting limits and method detection limits (MDLs). Dr. Garrett has extensively validated and evaluated analytical data.

PROJECT EXPERIENCE

Project Manager: Molycorp RCRA Facility Investigation (RFI) and Site Closure Remediation Services, Louviers, Colorado. Dr. Garrett managed design and construction of a full-scale in situ biodenitrification system (under RCRA) to treat the groundwater nitrate plume at the facility's 34-acre pond area and 32acre operations area. He developed an innovative in situ remediation system to remove nitrate from groundwater that minimized system complexity and minimized treatment costs to the client. Negotiated and developed the technical approach and justification to close 6 process water holding ponds two years ahead of the original schedule. Included in the technical approach were negotiations with the state regulatory agency on site-specific soil standards for nitrate that met the state goal of being protective of groundwater. Provided technical oversight of the pond closure contractor to ensure that the closure plan requirements were met. Closure of the ponds allowed for expansion of the groundwater treatment system. The expanded in situ treatment system reduced the time required to meet the compliance schedule with respect to nitrate in groundwater. Developed monitoring and characterization plan for perchlorate and demonstrated that the nitrate treatment was effective in meeting the negotiated site specific remediation goals with CDPHE. Performed radiological dose assessment for groundwater and soil in support of the facilities request to terminate their radioactive materials license. This effort included modeling potential radiation dose to hypothetical future residents from exposure to the sites soil and groundwater.

Project Manager: GSA - Denver Federal Center (DFC), Site-Wide Long-Term Monitoring, Lakewood, Colorado. As project manager, Dr. Garrett is leading the site-wide long-term monitoring activities at the Denver Federal Center. These activities include quarterly sampling of up to 250 monitoring wells and surface water locations on and off of the DFC. Quarterly activities include water level measurements, sampling, data validation, data management, and reporting. Additional activities include a 5-Year Review of the performance of the groundwater corrective measures. These corrective measures include, funnel and gate barrier system, source area pump and treat system, and off site plume. At project manager, Dr. Garrett is responsible for ensuring that the activities area completed on time and within budget.

Project Manager: GSA - Denver Federal Center (DFC), Investigative Area (IA) 13 and 16 Corrective Measures, Lakewood, Colorado. As project manager, Dr. Garrett lead the IA 13 source area characterization activities. These activities included characterization of 2 geophysical anomalies by trenching and soil sampling. In addition, the extent of the source area groundwater plume was evaluated using a Membrane Interface Probe (MIP). Based on the MIP results 20 additional monitoring wells were installed. After characterization activities, AMEC implemented the corrective measure which included injection of potassium permanganate into the alluvium and upper weathered bedrock (UWB) and injection of sodium permanganate into the lower weathered bedrock (LWB). Of particular interest was injection of permanganate at the LWB/consolidated bedrock interface. Injections were conducted in approximately 157 alluvium/UWB locations and 60 LWB locations. Post injection monitoring is currently being performed to evaluate the remediation effort to date.

Project Manager: GSA - Denver Federal Center (DFC), Investigative Area (IA) 04D RCRA Facility Investigation (RFI), Lakewood, Colorado. Dr. Garrett conducted two RCRA Facility Investigations (RFIs) and a survey of asbestos in soil for two parcels for the General Services Administration (GSA) at the DFC. The Interior RFI was completed at Building 41 and 42 and consisted of 68 borings and monitoring wells installed inside the buildings. The drilling was completed in conjunction with the facilities ongoing operations. The work included extensive coordination with the GSA and building tenants to ensure that the RFI activities did not impact their normal business activities. The Exterior RFI for the investigation area 04D included installing 80 borings and monitoring wells, excavating 11 trenches to characterize soil and potential impacts from historic operations at the DFC. The investigation included jetting/cleaning and video survey of sanitary and storm water sewer lines in IA04D. Responsibilities included general supervision of the work and activities such as development of subcontractor scopes of work, soliciting competitive subcontractor bids, insuring compliance with standard operating procedures, and health and safety plan development/implementation. Dr. Garrett was responsible for maintaining project schedules, monitoring the budget and costs, and preparing invoices for submittal to GSA. Dr. Garrett also provided regular project status updates to the GSA Project Manager.

Principal-in-Charge: Colorado Department of Transportation (CDOT) Region 6 Headquarters RCRA Facility Investigation (RFI) and Remediation Project, Denver, Colorado. Dr. Garrett served as a Remediation Specialist and Principal Chemist responsible for evaluating and interpreting groundwater monitoring and treatment data as well as conducting statistical evaluation of the treatment data. He oversees engineering and environmental services implemented to remediate soil and groundwater contaminated with methylene chloride, TCE, PCE, and 1,1-DCE. Dr. Garrett’s responsibilities include ensuring that the project meets the technical and quality requirements for the engineering and environmental services implemented to remediate groundwater and soil. He has assisted in (1) site investigations; (2) design and construction of the bioremediation system; and (3) ongoing O&M activities for the groundwater treatment system.

Remediation Specialist and Principal Chemist: Lowry Assumption Company - Former Lowry Air Force Base Redevelopment Design / Build, Denver, Colorado. Remediation Specialist responsible as for assisting in development of groundwater and soil analytical programs for Operable Unit 2 (OU2) work, and assisting in development of OU2 Work Plan and final report for OU2 landfill closure. Scope: Design and construction of a 67-acre landfill cap, remediation of major groundwater plume, and privatized contaminant characterization and cleanup including groundwater monitoring at 1,866-acre former air force base in large urban area. Services included engineering design and construction quality assurance. Approach is predicted to save several years of cleanup time and has allowed for more efficient and quicker redevelopment activities into a mixed-use community that has been recognized with the Governor’s Award for Smart Growth.

Project Manager, Petroleum Distribution Center, Denver, Colorado. Through a comprehensive liability assessment of the site, AMEC identified an alternative approach to obtaining site closure and significantly reducing the cleanup costs and the amount of time needed to obtain closure from the regulators. This approach required the transfer of the site from the EPA Region VIII’s Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Emergency Response Administrative Order to the Colorado Department of Public Health and Environment’s (CDPHE’s) Voluntary Cleanup program (VCUP). This strategic transfer from EPA CERCLA oversight to the CDPHE VCUP oversight resulted in an overall project remediation cost savings and has expedited the time necessary to obtain closure from the regulators thereby reducing the time required for remediation activities at the site. Negotiated with CDPHE and developed a strategy to break the site into 5 parcels. Wrote VCUP applications for 4 of the 5 parcels and received no action determinations for 3 of the parcels. Dr. Garrett was responsible for the site-wide operation and maintenance reporting and groundwater monitoring compliance program. The monitored natural attenuation (MNA) approach for groundwater remediation has been implemented. VOC contamination was reduced in soil source areas by applying soil vapor extraction (SVE) remediation strategy. Contracted and provided oversight for the demolition of 3 buildings on the client’s property.

Project Manager: Rocky Mountain Steel Mills South Mills Solid Waste Management Units (SWMUs), RCRA Facility Investigation (RFI), Pueblo, Colorado. Dr. Garrett was responsible for managing the project that included a RCRA Facility Investigation (RFI) for the South Mills SWMUs that includes the South Mills waste water treatment lagoons. RFI work included sampling of soil borings, waste oil skimmer remediation, including surface soil sampling, soil removal and disposal. Sixteen soil borings were logged and sampled and soil around 4 oil water separator were removed and backfilled with clean material. In addition, sediment from three lagoons was samples. An RFI report was prepared and submitted to the CDPHE for approval.

Project Manager: Rocky Mountain Steel Mills Solid Waste Management Unit (SWMU) No. 78 Desulfurizer Baghouse, RCRA Facility Investigation (RFI), Pueblo, Colorado. Dr. Garrett was responsible for managing the project, writing the RFI report, and performing historic research on the design and historic operation of the desulfurizer baghouse facility. He conducted the RCRA Facility Investigation (RFI) for Solid Waste Management Unit (SWMU) No. 78, a former desulfurizer baghouse that was part of former blast furnace operations at the steel mill facility. Research of historic records conducted to demonstrate to State Regulator that the baghouse facility was not connected to the historic coke oven facility (as historic permits incorrectly indicated). This research enabled the client to limit the SWMU investigation and facilitate closure, thereby saving both time and money. Thirty samples also collected from five boring locations as part of investigation.

Project Manager: Confidential Client Site Characterization and Remediation Services, Olathe, Kansas. Responsible for overseeing on-site groundwater monitoring activities, developing budgets, developing site closure and remediation strategy; and providing oversight of remediation activities. The scope includes site characterization and development of final groundwater and soil remediation strategy and plan for final closure of 9,000-SF building site occupying corner of property near source area. Plume extends 1,000 feet to near property boundary.

Remediation Specialist and Principal Chemist: Hamilton Sundstrand, RCRA Facility Investigation (RFI) Project, Denver, Colorado. Dr. Garrett has evaluated the analytical data for this project since 1992. He also assisted in design and implementation of soil, groundwater, NAPL and seepage water investigations (RFIs); feasibility and treatability studies; remedial design pilot-scale testing, engineering and construction; regulatory permitting, treatment systems O&M; treatment systems monitoring and reporting; risk assessments; RCRA and CAP designs and implementation. He redesigned the groundwater quality monitoring program incorporating elements of the RCRA Groundwater Monitoring Technical Enforcement Guidance Document (EPA, 1996). He assisted in preparation of an accelerated RCRA Corrective Action Strategy for site. As Principal Chemist, he was responsible for data evaluation, validation, and interpretation as well as site conceptual model development.

Chemist: University of Nebraska Agricultural Research & Development Center (ARDC) Remedial Investigation / Feasibility Study, Remedial Assessment and Removal Action, Ithaca, Nebraska. Responsible as principal chemist for writing and reviewing project Quality Assurance Project Plan (QAPP), oversight of the analytical program, and project quality assurance program. The scope includes Remedial Investigation / Feasibility Study (RI/FS) and removal actions involving four different sites from one-half to five acres each, distributed over the 9,600-acre R&D facility and including eight disposal trenches, a former landfill and a pesticide rinsate area. Work included excavation, characterization, packaging, disposal and transportation of 30,000 CY of radioactive and chemical wastes produced as part of University medical research program and buried at site many years earlier, quality control planning and data management.

Project Manager, Landfill Monitoring Program, Denver, Colorado Managed groundwater monitoring and reporting for EPA CERCLA groundwater and surface-water monitoring program. Tasks include coordinating the analytical laboratory and field activities for the Landfill Operation and Maintenance (O&M) monitoring program for the semiannual groundwater and surface-water sampling. Prepare laboratory scope of work, oversight of data management activities, and coordination with field and laboratory personnel. Oversaw data validation for the project and reported the analytical and QA/QC results to the client and regulatory agencies. Dr. Garrett prepared a statistical approach to find potentially flawed or inconsistent data. Reported results of site O&M and groundwater monitoring program to the EPA on a semiannual basis.

CHEMICAL RESEARCH

Research Associate, University of Delaware. Research Associate in organometallic, inorganic, and catalytic chemistry. Studied the interaction of metal clusters on metal oxide supports. Developed new methodology for the synthesis of mixed metal transition metal clusters on metal oxide supports. Studied these supported metal clusters by a variety of instrumental and analytical techniques.

Graduate Student Researcher, Pennsylvania State University. Researcher in organometallic and inorganic chemistry. Studied the interaction of a variety of organic compounds with highly reactive transition metal complexes. Demonstrated the use of tungsten complexes as substrates in the synthesis of organic compounds such as naphthols. Studied the mechanisms by which the organic products are formed. Studied organic, organometallic, and inorganic compounds by a variety of instrumental and analytical techniques.

CERTIFICATIONS AND TRAINING

OSHA 8-Hour Hazardous Materials/Waste Health and Safety Training Refresher Course
OSHA 40-Hour Hazardous Materials/Waste Health and Safety Training Course
OSHA 8-Hour Supervisory Hazardous Materials/Waste Health and Safety Training Course
Project Management Training the AMEC Way, 2012
Project Controls Level I and Level II Training, 2010
Capturing and Winning AMEC Business, Shipley 2006
Optimizing Injection Strategies for Full-Scale In Situ Reactive Zone Remediation, 2005
Contract Review Seminar, 2005
Applications of Ground Water Geochemistry, 2004
Economic Analysis for Ground Water Remediation a Tool for Decision Making, 2003
The Remediation Course, Princeton Groundwater, Inc., 2003
Environmental Geochemistry of Metals, 2003
Principles and Practices of Project Management, 2002
Groundwater Pollution and Hydrology Course, Princeton Groundwater, Inc., 2001
Environmental Law Short Course, Environmental Education Enterprises, Inc., 1996

PUBLICATIONS AND PRESENTATIONS

2007. Selecting the Optimal Remediation Strategy. *Presentation at the March 2007 Society of American Military Engineers Frontier Post Meeting, March 22, 2007, Cheyenne Wyoming.*

2005. In situ Biodenitrification Groundwater Remediation System. *Proceedings of the Eighth International In Situ and On-Site Bioremediation Symposium, Baltimore, Maryland, June 6-9, 2005*, B.C. Alleman and M.E. Kelley: Battelle Press: Columbus, OH, 2005; Paper O-02 (with Amy L. Hudson).

2005. In situ Biodenitrification Groundwater Treatment System. *Presentation to the New Mexico Environment Department, May 9, 2005, Santa Fe, New Mexico.*

2005. Large-Scale Application of In Situ Remediation to Remove Nitrate from Groundwater. *Federal Facilities Environmental Journal*, Wiley Periodicals, Inc., Spring 2005; p 97 (with Amy L. Hudson)

2004. Impacts of Near Mountain Geology on an In Situ Biodenitrification System. *Presentation at the 2004 Geological Society of America (GSA) Annual Meeting, November 2004, Denver, Colorado* ; (with Amy Hudson).

2004. Large Scale Application of In Situ Biodenitrification. *Presentation at the 9th Annual Joint Services Environmental Management Conference , August 2004, San Antonio, Texas,* (with Amy Hudson).

2003. In Situ Biodenitrification – A Case Study. *Proceedings of NGWA Conference on Remediation: site Closure and the Total Cost of Clean-Up, November 13-14, 2003, New Orleans, Louisiana*: National Ground Water Association; p 378 (with Amy Hudson).

2001. Accelerating the Reductive Dechlorination Process in Groundwater. *Anaerobic Degradation of Chlorinated Solvents*, Magar V.S., et. al.: Battelle Press: Columbus, 2001; p. 205 (with D. South, J. Seracuse, D. Li).

1996. Removal of N-nitrosodimethylamine from Rocky Mountain Arsenal waters using innovative adsorption technologies. Technical report EL-96-11, U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS (with E. C. Fleming, J. C. Pennington, N. R. Francingues, D. R. Felt, B. G. Wachob, R. A. Howe, and M. R. Colsman).

1990. Further studies of the synthesis of 1-naphthols and 4-hydroxy-5,6-dimethylbenzothiophene by protonation of $Cp(CO)_2WCTol$ and $Cp(CO)_2WC(2\text{-}C_4H_3S)$ in the presence of alkynes and CO. *J. Organomet. Chem.*, 394, 251 (with W. C. Feng, H. Matsuzaka, G. L. Geoffroy, and A. L. Rheingold).

1990. The synthesis and characterization of size selective Pt-Ir clusters on metal oxide surfaces. Annual Research Review, Center for Catalytic Science and Technology, University of Delaware, October (with B. C. Gates, and A. L. Rheingold).

1989. Transient generation of the reactive carbene complex $[Cp(CO)_2W{=}CH(Tol)]^+$ and its reactions with alkynes to form vinylcarbene, allyl, naphthol, diene, and metallafuran complexes. *J. Am. Chem. Soc.*, 111, 8383 (with J. B. Sheridan, D. B. Pourreau, W. C. Feng, G. L. Geoffroy, D. L. Staley, and A. L. Rheingold).

1989. In situ generation of the benzylidene complex $[Cp(CO)_2W{=}CH(Tol)]^+$ and its reaction with alkynes. *Advances in Metal Carbene Chemistry,* Schubert U. Ed.: Kluwer Academic Publishers: Dordrecht, 1989; p. 189 (with G. L. Geoffroy, J. B. Sheridan, and D. B. Pourreau).

1989. Cycloaddition of imines and $Bu^tN{=}O$ with the carbyne complexes $[Cp(CO)_2MCTol]^+$ (M=Mn, Re). *Organometallics*, 9, 1562 (with B. M. Handwerker, K. L. Nagle, G. L. Geoffroy, and A. L. Rheingold).

1989. New types of metallacycles formed by cycloaddition of imines and $Bu^tN{=}O$ with Mn and Re carbyne complexes. *J. Am. Chem. Soc.*, 111, 369 (with B. M. Handwerker, G. L. Geoffroy, and A. L. Rheingold).

1989. Transient generation of the reactive carbene complex $[Cp(CO)_2W{=}CH(Tol)]^+$ and its reactions with alkynes to form vinylcarbene, allyl, naphthol, and metallafuran complexes. Presented at 23rd Middle Atlantic Regional Meeting of the American Chemical Society, May (with J. B. Sheridan, D. B. Pourreau, G. L. Geoffroy, and A. L. Rheingold).

1988. Preparation and structural characterization of $[\{Cp(CO)_2W\}_2(\eta$□$TolCC(OH)CTol)][BF_4]\ CH_2Cl_3$. *Inorg. Chem.*, 27, 3248 (with J. B. Sheridan, G. L. Geoffroy, and A. L. Rheingold).

1988. Reaction of $[Cp(CO_2MCTol]^+$ (M=Mn, Re) with imines and hydrazones. *Third Chemical Congress of North America*, June (with B. M. Handwerker, G. L. Geoffroy, and A. L. Rheingold).

Scott Graham

Project Geologist

Professional summary

Mr. Graham, a Geologist and Environmental Scientist, has been working in the environmental consulting field since 1995. He has demonstrated ability to effectively manage projects, personnel, and budgets. He has extensive knowledge of environmental compliance, including site assessments, remedial feasibility testing, remediation system design and construction, reporting, risk assessment, project and lifecycle budget forecasting, case planning, client and regulatory liaison, and staff training and management. The majority of his project experience is in the governmental, real estate, and petroleum industries.

Employment history

Wood Environment & Infrastructure, Petaluma, CA, Technical Professional 3, 2017-Present

Amec Foster Wheeler Environment & Infrastructure, Inc., Petaluma, CA Project Geologist, 2014 to 2017

AMEC Environment & Infrastructure, Inc., Petaluma, CA, Project Geologist, 2011–2014

MACTEC Engineering and Consulting, Inc., Petaluma, CA, Project Geologist, 2005–2011

SCS Engineers, Santa Rosa, CA, Geologist, 6/2005–12/2005

Delta Environmental Consultants, Incorporated, Sacramento, Project Manager, 10/2004–5/2005

SECOR International, Incorporated, Sacramento, CA, Associate Geologist, 7/2003–10/2004

Environmental Resolutions, Incorporated, Novato, CA, Project Manager, 1/2001–6/2003

Environmental Resolutions, Incorporated, Novato, CA, Senior Staff Geologist, 4/2000–1/2001

Environmental Resolutions, Incorporated, Novato, CA, Staff Geologist, 7/1998–4/2000
Environmental Resolutions, Incorporated, Novato, CA, Environmental Technician, 5/1995–7/1998

Non-professional certifications and training

CPR/AED

Defensive Driving

First Aid

HAZWOPER 40 Hour

HAZWOPER 8 Hour Refresher

HAZWOPER 8 Hour Supervisor

OSHA 10 Hour Construction Safety and Health

OSHA 30 Hour Construction Safety and Health

U.S. Army Corps of Engineers Construction Quality Management for Contractors

Doyle Scholarship, Santa Rosa Junior College, 1988

Representative projects

Beale Air Force Base, 2017, Yuba City, CA, Field Geologist. As Field Geologist, oversaw installation of soil borings and monitoring wells. Scope: Perform remedial investigation tasks as associated with the Air Force's PFAS Investigation activities. Tasks include planning, driller oversight, and soil and groundwater sampling.

March Air Force Base, 2017, Riverside County, CA, Field Geologist. As Field Geologist, oversaw installation of soil borings and monitoring wells. Scope: Perform remedial

Years with Wood: 13

Years' Experience: 23

Education

Bachelor of Science, Geology, California State University, Sonoma, 1995

Associate of Science, Science, Santa Rosa Junior College, 1991

Location

West US - Petaluma

Languages

English

investigation tasks as associated with the Air Force's PFAS Investigation activities. Tasks include planning, driller oversight, and soil and groundwater sampling.

Alameda Naval Air Force Base, 2016 and 2017, Alameda, CA, Field Geologist. As Field Geologist oversaw the installation and development of groundwater monitoring wells. Tasks include permitting, driller oversight, soil and groundwater sampling.

Borehole Field Verification Activities, 2016 to 2018, California Department of Transportation (Caltrans), Various Cities and Counties, CA. As Field Geologist, Perform Field verification of the presence and location of geotechnical borings and wells throughout the state. Tasks include planning, research of online databases, QA/QC of historical documents, and field verification activities associated with locating geotechnical borings and wells installed at various construction sites throughout the state.

ABB Chico 2012, Chico, CA 107652, 880,000, 2010. Field Geologist. As Field Geologist, oversaw installation of monitoring wells. Scope: Perform remedial investigation/feasibility study tasks specified by the DTSC's Partial Consent Agreement issued to ABB Inc. to investigate and remediate impacted groundwater at the site. Tasks include litigation support and project management, monthly status reports, RI implementation, annual wellhead treatment system sampling, and quarterly groundwater monitoring. Chlorinated solvents and TCE were found along the Skyway plume.

Roadside Vegetated Treatment System (RVTS) Study Oversight 2007-2008, California Department of Transportation (Caltrans) - Environmental Program Office, Various Cities, CA, United States. 074859 RVTS, 250,080, 2010. Project Geologist. Responsible for conducting stormwater monitoring and maintenance activities at two sites (Napa and San Mateo) in Northern California. Collected water samples and tabulated data related to major storms at both sites. Scope: Monitoring oversight, data management, and reporting for 2007-2008 Roadside Vegetated Treatment Study (RVTS). Study designed to assess treatment performance of vegetated slopes with varied configurations of vegetative cover, dependent on slope and soil, for effectiveness of erosion control. Services also included post-storm monitoring of stormwater runoff; technical memorandum reviews; and updating of both Sampling & Analysis Plan and Health & Safety Plan.

Casmalia Resources Superfund Site Maintenance, Remedial Investigation / Feasibility Study (RI/FS), Groundwater Monitoring, Bingham McCutchen, LLP (formerly McCutchen, Doyle, Brown & Enerson), Casmalia, CA, United States. 990061, 21,900,000, 2009. Geologist. Responsible for assisting with non-aqueous phase liquid monitoring and well development via air lifting and WaTerra Pump under work conditions involving development and monitoring in Class C PPE. Scope: Site maintenance and management, RI/FS, regulatory compliance and support of investigation at a 252-acre, former Class I Superfund, Hazardous Waste Management Facility comprising five separate landfills and which included approximately 40,000 tons of industrial waste on site (with acids, caustics, solvents, pesticides and metals). Implemented 24-hour operating leachate collection and contaminated groundwater treatment system, and over 300 monitoring wells.

Chico Facility Regulatory Review Environmental Support Services, Major Chemical Manufacturing Company, CONFIDENTIAL CLIENT ABB, Inc.- Combustion Engineering (CE), Chico, CA, United States. 072198, 3,400,000, 2016. Geologist. Responsible for providing drilling/well construction oversight for installation of sonic wells. Finished long-term, out of town project on schedule with a minimum downtime. Assisted with preparation of RI/FS Work Plan, with drilling price quote and drilling set-up, and provided oversight of drilling and sampling.**DO NOT USE THIS PROJECT IN ANY PROPOSAL OR MARKETING MATERIALS WITHOUT FIRST CONTACTING THE AMEC PROJECT MANAGER. DUE TO LITIGIOUS OF THIS PROJECT, WHICH IS THE REASON IT IS BEING PERFORMED IN THE FIRST PLACE, THIS CLIENT DOES NOT WANT US TO USE THEIR PROJECTS IN ANY PUBLIC COMMUNICATIONS OR MARKETING EFFORTS WITHOUT FIRST OBTAINING THEIR PERMISSION.** Scope: Regulatory review and litigation-related environmental support services for former industrial building products manufacturer. Services include subsurface characterization, groundwater quality testing and sampling pertaining to characterizing the extent of a groundwater plume impacted by the historic disposal of solvents (PCE and TCE).

Signal Oil Semiannual Groundwater Sampling, Major Industrial Client, CONFIDENTIAL CLIENT Honeywell International, Inc., Edgewood, WA, United States. 031612, 38,000, 2007. Geologist. Responsible for site schedule, performing pre-drill protocols, writing HASP, coordinating equipment shipment for out of state locations, overseeing drilling of five hollow stem auger borings to collect soil and water data, performing quarterly monitoring, and sampling field work for the 4th quarter 2005; assisted in determining the extent of hydrocarbon contamination and future placement of oxygen releasing product injection.**DO NOT USE THIS PROJECT IN ANY PROPOSAL OR MARKETING MATERIALS WITHOUT FIRST CONTACTING THE AMEC PROJECT MANAGER. Although this project was not performed under the Alliance agreement, it should be considered CONFIDENTIAL in view of the client's recent mandate.** Scope: Semiannual groundwater monitoring and sampling of three onsite wells at site of former service station (approximately 110 ft. X 120 ft. site) and installation of soil borings. One well exhibits concentrations of fuel hydrocarbons.

Former Chemical Manufacturing Facility Perchlorate Investigation, Remediation, Confidential Chemical Manufacturer, CONFIDENTIAL CLIENT, Morgan Hill, CA, United States. 020905, 6,000,000, 2010. Geologist. Responsible for assisting in door-to-door sampling of privately-owned domestic wells, and well development of offsite monitoring wells using airlifting, and groundwater sampling using airlifting and a WaTerra pump. PLEASE CONTACT THE AMEC PROJECT MANAGER BEFORE USING THIS PROJECT IN ANY PROPOSAL OR MARKETING MATERIALS. Scope: Prepared and implemented several phases of remedial investigation to delineate lateral and vertical extent of perchlorate in soil and groundwater for design of an on-site remediation system at the site of a former flare manufacturing facility. Perchlorate has been detected in on-site soil, and on-site and off-site groundwater extending from the site and to depths in excess of 600 feet below ground surface. AMEC identified and implemented innovative monitoring well installation techniques, in situ aquifer testing procedures, and groundwater sampling methods. AMEC devised several monitoring and evaluation programs to save the client additional future remediation and monitoring well installation costs.

Hunters Point Naval Shipyard Parcel A Environmental Consulting Services, Lennar / BVHP, LLC, San Francisco, CA, United States. 053085, 850,000, 2012. Project Geologist. Provided review of and recommendations on existing documents. Lennar achieved compliance with regulatory requirements with Amec Foster Wheeler's assistance. Performed air/dust monitoring at Hunters Point. Scope: Environmental consulting services to support client's legal counsel, address special requests for information from project stakeholders, and present information at planning and technical meetings as part of ongoing effort to redevelop Parcel A of area formerly occupied by U.S. Naval shipyard. Provided review of and recommendations on existing documents. ***Lennar achieved compliance with regulatory requirements with AMEC's assistance.***

Leviathan Mine Field Support (IWO), Atlantic Richfield Company, Markleeville, CA 115724, 75,600, 2011. Field Geologist. Performed drilling and exploration services at Leviathan Mine. Scope: Drilling and exploration services at Leviathan Mine. This site is an abandoned open-pit sulfur mine located in Alpine County, California. The mine is located at on the eastern slope of the Sierra Nevada at about 7,000-foot (2,100 m) elevation, 6 miles (9.7 km) east of Markleeville and 24 miles (39 km) southeast of Lake Tahoe. The mine site comprises approximately 250 acres.

Brownfields Land Recycling Program, Nevada Division of Environmental Protection (NDEP), Henderson, NV, United States. 010476, 850,000, 2007. Geologist. Responsible for writing the Work Plan and Sampling and Analysis Plan for future excavation work to remove lead contamination at a former firing range. Scope: Master Services Agreement for 4 years to provide brownfields assessment and cleanup services in a statewide program to recycle / redevelop brownfields sites. ***Project included successful completion of cleanup of almost a century's worth of waste materials at the Northern Nevada Railway Museum (Ely, NV), which allowed continuation of preservation efforts, and should improve attendance and increase local revenue because more historical buildings on the site will soon be open to the public.***

Queen of the Valley Medical Center Geotechnical Engineering Services, St. Joseph Health System, Napa, CA 107815, 127,000, 2011. Field Geologist. Served as Field Geologist with responsibility for overseeing the exterior site grading and pavement construction. Scope: Geotechnical engineering services during the construction of the new, three-story acute care building in Napa. Building footprint dimensions are 105 x 225 feet.

Site Closure Environmental Services, The Presidio Trust, San Francisco, CA, United States. 008379, 6,655,330, 2011. Geologist. Oversaw the installation of Test pits to determine the extent of fill materials and contaminants, install soil borings and test pits to determine extent of asphalt roofing materials, log soils and debris across site, collect soil samples, and assist in results report. As a Field Geology Professional, conducted field operations for a subsurface investigation, assisted in writing a technical memorandum and Corrective Action Plan, wrote a Corrective Action Implementation Work Plan, and attended site meetings with clients and regulators. Also assisted with developing a master reference cost spreadsheet and providing quality assurance/control of several cost spreadsheets used to price remedial options for Corrective Action Plans. Produced investigation reports for multiple sites within the Presidio. Performed field investigations (i.e., surface sediments and shallow soil borings) at Building 1450/1451, Nike Facility, and Building 1369 sites to specify excavation areas, amounts to be excavated, procedures, and remedial methods to be used in site cleanup.

- For Fill Site 1 and Landfill 2, provided drilling oversight for the installation of hollow stem auger soil borings to delineate the boundaries of the debris, fill, and native materials.
- For Building 1065, developed construction completion report. Also authored Corrective Action Implementation Work Plan; oversaw field work, including excavation, collection of soil and water samples, land use control cap inspection; served as regulatory liaison between Presidio and regulators to complete work in a manner acceptable to all parties.
- Assisted with the production of pre-remedial investigation Work Plans, Corrective Action Plans, a technical memorandum, and investigation reports for multiple sites within the Presidio; performed field investigations (surface sediments and shallow soil borings) at Building 1450/1451, Nike Facility, and Building 1369 sites to specify excavation areas, amounts to be excavated, procedures, and remedial methods to be used in site cleanup.
- Oversaw the installation of Test pits to determine the extent of fill materials and contaminants, install soil borings and test pits to determine extent of asphalt roofing materials, log soils and debris across site, collect soil samples, and assist in results report.

Environmental services associated with site closure, including site investigation, risk assessment, feasibility study (FS), engineering design, data management, ecological risk assessment, remediation, and reporting at historic 1,416-acre former military base at the south end of the Golden Gate Bridge.

Environmental Services at 8 Army Reserve Centers, Kemron - North Division, Seven U.S. Department of the Army - Northern Region Contracting Center, US, United States. 040979, 3,387,120, 2010. Project Geologist. Responsible for

Continued...

remediation implementation for Camp Parks Site and organized remediation field efforts and reporting. Scope: Full range of environmental and technical services at eight U.S. Army installations in five states (Massachusetts, Connecticut, Rhode Island, Maine, and California) addressing soil and groundwater contamination at landfills, underground storage tank sites and other waste storage and disposal sites. Work included remedial investigations / feasibility studies (RI/FS) and environmental remediation design services.

Fort Ord Operable Unit (OU) Habitat Remedial Investigation / Feasibility Study (RI/FS), U.S. Army Corps of Engineers (USACE) – Huntsville District, Monterey, CA, United States. 027629 FTORD, 20,000,000, 2009. Project Geologist. 1) Responsible for gathering, reviewing, and summarizing historical data for a Basewide RI/FS. Assisted with the development of tables and site maps and addressed agency comments regarding the RI/FS. Assisted in developing and writing a Technical Memo for part of the Base detailing the site history and proposed scope of future work. 2) Assisted in data gathering and writing of a technical memorandum and assessment approach for multiple sites across Fort Ord. Assisted in design of the RI pathways and methods. Scope: Since 2004, AMEC has been conducting full remediation investigation / feasibility study (RI/FS) to address munitions and explosives of concern (MEC) at the Impact Area Munitions Response Area (MRA) for 6,500 acres of a 8,000-acre former U.S. Army training range complex (small arms to artillery fire). Activities included planning, site characterization, archival (historic) search, risk assessment (human health), feasibility study, and community relations support.

Unlinked Amec Foster Wheeler projects

Industrial Hygiene Services, 50 California Street, Shorenstein Realty Services, San Francisco, CA, United States. 8415180450. Ongoing. Industrial Hygiene Technician. Performed annual Heating, Ventilation, and Air Conditioning (HVAC) and Transmission Electron Microscopy (TEM) surveys and reporting to monitor the air quality and performance of the HVAC system to ensure compliance with applicable health and safety standards.

Environmental Services, MDC Engineered Process Solutions, Hayward and San Jose, CA, United States. 8615180420. Geology Professional. Performed site inspection (phase I environmental screening analysis) and comprehensive compliance audit of environmental program.

Environmental Services, California Paperboard Company, Santa Clara, CA, United States. OD13165230. December 2015. Geologic Professional. Performed permitting, job preparation and setup, and field oversight for the installation of two monitoring wells, direct push soil borings, and soil vapor wells. Performed site oversight for the removal and over excavation of three undocumented underground storage tanks (USTs) and performed set up and sampling of groundwater, over excavation soil samples, and soil vapor.

Environmental Services, Hertz Northfield QTA Facility, Oakland, CA, United States. Ongoing. Geologic Professional. Performed field oversight and reporting for the installation and sampling of 25 direct push soil borings, three test trenches, and six groundwater monitoring wells to evaluate the site conditions, transport mechanisms, and extent of the hydrocarbon plume. Performed oversight and soil sampling for over excavation and removal of impacted soils in source area.

Environmental Services, Alameda Naval Yard – Site 6, Alameda CA, United States. 5023136030. Geology Professional. Performed operations and oversight of 2 subcontractors during the extraction and injection activities of 30+ wells and 20,000 gallons of injection materials. Scheduling, set-up, and operation of post-injection groundwater monitoring activities.

Environmental services, Former Honeywell Site, Newark CA, United States. OD14171100. Geology Professional. Performed oversight and soil logging for the installation of 29 injection wells and four groundwater monitoring wells.

Environmental Investigation Chevron Estero Facility, Chevron, Morro Bay, CA, United States. OD11161540. Estimate completion: April through October 2012. Geologic Professional. Performed job preparation and field oversight for the installation of four well pairs using hollow stem auger and attempted water supply wells using air-rotary drilling techniques. Oversaw well development and pump testing of one water supply well. Helped to develop an asbestos monitoring/abatement plan and performed the asbestos monitoring and oversight during drilling through rock containing naturally occurring asbestos (NOA).

Environmental Services, Fort Hunter Liggett, U.S. Army, Jolon, CA, United States. 4084106586.02.3. June 2011. Geologic Professional. Performed field oversight for the installation of direct push borings using a membrane interface probe and a ultra-violet optical screening tool to detect free product and PAHs to get an estimate of the vertical and horizontal extent of the hydrocarbon plume and determine any data gaps in the monitoring well setup.

Santa Rosa Service Center, CONFIDENTIAL CLIENT, Pacific Gas and Electric, Santa Rosa, CA, United States. 013045005H.2. Geologic Professional. Performed field oversight for the installation of sub-slab and subsurface soil vapor sampling probes and direct push soil borings onsite and offsite. Soil vapor sampling probes and onsite soil borings were installed inside buildings using limited access rigs.

Mojave National Preserve, National Park Service, Mojave, CA, United States. Geology Professional. Performed planning, field oversight, sampling, and reporting in conjunction with excavation work at three sites within the preserve. Site work performed for auditing purposes and to allow for site closures.

Continued...

Site Conceptual Model and Corrective Action Plan, Mariposa Ranger Unit Headquarters, Mariposa, CA, United States. Geology Professional. Developed and wrote a Site Conceptual Model and Corrective Action Plan recommending hydrogen peroxide injection to treat residual hydrocarbon concentrations in groundwater at the subject site. Wrote the fourth quarter 2005 quarterly monitoring and sampling report.

Camp Parks, Corrective Action Plan, Dublin, CA, United States. Geology Professional. Wrote corrective action plan and helped to compile data from site conceptual model, assessment report, and CAP into one coherent report. Allowed for future excavation of contaminated soils and providing remedy in place to allow for property transfer. Provided oversight of excavation and injection activities to finish cleanup activities at site and help to develop results and closure report which allowed final site closure.

Circuit City, Puyallup, WA, United States. Geology Professional. Setup drilling, performed pre-drill protocols, wrote HASP, coordinated equipment shipment (for out of state job), and oversaw drilling of 2 hollow stem auger borings to geotechnical data for new loading dock.

Phase I Environmental Site Assessments, Pacific Oroville Power, Inc., Oroville, CA, United States. 3031122016. Geologic Professional. Performed a Phase 1 Environmental Site Assessment at the former power plant for use as due diligence as part of a potential property transaction. Wrote the report detailing the findings of the site visit.

Caitlin Elizabeth Brice, M.Sc.

315 Bellerose Dr. Apt. 2
San Jose, CA 95128
Tel. 954-651-3395
caity63@yahoo.com
LinkedIn Profile

EDUCATION

Nova Southeastern University, Master of Science in Marine Biology **May 2014**
Thesis title: "The Detection of Amazonian Manatees (*Trichechus inunguis*) Using Side-Scan Sonar and the Effect of Oil Activities on Their Habitats in Eastern Ecuador" GPA: 3.79
http://nsuworks.nova.edu/occ_stuetd/8/
GRE: Verbal – 530, Quantitative – 750, Writing – 4.5

St. Andrews University, Introduction to Distance® Sampling **August 2012**

Drury University, Bachelor of Arts in Biology and Chemistry (with Honors) **May 2009**
Minor in Global Studies GPA 3.95
Summa Cum Laude
ACT: 31

PROFESSIONAL EXPERIENCE

Accutest Northern California, Quality Assurance Officer **Jan. 2015 – Present**
- Manage, enforce, and audit the quality systems, procedures, data, reports, and analyst competency at a certified environmental laboratory for conformance to NELAC, DOD, DOE, ISO, and EPA requirements, state specific requirements (CA, AK, AZ, OR, WA, NV), client specific objectives, and improvement of laboratory performance.

Florida Spectrum Environmental Services, Inc., Quality Assurance Director **Dec. 2012-Jan. 2015**
- Direct, enforce, and audit the quality systems, procedures, data, reports, and analyst competency at five certified laboratories for conformance to NELAC, FDOH, FDEP, and EPA requirements, client specific objectives, and improvement of laboratory performance.

Florida Spectrum Environmental Services, Inc., **Feb. 2010 – Dec. 2012**
Analytical Chemist and Microbiologist
- Performed EPA methods in inorganics, organics, extractions, and microbiology in solid, water, and chemical matrices.
- Analyzed samples using HPLC, IC, GC/MS, Flow Analyzers, Discrete Analyzers, Block Digesters, Distillation Units, and Incubators.

RESEARCH EXPERIENCE

Nova Southeastern University, Graduate Research Assistant **August 2010 – May 2014**
- Collected water samples, conducted interviews, and performed side-scan sonar surveys to detect Amazonian Manatees and investigate their population ecology in the rivers and lagoons of the Amazon River basin in Eastern Ecuador. Field time: 6 weeks.

Newfound Harbor Marine Institute Seacamp, Research Intern **May 2006**
- Surveyed marine life in Big Pine Key, FL.

TEACHING EXPERIENCE

Nova Southeastern University, Laboratory Assistant **Aug. 2009-May 2011**

- Assisted with the set-up and teaching of Biology 101 laboratory classes.

PUBLICATIONS

Brice, Caitlin E. 2014. "The Detection of Amazonian Manatees (Trichechus inunguis) Using Side-Scan Sonar and the Effect of Oil Activities on Their Habitats in Eastern Ecuador." http://nsuworks.nova.edu/occ_stuetd/8.

Brice, Caitlin. October 2011. "The Status of Amazonian Manatees (*Trichechus inunguis*) and Their Habitats in Eastern Ecuador". Sirenews. Number 56. www.sirenian.org/sirenews/56OCT2011.pdf

PRESENTATIONS

Florida Marine Mammal Health Conference, Poster Presenter **April 2012**
"Oil Effects on the Amazonian Manatee (*Trichechus inunguis)* in Eastern Ecuador: Evaluating the Risks"
Southeast and Mid Atlantic Marine Mammal Symposium, Oral Presenter **March 2012**
"Oil Effects on the Amazonian Manatee (*Trichechus inunguis*) in Eastern Ecuador: Evaluating the Risks"
19th Biennial Conference on the Biology of Marine Mammals, Oral Presenter **Nov. 2011**
"The Status of Amazonian Manatees (*Trichechus inunguis*) and Their Habitats in Eastern Ecuador"
Fifth Annual International Sirenian Symposium, Oral Presenter **Nov. 2011**
"The Status of Amazonian Manatees (*Trichechus inunguis*) and Their Habitats in Eastern Ecuador"

SKILLS

Superior Organization and Communication
Management of Multiple Teams Effectively Toward a Common Goal
Rapid Learning and Adaptability
Trained Protected Species Observer (PSO)
Certified PADI Open Water Diver
Proficient with Laboratory Internal Management Systems (LIMS), JMP®, Humviewer®, ArcGIS®, Agilent ChemStation®, Distance® software, and Microsoft® Office
Intermediate Spanish Reading, Writing, and Conversational Skills
Violinist

HONORS AND AWARDS

First Place - Southeast and Mid Atlantic Marine Mammal Symposium (2012)
Walter H. Hoffman Chemistry Award for outstanding academic performance (2009)
Beta Beta Beta, Chi Chapter Inductee – Biology Honor Society (2008)
Omicron Delta Kappa – Leadership Honor Society Inductee (2008)
National Honor Society (Inducted 2003)
Concert Master – Drury Chamber Orchestra and Drury String Quartet (2007-2009)
Girl Scout Gold Award Recipient (2008)
Community Leadership Scholarship (2005)
Elk's Lodge Scholarship (2005)
Presidential Academic Scholarship (2005)
Presidential Musical Scholarship for Violin (2005)
Women in Science Award (May 2005)

ORGANIZATIONS AND AFFILIATIONS

Marine Animal Rescue Society (MARS) – Trained Volunteer
The Society of Marine Mammalogy
Florida Society of Environmental Analysts (FSEA)
The NELAC Institute (TNI)
American Chemical Society

REFERENCES

Dr. Caryn Self-Sullivan, Ph.D.
Areas of Expertise: Marine Mammal Surveys and Surveys in Remote Areas
Major Thesis Advisor - Nova Southeastern University Oceanographic Center
Co-founder - Sirenian International, Inc.
540-287-8207
cs1733@nova.edu

Dr. Donald McCorquodale, Ph.D.
Areas of Expertise: Environmental Assessments, Project Management, and Microbiology
Thesis Committee Member - Nova Southeastern University Oceanographic Center
Founder, Former Quality Assurance Director, Microbiologist, and Mentor - Florida Spectrum Environmental Services, Inc.
954-258-4630
mccorq@nova.edu

Richard Vicchiarelli, M.S.
Areas of Expertise: Analytical Chemistry
Chemist – Florida Spectrum Environmental Services, Inc.
954-547-4296
vicchi@bellsouth.net

Dr. Daniel Gonzalez-Socoloske, Ph.D.
Areas of Expertise: Marine Mammal Surveys and Side-Scan Sonar Surveys
Thesis Committee Member – Andrews University
Associate Editor – Latin American Journal of Aquatic Mammals
gonzalezd@andrews.edu

Dr. Roger Reep, Ph.D.
Areas of Expertise: Florida Manatees and Marine Mammal Surveys
Thesis Committee Member – University of Florida
reepr@ufl.edu

SGS ACCUTEST

Professional Summary

Name: **Norman Farmer**
Title: **Corporate Technical Director,**
SGS Accutest Inc.

Education: BS Chemical Oceanography
Florida Institute of Technology

Post Baccalaureate Study
Florida Institute of Technology

Employment History:

2014 – present	Accutest Laboratories Southeast, SGS-Accutest Technical Director, Corporate Technical Director
2001 – 2014	Accutest Laboratories Southeast Technical Director
1996 – 2001	Accutest Laboratories Southeast Organics Manager
1994 – 1996	Orlando Laboratories, Inc. Organics Supervisor (Semivolatiles)
1991 – 1994	Orlando Laboratories, Inc. Senior GC/MS Analyst
1990 – 1992	Orlando Laboratories, Inc. Extraction Supervisor

Experience/Qualifications:

Mr. Farmer currently oversees the technical operation for SGS-Accutest. This includes co-ordinating projects between the facilities, project review, Research and Development oversight, instrumentation acquisition and method validation. In addition, Mr. Farmer is responsible for creating and maintaining project specific requirements in the LIMS and EDD development.

Mr. Farmer is also active on various regulatory committees and advisory groups.

Prior Mr. Farmer managed the Organics Department of Accutest Laboratories' Southeast Lab. The laboratory utilizes GC, GC/MS, and HPLC instrumentation to analyze samples by EPA 600 and 8000 Series Methods.

Mr. Farmer is familiar with the various QC and reporting criteria for Navy, U. S. Army Corps of Engineers, and AFCEE. Mr. Farmer reviews Quality Assurance Project Plans to ensure that all data quality objectives and reporting requirements are met by laboratory.

Professional Summary

Name:	**Elvin Kumar**
Title:	**Project Manager** **SGS Accutest Inc. – Orlando**
Education:	Auckland University of Technology, New Zealand. **2004** Fiji Institute of Technology Bachelor of Applied Science (Environmental Studies)
	Fiji Institute of Technology Diploma in Environmental Science

Additional Professional courses/Certificates

40 Hour HAZWOPER – 29CFR 1910.120(e)
DOT 49 CFR 172.704 - Hazardous Material Transportation
IATA-Shipping Dangerous Goods by Air
Compliance Solution Occupational Trainers, Inc.

Employment History:

2016-Present	SGS Accutest – Orlando Project Manager
2013-2016	SGS Accutest – San Jose Project Manager
2008-2013	Accutest Laboratories, Northern California Sample Control Manager/Safety Officer
2007-2008	Entech Analytical Labs, Santa Clara Laboratory Technician
2005-2006	Emperor Gold Mining Co., Fiji Islands Environmental Technician/EHS/Field Sampler

Experience/Qualifications:

Mr. Kumar is currently a Project Manager for the SGS Accutest – Orlando, assisting both commercial clients and clients serving the Department of Defense. His background includes client services, sample management and routine interface with various departments to ensure timeliness of sample analyses. His responsibilities include management of client projects, addressing client inquiries and issues, and preparing sample bottle orders. Additionally, Mr. Kumar acts as a liaison between the clients and various laboratory departments to ensure timeliness of data and addressing project-specific requirements.

SGS ACCUTEST

Professional Summary

Name: **Svetlana Izosimova**
Title: **Quality Assurance Officer**
Southeast Regional Laboratory

Education: B.S./M.S. – Chemical Engineering
Waste Recovery Technology – 1987, Leningrad Institute of Pulp and Paper Industry, Russia.

Ph.D. – Colloid Chemistry, “Physical-Chemical Basis of Pulp Deresination Using Surfactants” – 1991, Leningrad Institute of Pulp and Paper Industry, Russia.

Employment History:

2001 – Present Accutest Laboratories Southeast, SGS Accutest - Orlando
Quality Assurance Officer

2000 – 2001 STL Tampa East, Tampa, FL
MS/Semivolatiles Section Leader

1999 – 2000 PBS&J Analytical Services, Orlando, FL
Quality Assurance Officer

1991 – 1998 PBS&J Analytical Services, Orlando, FL
GC/MS Analyst

1987 – 1991 Leningrad Institute of Pulp and Paper Industry, Russia
Researcher, Junior Grade

Experience/Qualifications:

Ms. Izosimova is currently the Quality Assurance Officer for Accutest Laboratories Southeast. She is responsible for implementing the Corporate Quality Assurance Program in the Southeast Laboratory. Ms. Izosimova has 25 years of experience in environmental analytical chemistry, organic and inorganic testing instrumentation, and industrial hygiene. Ms. Izosimova has served as a QA Officer for projects performed under U.S. Department of Defence.

ATTACHMENT C

Field Documentation Forms

1. Example Field Daily Logbook
2. Water Level Field Data Worksheet
3. Passive Diffusion Sampler (PDS) Groundwater Sampling Form
4. Groundwater Sampling and Pressure Levels Form for Westbay Wells
5. Water Level Indicator Calibration by Steel Tape
6. Ahtna Daily Site Safety Tailgate / Inspection Log
7. Task Specific Health and Safety Worksheet
8. Fort Ord Munitions and Explosives of Concern (MEC) Incident Reporting Form
9. Wood Chain of Custody Form
10. Ahtna Chain of Custody (Water / Soil)
11. Example Sample Labels
12. Post-Treatment Parameter Monitoring Form

PM Jeff Fenton
Ft. Ord. GW monitoring Q406
12/14

Team 2
SB/JK
Sounder 36392
Cor. -.06

0746 @ MW-02-04-180 WL - 94.57
Cor - -.06
SN2 @ 103'

0757 sampled # 0650L002024F
Dropped 1@2

0808 @ mw-12-05-180 WL - 74.61
Cor - -.06
SN3 @ 88'

18
0820 sampled # 0650L012025F & 026D
Dropped 1 @ 3

0835 @ mw-10-04-180 WL - 259.75
Cor. -.06
SN2 @ 271'

0845 sampled # 0650L010027F
Dropped 1@2

0902 @ mw-OU2-25-A WL - 129.38
Cor. -.06
SN4 @ 146'

0910 sampled # 0650LOU2028F
Dropped 1@4

0919 @ mw-OU2-53-180 WL - 204.09
Cor. -.06
SN5 @ 259'

0927 sampled # 6650OU2029F
Dropped 1@5

0934 @ mw-OU2-39-180 WL - 203.99
Cor. -.06
SN4 @ 244'

0943 sampled # 0650LOU2030F
Dropped 1@4

Team 2
SB/JK
12/14/06

0950 @ mw-OU2-24-180 WL - 187.97
Cor. -.06
SN3 @ 214

1002 sampled # 0650LOU2031F
Dropped 1@3

1009 @ mw-OU2-09-180R
SN2 @ 199' WL - 156.08
Cor. -.06

1022
1024 sampled # 0650LOU2032F & 033D
Dropped 1@2

1029 @ mw-OU2-06-A WL - 106.26
Cor. -.06
SN6 @ 128'

1039 Sampled # 0650LOU2034F
Dropped 1@6

1046 @ mw-OU2-06-180R WL - 157.87
Cor. -.06
SN4 @ 214'

1053 sampled # 0650LOU2035F (ms/msd)
Dropped 1@4

1110 @ mw-OU2-07-180R WL - 182.36
Cor. -.06
SN3 @ 233'

1117 sampled # 0650LOU2036F
Dropped 1@3

1123 @ mw-OU2-05-180 WL - 155.49
Cor. -.06
SN4 @ 215'

1130 sampled # 0650LOU2037F
Dropped 1@1

Water Level Field Data Worksheet

Sampling DB; Version 7EX

For Event: WL2011Q2, 2011 2nd Quarter water levels

Team: 3 Sounder Serial #:________ Calibration Diff :_________ Initials::_________ Scheduled Sampling Date: 06/20/ 2011

Station Name	Plate #	Notes	Avg. DTW (ft)	Date	Time	Measured DTW:1	Measured DTW: 2	Calibration Difference from Steel Tape	Calc. DTW	Total Depth (ft)	Measured Total Depth	Comments
MP-BW-34-492		westbay	140									
MP-BW-34-537		westbay	141									
MP-BW-35-242		westbay	146									
MP-BW-35-312		westbay	152									
MP-BW-35-366		westbay	152									
MP-BW-35-467		westbay	151									
MP-BW-35-527		westbay	151									
MP-BW-35-562		westbay	153									
MP-BW-35-402		westbay	152									
MP-BW-37-178	4	westbay	143							477.		
MP-BW-37-193	4	westbay	143							477.		
MP-BW-37-303	4	westbay	146							477.		
MP-BW-37-328	4	westbay	146							477.		
MP-BW-37-368	4	westbay	146							477.		
MP-BW-37-398	4	westbay	145							477.		
MP-BW-38-327	5	westbay	139							457.		
MP-BW-38-341	5	westbay	132							457.		
MP-BW-38-353	5	westbay	135							457.		
MP-BW-38-368	5	westbay	139							457.		
MP-BW-38-418	5	westbay	139							457.		
MP-BW-39-310	4	westbay	152							467.		
MP-BW-39-330	4	westbay	152							467.		
MP-BW-39-350	4	westbay	152							467.		
MP-BW-39-395	4	westbay	151							467.		
MP-BW-40-333	5	westbay	142							496.		

Reviewed by ________________________ Date ____________

Passive Diffusion Sampler (PDS) Groundwater Sampling Form
Former Fort Ord Groundwater Sampling Program

wood.

Project_Task Number: ______________________ Sampled By: __________
Task Manager: ______________________
Team Number: ____________ Site Report: __________
Recorded by: ______________________
Reviewed by: ______________________ Water Level Indicator Serial #: ______________

Well	**# Stations**	**Sample Number**	**Dup**	**Bag Sampled**	**# of bottles**	**Analysis**	**Pres.**	**Lab**	**Sample Date**	**Sample Time**	**Bag Drop**	**DTW**	**Cooler Temp.**

Quality Control Samples

Type		Sample No.

General Comments: ____

wood.

Groundwater Sampling and Pressure Levels Form for Westbay Wells

Project Number: ____________________

Task Manager ____________________

Technicians: ____________________

Recorded By: ____________________ / ______
(Signature) (Initials)

Reviewed By: ____________________ / ______
(Signature) (Initials)

Well Name: ____________________

Sample Date: ____________________

Barometric Pressure: ____________________

Sample Time: **Start:** ____________________
Finish: ____________________

Sample # First Port: ____________________

Client: USACE

Location: Former Fort Ord

Probe Type: West Bay

Probe Serial No.: ____________________

Port Identification			**Surface Functioning Tests (Probe in Flushing Collar)**						**Position Sampler**	**Pressure Test and Sample Collection Check at Port (Pressure Test) (Sample Collection)**								
Port No.	Port Name	Port Depth (Cable)	Arm Out Land Probe Shoe Out	Close Valve	Check Vacuum	Open Valve	Evacuate Container	Close Valve Shoe In	1. Locate Port 2. Arm Out 3. Land Probe	Pressure in MP (Internal)	Shoe Out	Zone Pressure (External)	Open Valve	Zone Pressure (External)	Close Valve	Shoe In	Pressure in MP (Internal)	Last 4 Digits of Sample #
1	**282**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
2	**317**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
3	**342**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
4	**397**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
5	**467**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
6	**537**		☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
			☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		
			☐	☐	☐	☐	☐	☐	☐		☐		☐		☐	☐		

General Comments: **Cooler Temp:** ^{o}C

QC Sample # Associated Sample:

Page ______ of ______

Second Quarter, 2008
4084086506 02.1.1

Fort Ord Quarterly Groundwater Monitoring Program

Water Level Indicator Calibration by Steel Tape

Well #:	
Steel Tape DTW:	
Date:	

Serial No.	Measured DTW	Calibration Differential

Reviewed by:	
Date:	

AHTNA DAILY SITE SAFETY TAILGATE / INSPECTION LOG

GENERAL DATA **Date:**

Site: Site Location:

AHTNA Site Manager: AHTNA SSHO:

DOCUMENTATION OF WORKDAY SAFETY MEETING (List Topics of Discussion**):**

Other items to address as appropriate (**check those discussed**):

- ☐ Scope of day's work
- ☐ Site SH&E Plan / Revisions
- ☐ AHA's / PTSP's completed/reviewed?
- ☐ Emergency SOPs (i.e. rally pt., tele #s)
- ☐ Communications Check
- ☐ PPE Requirements
- ☐ OSHA's Focus Four
  - ☐ Fall Hazards
  - ☐ Electrical Hazards
  - ☐ Struck-by Hazards
  - ☐ Caught in / between Hazards
- ☐ Other Primary Hazards
- ☐ Recent near miss / injuries / lessons
- ☐ Lifting Safety / Materials Handling
- ☐ BBS Hazard Triggers[1]
- ☐ BBS Trigger Controls[2]
- ☐ Other (heat, noise, trench, confine sp)

MEETING ATTENDEES: (place * next to subcontractor safety representatives**)**

NAME / COMPANY	NAME / COMPANY

SUBCONTRACTOR SAFETY REPs COMMENTS**?**

DAILY INSPECTIONS: (SSHO shall initial each completed applicable inspection item)

Y	N	NA	Inspection Item	Y	N	NA	Inspection Item	Y	N	NA	INSPECTION ITEM OTHER (List)
☐	☐	☐	Postings/Plans (APP) readily avail.	☐	☐	☐	Signs (No Smoking, Site Control)	☐	☐	☐	
☐	☐	☐	Designated Parking / Traffic Control	☐	☐	☐	PPE(head/eye/foot/hand/ear/body)	☐	☐	☐	
☐	☐	☐	Subcontractor Safety Rep Involved	☐	☐	☐	Hi-Vis, PFD's, Ring Buoys, Etc.	☐	☐	☐	
☐	☐	☐	Subcontractor / Task AHA's	☐	☐	☐	Excav./Trench/Spoils Protection	☐	☐	☐	
☐	☐	☐	Subcontractor Equip. Inspections	☐	☐	☐	Confined Spaces Management	☐	☐	☐	
☐	☐	☐	Emergency Equip. (PFE's, FA Kits)	☐	☐	☐	Physical Barriers / Covers	☐	☐	☐	
☐	☐	☐	Eye Wash / Shower	☐	☐	☐	Fall Hazards (Protected)	☐	☐	☐	
☐	☐	☐	Communications Check	☐	☐	☐	Ladders	**ISSUES TO FOLLOW-UP** (Immediately Correct Deficiencies if able)			
☐	☐	☐	Sanitation (Toilets, Hand Wash)	☐	☐	☐	Power & Portable Hand Tools				
☐	☐	☐	Water & Shade, Non-Pot Identified	☐	☐	☐	Company Field Equipment				
☐	☐	☐	Utilities Identified / Controlled	☐	☐	☐	Alarms / Seatbelts				
☐	☐	☐	Material Storage Proper	☐	☐	☐	GFCI's, Whip-Checks, Slings				
☐	☐	☐	Lay Down Areas Orderly	☐	☐	☐	Exposed Rebar Protected				
☐	☐	☐	Waste Containers	☐	☐	☐	Safety / Health Behaviors:				
☐	☐	☐	Spill Control (Pads, Snakes, Drums)	☐	☐	☐	Competent / Qualified Persons				

Immediately Correct any deficiencies. Note any uncorrected deficiencies on the APP Safety and Occupational Health Deficiency Tracking Log.

Comments/Field Notes:

I acknowledge that above elements performed (SSHO/Inspector signature): **Date:**

---

[1] **BBS Triggers**: (e.g. Distractions, rushing, short-cuts, frustration, exhaustion, complacency, anger, multi-tasking, mind elsewhere)

[2] **BBS Trigger Controls**: (e.g. communicating, accountability, patience, relaxation techniques, healthy lifestyle, and adequate sleep).

AHTNA DAILY SITE SAFETY TAILGATE / INSPECTION LOG

Additional MEETING ATTENDEES: **(**place * next to subcontractor safety representatives**)**

NAME / COMPANY		NAME / COMPANY

NOTES / COMMENTS / SKETCHES

TASK SPECIFIC HEALTH AND SAFETY WORKSHEET
SUPPLEMENT TO THE PROGRAM HEALTH AND SAFETY PLAN

This worksheet shall be used in conjunction with the AHTNA Accident Prevention Plan, March 2015, and the U.S. Army Corps of Engineers Safety and Health Manual, EM 385-1-1, November 2014.

GENERAL PROJECT INFORMATION

Project Number:_______________________________
Site or Activity Description:____________________
____
Location Description:__________________________

Date:___________________________________
Prepared by:_____________________________

Reviewed by:_____________________________

TASK DESCRIPTION (Check all that apply)

_____Sample Location Marking
_____Geophysics borehole clearance
_____Biological borehole clearance
_____Monitoring well installation
_____Soil Borings
_____Trenching
_____Hand augering
_____Soil gas survey
_____Geophysics
_____Groundwater sampling
_____Soil sampling
_____Other (specify)_____________________________________
_____Water level surveys
_____Sediment sampling
_____Biological inventory
_____Hazardous waste handing /mgmt
_____Hydropunch

SITE HAZARDS (check all that apply)

_____Contaminated water
    _____VOC
    _____SOC
    _____Metals
    _____PCB
    _____Pesticides
    _____Petroleum
    _____Chlorinated hydrocarbons
    _____Other (specify_______________

_____Contaminated Soil
    _____VOC
    _____SOC
    _____Metals
    _____PCB
    _____Pesticides
    _____Petroleum
    _____Chlorinated hydrocarbons
    _____Other (specify)____________

_____Contaminated Air
    _____VOC
    _____SOC
    _____Metals
    _____PCB
    _____Pesticides
    _____Petroleum
    _____Chlorinated hydrocarbons
    _____Other (specify)___________________

_____Ionizing radiation (specify)_______
____
_____Non-ionizing radiation (specify)
____
_____Noise
_____Biological hazards (specify) mountain lions, dogs, spiders, snakes, ticks, poison oak__
_____Temperature extremes Heat______Cold_________
_____Overhead/underground utilities
_____Vehicle traffic
_____Air traffic/noise
_____Unexploded ordnance (UXO)
_____Equipment/mechanical
_____Other (specify)________________
____

LEVEL OF PROTECTION REQUIRED (A, B, C, or D) _____minimum______maximum

PPE REQUIRED (Check all that apply)

Head:_____hardhat
Eye: _____safety glasses
_____chemical goggles
_____face shield
Ear: _____earplug
_____earmuff
Foot: _____steel-toed boots (specify)____________________
_____disposable overbooties (specify)______________
Hand: _____gloves (check type)
_____Neoprene
_____Viton
_____Nitrile
_____PVC
_____Underglove (type)____________________
_____Other (specify)_______________________

Body: _____ fully encapsulated suit
_____two-piece rain suit
_____apron
_____Tyvek suit
_____Saranex suit
_____hooded Tyvek suit
_____hooded Saranex suit
_____hooded polyethylene suit
_____cloth overalls
_____high visibility vest
_____Other (specify)____________
Respiratory: _____SCBA (pressure demand)
_____airline respiratory (pressure demand)
_____full face respirator, cartridge=____
_____half mask respirator cartridge=___
_____escape mask/bottle (specify)_____

OTHER SAFETY EQUIPMENT REQUIRED (Check all that apply)

______ventilation blower/fan
______traffic cones
______barrier tape
______blast alarm
______ground fault circuit interrupter
______lifeline with harness
______radiation dosimeter
______first aid kit
______fire extinguisher
______emergency eye wash
______cellular telephone
______Other (specify)___________

REQUIRED CLEARANCES

______Utilities Date Completed:__________
______Biological Date Completed:__________
______Airfield Date Completed:__________
______UXO/EOD Date Completed:__________
______Military Operations Date Completed:_______________________
______ Vehicle traffic area: Date Completed:_______________________
______Archaeological: Date Completed:_______________________
______Other (specify):______Date Completed:_______________________

LIST OF PERSONNEL ASSIGNED TO SITE AND RECORDS VERIFICATION

(Note: SSHO must initial verification that each personnel record is present in field binder.)

NAME	HAZWOPER CERTIFICATION	MEDICAL CLEARANCE	RESPIRATOR FIT TEST	FIRST AID/CPR	CELL PHONE NUMBER

I have read and become familiar with all aspects of the Site Safety and Health Plan. I also understand that the Site Safety and Health Plan may be supplemented with other site-specific health and safety documents for which I will be held equally responsible.

NAME	**DATE**	**COMPANY**	**SIGNATURE**

USACE PROJECT SITE SAFETY LOG

GENERAL DATA

Job # ____

Activity ____

Location Description ____

____

DOCUMENTATION OF DAILY MORNING SAFETY MEETING: TOPICS OF DISCUSSION (check all that apply)

______scope of work/SAP
______potential hazards
______health and safety plan highlights/revisions
______emergency procedures

______PPE requirements
______equipment calibration
______special topics (specify)_________
____

MEETING ATTENDEES:

NAME	DATE	COMPANY	SIGNATURE

DAILY INSPECTIONS: (Site crew chief shall initial each completed inspection)

______PPE
______field equipment
______vehicles
______safety equipment
______field health and safety binder in vehicle
______first aid kit

_______required eyewash station filled, and charged
_______fire extinguisher
_______communication check
method____________________________
time_______________________________

Note any deficiencies:

____

____

I acknowledge that the above health and safety program self audit and inspections have been performed prior to the initiation of scheduled work.

Signature of Site Safety and Health Officer (SSHO)_____________________________

LIST OF AUTHORIZED VISITORS NOT NORMALLY ASSIGNED TO THIS SITE

(Note: SSHO must initial verification that each personnel record is present in the field binder.)

NAME	HAZWOPER CERTIFICATION	MEDICAL CLEARANCE	RESPIRATOR FIT TEST	FIRST AID/CPR

FORT ORD MUNITIONS AND EXPLOSIVES OF CONCERN (MEC) INCIDENT REPORTING FORM

If you recognize any object that resembles munitions or explosives on current or former Fort Ord property, retreat to a safe location, and report the finding to the **appropriate agencies immediately** (see below)

A. PROVIDE THE FOLLOWING INFORMATION:

Name of Person Reporting:	Telephone:
Agency:	Fax:
Date & Time of Incident/Discovery:	
Description of Item Found (refer to the "Safety Alert" pamphlet if possible):	
Location (direction from nearest road/building, attach map if possible):	
GPS Coordinate Location: (Type of Instrument, NAD83 California State Plan Coordinates Zone IV, feet)	
Describe how the item was found:	

CONTACT THE APPROPRIATE AGENCIES IMMEDIATELY:

Initial when completed	**Mon– Thu (6 a.m. – 5 p.m.) Contact and FAX Form to:**	**Contact Number**	**Date & Time Called**
	USACE Ordnance Safety Specialist or MMRP Site Safety Manager	Ph: (831) 884-9925 ext.226 Cell: (831) 760-2571 Fax:(831) 884-9030 Ph: (831) 242-7919 Fax:(831) 242-7019 Cell: (831) 760-2575	
	Fri – Sun (24 Hours) 60th Civ Engr Sqdn EOD	Phone: (707) 424-5517	
	Note: If 60th Civ Engr Sqdn EOD is contacted, notify the MMRP Site Safety Manager: (831) 242-7919, Cell (831) 760-2575.		

B. To be completed by USACE Ordnance Safety Specialist when applicable (Mon – Thu)

Form Received By:		Date & Time:
Identification of Item Found:		
Extent of Area Surveyed:		Name of digital file for picture (date):
Disposition of Item:		
Fax completed form to MMRP Site Safety Mgr Bldg 4463 Gigling Rd, POM (Fort Ord) when response complete	Fax: (831) 242-7091 Phone: (831) 242-7919	Date & Time:

C. To be completed by MMRP Site Safety Manager:

Acknowledge Completed Form Received:	Date & Time:
Regulatory Agencies Notified (Date):	

Seq. No. 1389

Lab: ____________________

1465 North McDowell Blvd.
Suite 200
Petaluma, CA 94954
(707) 793-3800

CHAIN OF CUSTODY FORM

Samplers: ____________________

wood.

Job Number: ____________________

Name/Location: ____________________

Project Manager: ____________________

Recorder: ____________________ (Signature Required)

MATRIX				# CONTAINERS						SAMPLE NUMBER	DATE				STATION DESCRIPTION		ANALYSIS REQUESTED																	
Water	Soil	Air		Unpres.	H2SO4	HNO3	HCL				YR	MO	DAY	TIME		DEPTH	8260	8270	TITLE 22 METALS															

ADDITIONAL INFORMATION

REPORT TO: ____________________

PO#: ____________________

TAT: ____________________

Comments: Field Filtered Y/N

CHAIN OF CUSTODY RECORD

Relinquished By *(Signature)*	*(Print Name)*	*(Company)*	*(Date/Time)*
Received By (Signature):	*(Print Name)*	*(Company)*	*(Date/Time)*
Relinquished By *(Signature)*	*(Print Name)*	*(Company)*	*(Date/Time)*
Received By (Signature):	*(Print Name)*	*(Company)*	*(Date/Time)*
Relinquished By *(Signature)*	*(Print Name)*	*(Company)*	*(Date/Time)*
Received By (Signature):	*(Print Name)*	*(Company)*	*(Date/Time)*

Method of Shipment:

White - Laboratory Copy   Yellow - Project Office Copy   Pink - Field or Office Copy

F1008-E

Ahtna

296 12th St
Marina, CA 93933
(831) 384-3735

CHAIN OF CUSTODY

WATER / SOIL

Chain of Custody #: ____________________
Carbon Copies: White - Laboratory Yellow - Ahtna

Project Information:

Project Location: ____________________________________ **Sampler/s:** ____

Project Name: ____________________________________ **Report To:** ____

Project Number: ____________________________________ **E-Mail:** ____

Sampling Event: ____________________________________ **Laboratory:** ____

Lab Sample Receipt

Laboratory Sample Delivery

Group #: __________________

Custody Seal: ______________

Temp (°C): ________________

Lab Number	Sample Number/Description	Sample Collection		Matrix			Total # of Bottles	Number of Preserved Bottles								Analysis Requested								Notes
		Date	Time	Water	Soil	Other		HCl	HNO_3	H_2SO_4	NaOH	MeOH	$NaHSO^4$	None	Other									

Turnaround Time: _____: Standard _____: 3-5 Day Rush _____: 48 Hour Rush _____: 24 Hour Rush

Shipment: **Method:** ________________ **Tracking ID:** __________________________________

Comments:

Chain of Custody Tracking:

Relinquished By Sampler:	**Date/Time:**	**Received By:**	**Date/Time:**
Relinquished By:	**Date/Time:**	**Received By:**	**Date/Time:**
Relinquished By:	**Date/Time:**	**Received By Laboratory:**	**Date/Time:**

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Wood/Ahtna
Ft Ord GW Monitoring-
Samplers:
Date: Time: ________
Sample #:

Ahtna

POST-TREATMENT PARAMETER MONITORING FORM

Project Information:

Project and Task No.: ______________________________________

Project Name: ____

Date: ____

Field Personnel Name/s: ______________________________

Well Information:

Well ID: ____

Total Depth: __________ **Well Diameter:** _____________

Three Casing Volumes: ______________________________

Parameter Collection Information:

Method of Monitoring: ☐ **Purging** ☐ **Downhole Meter**

Downhole Meter Type and ID: _________________________

Pump Type and ID:__________________________________

Multi-Meter Type and ID:____________________________

Meter Calibration Completed (except Temperature)[1]**:** ☐

Water Level Information:

Initial Depth to Water: __________________________________

Depth to Water after Monitoring: _________________________

Time	Pump Intake Depth	Rate (mL/min)	Cum. Vol. (L)	Temp. (°C)	pH (units)	Specific Electrical Conductance (µS/cm)	Dissolved Oxygen (mg/L)	Oxidation-Reduction Potential (mV)	Turbidity (NTU)	Remarks (color, odor, suspended materials, etc.)

NOTES:

---

[1] If the Horiba U-50 Series multi-meter is used, calibration should occur daily. If the YSI 6-Series Multi-Parameter Water Quality Sonde with downhole probe is used, calibration is performed by the vendor and field calibration is not required for field events lasting less than 1 month, unless field conditions present erroneous data or the Sonde experiences mechanical issues.

ATTACHMENT D

Three Phase Quality Control Process and Documentation

INVESTIGATION, MONITORING, O&M PROJECTS
PREPARATORY PHASE INSPECTION COVER SHEET

Contract No.: ____________________ Date: _______________
Task No.: ____________________
Location/Project: ____________________

A. Key Personnel Present:

	Name	Position	Company
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

B. Submittals:

1. Review submittals and/or submittal register. Have all applicable submittals been approved? Yes___ No___

If No, what items have not been submitted?

a. ______________________________
b. ______________________________
c. ______________________________

______________________ ______________________
USACE Representative Signature Quality Control Manager Signature

INVESTIGATION, MONITORING, O&M PROJECTS: PREPARATORY PHASE INSPECTION CHECKLIST

Assessment Activity	Assessment Mechanism	Person(s) Responsible	Response Action	Completed by/Date
Have planning documents been prepared in accordance with the statement of work, regulatory requirements, and contract requirements?	Quality control review of document by Project Manager and QC reviewer.	Project Manager, QC Reviewer	Modify document as directed by reviewers	
Prior to project activities: Have planning documents been read by appropriate project personnel (including subcontractors) before work is conducted.	Documentation (e.g., sign-off form, note to file, email acknowledgement) that document has been read and requirements are understood.	Subcontractors as required. Project Manager, Task Manager, and Project Chemist to check signoff and forms.	Direct project personnel to read relevant documents.	
Prior to project activities: Has required preliminary work (e.g., clearance activities, permits, site access) been completed in accordance with project plan.	Comparison of information obtained from preliminary work completion assessment as specified in the project planning document(s).	Project Manager, Safety and Health Officer, QC Manger/Reviewer, Task Manager, Project Chemist, Field Staff	Delay startup if necessary preliminary work has not been completed. Implement corrective actions by directing appropriate personnel or subcontractors to complete necessary preliminary work.	
Prior to project activities: Are staff and subcontractors prepared to implement project activities according to planning documents?	Review and discussion of planned activities prior to implementation.	Project Manager, Safety and Health Officer, Quality Control System Manager, Task Manager, Project Chemist, Field staff.	Delay startup if staff and subcontractors are not prepared to implement activities *in* accordance with specification.	
Prior to project activities: Is necessary field equipment available and in acceptable working order?	Compare field equipment list with planned activities. Compare field equipment calibration documentation with project goals specified in the SAP.	Project Manager, Quality Control System Manager, Task Manager, Project Chemist, Field staff.	Delay startup if equipment is unavailable or not in proper working order. Implement corrective actions to include use of alternate equipment, or recalibration of available equipment.	

INVESTIGATION, MONITORING, O&M PROJECTS
INITIAL PHASE INSPECTION COVER SHEET

Contract No.: ______________________ Date: ________________
Task No.: ______________________
Location/Project: ______________________

Description and Location of Work Inspected: ____
____

A. Key Personnel Present:

	Name	Position	Company
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

____
Quality Control Manager Signature

INVESTIGATION, MONITORING, O&M PROJECTS: INITIAL PHASE INSPECTION CHECKLIST

Assessment Activity	Assessment Mechanism	Person(s) Responsible	Response Action	Completed by/Date
Beginning of project activity: Is work being performed according to project plans?	Conduct field and laboratory audits.	Project Manager, Quality Control System Manager, Task Manager, Project Chemist, Field staff.	Stop work if audits indicate significant deviation from project plan. Implement immediate or long- term corrective actions. Communicate deficiencies to USACE Project Manager.	
Early phase of project: Have necessary audits been performed?	Review project phase and check to see if required audits have *been* satisfactorily completed.	Project Manager, Project Manager, Quality Control System Manager	Stop work if reviewer decides that absence of audit jeopardizes successful implementation of project plans. Immediately schedule necessary audits.	
Ongoing throughout project: Are daily quality control reports being prepared according to contract requirements?	Review Content and delivery schedules of daily quality control reports.	Project Manager, Task Manager, Project Chemist, Project Staff	Correct deficiencies in reports or reporting delays.	
Ongoing throughout project: Do project plans adequately address any changes in project activities or goal?	Compare data gathered to assess conformance to the project plan and conceptual site model.	Project Manager, Safety and Health Officer, Quality Control System Manager, Task Manager, Project Chemist, Field staff.	Stop work if assessor decides that project plan deficiencies are significant. Implement corrective action to include modification of project plans. Notify USACE Project Manager.	
Ongoing throughout project: Do project plans adequately address any changes in project activities or goals?	Compare data gathered to assess conformance to the conceptual site model, data quality objectives, and project plan.	Project Manager, Quality Control System Manager, Task Manager, Project Chemist, data users and evaluators.	Propose additional data collection activities to fill data gaps. Notify USACE Project Manager. Revise or update planning documents as appropriate.	

INVESTIGATION, MONITORING, O&M PROJECTS
FOLLOW-UP PHASE INSPECTION COVER SHEET

Contract No.: ______________________ Date: ________________

Task No.: ______________________

Location/Project: ______________________

Project/Area of Inspection: ____

A. Key Personnel Present:

Name	Position	Company
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		

B. Definable Features of Work: Status of Inspection:

____

Quality Control Manager

INVESTIGATION PROJECT FOLLOW-UP PHASE INSPECTION CHECKLIST

Assessment Activity	Assessment Mechanism	Person(s) Responsible	Response Action	Completed by/Date
Reporting phase of project: Have data reports been prepared in accordance with project plans?	Compare data reports to specifications detailed in planning documents.	Project Manager, Quality Control Manager, Task Manager, Project Chemist, data users and evaluators.	Revise documents and reports as appropriate.	
After draft report submittal or project completion: Are reports adequate to meet client and regulatory agency requirements?	Review client and agency comments. Prepare responses to comments.	Project Manager, Quality Control Manager, Task Manager, Project Chemist, data users and evaluators.	Revise documents and reports as appropriate.	
Have other definable features of work been completed in accordance to project requirements	Compare definable features of work with project requirements.	Project Manager, Quality Control Manager	Complete definable feature of work as required.	

ATTACHMENT E

ADR Library and Qualifier Tables

Project Accuracy and Precision Report

eQapp Name: FtOrd_UFP_QAPP_Rev7
Description: Quality Assurance Project Plan Former Fort Ord, California

Analyte Name	Analyte Label (CAS)	Lower Rejection (%)	Lower Recovery (%)	Upper Recovery (%)	Upper Rejection (%)	RPD (%)
Method: EPA6010C	**Matrix: AQ**					
QC Type: LCS						
ANTIMONY	7440-36-0		80.00	120.00		20.00
COPPER	7440-50-8		80.00	120.00		20.00
LEAD	7439-92-1		80.00	120.00		20.00
QC Type: MS						
ANTIMONY	7440-36-0		80.00	120.00		20.00
COPPER	7440-50-8		80.00	120.00		20.00
LEAD	7439-92-1		80.00	120.00		20.00
Method: EPA8260-SIM	**Matrix: AQ**					
QC Type: LCS						
1,1-DICHLOROETHANE	75-34-3		81.00	122.00		15.00
1,1-DICHLOROETHYLENE	75-35-4		78.00	137.00		18.00
1,2-DICHLOROETHANE	107-06-2		75.00	125.00		14.00
1,2-DICHLOROETHENE (TOTAL)	540-59-0		76.00	127.00		17.00
1,2-DICHLOROPROPANE	78-87-5		76.00	124.00		14.00
1,3-Dichloropropene (total)	542-75-6		75.00	120.00		23.00
BENZENE	71-43-2		81.00	122.00		14.00
CARBON TETRACHLORIDE	56-23-5		76.00	136.00		23.00
CHLOROFORM	67-66-3		80.00	124.00		15.00
CIS-1,2-DICHLOROETHYLENE	156-59-2		78.00	120.00		15.00
METHYLENE CHLORIDE	75-09-2		69.00	135.00		16.00
TETRACHLOROETHYLENE	127-18-4		76.00	135.00		16.00
TRICHLOROETHYLENE	79-01-6		81.00	126.00		15.00
VINYL CHLORIDE	75-01-4		69.00	159.00		18.00

Analyte Name	Analyte Label (CAS)	Lower Rejection (%)	Lower Recovery (%)	Upper Recovery (%)	Upper Rejection (%)	RPD (%)
Method: **EPA8260-SIM**	**Matrix:** **AQ**					
QC Type: **MS**						
1,1-DICHLOROETHANE	75-34-3		81.00	122.00		15.00
1,1-DICHLOROETHYLENE	75-35-4		78.00	137.00		18.00
1,2-DICHLOROETHANE	107-06-2		75.00	125.00		14.00
1,2-DICHLOROETHENE (TOTAL)	540-59-0		76.00	127.00		17.00
1,2-DICHLOROPROPANE	78-87-5		76.00	124.00		14.00
1,3-Dichloropropene (total)	542-75-6		75.00	120.00		23.00
BENZENE	71-43-2		81.00	122.00		14.00
CARBON TETRACHLORIDE	56-23-5		76.00	136.00		23.00
CHLOROFORM	67-66-3		80.00	124.00		15.00
CIS-1,2-DICHLOROETHYLENE	156-59-2		78.00	120.00		15.00
METHYLENE CHLORIDE	75-09-2		69.00	135.00		16.00
TETRACHLOROETHYLENE	127-18-4		76.00	135.00		16.00
TRICHLOROETHYLENE	79-01-6		71.00	126.00		15.00
VINYL CHLORIDE	75-01-4		69.00	159.00		18.00
QC Type: **SURR**						
1,2-DICHLOROETHANE-D4	17060-07-0	30.00	74.00	125.00		
TOLUENE-D8	2037-26-5	30.00	88.00	111.00		
Method: **EPA9056A**	**Matrix:** **AQ**					
QC Type: **LCS**						
Chloride	1003		90.00	110.00		
QC Type: **MS**						
Chloride	1003		90.00	110.00		20.00

Project Holding Time Report

eQapp Name: FtOrd_UFP_QAPP_Rev7
Description: Quality Assurance Project Plan Former Fort Ord, California

Analyte Group	Sampling to Analysis	Sampling to Extraction	Sampling to Leaching	Leaching to Extraction	Leaching to Analysis	Extraction to Analysis	Units	Rejection Factor
Method: EPA6010C **Matrix: AQ**								
Primary	180.00						Days	2.00
Method: EPA8260-SIM **Matrix: AQ**								
Primary	14.00						Days	2.00
Method: EPA9056A **Matrix: AQ**								
Primary	28.00						Days	2.00

Project Target Analyte Reporting Limit, Blank Contamination, and Lab & Field Duplicate RPD Criteria

eQapp Name: FtOrd_UFP_QAPP_Rev7
Description: Quality Assurance Project Plan Former Fort Ord, California

Target Analyte Name	Analyte Label (CAS)	Quantitation Limit	Detection Limit	Units	Blank Contamination Rule	LabDup RPD	FieldDup RPD
Method: EPA6010C	**Matrix: AQ**						
ANTIMONY	7440-36-0	6.0	5.0	ug/L	5.00	20.00	30.00
COPPER	7440-50-8	10	5.0	ug/L	5.00	20.00	30.00
LEAD	7439-92-1	10	3.0	ug/L	5.00	20.00	30.00
Method: EPA8260-SIM	**Matrix: AQ**						
1,1-DICHLOROETHANE	75-34-3	0.50	0.25	ug/L	5.00	20.00	30.00
1,1-DICHLOROETHYLENE	75-35-4	0.50	0.25	ug/L	5.00	20.00	30.00
1,2-DICHLOROETHANE	107-06-2	0.50	0.25	ug/L	5.00	20.00	30.00
1,2-DICHLOROETHENE (TOTAL)	540-59-0	1.0	0.25	ug/L	5.00	20.00	30.00
1,2-DICHLOROPROPANE	78-87-5	0.50	0.25	ug/L	5.00	20.00	30.00
1,3-Dichloropropene (total)	542-75-6	0.50	0.25	ug/L	5.00	20.00	30.00
BENZENE	71-43-2	0.50	0.25	ug/L	5.00	20.00	30.00
CARBON TETRACHLORIDE	56-23-5	0.50	0.25	ug/L	5.00	20.00	30.00
CHLOROFORM	67-66-3	0.50	0.25	ug/L	5.00	20.00	30.00
CIS-1,2-DICHLOROETHYLENE	156-59-2	0.50	0.25	ug/L	5.00	20.00	30.00
METHYLENE CHLORIDE	75-09-2	2.0	1.0	ug/L	10.00	20.00	30.00
TETRACHLOROETHYLENE	127-18-4	0.50	0.25	ug/L	5.00	20.00	30.00
TRICHLOROETHYLENE	79-01-6	0.50	0.25	ug/L	5.00	20.00	30.00
VINYL CHLORIDE	75-01-4	0.10	0.050	ug/L	5.00	20.00	30.00
Method: EPA9056A	**Matrix: AQ**						
Chloride	1003	250	0.50	mg/L	5.00	20.00	30.00

ADR **Data Qualification Table**

Description	VOA	
	Detect Qualifier	Non-detect Qualifier
Calibration Blank Contamination	U	
Continuing Calibration Verification Percent Difference Lower Estimation	J-	UJ
Continuing Calibration Verification Percent Difference Lower Rejection	J-	R
Continuing Calibration Verification Percent Difference Upper Estimation	J+	
Continuing Calibration Verification Percent Difference Upper Rejection	J+	UJ
Continuing Calibration Verification Relative Response Factor	J	UJ
Continuing Tune	J	R
Equipment Blank Contamination	U	
Extraction to Analysis Estimation	J-	UJ
Extraction to Analysis Rejection	J-	R
Field Blank Contamination	U	
Initial calibration Correlation Coefficient	J	UJ
Initial Calibration Percent Relative Standard Deviation	J	UJ
Initial Calibration Relative Response Factor	J	UJ
Initial Calibration Verification Percent Difference Lower Estimation	J-	UJ
Initial Calibration Verification Percent Difference Lower Rejection	J-	R
Initial Calibration Verification Percent Difference Upper Estimation	J+	
Initial Calibration Verification Percent Difference Upper Rejection	J+	UJ
Initial Calibration Verification Relative Response Factor	J	UJ
Initial Tune	J	R
Internal Standard Estimation	J	UJ
Internal Standard Rejection	J	R
Laboratory Control Precision	J	UJ
Laboratory Control Spike Lower Estimation	J-	UJ
Laboratory Control Spike Lower Rejection	J-	R
Laboratory Control Spike Upper Estimation	J+	
Laboratory Control Spike Upper Rejection	J+	R
Laboratory Duplicate Precision	J	UJ
Matrix Spike Lower Estimation	J-	UJ
Matrix Spike Lower Rejection	J-	R
Matrix Spike Precision	J	UJ
Matrix Spike Upper Estimation	J+	
Matrix Spike Upper Rejection	J+	R
Method Blank Contamination	U	
Preservation	J-	UJ
Sampling to Analysis Estimation	J-	UJ
Sampling to Analysis Rejection	J-	R
Sampling to Extraction Estimation	J-	UJ
Sampling to Extraction Rejection	J-	R
Sampling to Leaching Estimation	J-	UJ
Sampling to Leaching Rejection	J-	R
Surrogate Recovery Lower Estimation	J-	UJ
Surrogate Recovery Lower Rejection	J-	R
Surrogate Recovery Upper Estimation	J+	
Surrogate Recovery Upper Rejection	J+	R
Temperature Estimation	J-	UJ
Temperature Rejection	J-	R
Trip Blank Contamination	U	

ADR **Data Qualification Table**

Description	Metals	
	Detect Qualifier	Non-detect Qualifier
Calibration Blank Contamination	U	
Continuing Calibration Verification Percent Recovery Lower Estimation	J-	UJ
Continuing Calibration Verification Percent Recovery Lower Rejection	R	R
Continuing Calibration Verification Percent Recovery Upper Estimation	J+	
Continuing Calibration Verification Percent Recovery Upper Rejection	R	
Equipment Blank Contamination	U	
Extraction to Analysis Estimation	J-	UJ
Extraction to Analysis Rejection	J-	R
Field Blank Contamination	U	
Initial Calibration Relative Response Factor	J	UJ
Initial Calibration Verification Percent Recovery Lower Estimation	J-	UJ
Initial Calibration Verification Percent Recovery Lower Rejection	R	R
Initial Calibration Verification Percent Recovery Upper Estimation	J+	
Initial Calibration Verification Percent Recovery Upper Rejection	R	
Laboratory Control Precision	J	UJ
Laboratory Control Spike Lower Estimation	J-	UJ
Laboratory Control Spike Lower Rejection	J-	R
Laboratory Control Spike Upper Estimation	J+	
Laboratory Control Spike Upper Rejection	J+	R
Laboratory Duplicate Precision	J	UJ
Matrix Spike Lower Estimation	J-	UJ
Matrix Spike Lower Rejection	J-	R
Matrix Spike Precision	J	UJ
Matrix Spike Upper Estimation	J+	
Matrix Spike Upper Rejection	J+	R
Method Blank Contamination	U	
Sampling to Analysis Estimation	J-	UJ
Sampling to Analysis Rejection	J-	R
Sampling to Extraction Estimation	J-	UJ
Sampling to Extraction Rejection	J-	R
Sampling to Leaching Estimation	J-	UJ
Sampling to Leaching Rejection	J-	R
Trip Blank Contamination	U	

ADR **Data Qualification Table**

Description	GenChem	
	Detect Qualifier	Non-detect Qualifier
Calibration Blank Contamination	U	
Continuing Calibration Verification Percent Recovery Lower Estimation	J-	UJ
Continuing Calibration Verification Percent Recovery Lower Rejection	R	R
Continuing Calibration Verification Percent Recovery Upper Estimation	J+	
Continuing Calibration Verification Percent Recovery Upper Rejection	R	
Equipment Blank Contamination	U	
Extraction to Analysis Estimation	J-	UJ
Extraction to Analysis Rejection	J-	R
Field Blank Contamination	U	
Initial Calibration Relative Response Factor	J	UJ
Initial Calibration Verification Percent Recovery Lower Estimation	J-	UJ
Initial Calibration Verification Percent Recovery Lower Rejection	R	R
Initial Calibration Verification Percent Recovery Upper Estimation	J+	
Initial Calibration Verification Percent Recovery Upper Rejection	R	
Laboratory Control Precision	J	UJ
Laboratory Control Spike Lower Estimation	J-	UJ
Laboratory Control Spike Lower Rejection	J-	R
Laboratory Control Spike Upper Estimation	J+	
Laboratory Control Spike Upper Rejection	J+	R
Laboratory Duplicate Precision	J	UJ
Matrix Spike Lower Estimation	J-	UJ
Matrix Spike Lower Rejection	J-	R
Matrix Spike Precision	J	UJ
Matrix Spike Upper Estimation	J+	
Matrix Spike Upper Rejection	J+	R
Method Blank Contamination	U	
Sampling to Analysis Estimation	J-	UJ
Sampling to Analysis Rejection	J-	R
Sampling to Extraction Estimation	J-	UJ
Sampling to Extraction Rejection	J-	R
Sampling to Leaching Estimation	J-	UJ
Sampling to Leaching Rejection	J-	R
Trip Blank Contamination	U	

ATTACHMENT F

Analytical Laboratory Certifications

CERTIFICATE OF ACCREDITATION

ANSI-ASQ National Accreditation Board
500 Montgomery Street, Suite 625, Alexandria, VA 22314, 877-344-3044

This is to certify that

SGS North America Inc. - Orlando
4405 Vineland Road, Suite C-15
Orlando, FL 32811

has been assessed by ANAB
and meets the requirements of international standard

ISO/IEC 17025:2005

and DoD Quality Systems Manual for Environmental Laboratories (DoD QSM V 5.1.1)

while demonstrating technical competence in the fields of

TESTING

Refer to the accompanying Scope of Accreditation for information regarding the types of calibrations and/or tests to which this accreditation applies.

L2229
Certificate Number

ANAB Approval

Certificate Valid: 12/05/2018-12/15/2021
Version No. 003 Issued: 12/05/2018

ilac-MRA

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005 AND DOD QUALITY SYSTEMS MAUAL FOR ENVIRONMENTAL LABORATORIES (DOD QSM V 5.1.1)

SGS North America Inc. - Orlando

4405 Vineland Road, Suite C-15
Orlando, FL 32811
Svetlana Izosimova, Ph. D., QA Officer
407-425-6700

TESTING

Valid to: **December 15, 2021** Certificate Number: **L2229**

Environmental

Drinking Water		
Technology	**Method**	**Analyte**
LC/MS/MS	EPA 537 rev. 1.1	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorononanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 rev. 1.1	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 rev. 1.1	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 rev. 1.1	N-Ethyl perfluorooctanesulfonamidoacetic acid

Non-Potable Water

Technology	Method	Analyte
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)
GC/ECD	EPA 504.1	1,2-Dibromoethane (EDB)
GC/ECD	EPA 504.1	1,2-Dibromo-3-Chloropropane (DBCP)
GC/ECD	EPA 504.1	1,2,3-Trichloropropane (1,2,3-TCP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/ECD	EPA 608.3; EPA 8081B	4,4`-DDD
GC/ECD	EPA 608.3; EPA 8081B	4,4`-DDE
GC/ECD	EPA 608.3; EPA 8081B	4,4`-DDT
GC/ECD	EPA 608.3; EPA 8081B	Aldrin
GC/ECD	EPA 608.3; EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 608.3; EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 608.3; EPA 8081B	delta-BHC
GC/ECD	EPA 608.3; EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 608.3; EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 608.3; EPA 8081B	alpha-Chlordane
GC/ECD	EPA 608.3; EPA 8081B	gamma-Chlordane
GC/ECD	EPA 608.3; EPA 8081B	Dieldrin
GC/ECD	EPA 608.3; EPA 8081B	Endosulfan I
GC/ECD	EPA 608.3; EPA 8081B	Endosulfan II
GC/ECD	EPA 608.3; EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 608.3; EPA 8081B	Endrin
GC/ECD	EPA 608.3; EPA 8081B	Endrin aldehyde
GC/ECD	EPA 608.3; EPA 8081B	Endrin ketone
GC/ECD	EPA 608.3; EPA 8081B	Heptachlor
GC/ECD	EPA 608.3; EPA 8081B	Heptachlor epoxide

Non-Potable Water

Technology	Method	Analyte
GC/ECD	EPA 608.3; EPA 8081B	Methoxychlor
GC/ECD	EPA 608.3; EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1254 (PCB-1254)
GC/ECD	EPA 608.3; EPA 8081B	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	RSK-175	Acetylene
GC/FID	RSK-175	Methane
GC/FID	RSK-175	Ethane
GC/FID	RSK-175	Ethene
GC/FID	RSK-175	Propane
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)
GC/FID	WI-DRO	Diesel range organics (DRO)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)

Non-Potable Water

Technology	Method	Analyte
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/FID	KS LRH	Low-Range Hydrocarbons (LRH)
GC/FID	KS MRH	Mid-Range Hydrocarbons (MRH)
GC/FID	KS HRH	High-Range Hydrocarbons (HRH)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 624.1; EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 624.1; EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	4-Chlorotoluene

Non-Potable Water

Technology	Method	Analyte
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	4-Methyl-2-pentanone (MIBK)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 624.1; EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 624.1; EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Bromobenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Bromochloromethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Bromoform
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	sec-Butylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Carbon disulfide
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Chlorobenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Chloroethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 624.1; EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C SIM	p-Dioxane (1,4-Dioxane)

Non-Potable Water

Technology	Method	Analyte
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethylene Oxide
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 624.1; EPA 8260B/C	Methyl Acetate
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Methyl bromide (Bromomethane)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 624.1; EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Methylene chloride
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Styrene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Toluene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Vinyl acetate
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Vinyl chloride

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	Xylene (total)
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	m,p-Xylene
GC/MS	EPA 624.1; SM 6200B-11; EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	1-Bromopropane
GC/MS	EPA 8260B/C	Isopropyl Alcohol
GC/MS	EPA 8260B/C	n-Butyl Alcohol
GC/MS	EPA 625.1; EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 625.1; EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 625.1; EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 625.1; EPA 8270D	1,2-Diphenylhydrazine
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 625.1; EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 625.1; EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 625.1; EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 625.1; EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 625.1; EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 625.1; EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 625.1; EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 625.1; EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 625.1; EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 625.1; EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 625.1; EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 625.1; EPA 8270D	2-Chlorophenol
GC/MS	EPA 625.1; EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	2-Methylnaphthalene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625.1; EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 625.1; EPA 8270D	2-Nitroaniline
GC/MS	EPA 625.1; EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 625.1; EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 625.1; EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 625.1; EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 625.1; EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 625.1; EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 625.1; EPA 8270D	4-Chloroaniline
GC/MS	EPA 625.1; EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene
GC/MS	EPA 625.1; EPA 8270D	4-Nitroaniline
GC/MS	EPA 625.1; EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4’-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Acenaphthene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Acenaphthylene
GC/MS	EPA 625.1; EPA 8270D	Acetophenone
GC/MS	EPA 625.1; EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 625.1; EPA 8270D	Atrazine
GC/MS	EPA 625.1; EPA 8270D	Benzaldehyde
GC/MS	EPA 625.1; EPA 8270D	Benzidine
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Benzo(a)anthracene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Benzo(a)pyrene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Benzo(b)fluoranthene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Benzo(k)fluoranthene
GC/MS	EPA 625.1; EPA 8270D	Benzoic acid
GC/MS	EPA 625.1; EPA 8270D	Benzyl alcohol
GC/MS	EPA 625.1; EPA 8270D	Biphenyl (1,1’-Biphenyl)
GC/MS	EPA 625.1; EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 625.1; EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 625.1; EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 625.1; EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 625.1; EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 625.1; EPA 8270D	Carbazole
GC/MS	EPA 625.1; EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 8270D	Dinoseb
GC/MS	EPA 625.1; EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 625.1; EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Dibenz(a,h)anthracene
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 625.1; EPA 8270D	Dibenzofuran
GC/MS	EPA 625.1; EPA 8270D	Diethyl phthalate
GC/MS	EPA 625.1; EPA 8270D	Dimethyl phthalate
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Fluoranthene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Fluorene
GC/MS	EPA 625.1; EPA 8270D	Hexachlorobenzene

Non-Potable Water		
Technology	**Method**	**Analyte**
GC/MS	EPA 625.1; EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 625.1; EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 625.1; EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 625.1; EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 625.1; EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 625.1; EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 625.1; EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 625.1; EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Phenanthrene
GC/MS	EPA 625.1; EPA 8270D	Phenol

Non-Potable Water

Technology	Method	Analyte
GC/MS	EPA 8270D	Pronamide (Kerb)
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 625.1; EPA 8270D; EPA 8270D SIM	Pyrene
GC/MS	EPA 625.1; EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	Thionazin (Zinophos)
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 610	1-Methylnaphthalene
HPLC	EPA 610	2-Methylnaphthalene
HPLC	EPA 610	Acenaphthene
HPLC	EPA 610	Acenaphthylene
HPLC	EPA 610	Anthracene
HPLC	EPA 610	Benzo(a)anthracene
HPLC	EPA 610	Benzo(a)pyrene
HPLC	EPA 610	Benzo(b)fluoranthene
HPLC	EPA 610	Benzo(g h i)perylene
HPLC	EPA 610	Benzo(k)fluoranthene
HPLC	EPA 610	Chrysene
HPLC	EPA 610	Dibenz(a,h)anthracene
HPLC	EPA 610	Fluoranthene
HPLC	EPA 610	Fluorene
HPLC	EPA 610	Indeno(1,2,3-cd)pyrene
HPLC	EPA 610	Naphthalene
HPLC	EPA 610	Phenanthrene
HPLC	EPA 610	Pyrene
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)

Non-Potable Water		
Technology	**Method**	**Analyte**
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
HPLC	EPA 8330A	Nitroguanidine
HPLC	EPA 8330A	Guanidine Nitrate
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD[2]	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorodecanoic Acid

Non-Potable Water

Technology	Method	Analyte
LC/MS/MS	EPA 537 MOD[2]	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorononanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoroheptanesulfonic acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoropentanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	Perfluoro-1-octanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD[2]	4:2 Fluorotelomer Sulfonate
LC/MS/MS	EPA 537 MOD[2]	6:2 Fluorotelomer Sulfonate
LC/MS/MS	EPA 537 MOD[2]	8:2 Fluorotelomer Sulfonate
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorobutanoic Acid (PFBA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoropentanoic Acid (PFPeA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorohexanoic Acid (PFHxA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroheptanoic Acid (PFHpA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanoic Acid (PFOA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorononanoic Acid (PFNA)

Non-Potable Water		
Technology	**Method**	**Analyte**
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorodecanoic Acid (PFDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroundecanoic Acid (PFUnA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorododecanoic Acid(PFDoA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorotridecanoic Acid (PFTrDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorotetradecanoic Acid (PFTA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorobutanesulfonic Acid (PFBS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorohexanesulfonic Acid(PFHxS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanesulfonic Acid(PFOS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorononanesulfonic Acid(PFNS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorodecanesulfonic Acid(PFDS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroheptanesulfonic acid(PFHpS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoropentanesulfonic Acid(PFPeS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctane sulfonamide (PFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-Methyl perfluorooctanesulfonamidoacetic acid (MeFOSAA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-Ethyl perfluorooctanesulfonamidoacetic acid (EtFOSAA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	4:2 Fluorotelomer Sulfonate (FTS 4:2)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	6:2 Fluorotelomer Sulfonate(FTS 6:2)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	8:2 Fluorotelomer Sulfonate (FTS 8:2)
ICP	EPA 200.7; EPA 6010C/D	Aluminum
ICP	EPA 200.7; EPA 6010C/D	Antimony
ICP	EPA 200.7; EPA 6010C/D	Arsenic
ICP	EPA 200.7; EPA 6010C/D	Barium
ICP	EPA 200.7; EPA 6010C/D	Beryllium

Non-Potable Water		
Technology	**Method**	**Analyte**
ICP	EPA 200.7; EPA 6010C/D	Cadmium
ICP	EPA 200.7; EPA 6010C/D	Calcium
ICP	EPA 200.7; EPA 6010C/D	Chromium
ICP	EPA 200.7; EPA 6010C/D	Cobalt
ICP	EPA 200.7; EPA 6010C/D	Copper
ICP	EPA 200.7; EPA 6010C/D	Iron
ICP	EPA 200.7; EPA 6010C/D	Lead
ICP	EPA 200.7; EPA 6010C/D	Magnesium
ICP	EPA 200.7; EPA 6010C/D	Manganese
ICP	EPA 200.7; EPA 6010C/D	Molybdenum
ICP	EPA 200.7; EPA 6010C/D	Nickel
ICP	EPA 200.7; EPA 6010C/D	Potassium
ICP	EPA 200.7; EPA 6010C/D	Selenium
ICP	EPA 200.7; EPA 6010C/D	Silver
ICP	EPA 200.7; EPA 6010C/D	Sodium
ICP	EPA 200.7; EPA 6010C/D	Strontium
ICP	EPA 200.7; EPA 6010C/D	Thallium
ICP	EPA 200.7; EPA 6010C/D	Tin
ICP	EPA 200.7; EPA 6010C/D	Titanium
ICP	EPA 200.7; EPA 6010C/D	Vanadium
ICP	EPA 200.7; EPA 6010C/D	Zinc
ICP/MS	EPA 200.8; EPA 6020A/B	Aluminum
ICP/MS	EPA 200.8; EPA 6020A/B	Antimony
ICP/MS	EPA 200.8; EPA 6020A/B	Arsenic
ICP/MS	EPA 200.8; EPA 6020A/B	Barium
ICP/MS	EPA 200.8; EPA 6020A/B	Beryllium
ICP/MS	EPA 200.8; EPA 6020A/B	Cadmium
ICP/MS	EPA 200.8; EPA 6020A/B	Calcium
ICP/MS	EPA 200.8; EPA 6020A/B	Chromium
ICP/MS	EPA 200.8; EPA 6020A/B	Cobalt
ICP/MS	EPA 200.8; EPA 6020A/B	Copper
ICP/MS	EPA 200.8; EPA 6020A/B	Iron
ICP/MS	EPA 200.8; EPA 6020A/B	Lead
ICP/MS	EPA 200.8; EPA 6020A/B	Magnesium
ICP/MS	EPA 200.8; EPA 6020A/B	Manganese
ICP/MS	EPA 200.8; EPA 6020A/B	Molybdenum
ICP/MS	EPA 200.8; EPA 6020A/B	Nickel

Non-Potable Water

Technology	Method	Analyte
ICP/MS	EPA 200.8; EPA 6020A/B	Potassium
ICP/MS	EPA 200.8; EPA 6020A/B	Selenium
ICP/MS	EPA 200.8; EPA 6020A/B	Silver
ICP/MS	EPA 200.8; EPA 6020A/B	Sodium
ICP/MS	EPA 200.8; EPA 6020A/B	Strontium
ICP/MS	EPA 200.8; EPA 6020A/B	Thallium
ICP/MS	EPA 200.8; EPA 6020A/B	Tin
ICP/MS	EPA 200.8; EPA 6020A/B	Titanium
ICP/MS	EPA 200.8; EPA 6020A/B	Vanadium
ICP/MS	EPA 200.8; EPA 6020A/B	Zinc
CVAA	EPA 7470A	Mercury
CVAA	EPA 245.1	Mercury
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 300; EPA 9056A	Bromide
IC	EPA 300; EPA 9056A	Chloride
IC	EPA 300; EPA 9056A	Fluoride
IC	EPA 300; EPA 9056A	Nitrate
IC	EPA 300; EPA 9056A	Nitrite
IC	EPA 300; EPA 9056A	Sulfate
IC	EPA 300; EPA 9056A	Total nitrate-nitrite
Automated Colorimetry	EPA 350.1	Ammonia
Automated Colorimetry	EPA 350.1	Ammonia, Gas Diffusion Option
Automated Colorimetry	EPA 351.2	Total Kjeldahl Nitrogen
Automated Colorimetry	EPA 420.4	Total Phenolics
Automated Colorimetry	EPA 353.2	Nitrate
Automated Colorimetry	EPA 353.2	Nitrite
Automated Colorimetry	EPA 353.2	Nitrate+Nitrite
Manual Colorimetry	EPA 365.3	Orthophosphate
Manual Colorimetry	EPA 365.3	Total Phosphorus
Titrimetric	SM 2320B-11	Alkalinity, Total
Titrimetric	SM 4500-S2 F-11	Sulfide, Iodometric
Gravimetric Methods	EPA 1664A; EPA 1664B; EPA 9070A	Oil and Grease
Gravimetric Methods	SM 2540B-11	Total Residue (Total Solids)
Gravimetric Methods	SM 2540C-11	Filterable Residue (Total Dissolved Solids)
Gravimetric Methods	SM 2540D-11	Non-Filterable Residue (Total Suspended Solids)

Non-Potable Water		
Technology	**Method**	**Analyte**
Electrometric Methods	SM 4500H+B-11; EPA 9040C	Hydrogen Ion (Ph)
Electrometric Methods	EPA 120.1	Specific conductivity
Combustion	EPA 9060A	Total Organic Carbon
Combustion	SM 5310B-11	Total Organic Carbon
Ignitability	EPA 1010A	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide
Waste Characterization	EPA Section 7.3	Reactive Cyanide
Waste Characterization	EPA Section 7.3	Reactive Sulfide
Preparation	**Method**	**Type**
Organic Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction
Organic Preparation	EPA 3511	Micro-extraction
Organic Preparation	EPA 3535A; EPA 3535A MOD	Solid Phase Extraction
Organic Preparation	EPA 8015C/D	Non-Halogenated Organics (Alcohols), direct injection
Organic Preparation	EPA 8151A	Chlorinated Herbicides, Liquid-Liquid Extraction
Organic Preparation	EPA 608; EPA 610; EPA 625	Separatory Funnel Liquid-Liquid Extraction
Volatile Organic Preparation	SW836 5030B	Closed System Purge and Trap
Volatile Organic Preparation	EPA 624	Closed System Purge and Trap
Volatile Organic Preparation	SM 6200B-11	Closed System Purge and Trap
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010A	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock
Organics Cleanup	EPA 3660B	Sulfur Cleanup
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8011	1,2-Dibromoethane (EDB)
GC/ECD	EPA 8011	1,2-Dibromo-3-Chloropropane (DBCP)
GC/FID	EPA 8015C/D	Diesel range organics (DRO)
GC/FID	EPA 8015C/D	Oil Range Organics (ORO)
GC/FID	EPA 8015C/D	Gasoline range organics (GRO)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/FID	EPA 8015C/D	Ethanol
GC/FID	EPA 8015C/D	2-Ethoxyethanol
GC/FID	EPA 8015C/D	Isobutyl alcohol (2-Methyl-1-propanol)
GC/FID	EPA 8015C/D	Isopropyl alcohol (2-Propanol)
GC/FID	EPA 8015C/D	Methanol
GC/FID	EPA 8015C/D	n-Butyl alcohol
GC/FID	EPA 8015C/D	n-Propanol
GC/ECD	EPA 8081B	4,4`-DDD
GC/ECD	EPA 8081B	4,4`-DDE
GC/ECD	EPA 8081B	4,4`-DDT
GC/ECD	EPA 8081B	Aldrin
GC/ECD	EPA 8081B	alpha-BHC (alpha-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	beta-BHC (beta-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	delta-BHC
GC/ECD	EPA 8081B	gamma-BHC (Lindane gamma-Hexachlorocyclohexane)
GC/ECD	EPA 8081B	Chlordane (tech.)
GC/ECD	EPA 8081B	alpha-Chlordane
GC/ECD	EPA 8081B	gamma-Chlordane
GC/ECD	EPA 8081B	Dieldrin
GC/ECD	EPA 8081B	Endosulfan I
GC/ECD	EPA 8081B	Endosulfan II
GC/ECD	EPA 8081B	Endosulfan sulfate
GC/ECD	EPA 8081B	Endrin
GC/ECD	EPA 8081B	Endrin aldehyde
GC/ECD	EPA 8081B	Endrin ketone
GC/ECD	EPA 8081B	Heptachlor
GC/ECD	EPA 8081B	Heptachlor epoxide
GC/ECD	EPA 8081B	Methoxychlor
GC/ECD	EPA 8081B	Toxaphene (Chlorinated camphene)
GC/ECD	EPA 8082A	Aroclor-1016 (PCB-1016)
GC/ECD	EPA 8082A	Aroclor-1221 (PCB-1221)
GC/ECD	EPA 8082A	Aroclor-1232 (PCB-1232)
GC/ECD	EPA 8082A	Aroclor-1242 (PCB-1242)
GC/ECD	EPA 8082A	Aroclor-1248 (PCB-1248)
GC/ECD	EPA 8082A	Aroclor-1254 (PCB-1254)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8082A	Aroclor-1260 (PCB-1260)
GC/ECD	EPA 8082A	Aroclor-1262 (PCB-1262)
GC/ECD	EPA 8082A	Aroclor-1268 (PCB-1268)
GC/FPD	EPA 8141B	Azinphos-methyl (Guthion)
GC/FPD	EPA 8141B	Bolstar (Sulprofos)
GC/FPD	EPA 8141B	Carbophenothion
GC/FPD	EPA 8141B	Chlorpyrifos
GC/FPD	EPA 8141B	Coumaphos
GC/FPD	EPA 8141B	Demeton-o
GC/FPD	EPA 8141B	Demeton-s
GC/FPD	EPA 8141B	Diazinon
GC/FPD	EPA 8141B	Dichlorovos (DDVP Dichlorvos)
GC/FPD	EPA 8141B	Dimethoate
GC/FPD	EPA 8141B	Disulfoton
GC/FPD	EPA 8141B	EPN
GC/FPD	EPA 8141B	Ethion
GC/FPD	EPA 8141B	Ethoprop
GC/FPD	EPA 8141B	Famphur
GC/FPD	EPA 8141B	Fensulfothion
GC/FPD	EPA 8141B	Fenthion
GC/FPD	EPA 8141B	Malathion
GC/FPD	EPA 8141B	Merphos
GC/FPD	EPA 8141B	Methyl parathion (Parathion methyl)
GC/FPD	EPA 8141B	Mevinphos
GC/FPD	EPA 8141B	Monocrotophos
GC/FPD	EPA 8141B	Naled
GC/FPD	EPA 8141B	Parathion ethyl
GC/FPD	EPA 8141B	Phorate
GC/FPD	EPA 8141B	Ronnel
GC/FPD	EPA 8141B	Stirofos
GC/FPD	EPA 8141B	Sulfotepp
GC/FPD	EPA 8141B	Tetraethyl pyrophosphate (TEPP)
GC/FPD	EPA 8141B	Thionazin (Zinophos)
GC/FPD	EPA 8141B	Tokuthion (Prothiophos)
GC/FPD	EPA 8141B	Trichloronate
GC/FPD	EPA 8141B	O,O,O-Triethyl phosphorothioate
GC/ECD	EPA 8151A	2,4,5-T

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/ECD	EPA 8151A	2,4-D
GC/ECD	EPA 8151A	2,4-DB
GC/ECD	EPA 8151A	Dalapon
GC/ECD	EPA 8151A	Dicamba
GC/ECD	EPA 8151A	Dichloroprop (Dichlorprop)
GC/ECD	EPA 8151A	Dinoseb (2-sec-butyl-4,6-dinitrophenol DNBP)
GC/ECD	EPA 8151A	MCPA
GC/ECD	EPA 8151A	MCPP
GC/ECD	EPA 8151A	Pentachlorophenol
GC/ECD	EPA 8151A	Silvex (2,4,5-TP)
GC/FID	FL-PRO	Total Petroleum Hydrocarbons (TPH)
GC/FID	MA-VPH	Volatile petroleum range organics (VPH)
GC/FID	MA-EPH	Extractable petroleum range organics (EPH)
GC/FID	IA-OA1	Gasoline range organics (GRO)
GC/FID	IA-OA2	Diesel range organics (DRO)
GC/FID	TN-GRO	Gasoline range organics (GRO)
GC/FID	TN-EPH	Extractable petroleum range organics (EPH)
GC/FID	AK-101	Gasoline range organics (GRO)
GC/FID	AK-102	Diesel range organics (DRO)
GC/FID	AK-103	Residual range organics (RRO)
GC/FID	OK-GRO	Gasoline range organics (GRO)
GC/FID	OK-DRO	Diesel range organics (DRO)
GC/FID	TX-1005	Total Petroleum Hydrocarbons (TPH)
GC/FID	KS LRH	Low-range Hydrocarbons (LRH)
GC/FID	KS MRH	Mid-Range Hydrocarbons (MRH)
GC/FID	KS HRH	High-Range Hydrocarbons (HRH)
GC/MS	EPA 8260B/C	1,1,1,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,1-Trichloroethane
GC/MS	EPA 8260B/C	1,1,2,2-Tetrachloroethane
GC/MS	EPA 8260B/C	1,1,2-Trichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethane
GC/MS	EPA 8260B/C	1,1-Dichloroethylene
GC/MS	EPA 8260B/C	1,1-Dichloropropene
GC/MS	EPA 8260B/C	1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113)

Solid and Chemical Materials

Technology	Method	Analyte
GC/MS	EPA 8260B/C	1,2,3-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,3-Trichloropropane
GC/MS	EPA 8260B/C	1,2,4-Trichlorobenzene
GC/MS	EPA 8260B/C	1,2,4-Trimethylbenzene
GC/MS	EPA 8260B/C	1,2-Dibromo-3-chloropropane (DBCP)
GC/MS	EPA 8260B/C	1,2-Dibromoethane (EDB Ethylene dibromide)
GC/MS	EPA 8260B/C	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,2-Dichloroethane
GC/MS	EPA 8260B/C	1,2-Dichloropropane
GC/MS	EPA 8260B/C	1,2-Dichlorotrifluoroethane (Freon 123)
GC/MS	EPA 8260B/C	1,3,5-Trimethylbenzene
GC/MS	EPA 8260B/C	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8260B/C	1,3-Dichloropropane
GC/MS	EPA 8260B/C	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8260B/C	1-Chlorohexane
GC/MS	EPA 8260B/C	2,2-Dichloropropane
GC/MS	EPA 8260B/C	2-Butanone (Methyl ethyl ketone MEK)
GC/MS	EPA 8260B/C	2-Chloroethyl vinyl ether
GC/MS	EPA 8260B/C	2-Chlorotoluene
GC/MS	EPA 8260B/C	2-Hexanone
GC/MS	EPA 8260B/C	2-Nitropropane
GC/MS	EPA 8260B/C	4-Chlorotoluene
GC/MS	EPA 8260B/C	4-Methyl-2-pentanone (MBK)
GC/MS	EPA 8260B/C	Acetone
GC/MS	EPA 8260B/C	Acetonitrile
GC/MS	EPA 8260B/C	Acrolein (Propenal)
GC/MS	EPA 8260B/C	Acrylonitrile
GC/MS	EPA 8260B/C	Allyl chloride (3-Chloropropene)
GC/MS	EPA 8260B/C	Benzene
GC/MS	EPA 8260B/C	Benzyl Chloride
GC/MS	EPA 8260B/C	Bromobenzene
GC/MS	EPA 8260B/C	Bromochloromethane
GC/MS	EPA 8260B/C	Bromodichloromethane
GC/MS	EPA 8260B/C	Bromoform
GC/MS	EPA 8260B/C	n-Butylbenzene
GC/MS	EPA 8260B/C	sec-Butylbenzene

Solid and Chemical Materials

Technology	Method	Analyte
GC/MS	EPA 8260B/C	tert-Butylbenzene
GC/MS	EPA 8260B/C	Carbon disulfide
GC/MS	EPA 8260B/C	Carbon tetrachloride
GC/MS	EPA 8260B/C	Chlorobenzene
GC/MS	EPA 8260B/C	Chloroethane
GC/MS	EPA 8260B/C	Chloroform
GC/MS	EPA 8260B/C	Chloroprene
GC/MS	EPA 8260B/C	Cyclohexane
GC/MS	EPA 8260B/C	Cyclohexanone
GC/MS	EPA 8260B/C	cis-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	trans-1,2-Dichloroethylene
GC/MS	EPA 8260B/C	cis-1,3-Dichloropropene
GC/MS	EPA 8260B/C	trans-1,3-Dichloropropylene
GC/MS	EPA 8260B/C	cis-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	trans-1,4-Dichloro-2-butene
GC/MS	EPA 8260B/C	Di-isopropylether (DIPE)
GC/MS	EPA 8260B/C	Dibromochloromethane
GC/MS	EPA 8260B/C	Dibromomethane (Methylene Bromide)
GC/MS	EPA 8260B/C	Dichlorodifluoromethane
GC/MS	EPA 8260B/C	Diethyl ether
GC/MS	EPA 8260B/C; EPA 8260B/C SIM	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8260B/C	Ethanol (Ethyl Alcohol)
GC/MS	EPA 8260B/C	Ethyl acetate
GC/MS	EPA 8260B/C	Ethyl methacrylate
GC/MS	EPA 8260B/C	Ethyl tert-butyl alcohol (ETBA)
GC/MS	EPA 8260B/C	Ethyl tert-butyl ether (ETBE)
GC/MS	EPA 8260B/C	Ethylbenzene
GC/MS	EPA 8260B/C	Ethylene Oxide
GC/MS	EPA 8260B/C	Hexachlorobutadiene
GC/MS	EPA 8260B/C	Hexane
GC/MS	EPA 8260B/C	Iodomethane (Methyl iodide)
GC/MS	EPA 8260B/C	Isobutyl alcohol (2-Methyl-1-propanol)
GC/MS	EPA 8260B/C	p-Isopropyltoluene
GC/MS	EPA 8260B/C	Isopropylbenzene
GC/MS	EPA 8260B/C	Methacrylonitrile
GC/MS	EPA 8260B/C	Methyl Acetate
GC/MS	EPA 8260B/C	Methyl bromide (Bromomethane)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8260B/C	Methyl chloride (Chloromethane)
GC/MS	EPA 8260B/C	Methylcyclohexane
GC/MS	EPA 8260B/C	Methyl methacrylate
GC/MS	EPA 8260B/C	Methyl tert-butyl ether (MTBE)
GC/MS	EPA 8260B/C	Methylene chloride
GC/MS	EPA 8260B/C	Naphthalene
GC/MS	EPA 8260B/C	Pentachloroethane
GC/MS	EPA 8260B/C	Propionitrile (Ethyl cyanide)
GC/MS	EPA 8260B/C	n-Propylbenzene
GC/MS	EPA 8260B/C	Styrene
GC/MS	EPA 8260B/C	tert-Amyl alcohol (TAA)
GC/MS	EPA 8260B/C	tert-Amyl methyl ether (TAME)
GC/MS	EPA 8260B/C	tert-Butyl alcohol (TBA)
GC/MS	EPA 8260B/C	tert-Butyl formate (TBF)
GC/MS	EPA 8260B/C	Tetrachloroethylene (Perchloroethylene)
GC/MS	EPA 8260B/C	Tetrahydrofuran
GC/MS	EPA 8260B/C	Toluene
GC/MS	EPA 8260B/C	Trichloroethene (Trichloroethylene)
GC/MS	EPA 8260B/C	Trichlorofluoromethane
GC/MS	EPA 8260B/C	Vinyl acetate
GC/MS	EPA 8260B/C	Vinyl chloride
GC/MS	EPA 8260B/C	Xylene (total)
GC/MS	EPA 8260B/C	m,p-Xylene
GC/MS	EPA 8260B/C	o-Xylene
GC/MS	EPA 8260B/C	1-Bromopropane
GC/MS	EPA 8260B/C	Isopropyl Alcohol
GC/MS	EPA 8260B/C	n-Butyl Alcohol
GC/MS	EPA 8270D	1,2,4,5-Tetrachlorobenzene
GC/MS	EPA 8270D	1,2,4-Trichlorobenzene
GC/MS	EPA 8270D	1,2-Dichlorobenzene (o-Dichlorobenzene)
GC/MS	EPA 8270D	1,2-Diphenylhydrazine
GC/MS	EPA 8270D	1,3,5-Trinitrobenzene (1,3,5-TNB)
GC/MS	EPA 8270D	1,3-Dichlorobenzene (m-Dichlorobenzene)
GC/MS	EPA 8270D	1,3-Dinitrobenzene (1,3-DNB)
GC/MS	EPA 8270D	1,4-Dichlorobenzene (p-Dichlorobenzene)
GC/MS	EPA 8270D	1,4-Dithiane
GC/MS	EPA 8270D	1,4-Oxathiane

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	1,4-Naphthoquinone
GC/MS	EPA 8270D	1,4-Phenylenediamine
GC/MS	EPA 8270D	1-Chloronaphthalene
GC/MS	EPA 8270D; EPA 8270D SIM	1-Methylnaphthalene
GC/MS	EPA 8270D	1-Naphthylamine
GC/MS	EPA 8270D	2,3,4,6-Tetrachlorophenol
GC/MS	EPA 8270D	2,4,5-Trichlorophenol
GC/MS	EPA 8270D	2,4,6-Trichlorophenol
GC/MS	EPA 8270D	2,4-Dichlorophenol
GC/MS	EPA 8270D	2,4-Dimethylphenol
GC/MS	EPA 8270D	2,4-Dinitrophenol
GC/MS	EPA 8270D	2,4-Dinitrotoluene (2,4-DNT)
GC/MS	EPA 8270D	2,6-Dichlorophenol
GC/MS	EPA 8270D	2,6-Dinitrotoluene (2,6-DNT)
GC/MS	EPA 8270D	2-Acetylaminofluorene
GC/MS	EPA 8270D	2-Chloronaphthalene
GC/MS	EPA 8270D	2-Chlorophenol
GC/MS	EPA 8270D	2-Methyl-4,6-dinitrophenol (4,6-Dinitro-o-cresol)
GC/MS	EPA 8270D; EPA 8270D SIM	2-Methylnaphthalene
GC/MS	EPA 8270D	2-Methylphenol (o-Cresol)
GC/MS	EPA 8270D	2-Naphthylamine
GC/MS	EPA 8270D	2-Nitroaniline
GC/MS	EPA 8270D	2-Nitrophenol
GC/MS	EPA 8270D	2-Picoline (2-Methylpyridine)
GC/MS	EPA 8270D	3,3`-Dichlorobenzidine
GC/MS	EPA 8270D	3,3`-Dimethylbenzidine
GC/MS	EPA 8270D	3-Methylcholanthrene
GC/MS	EPA 8270D	3&4-Methylphenol (m,p-Cresol)
GC/MS	EPA 8270D	3-Nitroaniline
GC/MS	EPA 8270D	4-Aminobiphenyl
GC/MS	EPA 8270D	4-Bromophenyl phenyl ether
GC/MS	EPA 8270D	4-Chloro-3-methylphenol
GC/MS	EPA 8270D	4-Chloroaniline
GC/MS	EPA 8270D	4-Chlorophenyl phenylether
GC/MS	EPA 8270D	4-Dimethyl aminoazobenzene
GC/MS	EPA 8270D	4-Nitroaniline

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	4-Nitrophenol
GC/MS	EPA 8270D	4,4’-methylene-bis(2-chloroaniline)
GC/MS	EPA 8270D	5-Nitro-o-toluidine
GC/MS	EPA 8270D	7,12-Dimethylbenz(a) anthracene
GC/MS	EPA 8270D; EPA 8270D SIM	Acenaphthene
GC/MS	EPA 8270D; EPA 8270D SIM	Acenaphthylene
GC/MS	EPA 8270D	Acetophenone
GC/MS	EPA 8270D	Aniline
GC/MS	EPA 8270D	Anilazine
GC/MS	EPA 8270D; EPA 8270D SIM	Anthracene
GC/MS	EPA 8270D	Aramite
GC/MS	EPA 8270D	Atrazine
GC/MS	EPA 8270D	Benzaldehyde
GC/MS	EPA 8270D	Benzidine
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(a)anthracene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(a)pyrene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(b)fluoranthene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(g,h,i)perylene
GC/MS	EPA 8270D; EPA 8270D SIM	Benzo(k)fluoranthene
GC/MS	EPA 8270D	Benzoic acid
GC/MS	EPA 8270D	Benzyl alcohol
GC/MS	EPA 8270D	Biphenyl (1,1’-Biphenyl)
GC/MS	EPA 8270D	bis(2-Chloroethoxy)methane
GC/MS	EPA 8270D	bis(2-Chloroethyl) ether
GC/MS	EPA 8270D	bis(2-Chloroisopropyl) ether (2,2`-Oxybis(1-chloropropane))
GC/MS	EPA 8270D	bis(2-Ethylhexyl) phthalate (DEHP)
GC/MS	EPA 8270D	Butyl benzyl phthalate
GC/MS	EPA 8270D	Carbazole
GC/MS	EPA 8270D	Caprolactam
GC/MS	EPA 8270D	Chlorobenzilate
GC/MS	EPA 8270D; EPA 8270D SIM	Chrysene
GC/MS	EPA 8270D	Diallate
GC/MS	EPA 8270D	Dinoseb
GC/MS	EPA 8270D	Di-n-butyl phthalate
GC/MS	EPA 8270D	Di-n-octyl phthalate
GC/MS	EPA 8270D; EPA 8270D SIM	Dibenz(a,h)anthracene

Solid and Chemical Materials

Technology	Method	Analyte
GC/MS	EPA 8270D	Dibenz(a,j)acridine
GC/MS	EPA 8270D	Dibenzofuran
GC/MS	EPA 8270D	Diethyl phthalate
GC/MS	EPA 8270D	Dimethyl phthalate
GC/MS	EPA 8270D	a,a-Dimethylphenethylamine
GC/MS	EPA 8270D	Diphenyl Ether
GC/MS	EPA 8270D	p-Dioxane (1,4-Dioxane)
GC/MS	EPA 8270D	Ethyl methanesulfonate
GC/MS	EPA 8270D; EPA 8270D SIM	Fluoranthene
GC/MS	EPA 8270D; EPA 8270D SIM	Fluorene
GC/MS	EPA 8270D	Hexachlorobenzene
GC/MS	EPA 8270D	Hexachlorobutadiene
GC/MS	EPA 8270D	Hexachlorocyclopentadiene
GC/MS	EPA 8270D	Hexachloroethane
GC/MS	EPA 8270D	Hexachlorophene
GC/MS	EPA 8270D	Hexachloropropene
GC/MS	EPA 8270D; EPA 8270D SIM	Indeno(1,2,3-cd)pyrene
GC/MS	EPA 8270D	Isodrin
GC/MS	EPA 8270D	Isophorone
GC/MS	EPA 8270D	Isosafrole
GC/MS	EPA 8270D	Kepone
GC/MS	EPA 8270D	Methapyrilene
GC/MS	EPA 8270D	Methyl methanesulfonate
GC/MS	EPA 8270D; EPA 8270D SIM	Naphthalene
GC/MS	EPA 8270D	Nicotine
GC/MS	EPA 8270D	Nitrobenzene
GC/MS	EPA 8270D	Nitroquinoline-1-oxide
GC/MS	EPA 8270D	n-Nitroso-di-n-butylamine
GC/MS	EPA 8270D	n-Nitrosodi-n-propylamine
GC/MS	EPA 8270D	n-Nitrosodiethylamine
GC/MS	EPA 8270D	n-Nitrosodimethylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine
GC/MS	EPA 8270D	n-Nitrosodiphenylamine/Diphenylamine (analyte pair)
GC/MS	EPA 8270D	n-Nitrosomethylethylamine
GC/MS	EPA 8270D	n-Nitrosomorpholine
GC/MS	EPA 8270D	n-Nitrosopiperidine

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
GC/MS	EPA 8270D	n-Nitrosopyrrolidine
GC/MS	EPA 8270D	Pentachlorobenzene
GC/MS	EPA 8270D	Pentachloroethane
GC/MS	EPA 8270D	Pentachloronitrobenzene
GC/MS	EPA 8270D; EPA 8270D SIM	Pentachlorophenol
GC/MS	EPA 8270D	Phenacetin
GC/MS	EPA 8270D; EPA 8270D SIM	Phenanthrene
GC/MS	EPA 8270D	Phenol
GC/MS	EPA 8270D	Pronamide (Kerb)
GC/MS	EPA 8270D	Propazine
GC/MS	EPA 8270D; EPA 8270D SIM	Pyrene
GC/MS	EPA 8270D	Pyridine
GC/MS	EPA 8270D	Resorcinol
GC/MS	EPA 8270D	Safrole
GC/MS	EPA 8270D	Simazine
GC/MS	EPA 8270D	o-Toluidine
GC/MS	EPA 8270D	Dimethoate
GC/MS	EPA 8270D	Disulfoton
GC/MS	EPA 8270D	Famphur
GC/MS	EPA 8270D	Methyl parathion (Parathion methyl)
GC/MS	EPA 8270D	Parathion ethyl
GC/MS	EPA 8270D	Phorate
GC/MS	EPA 8270D	Sulfotepp
GC/MS	EPA 8270D	Thionazin (Zinophos)
GC/MS	EPA 8270D	O,O,O-Triethyl phosphorothioate
HPLC	EPA 8330A/B	1,3,5-Trinitrobenzene (1,3,5-TNB)
HPLC	EPA 8330A/B	1,3-Dinitrobenzene (1,3-DNB)
HPLC	EPA 8330A/B	2,4,6-Trinitrotoluene (2,4,6-TNT)
HPLC	EPA 8330A/B	2,4-Dinitrotoluene (2,4-DNT)
HPLC	EPA 8330A/B	2,6-Dinitrotoluene (2,6-DNT)
HPLC	EPA 8330A/B	2-Amino-4,6-dinitrotoluene (2-am-dnt)
HPLC	EPA 8330A/B	2-Nitrotoluene
HPLC	EPA 8330A/B	3,5-Dinitroaniline
HPLC	EPA 8330A/B	3-Nitrotoluene
HPLC	EPA 8330A/B	4-Amino-2,6-dinitrotoluene (4-am-dnt)
HPLC	EPA 8330A/B	4-Nitrotoluene

Solid and Chemical Materials

Technology	Method	Analyte
HPLC	EPA 8330A/B	Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
HPLC	EPA 8330A/B	Nitrobenzene
HPLC	EPA 8330A/B	Nitroglycerin
HPLC	EPA 8330A/B	Methyl-2,4,6-trinitrophenylnitramine (Tetryl)
HPLC	EPA 8330A/B	Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)
HPLC	EPA 8330A/B	Pentaerythritoltetranitrate (PETN)
HPLC	EPA 8330A	2,2’,6,6’-Tetranitro-4,4’-azoxytoluene
HPLC	EPA 8330A/B	2-amino-6-Nitrotoluene
HPLC	EPA 8330A/B	4-amino-2-Nitrotoluene
HPLC	EPA 8330A/B	2-amino-4-Nitrotoluene
HPLC	EPA 8330A/B	2,4-diamino-6-Nitrotoluene
HPLC	EPA 8330A/B	2,6-diamino-4-Nitrotoluene
HPLC	EPA 8330A/B	DNX
HPLC	EPA 8330A/B	MNX
HPLC	EPA 8330A/B	TNX
HPLC	EPA 8330A	Nitroguanidine
HPLC	EPA 8330A	Guanidine Nitrate
LC/MS/MS	EPA 6850	Perchlorate
LC/MS/MS	EPA 537 MOD[2]	Perfluorobutanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoropentanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorohexanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoroheptanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorononanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorodecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoroundecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorododecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorotridecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorotetradecanoic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorononanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorobutanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorohexanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorodecanesulfonic Acid
LC/MS/MS	EPA 537 MOD[2]	Perfluoropentanesulfonic Acid

Solid and Chemical Materials

Technology	Method	Analyte
LC/MS/MS	EPA 537 MOD[2]	Perfluoroheptanesulfonic acid
LC/MS/MS	EPA 537 MOD[2]	Perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctane sulfonamide
LC/MS/MS	EPA 537 MOD[2]	Perfluoro-1-octanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctanesulfonamidoacetic acid
LC/MS/MS	EPA 537 MOD[2]	N-Methyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD[2]	4:2 Fluorotelomer Sulfonate
LC/MS/MS	EPA 537 MOD[2]	N-Ethyl perfluorooctane sulfonamidoethanol
LC/MS/MS	EPA 537 MOD[2]	6:2 Fluorotelomer Sulfonate
LC/MS/MS	EPA 537 MOD[2]	8:2 Fluorotelomer Sulfonate
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorobutanoic Acid (PFBA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoropentanoic Acid (PFPeA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-1515	Perfluorohexanoic Acid (PFHxA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroheptanoic Acid (PFHpA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanoic Acid (PFOA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorononanoic Acid (PFNA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorodecanoic Acid (PFDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroundecanoic Acid (PFUnA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorododecanoic Acid(PFDoA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorotridecanoic Acid (PFTrDA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorotetradecanoic Acid (PFTA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorobutanesulfonic Acid (PFBS)

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorohexanesulfonic Acid(PFHxS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctanesulfonic Acid(PFOS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorononanesulfonic Acid(PFNS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorodecanesulfonic Acid(PFDS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoroheptanesulfonic acid(PFHpS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluoropentanesulfonic Acid(PFPeS)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	Perfluorooctane sulfonamide (PFOSA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-Methyl perfluorooctanesulfonamidoacetic acid (MeFOSAA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	N-Ethyl perfluorooctanesulfonamidoacetic acid (EtFOSAA)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	4:2 Fluorotelomer Sulfonate (FTS 4:2)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	6:2 Fluorotelomer Sulfonate(FTS 6:2)
LC/MS/MS	PFAS by LCMSMS Compliant with QSM 5.1 Table B-15	8:2 Fluorotelomer Sulfonate (FTS 8:2)
ICP	EPA 6010C/D	Aluminum
ICP	EPA 6010C/D	Antimony
ICP	EPA 6010C/D	Arsenic
ICP	EPA 6010C/D	Barium
ICP	EPA 6010C/D	Beryllium
ICP	EPA 6010C/D	Cadmium
ICP	EPA 6010C/D	Calcium
ICP	EPA 6010C/D	Chromium
ICP	EPA 6010C/D	Cobalt
ICP	EPA 6010C/D	Copper
ICP	EPA 6010C/D	Iron
ICP	EPA 6010C/D	Lead
ICP	EPA 6010C/D	Magnesium
ICP	EPA 6010C/D	Manganese
ICP	EPA 6010C/D	Molybdenum

Solid and Chemical Materials

Technology	Method	Analyte
ICP	EPA 6010C/D	Nickel
ICP	EPA 6010C/D	Potassium
ICP	EPA 6010C/D	Selenium
ICP	EPA 6010C/D	Silver
ICP	EPA 6010C/D	Sodium
ICP	EPA 6010C/D	Strontium
ICP	EPA 6010C/D	Thallium
ICP	EPA 6010C/D	Tin
ICP	EPA 6010C/D	Titanium
ICP	EPA 6010C/D	Vanadium
ICP	EPA 6010C/D	Zinc
ICP/MS	EPA 6020A/B	Aluminum
ICP/MS	EPA 6020A/B	Antimony
ICP/MS	EPA 6020A/B	Arsenic
ICP/MS	EPA 6020A/B	Barium
ICP/MS	EPA 6020A/B	Beryllium
ICP/MS	EPA 6020A/B	Cadmium
ICP/MS	EPA 6020A/B	Calcium
ICP/MS	EPA 6020A/B	Chromium
ICP/MS	EPA 6020A/B	Cobalt
ICP/MS	EPA 6020A/B	Copper
ICP/MS	EPA 6020A/B	Iron
ICP/MS	EPA 6020A/B	Lead
ICP/MS	EPA 6020A/B	Magnesium
ICP/MS	EPA 6020A/B	Manganese
ICP/MS	EPA 6020A/B	Molybdenum
ICP/MS	EPA 6020A/B	Nickel
ICP/MS	EPA 6020A/B	Potassium
ICP/MS	EPA 6020A/B	Selenium
ICP/MS	EPA 6020A/B	Silver
ICP/MS	EPA 6020A/B	Sodium
ICP/MS	EPA 6020A/B	Strontium
ICP/MS	EPA 6020A/B	Thallium
ICP/MS	EPA 6020A/B	Tin
ICP/MS	EPA 6020A/B	Titanium
ICP/MS	EPA 6020A/B	Vanadium

Solid and Chemical Materials		
Technology	**Method**	**Analyte**
ICP/MS	EPA 6020A/B	Zinc
CVAA	EPA 7471B	Mercury
UV/VIS	EPA 7196A	Hexavalent Chromium (Cr6+)
UV/VIS	EPA 9012B	Cyanide (Total)
IC	EPA 9056A	Bromide
IC	EPA 9056A	Chloride
IC	EPA 9056A	Fluoride
IC	EPA 9056A	Nitrate
IC	EPA 9056A	Nitrite
IC	EPA 9056A	Sulfate
IC	EPA 9056A	Total nitrate-nitrite
Gravimetric Methods	SM 2540G	% solids
Electrometric Methods	EPA 9045D	Hydrogen Ion (pH)
Ignitability	EPA 1010A MOD	Flash Point
Waste Characterization	EPA Ch.7	Reactive Cyanide and Reactive Sulfide
Waste Characterization	EPA Section 7.3	Reactive Cyanide
Waste Characterization	EPA Section 7.3	Reactive Sulfide
Preparation	**Method**	**Type**
Organics Preparation	EPA 3510C	Separatory Funnel Liquid-Liquid Extraction; Leachates
TCLP Preparation	EPA 1311	Toxicity Characteristic Leaching Procedure
SPLP Preparation	EPA 1312	Synthetic Precipitation Leaching Procedure
Organics Preparation	EPA 8011	Microextraction
Organics Preparation	EPA 3546	Microwave Extraction
Organics Preparation	EPA 3550C	Ultrasonic Extraction
Organics Preparation	EPA 3580A	Waste Dilution for Extractable Organics
Organics Preparation	EPA 8330A; EPA 8332	Ultrasonic Extraction
Organics Preparation	EPA 8330B	Shaker Table Extraction
Volatile Organics Preparation	EPA 3585	Waste Dilution for Volatile Organics
Volatile Organics Preparation	EPA 5030A	Closed System Purge and Trap; Bulk Soils
Volatile Organics Preparation	EPA 5030B	Closed System Purge and Trap; Leachates and Methanol Extracts
Volatile Organics Preparation	EPA 5035; EPA 5035A	Closed System Purge and Trap
Organics Cleanup	EPA 3660B	Sulfur Cleanup

Solid and Chemical Materials

Technology	Method	Analyte
Organics Cleanup	EPA 3665A	Sulfuric Acid Cleanup
Lachat MicroDistillation	EPA 9012B	Cyanide MicroDistillation; proprietary method
Inorganic Preparation	EPA 3010A	Metals Acid Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 3050B	Metals Acid Digestion by Hotblock
Inorganic Preparation	EPA 3060A	Alkaline Digestion, Cr6+
Inorganic Preparation	EPA 7470A	CVAA Digestion by Hotblock; Leachates
Inorganic Preparation	EPA 7471B	CVAA Digestion by Hotblock

Note:

1. This scope is formatted as part of a single document including Certificate of Accreditation No. L2229
2. Not compliant with QSM V5.1.1 Table B-15

Vice President

ATTACHMENT G

Response to Comments on the Draft QAPP

Responses to Comments submitted by the Central Coast Regional Water Quality Control Board (CCRWQCB)[1]

SPECIFIC COMMENT 1: Section 3.1.3 Known Contaminants and Section 3.6.1 – Worksheet #15a: VOCs by EPA Method 8260-SIM: Section 3.1.3 indicates that known contaminants, or contaminants of concern (COCs), were identified during Remedial Investigations at the sites and documented in the decision documents for each site. The COCs for each site are listed in Section 3.6.1, Worksheet #15a. Based on a review of groundwater analytical data for the site, it appears that select wells were historically sampled and analyzed for 1,2,3-trichloropropane (1,2,3-TCP). This constituent was ruled out as a potential COC however, the detection limits were above the California Maximum Contaminant Level (MCL) of 0.005 micrograms per liter (µg/L) that was adopted in 2017. Therefore, the Water Board recommends selecting one key groundwater monitoring well (i.e.: the well with the highest concentrations of a known COC) at each of the OU2, Sites 2/12, and OUCTP Areas to sample and analyze for 1,2,3-TCP to confirm non-detectable results using a detection limit below the MCL. In 2018, the municipal water supply wells in the former Fort Ord Area (FO-29 through FO-31) were sampled and analyzed for 1,2,3-TCP using a detection limit below 0.005 µg/L. 1,2,3-TCP was not detected in the samples collected from the municipal water supply wells.

RESPONSE TO SPECIFIC COMMENT 1: *It is acknowledged the analytical detection limits for groundwater samples historically collected at the former Fort Ord are higher than the current California MCL, but additional sampling and analysis for 1,2,3-TCP is not warranted based on the following lines of evidence:*

- *Common uses of 1,2,3-TCP included use as a paint and varnish remover, and a cleaning and degreasing agent.*[2] *These uses would be consistent with historical uses of other solvents, including carbon tetrachloride (CT), tetrachloroethene (PCE), and trichloroethene (TCE), at the former Fort Ord when it was an active military installation. However, while CT, PCE, and TCE have historically been detected in groundwater, soil, and soil gas at the former Fort Ord at concentrations exceeding MCLs or screening levels by several orders of magnitude, there have been no corresponding detections of 1,2,3-TCP, indicating there was no significant usage of this compound.*
- *The vapor pressure of 1,2,3-TCP (3.1 mmHg at 25°C) and the calculated Henry's law constant (3.17×10^{-4} atm-m^3/mol at 25°C) suggest volatilization from either dry or moist soil to the atmosphere will be a significant environmental process.*[3] *Therefore, if there was any release of 1,2,3-TCP to the ground surface, it is likely most or all of it would have volatilized to the atmosphere before it could leach to groundwater.*
- *Other media, including soil and soil gas, have been sampled and analyzed for 1,2,3-TCP at various sites across the former Fort Ord, including OU1, OU2, OUCTP, and Sites 2/12, and 1,2,3-TCP has never been detected, further indicating no significant usage of this compound at the former Fort Ord.*

---

[1] In a letter dated March 22, 2019 (see Administrative Record No. BW-2785G.4).

[2] Agency for Toxic Substances and Disease Registry: Toxicological Profile for 1,2,3-Trichloropropane, May 2019: https://www.atsdr.cdc.gov/toxprofiles/tp57.pdf

[3] Ibid.

- *CT and TCE have historically been detected in municipal water supply wells FO-29, FO-30, and FO-31, and these compounds are associated with identified upgradient operable units; however, as noted in the comment, 1,2,3-TCP has not been detected in these wells. Because 1,2,3-TCP is a chlorinated solvent with high mobility, it would be expected to be present concurrently with CT and TCE; however, its absence indicates there is no upgradient source.*

SPECIFIC COMMENT 2: Section 3.1.4 – Fate and Transport Considerations, OU2 and OUCTP: The subsections for OU2 and OUCTP indicate the aquifers that are impacted by COCs. In the subsection for Sites 2/12 please add the aquifer(s) impacted by COCs.

RESPONSE TO SPECIFIC COMMENT 2: *The text was revised per the comment.*

SPECIFIC COMMENT 3: Section 3.1.4 – Fate and Transport Considerations, OU2 and OUCTP: In the subsection for OUCTP consider adding the following discussion related to TCE in the Lower 180-Foot Aquifer: *Due to the lateral discontinuity in the Intermediate 180-Foot Aquitard between the Upper and Lower 180-Foot Aquifers, existing TCE data for the A-Aquifer in the OU2 Area and for the Upper and Lower 180-Foot Aquifers in the OUCTP and OU2 Areas will be reviewed and evaluated to determine the source of TCE concentrations above the California MCL of 5 µg/L in the Lower 180-Foot Aquifer.* Please cite reference documents that include information on the discontinuity of the Intermediate 180-Foot Aquitard, as appropriate.

RESPONSE TO SPECIFIC COMMENT 3: *Text was added to Section 3.1.4 to provide more detail about the migration of CT in the affected aquifers at OUCTP, and to note the presence of TCE in the Lower 180-Foot Aquifer and its possible association with OU2. However, the Quality Assurance Project Plan (QAPP) is a guidance document for groundwater sampling and analysis activities at the former Fort Ord; therefore, the suggested discussion would be more appropriately included in the "Suggested Monitoring Modifications" section of the OUCTP Fourth Quarter 2018 through Third Quarter 2019 Groundwater Monitoring Report.*

SPECIFIC COMMENT 4: Section 3.1.8 – Geology and Hydrogeology: This section indicated that the aquifers consist predominantly of fine to coarse-grained sands which are separated by silty clay or clayey fine-grained sand aquitards. Please consider including additional information on the aquitards such as that the Fort Ord Salinas Valley Aquitard pinches out to the west towards the Pacific Ocean and that the Intermediate 180-Foot Aquitard that separates the Upper 180-Foot Aquifer and Lower 180-Foot Aquifer appears to be laterally discontinuous in the eastern portion of the former Fort Ord near the OU2 and OUCTP Areas. Additionally, please cite reference documents that include information on the aquitards, as appropriate.

RESPONSE TO SPECIFIC COMMENT 4: *The text was revised per the comment.*

SPECIFIC COMMENT 5: Section 3.2.1 – Step 1: State the Problem, OUCTP Lower 180-Foot Aquifer: Consider adding the following discussion related to TCE detections in the Lower 180-Foot Aquifer: *Due to the lateral discontinuity in the Intermediate 180-Foot Aquitard between the Upper and Lower 180-Foot Aquifers, existing TCE data for the A-Aquifer in the OU2 Area and for the Upper and Lower 180-Foot Aquifers in the OUCTP and OU2 Areas will be reviewed and evaluated to determine the source of recent detections of TCE above the California MCL of 5 µg/L in the Lower 180-Foot Aquifer. Please cite reference* *documents that include information on the discontinuity of the Intermediate 180-Foot Aquitard, as appropriate.*

RESPONSE TO SPECIFIC COMMENT 5: *Consistent with the response to Specific Comment 3, text was added to the OUCTP Lower 180-Foot Aquifer subsection of Section 3.2.1 to note the presence of TCE in the Lower 180-Foot Aquifer and its possible association with OU2. Accordingly, Section 3.2.2 was revised to identify additional study goals to address the revised problem statement.*

SPECIFIC COMMENT 6: Section 3.2.6 – Step 6: Specify Performance or Acceptance Criteria, OU2, Sites 2/12, and OUCTP GWMP: This section includes the following information: VOCs in groundwater at the former Fort Ord range in concentration from ND to 27.4 micrograms per liter (µg/L) PCE (at Sites 2/12), 19.6 µg/L TCE (at site OU2), and 6.5 µg/L CT (at OUCTP), the primary COCs at these sites (as measured in the Third Quarter 2016 GWMP). Please update the ranges in concentrations of VOCs in groundwater with the concentrations measured in the Third Quarter 2017 GWMP.

RESPONSE TO SPECIFIC COMMENT 6: *The data was updated with Third Quarter 2018 GWMP information in the OU2, Sites 2/12, and OUCTP GWMP subsection of Section 3.2.6.*

SPECIFIC COMMENT 7: Section 3.5.16 – Project Schedule: In the table for the general project schedule under the activity column OU2 GWMP is listed twice. It appears that Sites 2/12 GWMP is missing from the list. Please modify the activity list as appropriate.

RESPONSE TO SPECIFIC COMMENT 7: *The table was revised per the comment.*

SPECIFIC COMMENT 8: Section 4.1.5 – Worksheet #17c1: Sites 2/12 GWMP and Figure 2: Following submittal of the Draft QAPP for review, Ahtna requested a modification to the Sites 2/12 GWMP in an email on February 25, 2019 and the Water Board approved the modifications by email on February 28, 2019. Provided that the United States Environmental Protection Agency (USEPA) and Department of Toxic Substances Control (DTSC) concur, please update the sampling frequency for well MW-12-26-180U from quarterly to annual on Worksheet #17c1 and Figure 2.

RESPONSE TO SPECIFIC COMMENT 8: *Worksheet #17c1 and Figure 2 were edited to move MW-12-26-180U from quarterly to annual monitoring frequency.*

SPECIFIC COMMENT 9: Section 4.1.7 – Worksheet #17c3: OUCTP A-Aquifer GWMP and Figure 8A: Following submittal of the draft QAPP for review, Ahtna requested modifications to the OUCTP A-Aquifer GWMP in an email on February 25, 2019 and the Water Board approved the modifications by email on February 28, 2019. Provided that the EPA and DTSC concur, please update the following on Worksheet #17c3 and Figure 8A:

- Modify the sampling frequency for wells EW-BW-132-A, EW-BW-163-A, EW-BW-167-A, EW-BW-168-A, and EW-BW-169-A from quarterly to annual.
- Remove wells EW-BW-161-A, EW-BW-162-A, EW-BW-164-A, EW-BW-165-A, MW-BW-16-A, and MW-BW-57-A from the sampling program.
- Include quarterly DO/ORP monitoring at wells MW-BW-87-A and MW-BW-91-A.

RESPONSE TO SPECIFIC COMMENT 9: *Worksheet #17c3 and Figure 8A were edited to change the frequency of monitored wells as described above, with the following exceptions:*

- *EW-BW-163-A is removed from the program.*
- *EW-BW-165-A sampling frequency is reduced from quarterly to annual.*
- *MW-BW-87-A and MW-BW-91-A casing diameters are too small for the DO/ORP meter; therefore, they were substituted with EW-BW-161-A and EW-BW-164-A for DO/ORP monitoring.*
- *MW-BW-30-A sampling frequency was increased to annual.*

Responses to Comments submitted by the Fort Ord Community Advisory Group (FOCAG)[1]

COMMENT 1: To begin, please reference and review previous responses found on the Administrative Record
BW-2327E.1
OU2-630F
And this from the CCRWQCB dated December 19, 1986 http://docs.fortordcleanup.com/ar_pdfs/AR-OU2-019//ou2-019.pdf. To quote a portion: "The plan does not fully address the extent of contamination in the deeper aquifers. For example, Marina's Well No. 10 is perforated solely in the 900 foot aquifer. The well has shown Trichloroethane contamination. The source of the contamination is most likely from the shallower aquifers. This should be addressed in your sampling plan."

The current document, Version 7, does not address VOC contamination in the Marina Coast Water District supply wells that draw water from the 900-foot aquifer. How often are these wells tested for VOCs? Have the sources of the contamination been determined? Is the water being pumped from these three 900-foot deep wells still being blended to meet State water quality standards?

RESPONSE TO COMMENT 1: *The U.S. Department of the Army (Army) conducted a basewide hydrogeologic evaluation and determined volatile organic compound (VOC) contamination in groundwater at the former Fort Ord does not impact the 400-Foot Aquifer and 900-Foot Aquifer.*[2] *Drinking water supplied by the Marina Coast Water District (MCWD) meets all Federal, State, and local regulatory standards. MCWD regularly tests drinking water quality and reports the results in an annual Consumer Confidence Report (CCR) found at www.mcwd.org. Water quality data and operational information are available at MCWD. Contact information for MCWD is available at https://mcwd.org/customer_service_contact.html.*

COMMENT 2: Large Army burns on the former Army Training Range lands called Site 39 was a common occurrence. The Army would extinguish these brush and ordnance fires. We ask, where are the test results for Perfluorooctanoic Acid and Perflorooctane Sulfanate in the groundwater beneath Site 39? Because a good portion of Site 39 sits directly atop the Seaside Groundwater Basin.

RESPONSE TO COMMENT 2: *The Army is currently conducting a basewide review of historical activities at the former Fort Ord that may have resulted in releases of PFOA/PFOS to soil and groundwater, and the results will be included in a report scheduled to be issued in summer 2019. Based on the preliminary results of this review, there is no suspected release of perfluorooctanoic acid (PFOA) or perfluorooctane sulfonate (PFOS) at Site 39. During prescribed burning at the former Fort Ord, fire foam or retardant may be used for pretreatment of the containment line around the burn unit, or to extinguish fires that have gone outside the containment line; however, these are Class A foams or retardants designed for use on combustible materials, such as wood, and not Class B foams designed for use on petroleum-based fires that may contain PFOA or PFOS. Additionally, the Fort Ord fire department historically used water tenders and not foam for fighting fires at Site 39.*

---

[1] In a letter dated March 8, 2019 (see Administrative Record No. BW-2785G.2). The comments are reproduced here as provided to the Army and there have been no changes to spelling, grammar, or punctuation.
[2] See Administrative Record No. BW-1283A.

As required by the federal third Unregulated Contaminant Monitoring Rule, water systems in the vicinity of the former Fort Ord, including the MCWD and California American Water, collected and analyzed drinking water samples for PFOA and PFOS from 2013 to 2015 and there were no detections. Analytical results are available in a downloadable Microsoft Excel file at the State Water Resources Control Board (SWRCB) website under the heading "Findings in California Drinking Water:"

https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/PFOA_PFOS.html

The SWRCB has also issued orders to public water systems in the vicinity of the former Fort Ord requiring testing for PFOA and PFOS. The SWRCB will also prepare a map of the sampling completed to date by the end of summer 2019. The map, along with a spreadsheet of all available data, will be made available to the public.

COMMENT 3: Please have the document tell of the decision to create an unlined landfill and transfer contamination and waste from one cell to another new one across the road at OU2.

RESPONSE TO COMMENT 3: *When the Fort Ord Landfills were receiving waste from 1956 to 1987, the waste was placed in shallow unlined trenches; however, the remedial action for the Fort Ord Landfills does not include creating an unlined landfill, and no new landfill cells were created as part of the remedy for OU2. In accordance with the Record of Decision, Operable Unit 2, Fort Ord Landfills (OU2 ROD)[3] and OU2 Area A Explanation of Significant Differences (ESD),[4] waste was consolidated in the existing landfill areas south of Imjin Parkway and an engineered cover system, including a linear low-density polyethylene liner, was constructed over the top of the waste. With implementation of the remedy, the overall area of the Fort Ord Landfills decreased by approximately 20 percent.[5]*

Regardless, the information requested to be included in the Quality Assurance Project Plan (QAPP) is not relevant because the QAPP is a guidance document for groundwater sampling and analysis activities at the former Fort Ord; however, the OU2 Landfills QAPP is referenced in Section 3.1.3, and this document contains detailed information about the Fort Ord Landfills and the OU2 remedy.

COMMENT 4: Page 18, Section 3.1.8 Geology and Hydrology: The two paragraphs are insufficient. During the 1990's the Army BRAC held Community Involvement Workshops (C.I.W.). The community was informed that there was an impermeable clay aquitard that prevented contamination from flowing into the Lower 180-ft aquifer. Some community members expressed skepticism at the time. Later we learned that, Oops, guess there was a hole in the aquitard.

RESPONSE TO COMMENT 4: *Additional information regarding the system of aquifers and aquitards at the former Fort Ord was added to Section 3.1.8.*

COMMENT 5: Page 19, Section 3.2.1 Step 1: State the Problem: We suggest that since water and VOC contaminants run downhill, that the 900-ft aquifer be studied, and reported on too.

RESPONSE TO COMMENT 5: *See response to Comment 1.*

---

[3] See Administrative Record No. OU2-480.
[4] See Administrative Record No. OU2-458.
[5] See Administrative Record No. OU2-630B.

COMMENT 6: Was the source of the Meningitis outbreak among the troops training at Fort Ord in the 1962-1964 time frame ever determined?

RESPONSE TO COMMENT 6: *There was no determination of the source as noted in the following article: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1515912/.*

COMMENT 7: Page 19-20, Sites 2/12, second paragraph, regarding contamination of the groundwater by COC's and seawater intrusion. The FOCAG asks about a timeline here because initially wells had to be closed and moved inland and the reason given, at the time, was because of chloride concentrations (sea water).

RESPONSE TO COMMENT 7: *In 1940 and 1941 there were nine water supply wells constructed in the Main Garrison area (some in the vicinity of Sites 2/12). Two of these were never used and most of the others pumped sand and produced water with high chloride concentrations. Seven of the water supply wells were decommissioned in 1951 or 1952, and the last two were decommissioned in 1989. From 1942 until 1984, additional water supply wells were constructed further inland. Most of these have been decommissioned, with only FO-29, FO-30, and FO-31 remaining.*[6] *Wells constructed in the Sites 2/12 area since 1989 have been for groundwater monitoring and groundwater extraction and treatment, not for water supply. Because seawater intrusion can damage groundwater remediation equipment, the Army measures chloride concentrations annually at Sites 2/12 in select groundwater wells, as noted in QAPP Worksheet #17c1, to ensure groundwater extraction and treatment activities do not make seawater intrusion worse in this area.*

COMMENT 8: Page 20, OU2; Please make it clear that moving a portion of the landfill to an unlined landfill contributed to the migration of contaminants downward into the aquifers. Secondly, the three wells referenced; FO-29, FO-30, and FO-31, located near the OU2 area are the Marina Coast Water District's source wells. The MCWD currently serves residential and commercial service connections on former Fort Ord and the City of Marina.

RESPONSE TO COMMENT 8: *Excavating waste from Landfills Area A on the north side of Imjin Parkway and consolidating it with waste in Landfills Areas B through F on the south side of Imjin Parkway did not contribute to migration of COCs to groundwater. The remedy for the Fort Ord Landfills is functioning as designed and is protective of human health and the environment.*[7] *The engineered landfill cover system, constructed in accordance with the remedy identified in the OU2 ROD, is specifically designed to prevent migration of contaminants to the groundwater. Migration of contaminants from the Fort Ord Landfills to groundwater that occurred prior to construction of the engineered cover system has been mitigated through extraction and treatment of landfill gas and groundwater per the requirements of the OU2 ROD (see also the response to Comment 3).*

The text was revised to state that MCWD owns and operates FO-29, FO-30, and FO-31 as part of the water supply system for the former Fort Ord and the City of Marina.

COMMENT 9: Page 21, 3.2.2, Step 2: Identify the Goals of the Study: We call your attention to the second "bullet" below OU2 and Sites 2/12 GWTS. GWTS stands for Ground Water Treatment Systems. It

---

[6] See Administrative Record No. BW-2002A.

[7] See Administrative Record No. OU2-480.

states here that, "Assess whether GWTS effluent meets discharge requirements before it is used for groundwater recharge or onsite for non-potable construction purposes (dust control, soil compaction, etc.)" We ask that you please expand this to include analysis of the goal of the Monterey Peninsula Water Management District's plan to inject treated sewer water, and water used for washing pesticides from produce, and other waste water, directly into the ground above a portion of the Seaside Groundwater Basin. This is a groundwater recharge effort, and we ask for clarification as to how much Fort Ord GWTS effluent might, or will, be mixed with this either intentionally or unintentionally?

RESPONSE TO COMMENT 9: *It is assumed the comment is referring to the Pure Water Monterey project, which includes replenishment of the Seaside Groundwater Basin with purified recycled water.*[8] *This type of analysis is not within the scope of the QAPP, which is a guidance document for groundwater sampling and analysis activities at the former Fort Ord. However, according to the* Final Engineering Report, Monterey One Water Pure Water Monterey Groundwater Replenishment Project*, replenishment is to occur via four injection wells that will recharge the Santa Margarita Aquifer and the Paso Robles Aquifer.*[9] *No mixing of purified recycled water and the Army's groundwater treatment systems (GWTS) treated effluent can occur because:*

- *The Santa Margarita Aquifer and the Paso Robles Aquifer are significantly deeper than, and not hydrologically connected to, the Upper 180-Foot Aquifer being recharged by the Army's GWTS.*
- *The northern boundary of the Seaside Groundwater Basin is at least 1.6 miles south of the Army's closest groundwater recharge structures.*
- *The general groundwater flow direction in the Seaside Groundwater Basin is to the west (i.e., parallel to flow in the Upper 180-Foot Aquifer).*

COMMENT 10: Bottom of page 22, Footnote 7 states, "Antimony, copper, and lead are the primary metals found in spent ammunition deposited in the Fort Ord landfills. MCL's are used to evaluate concentrations of these dissolved metals in groundwater near the Fort Ord Landfills; however, the groundwater being monitored is not intended for use as drinking water." The FOCAG asks for clarification of this footnote. Also, Army training involved dozens of chemicals. We understand the intent wasn't to drink it. But it is in the groundwater now, or headed there. Please reference the Administrative record for FOCAG document OTH-253 dated 01/02/2010.

RESPONSE TO COMMENT 10: *Footnote 7 was revised to clarify that:*

- *Detected concentrations of antimony, copper, and lead are compared to Federal and California Maximum Contaminant Levels (MCLs) because there are no Aquifer Cleanup Levels (ACLs) for these metals identified in the OU2 ROD.*
- *The groundwater being monitored is not intended for use as drinking water because it is within the Prohibition Zone of the Special Groundwater Protection Zone.*

---

[8] At its public meeting on March 9, 2017, the Central Coast Regional Water Quality Control Board adopted waste discharge and water recycling requirements for the Pure Water Monterey Advanced Water Purification Facility and Groundwater Replenishment Project; a copy of the order is available at https://www.waterboards.ca.gov/centralcoast/board_decisions/adopted_orders/

[9] The Engineering Report is available at http://purewatermonterey.org/wp/wp-content/uploads/M1W-Final-Title-22-Engineering-Report-April-2019.pdf

Section 3.2.1 of the QAPP was also revised to clarify the rationale for monitoring for antimony, copper, and lead in groundwater near the Fort Ord Landfills. Results of the sampling for metals analysis described in QAPP Worksheet #17c2 are in the OU2 reports for Third Quarter groundwater monitoring events, which are included in the Administrative Record. Concentrations of these metals in groundwater samples are all below MCLs.

Based on the reference to Administrative Record No. OTH-253, it is assumed the comment is concerned with chemical warfare material (CWM) contaminating groundwater at the former Fort Ord. There is no evidence of CWM having been used at the former Fort Ord. A comprehensive search was conducted at Fort Ord and did not uncover any evidence in records, interviews, or other information sources to indicate that chemical weapons were ever stored, used, or buried at Fort Ord. Evidence indicates the only CWM used at the former Fort Ord were Chemical Agent Identification Sets, which were used to train soldiers to recognize and protect themselves from chemical agents. In addition, more than 13 million anomalies have been investigated and more than 300,000 cubic yards of contaminated soil have been excavated during investigations and removals at Fort Ord without any evidence of CWM.[10]

---

[10] Technical Memorandum, CWM-Related Responses and Reports, Administrative Record No. OE-0726.

ATTACHMENT H

Response to Comments on the Draft Final QAPP

Responses to Comments submitted by the Central Coast Regional Water Quality Control Board (Water Board)[1]

In the Draft Final QAPP, Ahtna provides Attachment G: Responses to Comments Submitted by the Central Coast Regional Water Quality Control Board on the Draft QAPP. The Water Board has the following comments on the responses provided in Attachment G:

COMMENT 1: In Specific Comment 1, the Water Board recommended selecting one key groundwater monitoring well (i.e.: the well with the highest concentration of a known COC) at each of the OU2, Sites 2/12, and OUCTP Areas to sample and analyze for 1,2,3-Trichloropropane (1,2,3 -TCP) to confirm non-detectable results using a detection limit below the California Maximum Contaminant Limit (MCL) of 0.005 micrograms per liter (µg/L).

In response to Specific Comment 1, Ahtna acknowledged the analytical detection limits for groundwater samples historically collected at the former Fort Ord are higher than the current California MCL, but additional sampling and analysis for 1,2,3-TCP is not warranted based on the following lines of evidence:

- Common uses of 1,2,3-TCP included use as a paint and varnish remover, and a cleaning and degreasing agent. These uses would be consistent with historical uses of other solvents, including carbon tetrachloride (CT), tetrachloroethene (PCE), and trichloroethene (TCE), at the former Fort Ord when it was an active military installation. However, while CT, PCE, and TCE have historically been detected in groundwater, soil, and soil gas at the former Fort Ord at concentrations exceeding MCLs or screening levels by several orders of magnitude, there have been no corresponding detections of 1,2,3-TCP, indicating there was no significant usage of this compound.
- The vapor pressure of 1,2,3-TCP (3.1 mmHg at 25°C) and the calculated Henry's law constant (3.17×10^{-4} atm-m^3/mol at 25°C) suggest volatilization from either dry or moist soil to the atmosphere will be a significant environmental process.[2] Therefore, if there was any release of 1,2,3-TCP to the ground surface, it is likely most or all of it would have volatilized to the atmosphere before it could leach to groundwater.
- Other media, including soil and soil gas, have been sampled and analyzed for 1,2,3-TCP at various sites across the former Fort Ord, including OU1, OU2, OUCTP, and Sites 2/12, and 1,2,3-TCP has never been detected, further indicating no significant usage of this compound at the former Fort Ord.

The Water Board appreciates the information provided in response to Specific Comment 1. Based on this information at a minimum the Central Coast Water Board recommends that the OU2 Groundwater Treatment System influent be sampled and analyzed for 1,2,3-TCP using a detection limit below the MCL of 0.005 µg/L. This data would confirm that 1,2,3-TCP is not present in the influent groundwater extracted as part of the groundwater remediation activities. If 1,2,3-TCP is present in influent groundwater extracted for treatment and recharge back into the aquifer, an effluent sample should also

---

[1] In a letter dated July 17, 2019 (see Administrative Record No. BW-2785G.4).

[2] Ibid.

be collected confirm that 1,2,3-TCP is removed to levels below the MCL prior to recharge back into the aquifer.

RESPONSE TO COMMENT 1: *The U.S. Department of the Army (Army) agrees to collecting a sample at the influent to the Operable Unit 2 (OU2) groundwater treatment plant (GWTP) to analyze for 1,2,3-TCP using a detection limit below the MCL of 0.005 µg/L. The sample will be collected during a regularly scheduled quarterly groundwater monitoring event or concurrently with GWTP process monitoring. Depending on the analytical results, the Army will evaluate the need for additional sampling in consultation with the Water Board.*

COMMENT 2: In response to Specific Comment 9, Worksheet #17c3 and Figure 8A were updated to remove well EW-BW-162-A from the OUCTP A-Aquifer sampling program. Well EW-BW-162-A appears on Figure 8A as a well that will be monitored for water levels however this well is not included on Worksheet #17c3.

Please update Worksheet #17c3 to show that well EW-BW-162-A will continue to be monitored for water levels.

RESPONSE TO COMMENT 2: *Figure 8A was revised to remove well EW-BW-162-A, and this well was not added to Worksheet #17c3. Per QAPP decision criteria, this well will not be monitored for chemicals of concern or for water levels.*

Appendix 7D

Monterey County Quality Assurance Project Plan

Quality Assurance Project Plan (QAPP) For Water Quality Monitoring Associated with the Salinas Valley Integrated Water Management Plan (SVIWMP)

EPA R9#03-238
X-97994701-0

Monterey County Water Resources Agency
P.O. Box 930
Salinas, CA 93902
Telephone: (831) 755-4860
Fax: (831) 424-7935
Website: http://www.mcwra.co.monterey.ca.us

WATR0584QV4 (COPY 2)

1.0 PROJECT MANAGEMENT

1.1 TITLE AND APPROVAL PAGE

Quality Assurance Project Plan
For
Water Quality Monitoring Associated with
The Salinas Valley Integrated Water Management Plan (SVIWMP)
EPA R9#03-238
X-97994701-0

Prepared by:
Monterey County Water Resources Agency (MCWRA)
P.O. Box 930
Salinas, CA 93902

Prepared for:
US EPA Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Approval Signatures

Elizabeth Krafft Agency Project Manager:	8/12/07 Date:
Kathleen Thomasberg Agency Project QA/Task Manager:	8/17/07 Date:
Eugenia McNaughton, Ph.D. USEPA Region 9 QA Program Manager:	10/22/07 Date:
Carolyn G Yale Carolyn Yale USEPA Region 9 Project Officer:	12/3/07 Date:
Mark Kutnink Mark Kutnink USEPA Region 9 Chemist:	22 OCT 2007 Date:

1.2 TABLE OF CONTENTS

1.0 PROJECT MANAGEMENT
1.1 Title and Approval Page....2
1.2 Table of Contents....3
1.3 Distribution List....6
1.4 Project/Task Organization....7
1.5 Problem Identification/Background....9
  1.5.1 Background....9
  1.5.2 Program Objectives....10
  1.5.3 Program Goals....10
1.6 Project/Task Description....11
  1.6.1 Work Statement and Produced Products....11
  1.6.2 Constituents to be monitored and measurement techniques....11
  1.6.3 Project Schedule....12
  1.6.4 Geographical Setting....12
  1.6.5 Constraints....12
1.7 Data Quality Objectives for Measurement Data....13
  1.7.1 Objectives and Project Decisions....13
  1.7.2 Action Limits/Levels....14
  1.7.3 Measurement Performance Criteria....14
1.8 Training Requirements/Certification....16
  1.8.1 Training of Field Personnel....16
  1.8.2 Training of Laboratory Personnel....17
  1.8.3 GPS Training Documentation.... 17
1.9 Documentation and Records....17
  1.9.1 QA Project Plan Distribution....17
  1.9.2 Field Documentation and Records....17
    1.9.2.1 Field Sheets....17
    1.9.2.2 Chain of Custody (COC) Forms....18
    1.9.2.3 Photographs....19
    1.9.2.4 Labels....19
    1.9.2.5 Field Quality Control Sample Records....19
  1.9.3 Laboratory Documentation and Reports....20
  1.9.4 Technical Reviews and Evaluations....20
    1.9.4.1 Field Activities Review Checklist....20
    1.9.4.2 Laboratory Data Review Checklist....20
  1.9.5 Technical Memorandum....21

2.0 DATA GENERATION AND ACQUISITION....21
2.1 Sampling Process Design....21
  2.1.1 Salinas Valley Ground Water....22
  2.1.2 Coastal Ground Water....22
2.2 Sampling Methods 23
2.3 Sample Handling and Custody....23
  2.3.1 Sample Containers and Preservatives....24
  2.3.2 Sample Packaging and Transport....24
  2.3.3 Sample Custody....24
  2.3.4 Sample Disposal....25

2.4 Analytical Methods....25
2.5 Quality Control....25
  2.5.1 Field Sampling Quality Control....25
  2.5.2 Laboratory Analyses Quality Control....26
2.6 Instrument/Equipment Testing, Inspection, and Maintenance....26
2.7 Instrument Calibration and Frequency....26
2.8 Inspection/Acceptance Requirements for Supplies....26
  2.8.1 Initial Inspection of Supplies....26
  2.8.2 Field Inspection of Supplies....26
  2.8.3 Laboratory Inspection of Supplies....27
2.9 Data Acquisition Requirements (Non-Direct Measurements)....27
2.10 Data Management....27

3.0 ASSESSMENT AND RESPONSE ACTIONS....27
3.1 Reviews....27
  3.1.1 Readiness Reviews....27
  3.1.2 Field Reviews....27
  3.1.3 Post Sampling Reviews....28
  3.1.4 Laboratory Data Reviews....28
3.2 Reports....28

4.0 DATA VALIDATION AND USABILITY....28
4.1 Data Verification and Validation....28
  4.1.1 Field Data....28
  4.1.2 Laboratory Data....28
4.2 Reconciliation with User Requirements....29

5.0 REFERENCES....30

FIGURES

1 Monterey County, California
2 Salinas Valley Hydrologic Subareas
3 Salinas Valley Wells in the Pressure Subarea
4 Salinas Valley Wells in the East Side Subarea
5 Salinas Valley Wells in the Forebay Subarea
6 Salinas Valley Wells in the Upper Valley Subarea
7 Coastal Ground Water Monitoring Program Wells

TABLES

1 Complete Mineral Panel Analytes
2 Quality Control Requirements for Laboratory Analyses
3 Laboratory Data Quality Objectives (DQOs)
4 Salinas Valley Wells and Locations
5 Coastal Wells and Locations
6 Requirements for Sample Collection

APPENDICES

A GPS Training Record
B Field Documentation
  B-1 Example of Field Sheet
  B-2 Example of Chain of Custody Form (COC)
  B-3 Example of Photo-Log

- B-4 Example of Sample Labels
- C Review Checklists
  - C-1 Field Activities Review Checklist
  - C-2 Laboratory Data Review Checklist
- D Monterey County Consolidated Chemistry Laboratory
  - D-1 QA Manual
  - D-2 Specific Conductance
  - D-3 pH
  - D-4 Total Alkalinity
  - D-5 Metals
  - D-6 Anions

1.3 DISTRIBUTION LIST

The following is a list of organizations and persons who will receive copies of the approved QA Project Plan and any subsequent revisions:

Monterey County Water Resources Agency (Agency)
P.O. Box 930
Salinas, CA 93902

Elizabeth Krafft
Project Manager
(831) 755-4860
krafftea@co.monterey.ca.us

Kathleen Thomasberg
Project QA/Task Manager
(831) 755-4860
thomasbergk@co.monterey.ca.us

Manuel Saavedra
Hydrologist/ Team Lead
(831) 755-4860
saavedram@co.monterey.ca.us

Carla James
Water Resources Technician/ Field Sampler
(831) 755-4860
JamesCR@co.monterey.ca.us

Tamara Voss
Water Resources Technician/ Field Sampler
(831) 755-4860
vosstl@co.monterey.ca.us

U.S. Environmental Protection Agency, Region 9
75 Hawthorne Street
San Francisco, CA 94105-3901

Eugenia McNaughton, Ph.D.
QA Program Manager
(415) 972-1111

Carolyn Yale
Project Officer
(415) 972-3482

Mark Kutnink
Chemist
(415) 972-3801

Monterey County Consolidated Chemistry Laboratory (CCL)
1270 Natividad Road, Room A15
Salinas, CA 93906

Germain Guibert
Laboratory Director
(831) 755-4516

1.4 PROJECT/TASK ORGANIZATION

The organization responsible for overseeing this ground water monitoring program is the Monterey County Water Resources Agency (Agency). This project is funded through a grant from the Environmental Protection Agency (EPA), under the authority of Section §104 (b)(3) of the Clean Water Act. This project falls under the Monitoring and Assessment funding category. The Monterey County Health Department's Consolidated Chemistry Laboratory is a California state certified laboratory that will perform the chemical analyses for this ground water monitoring program. The laboratory will use standard analytical methods.

The roles and responsibilities of those involved in the implementation of the ground water monitoring program are described below. An organizational chart for the program is shown below.

Project Manager is the responsible official who will oversee the preparation of grants and the fiscal management of the project.

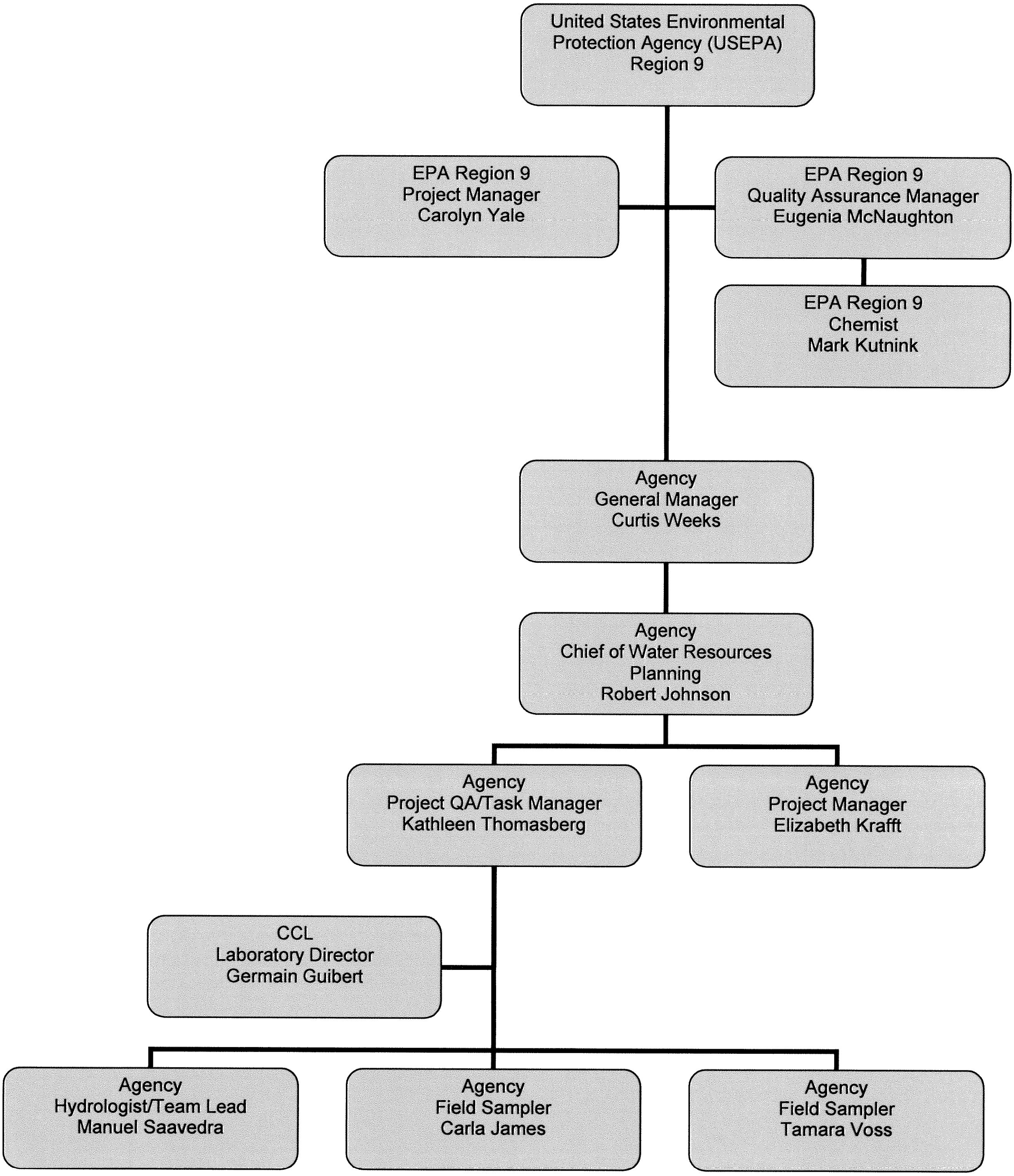
Project QA Manager is in charge of establishing the QA/QC protocols found in the QAPP as part of the sampling and analysis procedures. The QA Manager will also review and assess all analytical data from the contract laboratory and will be the liaison regarding data quality issues and concerns. She may stop all actions, including those conducted by the contract laboratory and will be responsible for ensuring that any amended versions of the QAPP are distributed to the organizations and individuals listed in Section 1.3.

Project Task Manager will oversee the ground water monitoring program. She will ensure that all QAPP protocols are followed and will oversee the writing and revisions of the QAPP. Since the Agency's Water Quality Department is not large, the Project Task Manager will function in the dual role of Task Manager and QA Manager.

Hydrologist/Team Lead will be responsible for coordinating with the Water Resources Technicians/ Field Samplers to review field and analytical requirements, documentation, and sampling schedules.

Water Resources Technicians/Field Samplers will be responsible for sample collection and communication with the contract laboratory regarding the sampling shipment schedule. They are also responsible for writing the QAPP.

ORGANIZATIONAL CHART



1.5 PROBLEM DEFINITION/BACKGROUND

1.5.1 Background

The Monterey County Water Resources Agency's (Agency) mission is to manage, protect, and enhance the quantity and quality of water for present and future generations of Monterey County (County). Monterey County, located along the California Central Coast, covers 3,322 square miles (8604 km^2) and has a resident population of 424,842 (Fact Finder, 2007). The County supports a \$3.4 billion agricultural industry (Ag Commission, 2006) and a \$1.75 billion tourism industry (EPA Grant R9#03-238). The primary land use within the Salinas Valley is agricultural. Since the 1940's, irrigated acreage within the valley has increased substantially. Coastal regions of California are subject to rapid urbanization, and the milder coastal climate supports year-round intensive cultivation of many high-value crops (Hunt et al, 2003). As agricultural and urban areas have expanded, so have the water needs of the County (EPA Grant R9#03-238).

The Agency uses a network of wells to monitor ground water conditions in the Salinas Valley Ground Water Basin (Basin) (Geomatrix, 2001). The Basin is situated entirely within the County (EPA Grant R9#03-238). The Salinas Valley is surrounded by the Gabilan and Diablo Ranges on the east, by the Sierra de Salinas and Santa Lucia Range on the west, and is drained by the Salinas River, which empties into Monterey Bay in the north (DWR 1946a) (Fig 1). Four subareas based on differences in local hydrogeology and recharge have been identified (White Paper, 1995; DWR, 2003). These are known as the Pressure, East Side, Forebay, and Upper Valley subareas (Fig 2). These subareas are hydrologically and hydraulically connected (EPA Grant R9#03-238); all information collected to date indicates there are no barriers to the horizontal flow (of ground water) between these subareas (White Paper, 1995). The "boundaries" between these subareas have been identified as zones of transition between different depositional environments in past millennia (White Paper, 1995).

The primary surface water features overlying and influencing the Basin's hydrology are the Salinas River and its tributaries, the Nacimiento and San Antonio reservoirs, and the Monterey Bay (EPA Grant R9#03-238). The Salinas River extends approximately 120 miles from the river's headwaters in San Luis Obispo County, near Santa Margarita, and flows north/northwest and discharges into the Monterey Bay National Marine Sanctuary near Moss Landing in Monterey County (EPA Grant R9#03-238). The Nacimiento and San Antonio reservoirs, located in the upper watershed, serve as storage and flood control for the Basin.

Ground water recharge in Salinas Valley is principally from infiltration from the Salinas River, Arroyo Seco Cone, and to a much lesser extent, from deep percolation of rainfall (White Paper, 1995). Deep percolation of applied irrigation water is the second largest component of the ground water budget, but because it represents recirculation of existing ground water rather than an inflow of "new" water, it is not considered a source of recharge (White Paper, 1995). Nitrate contamination of ground water poses a significant threat to the beneficial use of ground water for drinking water and for some agricultural water uses (White Paper, 1995). Nitrate concentrations exceed drinking water standards in some parts of the Basin (MCWRA, 1997). The principal source of nitrates to ground water is almost certainly excess fertilizer that is leached by rainfall and applied irrigation water (White Paper, 1995).

Seawater intrusion is another source of inflow to the Basin, but because it is not usable freshwater it is also excluded as a source of recharge (White Paper, 1995). Historically, ground water flowed from subareas to the south and east through the (Pressure) and seaward to discharge zones in the walls of the submarine canyon in Monterey Bay (Durbin et al 1978; Greene 1970). Within the Pressure subarea, due to the impermeable nature of the clay aquitard above the 180-Foot Aquifer, recharge from precipitation, agricultural return flows, or river flow is nil (DWR, 2003). Instead, recharge is from underflow originating in Upper Valley areas such as the Arroyo Seco Cone and Salinas River bed or the East Side subarea, and more recently, from seawater intrusion (DWR, 2003). Heavy pumping of the Pressure-180 Foot and Pressure-400 Foot aquifers has caused significant seawater intrusion into both of these aquifers, which was first documented in the1930's (DWR 1946a). Ground water flow in the northernmost area of the Pressure subarea has been directed from the Monterey Bay inland since this time (DWR, 2003). With increased pumping in the East Side subarea since the 1970's, ground water flow is dominantly northeast in the Pressure's central and southern locations (DWR, 2003).

Declining ground water levels in the Pressure and East Side subareas, Basin overdraft, ground water contamination, including nitrate and seawater intrusion are serious concerns for the Agency. (EPA Grant R9#03-238)

1.5.2 Program Objectives

The Agency is charged with management of the Basin's ground water resources. Much of the Agency's investigative work pertaining to the occurrence and use of ground water is to identify the quality, quantity, and temporal trends of ground water resources within the County. A network of monitoring wells provides the information needed to manage and protect ground water resources and sustain beneficial uses. In order for the Agency to develop projects to mitigate problems, such as seawater intrusion, local ground water overdraft, and high nitrate concentrations, the Agency must first implement an effective and accurate monitoring program to identify the extent of the potential problem.

The Ground Water Quality Monitoring Objectives are:
-continued monitoring of the ambient ground water quality, including general minerals
-continued monitoring of coastal aquifers (including Pressure Deep Aquifer) for detection of advancing seawater intrusion
-continued monitoring to determine distribution of conductivity in ground water
-continued monitoring to determine distribution of nitrate in ground water and identification of problem areas

Ambient ground water quality will be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. For the purposes of this QAPP, the EPA-I grant has funded the Agency to develop this QAPP. The EPA-II grant is funding the Agency to implement the sampling described in the QAPP.

1.5.3 Program Goals

The ground water monitoring objectives in the Salinas Valley will be met by the goal of sampling all 344 wells located throughout the four subareas within the Salinas Valley Ground Water Basin, during the 2007 summer field season.

The ground water monitoring objectives along the coast, specifically located within the Pressure subarea will be met by the goal of sampling all 85 monitoring wells, during the 2007 summer field season.

The Agency's overarching goal for this program is the continued monitoring of the Basin's ambient ground water for use in the management of this important resource, and *not* for the purpose of regulatory control.

1.6 PROJECT/TASK DESCRIPTION

1.6.1 Work Statement and Produced Products

The Salinas Valley Ground Water monitoring will sample 344 wells located throughout the Salinas Valley Ground Water Basin for ten constituents (Table 1). Each well will be sampled once. Samples will be collected during the 2007 summer agricultural growing season and analyzed for a complete mineral panel. The Coastal Ground Water monitoring will sample 85 wells located within the area of historic seawater intrusion. Each well in the Coastal Program will be sampled once a month during the agricultural growing season. The first month's sample will be analyzed for complete mineral panel and the two remaining sampling events will by analyzed for partial mineral panel (three constituents) (Table 1). All water monitoring samples will be delivered the same day as collected to the contract laboratory for analysis.

All ground water sampling locations are accessible using a 4-wheel drive vehicle. All samples will be collected as a grab sample. All sampling locations will be recorded using global positioning system (GPS) equipment, and digital pictures will be taken at each site.

After laboratory analysis and data validation is completed, a technical memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) will be written and submitted to US EPA. The technical memorandum, EPA II, XP-96995301 Task 2 Water Quality Assessment, will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradient contours.

1.6.2 Constituents to be monitored and measurement techniques

Samples will be sent to an off-site laboratory for analysis. Ground water samples will be analyzed for either complete or partial mineral panels. A complete mineral panel includes calcium, cation-anion balance, chloride, conductivity, magnesium, nitrate, pH, potassium, sodium, sulfate, and total alkalinity. A partial mineral panel consists of chloride, conductivity, and nitrate.

Sample analysis will be preformed at the Monterey County Consolidated Chemistry Laboratory (CCL), which is part of the Environmental Health Department. Listed below is the laboratory's contact information and ELAP Certification number.

Laboratory Name	***Contact Information***	***Abbreviation***
Monterey County Consolidated Chemistry Laboratory ELAP Certification No 1395	1270 Natividad Road Salinas, CA 93906 Phone: 831-755-4516 Fax: 831-755-4652 http://www.co.monterey.ca.us/health	CCL

1.6.3 Project Schedule

The proposed project schedule is summarized below.

Prior to Sample Collection	
January 2006 - January 2007	Develop project strategy
15 January, 2007	Submit Draft QA Project Plan
22 March, 2007	Receive review comments on QA Project Plan from US EPA
6 July, 2007	Submit Draft Final QA Project Plan
13 July, 2007	Obtain QA Project Plan approval (to begin fieldwork)
20 July, 2007	Submit Final QA Project Plan (signatory copy) EPA R9#03-238; X-97994701-0
Sample Collection	
August 2007 - September 2007	Coastal Ground Water (each well 3x, once per month)
August 2007 - September 2007	Salinas Valley Ground Water (each well 1x)
Post Sample Collection	
November 2007	Compile all remaining laboratory analyses reports
1 - 15 December, 2007	Evaluate laboratory data for QA/QC requirements
15 December, 2007	Copy of analytical results sent to well owner/operators
16 - 31 December, 2007	Summarize and tabulate data
January 2008	Write Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment)
March 2008	Submit Technical Memorandum (EPA II, XP-96995301 Task 2 Water Quality Assessment) to US EPA

1.6.4 Geographical Setting

The Salinas Ground Water Basin encompasses approximately 537.5 square miles (1,392 km^2). The regional ground water flow is to the northwest. Seawater intrusion is a result of coastal pumping (Figure 3). Ground water pumping can dramatically impact localized coastal ground water flow.

1.6.5 Constraints

Ground water samples must be taken from the well while the pump is operating to ensure that the sample is representative of the aquifer and not standing water within the well casing. The Agency wants to measure the water quality when the aquifers are stressed due to pumping. For this reason the 2007 field sampling season will coincide with the agricultural irrigation season.

1.7 DATA QUALITY OBJECTIVES FOR MEASUREMENT DATA

This section describes the data objectives of the project and defines the measurement performance criteria deemed necessary to meet those objectives.

1.7.1 Objectives and Project Decisions

In Monterey County the Salinas Valley and Coastal Ground Water ambient monitoring programs are designed to characterize the ground water quality conditions of the Basin. All data generated from the sampling program in this project are tabulated as they have been over the many years of the program. Data generated from these monitoring activities allows the Agency to track changes in ground water quality over time and to assess potential impacts to ground water in the Basin. Water resource management and policy decisions may follow based on maps and tabulated data generated as a part of this project (program).

For the coastal ground water sampling program, the general mineral data are evaluated to determine if seawater intrusion is progressing landward as indicated by increasing well chloride values. The chloride values for all wells are evaluated, and then the 500mg/L chloride isochlor contours are mapped for the two coastal aquifers. When the maps are published, the information generated by MCWRA staff and approved by the MCWRA Board of Directors, is posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page, presentations, public meetings, and networking.

Monterey County departments such as the Planning Department and Health Department utilize the advancement of seawater as it relates to potable water and public health, while the agricultural community becomes aware of the proximity of their wells to the intrusion advancement, and the possible need for funds to drill new, deeper, wells and destroy the older high nitrate wells. Actions by regulators, depending on the entity, are related to prioritization of Regional Watershed and Water Quality Action Plans, and the associated success of MCWRA capital projects to halt seawater intrusion as governed by the State Water Resources Control Board adjudication process.

Actions by the MCWRA after the landward advancement of seawater have been ongoing for many years. Actions include consideration of more stringent Monterey County well drilling ordinances for assuring the continued prevention of cross-aquifer contamination in the coastal Salinas Valley, *"Zone 6 Drilling Standards", April 19, 1988;* the development and implementation of the Monterey County Recycling Projects, a tertiary treatment plant and treated water distribution system, to help further reduce agricultural pumping in the coastal Salinas Valley for halting seawater intrusion; and future use of these data will be utilized by the newly established Seaside Watermaster for comparison to and the development of the Monterey Peninsula seawater intrusion front.

For the Salinas Valley general mineral ground water sampling program, nitrate data tabulation and map representation has been the focus of the MCWRA for many years. All results over the laboratory's practical quantitative limit generated from this program are tabulated to evaluate the minimum, maximum, median, and mean value of nitrate as NO_3 in mg/L for each of the Salinas Valley Hydrogeologic Subareas.

For the Salinas Valley monitoring program, the Agency sends the general mineral testing results, including nitrate, to the well owners/growers who operate the wells sampled. Also, in this transmittal, the well operators are also provided with a conversion sheet of the nitrate concentration *from mg/L nitrate as NO_3 to pounds of nitrate per acre inch of water*, agricultural terms. If a nitrate value in ground source water is elevated, then that growers can incorporate this available nitrate into their fertilizer crop scheduling. This is a method for growers to reduce applied nitrate to crops, while maintaining maximum crop productivity.

And, as with the Coastal monitoring program, the tabulated and mapped Salinas Valley nitrate data are posted and passed on to Monterey County departments, regional government regulatory agencies, and public / private entities via the MCWRA web page.

The MCWRA uses the well nitrate data during the technical well application review process. Monterey County Health Department (Heatlh Department) issues well permits after the Agency provides a technical review of well applications for new, abandoned, or repaired wells. The well application proposal is evaluated with other well construction and water quality within a one miles radius of the new well and represented on a map. Agency staff makes qualitative recommendations to the Health Department on the new well's sanitary seal based on other well seals, the perforated intervals, and the nitrate values of wells in the area. The final decision for the well construction is made by the Health Department after the well drilling progresses.

Actions taken by the MCWRA are conditional. If extreme nitrate values are observed in agricultural production wells, then re-sampling of the wells may take place to confirm the elevated concentrations and may lead to increased sampling points for wells in the same vicinity and with the same well design. Continued increases in Salinas Valley ground water nitrate values could lead to special nitrate investigations on movement of nitrate in ground water and also outreach to the public on the reduction of nitrate to the environment.

1.7.2 Action Limits/Levels

Since the overarching goal for this project is the continued monitoring of ambient ground water, the Agency has set no specific water quality standards. As a result, the laboratory's practical quantitation limits (PQL) will serve as the Project Action Levels (PALs). Table 1 provides a listing of the parameter to be sampled and a summary of the laboratory's method detection limit, those minimum concentrations that can be detected above the instrumental background/baseline signal noise. Table 1 also provides the PQL, lowest calibration standard and PALs required by the Agency for the QAPP. The quality limits listed are deemed acceptable by the Agency to meet the project objectives.

1.7.3 Measurement Performance Criteria

The objective of data collection for this Monitoring Project is to produce data that represent the *in situ* conditions of the ground water. This objective will be achieved by using accepted standard methods for water collection and analysis and defining data quality indicators (DQIs) for each analytical parameter. The DQIs include accuracy, precision, comparability, sensitivity, completeness, and representativeness and are defined below and presented in Table 2. Some DQIs will be assessed quantitatively, while others will be qualitatively assessed. Example calculations have been provided for quantitative assessments and appropriate quality control (QC) samples have been identified. Laboratory Data Quality Objectives are given in Table 3.

Accuracy, or bias, is a measure of how close a result is to the expected value of the target analyte in a sample. Accuracy will be determined by the analysis of certified reference materials and matrix spikes, where the results can be compared with an expected value and expressed as %recovery. This is an assessment of laboratory analytical methods. For Laboratory Control Samples (LCS), it will be expressed as %recovery by the following equation:

$$\%\text{Recovery} = \frac{X}{T} \times 100$$

where,

X = Measured concentration
T = True spiked concentration

or, for Matrix Spike (MS) samples, by the following equation:

$$\%\text{Recovery} = \frac{(B - A)}{T} \times 100$$

where,

B = Measured concentration of spiked sample
A = Measured concentration of unspiked sample
T = True spiked concentration

The frequency of the LCS and MS samples associated with the analytical parameters will be 5%. MS and MSD samples will be spiked at 3-10 times the native sample concentration.

Accuracy/bias as related to contamination involves both field and laboratory components. Field blanks will be collected at a frequency of 5%. Laboratory blanks will be prepared and analyzed at a one per batch or 5% frequency.

Precision is concerned with the ability to quantitatively repeat results. To demonstrate the precision of a method or instrument, field duplicates will be collected, analyzed, and their results compared. Precision is expressed as relative percent difference (RPD) by the following equation:

$$\text{RPD (\%)} = \frac{|X_1 - X_2|}{(X_1 + X_2)/2} \times 100$$

where,

X_1 = Original sample concentration
X_2 = Duplicate sample concentration
$|X_1 - X_2|$ = Absolute value of $X_1 - X_2$

Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Laboratory duplicates will be prepared and analyzed at a one per batch or 5% frequency.

Comparability of the data can be defined as the similarity of data generated by different monitoring programs. Comparability helps to measure the scientific coherence and validity of a project. This objective is addressed primarily by using standard sampling and analytical procedures. Additionally, comparability of analytical data is addressed by result comparison of certified reference materials.

Sensitivity of the analytical instrument or method is the ability to detect and quantify an analytical parameter at the concentration level of interest. Sensitivity can be evaluated by method or instrument detection limit studies (MDL and IDL) or calculated practical quantitative limits (PQL) and method report limits (MRL).

Completeness is a measure of the amount of successfully collected and validated data relative to the amount of data planned to be collected for the project. Project completeness is typically based on the percentage of the data needed for the program or study to reach statistically valid conclusions. Because the SVIWMP is a monitoring program, data that are not successfully collected for a specific sample event or site can typically be recollected at a later sampling event. For this reason, most of the data planned for collection can not be considered statistically critical, and it is difficult to set a meaningful objective for data completeness. However, some reasonable objectives for the data are desirable, if only to measure the effectiveness of the Monitoring Program. %Completeness will be expressed by the following equation:

$$\%\text{Completeness} = \frac{N}{T} \times 100$$

where,

N = Number of usable results
T = Total number of samples planned to be collected

A completeness goal of 90% has been set for the ground water monitoring program.

Representativeness can be defined as the degree to which the environmental data generated by the monitoring program accurately and precisely represent actual environmental conditions. This objective is addressed by the overall design of the monitoring program. Specifically, assuring the representativeness of the data is addressed primarily by selecting appropriate locations, methods, times, and frequencies of sampling for each environmental parameter, and by maintaining the integrity of the sample after collection. Representativeness judges how well a single sample can describe the conditions of an entire sample population. Accurate, artifact-free sampling procedures and appropriate sample homogenization achieve representativeness.

1.8 TRAINING REQUIREMENTS/CERTIFICATION

1.8.1 Training of Field Personnel

A specialized training requirement for this project is for the use of Global Positioning Systems (GPS) Technology. Training in the use of handheld GPS units and software will be performed on an individual basis between the trainer and the trainee. Training will be provided by staff experienced in the use of GPS and Geographic Information Systems (GIS).

Field personnel will also be given initial instructions prior to the beginning of sample collection activities. These initial instructions will help familiarize the field personnel with sample collection containers, sample handling techniques, chain-of-custody forms, and sample transport. New field personnel will be accompanied by a trainer in the field as part of the initial instructions. All field samplers have completed a four-hour training session in the field. Training included confirmation of the well ID electrical meter tag number and MCWRA tag number, recognizing the appropriate sampling port, sample collection technique, proper handling of the sample during transportation to the lab, and accurate completion of the chain-of-custody forms. The completion of field training session has been documented in the Agency's personnel files.

All field personnel will follow sample collection procedures from accepted methods for the collection of ground water. Sample collection will follow protocols in accordance with recommended guidelines established by the U.S. Geological Survey (USGS) for ground water collection as described in the

National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9. Field personnel will be familiar with the above-mentioned document.

Field personnel will also read and be familiar with this Quality Assurance Project Plan (QAPP) prior to beginning any sample collection activities.

1.8.2 Training of Laboratory Personnel

No specialized training of laboratory personnel is required for this project. The ground water constituents to be analyzed by the laboratory are routine and do not require additional expertise. In addition, the laboratory's QA plan notes that analysts 'must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure'.

1.8.3 GPS Training Documentation

Documentation of field personnel training for GPS includes: the name of the staff member being trained, the training date, the name of the trainer (instructor), and a checklist of satisfactory completion of each step. These training records are stored inside a monitoring binder and filed in the Agency's Water Quality Section. A sample GPS training record is attached in Appendix A.

Training documentation of laboratory personnel for routine methods is kept on file at the Consolidated Chemistry Laboratory (CCL). The CCL has written a policy regarding laboratory personnel training in their lab QA plan.

1.9 DOCUMENTATION AND RECORDS

1.9.1 QA Project Plan Distribution

The MCWRA Hydrologist/ Team Lead will safeguard the original QAPP and any subsequent revisions (both hard and electronic), plus keep a record of the distribution list in order to send out amendments to the QAPP and retrieve any obsolete versions (from the individuals listed earlier in section 1.3).

1.9.2 Field Documentation and Records

All field documentation generated by the sampling program will be kept on file in the Water Quality Section of the Agency. Field documentation includes field sheets, chain of custody (COC) forms, photographs, and labels (see Appendix B for examples of each).

1.9.2.1 Field Sheets

Field sheets are used to aid in the identification of each ground water source (well). The field sheets list the name of each well (as assigned by the well owner) and the State Well Number. The field sheets also contain a section that describes who the sampler should contact in order to have a well turned on, where to find the sample port, etc. The sampler is responsible for recording the sample date and time on the field sheet. Site observations should be written in the comments section of the field sheet, and initialed by the sampler. Site observations may include information such as detailed directions to the well location, changes to the electrical meter tag number, and the owner contact name and phone number. Field sheets also contain PG&E electrical meter numbers, which can be either verified or updated while the sampler is in the field.

Field sheets are double-checked by the sampler for completeness and accuracy while still in the field. The sampler should look for: incomplete and/or missing data/omissions, incorrect or invalid information, and clarity problems. Any discrepancies should be cleared up before the sampler leaves the field. Data that has been entered by one field sampler will be reviewed by a different field sampler to verify that no transcription errors have occurred. These data entry reviews will take place at least weekly.

Original field sheets are categorized (according to Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time, the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Data collected on field sheets will also be recorded electronically and stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.2 Chain Of Custody (COC) Forms

Chain-of-custody (COC) forms will be provided by the Consolidated Chemistry Laboratory and filled out while the sampler is in the field. The COC will accompany the samples at all times in order to insure the custodial integrity of the samples. A sample is considered to be in custody if it is: in someone's physical possession, in someone's view, locked up, or secured in an area that is restricted to authorized personnel.

Care should be taken to protect the COC from physical damage (i.e., water, wind, etc). The COC will have the following information:

- Client Code
- Client Name
- Client Address
- Client Phone Number
- Client Fax Number
- Report Attention
- Sampler Name
- Collection Date
- Collection Time
- Sample Site (identified by state well identification number) or QC sample (if appropriate)
- Sample Type (all of the samples in this project will be **grab** samples)
- Matrix (all of the samples in this project will be **ground water** samples)
- Analyses Requested

Upon relinquishing the sample(s) to the Consolidated Chemistry Laboratory, the sampler will sign and date the COC form. Lab personnel will then receive the sample(s), mark the date and time received, assign unique lab identification numbers (lab IDs) to each sample, and sign the COC form. The signed COC form is then photocopied; the lab keeps the original, and a copy is given to the sampler.

Hard copies of COC forms are categorized (Coastal wells or Salinas Valley wells) inside binders which are kept in the Water Quality Section at the Agency for a period of 10 years. After such time, the copies are transferred to the Monterey County Record Retention Center and archived for a period of 5 years.

Electronic COC information is also stored in an Access database inside a shared network drive that is backed-up on a daily basis. These electronic records will be retained permanently.

1.9.2.3 Photographs

The Agency maintains a photo catalog which contains photographs of the Coastal well site locations. The photo catalog is carried into the field to assist with the identification of each well. If there are significant changes to the appearance of the well site, then staff will take a new digital photo. The old photo in the catalog will then be replaced with a copy of the new photo. Photographs will be taken of the Salinas Valley wells after confirming the correct well location of each.

Two photographs of each well location will be taken using a high resolution digital camera. One photograph will be from a distance of 100 ft. or more to aid in the identification of the correct site location. The second photograph will be a close up of the well and pump head, which will be used to verify location of the correct sampling port. Printed hard copies of these two photographs for each well will be kept in the photo log book and labeled with the state well identification number as listed on the field sheets.

Photographs will serve to help verify information entered into the field sheets. Photographs are stored in an electronic database and labeled according to site number and date last photographed. Previous photos will be archived electronically for retrieval purposes if the need arises.

1.9.2.4 Labels

Labels for each sample site are pre-printed on Avery (size 5163) sheets (10 labels per sheet). Indelible ink will be used on the labels and clear packing tape will be applied over the label to prevent it from coming off if it gets wet. Each label will have the following information:

- Sample Site (pre-printed)
- Collection Date (to be filled out in the field)
- Collection Time (to be filled out in the field)
- Analyses Requested (complete or partial mineral panel)
- Sampler Name (to be filled out in the field)
- Comments (if any)

The sample site name (state well identification number) will serve as the unique identifier for each sample (e.g. 14S/02E-08M02). When the samplers arrive at the CCL a unique in-house lab number is assigned to each sample.

1.9.2.5 Field Quality Control Sample Records

Quality Control samples from the field will be identified using the state well identification number plus either -1 or -2 (e.g. 14S/02E-08M02-1, for a field blank).

- -1 = Field Blank
- -2 = Field Duplicate

1.9.3 Laboratory Documentation and Records

The Consolidated Chemistry Laboratory will keep a sample receiving log containing the completed COC forms submitted with the samples collected for this project. The CCL will keep records of all analyses performed as well as associated QC information, including: laboratory blanks, laboratory duplicates, matrix spikes, matrix spike duplicates and laboratory control samples. Hard copy data of analytical results will be maintained for three years by the CCL. The CCL maintains a Laboratory Information Management System (LIMS) which will be used to store electronic data.

The data generated by the CCL for each sampling event will be compiled into individual data reports. The individual data reports will include the following information:

- Sample results and associated Quantitative Limits (QLs)
- Cation-Anion Balance Sheet
- QC check sample records and acceptance criteria for the following:
    - Laboratory Control Sample(s)
    - Matrix Spike(s)
    - Matrix Spike Duplicate(s)
    - Analytical Duplicate(s)
    - Method Blank(s)
- Project narrative including a discussion of problems or unusual events (including, but not limited to, topics such as: receipt of samples in incorrect, broken, or leaky containers, with improperly or incompletely filled out COC forms; receipt and/or analysis of samples after the holding times have expired; summary of QC results exceeding acceptance criteria; etc.)

The above information is logged into the LIMS database at CCL.

The Public Health Chemist of the Consolidated Chemistry Laboratory will be responsible for reviewing, validating, and/or qualifying results on the data reports. Any deviations from sample preparation, analysis, and/or QA/QC procedures will be documented. Departure from QC acceptance limits will be highlighted. Once the data reports are finalized, the hard copy will be sent to the Project QA Manager at the Agency.

At the end of the sampling season, all data for both programs (Coastal and Salinas Valley) will be electronically transferred to the Agency. After data verification, the Agency Hydrologist/ Team Lead will upload the data to the Agency's Water Resources Agency Information Management System (WRAIMS) relational database.

1.9.4 Technical Reviews and Evaluations

Technical reviews and evaluations are limited to Field Activities and Laboratory Data Review Checklists.

1.9.4.1 Field Activities Review Checklist

Field personnel will be required to fill out a Field Activities Review Checklist as part of the double-check process upon returning from the field after each sampling event (see Appendix C).

1.9.4.2 Laboratory Data Review Checklist

Laboratory data reports from the CCL will be routed to the Project QA Manager at the Agency, who will do a preliminary assessment of the data. The data reports will then be given to the Agency

Hydrologist/ Team Lead who will be responsible for completing a Laboratory Data Review Checklist (see Appendix C).

1.9.5 Technical Memorandum

The Agency Project QA Manager is responsible for the preparation of the technical memorandum. The technical memorandum will be written in the "post sample collection" phase (see section 1.6.3). The technical memorandum will be submitted to USEPA for review by the EPA Region 9 Project Manager.

The technical memorandum will contain the following elements:

- Table of results for Chloride
- Table of results for Nitrate
- Table of results for Specific Conductance
- Map of Chloride contours for 500 mg/L values
- Map of Nitrates showing those sites which have values above and below the Drinking Water Standard Limit of 45 mg/L (nitrate as NO3)
- Map of Conductivity contours

2.0 DATA GENERATION AND ACQUISITION

2.1 SAMPLING DESIGN

In the Salinas Valley, there are four hydrogeologic subareas: Pressure, East Side, Forebay, and Upper Valley. All four subareas were selected using a directed sampling design approach. These subareas were selected deliberately based on knowledge from previous monitoring work to contain analytes of interest, specifically nitrate and conductivity in the Salinas Valley Program, and chloride and conductivity in the Coastal Program. Actual sampling sites/wells within the Salinas Valley Basin Monitoring Program were chosen using a non-deliberate sampling approach. The wells included are acquired opportunistically. Site accessibility is a key issue for sampling. Permission of property owners must be secured before accessing private wells.

There are just over 1700 active wells in the Salinas Valley. Of this total number of wells, 344 wells make up the Salinas Valley Ground Water program and 85 wells make up the Coastal Ground Water program. The wells that make up these two programs have all been sampled in the past; some have data sets as far back as the 1950's, when this was a State of CA Department of Public Works (now the Department of Water Resources) program. The Agency wants to keep as complete and continuous a data set for each of these wells as possible.

Due to the time constraints the Agency is facing during this shortened 2007 field season, June - September, staff will prioritize which wells within the Salinas Valley portion of this project will be sampled. Wells to be sampled first will be located within approximately one mile radius of municipalities and industries (such as vegetable packing plants). We refer to these areas as high beneficial use areas. Ground water wells will be identified by State Well Numbers (Township, Range, Section, and Subsection).

All wells are high production agricultural wells. All wells are sampled in the same way, if the pump is in operation then a sample will be collected. If the pump if not operating then the field sampler will note it on the field sheets and come back to the well at a later date when the well is in operation. The pump must be operating for a sample to be collected. The age of well does not alter sampling protocols. If a well is found to have been abandoned since the Agency last sampled the well, a notation will be made on the field sheets and the well will be removed from future sampling efforts.

2.1.1 Salinas Valley Ground Water

While it is known that high levels of nitrates exist in some aquifers of the Salinas Valley Ground Water Basin, a significant sampling effort to determine the extent in the ground water has not been conducted by the Agency for several years. There are a total of 344 sample locations within the Salinas Valley monitoring program. Sample locations are operational ground water wells, the majority of which are used for agricultural irrigation. The Pressure subarea has 158 wells, the East Side subarea has 66 wells, the Forebay has 84 wells, and the Upper Valley has 35 wells (Figures 4-7). Each of these wells will be sampled once during the 2007 summer field season (July-September). The primary criterion currently used to determine if a well will be included in the Salinas Valley monitoring program has been its status as previously sampled. This program is an ongoing ambient ground water monitoring program and continuity in sampling the same wells each field year is of prime importance, especially for water quality trend analysis. Other factors that are important in deciding if a well should be included in the monitoring program are; copy of the well completion report (commonly referred to as the driller's log), location of the perforation interval along the well casing to determine which aquifer is sampled, age of the well, and construction method used to drill the well. Additionally it is useful to know the proximity of the well to other water use (industrial, municipal, or domestic) areas. A list of Salinas Valley well names and locations are given in Table 4. All wells on this program are planned to be part of the monitoring design for subsequent years. Until these monitoring wells are abandoned or destroyed, they will remain part of this program.

2.1.2 Coastal Ground Water

The Agency currently conducts a seawater intrusion monitoring and mapping program (EPA II). This program will continue to evaluate the extent and status of seawater intrusion in the coastal areas of the Salinas Valley Basin (EPA II). The Coastal portion of the ground water program contains 85 wells, most of which are located in the Pressure subarea (Figure 8). Each well will be sampled three times, once each month of the summer 2007 field season (July-September). The first sample collection at each well will be analyzed for a complete mineral panel (Table 1), and following two collections will be analyzed for a partial mineral panel (Table 1). There are 21 wells located in the Pressure 180-Foot Aquifer, 52 wells within the Pressure 400-Foot Aquifer, two wells with perforations within both the Pressure180-Foot and 400-Foot Aquifers, four wells are located within the Pressure Deep Zone Aquifer, three in the East Side Deep Aquifer, one in the East Side Shallow Aquifer, and one in the Prunedale Aquifer. The principal criterion for inclusion in the Coastal monitoring program is historical sampling and well availability. Additional criteria for selecting a well for inclusion into the Coastal monitoring program are: a well completion report, location of the perforation interval along the well casing to determine which aquifer is sampled (180, 400, or deep zone AQ), well age, and well construction type. A list of Coastal sites and their representative aquifers are listed in Table 5.

It can not be stressed enough how important the continued monitoring of these ground water wells are for the Agency to meet its mission of monitoring the quality of the County's ground water resources. Some of these well have been sampled since the 1950's and the loss of such a long term water quality record within the County of Monterey would irreplaceable.

2.2 SAMPLING METHODS

The objectives of the sampling procedure are to minimize changes in ground water chemistry during sample collection and transport to the laboratory, and to maximize the probability of obtaining a representative, reproducible ground water sample. This well-volume purging procedure provides a reproducible sampling technique with the goal that the samples obtained will represent water quality over the entire screen interval of the well.

Standing water in the well casing can be of a different chemical composition than that contained in the aquifer to be sampled. Solutes may be adsorbed on to, or desorbed from the well casing material, oxidation may occur, and biological activity is possible. Therefore, the stagnant water within the well must be purged so that the sample is representative of the aquifer. As a result, a well may be sampled only after the pump has been in operation for at least 15-20 minutes.

All the wells included in this project, from both the Salinas Valley area and the Coastal monitoring area are high production agricultural wells that contain deep turbine pumps operating at 500-1200 gallons per minute (gpm). Over the years of managing the ambient monitoring program, the Agency has determined that operating a deep turbine pump for 15-20 minutes before taking a sample is sufficient time to clear the entire well casing of three well volumes for ensuring a representative well sample. For referencing well casing volume, the Agency uses the well casing size provided in the well completion reports (driller's log) for each of the wells included in this monitoring program (National Field Manual for the Collection of Water-Quality Data, Chapter A2).

Sample bottles and caps are rinsed three times with ambient ground water prior to collection. The sample container is then filled, tightly capped, and labeled. No field sample filtration is required. Samples are put into a cooler with ice immediately and maintained at 4°C and delivered to the laboratory daily. See Table 6 for sample collection requirements. Extra sample containers, caps and field supplies will be carried in the truck as back-up should any problem arise in the field. Additionally, the Field Sampler will carry and maintain an updated hardcopy of the QAPP in the field to be used as a reference.

The following precautions will be followed in order to limit sampling error at the wellhead:

- Operate the pump long enough to produce water that is representative of the aquifer and not stagnant water from the casing.
- Take samples at the wellhead or near the wellhead and away from fertilizer injection ports.

Sample collection will follow protocols in accordance with recommended guidelines established by the U. S. Geological Survey (USGS) for ground water collection as described in the National Field Manual for the Collection of Water-Quality Data.

The National Field Manual for the Collection of Water-Quality Data, U.S. Geological Survey, Techniques of Water-Resources Investigations, Book 9, Chapters A1-A9 is maintained as a web-based document and is located at http://pubs.water.usgs.gov/twri9A. Updates and revisions for the National Field Manual can be found using this web-based approach.

2.3 SAMPLE HANDLING AND CUSTODY

This section describes how all samples will be treated after collection, during transport, and upon arrival at the CCL. It also includes information on proper sample disposal after laboratory analysis.

2.3.1 Sample Containers and Preservatives

Sample containers to be used in this project are high density polyethylene (HDPE), one pint (~0.5 L) and 0.5 gallon (~2 liter) sizes, for partial mineral or complete mineral analyses, respectively. The Agency has used these same sample container types during previous years of this ongoing ambient monitoring program and has never had any problems with container contamination issues. Field blanks will be closely monitored and, should a problem arise, corrective actions will be taken. Only one container (pint *or* half gallon) is needed per sampling site to provide the necessary volume to run the required lab analyses (see Table 6). Sample containers and caps are purchased in bulk from a plastic container manufacturer (Consolidated Container Company). The caps for the containers are packaged separately. The containers and caps are clean upon receipt, as long as they arrive with the outer cardboard packaging intact. The containers will be kept in a closed, dry environment away from the outside elements. Sterility is not of importance because this sampling project does not include microbiological testing. As previously mentioned, all containers and caps will be rinsed three times with ambient sample water prior to sample collection.

Sample containers are labeled with pre-printed labels, which lists which panel of analytes is requested, either complete mineral or partial mineral. The collection date, collection time, and sampler name are recorded in the field with an indelible marker. After being filled out, labels will be covered with clear plastic tape (packaging type) to protect the labels from destruction during transport.

No chemical *field preservation* of the samples is required. All samples will be kept at 4±2°C.

Preservation of samples, if required prior to analysis, will be the responsibility of the contract lab (CCL). Part of the CC lab sample receiving protocols includes lab personnel verifying, at the time of sample receipt, if any samples require lab preservation. Refer to Table 6 for listings of preservatives for specific analytes.

2.3.2 Sample Packaging and Transport

All samples will be handled, prepared, transported and stored in a manner so as to minimize contamination and spills. After collection, sample caps will be checked for tightness, and the samples will be put in ice chests immediately. During travel between sites, ice chest lids will be kept tightly closed in order to keep the samples at the correct temperature and protect them from sunlight. Ice used for maintaining sample temperature will be double-bagged inside durable plastic bags (Ziploc type) and be of sufficient quantity so that all samples will stored at 4±2°C. Maximum holding times for specific analytes are listed in Table 6.

2.3.3 Sample Custody

Chain of custody (COC) procedures require that possession of samples be traceable from the time the samples are collected until completion and submittal of the analytical results. A completed chain of custody form is to accompany the samples to the contract laboratory (CCL). Requirements for COC paperwork can be found in Section 1.9.2.2 of this document.

All samples collected for this project will be transported from the field to the CCL via an Agency vehicle. The field sampler will deliver the samples directly to the CCL daily; there will be no intermediary transfers. Samples need to arrive at the CCL no later than 15:00, to ensure log-in and laboratory preservation. Personnel at the CCL will examine the samples for correct documentation and holding times. The CCL will follow sample custody procedures as outlined in their QA plan (see Appendix D).

2.3.4 Sample Disposal

All samples remaining after successful completion of analyses will be disposed of properly. It is the responsibility of the personnel at the CCL to ensure that all applicable regulations are followed in the disposal of samples or related chemicals. Sample disposal procedures used by the CCL are discussed in their QA plan (see Appendix D).

2.4 ANALYTICAL METHODS

All samples will be analyzed at the County Consolidated Chemistry Laboratory (CCL). Analyses will be performed following either EPA approved methods or methods from *Standard Method for the Examination of Water and Wastewater, 18th Edition,* see Table 1 (CCL's QA Manual cites *18th Edition,* see Appendix D). Standard operating procedures (SOPs) from CCL have been included in Appendix D for each of the analyses. Should there be any deviation from these SOPs the Laboratory Director must contact the Project QA Manager.

The CCL will submit a data report and associated QC results after analyses are complete to the Project QA Manager. This data report is described in Section 1.9.3. After a preliminary assessment the Project QA Manager will pass the data on to the Team Lead, who will review the data report and QC results and evaluate its quality and usability in addressing the Project objectives.

2.5 QUALITY CONTROL

2.5.1 Field Sampling Quality Control

The assessment of field measurements will be determined from the collection and analysis of field blanks and field duplicates. For this monitoring program the field blanks will be collected at one every 20 samples or a frequency of 5%. Field duplicates will be collected at a frequency of 10% for the first two sampling events. If the criterion of <25% RPD is met, then the remaining field duplicates will be collected at a 5% frequency. Analytical acceptance criteria and corrective actions for field QC are listed in Table 2.

Deionized (DI) water will be acquired from the CCL and kept at 4±2°C, while transported into the field. Field blank samples will be obtained by pouring DI water into a pint (~500 mL) HDPE sample container that has been triple-rinsed with DI water at the sampling location. The container will be tightly capped, placed in the cooler and delivered to the contract laboratory. Field blanks are labeled with the sampling location (State Well Number) followed by "-1".

Field blanks will be used to evaluate the collection process (from field sampling through sample analysis) for contamination from exposure to ambient conditions, from sample containers or from improper sampling and handling technique. If target analytes are found in field blanks, sampling and handling procedures will be reevaluated and corrective actions taken. Corrective actions may consist of, but are not limited to, re-training of field personnel, discussions with the contract laboratory, invalidation or qualifying of results.

Field duplicates will be collected for every analytical parameter. The duplicate sample will be collected immediately after collection of the native, following the same sampling protocols. Field duplicates are labeled with the sampling location (State Well Number) followed by "-2".

Field duplicates will be used to evaluate the precision of the sample collection through analysis. The combined variability from sampling and analysis technique, in addition to sample heterogeneity, will be assessed using field duplicates. If acceptance criteria are exceeded, field sampling and handling protocols will be reviewed and problems corrected. These may consist of, but are not limited to, additional training, revised sampling techniques and reevaluation of sampling location.

2.5.2 Laboratory Analyses Quality Control (Contract Laboratory)

The Monterey County Consolidated Chemistry Laboratory's (CCL) personnel are responsible for analytical Quality Control. Standard laboratory quality control elements include method blanks, laboratory control samples, analytical duplicates, matrix spikes and calibration procedures. Laboratory data quality objectives include QC acceptance criteria, frequency of analysis, and corrective actions. These data quality objectives and quality control elements for CCL are described in its QA Manual (Appendix D) and SOPs (Appendix D) and are listed in Table 3. After examination of these documents, the Agency believes that the laboratory will be able to meet the project data quality needs. Any deviation from these written procedures must be documented by the laboratory and reported to the Project QA Manager.

2.6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION, AND MAINTENANCE REQUIREMENTS

Testing, inspection, and maintenance of laboratory equipment are the responsibility of the Monterey County Consolidated Chemistry Laboratory and are detailed in its QA manual in Appendix D.

2.7 INSTRUMENT CALIBRATION AND FREQUENCY

Instrument calibrations are the responsibility of the Monterey County Consolidated Chemistry Laboratory and acceptance criteria for calibrations are detailed in its QA manual in Appendix D.

2.8 INSPECTION/ACCEPTANCE REQUIREMENTS FOR SUPPLIES

2.8.1 Initial Inspection of Supplies

As mentioned previously in Section 2.3.1, sample containers are purchased in bulk from an outside vendor who specializes in supplying plastics to the beverage industry. An initial inspection will be conducted upon receipt of each shipment. Each shipment will be considered acceptable for use if *all* of the following are true:

- The shipment arrives with the outer cardboard packaging intact.
- The containers are the correct type (HDPE) and size (0.5 gal/~2L *or* 1 pint/~0.5L).
- The insides of the containers are dry.
- The insides of the containers are free of dirt or any particulate matter.

2.8.2 Field Inspection of Supplies

Immediately prior to sample collection, field samplers will visually inspect each sample container for the following:

- Dirt or any particulate matter
- Cracks of any size
- Improper fit of the cap on the container

If the field sampler observes any of the above, then the container will be discarded and an acceptable container will be used instead.

2.8.3 Laboratory Inspection of Supplies

CCL will be responsible for establishing inspection and acceptance criteria for supplies that adhere to their internal QA/QC policies.

2.9 DATA ACQUISITION REQUIREMENTS (NON-DIRECT MEASUREMENTS)

Non-direct measurement data will not be used during this monitoring program. Should at some time in the future the Agency decide to use data from an external source, QA/QC requirements will be established. Should this occur, an addendum to this QAPP will be submitted to USEPA.

2.10 DATA MANAGEMENT

Data, as related to documentation and records, will be managed as outlined earlier in Section 1.9 of this QAPP.

In addition, the CCL will group QA/QC data under a separate client code so that QA/QC data can be filtered from regular sample data before being uploaded into the Agency's Data Management System (WRAIMS). This allows the Agency a greater flexibility both in quickly and easily accessing the data that included QA/QC samples for initial review, and increased flexibility in uploading and moving large data sets.

3.0 ASSESSMENT AND RESPONSE ACTIONS

This section lists review procedures that will be taken to ensure all the protocols outlined in the QAPP are consistently followed.

3.1 REVIEWS

3.1.1 Readiness Reviews

Water Resources Technicians/ Field Samplers will be trained by the Hydrologist/Team Lead before any field sampling begins. Training will cover proper sample collection and handling and the completion of all paperwork (COCs, field logbooks, etc). The Team Lead will ensure that Field Samplers have properly prepared all collection containers, paperwork and other supplies needed to complete a successful sampling event. Any problems discovered during the readiness review will be corrected before the Samplers begin work.

3.1.2 Field Reviews

The Team Lead will be responsible for overseeing that all field activities are incompliance with Agency protocols. The Team Lead will be available via phone should any questions arise while the Samplers are in the field. The Team Lead will also review all field paperwork such as COCs and field logbooks for completion. Additionally the field QC samples (field blanks and duplicates) will be used to evaluate the individual Sampler's technique. If problems are exposed they will be corrected straight away so that all further samples are valid. A stop-work order may be issued by the Project QA Manager at any time if a discrepancy or error is found that could negatively affect the data being collected.

3.1.3 Post Sampling Reviews

Post sampling reviews will be conducted following each sampling event in order to ensure all information is complete. Reviews will be conducted by the Field Sampler due to the small size of the staff. They will include evaluation of sampling activities and field documentation and will take place in the office, not in the field. Findings will be passed on to the Team Lead and the Project QA Manager to be incorporated into the next field event.

3.1.4 Laboratory Data Reviews

The Team Lead will be responsible for reviewing the laboratory's data for completeness and accuracy. The data will also be checked to determine that all specified methods were used and all related QC data was provided with the sample analytical results. These reviews will take place immediately upon receipt of data reports from the laboratory. This will ensure that any method deviations are corrected or explained, and any missing or incomplete data are provided. The Project QA Manager has the authority to request re-testing of laboratory data if it is invalid or would otherwise compromise the quality of the resulting project conclusions.

3.2 REPORTS

The Project QA Manager will be responsible for the technical memorandum (EPA R9# 03-238 Task 3.3) which will be provided in March 2008 to US EPA. The technical memorandum (EPA R9# 03-238 Task 3.3) will include result tables for chloride, nitrate, and specific conductivity, and maps of chloride, nitrate, and specific conductivity gradients. The technical memorandum will include a summary of any significant QA/QC issues and how they were resolved. It is currently understood that this project is of short enough duration that only a final technical memorandum to the EPA is necessary.

4.0 DATA VALIDATION AND USABILITY

4.1 DATA VERIFICATION AND VALIDATION

Data review is the in-house examination to ensure that the data have been recorded, transmitted, and processed correctly. The Team Lead is responsible for the data review. This examination will check for data entry errors, calculation errors, and data omission errors. If possible these errors will be corrected.

4.1.1 Field Data

Field data include logbooks, photographs, and COCs. The Field Sampler is responsible for reviewing the field data at the end of the sampling event. This includes determining that all information is complete and any deviations from the sampling methodologies are documented using the Field Activities Review Checklist (Appendix C).

4.1.2 Laboratory Data

Initial evaluation of the laboratory data are carried out by the CCL in agreement with protocols listed in their SOPs and QA manual. The Team Lead will also conduct an independent review of the data and QC parameters as described in sections 3.1.4 and using the Laboratory Data Review Checklist as detailed in section 1.9.4.4 and Appendix C.

4.2 RECONCILIATION WITH USER REQUIREMENTS

The purpose of the continued ambient monitoring of the Salinas Valley Basin Ground Water is to assess the water quality to manage and protect ground water resources. For data to be useful in developing the overreaching Salinas Valley Integrated Water Management Plan, it must first meet the requirement of this QA project Plan. The Project QA Manager will be responsible for making the final evaluation of the data's usability in meeting the Project objectives. All data passing this final evaluation will then be used to establish a cohesive and succinct Water Quality Management Plan in accordance to the work begun under EPA-I and continued under EPA-II. Additionally, the Agency will integrate these ground water quality data with previously collected data for use in trend analysis.

5.0 REFERENCES

Department of Public Works, Division of Water Resources (DWR). 1946. *Bulletin 52: Salinas Basin Investigation.*

Durbin, TJ, GW Kapple, JR Freckleton. 1978. *Two-Dimensional and Three-Dimensional Digital Flow Models of the Salinas Valley Ground-Water Basin, California.* US Geological Survey. Water Resources Investigations Report 78-113. Prepared in cooperation with the US Army Corps of Engineers.

Geomatrix Consultants. 2001. *Evaluation of the Salinas Valley Groundwater Monitoring Network and Proposed Redesign.* Prepared for The Monterey County Water Resources Agency.

Greene, HG. 1970. *Geology of Southern Monterey Bay and its Relationship to the Ground-Water Basin and Seawater Intrusion.* US Geological Survey Open File Report.

Hunt, JW, BS Anderson, BM Phillips, PA Nicely, RS Tjeerdema, HM Puckett, M Stephenson, K Worcester, V deVlaming. 2003. *Ambient toxicity due to chlorpyrifos and diazinon in a Central California Watershed.* Environ. Monit. Assess. 82: 83-112.

Monterey County Agricultural Commissioner's Office (Ag Commission). 2006. *Monterey County Crop Report.*

Monterey County. 2007. *Fact Finder.* Prepared by Monterey County Administrative Office.

Monterey County Water Resources Agency (MCWRA). 1997. *Water Resources Data Report, Water Year 1994-1995.*

Quality Assurance Project Plan for Monitoring of Surface Water Eagle Valley Reservation. 2005. Prepared by Eagle Valley Environmental Program Eagle Valley Band of Indians Eagle Valley Reservation. Prepared for US EPA Region 9.

Salinas Valley Ground Water Basin Hydrology Conference (White Paper). 1995. *Hydrogeology and Water Supply of Salinas Valley.* Prepared for The Monterey County Water Resources Agency.

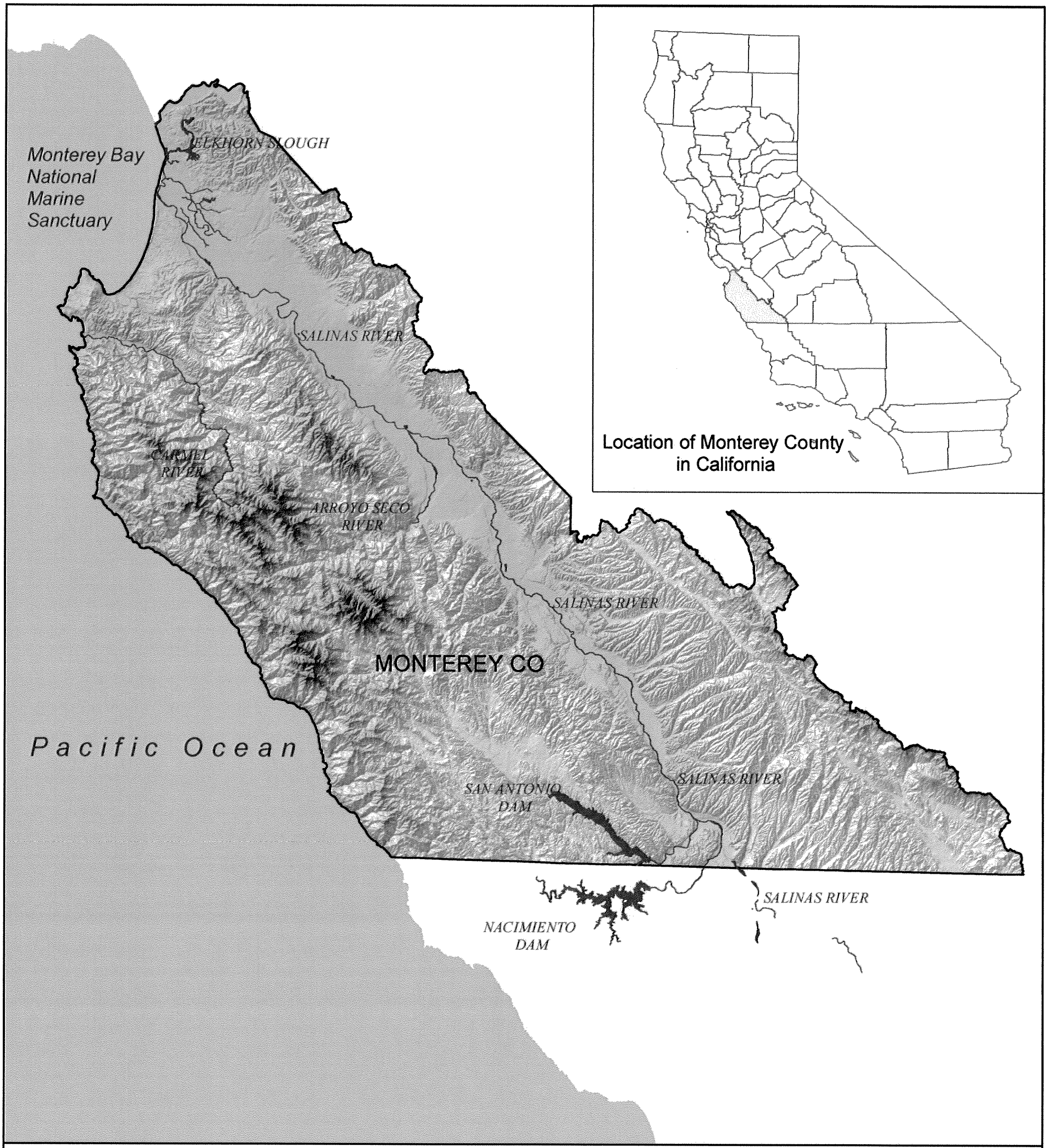
State of California, Department of Water Resources (DWR). 2003. *Bulletin 118 Update: California's Groundwater.*

Sycamore Creek Quality Assurance Management Plan. 2006. Prepared by Instant Reference Sources, Inc. Prepared for California State Water Resources Control Board.

US EPA. 2002. *Guidance for Quality Assurance Project Plans.*

US EPA Grant R9# 03-238. 2003. *Salinas Valley Integrated Water Management Plan.* Prepared by The Monterey County Water Resources Agency. Prepared for US EPA Region 9. Grants Management Office.

FIGURES



Legend

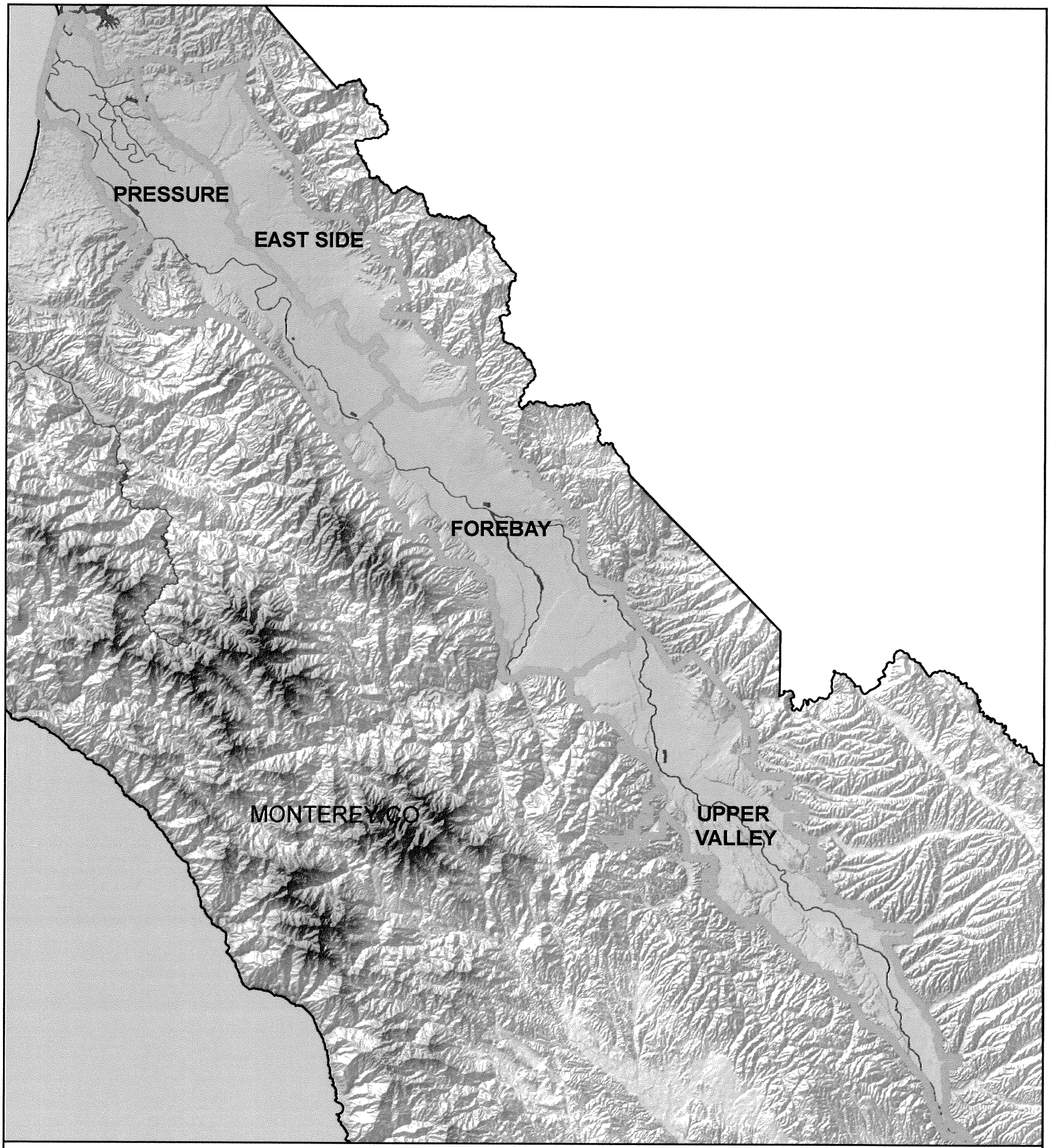
■ Water Bodies/ Channels

Monterey County, California

Figure 1

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Legend

▨ Water Bodies/ Channels

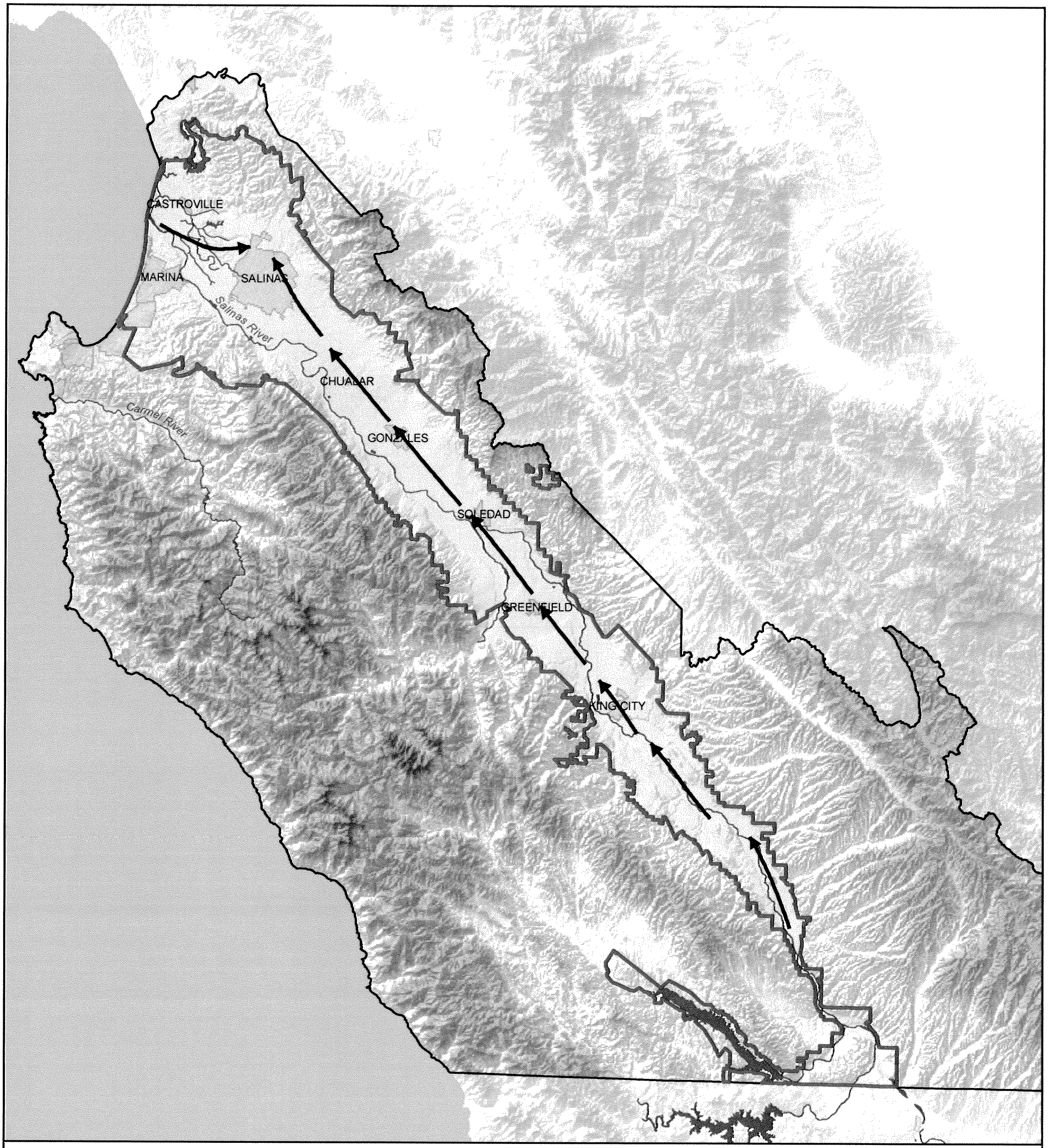
Salinas Valley Aquifers

Figure 2

0 2 4 6 8 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Ground Water Flow Direction in the Salinas Valley

Figure 3

Legend

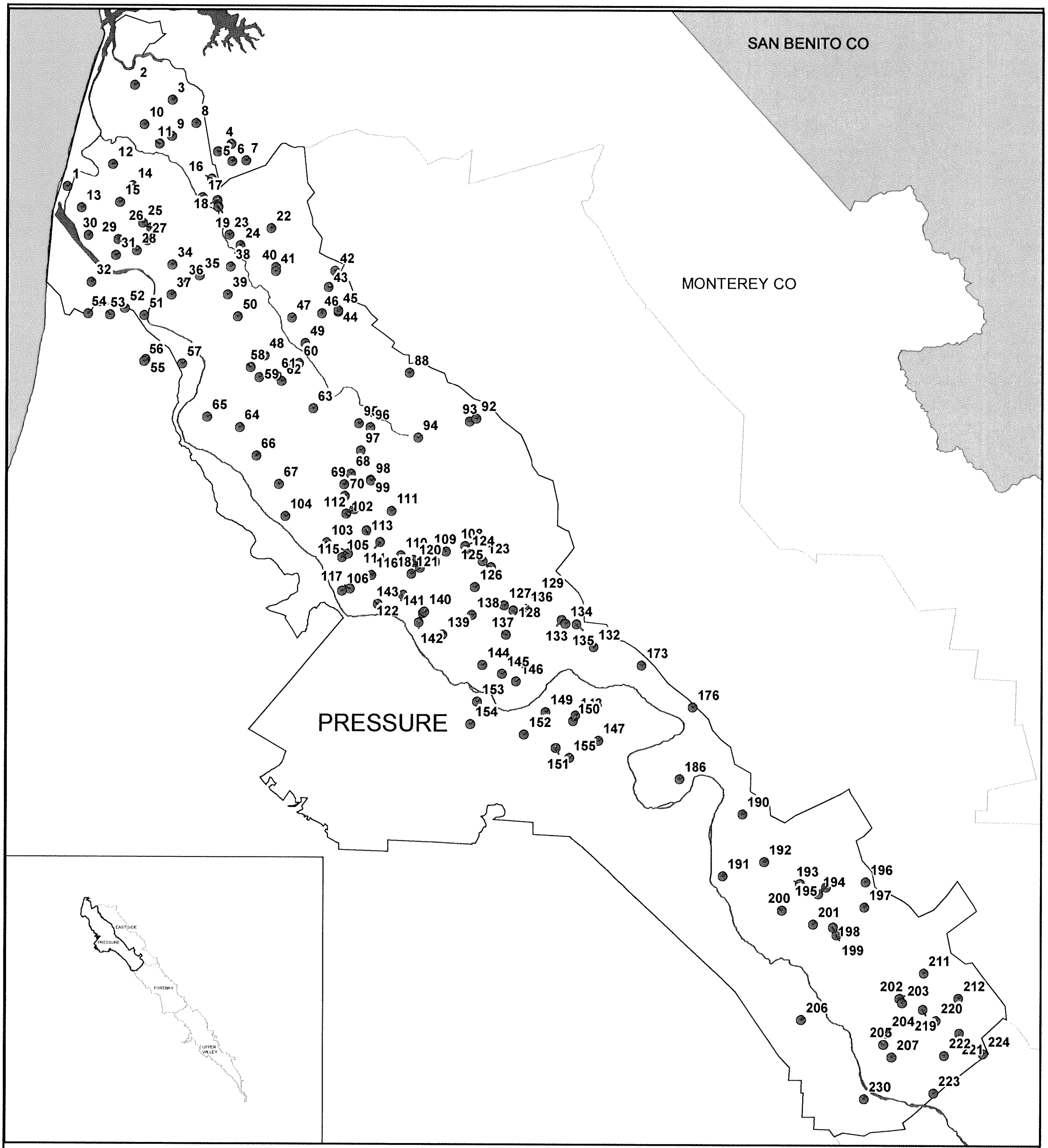
- ➔ Ground Water Flow Direction
- ☐ Assessment Zone 2C
- ☐ Monterey County
- ▨ Rivers and Other Bodies of Water

0 10 20 Miles

Monterey County Water Resources Agency 1947

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 6, 2007



Salinas Valley Wells in the Pressure Subarea

Figure 4

Legend:

● Study Well

▬ Rivers

SUBAREA

☐ SUBAREA

☐ PRESSURE

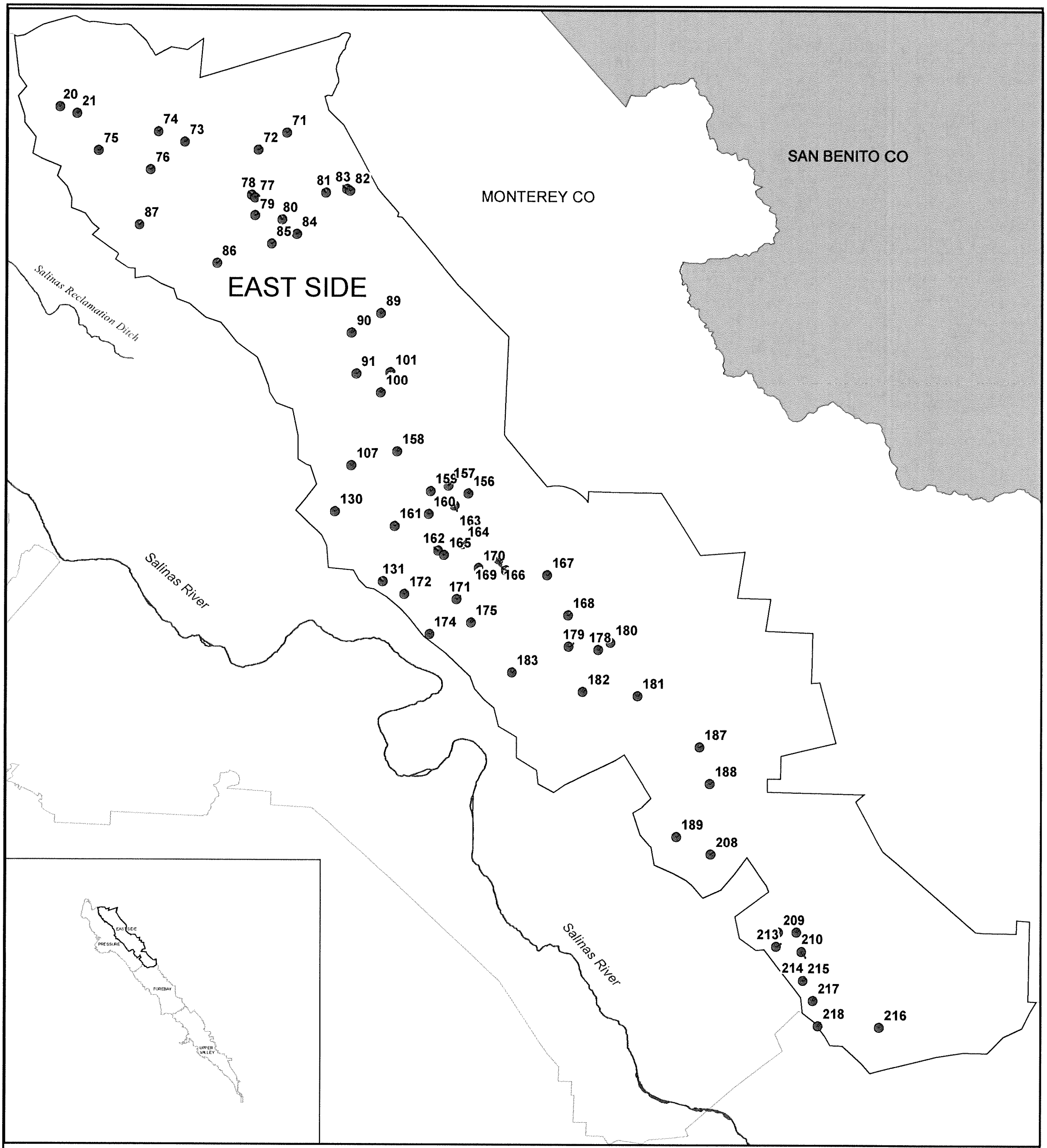
N
W E
S

0 0.75 1.5 2.25 3 Miles

MONTEREY COUNTY WATER RESOURCES AGENCY
1947

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Salinas Valley Wells in the East Side Subarea

Figure 5

Legend:
● Study Well
▬ Rivers
SUBAREA
☐ SUBAREA
☐ EAST SIDE

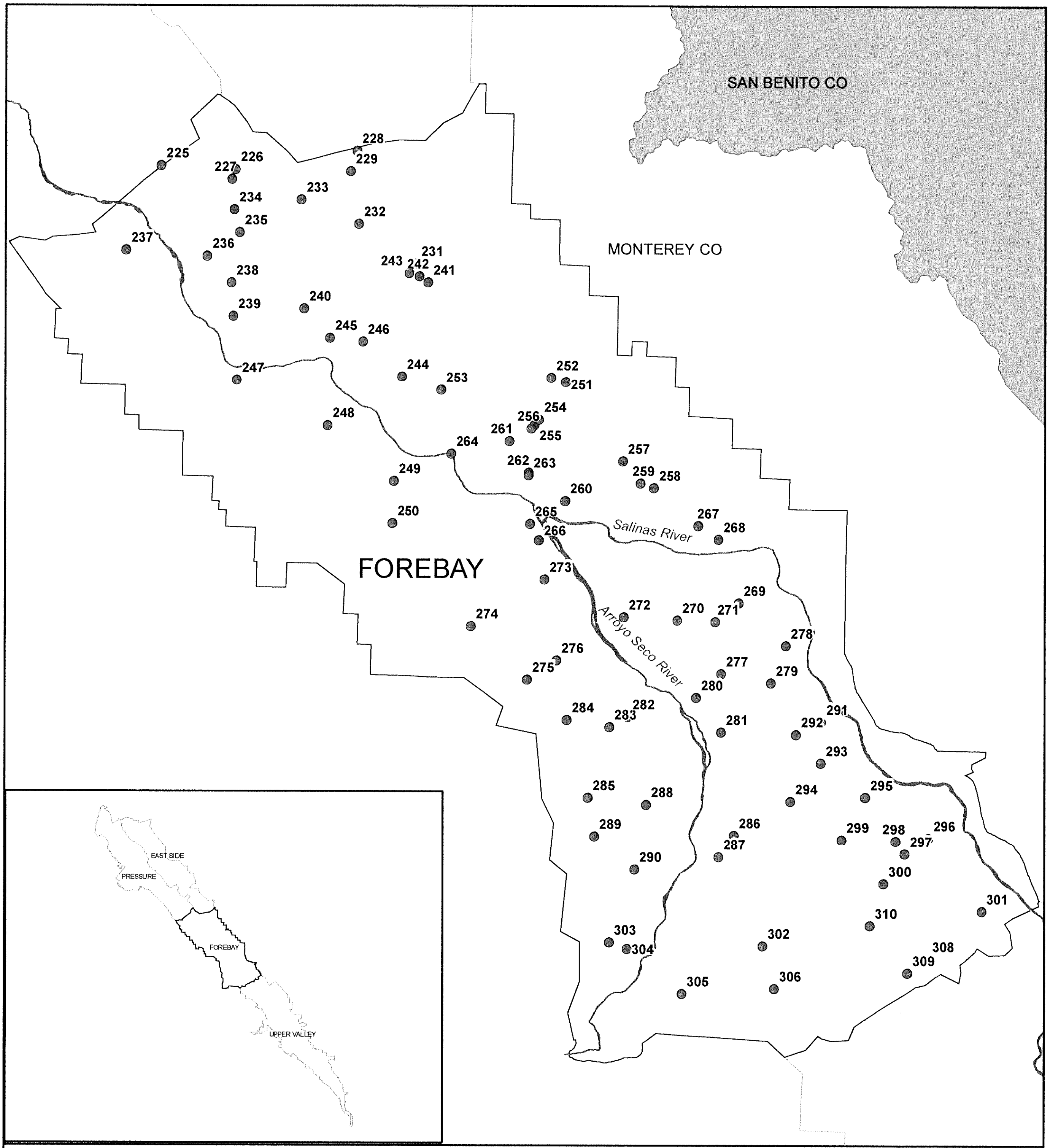
N
W E
S

0 0.75 1.5 2.25 3
Miles

MONTEREY COUNTY WATER RESOURCES AGENCY 1947

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Salinas Valley Wells in the Forebay Subarea

Figure 6

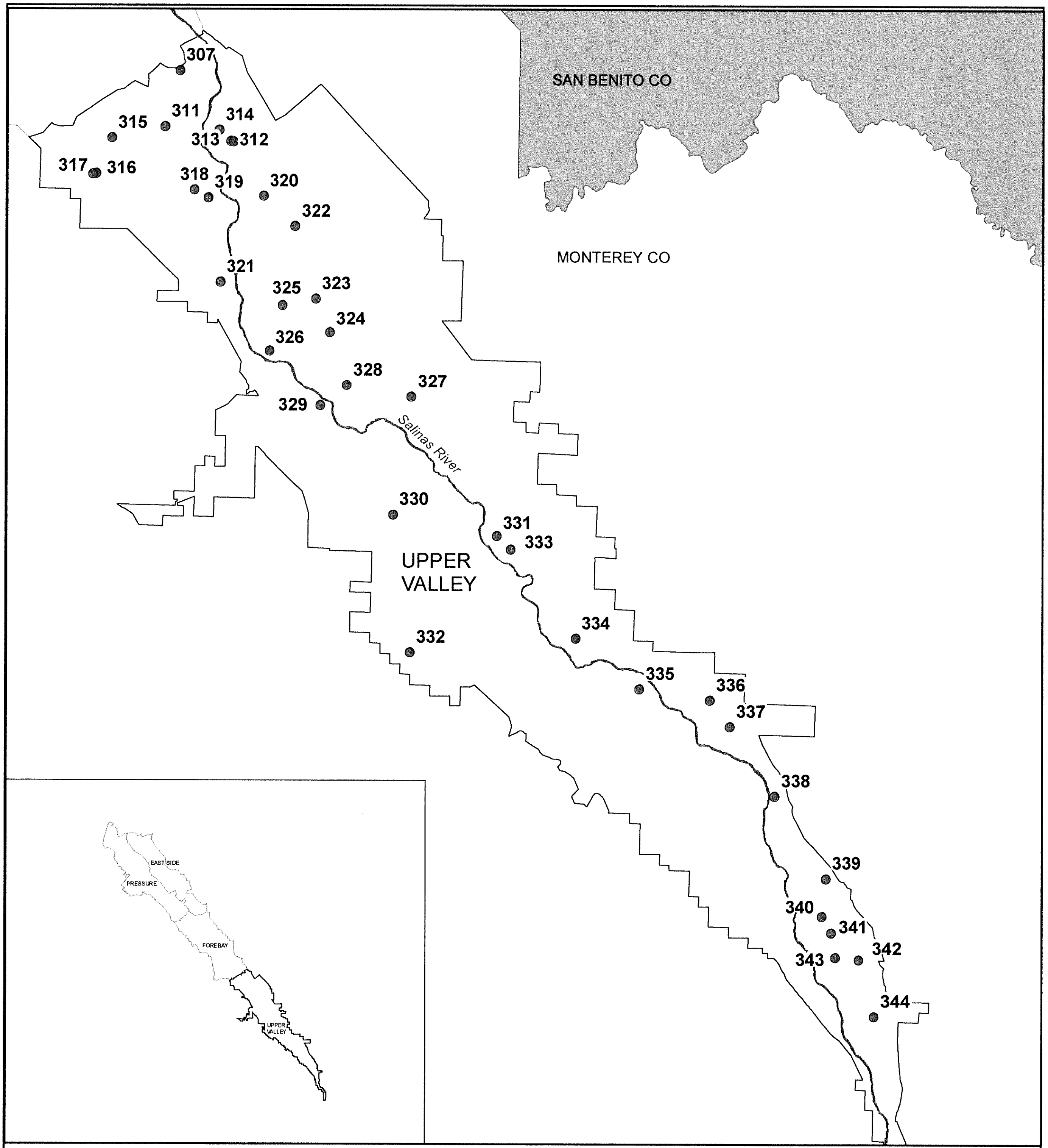
Legend:
● Study Well
▨ Rivers
SUBAREA
☐ SUBAREA
☐ FOREBAY

N
W E
S

0 0.75 1.5 2.25 3
Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Salinas Valley Wells in the Upper Valley Subarea

Figure 7

Legend:

● Study Well

▬ Rivers

SUBAREA

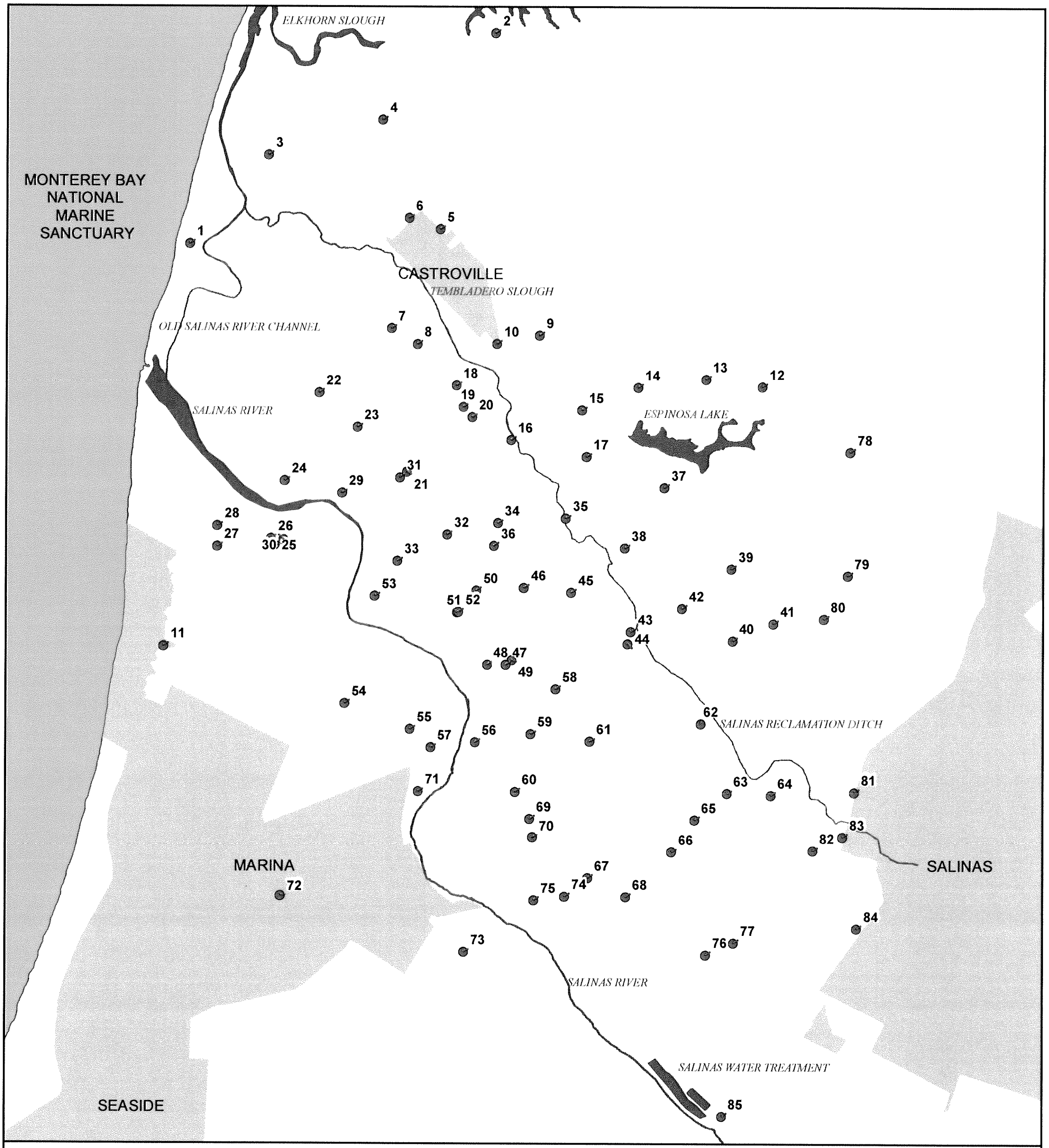
☐ SUBAREA

☐ UPPER VALLEY

0 0.75 1.5 2.25 3 Miles

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 5, 2007



Coastal Ground Water Monitoring Program Wells

Figure 8

Legend:

- ● Study Well
- ▨ Cities
- ■ Water Bodies/ Channels

Note: The scale and configuration of all information shown hereon are approximate and are not intended as a guide for survey or design work.

Map Date: July 02, 2007

TABLES

Table 1 COMPLETE MINERAL PANEL ANALYTES

ANALYTE	*METHOD*	*LABORATORY MDL***	*LABORATORY PQL*	*LOWEST CALIB. STD.*	*PAL*
Calcium (Ca)	SM 3111 B[1]	0.02 mg/L	1.0 mg/L	1.0 mg/L	1.0 mg/L
CATION ANION BALANCE	Calculated	--	--	--	--
*Chloride (Cl)	EPA 300.0[2]	0.01 mg/L	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Conductivity (SEC)	SM 2510 B	1 umho/cm @ 25 C	1 umho/cm @ 25 C	N/A	1 umho/cm @ 25 C
Magnesium (Mg)	SM 3111 B	0.005 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
*Nitrate (NO3)	EPA 300.0	0.002 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
pH (Laboratory)	SM 4500-H B	pH Units (2 sig figs)	pH Units (2 sig figs)	N/A	pH Units (2 sig figs)
Potassium (K)	SM 3111 B	0.025 mg/L[1]	0.1 mg/L	0.1 mg/L	0.1 mg/L
Sodium (Na)	SM 3111 B	0.03 mg/L[1]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Sulfate (SO4)	EPA 300.0	0.03 mg/L[2]	1.0 mg/L	0.1 mg/L	1.0 mg/L
Total Alkalinity (as CaCO3)	SM 2320 B	1.0 mg/L	1.0 mg/L	N/A	1.0 mg/L

[1] = MDL study completed February 2007

[2] = MDL study completed May 2007

* = Partial Mineral Panel analytes

** = These are the laboratory's latest MDLs and supersede the MDLs listed in Appendix D-1.

MDL = method detection limit; PQL = practical quantitative limit; PAL = project action level

All laboratory results are bracketed by calibration standards. No "estimated" results (below the lowest calib std and above the MDL) are given to the Agency.

Table 2 QUALITY CONTROL REQUIREMENTS FOR LABORATORY ANALYSES

QA PROCEDURE	QA PARAMETER	FREQUENCY	CRITERION	CORRECTIVE ACTION
Field Blank	Field Contamination	1/20 field samples; 5% frequency	<MDL	Recollect sampling event or flag data if unable recollect
Field Duplicate	Field Precision	1/10 field samples for first two events; if criterion is met, then 1/20 field samples	RPD < 25%	Recollect sampling event or flag data if unable recollect
Method Blank	Analytical Contamination	3 per analytical batch	< RL	Reanalyze analytical batch
LCS (CRM)	Accuracy	1 per analytical batch	80-120% REC	Reanalyze analytical batch
Analytical Duplicate	Analytical Precision	1 per analytical batch	RPD < 25%	Reanalyze analytical batch
Matrix Spike	Matrix Interference and Accuracy	1 per analytical batch; at 3-10x the native conc.	75-125% REC	Reanalyze analytical batch
Matrix Spike Duplicate	Precision and Accuracy	1 per analytical batch; at 3-10x the native conc.	RPD <25%	Reanalyze analytical batch
Continuing Calibration	Analytical Control	1 per 10 sample runs	80-120% of initial slope	Reanalyze analytical batch
Assess percent of data successfully collected	Data Completeness	N/A	90%	N/A

MDL=Method Detection Limit; RPD=Relative Percent Difference; RL=Report Limit;

REC=Recovery; LCS=Laboratory Control Sample; CRM=Certified Reference Material

An analytical batch is defined as 20 or fewer samples.

Table 3 LABORATORY DATA QUAILITY OBJECTIVES (DQOs)

ANALYTE	***METHOD BLANK***	***LCS (CRM)***	***ANALYTICAL DUPLICATE***	***MATRIX SPIKE***	***MATRIX SPIKE DUPLICATE***	***CONTINUING CALIBRATION***
Calcium (Ca)	yes	yes	yes	yes	yes	yes
Chloride (Cl)	yes	yes	yes	yes	yes	yes
Conductivity (SEC)	yes	yes	yes	no	no	yes
Magnesium (Mg)	yes	yes	yes	yes	yes	yes
Nitrate (NO3)	yes	yes	yes	yes	yes	yes
pH (Laboratory)	no	yes	yes	no	no	yes
Potassium (K)	yes	yes	yes	yes	yes	yes
Sodium (Na)	yes	yes	yes	yes	yes	yes
Sulfate (SO4)	yes	yes	yes	yes	yes	yes
Total Alkalinity (as CaCO3)	yes	yes	yes	no	no	yes

Table 4 SALINAS VALLEY WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-36J01	PRESSURE 900	1	5741483.0	2170847.00002
13S/02E-20M02	PRESSURE 400	2	5748878.5	2182094.25003
13S/02E-21N01	PRESSURE 400	3	5753018.5	2180456.75002
13S/02E-27L01	PRESSURE 180	4	5759500.0	2175572.50002
13S/02E-27M01	PRESSURE 400	5	5758010.0	2174784.50002
13S/02E-27P01	PRESSURE 400	6	5759593.5	2173660.50002
13S/02E-27Q02	PRESSURE 400	7	5761129.5	2173768.75002
13S/02E-28B01	PRESSURE 400	8	5755624.0	2177900.75002
13S/02E-28E01	PRESSURE 400	9	5752984.0	2176434.75002
13S/02E-29F02	PRESSURE 400	10	5749961.0	2177732.25002
13S/02E-29J01	PRESSURE 400	11	5751657.5	2175604.25002
13S/02E-31A02	PRESSURE 900	12	5746516.5	2173308.00002
13S/02E-31N02	PRESSURE 400	13	5743060.5	2168496.25002
13S/02E-32M02	PRESSURE 900	14	5748673.0	2170965.00002
13S/02E-32N01	PRESSURE 400	15	5747285.0	2169132.75003
13S/02E-33H03	PRESSURE 180	16	5757325.5	2171726.00002
13S/02E-33R01	PRESSURE 180	17	5756359.5	2169699.75003
13S/02E-34M02	PRESSURE 180	18	5757952.0	2169365.25003
13S/02E-34N01	PRESSURE 180	19	5758043.5	2168657.25003
13S/02E-36J01	EAST SIDE BOTH	20	5772057.0	2168257.00002
14S/02E-01A01	EAST SIDE	21	5773736.0	2167596.00002
14S/02E-02E02	PRESSURE 400	22	5763989.0	2166284.00003
14S/02E-03F02	PRESSURE 180	23	5759284.0	2165549.00003
14S/02E-03K02	PRESSURE 400	24	5760546.0	2164390.00002
14S/02E-05F04	PRESSURE 400	25	5749784.5	2166850.50002
14S/02E-05G03	PRESSURE 400	26	5750701.5	2166258.50002
14S/02E-05K01	PRESSURE 400	27	5750303.5	2164892.00002
14S/02E-05P02	PRESSURE 400	28	5749120.0	2163754.25002
14S/02E-06J03	PRESSURE 400	29	5747119.5	2164986.75002
14S/02E-06L01	PRESSURE 900	30	5743826.5	2165438.75002
14S/02E-06R02	PRESSURE 400	31	5746852.5	2163229.50003
14S/02E-07K01	PRESSURE 400	32	5744199.0	2160286.75002
14S/02E-08A01	PRESSURE 400	33	5751818.0	2162226.75002
14S/02E-09D03	PRESSURE 400	34	5753098.5	2162246.50002
14S/02E-09H03	PRESSURE 400	35	5756070.0	2161048.75002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-09L02	PRESSURE 400	36	5754291.5	2160250.25002
14S/02E-09N01	PRESSURE 400	37	5752950.5	2158867.00003
14S/02E-10C01	PRESSURE 400	38	5759437.0	2162015.75002
14S/02E-10P02	PRESSURE 400	39	5759125.0	2158942.75002
14S/02E-11C01	PRESSURE 180	40	5764471.5	2161959.50002
14S/02E-11D01	PRESSURE 180	41	5764508.5	2161568.25002
14S/02E-12B01	PRESSURE 400	42	5771184.5	2161614.00002
14S/02E-12L02	PRESSURE 400	43	5770434.5	2159815.50002
14S/02E-12Q01	PRESSURE 400	44	5771537.0	2157088.75002
14S/02E-13B02	PRESSURE 180	45	5771526.0	2157219.75003
14S/02E-13D01	PRESSURE 180	46	5769699.5	2156883.75002
14S/02E-14B01	PRESSURE 180	47	5766275.0	2156434.00002
14S/02E-14N03	PRESSURE 400	48	5763230.0	2152205.50003
14S/02E-14R01	PRESSURE 180	49	5767842.5	2153580.50002
14S/02E-15B01	PRESSURE 400	50	5760275.5	2156533.25002
14S/02E-17B02	PRESSURE 400	51	5749990.5	2156598.25002
14S/02E-17C01	PRESSURE 180	52	5747844.0	2157381.75003
14S/02E-18A01	PRESSURE 400	53	5746233.0	2156686.25002
14S/02E-18C01	PRESSURE 400	54	5743827.5	2156787.25002
14S/02E-20B01	PRESSURE 180	55	5750165.5	2151711.75003
14S/02E-20B02	PRESSURE 180	56	5750001.0	2151554.75003
14S/02E-21F02	PRESSURE 180	57	5754169.5	2151251.50002
14S/02E-22H01	PRESSURE 400	58	5761690.5	2150902.75002
14S/02E-22H02	PRESSURE 180	59	5762674.0	2149777.00002
14S/02E-23A01	PRESSURE 180	60	5767130.0	2151399.50002
14S/02E-23F01	PRESSURE 180	61	5764570.5	2149971.00002
14S/02E-23L03	PRESSURE 400	62	5765164.5	2149382.00002
14S/02E-25D03	PRESSURE 400	63	5768753.5	2146325.50002
14S/02E-27K01	PRESSURE 180	64	5760536.0	2144212.25002
14S/02E-28H02	PRESSURE 180	65	5756940.5	2145354.75002
14S/02E-34A03	PRESSURE 400	66	5762394.5	2141097.75002
14S/02E-35L02	PRESSURE 400	67	5764879.0	2137944.25002
14S/02E-36H01	PRESSURE 180	68	5773015.5	2139158.50003
14S/02E-36J02	PRESSURE 400	69	5772268.5	2137939.00002
14S/02E-36R02	PRESSURE 400	70	5772326.5	2136698.50002
14S/03E-02E03	EAST SIDE BOTH	71	5794727.5	2165742.50002
14S/03E-03K01	EAST SIDE BOTH	72	5791884.0	2164011.25002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/03E-04E01	EAST SIDE BOTH	73	5784479.5	2164809.75002
14S/03E-05B02	EAST SIDE BOTH	74	5781839.5	2165837.25002
14S/03E-06L01	EAST SIDE SHALLOW	75	5775895.0	2163924.50003
14S/03E-08C01	EAST SIDE BOTH	76	5781050.5	2162072.25002
14S/03E-10F02	EAST SIDE	77	5791569.0	2159330.50002
14S/03E-10F03	EAST SIDE BOTH	78	5791236.5	2159578.00002
14S/03E-10P01	EAST SIDE	79	5791544.0	2157558.25002
14S/03E-10R02	EAST SIDE BOTH	80	5794251.5	2157151.00002
14S/03E-11H01	EAST SIDE SHALLOW	81	5798504.0	2159823.00002
14S/03E-12E01	EAST SIDE SHALLOW	82	5800865.5	2160009.25003
14S/03E-12E02	EAST SIDE	83	5800608.5	2160173.25003
14S/03E-14D01	EAST SIDE SHALLOW	84	5795697.5	2155748.25003
14S/03E-15H03	EAST SIDE BOTH	85	5793222.5	2154777.00002
14S/03E-16K03	EAST SIDE	86	5787748.0	2152845.50003
14S/03E-17D01	EAST SIDE	87	5779979.0	2156594.00002
14S/03E-20D01	PRESSURE 400	88	5779540.0	2150357.75002
14S/03E-24H01	EAST SIDE SHALLOW	89	5803951.0	2147934.50002
14S/03E-24N01	EAST SIDE	90	5801060.0	2146002.50002
14S/03E-25L02	EAST SIDE BOTH	91	5801508.5	2141975.75002
14S/03E-28B02	PRESSURE 400	92	5786919.0	2145249.50002
14S/03E-28F02	PRESSURE 400	93	5786200.6	2144963.98574
14S/03E-29L04	PRESSURE 180	94	5780547.4	2143125.21920
14S/03E-30E01	PRESSURE 180	95	5773899.5	2144670.25003
14S/03E-30F02	PRESSURE 180	96	5775180.5	2144268.50002
14S/03E-30N01	PRESSURE 180	97	5774083.5	2141696.50002
14S/03E-31F01	PRESSURE 180	98	5775271.5	2138346.50003
14S/03E-31F02	PRESSURE 400	99	5775228.5	2138492.00002
14S/03E-36A01	EAST SIDE SHALLOW	100	5803921.0	2140085.50002
14S/04E-30N01	EAST SIDE BOTH	101	5804847.5	2142132.00001
15S/02E-01A03	PRESSURE 400	102	5772482.0	2134724.00002
15S/02E-01K01	PRESSURE 180	103	5770291.5	2131514.75002
15S/02E-02G01	PRESSURE 400	104	5765615.0	2134401.50002
15S/02E-12A01	PRESSURE 400	105	5772051.5	2129878.50002
15S/02E-12R01	PRESSURE 400	106	5772057.5	2126203.25003
15S/03E-01L01	EAST SIDE	107	5801038.5	2132896.75002
15S/03E-04K03	PRESSURE 400	108	5785732.5	2131172.00002
15S/03E-04N03	PRESSURE 400	109	5783621.0	2130577.75002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-05N01	PRESSURE 180	110	5778619.0	2130164.00003
15S/03E-06A03	PRESSURE 180	111	5777613.0	2135010.00002
15S/03E-06D02	PRESSURE 400	112	5773392.0	2135175.75002
15S/03E-06F02	PRESSURE 400	113	5774781.5	2132857.75002
15S/03E-06K01	PRESSURE 400	114	5776302.5	2131605.50002
15S/03E-07D02	PRESSURE 400	115	5772729.0	2130304.25002
15S/03E-07G01	PRESSURE 400	116	5775356.0	2127909.75002
15S/03E-07N01	PRESSURE 180	117	5772911.5	2126430.50002
15S/03E-08B04	PRESSURE 400	118	5780790.5	2128738.25002
15S/03E-08C06	PRESSURE 180	119	5780025.5	2129640.75003
15S/03E-08C07	PRESSURE 400	120	5780124.5	2129385.50002
15S/03E-08F07	PRESSURE 400	121	5779786.0	2128096.50002
15S/03E-08N03	PRESSURE 400	122	5778859.5	2125760.50002
15S/03E-09B01	PRESSURE 180	123	5787613.5	2129526.50003
15S/03E-09C01	PRESSURE 180	124	5785912.0	2130387.75002
15S/03E-09H02	PRESSURE 180	125	5788543.5	2128841.50003
15S/03E-09K04	PRESSURE 400	126	5786815.0	2126625.50003
15S/03E-10P01	PRESSURE 180	127	5789973.0	2124641.25002
15S/03E-10P03	PRESSURE 180	128	5790992.5	2124075.25002
15S/03E-10R02	PRESSURE 180	129	5793537.5	2125764.25002
15S/03E-12E02	EAST SIDE BOTH	130	5799472.0	2128349.25000
15S/03E-13J02	EAST SIDE	131	5804170.5	2121482.50002
15S/03E-13N01	PRESSURE 180	132	5799834.5	2120075.00003
15S/03E-14C01	PRESSURE 180	133	5796323.5	2123063.75002
15S/03E-14G01	PRESSURE 180	134	5796738.0	2122656.50003
15S/03E-14H01	PRESSURE 180	135	5797941.0	2122606.00002
15S/03E-15B01	PRESSURE 400	136	5792336.0	2124219.00002
15S/03E-15L02	PRESSURE 180	137	5790177.0	2121393.00002
15S/03E-16B03	PRESSURE 400	138	5786481.0	2123545.50002
15S/03E-16M01	PRESSURE 180	139	5783233.5	2121388.25002
15S/03E-17B01	PRESSURE 180	140	5781259.5	2123911.75003
15S/03E-17B02	PRESSURE 180	141	5781099.5	2123757.50002
15S/03E-17G01	PRESSURE 180	142	5780630.0	2122750.25002
15S/03E-18B01	PRESSURE 180	143	5776074.5	2124737.50002
15S/03E-21A01	PRESSURE 180	144	5787617.0	2118056.00002
15S/03E-22F02	PRESSURE 180	145	5789756.5	2117099.00002
15S/03E-22G01	PRESSURE 180	146	5791343.0	2116241.25002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/03E-25L01	PRESSURE 180	147	5800408.5	2109728.50003
15S/03E-26A01	PRESSURE 400	148	5797857.5	2112518.00002
15S/03E-26D01	PRESSURE 180	149	5794548.5	2112893.75003
15S/03E-26H02	PRESSURE 180	150	5797573.5	2111904.75002
15S/03E-26P01	PRESSURE 400	151	5795686.5	2108925.25002
15S/03E-27J01	PRESSURE 400	152	5792207.5	2110413.00002
15S/03E-28B02	PRESSURE 400	153	5787075.5	2113993.25002
15S/03E-28G01	PRESSURE 180	154	5786358.0	2111546.50003
15S/03E-35B05	PRESSURE 180	155	5797153.0	2107813.50003
15S/04E-05K01	EAST SIDE	156	5812585.0	2130171.00001
15S/04E-05M01	EAST SIDE BOTH	157	5810608.5	2130920.50001
15S/04E-06D04	EAST SIDE BOTH	158	5805535.0	2134296.75001
15S/04E-06R01	EAST SIDE BOTH	159	5808832.0	2130397.50001
15S/04E-07A01	EAST SIDE BOTH	160	5808667.0	2128112.25001
15S/04E-07E02	EAST SIDE	161	5805290.0	2126918.25001
15S/04E-07R01	EAST SIDE SHALLOW	162	5809617.5	2124497.75001
15S/04E-08C01	EAST SIDE SHALLOW	163	5811226.0	2128961.75001
15S/04E-08L01	EAST SIDE BOTH	164	5812038.0	2125163.50001
15S/04E-08N01	EAST SIDE BOTH	165	5810237.5	2124086.00001
15S/04E-09N01	EAST SIDE	166	5815679.0	2123673.25001
15S/04E-15D02	EAST SIDE SHALLOW	167	5820525.5	2122131.50001
15S/04E-15P02	EAST SIDE BOTH	168	5822591.0	2118164.75001
15S/04E-16D01	EAST SIDE BOTH	169	5816370.5	2122604.00001
15S/04E-17B01	EAST SIDE	170	5813674.5	2122802.00001
15S/04E-17P02	EAST SIDE SHALLOW	171	5811444.0	2119748.75001
15S/04E-18L01	EAST SIDE	172	5806258.0	2120249.25001
15S/04E-19D02	PRESSURE 400	173	5805231.0	2118084.25001
15S/04E-19H03	EAST SIDE	174	5808765.0	2116311.75003
15S/04E-20B02	EAST SIDE SHALLOW	175	5812893.0	2117437.00001
15S/04E-20N01	PRESSURE 400	176	5810999.0	2113437.25001
15S/04E-20Q01	EAST SIDE	177	5813019.5	2113916.75003
15S/04E-22J01	EAST SIDE	178	5825620.5	2114797.50001
15S/04E-22L02	EAST SIDE BOTH	179	5822626.0	2115130.25001
15S/04E-23M01	EAST SIDE	180	5826800.0	2115510.00001
15S/04E-26G01	EAST SIDE	181	5829452.0	2110273.75001
15S/04E-27G01	EAST SIDE BOTH	182	5824082.0	2110658.00001
15S/04E-28C01	EAST SIDE	183	5817013.0	2112539.50001

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
15S/04E-28C01	EAST SIDE	184*	*	*
15S/04E-29K03	EAST SIDE	185*	*	*
15S/04E-32E01	PRESSURE 180	186	5809573.0	2105524.75003
15S/04E-36H01	EAST SIDE BOTH	187	5835591.5	2105235.00001
15S/04E-36R02	EAST SIDE BOTH	188	5836592.5	2101652.75001
16S/04E-01L02	EAST SIDE	189	5833261.5	2096387.25003
16S/04E-04C01	PRESSURE 400	190	5816563.5	2101653.00001
16S/04E-08J01	PRESSURE 180	191	5814399.5	2094772.87501
16S/04E-09A01	PRESSURE 180	192	5818962.5	2096385.75001
16S/04E-10K01	PRESSURE 400	193	5822871.5	2093933.87501
16S/04E-10R02	PRESSURE 400	194	5824891.5	2092808.00001
16S/04E-11E02	PRESSURE 400	195	5825734.0	2093587.12501
16S/04E-12M01	PRESSURE 400	196	5830110.0	2094179.62501
16S/04E-13D01	PRESSURE 400	197	5829977.5	2091400.75001
16S/04E-14M01	PRESSURE 400	198	5826507.0	2089158.00001
16S/04E-14M02	PRESSURE 400	199	5826934.0	2088314.12501
16S/04E-15D01	PRESSURE 180	200	5820915.5	2091029.00003
16S/04E-15H02	PRESSURE 400	201	5824314.0	2089470.00001
16S/04E-24R01	PRESSURE 400	202	5833826.5	2081330.00003
16S/04E-25A01	PRESSURE 400	203	5834115.0	2080854.00001
16S/04E-25K01	PRESSURE 180	204	5832503.0	2077482.12501
16S/04E-25Q01	PRESSURE 400	205	5832125.5	2076199.75001
16S/04E-27G01	PRESSURE 180	206	5823057.0	2078926.75001
16S/04E-36B01	PRESSURE 180	207	5833029.5	2074811.87501
16S/05E-07G01	EAST SIDE BOTH	208	5836648.0	2094674.00003
16S/05E-17P01	EAST SIDE BOTH	209	5843361.0	2086999.12503
16S/05E-17R01	EAST SIDE SHALLOW	210	5845212.0	2087024.25003
16S/05E-19F01	PRESSURE 180	211	5836477.0	2084158.37503
16S/05E-19R01	PRESSURE 180	212	5840423.0	2081360.37503
16S/05E-20C01	EAST SIDE	213	5843125.0	2085585.12503
16S/05E-20H01	EAST SIDE	214	5845691.0	2085074.25003
16S/05E-20R01	EAST SIDE BOTH	215	5845834.0	2082220.00003
16S/05E-27G01	EAST SIDE	216	5853466.8	2077678.05320
16S/05E-28D01	EAST SIDE BOTH	217	5846865.0	2080272.25003
16S/05E-28P01	EAST SIDE BOTH	218	5847355.5	2077784.37503
16S/05E-30C01	PRESSURE 180	219	5836401.5	2080129.50003
16S/05E-30G01	PRESSURE 180	220	5837912.0	2078876.87503

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
16S/05E-30J02	PRESSURE 400	221	5840526.5	2077512.50003
16S/05E-31A01	PRESSURE 180	222	5838804.0	2075067.12503
16S/05E-31Q01	PRESSURE 180	223	5837656.0	2070857.75003
16S/05E-32C01	PRESSURE 180	224	5843159.0	2075228.62503
16S/05E-32M01	FOREBAY	225	5840439.0	2072879.00003
16S/05E-33F01	FOREBAY	226	5847064.0	2072544.75003
16S/05E-33Q01	FOREBAY	227	5846731.0	2071679.00003
16S/05E-35C01	FOREBAY	228	5857923.0	2074215.75003
16S/05E-35L01	FOREBAY	229	5857341.0	2072381.25003
17S/04E-01D01	PRESSURE 180	230	5829970.4	2070190.88233
17S/05E-01R01	FOREBAY	231	5863270.5	2064114.75003
17S/05E-02G01	FOREBAY	232	5858061.5	2067655.75001
17S/05E-03B01	FOREBAY	233	5852910.5	2069821.37503
17S/05E-04C01	FOREBAY	234	5846947.5	2068985.25003
17S/05E-04K01	FOREBAY	235	5847433.5	2066928.37503
17S/05E-04N01	FOREBAY	236	5844523.0	2064819.50003
17S/05E-06Q01	FOREBAY	237	5837274.0	2065350.12503
17S/05E-09G01	FOREBAY	238	5846689.0	2062431.75003
17S/05E-09Q01	FOREBAY	239	5846868.5	2059437.25003
17S/05E-10Q01	FOREBAY	240	5853142.5	2060133.00003
17S/05E-12B01	FOREBAY	241	5864362.0	2062470.37503
17S/05E-12B02	FOREBAY	242	5863570.5	2063023.50003
17S/05E-12B03	FOREBAY	243	5862636.0	2063300.00003
17S/05E-13L02	FOREBAY	244	5861995.0	2054065.12503
17S/05E-14D01	FOREBAY	245	5855476.7	2057512.98904
17S/05E-14G01	FOREBAY	246	5858431.5	2057156.87503
17S/05E-21A01	FOREBAY	247	5847203.9	2053734.78530
17S/05E-23L01	FOREBAY	248	5855276.5	2049667.00003
17S/05E-25L01	FOREBAY	249	5861282.5	2044709.87503
17S/05E-36F02	FOREBAY	250	5861156.5	2040988.13679
17S/06E-16N01	FOREBAY	251	5876658.0	2053579.37503
17S/06E-17R01	FOREBAY	252	5875370.0	2053960.00003
17S/06E-19D01	FOREBAY	253	5865512.0	2052870.75003
17S/06E-20K01	FOREBAY	254	5874270.5	2050202.50003
17S/06E-20Q02	FOREBAY	255	5873861.0	2049734.12503
17S/06E-20Q03	FOREBAY	256	5873624.0	2049413.37503
17S/06E-27E03	FOREBAY	257	5881725.5	2046512.12503

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
17S/06E-27K01	FOREBAY	258	5884526.5	2044144.50003
17S/06E-27L01	FOREBAY	259	5883319.0	2044534.62503
17S/06E-28N01	FOREBAY	260	5876603.5	2042971.37503
17S/06E-29C01	FOREBAY	261	5871659.0	2048323.00003
17S/06E-29K01	FOREBAY	262	5873377.5	2045490.50003
17S/06E-29Q01	FOREBAY	263	5873361.0	2045274.25003
17S/06E-30F01	FOREBAY	264	5866434.0	2047190.00003
17S/06E-32G01	FOREBAY	265	5873481.5	2040947.12503
17S/06E-32J02	FOREBAY	266	5874264.0	2039466.50003
17S/06E-35F01	FOREBAY	267	5888535.0	2040776.00003
17S/06E-35J01	FOREBAY	268	5890370.5	2039573.75003
18S/06E-01E01	FOREBAY	269	5892201.0	2033873.12503
18S/06E-02N01	FOREBAY	270	5886656.0	2032336.12503
18S/06E-02R01	FOREBAY	271	5890070.0	2032210.75003
18S/06E-03P01	FOREBAY	272	5881836.0	2032629.37503
18S/06E-05H01	FOREBAY	273	5874765.0	2035980.12503
18S/06E-07A01	FOREBAY	274	5868250.5	2031805.25003
18S/06E-08R01	FOREBAY	275	5873246.0	2027074.87503
18S/06E-09M02	FOREBAY	276	5875856.5	2028751.00003
18S/06E-11J01	FOREBAY	277	5890622.5	2027590.87503
18S/06E-12A01	FOREBAY	278	5896424.0	2030093.87503
18S/06E-12R02	FOREBAY	279	5895096.5	2026768.25003
18S/06E-14B01	FOREBAY	280	5888379.5	2025469.87503
18S/06E-14R01	FOREBAY	281	5890625.0	2022391.37503
18S/06E-15F01	FOREBAY	282	5882187.0	2023781.12503
18S/06E-15M01	FOREBAY	283	5880584.0	2022838.50003
18S/06E-16L01	FOREBAY	284	5876773.5	2023478.50003
18S/06E-21Q01	FOREBAY	285	5878665.0	2016542.37503
18S/06E-25F01	FOREBAY	286	5891762.0	2013188.12503
18S/06E-26R01	FOREBAY	287	5890408.5	2011271.25003
18S/06E-27A01	FOREBAY	288	5883864.0	2015914.75003
18S/06E-28J01	FOREBAY	289	5879251.0	2013091.87503
18S/06E-34B01	FOREBAY	290	5882838.0	2010128.37503
18S/07E-18K01	FOREBAY	291	5899619.5	2023322.62503
18S/07E-18P01	FOREBAY	292	5897367.5	2022162.75003
18S/07E-19G02	FOREBAY	293	5899561.5	2019657.12503
18S/07E-19N01	FOREBAY	294	5896875.0	2016213.75002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
18S/07E-20K01	FOREBAY	295	5903526.5	2016596.50003
18S/07E-28K01	FOREBAY	296	5909064.5	2012996.12503
18S/07E-28N02	FOREBAY	297	5906995.5	2011573.25003
18S/07E-29J01	FOREBAY	298	5906172.5	2012704.50003
18S/07E-29M01	FOREBAY	299	5901432.0	2012790.87503
18S/07E-32G02	FOREBAY	300	5905129.0	2008896.37503
18S/07E-34P02	FOREBAY	301	5913853.5	2006429.50003
19S/06E-01H01	FOREBAY	302	5894418.0	2003322.50003
19S/06E-03E02	FOREBAY	303	5880577.0	2003637.62503
19S/06E-03K01	FOREBAY	304	5882172.5	2003068.00003
19S/06E-11C01	FOREBAY	305	5887118.5	1999053.25003
19S/06E-12A01	FOREBAY	306	5895441.5	1999532.50003
19S/07E-03H02	UPPER VALLEY	307	5916058.0	2002263.25003
19S/07E-04G01	FOREBAY	308	5908976.0	2002192.50003
19S/07E-04Q01	FOREBAY	309	5907241.5	2000938.12503
19S/07E-05B02	FOREBAY	310	5903922.5	2005128.00003
19S/07E-10P02	UPPER VALLEY	311	5914112.0	1994937.37503
19S/07E-13D01	UPPER VALLEY	312	5923060.5	1993005.87503
19S/07E-13D02	UPPER VALLEY	313	5922703.0	1993016.87503
19S/07E-13D03	UPPER VALLEY	314	5921177.5	1994464.25003
19S/07E-16D01	UPPER VALLEY	315	5907215.0	1993447.25003
19S/07E-20A01	UPPER VALLEY	316	5904728.0	1988737.75003
19S/07E-20A02	UPPER VALLEY	317	5905140.0	1988780.50003
19S/07E-23F01	UPPER VALLEY	318	5917918.5	1986682.87503
19S/07E-23G01	UPPER VALLEY	319	5919819.5	1985678.50003
19S/07E-24H02	UPPER VALLEY	320	5927076.5	1985899.12503
19S/07E-36N01	UPPER VALLEY	321	5921376.0	1974705.75003
19S/08E-30A01	UPPER VALLEY	322	5931268.5	1981945.62503
20S/08E-05C02	UPPER VALLEY	323	5933968.0	1972500.37503
20S/08E-05R03	UPPER VALLEY	324	5935855.5	1968133.00003
20S/08E-06B01	UPPER VALLEY	325	5929631.0	1971657.50003
20S/08E-07E01	UPPER VALLEY	326	5927847.5	1965744.25003
20S/08E-15H03	UPPER VALLEY	327	5946414.0	1959720.37503
20S/08E-16C01	UPPER VALLEY	328	5938055.0	1961243.37501
20S/08E-17K03	UPPER VALLEY	329	5934573.0	1958618.62503
20S/08E-34G01	UPPER VALLEY	330	5944061.5	1944379.50003
20S/08E-36R01	UPPER VALLEY	331	5957517.0	1941628.62503

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
21S/08E-15J01	UPPER VALLEY	332	5946267.0	1926489.62503
21S/09E-06C01	UPPER VALLEY	333	5959365.5	1939884.62503
21S/09E-16E02	UPPER VALLEY	334	5967913.5	1928310.37503
21S/09E-22J01	UPPER VALLEY	335	5976378.5	1921774.75003
21S/09E-24Q01	UPPER VALLEY	336	5985537.5	1920320.00003
21S/10E-30E02	UPPER VALLEY	337	5988110.5	1916891.25003
21S/10E-32N01	UPPER VALLEY	338	5993930.5	1907839.00003
22S/10E-09P01	UPPER VALLEY	339	6000619.0	1897117.87503
22S/10E-16P01	UPPER VALLEY	340	6000072.0	1892154.87503
22S/10E-21C01	UPPER VALLEY	341	6001268.5	1890089.75003
22S/10E-22N01	UPPER VALLEY	342	6004921.0	1886561.87503
22S/10E-28B01	UPPER VALLEY	343	6001816.0	1886849.25003
22S/10E-34G01	UPPER VALLEY	344	6007012.0	1879185.87503

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

*Coordinates to be collected

Table 5 COASTAL WELLS AND LOCATIONS

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
13S/01E-25R01	PRESSURE 900	1	5742345.5	2174687.00002
13S/02E-15M01	PRUNEDALE	2	5757881.5	2185405.50002
13S/02E-19Q03	PRESSURE 900	3	5746313.5	2179184.50002
13S/02E-20J01	PRESSURE 400	4	5752096.0	2180981.25002
13S/02E-28L02	PRESSURE BOTH	5	5755055.5	2175441.75002
13S/02E-28M02	PRESSURE 400	6	5753447.0	2175997.50002
13S/02E-32J03	PRESSURE 400	7	5752560.0	2170401.75002
13S/02E-33N04	PRESSURE 400	8	5753898.0	2169605.00002
13S/02E-34G01	PRESSURE 400	9	5760129.5	2170052.25002
13S/02E-34M01	PRESSURE 400	10	5757997.5	2169621.75002
14S/01E-13J02	PRESSURE 400	11	5741048.0	2154289.50002
14S/02E-01C01	EASTSIDE DEEP	12	5771477.5	2167454.25002
14S/02E-02A02	EASTSIDE DEEP	13	5768561.0	2167823.50002
14S/02E-02C03	PRESSURE 400	14	5765109.0	2167416.00002
14S/02E-03H01	PRESSURE 400	15	5762283.0	2166255.50002
14S/02E-03M02	PRESSURE 400	16	5758710.5	2164740.50002
14S/02E-03R02	PRESSURE 400	17	5762517.0	2163892.75002
14S/02E-04B01	PRESSURE 400	18	5755909.0	2167499.00002
14S/02E-04G02	PRESSURE 400	19	5756262.0	2166403.75002
14S/02E-04H01	PRESSURE 400	20	5756715.0	2165886.25002
14S/02E-04N03	PRESSURE 400	21	5753365.0	2163112.75002
14S/02E-05C03	PRESSURE 400	22	5748893.5	2167132.50002
14S/02E-05K02	PRESSURE 400	23	5750829.0	2165370.75002
14S/02E-07A01	PRESSURE 400	24	5747142.5	2162655.25002
14S/02E-07J02	PRESSURE 400	25	5746655.0	2159408.25002
14S/02E-07J03	PRESSURE DEEP ZONE	26	5746476.9	2159735.06998
14S/02E-07L04	PRESSURE 400	27	5743780.0	2159328.00002
14S/02E-07L05	PRESSURE 400	28	5743784.5	2160380.50002
14S/02E-08C03	PRESSURE 400	29	5750055.0	2162036.75002
14S/02E-08M02	PRESSURE 400	30	5747103.0	2159672.50002
14S/02E-09D04	PRESSURE 400	31	5753016.5	2162818.75002
14S/02E-09K02	PRESSURE 400	32	5755450.0	2159946.25002
14S/02E-09N02	PRESSURE 400	33	5752897.5	2158609.50002
14S/02E-10E02	PRESSURE 400	34	5758062.0	2160525.75002
14S/02E-10H01	PRESSURE 400	35	5761492.0	2160761.75002

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-10M02	PRESSURE 400	36	5757853.5	2159387.75002
14S/02E-11B01	PRESSURE 400	37	5766446.0	2162325.25002
14S/02E-11M03	PRESSURE 400	38	5764448.5	2159266.75002
14S/02E-12N02	PRESSURE 180	39	5769893.5	2158219.50002
14S/02E-13F01	PRESSURE 180	40	5769952.5	2154587.75002
14S/02E-13G01	PRESSURE 400	41	5772057.5	2155470.50002
14S/02E-14A01	PRESSURE 400	42	5767367.0	2156210.25002
14S/02E-14L02	PRESSURE 180	43	5764775.5	2155024.75003
14S/02E-14L03	PRESSURE 400	44	5764610.5	2154419.75002
14S/02E-15A01	PRESSURE 400	45	5761774.5	2157015.50002
14S/02E-15C02	PRESSURE 400	46	5759385.5	2157259.00002
14S/02E-15L02	PRESSURE 180	47	5758452.0	2153366.00003
14S/02E-15N01	PRESSURE 400	48	5757522.5	2153353.25002
14S/02E-15P01	PRESSURE 400	49	5758767.5	2153584.50002
14S/02E-16A02	PRESSURE 400	50	5756957.5	2157123.50002
14S/02E-16G01	PRESSURE 400	51	5755957.0	2155999.50002
14S/02E-16H01	PRESSURE 400	52	5756041.0	2156035.25002
14S/02E-17A02	PRESSURE 400	53	5751744.5	2156837.50002
14S/02E-20B03	PRESSURE 900	54	5750210.5	2151407.25003
14S/02E-21E01	PRESSURE 400	55	5753561.0	2150101.50003
14S/02E-21J01	PRESSURE 180	56	5756896.0	2149447.75002
14S/02E-21L01	PRESSURE 180	57	5754605.0	2149175.75002
14S/02E-22B01	PRESSURE 400	58	5760986.0	2152124.75002
14S/02E-22L01	PRESSURE 400	59	5759725.0	2149855.00002
14S/02E-22P02	PRESSURE 180	60	5758952.5	2146937.25002
14S/02E-23M01	PRESSURE 180	61	5762708.0	2149478.75002
14S/02E-24E01	PRESSURE 180	62	5768326.5	2150393.25002
14S/02E-24P02	PRESSURE 400	63	5769670.0	2146858.75002
14S/02E-24Q01	PRESSURE 180	64	5771942.5	2146772.50003
14S/02E-25D04	PRESSURE 180	65	5768019.0	2145519.50003
14S/02E-26J03	PRESSURE 400	66	5766847.5	2143883.00002
14S/02E-26N03	PRESSURE 180	67	5762617.0	2142567.75002
14S/02E-26P01	PRESSURE 180	68	5764519.0	2141615.00003
14S/02E-27C02	PRESSURE 400	69	5759686.0	2145562.00002
14S/02E-27F02	PRESSURE 180	70	5759825.0	2144647.75002
14S/02E-28C01	PRESSURE 400	71	5753983.5	2146953.50002
14S/02E-32D06	PRESSURE 180	72	5746981.0	2141653.75003

STATE WELL NUMBER	AQUIFER	MAP ID	FALSE EASTING[1]	FALSE NORTHING[1]
14S/02E-33P01	PRESSURE BOTH	73	5756348.0	2138806.75003
14S/02E-34A04	PRESSURE 180	74	5761465.0	2141623.00002
14S/02E-34B03	PRESSURE 180	75	5759909.5	2141431.00002
14S/02E-36E01	PRESSURE 180	76	5768600.0	2138685.00002
14S/02E-36G01	PRESSURE 400	77	5770039.0	2139297.50002
14S/03E-06L02	EASTSIDE DEEP	78	5775957.0	2164155.50002
14S/03E-07P02	EASTSIDE SHALLOW	79	5775832.0	2157899.00003
14S/03E-18E02	PRESSURE 400	80	5774633.5	2155704.50003
14S/03E-19Q02	PRESSURE 180	81	5776192.0	2146948.50002
14S/03E-30E03	PRESSURE 400	82	5774081.0	2143975.75002
14S/03E-30F01	PRESSURE 180	83	5775609.5	2144673.00002
14S/03E-31B01	PRESSURE 180	84	5776312.0	2140030.50002
15S/02E-12C01	PRESSURE 180	85	5769441.0	2130513.75002

---

[1] State Plane Coordinate System, California Zone IV, Feet, North American Datum 1983

Table 6 REQUIREMENTS FOR SAMPLE COLLECTION[1]

ANALYTE	CONTAINER TYPE	SAMPLE VOLUME	PRESERVATIVE	HOLDING TIME
Calcium (Ca)	polyethylene (HDPE[2])	200 mL[3]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
CATION ANION BALANCE[4]	N/A Calculation	N/A Calculation	N/A Calculation	N/A Calculation
Chloride (Cl)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2°C	28 days
Conductivity (SEC)[5]	polyethylene (HDPE[1])	100 mL[2]	4±2°C	28 days
Magnesium (Mg)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Nitrate (NO3)[5]	polyethylene (HDPE[1])	100 mL[2]	none HSO_4; pH<2	48 hours at 4° C 28 days
pH (Laboratory)	polyethylene (HDPE[1])	30 mL[2]	none	48 hours at 4° C
Potassium (K)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sodium (Na)	polyethylene (HDPE[1])	200 mL[2]	HNO_3 pH<2	3 days w/o pres. 6 months w/ pres.
Sulfate (SO4)	polyethylene (HDPE[1])	100 mL[2]	4±2°C	28 days
Total Alkalinity (as CaCO3)	polyethylene (HDPE[1])	100 mL[2]	4±2°C	14 days

---

[1] = CCL QA Manual and SOPs

[2] = High Density Polyethylene

[3] = only one 0.5 gal (~2L) container is needed for all analyses

[4] = Cation anion balance is a calculation

[5] = Analytes in partial mineral panel, one pint (~500 mL) container is need for analyses

APPENDICES

APPENDIX A

GLOBAL POSITIONING SYSTEM (GPS) TRAINING

Appendix A-1: GPS Training Record

Appendix A-2: TSC1 Asset Surveyor Manual

Appendix A-3: Pro XR/XRS Receiver Manual

Geographic Positioning System (GPS) Training Record

Name of Trainee

Name of Trainer

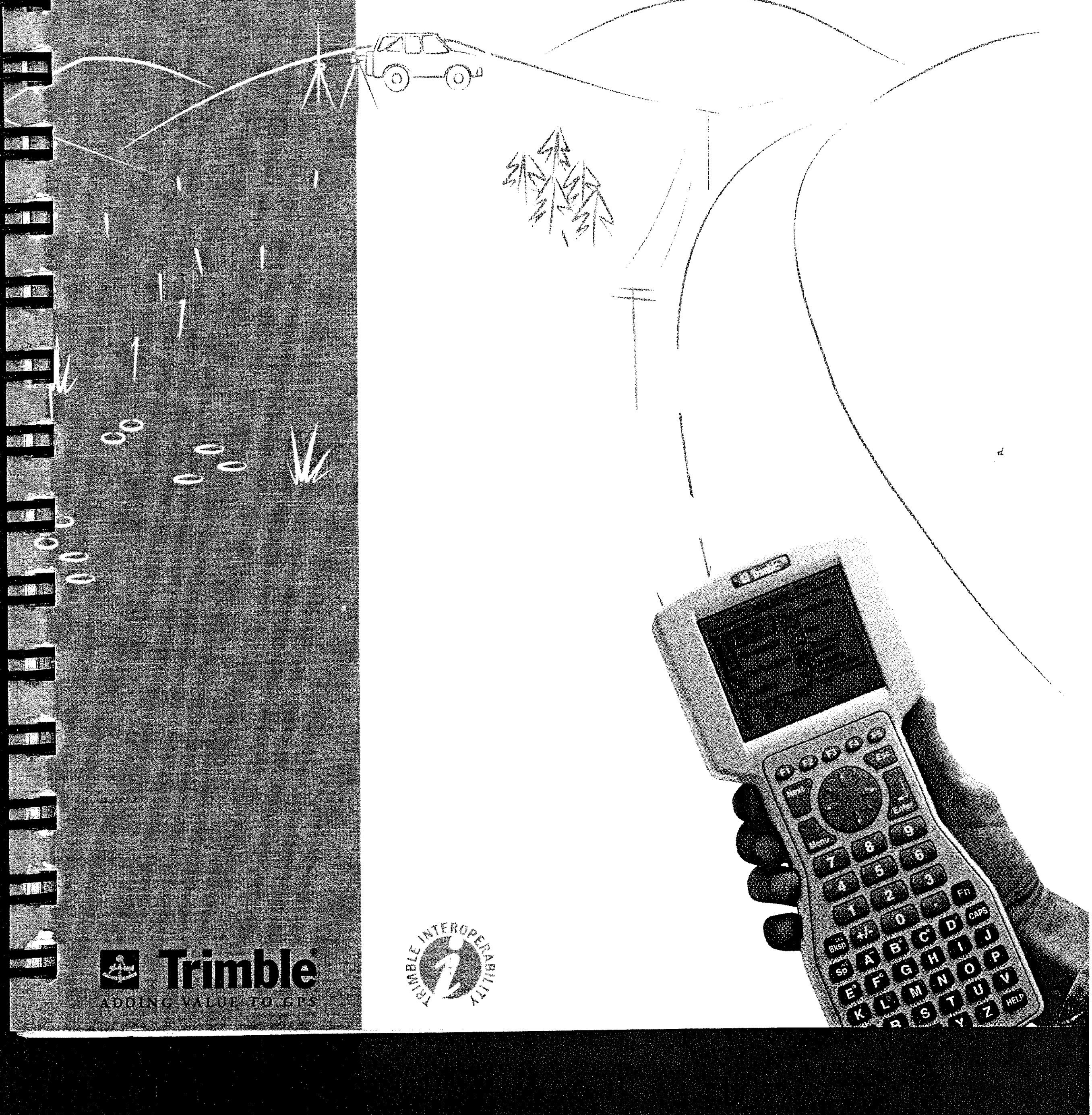
Date of Training

	Satisfactory Completion / Understanding
Verification of access to Pathfinder Office software	
Preparation of data dictionary	
Set-up of equipment	
Trimble® TSC1 Asset Surveyor[1]	
Trimble® Pro XR Receiver[1]	
Connector cables	
Batteries (Asset Surveyor and Receiver)	
Confirmation of communication between Asset Surveyor and Receiver	
Acquiring satellites	
Setting up and checking critical settings	
-logging intervals	
-PDOP mask[2]	
Proper packing and unpacking of equipment	
Transferring data files from Asset Surveyor to the computer	

[1] The Agency uses Trimble® products, the GPS industry standard.

[2] PDOP = Position Dilution Of Precision

TSC1 Asset Surveyor
Operation Manual



Trimble
ADDING VALUE TO GPS

TRIMBLE INTEROPERABILITY

TSC1 Asset Surveyor

Operation Manual

Part Number 34182-05-ENG

Version 5.00

October 1999

Revision A

Trimble Navigation Limited
Mapping & GIS Systems
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088-3642
U.S.A.

1-800-827-8000 in North America
+1-408-481-8000 International
Fax: +1-408-481-7744
www.trimble.com

1 Quick Setup

The instructions in this chapter are a simplified version of the various steps found in Chapters 4, 5, and 6 of this manual. The purpose of the simplified version is to provide quick setup guides with reasonable default values that can be distributed to field crews to ensure proper setup of rover or base station receivers.

Data is logged to the TSC1 with the Asset Surveyor software. For full details on configuration and data collection, refer to the *TSC1 Asset Surveyor Software User Guide*.

Note – The steps outlined in this chapter do not include steps required to collect data using carrier phase information. For instructions on how to collect high accuracy features, see Chapter 7, Carrier Phase Data Collection.

1.1 Before Leaving the Office

1. Install the Pathfinder Office software on your office computer (refer to the *Pathfinder Office Getting Started Guide*).
2. Using the Pathfinder Office software, prepare any data files or data dictionaries you require, and transfer them to the TSC1. If you want to update GPS or attribute information on features stored in a GIS, import the data files and data dictionary into Pathfinder Office and then transfer them to the TSC1. You may also want to transfer any waypoint and coordinate system files to the datalogger.

3. Check that you have all the required equipment, and that it is operational. Set up and connect your GPS system (the appendix for your GPS receiver lists the equipment and shows you how to connect it).
4. If the GPS receiver has an On/Off switch, turn it on (the Series 4000, GPS Total Station 4700, GPS Total Station 4800, Site Surveyor 4400 and 4600LS receivers have an On/Off switch).

   Start the Asset Surveyor software to check that it and the GPS receiver are communicating correctly. If communication is established, the GPS status line appears. If communication fails, an error message pops up on the screen.
5. Check all critical settings in the Asset Surveyor software.

   You should also check non-critical and display settings, especially if the system has been used by someone else recently. For details of how to configure Asset Surveyor, refer to the *TSC1 Asset Surveyor Software User Guide*.
6. Turn everything off and pack it into carrying cases if you have to travel a significant distance to the survey site. Pack spare sets of batteries if you expect to operate the receiver for any length of time.

1.2 In the Field

1. Travel to the survey site, remembering to carry all the required equipment with you.
2. Reassemble the system.
3. If the GPS receiver has an On/Off switch, turn it on. Then start the Asset Surveyor software, if it is not already on.

   Wait until the GPS receiver acquires enough satellites to start computing GPS positions, before beginning to work. The number of satellites being tracked displays on the status line.

You should now change some of the configuration settings as follows:

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

Configuration menu

2.	*GPS rover options*	Press Enter
3.	*Logging options*	Press Enter

Logging options screen

4.	*Point feature*	Synchronized with the base station
5.	*Line/area*	Synchronized with the base station
6.	*Not in feature*	Synchronized with the base station
7.	*Minimum positions*	3
8.	*Allow GPS update*	'Warn first'
9.	*Warning distance*	'Any'
10.	To accept	Press Enter

Position filters screen

11.	*Position mode*	'Manual 3D' or 'Overdet. 3D' depending on canopy density
12.	*PDOP mask*	4 or 6 (depending on receiver)
13.	To accept	Press Enter

4. Create a new data file, associating the correct data dictionary with it. Alternatively, re-open an existing data file.
5. Begin collecting data. Collect, review and update all the features necessary.
6. Close the data file.
7. Disconnect and repack the components of the system. Remember to turn off the GPS receiver, if it has an On/Off switch. Return to your office.

1.3 Back in the Office

1. Transfer the data files from the TSC1 to the PC using the Pathfinder Office software.
2. Use the Pathfinder Office software for differential correction, plotting, and exporting the data file(s) to a GIS.
3. Recharge the TSC1 datalogger and GPS receiver batteries.

1.4 Rover Configuration

Use the following procedure to set up your system in a rover configuration.

From the *Utilities* menu, select *Factory defaults*. This resets the Asset Surveyor software to its default configuration and then restarts the datalogger.

Antenna options screen

14. *Height*	Height to antenna's phase center
15. *Measure*	'Vertical'
16. *Type*	For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
17. *Confirm*	Select 'Per feature', 'Per file', or 'Never'
18. To accept	Press Enter

GPS rover options menu

19. To return to the *Configuration* menu	Press Esc

Configuration menu

20. *Communication options*	Press Enter
21. *Real-time input options*	Press Enter

Real-time input options screen

22. RTCM age limit	5 or 10 (depending on your radio)
23. To accept	Press Enter
24. To return to the *Configuration* menu	Press Esc

Configuration menu

25. To exit the *Configuration* menu	Press Esc

1.4.1 Data Collection

Use the following procedure to set up your system for rover data collection.

Main menu

1. Select *Data collection* and press Enter

Data collection **menu**

2.	Create a data file -or- Open an existing data file	Select *Create new file*: Press Enter and then press Enter -or- Select *Open existing file.* Press Enter Select an existing file to append to or update, and press Enter
3.	To exit *Data collection*	Press Esc and press Yes to confirm exit

1.5 Base Station Configuration

Use the following procedure to set up your system in a base station configuration.

Main menu

1.	*Configuration*	Highlight *Configuration* then press the Enter key

Configuration **menu**

2.	*GPS base station options*	Press Enter
3.	*Logging options*	Press Enter

Logging options **screen**

4.	*Measurements*	One to five seconds (depending on rover interval and free space)
5.	To accept	Press Enter
6.	To return to the *Configuration* menu	Press Esc

Configuration **menu**

7.	To exit the *Configuration* menu	Press Esc

1.5.1 Base Station Data Collection

Use the following procedure to set up your system for base station data collection.

Main menu

1.	*Data collection*	Press Enter

Data collection menu

2.	*Create base file*	Press Enter

Create File screen

3.	Create file	Press Enter

Antenna options screen

4.	*Height*	Height to antenna's phase center
5.	*Measure*	'Vertical'
6.	*Type*	For a list of antenna types, see the *TSC1 Asset Surveyor Software User Guide*
7.	To accept	Press Enter

Reference Position **screen**

8.	Enter reference position	Type lat/lon (or north/east) and altitude, and press Enter
	-or-	-or-
	Use an existing waypoint	Press WayPt, select the waypoint and press Enter
	-or-	-or-
	Use an approximate position	Press Here and press Enter
	-or-	-or-
	Leave as is and set in the Pathfinder Office software	Press Enter

Base Station **screen**

9.	To exit *Base station*	Press Enter and press Yes to confirm exit.

Key Symbols

The Asset Surveyor software uses both *hard* (that is, physical) keys on a keypad and *soft* (that is, visual) keys on the datalogger's screen.

Hard (physical) keys on the TSC1 keypad are indicated as follows:

Enter, ◄, F1, and so on.

Softkeys on the TSC1 screen are indicated as follows:

Create, Del, Edit, and so on.

A softkey is activated by pressing the corresponding function key (F1...F5) on the TSC1 keypad.

Warnings, Cautions, Notes, and Tips

Warnings, cautions, notes, and tips draw attention to important information, and indicate its nature and purpose.

Warning – Warnings alert you to situations that could cause personal injury or unrecoverable data loss.

Caution – Cautions alert you to situations that could cause hardware damage or software error.

Note – Notes give additional significant information about the subject to increase your knowledge, or guide your actions.

Tip – Tips indicate a shortcut or other time- or labor-saving hint that can help you make better use of the product.

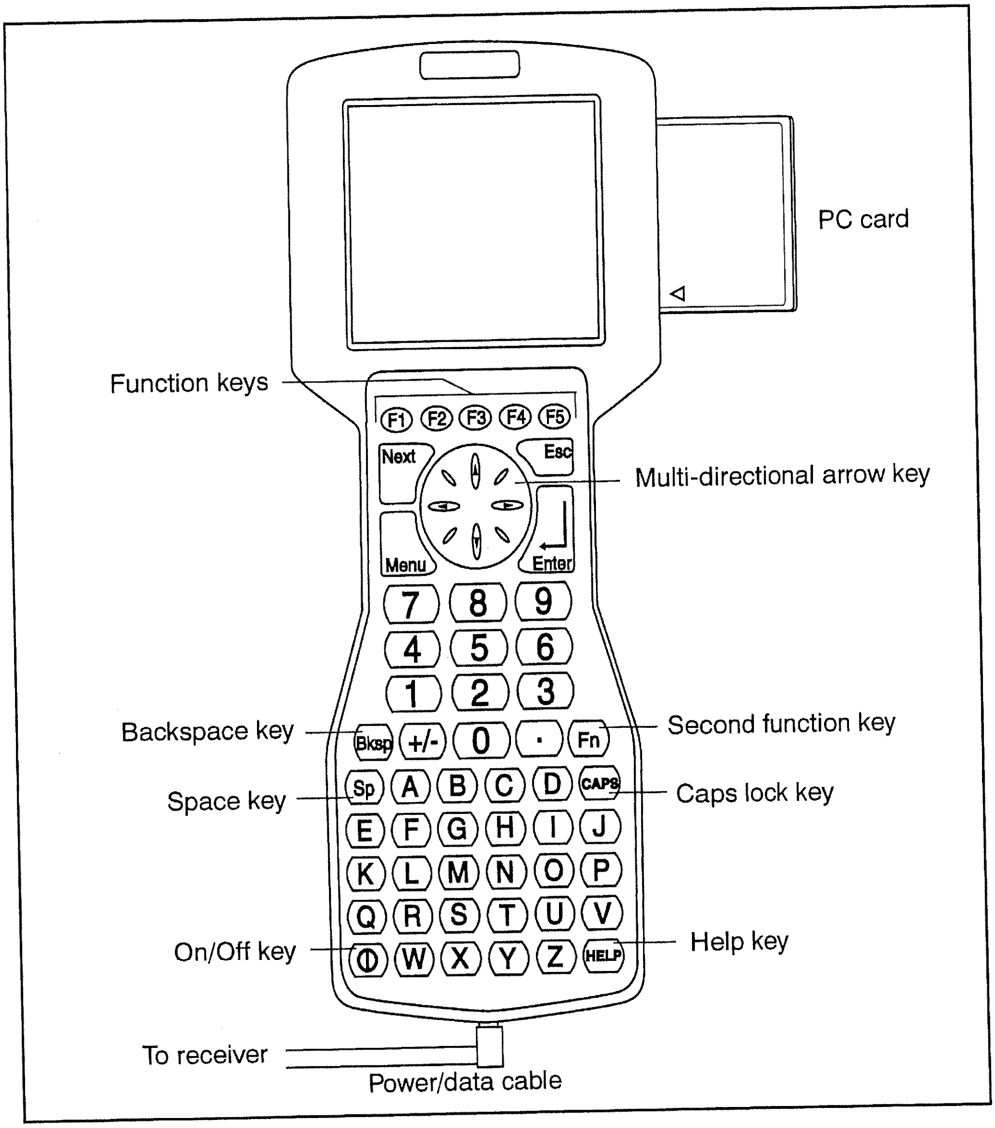


Figure 3-1 Front View of the TSC1 Datalogger

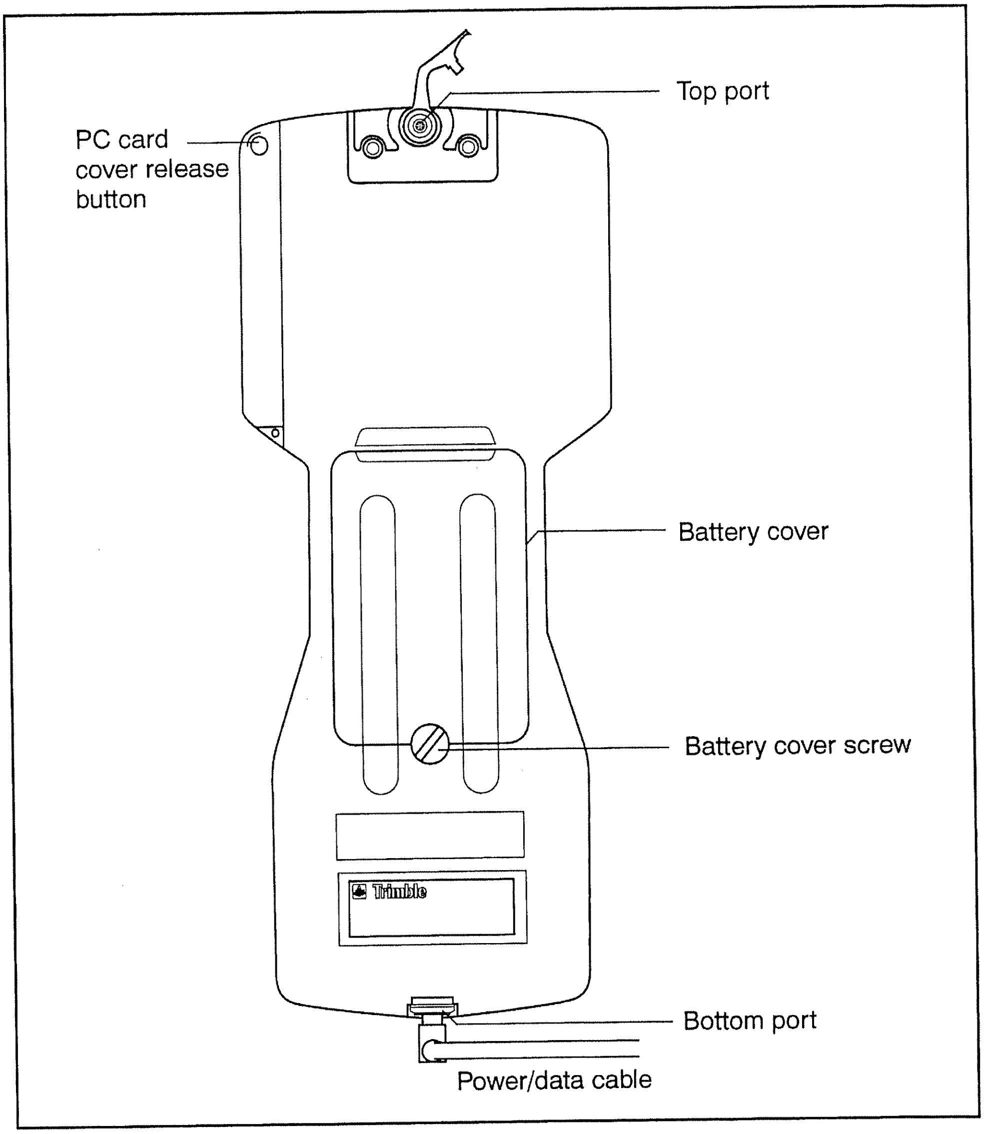


Figure 3-2 **Back View of the TSC1 Datalogger**

3.2 Turning the TSC1 Datalogger On and Off

To turn on the TSC1 datalogger, make sure that power is supplied (see Power Sources, page 3-11). Then press the green on/off key marked [⌽].

To turn off the TSC1, hold down [⌽] for one second.

Tip – For the location of the [⌽] key and other keys on the TSC1 datalogger's keypad, refer to Figure 3-1.

3.2.1 Hard Keys

Hard keys are the physical keys on the TSC1 keypad, such as [1], [A], [Enter], →, ↓, and [Esc]. Use these keys to enter data and to access different screens.

3.2.2 Alternate Keys

Alternate keys give some hard keys a second function. Some of the second functions are displayed on the hard keys in small yellow lettering. To use a second function, press the [Fn] hard key and then press the alternate hard key.

Table 3-1 shows some of the functions that you can access using alternate keys.

Table 3-1 Useful Second Functions

Keys	Function
[Fn] ↓	Page down
[Fn] ↑	Page up
[Fn] ←	Home
[Fn] →	End
[Fn] [Next]	Previous screen
[Fn] [E]	Contrast up
[Fn] [F]	Contrast down

3.2.3 Softkeys

Softkeys are displayed on the bottom line of the TSC1 screen. A softkey corresponds to the adjacent hard key: F1, F2, F3, F4, F5. Press the hard key to activate the softkey on the screen. To activate the Pause softkey, for example, press F1. See Figure 3-3.

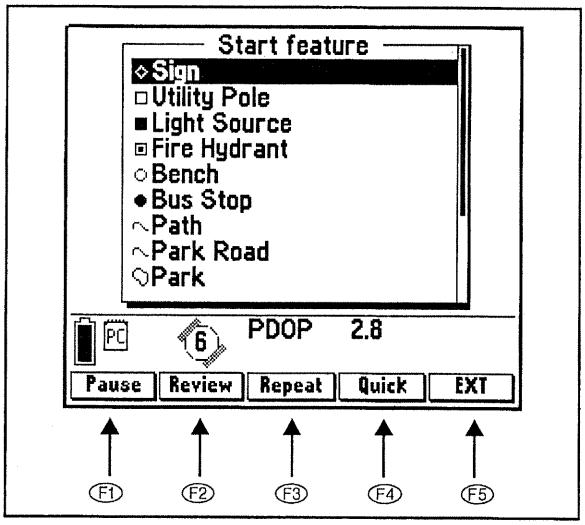


Figure 3-3 How Function Keys Correspond to Softkeys

Softkeys relate to particular forms or fields and only appear when these forms or fields are accessed. For example, the Seg softkey only appears when a line feature is opened for data collection, as this functionality applies to line features only.

3.2.4 Menu Key

To return to the *Main menu* at any time, press the Menu hard key. Use this key in conjunction with the Next key to move around the Asset Surveyor screens quickly.

3.2.5 Next Key

To simplify the task of moving around menus, the Next hard key offers quick access to open screens (windows).

3.2.6 Help Key

Press the HELP hard key at any time to obtain further information about a topic. When you press it, the *Help* menu appears. To exit *Help*, press Esc from the *Help* menu.

3.3 Screen

The TSC1 has an LCD screen. This screen responds to heat, and prolonged exposure to full sunlight can cause it to darken. If the screen does darken, turn it away from direct sunlight until it returns to normal.

Caution – Repeated exposure to direct sunlight can cause the screen to degrade.

3.3.1 Contrast

To increase the screen contrast, press Fn E.

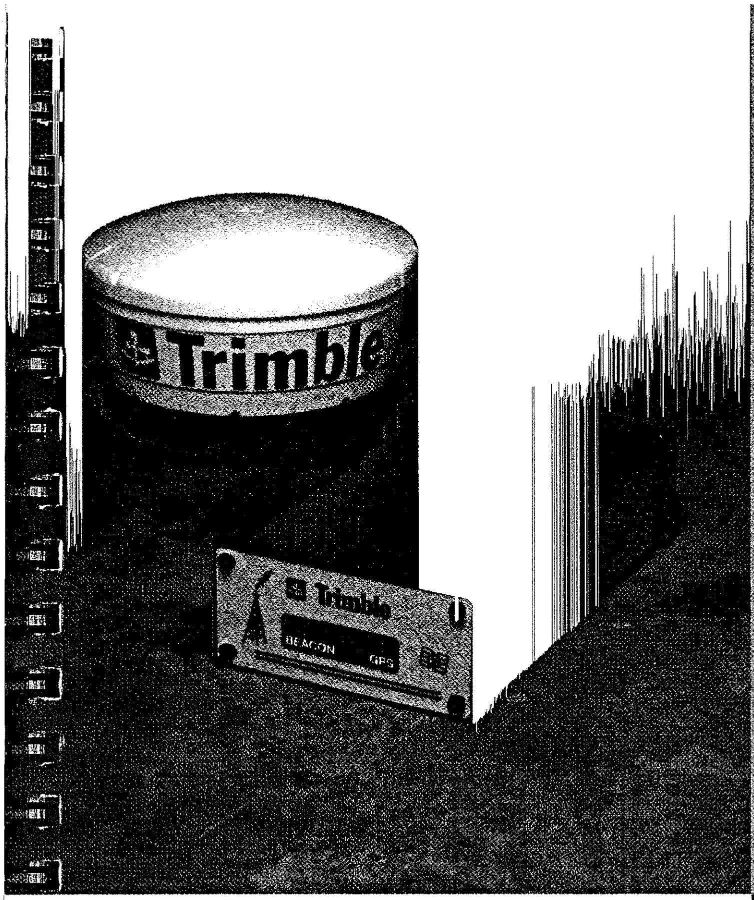
To decrease the screen contrast, press Fn F.

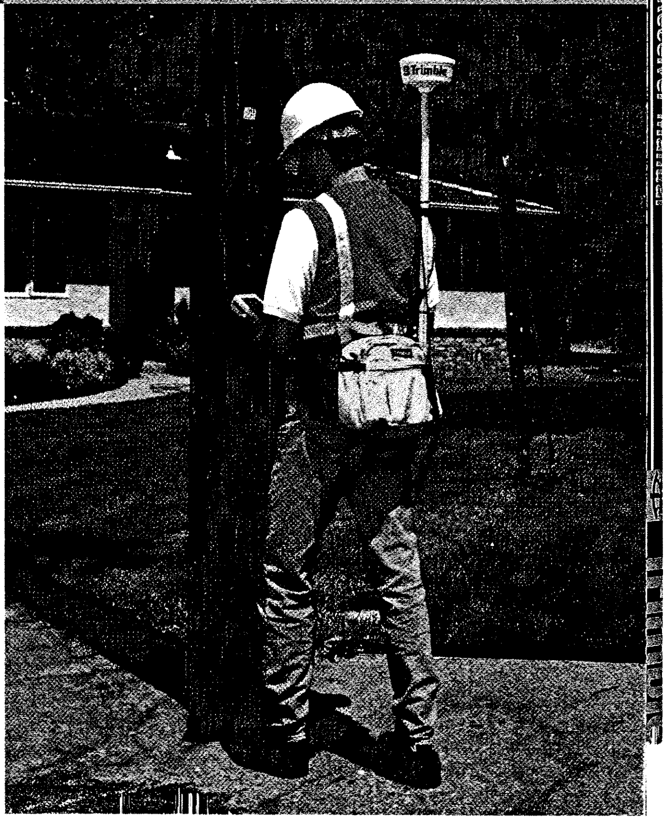
3.3.2 Backlight

To toggle the screen backlight on and off, press Fn L.

Pro XR/XRS

Receiver Manual





Trimble

Pro XR/XRS

Receiver Manual

Part Number 31172-20-ENG

Revision A

May 1998

Trimble Navigation Limited
Mapping and GIS Systems Division
645 North Mary Avenue
P.O. Box 3642
Sunnyvale, CA 94088-3642
U.S.A.

1-800-827-8000 in North America
+1-408-481-8000 International
Fax: +1-408-481-7744
www.trimble.com

4 Pro XR/XRS System Equipment

This chapter provides details of the equipment associated with the Pro XR and Pro XRS receivers and shows how to assemble the equipment.

4.1 Pro XR Receiver Front Panel

The Pro XR receiver, shown in Figure 4-1, is mounted in a weatherproof housing.

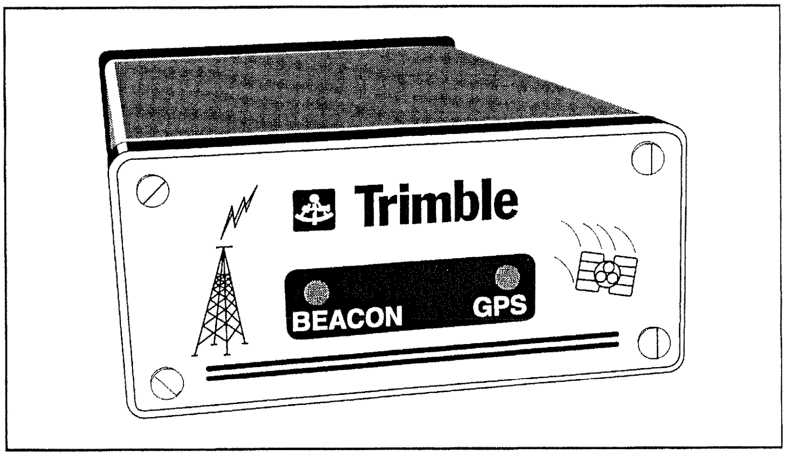


Figure 4-1 Pro XR Receiver Front Panel

4.2.1 Pro XR Status Lights

The two status lights on the front panel of the Pro XR receiver provide the status information listed in Table 4-1.

Table 4-1 Pro XR Status Lights

	GPS	**Beacon**
OFF	Unit not powered up	Unit not powered up or beacon function is disabled
FAST FLASH	Searching for satellites	Searching for MSK signals
SLOW FLASH	Found one or more satellites. Not enough for a position fix.	Found MSK signal. RTCM data has not been sent to GPS receiver.
ON	Performing position fixes	Good RTCM data is being provided to the GPS receiver

4.3 Back Panel

The Pro XR and Pro XRS receivers have two serial communications ports (RS232) and an antenna cable port. The serial communications ports, shown in Figure 4-3, are 12-pin(m) bulkhead connectors located on the back panel of the Pro XR and Pro XRS receivers.

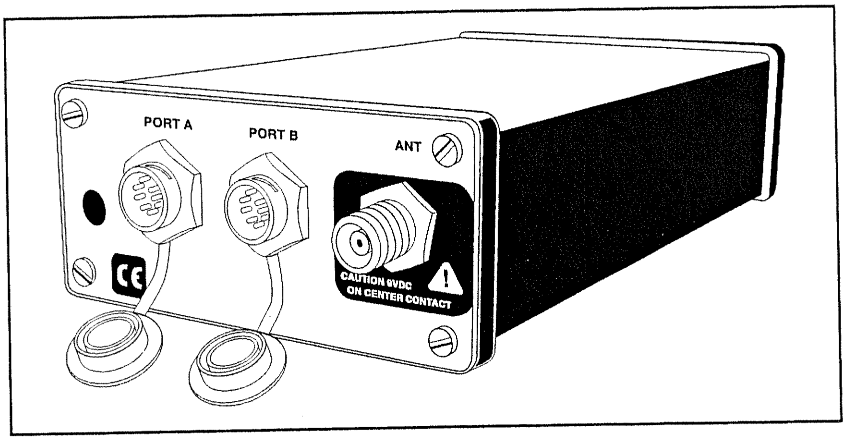


Figure 4-3 Pro XR/XRS Receiver Back Panel

4.3.1 Port A

Port A offers RS232 communication standards. It is designed for NMEA-0183 output and RTCM input.

4.3.2 Port B

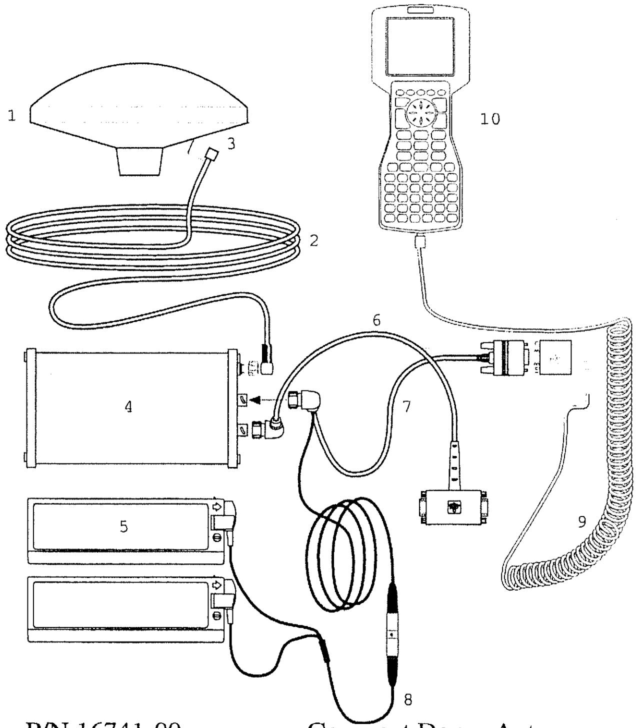
Port B also offers RS232 communication standards. It is designed for two-way data flow, external sensor input and power.

4.3.3 Antenna Port

The antenna connector is a TNC(f) connector located on the far right on the back panel of the Pro XR or Pro XRS receiver.

4.4 GPS Pro XR Cabling

To use the TSC1 handheld with a GPS Pro XR receiver, connect the system as shown in Figure 4-4.



1	P/N 16741-00	Compact Dome Antenna
2	P/N 22628	Antenna Cable
3	P/N 31180	Antenna Cable Adapter
4	P/N 29654-11	12-channel Pro XR receiver
5	P/N 17466	Camcorder Batteries
6	P/N 30232-00	NMEA/RTCM Cable
7	P/N 30231-00	Data/Power Cable
8	P/N 24333	Dual Battery Cable
9	P/N 32287-00	TSC1 Data/ESP Cable
10	P/N 29673-50	TSC1 Handheld

Figure 4-4 GPS Pro XR / TSC1 Connection Diagram

4.7 Pro XR/XRS System Hip Pack

The Pro XR and Pro XRS systems come equipped with an ergonomic hip pack carrying system, see Figure 4-18. The receiver, batteries and antenna are carried in the field using this hip pack/strapping system.

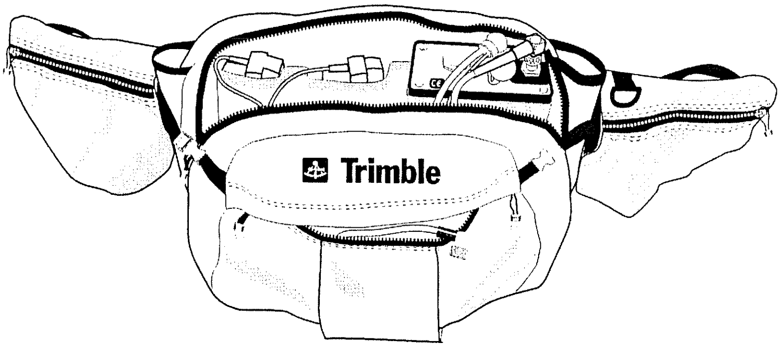


Figure 4-18 Pro XR/XRS System Hip Pack

4.7.1 Pro XR/XRS Hip Pack Contents

The Pro XR and Pro XRS systems are packed so that they are almost ready for use. The items not included in the hip pack are three 1-foot antenna poles, one 6-inch antenna pole and the data collector cable (P/N 30233-00 for TDC1, P/N 30234 for TDC2, or P/N 30236 for Field Computer/MC-V). These are located inside the shipping case.

The large interior of the hip pack contains: the Pro XR or Pro XRS receiver, two camcorder batteries, the power/data cable, and the camcorder power cable. All of these are set up inside the pack and ready for use. The exterior pocket of the hip pack contains a 3-meter antenna cable attached to the receiver and routed through a passage between the large interior pocket and exterior pocket. Both the data collector cable and antenna are routed out of the exterior pocket through the double zipper.

To route the data collector cable:

1. Locate the data collector cable and connect it to the data power cable, DE-9 connector labeled TO RECEIVER.
2. Once connected, feed the coiled cable through the passage and into the exterior pocket.

4.7.2 Wearing and Adjusting the Hip Pack

The Pro XR/XRS hip pack, once adjusted to suit, is comfortable and easy to use. See Figure 4-19.

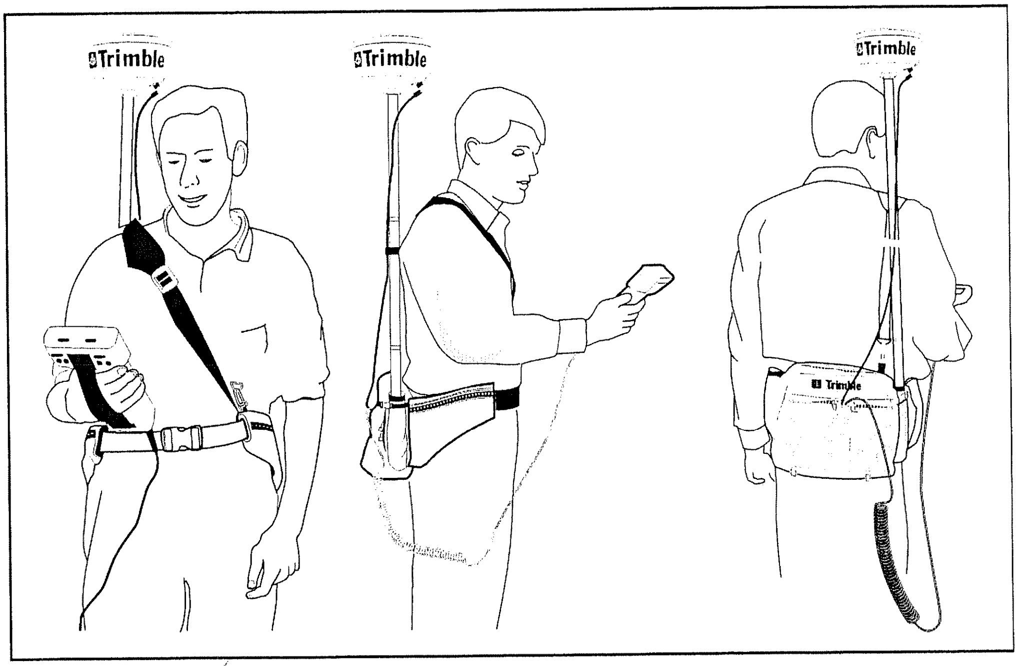


Figure 4-19 View of Hip Pack Setup

Antenna

When wearing the hip pack, the antenna height should be 3-4 inches above your head. The number of antenna pole sections required varies depending on your height. For example, if you are 5'5" tall, you may need two 1-foot and one 6-inch pole sections. If you are 6'2" tall, you may need three 1-foot poles. Try out different pole heights.

To set up the antenna with the hip pack:

1. Attach the pole sections together and connect the antenna onto the top of the pole sections.
2. Attach the pole/antenna to the hip pack.
3. Choose the side of your body that you prefer the antenna to be on and slide the pole sections into the small sleeve on that side of the hip pack.

Hip Pack and Strap

To adjust the hip pack and strap:

1. Connect the strap to the rear D-ring on the side of the pack on which the antenna is located.
2. Connect the other end of the strap to the D-ring on the belt on the opposite of the bag.
3. Slide the antenna pole through the velcro connection on the strap.
4. Put the strap over your head and across your opposite shoulder.

   At this point, the shoulder strap should lead naturally from the antenna pole across your chest to the belt.
5. Buckle the hip pack around your waist/hip area so that the belt buckle is centered in the middle of your body.

   The pack should adjust to fit close to the small of your back.

6. Adjust the front and back straps so the shoulder strap is situated squarely on your shoulder.
7. Put the pack on by slipping the strap over your head and across your body and then buckling the belt of the hip pack.

   The hip pack includes side compression straps that can be pulled towards you to hold the pack firmly and comfortably against your back.

Remove the hip pack/strap by unbuckling the belt and slipping the strap over your head.

The hip pack and strap can also double as a shoulder bag. Tuck the belt portion of the pack into the webbing material on the back of the pack and hook the strap on the large D-rings of the pack. The unit can now be carried on your shoulder instead of around your waist.

The pack has extra room in the interior and exterior pockets for additional items you may need in the field. The hip pack also includes straps on the bottom of the pack to secure an extra sweater or coat while in the field.

4.8 Optional Range Poles and Tripods

Range poles and tripods are very useful when collecting carrier phase data. The height of the antenna can be accurately measured, and the antenna can be held still easily, compared to an antenna mounted from the hip pack.

APPENDIX B

FIELD DOCUMENTATION

Appendix B-1: Example of Field Sheet

Appendix B-2: Example of Chain of Custody Form (COC)

Appendix B-3: Example of Photo-Log

Appendix B-4: Example of Sample Labels

MONTEREY COUNTY WATER RESOURCES AGENCY - COASTAL GROUND WATER MONITORING PROGRAM June 2007

F CODE	SWID	STATUS	AQUIFER	USE	WELL NAME	METER No	PLANT No	SMPLE PT	VISIT DATE	APPT. DATE	SMPLE DATE	SMPLE TIME	SMPLER	REMARKS
886	14S/02E-24E01	ACTIVE	P400	AG	R5P1	4571R8	92205	DL						D'Arrigo Bros. R5P1. Tag #1164. Well is at corner of San Jon Rd an Hwy 183. Go twice then call Ed Mora 206-9164 or Jesse Aragon 90 9073. See photo
331	14S/02E-36E01	ACTIVE	P180	AG	BARDIN 12	0R1749	92428	faucet on booster						T & A. Bardin #12. Tag #1037. Well on Hitchcock Rd. off Blanco b office. Go twice, then call Dennis. See photo
673	14S/02E-13F01	ACTIVE	P180	AG	SAN JON B	R39873	95522	DL						Sea Mist. San Jon well B. Tag #1186. Call Chris. Three day notice. S photo
975	14S/02E-12N02	CSIP-SBI	P180	AG		92593R	91785	DL						Schneider. Domestic well. Tag #2960. Run for 30 min. to stabilize conductivity, EC = 2920 (Jul '04). Call Tim Schneider 449-0874. Tv week notice. Take EC meter, a bucket and last years results. See phc
1055	14S/02E-15A01	CSIP-SUPP	P400	AG	15A01	R69587	94951	DL			6/12/2007	9:05:00 AM		CSIP-SUPP. Well 15A1. PCA site #17. Go twice, then call Bill or Je See photo
1324	14S/02E-15C02	CSIP-SUPP	P400	AG	15C02	42542R		DL			6/12/2007	8:55:00 AM		CSIP-SUPP. Well 15C2. Tag #2838. PCA site #19. Go twice, then c Bill or Jesse. See photo
861	14S/02E-15P01	CSIP-SBA	P400	AG	MORO COJO#1 (YARD)	31535R	95209	DL						Higashi Farms. Moro Cojo #1. By house and shed. Call Peter. 2 day notice. See photo
279	14S/02E-16H01	CSIP-SBA	P400	AG	CONLEY	91R418		DL						Higashi Farms. Connely Ranch well. Tag #2856. Call Peter Odello 5 7926 or Charlie 578-7416. See photo. INACTIVE
2779	14S/02E-21E01	ABAN	P400	AG	MARINA-ARMSTRONG WELL	02384R		DL						Armstrong. Marina-Amstrong well. Tag #2962. SW of MRWPCA, sample from ball valve on pressure/flow control valve. Jack Armstro 455-1901 See photo. INACTIVE
766	14S/02E-22P02	ACTIVE	P180	AG	VIERRA#1	1843T	95485	truck fill valve						Crown Packing. Vierra #1. Tag #1095. Call Bill or Jose. Two day notice. See photo
859	14S/02E-15N01	CSIP-SBA	P400	AG	MORO COJO#2	3538R4	95037	DL						Higashi Farms. Moro Cojo #2. Big yellow truck-fill. Call Peter. 2 da notice. See photo
1282	14S/02E-24P02	ACTIVE	P400	AG	BORONDA SCHOOLHOUSE#1	93258T		DL						Crown Packing. Boronda Schoolhouse well. Tag #1099. Call Bill Sullivan 214-4650 or Jose Luis Lepe 970-6889. Well next to house/metal shed on McFadden Road, close to elem. school. Two da
22929	14S/02E-28H04	ACTIVE	PDEEP	AG	JACKS YARD									New Deep aquifer well located .54 mi W of Cooper Rd & .27 mi S o McFadden Rd on the Nissen Rch

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

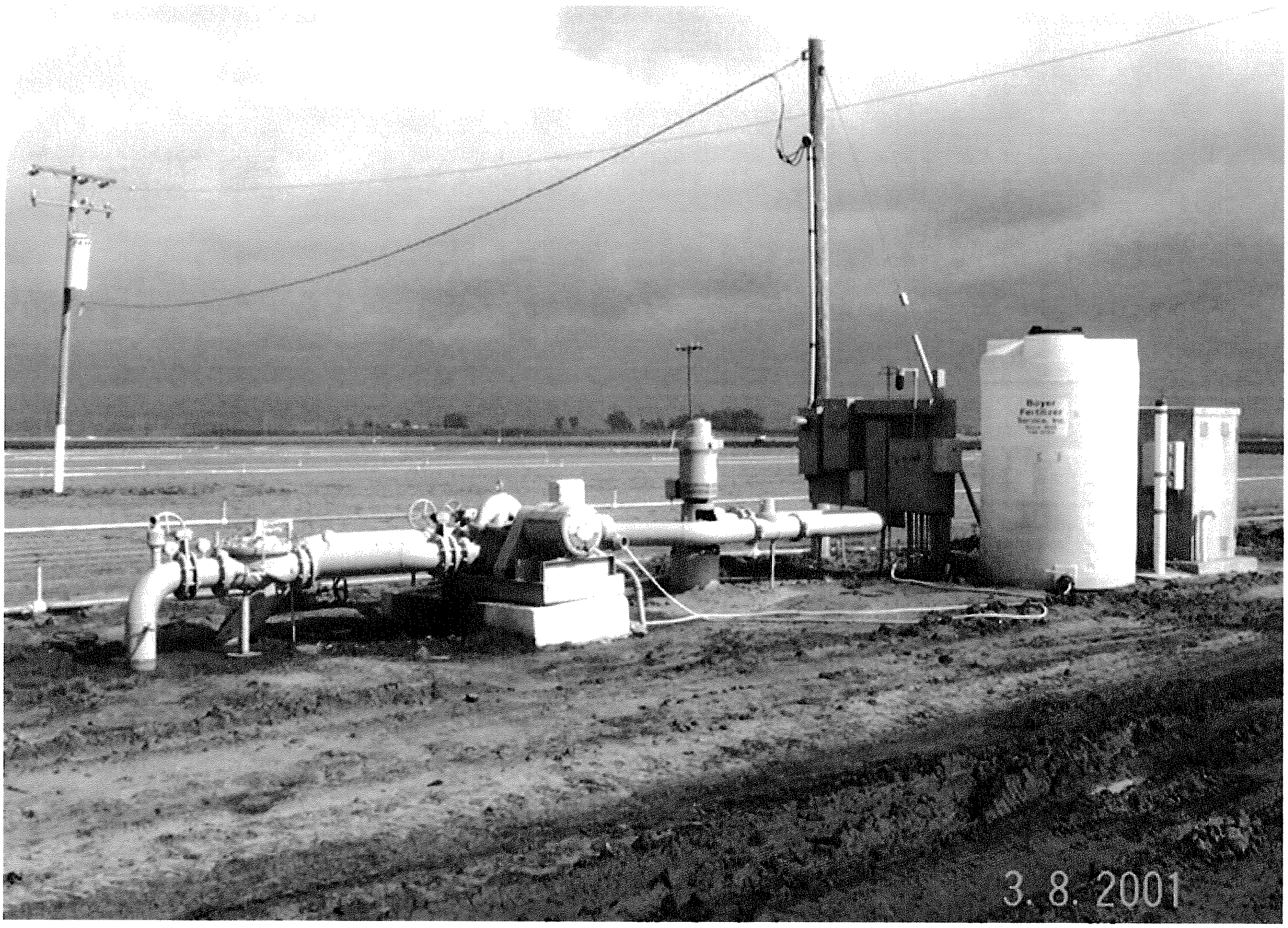
Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

					ANALYSES REQUESTED								
Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix[1] 1-Routine 2-Repeat 3-Replacement	No. of Containers	Coliform	MMO.....☐ Quanti..........☐ Low-D..................☐	Nitrate					

(1) **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery
Amount: ____________________
Check: ____________________
Initials: ____________________
Receipt #: ____________________
Date: ____________________

Sample comments (irregularities/preservation, billing information if different than reporting):


3. 8. 2001


3. 8. 2001

15S/04E-07A01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-08M04

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-15D02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-17P02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-19H03

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-20B02

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-26G01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

15S/04E-36H01

Sampling Date: Sampler:

Sampling Time:

Comments:
Complete General Mineral Analyses

APPENDIX C

REVIEW CHECKLISTS

Appendix C-1: Field Activities Review Checklist

Appendix C-2: Laboratory Data Review Checklist

Field Activities Review Checklist

Sampling Location(s):

Sampling Date:

Item	Yes	No	NA	Comment
All required information was entered into field sheets in ink, and sheets were signed and dated by the field sampler.				
Deviations from SOPs, along with any pertinent verbal approval authorizations and dates, were documented on the field sheets.				
Samples were collected at the correct sites.				
The correct number of samples for each type of analysis and the correct volume was collected (0.5 gal/ ~2L for complete mineral panel OR one pint/ ~0.5L for partial mineral panel).				
Acceptable sample containers, appropriate for the intended analysis, were used.				
Field blanks were collected, and at the correct frequency (one every 25 samples).				
Field duplicates were collected, and at the correct frequency (one every 25 samples).				
Samples were packed with double-bagged ice and transported at the proper temperature (4±2°C).				
Chain of custody (COC) documents were completed properly.				
Sample holding times were not exceeded during field operations. See Table 6 (QAPP).				

Reviewer's Name (print):

Reviewer's Signature:

Reviewer's Title:

Date of Review:

Laboratory Data Review Checklist

Sampling Location(s): ______________________________

Sampling Date: ______________________________

Item	Yes	No	NA	Comment
Samples arrived at the laboratory at the proper temperature (4±2°C).				
All requested analyses were performed and were documented in the analytical report.				
Analyses were performed according to the methods specified in the approved QA Project Plan.				
Holding times for extraction and analysis were not exceeded. See Table 6 (QAPP).				
Field Blanks results were below MDLs and were analyzed at a frequency of one every 25 samples.				
Field Duplicate results were ≤ 25% RPD and were analyzed at a frequency of one every 25 samples.				
Method detection limits were included in the report.				
A narrative summarizing the analyses and describing any analysis problems was included in the data report.				
Data qualifiers and flags were explained in the data report.				
Initial calibration data were within laboratory SOP defined acceptance criteria ($r^2 \geq 0.995$) for all analyses.				
Method blanks were performed at 3 per analytical batch, and were below MDL.				
Laboratory Control Sample (LCS) data were included for all analyses for every analytical batch.				
Laboratory Control Sample Results were within 80-120% recovery.				

Item	Yes	No	NA	Comment
Analytical Duplicate data were included for all analyses for every analytical batch.				
Analytical Duplicate results were < 25% RPD.				
Matrix spike data were included for all pertinent analyses for every analytical batch, and recoveries were within 75-125%.				
Matrix spike additions were at 3-10x the native.				
Matrix spike duplicates were ≤ 25% RPD.				
Continuing calibration data were within QAPP defined acceptance criteria (80-120% of initial slope) for all analyses.				

Reviewer's Name (print): ______

Reviewer's Signature: ______

Reviewer's Title: ______

Date of Review: ______

APPENDIX D

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY

QA MANUAL AND STANDARD OPERATING PROCEDURES

Appendix D-1: QA Manual

Appendix D-2: Specific Conductance, based on SM 2510 B

Appendix D-3: pH, based on SM 4500-H B

Appendix D-4: Total Alkalinity, based on SM 2320 B

Appendix D-5: Metals, based on SM 3111 B

Appendix D-6: Anions, based on EPA 300.0

TABLE OF CONTENTS

ORGANIZATION AND RESPONSIBILITY 2

QUALITY ASSURANCE OBJECTIVES FOR MEASUREMENT OF DATA............4

CUSTODY, HOLDING AND DISPOSAL OF SAMPLES......................................5

CALIBRATION PROCEDURES AND FREQUENCY 8

ANALYTICAL PROCEDURES 10

ACQUISITION, REDUCTION AND VALIDATION OF REPORTING DATA..........11

INTERNAL QUALITY CONTROL CHECKS 12

PREVENTIVE MAINTENANCE 14

PERFORMANCE AND SYSTEM AUDITS 16

REFERENCES 19

APPENDICES

ORGANIZATION AND RESPONSIBILITY

On October 11, 1988, the Monterey County Board of Supervisors, in Resolution No. 88-508, authorized the Director of the County Health Department and the General Manager of Monterey County Flood Control and Water Conservation District (MCFC&WCD) to consolidate laboratory services for their respective programs into one facility. A Laboratory Steering Committee, comprised of representatives from both agencies, was established for the purpose of providing the planning, operation, and future development of the Consolidated Environmental Laboratory.

Each year the Steering Committee develops a Memorandum of Agreement (MOA) that describes and confirms the services to be provided by the Health Department to the Water Resources Agency (formerly the Flood Control and Water Conservation District) and defines the responsibilities of each party. In addition to providing laboratory support for the Health Department and the Water Resources Agency, the Consolidated Chemistry Laboratory provides analytical services to the Monterey Regional Water Pollution Control District, the County Department of Public Works and numerous water supply systems and wastewater treatment facilities.

The Consolidated Environmental Laboratory is accredited by the State Department of to perform tests in the following fields: 1) microbiology of drinking water and waste water; 2) inorganic chemistry and physical properties of drinking water; 3) analysis of toxic chemical elements in drinking water; 4) wastewater inorganic chemistry, nutrients and demand; and 5) toxic chemical elements in wastewater. A list of analyses and methods used in the laboratory is included in Appendix A.

The following is a brief description of the staff support for the Consolidated Chemistry Laboratory:

1. Director - Plans, organizes and controls laboratory operations. Coordinates laboratory interactions with other programs in the Health Department. Administers laboratory budget, billing and purchasing. Develops laboratory policy and procedures and supervises staff.

2. Public Health Chemist – Principal analyst. Performs complex organic and inorganic chemical analysis, evaluates and implements laboratory methods, develops and maintains quality assurance, reports results and maintains records, purchases equipment and supplies, provides technical consultation to Environmental Health and Water Resources Agency. Trains analysts and documents competency

3. Water Quality Specialist- Performs broad range of professional scientific work related to water quality and environmental issues; is proficient in

performing water quality analyses and managing the laboratory water quality database. Interpret and explain regulatory guidelines to clients.

4. Public Health Microbiologists - Assist Public Health Chemist in performing microbiological analyses and performing quality control.

5. Laboratory Assistant - Prepares culture media and reagents, assists in the processing of specimens, performs low to moderately complex environmental analyses and clinical analyses where interpretation or medical judgement is not required.

5. Laboratory Helper - Washes and sterilizes glassware and supplies. Prepares and labels mailing containers and specimen collection kits. Accession laboratory specimens. Sterilizes and disposes infectious waste. Maintains stockroom.

6. Typist-Clerk II - Enters clients and laboratory results into computer. Prints reports/forms. Prepares billing statements; receives and accounts for payments. Distributes laboratory results, and maintains laboratory files.

QUALITY ASSURANCE OJECTIVES FOR MEASUREMENT OF DATA

Quality Assurance (QA) includes all aspects of laboratory operation that affect the accuracy and reliability of sample test results. In addition to quality control of the analytical test process, quality assurance practices include: 1) proper sample collection, receiving and holding, 2) proper maintenance of equipment, 3) accurate data reduction, validation and reporting; and, 4) periodic performance and systems audits.

CUSTODY, HOLDING AND DISPOSAL OF SAMPLES

Quality assurance includes proper labeling of samples, proper completion of the chain of custody/analysis request form, proper collection, preservation and storage of samples, proper accessioning of samples, and proper disposal of the sample.

1) Sample Collection/Labeling. Sample collection is a coordinated effort between the client and the laboratory. The laboratory will provide clients with appropriate sample containers and sample collection/preservation instructions. The laboratory will also request duplicates and blanks according to client's sample plan requirements. All samples submitted for testing should be appropriately labeled. Sample containers provided by our laboratory have a suitable label which should be filled out at the time of sampling by the sample collector. The following information must be provided with all samples:

    a) Sample identification - submitters identification of sample (e.g. well number)

    b) Location - an address or brief description of the place the sample was taken.

    c) Time and date taken.

    d) Name of sample collector.

    e) Any preservatives

2) Chain of Custody/Analysis Request Form. A Chain of Custody/Analysis Request form should accompany all samples (see Appendix B). The Chain of Custody/Analysis Request form must include the following information: submitter name and address; sample identification; location of sample collection; date & time of collection; sample type; analysis to be performed; signatures of persons involved in the collection and chain of possession; and inclusive dates of possession.

3) Sample Receiving. Laboratory personnel receiving samples should assure that samples are properly collected, labeled, and the Custody/Analysis Request form has been completed:

    a) The laboratory assistant receiving the specimen must sign and date the Custody/Analysis Request form. Make sure that any special requests made by the client are recorded under the comments section of the form

    b) Assign each sample a unique laboratory identification number. Place preprinted lab number on analysis request form and sample container. When a sample is collected in multiple containers for different analyses, each container should receive the same laboratory number. (Exception: sample containers for analytes requiring a rapid turnaround time (e.g. coliforms) may receive separate number to expedite reporting).

c) Check that the samples meet the criteria described in Table 1006:I Summary of Special Sampling or Handling Requirements in 18th ed. of *Standard Methods for the Examination of Water and Wastewater* (Appendix C)

   i) Samples should be collected in a suitable container; samples collected in bottles of unknown origin or questionable cleanliness should be brought to the attention of the Water Quality Specialist or the Public Health Chemist.

   ii) Samples should be adequately labeled

   iii) Samples should be checked for proper preservative, holding time, and holding temperature.

   iv) Samples should be adequately sealed. Notify public health chemist if there is evidence of leakage. Verify that adequate sample volume exists to perform requested analysis.

d) NOTE: Samples that are not properly identified or are otherwise unsuitable for testing (e.g. improperly preserved or exceeding holding/ transport time) are recorded on the "Sample Invalidation Log" and the Water Quality Specialist or Public Health Chemist notifies the client. Samples not meeting collection/preservation criteria may be tested only if resampling is impossible; results from such samples must be qualified on the laboratory report by comments describing sample deficiency.

4) When the sample meets criteria for acceptance by the laboratory, required preservatives are added immediately and the sample is stored under conditions specified by the analytical method to be used. For samples requiring thermal preservation, a laboratory refrigerator and freezer is available. The temperature is maintained at 4 degrees and below -10^{o}C respectively. Temperatures are monitored each day.

5) Chain of Custody/Analysis Request forms are given to the clerk to enter into a password protected computer laboratory information management system. Refer to "Water Sample Entry" in Clerical Manual for instructions on sample log-in.

6) Disposal of samples: Upon completion of all analyses, any remaining

sample will be stored for at least one month prior to disposal. Chain-of-Custody form, worksheets and lab reports are retained for three years. NOTE: Longer retention of samples or data may be required when legal action is probable. The samples and any associated extracts or digests are disposed of following recommendations found in the book, *Prudent Practices for Disposal of Chemicals from Laboratories*, National Academy Press, Washington, D.C. 1983.

CALIBRATION PROCEDURES AND FREQUENCY

Calibration is the process for determining the correctness of the assigned values of the physical standards used or the scales of the measuring instruments. Calibration accuracy is critically dependent on the reliability of the standards used for the required comparisons. Only the highest quality chemicals are used to provide necessary standard solutions, and due care is exercised in their preparation. The concentrations of the calibration standards bracket the expected concentration of the analyte in the samples. No data is reported beyond the range of calibration of the methodology. The calibration data, when plotted graphically, is referred to as a calibration curve. The calibration must be done under the same instrumental and chemical conditions as those that will exist during the measurement process. The frequency of calibration depends on the accuracy requirements of the investigation and the stability of the instrument used for the measurements:

At a minimum, three different dilutions of the standard will be measured when an analysis is initiated. Correlation coefficient must be > 0.995. Reportable analytical results are those within the range of the standard dilutions used. Do not report values above the highest standard. The lowest reportable value is the Method Detection Limit (MDL), providing that the lowest calibration standard is less than 10 times the MDL.

1) Atomic Absorption Spectrophotometers - Two approaches are used to calibrate atomic absorption spectrophotometers. These methods are direct comparison and standard additions.

    a) Direct comparison is the simple approach, and can be used with many instruments to give a direct readout of the concentration of an element in an unknown sample. To obtain good precision (e.g., 1-2% coefficient of variation), the absorbance levels measured must be about 0.1 to 0.6 units. Standard and sample solutions should be similar in bulk matrix constituents, particularly acid and salt content. Interference suppressants are used in all solutions when required. A number of standards (usually three to five in increasing concentration) as well as a blank, are prepared to cover the concentration range. A volume of type II reagent water with the same amounts of acids as the samples and standards) will be used for calibration blank. These solutions are run in absorbance to check linearity of the calibration curve.

    b) The method of standard additions is used when samples contains severe matrix interference. In this case it is possible to add small amounts of conventional standard solutions, in increasing amounts, to aliquots of each sample. A calibration graph can then be constructed. This method will often be used in work with the graphite furnace.

2) UV-VIS Spectrophotometer - The calibration procedure for the UV-VIS spectrophotometer is similar to that for the A.A. spectrophotometers. An integration interval is not required as the signal is very stable. It is important to use blanks and allow at least 1/2 hour warm up time.

3) PH Meters - The proper calibration of pH meters requires the use of two buffer solutions and a thermometer. The two buffer solutions must cover the expected range of samples to be tested. A third buffer is used to confirm calibration. The pH meter should be calibrated each day. The temperature of the buffers must be entered into the meter.

4) Conductivity Meter - The conductivity meter does not require frequent calibration but should be checked against a known standard each day of use. Recalibrate when there is significant deviation with the value of the standard.

5) Ion Chromatograph- Calibration of the Ion Chromatograph is performed at least once each year and whenever: 1) Controls are out of range; or, 2) the column, suppressor or detector is changed.

6) Inductively Coupled Plasma/Mass Spectrometer – Calibration of the ICP-MS is performed every day of analysis and whenever controls are out of range. See the SOP for more information.

ANALYTICAL PROCEDURES

The laboratory employs only methods approved by Environmental Laboratory Accreditation Program. Analysts must conduct sufficient preliminary tests using the methodology and typical samples to demonstrate competence in the use of the measurement procedure.

Each time an analytical procedure is performed controls are included and duplicate samples and known additions are tested to insure accuracy and precision. Results are not reported unless all controls are within acceptance limits referenced in Standard Methods 18th Edition, 1992.

To monitor reliability of analytical measurements, data is periodically obtained on detection limits, accuracy, precision and recovery.

ACQUISITION, REDUCTION, VALIDATION OF REPORTING DATA

The analytical chemist is responsible for describing and reporting the data in an appropriate manner. In order to insure the accurate transcription, calculation and reporting of analytical data, the chemist will adhere to the following quality assurance procedures.

1) Use documented procedures and record all significant experimental details in such a way that the measurements could be reproduced by a competent analyst at a later date.

2) All measurements are made so that results are representative of the matrix (soil, water, etc.) and conditions being measured.

3) Report data only to the number of significant figures consistent with their limits of uncertainty.

4) Report data with the proper units of concentration. Units should be chosen which clearly indicate whether the concentration is in terms of weight by weight, weight by volume or volume by volume. Unless otherwise specified, all data are calculated and reported in standard units to allow comparison with data reported by other laboratories.

5) The analytical methodology used will be cited. The raw data for each sample, along with reagent blanks, control, and spiked samples will be suitably identified if included in the report. If average values are reported, an expression of the precision, including the number of measurements, must be included.

6) The report should include date and place of sampling, sampling point, the name of the sample collector, identification as to type of sample, date and time of submittal to the lab, date of analysis, name of the analyst, and the result. Any conditions which may effect the interpretation of the data should be noted in the report.. All results will be reviewed by a Water Quality Specialist or Public Health Chemist before a final report is released.

7) Laboratory records will be retained in a permanent file for three years.

8) Retain samples for one month after issuing final report and retain data and documentary evidence for three years.

INTERNAL QUALITY CONTROL

Quality Control (QC) may be defined as those measures undertaken in the laboratory to maintain the analytical testing process within acceptable limits of accuracy and precision.
The Quality Control Program consists of the following elements: documentation of operator competence, recovery of known additions, analysis of externally supplied standards, analysis of method blanks, and testing of replicate samples:

1) Operator competence The principal analyst is responsible for: 1) developing a standardized training syllabus for the methods employed in the laboratory; 2) assuring that test personnel are adequately trained; 3) assessing the competency of test personnel, and 4) maintaining documentation of training and competency of all test personnel.

   a) Before test personnel are permitted to do reportable work , competency in performing the analysis is to be demonstrated. Commonly, the analyst performs replicate analysis under the supervision of the principal analyst. General limits for acceptable work are found in Standard Methods 18th Edition, 1992 in Table 1020 :I.

   b) After initial demonstration of competency, the principal analyst will assure test personnel maintain competency through testing internal or external proficiency test samples at least once each year.

2) With each batch of samples tested, controls will be tested to verify the accuracy of results as described below. Controls used with each method are outlined in Appendix D.

   a) Recovery of known additions as part of all regular analytical protocols except titrimetric and gravimetric methods. Use known additions to verify the absence of matrix effects. Spiked samples shall be analyzed with a minimum frequency of ten percent of the samples per matrix per batch of samples. Spike recovery must be between 80-120% for potable water (75-125% for waste water). When a spike sample fails to meet this criteria, retest all samples following the last acceptable spike sample. Spike recovery calculated as % of the known addition recovered.

   b) Analyze control standards with a minimum frequency of ten percent of the samples per matrix, per batch of samples. If there are less than 10 samples in a batch, at least one per matrix per batch must be analyzed. The concentration of the sample shall be within the working range of the method. Sources of these samples include but are not limited to: performance evaluation samples from the EPA, commercially available standards, or standards prepared in-house but from sources different from calibration standard. Control standards must be within the published acceptance range (for external controls). If the control standard does not have a published acceptance range, recovery of the control should be within 10% of the known value. When a control standard fails to meet this criteria, retest all samples following the last acceptable control.

c) Method blanks will be analyzed with each batch of samples. The use of method blanks provides a measurement of laboratory contamination. Blanks cannot exceed the minimum detection level. See Appendix A.

d) Replicate samples will be analyzed with a minimum frequency of ten percent of samples per matrix, per batch of samples for drinking water. For wastewater the requirement is 5%. If there are less than ten samples per batch, at least one sample per matrix per batch must be analyzed. If the analyte is not detected, replicate matrix spike samples will be analyzed. The percent difference between replicate samples must be within 20% for potable water (25% for wastewater). When a replicate sample fails to meet this criteria, retest all samples following the last acceptable replicates. Duplicate % difference calculated as the difference as a percent of the mean. [100(X1-X2)/avg].

e) In addition to the control standards tested with each run, an external reference standard for each analyte will be tested at least once each quarter.

All of the quality assurance control procedures will be followed in the laboratory. All documentation for these checks should be available for inspection by laboratory management.

PREVENTIVE MAINTENANCE

As part of the QA plan, the laboratory has a comprehensive preventive maintenance program. Balances, spectrophotometers, and other instruments undergo routine maintenance and accuracy checks by a manufacturer's representative or by laboratory personnel as described below. All preventive maintenance performed in-house is documented on preventive maintenance forms. Instrument s which undergo routine professional maintenance have labels affixed to indicate date of last servicing. Manufacturer's instructions and service manuals are readily accessible.

Adequate spare parts are kept on hand to perform routine maintenance and minimize downtime. The spectrophotometers have maintenance contracts that provide for immediate servicing in the event of malfunction. Equipment records documenting preventive maintenance and emergency servicing/repairs are kept for a minimum of three years.

1) Thermometer/temperature-reading instruments: Accuracy of thermometers or recording instruments are checked annually against a certified National Bureau of Standards (NBS) thermometer or one traceable to NBS and conforming to NBS specifications. All thermometers a relabeled with date calibrated and correction factor.

2) Balance: Balance accuracy is verified each week using ASTM type 1 reference weights. Accuracy checks are documented on preventive maintenance chart. Balances are serviced and certified annually through a maintenance contract. Type 1 weights are re-certified at least every five years.

3) pH meter: pH meters are standardized with at least two NIST traceable standard buffers (pH 4.0, 7.0, or 10.0) and compensated for temperature before each series of tests. A third buffer is used to confirm calibration. Date buffer solutions when opened and discard buffer after expiration date on bottle. Buffers prepared from powders are replaced after four weeks.

4) Water deionization unit: Conductivity of the RO and Nanopure water is checked each month. A heterotrophic plate count on Nanopure water is also performed monthly. Filters are changed as indicated by conductivity readings and heterotrophic plate count. Records are maintained on preventive maintenance chart. Water is tested annually for bacteriologic quality and heavy metals.

5) Autoclave: Autoclave charts are used to document date, time, temperature and contents of each load. Chem-di indicators and heat sensitive tape are used with each load to identify materials that have been autoclaved; results are recorded on autoclave chart. Autoclave performance is

checked each month with biological indicator (e.g. spore suspension). Autoclaves are serviced quarterly under maintenance contract. The accuracy of autoclave recording thermometer is checked annually. The autoclave operating temperature is monitored on a weekly basis.

6) Refrigerator: Temperatures are recorded daily and units defrosted and cleaned as needed. All media and reagents stored in the refrigerator are labeled.

7) Freezer: Temperatures are recorded daily. Identify and date materials stored. Defrost and clean semiannually; discard outdated materials.

8) Ultraviolet sterilization lamps: Unit is cleaned monthly by wiping lamps with a soft cloth moistened with ethanol. Test lamps quarterly with UV light meter and replace if they emit less than 70 % of initial output or if agar spread plates containing 200 to 250 microorganisms, exposed to the light for 2 minutes, do not show a count reduction of 99%.

9) Water bath: Fecal coliform water bath is checked twice daily. All other water baths are checked each day of use.

10) Incubator: Check and record temperature twice daily (morning and afternoon) on the shelf areas in use. Locate incubator where room temperature is in the range of 16 to 27O C.

11) Fume hoods/Biological Safety Cabinets: Fume hoods are checked once each month using a velometer; readings are recorded on preventive maintenance chart. Hoods and safety cabinets are certified annually through service contract.

PERFORMANCE AND SYSTEMS AUDITS

Corrective action is required when data is outside of predetermined limits for acceptability. The corrective actions can be triggered by the following quality assessment activities: Control Chart analysis; proficiency evaluation testing; and QA audits.

1) CONTROL CHART ANALYSIS:

The laboratory's quality assessment techniques will be used to maintain the precision and accuracy of all laboratory analyses within a state of statistical control. Precision and accuracy measurements are the best way to assess analytical performance. Precision is the degree of reproducibility of a particular analytical procedure. Accuracy is a measure of the agreement between an experimental determination and the true value.

a) PRECISION - Assess precision by replicate analysis, by repeated analysis of a stable standard, or by analysis of known additions to samples. Precision is specified by the standard deviation of the results. The formula for determining standard deviation (SD) is:

$$SD = \sqrt{\Sigma}\ (X1-X)^2/(N-1)$$

X1 is the value of the individual measurements; X is the mean of all measurements for a given sample and N is the number of measurements.

The purpose of determining precision is to establish the typical variance of the method in the absence of any matrix influence. In the course of determining precision, there are two cases that indicate there is a problem with the precision data:

i) The measured values show wide variation from one to another for a given day.

ii) The measured values show little variance from one to another for a given day, but the mean and standard deviation show wide variation from one day to another.

If either of the above occurs, factors such as sample homogeneity, instrument calibration, or analyst error should be checked, documented, and corrected. The precision measurements should then be repeated.

b) ACCURACY - The best method to determine accuracy is to spike an alequot of reagent water with a known amount of the constituent being measured and analyze the sample. The amount spiked should be at least five to ten times greater than the analytical detection limit.

To evaluate the data accuracy, the percent recovery of the spike must be determined. The formula for determining percent recovery is:

$$\% \text{ recovery} = [100(S - S1) \div S2]$$

Where S is the concentration of the spiked sample; S1 is the concentration of the unspiked sample; S2 is the concentration of the spike added to the sample.

If the percent recovery deviates significantly from 100% and the method has not demonstrated significant bias, the problem must be detected and corrected prior to continuing the analysis. Sources of this problem include incorrect standard or spike solution concentration or a problem in the procedural detection system.

Precision, accuracy, and detection limits for all methods used in the laboratory is comparable to values referenced in Standard Methods 18th Edition, 1992 and EPA Methods for Chemical Analysis of Water and Wastes, March 1983.

2) PERFORMANCE EVALUATION SAMPLES: The laboratory director is responsible for enrolling the laboratory in ELAP approved proficiency testing program(s) and assuring that proficiency testing is performed for all regulated tests. The principal analyst (Public Health Chemist) will conduct and document internal proficiency testing at least once a year for tests where proficiency testing is not available. Proficiency test samples are treated in the same manner as routine samples (ie. tested the same number of times, tested using personnel who routinely perform testing, tested using routine methods and tested during patient testing).

3) QUALITY ASSURANCE AUDIT: The quality assurance program will be audited quarterly and any deviations from the program will signal corrective action to be taken. Quality assurance audit will be documented in a written report. The audit will include the following aspect:

   a) Competency of test personnel must be evaluated annually and be documented

   b) Evidence of the systematic use of control samples, replicate measurements and reference materials all in conjunction with control charts.

   c) Proper labeling of reagents and samples.

   d) Use of approved methods.

e) Results on blind samples.

f) Acceptable safety equipment and procedures.

g) Quality assurance reports generated on a regular basis.

h) Documentation on equipment performance and maintenance.

i) Training records.

j) All relevant files accessible and organized.

k) Laboratory personnel following good laboratory practices.

l) Laboratory personnel following good measurement practices

The Public Health Chemist will be responsible for initiating and documenting any corrective action necessary. Corrective action will be documented on the appropriate control chart, performance evaluation report, or QA audit report. No data shall be reported until the cause of the problem is located and corrected or the laboratory demonstrates the cause was a random event and no longer affects data. Although the elimination of events requiring corrective action may not be achieved, a reduction in the repetition of these events is the objective of this program.

REFERENCES FOR QUALITY ASSURANCE DOCUMENT

1) Standard Method for the Examination of Water and Wastewater, 18th edition, 1992.

2) Handbook for Analytical Quality Control in Water and Wastewater Laboratories. EPA-600/4-79-019, March 1979, USEPA.

3) Manuals for the Certification of Laboratories Analyzing Drinking Water Criteria and Procedures/Quality Assurance. EPA QAMS-005/80, Interim Guidelines, EPA-570/9-82-009, USEPA.

4) Methods for Chemical Analysis for Water and Waste. EPA-600/4-79-020, March 1983.

Written by: Gerry Guibert & David Holland

Date: May 1993

Revised: January 1999
Revised: September 21, 2004

Approved by: ______________________________

(Laboratory Director's Signature)

Appendix A

Monterey County
Consolidated Chemistry Laboratory

ANALYTICAL METHODS FOR WATER ANALYSIS

PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Free Chlorine	.25 h; ASAP	SM 4500-Cl G	0.02	mg/L
Total Chlorine	.25 h; ASAP	SM 4500-Cl G	0.05	mg/L
Enterococcus	8 h	IDEXX	1/100 ml	
Heterotrophic Plate Count	8 h	SM 9215 B	1	CFU
E. coli – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Fecal Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	1/100 ml	
Total Coliform – MPN	6 h waste 8 h source 30 h potable	SM 9221 B	2/100 ml	
Total Coliform – Quantitray	6 h waste 8 h source 30 h potable	SM 9223	1/100 ml	
E. coli – Presence/Absence	30 h potable	SM 9223	1/100 ml	
Total Coliform – P/A	30 h potable	SM 9223	1/100 ml	
pH	.25 h; ASAP	SM4500H B		pH units
Bicarbonate	ASAP (with pH)	SM 2320 B	10	mg/L
Calcium Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Carbonate	ASAP (with pH)	SM 2320 B	1	mg/L
Solids	24 h	SM 2540 F	0.1	mL/L
Color Determination	48 h	SM 2120 B	2	CU
Odor	NS; 48 h (rec 6h)	SM 2150 B	1	TON
Turbidity	48 h	SM 2130 B	0.05	NTU
Nitrate	48 h	EPA 300.0	1	mg/L
Nitrite as (N)	48 h	SM 4500 NO2-B	10	ug/L
Total Dissolved Solids	7 d	SM 2540 C	5	mg/L
Total Suspended Solids	7 d	SM 2540 D	5	mg/L
Alkalinity	14 d	SM 2320 B	1.0	mg/L, CaCO3
Bromide	28 d	EPA 300.0	1	mg/L
Chloride	28 d	EPA 300.0	1	mg/L
Fluoride	28 d	EPA 300.0	0.02	mg/L
Sulfate	28 d	EPA 300.0	1	mg/L
Conductivity	28 d	SM 2510 B	1	umhos at 25C
Ammonia (N)	28 d	SM 4500 NH3 F	0.05	mg/L
Orthophosphate	NS; 28 d	SM 4500 P E	0.03	mg/L
Total Phosphorus	28 d	SM 4500 P E	0.03	mg/L

PARAMETER	HOLD TIMES	METHOD REFERENCE	MDL	UNITS
Aluminum	6 months	EPA 200.8	5	ug/L
Antimony	6 months	EPA 200.8	0.5	ug/L
Arsenic	6 months	EPA 200.8	1	ug/L
Barium	6 months	EPA 200.8	0.5	ug/L
Beryllium	6 months	EPA 200.8	0.5	ug/L
Cadmium	6 months	EPA 200.8	0.5	ug/L
Chromium	6 months	EPA 200.8	5	ug/L
Copper	6 months	EPA 200.8	0.5	ug/L
Iron	6 months	SM 3111B	100	ug/L
Lead	6 months	EPA 200.8	0.5	ug/L
Manganese	6 months	EPA 200.8	0.5	ug/L
Mercury	6 months	EPA 200.8	0.25	ug/L
Nickel	6 months	EPA 200.8	0.5	ug/L
Selenium	6 months	EPA 200.8	5	ug/L
Silver	6 months	EPA 200.8	5	ug/L
Thallium	6 months	EPA 200.8	0.5	ug/L
Zinc	6 months	EPA 200.8	5	ug/L
Calcium	6 months	SM 3111B	1.0	mg/L
Magnesium	6 months	SM 3111B	0.1	mg/L
Potassium	6 months	SM 3111B	0.1	mg/L
Sodium	6 months	SM 3111B	0.1	mg/L
Hardness as CaCO3	6 months	SM 2340 B	1.0	mg/L
Boron	6 months	SM 4500 B B	0.1	mg/L

Appendix B

ENVIRONMENTAL ANALYSIS REQUEST FORM

MONTEREY COUNTY CONSOLIDATED CHEMISTRY LABORATORY
1270 NATIVIDAD ROAD, SALINAS, CALIFORNIA 93906 Phone (831) 755-4516

Shaded areas for laboratory use only

Chain of Custody:

Collected by (Print & sign):	Received by:	Date & Time:
Relinquished by:	Received for Laboratory:	Date & Time:

Client Name:	Report Attention:	
Address:	Copy to:	
City, State, Zip:	Phone:	Fax:

Laboratory Number	Sample ID or System #	Sample Site or Description	Collection Date & Time	Matrix[1] 1-Routine 2-Repeat 3-Replacement	ANALYSES REQUESTED							
					No. of Containers	Coliform MMO..... ☐ Quanti............ ☐ Low-D................. ☐	Nitrate					

[1] **D**=Drinking Water (Specify as routine, repeat or replacement) **W**=Wastewater (Specify as grab or composite) **O**=Other (identify)

[ ] Payment received with delivery

Check: ____________________

Receipt #: ____________________

Amount: ____________________

Initials: ____________________

Date: ____________________

Sample comments (irregularities/preservation, billing information if different than reporting):

SPECIFIC CONDUCTANCE
EPA 120.1/SM 2510 B
umhos at 25°C

Scope and Application:

This method is applicable to drinking, surface and saline waters, domestic and industrial wastes and acid rain.

Summary of Method:

The specific conductance of a sample is measured by use of a self-contained conductivity meter, the YSI Model 32. The conductivity meter is used in the temperature compensated mode.

Sample Criteria & Acceptability:

A minimum of 100 ml sample should be submitted in a clean container provided by the laboratory. Samples can be stored for up to 28 days at 4oC. The samples must be brought to room temperature before testing. If the sample does not meet the above criteria, document it on the worksheet but perform the test.

Reagents:

0.02 Molar Standard Potassium Chloride Solution:

1. Dry 0.85 g of Reagent Grade Potassium Chloride (KCl) for 4 hours at 105°C. Use immediately or store in a desiccator until use.
2. Dissolve 0.7456g of pre-dried potassium chloride in a 1 liter Class A volumetric flask using deionized water.
3. Label the flask with Potassium Standard Solution, 0.7456 g KCl/L, date made, outdate of 3 months, and initial.
4. Alternately, order two 500 ml containers of the Traceable Conductivity Calibration Standard near the 1414 micromho/cm range; from Fisher Scientific, Cat No. 09-328-11.

Control

1. Check deionized water. It should read less than 1 umho. If the reading is higher, clean cell and repeat reading of deionized water. If reading is still high, notify the Chemist.
2. Use current Quality Control sample with each run. The control must be in range before proceeding with specimens. The 0.01 M KCl can be used as control.

Conductance Meter Maintenance:

1. Store cell in deionized water. If the cell has been stored dry, soak in deionized water for 24 hours.
2. Check the platinum black coating on the electrode. If the coating appears thin or if it is flaking off the electrode, the cell should be cleaned and the electrodes replatinized. See "Instruction Manual YSI Model 32 Conductance Meter" pages 11 and 12 for instructions.
3. The electrode should be cleaned and replatinized every four months. Record the preventative maintenance on the "PM Worksheet".

Conductance Meter Calibration Check:

Instrument must be standardized with KCl solution before daily use.

1. Pour 50 ml of the standard potassium chloride solution into a 250 ml beaker. Alternately, immerse the conductivity cell and thermometer in the Rinse Bottle, then transfer to the Read Bottle for actual reading
2. Immerse conductivity cell in sample. The electrodes must be submerged and the electrode chamber must be free of trapped air. Tap the cell to remove any bubbles, and dip it two or three times to assure proper wetting.
3. Rotate the Range Switch to the lowest range position that gives a reading (within range) on the display. An over-range value is indicated by a "1" followed by blanks. An under-range value is indicated by a reading followed by a small letter "u". Readings may be in error when operating in the under range conditions. On the 0.1 – 2 micromho range; allow extra time to stabilize.
4. The conductance value of the solution is displayed on the meter. The units in which it is to be read are determined by the Range Switch, either in mU or in uU (or milli and micro siemens).

   2 uU, 20 uU, 200 uU reading = final result
   2 mU, 20 mU, 200 mU readings x 1000 = final result

5. Use the table below to check accuracy of cell constant:

Conductivity of 0.01 M KCl

Temperature in Centigrade	Micro-omhos/cm
21	1305
22	1332
23	1359
24	1386
25	1413
26	1441
27	1468
28	1496

6. If the standard is within range, rinse the cell three times with deionized water, and start testing unknowns as described in steps 2-4.

Reporting:

Report results to three significant figures. Report in units of micromhos per centimeter at 25 °C

References:

1. Instruction Manual YSI Model 32 Conductance Meter", Item 060818, PN A32018 R, October 88 EP
2. Methods for Chemical Analysis of Water and Wastes", EPA- 600: 4-79-020, March 1983, pages 120.1-1 to 120.1-3.
3. "Standard Methods for the Examination of Water and Wastewater", 18th Edition, 1992.

Written by: David Perez, Date: February 1993
Revised: January 12, 2007

Approved by:______________________________
Chemist

pH
SM 4500-H B
Electrometric

Scope and Application
Application to drinking, surface, ground and saline waters as well as acid rain, and wastewater (domestic and industrial.

Principle of Operation
pH is defined as the negative logarithm of the hydrogen ion concentration in moles per liter. The pH scale goes from zero to fourteen with a value of seven units to be considered neutral. Values below seven are acid; values above seven are basic. It is important to note that a one-unit change in pH represents a ten-fold change in the concentration of the hydrogen ion.

pH has a great impact on almost all biological and chemical processes used for water and wastewater treatment, and proper measurement of this value is critical. pH is measured using a pH meter consisting of a potentiometer, glass pH electrode, reference electrode and temperature compensating device. When calibrating the instrument, use two buffers that bracket the expected pH value for greatest accuracy.

Specimen collection and Handling
Collect sample in plastic or glass container. Test sample immediately upon receiving and/or within two hours after collection.

Instrument Calibration:
Two buffer calibration:

1. Fill a 50 ml beaker with up to 30 ml of pH 7 buffer. Add a stir bar and set the knob on the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 7 buffer; make sure that the reference electrode is filled with KCl and is open. Allow the electrode to equilibrate for 5 minutes.

2. Release Standby button and press the pH button. Measure the temperature of the buffer solution and set the temperature control. Turn the large slope knob to 100 and the inner know fully clockwise.

3. Adjust the calibration control until the readout displays 7.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

4. Fill a 50 ml beaker with up to 30 ml of pH 4 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 4 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button.

5. Adjust the slope knob until the readout displays 4.00. Press the mv button and record the mv reading on the worksheet. Remove electrodes from the buffer and rinse with deionized water.

6. Fill a 50 ml beaker with up to 30 ml of pH 6.86 buffer. Add a stir bar and set the knob n the magnetic stirrer to the second line on the dial (slow spin). Place the electrode in the pH 6.86 buffer and allow the electrode to equilibrate for 5 minutes. Press the pH button and record the result on the worksheet and quality control graph. PH should be 6.86 ± 0.1; notify chemist if out of range.

7. Rinse the electrodes with deionized water.

8. Record mv readings of calibration buffers. Calculate change in millivolts and divide by 3. The result should be 58 ± 2 mv.

9. If the slope is within limits, begin testing unknowns. If the slope is out of range, re-calibrate the pH meter. If the second calibration slope is out of range, notify the chemist.

Controls

1. Run every tenth specimen in duplicate. The duplicates should be within 20% of each other.

2. Check the 6.86 control buffer after every tenth specimen. Record the results on the worksheet and quality control chart.

Procedure

Once the pH meter has been calibrated, the unknown samples can be tested.

1. Pour 30 ml of unknown (or 50 ml of unknown if also testing for alkalinity) into a 150 ml beaker containing a small stir bar. Start the stirrer. Keep the automatic stirrer at a constant moderate rate (The speed is marked on the dial by a pen marking).
2. Allow the display to stabilize, and record the results on the worksheet.
3. Rinse the electrode with deionized water between specimens. Blot dry with a ‘kimwipe’. Do not rub the electrode; the static electricity can alter readings.

Reporting

Report the result to the nearest tenth (0.1).

References:

1. “Method for Chemical analysis of Water and Wastes”, EPA 600/4-79-020, Revised March 1983.
2. Standard Methods for the Examination of Water and Wastewater 18th edition 1992

Written by: David Perez
Date: December 1994

Approved by: ____________________________
Chemist

Total Alkalinity
SM 2320 B
Titration

Principle

Total alkalinity is defined as the acid-neutralizing capability of water. It is reported as due to bicarbonate (HCO3), carbonate (CO3), and hydroxide (OH). Unaltered sample is titrated potentiometrically to pH 8.3 endpoint for "carbonate" alkalinity and 4.5 endpoint for "bicarbonate" alkalinity.

Note: Samples with a pH less than 8.3 (i.e. most drinking water samples) are reported as having non-detectable hydroxide and carbonate alkalinity; for these samples total alkalinity is due entirely to the bicarbonate content of the water. Bicarbonate alkalinity (as HCO3) can be calculated from total alkalinity (as CaCO3) by multiplying by a factor of 1.22.

Applicable to drinking and surface waters, domestic and industrial wastes, and saline waters.

Sample Criteria & Acceptability

Samples should be submitted in clean containers provided by the laboratory. A minimum of 100ml of sample should be submitted for testing. Samples, which cannot be tested within 24 hours of collection, should be stored at 4°C and tested within 14 days. If any sample does not meet the above criteria, document it on the worksheet but perform the test.

Equipment

1. pH meter that can read to 0.05 pH units.
2. Two 1,000 ml Class A volumetric flasks.
3. Magnetic stirrer and magnetic stir bars.
4. Two 100 mL beakers.
5. One 250 mL flask
6. One 50 mL graduated cylinder

Reagents

The day before preparing standardize sulfuric acid, dry 0.1 g of Tris Buffer for at least 3 hours at 103 C (overnight is acceptable). After drying, immediately weigh out the Tris buffer. If that is not possible, store the reagent in the desiccators until used.

1. Standardized 0.02 N H_2SO_4 (sulfuric acid) + 0.004 units:

   The concentrated H_2SO_4 and stock 1.0 N H2SO4 may be found in acid cabinet below hood.

   a. Prepare a 1.0 N H H_2SO_4 Stock Solution: Fill a 1,000 ml Class A volumetric flask three quarters full with deionized water. Carefully add 28.0 mL of concentrated H_2SO_4 using a 25 mL and 3 mL Class A volumetric pipette. Fill to the mark with deionized water and mix. Transfer to plastic bottle and label as 1.0 N H_2SO_4 Stock Solution, date made, outdate of 1 year, and initial. Cap tightly.

   b. Prepare a standardized 0.02 N H_2SO_4.
      1. Fill a 1,000 mL Class A volumetric flask three quarters full with deionized water. Carefully add 20.0 mL of the Stock H_2SO_4 using a 20 mL Class A pipette. Fill to mark and mix thoroughly.
      2. Weigh out between 0.0700 to 0.0800 g of Tris buffer using the analytical balance. Record the weight of the Tris Buffer to four places in the "Standard & Reagent Preparation" notebook. Add the buffer to 250 mL flask containing 25 mL of deionized water and stir bar; mix.

3. Add 3 drops of Hach Brom Cresol Green-Methyl Red indicator solution (Hach cat. number 451) to the Tris buffer solution.
4. Fill the titrating buret with the 0.02 N H_2SO_4 solution. Titrate the solution until a stable pink color is reached. Record the volume of reagent used.
5. Calculations:
   Normality of H_2SO_4 = Wt of Tris Buffer (g) ÷ (0.121137 g/meq Tris X mL of 0.02 N H_2SO_4 used)
   <u>Example</u>:
   0.0879 g Tris Buffer ÷ (0.121137 g/meq Tris X 35.7 ml H_2SO_4) = 0.0203 N H H_2SO_4
6. Transfer the 0.02 N H_2SO_4 to a one liter plastic bottle. Record the normality on the bottle, date made, outdate of 3 months, and initial. Store at room temperature.

2. Alternatively, order 0.02 N H_2SO_4, already prepared and standardized from a vendor such as Fisher Scientific. Record lot on QC worksheet.

Controls

1. Run deionized water as blank. Value of blank should be less than 2 mg/L of calcium carbonate (approximately 0.1 mL of H_2SO_4).

2. Use one quality control standard. This is a solution of sodium bicarbonate (100 mg/l). Run once with each set of samples and record results on control chart. Consult chemist if out of control situation exists.

3. Run every 10th specimen in duplicate. Calculate the relative standard deviation (RSD) of the replicates using the following formula: RSD=SD ÷ mean x 100. The RSD should be less than 10% If the replicates are outside of this range, repeat the specimen a third time. Check with the chemist for instructions.

4. Each quarter an external reference sample is to be analyzed. In the case of results exceeding acceptance values, document corrective action. Place any corrective action records in proficiency file

Procedure:

If applicable, standardize the pH meter each day of use (see supplemental procedure). Record slope with offset on worksheet.

Run the blank and control first. If the control is within range (range found in the "QC Inorganic True Value" binder), run the samples. Repeat the control if it is out of range. Notify the chemist if the control is out of range a second time.

1. Add 50 mL of control or sample to a 100 ml beaker containing a magnetic stir bar. Set magnetic stirrer at low speed.

2. Carefully lower pH probe into the solution. **If the pH is above 8.3 consult principal analyst!**

3. Fill the titrating buret to the zero mark with the standardized H2SO4. Carefully add the H2SO4 to the sample until a pH of 4.5 ± 0.05 is reached.

4. Record the volume of H_2SO_4 added to the sample, to the nearest tenth, on the chemistry worksheet.

5. Rinse the pH electrode with deionized water. Measure out the next sample, refill the buret, and titrate the next specimen.

Calculations:

Use the following formula to calculate the alkalinity as mg/L of calcium carbonate.
Exception: For alkalinity below 20 mg/L use low alkalinity calculation procedure (refer to SM2320B part 5)

mg/L = (mL of H_2SO_4 – 0.1) X normality of H_2SO_4 X (50,000 ÷ ml of sample)
Example (for 50 ml sample):
(28.6 mL – 0.1) X 0.02 X (50,000÷50ml) = 570 mg/L of Calcium Carbonate
or
(28.6 ml – 0.1 ml) X (20) = 570 mg/L of Calcium Carbonate

Reporting

Report in **whole** numbers; round off to 3 significant figures. Examples:
2,902.5 = 2,900; 1,125.9 = 1,130; 23.65 = 24

References

Standard Methods for the Examination of Water and Wastewater 18th edition 1992

Written by: David Perez
Date: January 1993
Revised by: G. R. Guibert
Date: August, 1998

Approved by:____________________________
Principal Analyst

Varian Flame AA Procedure
SM 3111B
For Ca, Mg, Na, K and Fe

Principle:
In flame atomic absorption spectrometry, a sample is aspirated into a flame and atomized. A light beam is directed through the flame, into a monochrometer and into a detector that measures the amount of light absorbed. Because each metal has its own characteristic absorption wavelength, a source lamp composed of that element is used. The amount of energy absorbed in the flame is proportional to the concentration of the element in the sample.

Sample Collection/Handling:
Use metal free collection bottle to collect sample. Collect one liter of sample. Smaller volumes (not less than 200 ml) can be used if necessary. On collection, acidify samples to pH <2 with 1:1 nitric acid, usually 3ml per liter. If samples are not acidified at time of collection, add acid upon receipt in lab and hold for minimum of 16 hours before analysis.[40 CFR 141.23(K)].

Sample Preparation:
Samples containing particulate or organic material require pretreatment before analysis. Samples with a turbidity <1 NTU, no odor and single phase may be analyzed directly. Digest all other samples before determining total metals.

Digestion Procedure for total metals:
Drinking water samples with turbidity >1 NTU can be analyzed following digestion with nitric acid. See procedure SM 3030E (Nitric Acid Digestion). Wastewater samples are better digested using method SM 3030F part b (Nitric Acid-Hydrochloric Acid Digestion). Report as total recoverable metal.

Sample criteria:
Except as noted, specimens that do not meet the criteria below should be immediately reported as "no test" with an explanatory note:

1. Samples submitted in improper collection container.
2. Sample inadequately identified. (Sample has no identification, or cannot be matched to a laboratory request form).
3. Sample quantity insufficient
4. Sample container broken or leaked in transit.

Special Instructions:
All glassware and pipettes used in this procedure must be cleaned using glassware-cleaning procedure. See document in kitchen.

Reagents:

1. Nitric Acid (HNO3). Use high purity nitric acid 1+1.
2. Lanthanum solution (1.11%): Dissolve 58.65 g lanthanum oxide in 250 ml of conc HCL. Add slowly with stirring until dissolved and dilute to about 900 ml. Allow to cool for a few hours then dilute to final 1000 ml volume. Used for Ca, Mg, Na, and K analysis.
3. Calcium solution: Dissolve 630 mg calcium carbonate, CACO3, in 50 ml of 1+5 HCL. If necessary, boil gently to obtain complete solution. Cool and dilute to 1000 mL with water. Used for Fe analysis.
4. Standard Metal solutions: Standard metal solutions are prepared from 1000 mg/l AA or ICP-MS standards purchased from Ricca Chemical company, Spex Certiprep, LabChem, Fisher Scientific or VWR. A standard from EM scientific (ICP Multi-element Standard) is very convenient for calibration standards.
5. Deionized Water from Millipore system – metal free water.

Instrument Set-up:
Use the Varian Spectra 300AA operating in the flame mode with Air Acetylene burner.

1. Turn on exhaust hood. Switch is located in the corner by the Chemistry room refrigerator. Note: Turn switch until it clicks on. If you continue turning the switch after it clicks, the airflow will be reduced.

2. Turn on "Acetylene" gas cylinder located outside in the "Safety Storage" shed. The correct door housing the tank is labeled "Acetylene". Pressure should be set at 8-9 PSI.
   Note: The cylinder valve is opened by turning the handle only 1/4 turn counterclockwise. Replace cylinder when pressure in tank drops below 100 psi. This prevents acetone from entering instrument.

3. Check the Varian Spectra AA 300A unit to see if the burner is installed.

4. Check to see if the cathode lamp required is in the correct socket position, and it is lined up in the "Operating Lamp"
   Note: Lamps are stored in the top drawer located directly across from the GTA 96 Graphite Tube Atomizer (next to hood).

5. Turn on the equipment in the following order (allow a 20 minute warm-up period):
   Note: If the computer is already on, turn it off.
   a. Spectra AA 300A: switch located on lower right front of instrument.
   b. IBM PC and Printer: Turn surge suppressor on (power supply); hit reset button.

Once the unit has been set-up, program the machine for testing by:

1. Start at the "C:" prompt. Press "M" and "Enter".

2. Press "Spectra Flame"

3. Press "Index" (F10). Enter number 10, "Sequence Selection", press "Enter" key.

4. Select element to be tested

5. Press "Sequence Control" (F6). Enter number of samples to be tested.

6. Press "Index" (F10), enter number 6, "Optimization", press "Enter" key.

7. The Screen will display two signal bar graphs. Check the previous week worksheet for the "Photomultiplier voltage" reading.

8. Maximize the lamp signal of the Cathode tube using the two thumbscrews located on the back of the lamp socket (see figure 5.8).
   a. Watch the bar graph as you turn one thumbscrew. Once the value reaches .9 or greater press "Rescale" (F1).
   b. Check the Photomutiplier Voltage display on the screen, after rescaling. If the voltage is higher than the preceding week, continue adjusting and rescaling until the proper voltage is reached. If you are unable to reach the proper voltage, try adjusting the second screw.
   c. Note: Normally the voltage stays the same from week to week, but as the lamp nears the end of its usefulness, the voltage reading will go up. If a new lamp is installed, the starting voltage may be different than the previous lamp. Record millivolt reading on worksheet.

9. After adjusting for maximum signal, hit "Rescale" (F1). The photomultiplier voltage will be displayed. If the reading matches the previous week, record the voltage on the new worksheet. If it is out of range, readjust lamps. If voltage is still out of range, notify Chemist.

10. Press "Index" (F10) key and select "Standards" (number 7). Verify that the values of the standards are correct (see previous worksheet for standard values). To select a value to change, use the up and down arrows. Enter the correct value with the keyboard.

11. Check to see that drain hose, located below the Spectra 300A, is inserted into the drain bottle. (empty after each use).

12. Press "Index" key, enter number 18 (Signal Graphics), and press "Enter".

13. Press "Shift" and "Instrument Zero" (F10).

14. Light burner by pressing ignite button. Aspirate DI water for about 10 minutes. This will allow burner temperature to stabilize.

Standard and Sample Preparation:

Required sample preparation depends on the metal form being measured.

Procedure for Ca, Mg, Na, and K

1. Label the 10 ml beakers with the standard value; label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of sample or standard into each disposable beakers.

2. Add 9.0 ml of 1.11% lanthanum to each sample or standard using the adjustable pipette.

3. Repeat the process once again by diluting 1 ml of the diluted sample to 10 ml with the 1.11% Lanthanum. The samples have now been diluted 1:10 and 1:100. Alternatively use proportionally smaller volumes (i.e. .5 ml sample and 4.5 ml of 1.11% lanthanum).

4. The standards are prepared from stock solutions that when diluted 1:10 will give the necessary concentrations for calibration. The stock solutions are prepared from 1000 ppm standard metal solutions purchased from Ricca Chemical Co. Record dates of preparation and expiration (3 months) in sample prep manual.

5. The final concentration of calibration standards will be,

    1. Ca: 1.00, 3.00, 5.00 and 10.00 mg/l
    2. Mg 0.10, 0.50, 1.00 and 1.50 mg/l
    3. Na 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l
    4. K 0.10, 0.50, 1.00, 1.50 and 2.50 mg/l

6. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

7. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

8. Calibration of other Metals besides Fe/Mn: The other metals tested by flame AA does not require an ionization suppressor and can be directly aspirated. See specific method on computer for required calibration standards.

Standard and Sample Preparation: Procedure for Fe:

1. Label the sample beakers with the last three numbers of the tiny tab number. Using the adjustable pipette, pipette 1.0 ml of Ca solution into each disposable beakers.

2. Add 4.0 ml of sample to each beaker using the adjustable pipette.

3. The standards are prepared from 1000 ppm standard metal solutions purchased from LabChem or Spex Certiprep. Add 20 ml Ca solution and 1 ml conc HNO3 to each 100 ml of standard prepared. Record dates of preparation and expiration (3 months) in sample prep manual.

4. The final concentration of Fe calibration standards will be: 0.3, 0.5, 1.0, and 3.00 mg/l

5. Set report format: Go back to index by pressing the "Index" (F10) key, then select the "Report Format" (number 13). Here you can enter the name of the operator, batch name, and date. No other changes are usually necessary.

6. Start program: Press the "Start" (F11). The screen will show the message "Select Lamp 3"; press "Start" (F11). The program will now run to completion.

Quality Control:

1. Analyze a Blank after every 10 samples to verify baseline stability. Rezero when necessary.
2. Duplicate Spikes - replicate spikes are to be performed on 10% of samples. Recovery of spike in drinking water should be between 80% and 120% with a precision of 20%. Recovery of spike in wastewater should be between 75-125% with a precision of 25%. Spike level should not exceed MCL for analyte. Spiking solutions are available from Cresent Chemical Co.or SPEX.
3. External Reference Sample - Analyze a known reference sample after initial calibration and after every ten samples to confirm the test is in control.
4. See Table 3111:III in Standard Methods for recommended concentrations of standards to be run, limits of acceptability, and reported single operator precision data.
5. Analyze External Reference Sample on quarterly basis. Solutions available from APG, ERA or SPEX.

CRITERIA FOR ACCEPTABILITY OF RUN

1. Recoveries of spikes and controls are within acceptable range.
2. Blank values below detection levels.
3. Acceptable levels of precision.

NOTE: If any of the acceptance criteria are not met, the analyst must stop the run, correct the problem and and retest the samples.

OUT OF CONTROL PLAN

No sample should be reported until the all acceptance criteria have met. Or the out-of-control condition has been corrected and any problems or departure from protocol identified.

Trouble Shooting:

1. PROBLEM - poor precision,
   Check alignment of hollow cathode lamp. Check that capillary hose is not clogged. Make sure burner is clean and flame appears smooth and even. Replace pinched or crimped capillary tubing.

2. PROBLEM - error message
   Refer to instrument service manual

3. PROBLEM - Contamination

Check supplies associated with sample collection for contamination. Check rinse water, sample diluent, pipettes, sample cups. Make sure work area is free from dust.

Shutdown Procedure:

Turn off acetylene, IBM PC,and AA300, and exhaust hood, in that order.

Calculations:

The results will be printed and should be recorded on a worksheet. The dilution factor must be shown and considered in the calculations.

Reporting:

1. The data from the printout should be transferred to the worksheet. Verify that controls were within acceptable range and that duplicates are within range.

2. The lab clerk enters the results into the computer. Results are reported in units and number of significant figures consistent with MDL of method.

References:

1. "Analytical Methods for Flame Atomic Absorption Spectrometry" Varian Techtron Pty, Limited, 1989.

2."Standard Methods for the Examination of Water and Wastewater"
18th Edition 1992 by APHA, AWWA, and the WEF.

Written by: David Holland
Date: January 1999

Approved by:________________________
Laboratory Director

DETERMINATION OF INORGANIC ANIONS
BY ION CHROMATOGRAPHY (EPA METHOD 300.0)
USING THE DIONEX DX-80 ION ANALYZER

PRINCIPLE

This method determines the following inorganic anions: fluoride, chloride, nitrite, bromide, nitrate, phosphate and sulfate.

A small volume of sample (approx. 1 ml) is loaded into the ion chromatograph. The injection valve injects 10 ul of the sample into the flow of eluent. The eluent (a NaHCO3 - Na2CO3 solution) flows continuously through the IC and serves as a carrier for the 10 ul of sample and facilitates in the separation process.

The anions of interest are separated using suppressed conductivity detection, and are identified and quantified by comparing data to those obtain from a standard solution. The major parts of the system are the liquid eluent, high pressure pump, sample injector, guard column, the separator column, the chemical suppressor and the conductivity detector. The guard column protects the separator column, which separates the anions based on their size and charge. The function of the suppressor is to chemically reduce the background conductivity of the electrolytes in the eluent, and to convert the sample anions into a more conductive form. The detector then detects the conductivity of the solution, which varies depending on the concentrations of the anions (higher conductivity indicates a greater concentration of the anion).

SAMPLE CRITERIA

The holding times for drinking water samples are as follows:

Fl^-	28 days
Cl^-	28 days
NO_2^-	48 hours
NO_3^-	48 hours
SO_4^-	28 days
Br^-	28 days

Samples submitted for IC testing routinely should be run within 48 hours of collection, especially for nitrite and nitrate. If testing needs to be delayed, the sample can be preserved with sulfuric acid; preserved samples can be held for up to 28 days and the nitrate results reported as combined Nitrate/Nitrite. Any samples not tested within specified holding times should be identified on the worksheet.

Samples bottles dedicated for IC testing only are placed on the IC bench. As soon as a sample is setup, place it on the white tray for easier storage. After 6 weeks the containers should be emptied and discarded. Nondedicated samples (i.e. those also submitted for additional testing) should be returned to the designated cart after IC testing.

QUALITY ASSURANCE

Operator competency - Ion chromatography may be performed only by analysts who have been trained and who have demonstrated competency with the procedure. One check consists of preparing the calibration standards and calibrating the I.C. An r-value of 0.995 or higher (correlation coefficient of 99.95%) in the linear fit type must be attained for each analyte of interest. Another way to demonstrate competence is to run a minimum of four replicate analyses of an independently prepared sample. Each analyte of interest in the sample should have a known concentration between 5 and 50 times the MDL.

Blank - A blank consisting of nanopure water should be included at the beginning of each run. The results for the blank must be below the MDL for each analyte.

Control standard(s) - Controls representing two concentration levels for each analyte (ICMIX HIGH & ICMIX LOW) must be analyzed as described below. The source of the analytes used to prepare these controls must be different from the source used to prepare the calibration standards. An ICMIX HIGH stock solution of the 7 anions with the following final concentrations:

Anion	*Final Conc*	*Preparation in 500 ml volumetric flask*
Fl^-	20 ppm	10 ml of 1000 ppm Fl std
Cl^-	100 ppm	50 ml of 1000 ppm Cl std
NO2	65.5 ppm	10 ml of 1000 ppm NO2-N std
Br^-	20 ppm	10 ml of 1000 ppm Br std
NO3	100 ppm	50 ml of 1000 ppm NO3 std
PO4	100 ppm	50 ml of 1000 ppm PO4 std
SO4	100 ppm	50 ml of 1000 ppm SO4 std

should be kept on hand. Use this undiluted at the beginning of the run and after every tenth sample. Each week, prepare an ICMIX LOW solution from the ICMIX HIGH solution as follows: Using a 100 ml volumetric flask add 1 ml if ICMIX HIGH using the 1 ml volumetric pipet and fill to mark with nanopure water. Record date made in the IC logbook under Quality Control. Run the IC LOW at the beginning of the days run and after every 10th sample after the IC HIGH. The percent recovery for each anion should be between 90 and 110%.

Duplicate spikes – Duplicate spikes should be run after every tenth sample. The spike should not be less than four times the MDL, and it should increase each anion concentration by more than 25% of the background value. A suitable spike can be prepared by adding one part ICMIX HIGH to three parts sample. The average percent recovery for each anion should be between 80 and 120%. The duplicate spikes should be within 10% of each other. Record average percent recovery of spikes and duplicate percent difference on worksheets. Note: if the concentration of the spike is less than 25% of the background concentration, the spike recovery should not be calculated.

If any of the above control criteria are not met, do not report sample results until the problem has been resolved.

External controls & chart analysis - In addition to the control standards tested with each batch of samples, an external reference standard (i.e. SPEX IC standard or WS proficiency sample) should be tested on a quarterly basis; however we like to run one at the end of each run.

CALIBRATION FOR GOUNDWATER (DRINKING WATER AND MONITORING WELLS):

Calibration for groundwater samples is described below. Calibration should be performed whenever: 1) controls are out of range; 2) a new batch/lot of eluent/regenerant is made or 3) when a column, suppressor or detector is changed.

1. Prepare 1/10, 1/100, 1/1000 dilutions of the calibration standard ordered from Dionex, which contains 20 mg/l fluoride, 100mg/l chloride, 100 mg/L nitrite, 100 mg/L bromide, 100 mg/l nitrate, 200 mg/L phosphate and 100 mg/l sulfate.

2. Run calibration standards beginning with the highest dilution (1/1000) first.

3. Create calibration sequence: File – New – Sequence – Standards – Next. Skip section on Choosing Timebase – name the sequence *calibMMDDYEAR* and initials – Next – Done.

4. Add sequence to batch file before starting

5. After all four calibration standards have been ran, check the calibration curve.

   a) Double click on any of the calibration standards (Cal Std 1). You will get a chromatograph

   b) Click on Calibration Plot icon, upper right corner or click on VIEW – Calibration Plot. You will see a graph of the first analyte along with the correlation coefficient percentage for each analyte. Only anaytes with percentage of 99.5 or greater are acceptable. Generally try for a 99.98% for an average of all seven analytes to pass quality control checks. See the principle analyst if the result is a lesser value.

   c) The mean retention times and detection range are automatic on the DX-80 Ion Analyzer and can not be changed or edited.

PREPARE MDL STUDY

The Method Detection Limit is the lowest concentration of a substance that can be identified with accuracy and confidence by a certain method or analysis.

1) Prepare a Cal Std 1 level each analyte separately using the secondary standards (not Dionex mix)
2) Make seven replicates of this dilution and run through the Ion Analyzer under the Unknown Method.
3) Collect data and calculate the standard deviation for the seven replicates. Multiply the standard deviation values by 3.143. This number will be the Method Detection Limit.

GENERATE BACKLOG REPORT:

1) On a network computer – not the Instrument computer. Double click on LABWORKS icon. Enter password. Click on OK. Click on backlog. Click on analysis code. Click on OK. Type in #ICANION. Click on OK. Click on display report. Click on print. Click on exit until you are out.

2) Check the clipboard to see if a worksheet has been initiated listing samples that need repeat testing; if so, append worksheet with samples on backlog report.
   a) Account for all specimens on backlog report
      i) Samples may have been tested in a previous run but not recorded. Record these results and give to the clerk.
      ii) If a sample appears on the backlog but needs to be tested by a different method (i.e. wastewater), inform the clerk so that the analysis ordered can be modified.
   b) Include any "new" samples on the I.C. bench that have not yet been entered into the computer.

SAMPLE PREPARATION

Groundwater (drinking water and monitoring wells) should be filtered through 0.45 um membrane filters before injection:

1) Rinse the syringe once with the sample water. Then fill syringe with about 10 ml of sample water.
2) Filter a minimum of 2 ml of sample through the 0.45 membrane into a labeled autosampler vial discarding the first few drops.
3) Place autosampler cap on vial and press down using the provided tool. Make sure the cap goes in straight and remove any air bubbles seen in the vial (invert or knock gently).
4) Place sample in autosampler rack. The order in the rack must match that on the schedule. Note: If you suspect the result of a sample to be above that of the calibration standard for an analyte, make an appropriate dilution. Check by measuring conductivity – anything greater than 700 uS will need to be diluted.
5) Include duplicate spikes for every 10th sample. Add 1 part ICMIX high to 3 parts filtered sample. Then IC HIGH, LRB, IC LOW. The laboratory reagent blank (LRB) is necessary to minimize carry over as the IC low is 100 times less than the High. Double check any samples where analyte concentrations are low after a high sample to verify analyte is even detected.

Samples which may contain high concentrations of chloride or organic contaminants (Carmel Area Wastewater District and ESF), are run on the DX-100 and require additional filtering through Dionex OnGuard P, Dionex OnGuard Ag, and Dionex OnGuard H filters before injection. See supplemental procedures.

SYSTEM START-UP:

1) Ensure the **eluent** bottle is at least ¼ full. If it is less, depending on size of run, prepare new eluent (and regenerant):
   a) Prepare 2 liters of a final eluent concentration of 8.0 mM Sodium Carbonate and 1.0 mM Sodium Bicarbonate by diluting one Dionex AS 14A Eluent Concentrate bottle (P/N 057060) into two 1L-volumetric flasks. Bring each to volume (1000 ml) with nanopure water. Makes 2 liters.
   b) Use the designated filter/vacuum flask, a filter funnel, a clean 0.45um membrane filter, and a large magnetic stir bar to degas the eluent. Pour the eluent into the filter funnel and turn on the vacuum. Set the magnetic sticker at medium to high speed. Once all the eluent has been filtered, keep the vacuum and magnetic stirrer on for 15-20 minutes, allowing the eluent to degas.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed eluent into the eluent bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

2) Whenever new eluent is prepared, new **regenerant** must also be made.
   a) Prepare 2 liters of a final anion regenerant concentration of 72 mN Sulfuric Acid by adding one Dionex Anion Regenerant Concentrate bottle (P/N 057559) to two liters of nanopure water.
   b) Mix in the regenerant in the designated filter flask using the stir bar and degas for 15-20 minutes.
   c) Turn off the magnetic stirrer and the vacuum. Remove the filter funnel. Carefully decant the degassed regenerant into the REGEN bottle, without aerating. Make sure the cap is on tightly, and the tubes are securely attached.

DX-80 OPERATION

1) Turn on nitrogen gas cylinder (main knob only), autosampler (rear right hand corner), ion analyzer (rear panel right hand side) and computer.

2) Double click on Peaknet to open computer program. **File – Panels\Dionex DX-80 System** for the Control Panel.

3) Under the DX-80 Status click on **CONNECT** to connect analyzer to computer

4) Turn on the pump by clicking the **ON** button on the DX-80 Control Panel. **Prime** the pump by turning the pump head waste valve knob counter clockwise and leaving it open for about 5 seconds. Close the pump valve knob by turning clockwise until secure. After changing to new eluent, it is a good idea to leave pump valve open until all air bubbles have been purged – look for the air bubbles coming out the eluent bottle until it reaches the waste line at the pump. This will allow any air bubbles to be pumped to waste instead of through the columns.
5) Allow the system to **equilibrate** for 30 minutes minimum, generally one hour if new eluent is used. Once ready, the **operating pressure** should be 2000+- 300 psi (usu 2100

psi); and the operating **total conductivity** background should be < 30 uS (usually 25.00uS). You can offset the background and zero the reading by clicking the Autozero button on the Control Panel.

6) To begin a run, create a sequence worksheet by clicking on **File – New – Sequence**. (May have to do this twice if worksheet is not already open.)
   a. It will then prompt you to choose Standard or Unknowns. Choose **Unknowns - Next**
   b. Skip **next** screen where it prompts you to specify timebase,
   c. **Estimate** number of unknowns (you can always add or delete samples from sequence when done.
   d. Fill out file name you wish to save the file We save under ***MMDDYEAR*** and **initials**: *(05052002tl)* and press **enter**.
   e. Press **Done** when prompted to exit wizard.
   f. A worksheet will appear where sample identifications can be added after the calibration data (line #5). Follow printed worksheet – first include a *blank, ic low, ic high, lrb*, then the samples. Note for the first set, the lrb is listed as a sample. *Duplicate spikes* are required for every 10th sample or a minimum of 10% of samples. Finish off sequence with a known quality control standard, usually a proficiency standard such as *WS 60* or Ultra QC and another blank (LRB).
   g. Change *dilution factor* if sample was diluted; default is one. Save by pressing the SAVE icon (floppy disk).

7) To start the run – click on **Batch – Edit – Add** – double click on the newly created sequence, or the one you want run – then **Start** to begin.

8) Make sure autosampler vials are in order and the green light is on 'Run' not 'Hold'.

9) Record date, total conductivity and pressure in the log notebook at which the run has started.

10) During or after the run, verify that the blank and QCs (IC HIGH, IC LOW, IC CHECK) are within range. If not stop the run by clicking on **Batch – Stop - after current sample**, and notify principal analyst to investigate and solve the problem before resuming the run.

REPORTING RESULTS

1) When run is complete the analyst performing the run is responsible for recording and reporting results. Review each chromatogram to verify that the peaks were properly identified. Retention times may shift if there was a sudden change in pressure. Changes to the peak name can be made by a right click on the peak and choosing the correct analyte then save.

2) The results are found on the worksheet next to the sample ID and can be exported to an excel file for accuracy calculation:
   a) Click on any sample cell – i.e. ic low, cell will be outlined.

- b) Click on **File – Batch Report – Export** (unclick the Printout option- computer is not connected to any printer) – **Excel file format**
- c) For sheets to be exported, choose only " **Summary – INJ vs. Area, Ht, Amt**." Unclick the Integration, Calibration, Peak analysis, Summary-INJ vs. Anion, and Audit Trail options as they are extra and rarely needed for our purpose.
- d) Click on **Finish** then **OK** on batch menu. Status will appear and when transfer is complete, press **OK** to exit.

3) To copy exported file onto a floppy, right click on Start icon on lower left screen and choose EXPLORE for Windows Explorer. Under **C:\Chromel\Export** folders are the files just exported. Highlight the correct sequence and drag to **A:** drive to copy file. (Make sure you have a floppy disk inserted).

4) Open exported file under an EXCEL program – the instrument computer does not have one so use a network computer. You will see three types of charts: first- Sample vs. Area, second - Sample vs. Height, and third - Sample vs. Amount. Copy all of the **Sample vs. Amount** table to an old/previous excel file.

5) The Excel Results worksheet is permanently saved under **G:\Laboratory\Data\Water\IC Data\2002** under the correct month. It is also saved in Tess' computer under **C:\My Documents\IC Data** and correct year and month. Easiest way to create the worksheet is to open a previously saved file (of the same year and month) and then cut and paste the data. There are two worksheets in each file, one for the complete results, the other for the raw data (the Sample vs Amount table exported from peaknet).
   - a) Before any changes are made, save the file under a new name: MMDDYY and initials
   - b) On RAW worksheet, delete old table and replace with recently ran sequence data. Add a column between Sample ID and Fluoride Amount for the dilution factor.
   - c) Change Date Analyzed and Analyst if applicable. Calibrations are generally done once a month with the most recent noted under Date of Calibration – change if necessary.
   - d) **Copy** and paste data results from raw worksheet onto Results worksheet under correct sample name. Use the **Paste Special option – Values** - to retain similar fonts on results worksheet. **% Recoveries** will be automatically calculated as will **% Differences**, and **Averages** for the duplicate spikes but references to certain cells may need to be changed for the correct result.
   - e) Verify that all QC are accurate before entering into labworks.

6) For drinking water, results should be recorded as ND – Not Detected for levels below DLR (Detection Limit for Reporting) as follows:

a) Fluoride	0.1 mg/L
b) Nitrate	2.0 mg/L
c) Sulfate	0.5 mg/L
d) Bromide	0.1 mg/L
e) Chloride, Nitrite, Phosphate	1.0 mg/L

   - f) Any samples with readings above the calibration range (20 mg/L fluoride, 100 mg/l chloride, nitrite, bromide, nitrate, sulfate, and 200 mg/l phosphate) needs to be diluted and repeated in the next run. List these samples on a new worksheet with the appropriate dilution and place the worksheet on the clipboard.

7) Do not report results if control/spike values do not fall within limits (refer to section on quality control). If controls, spikes, etc. are out of range, notify the principal analyst. If controls are within limits, date and initial the worksheet and give the worksheet to the clerk for data entry. When the worksheet and backlog are returned place them in the binder.

SHUT DOWN

After the run is complete the Ion Analyzer can be shut down. The IC should be shut down on weekends if the system is not in operation on Friday night so as not to damage the suppressor unit:

1) On the Control Panel screen of Peaknet - turn **OFF** pump and **DISCONNECT** DX-80
2) Close Peaknet.
3) Turn off DX-80, autosampler and close nitrogen cylinder valve.

PREVENTIVE MAINTENANCE:

1) Each quarter, replace the bed supports on guard column
2) Maintain the following spare parts. These items are considered consumables:
   a) Anion Refill Kit (Part No. 057069) contains 4 bottles each of AS14A eluent and anion regenerant concentrate.
   b) AS14A anion separator column, 3 mm (Part No. 056901)
   c) AS14G anion guard column (Part No. 056899)
   d) AMMS III suppressor (Part No. 056751)
   e) DS5 Detection Stabilizer (Part No. 057290T)

DOS AND DON'TS

* Try to make additions, changes, and deletions to the sequence during the middle of a run and then save immediately. If the changes are not saved immediately, the program may get confused on which sequence to use and will freeze. If this happens, wait until the current sample is completed, turn off all equipment and wait for about 15 minutes before restarting.

* Be gentle when loading samples onto the autosampler, especially the first rack. If racks are installed too roughly, conveyor belt may get stuck and samples will not be injected in the proper sequence.

REFERENCES:

1) DX-80 Ion Chromatograph with SRS Control Operator's Manual, Dionex Corporation, 2002.
2) Methods for the Determination of Inorganic Substances in Environmental Samples, Method Number 300.0, Determination of Inorganic Anions by Ion Chromatography, John D. Pfaff, U.S. Environmental Protection Agency, 1993.
3) Standard Methods, 18th Edition, 1992. Part 4110.

Originally written by: Johanna Rosen for DX-100
Date: 12-96
Updated by: Theresa Lam for DX-80 Ion Analyzer
Date: 05-02

Approved by: ____________________________
(Lab Director's signature)

Appendix 7E

Watermaster's Seaside Basin Monitoring and Management Program

SEASIDE BASIN MONITORING AND MANAGEMENT PROGRAM

Approved by the Seaside Groundwater Basin Watermaster Board
May 17, 2006

SEASIDE BASIN MONITORING AND MANAGEMENT PROGRAM

Seaside Groundwater Basin Watermaster Board

- Chairman: Mayor Ralph Rubio, City of Seaside
- Vice Chairman: Bob Costa, Laguna Seca Subarea Landowner
- Secretary/Clerk: Director Michelle Knight,
  Monterey Peninsula Water Management District
- Treasurer: Mayor Dan Albert, City of Monterey
- Mayor David Pendergrass, City of Sand City
- Steve Leonard, California-American Water Company
- Mayor Joseph Russell, City of Del Rey Oaks
- Jerry Smith, District 4 Supervisor,
  Monterey County/Monterey County Water Resources Agency
- Paul Bruno, Coastal Subarea Landowner

Seaside Groundwater Basin Watermaster Board Technical Committee

- Andrew Bell, District Engineer, Monterey Peninsula Water Management District
- Curtis Weeks, General Manager, Monterey County Water Resources Agency
- Joe Oliver, Water Resources Manager, Monterey Peninsula Water Management District
- Keith Larson, Director, Water Resources, California-American Water Company
- Dave Berger, General Manager, Monterey Peninsula Water Management District
- John Fischer, Member of the Public
- Steve Leonard, Vice President and Manager, California-American Water Company
- Steve Matarazzo, Community Development Director, City of Sand City
- Tim O'Halloran, Senior Engineer, City of Seaside
- Diana Ingersoll, Deputy City Manager – Resource Management Services, City of Seaside

Seaside Basin Monitoring and Management Program

Table of Contents

I. Introduction 1

II. Basin Monitoring Program 2

A. Basin Overview 2

B. Basin Monitoring Background 2
  1. Groundwater Production Monitoring 2
  2. Groundwater Level Monitoring 3
  3. Groundwater Quality Monitoring 3
  4. Surface Water Monitoring 4
  5. Precipitation Monitoring 4

C. Basin Monitor Well Construction Program 4
  1. Purpose 4
  2. Exploratory Borehole Drilling Program 6
  3. Geophysical Surveys 6
  4. New Monitoring Wells 7

D. Comprehensive Basin Production, Water Level and Water Quality Program 7
  1. Purpose 7
  2. Creation of Consolidated Basic Groundwater Resource Database 8
  3. Monitoring of Coastal "Sentinel" Monitor Wells 8
    a) Water Level Monitoring 8
    b) Water Quality Monitoring 8
  4. Monitoring of Inland Monitor Wells 9
    a) Water Level Monitoring 9
    b) Water Quality Monitoring 9
  5. Monitoring of Production Wells 9
    a) Water Level Monitoring 9
    b) Water Quality Monitoring 10
  6. Reporting of Monitoring Data 10

E. Estimated Monitoring Program Costs 17

III. Basin Management Program 17

A. Development of a Seaside Basin Management Program 17
  1. Program Objectives 17
  2. Program Development 17

3. Key Program Elements 17

IV. Seawater Intrusion Contingency Program 19

A. Objective 19

B. Seawater Intrusion Analysis 19
1. Seawater Intrusion – Description of Problem and Process 19
2. Seawater Intrusion – Definition 19
3. Description of Water Quality Related to Seawater Intrusion 20
4. Data Analysis Tools and Data Analysis 20

C. Actions to be Taken Subsequent to Detection of Seawater Within a Coastal Well 22

D. Efforts to Redistribute or Replace Water Lost Because of Seawater Intrusion Contingency Plan 23

V. Basin Monitoring and Management Program Implementation Schedule ... 24

List of Figures

Figure 1. Location of the Seaside Groundwater Basin 11
Figure 2. Location of Production and Monitor Wells In and Near the Seaside Basin 12
Figure 3. Location of Existing Coastal Groundwater Quality Monitor Wells In and Near the Seaside Basin 13
Figure 4. Location of Existing Coastal Sentinel Monitor Well Sites and Proposed Monitor Well Sites (Coastal and Inland) In and Near the Seaside Basin 14
Figure 5. Schedule by Task for Select Basin Monitoring Program Elements 15
Figure 6. “Order of Magnitude” Cost Estimate Summary for Basin Monitoring Program Portion 16

Appendices

Appendix 1. Exhibit A of the *Decision* in the Superior Court of the State of California in and for the County of Monterey, Case No. M66343 25
Appendix 2. *Expanded Conservation and Standby Rationing Plan*, by the Monterey Peninsula Water Management District 29

Seaside Basin Monitoring and Management Program

I.
Introduction

This Seaside Basin Monitoring and Management Program ("Program") is adopted by the Seaside Basin Watermaster to comply with the Judgment entered in the Seaside Groundwater Basin Adjudication (California American Water v. City of Seaside, Monterey County Superior Court, Case Number M66343) and to ensure that the Seaside Groundwater Basin ("Basin") is protected and managed as a perpetual source of water for beneficial uses.

The Judgment required the preparation of a comprehensive monitoring and management plan for the Seaside Basin (Monitoring and Management Plan") consistent with the criteria set forth in Exhibit A (Appendix 1) of the Judgment. The Technical Committee appointed by the Seaside Basin Watermaster Board has chosen to name this document the "Program" versus the "Plan" referred to in the Judgment. This was necessary to clarify that the tasks and schedule set forth in this document is the program that will create the Seaside Basin Monitoring and Management Plan.

The Program sets forth actions that will be taken to: (a) monitor current overdraft conditions and the present threat of potential seawater intrusion into the Coastal Subarea of the Basin; (b) develop and import supplemental water supplies for the purpose of eliminating Basin overdraft and the associated threat of seawater intrusion, and (c) establish procedures that will be implemented to address seawater intrusion should seawater intrude into the onshore portions of the Basin. All costs of undertaking the actions set forth within this Program shall be paid from the Monitoring and Management Program component of the Watermaster Budget, set forth in Section III.L.3.J.iv of the Judgment. The Court's Decree calls for the Seaside Basin Watermaster to develop a Basin Management Program within one year of the Court's judgment. The following is a description of the scope of work for the management program, the monitoring program and schedule that will be undertaken by the Watermaster over the next 12 to 18 months to complete the Basin Management Program.

II.
Basin Monitoring Program

A. Basin Overview

The Seaside Groundwater Basin has been characterized as underlying an approximately 19 to 24 square mile area at the northwestern corner of the Salinas Valley, adjacent to Monterey Bay. The general location of the basin and its four subareas are shown in **Figure 1**, which is from a study updating the condition of the basin completed by the Monterey Peninsula Water Management District (MPWMD) in 2005 (Yates and others, 2005. *Seaside Groundwater Basin: Update on Water Resource Conditions*. Prepared for MPWMD, April 14, 2005). The basin underlies a hilly coastal plain that slopes northward toward the Salinas Valley and westward toward Monterey Bay. The basin area includes Sand City, a portion of Monterey, and much of the cities of Seaside and Del Rey Oaks, as well as a portion of unincorporated Monterey County. In addition, the basin underlies most of the land occupied by the former Fort Ord military base. The basin consists of a sedimentary sequence of water-bearing materials that overly the relatively impermeable shales of the Monterey Formation. The two principal geologic units in terms of water supply potential are known as the “Paso Robles aquifer”, consisting of interbedded sand, gravel and clay deposits of continental origin, and the underlying “Santa Margarita aquifer”, consisting of a loose to weakly-cemented marine sandstone.

B. Basin Monitoring Background

Current water resource monitoring in the Seaside Groundwater Basin can be categorized into the following five principal types: groundwater production monitoring, groundwater level monitoring, groundwater quality monitoring, surface water monitoring, and precipitation monitoring. The history of development and current status of each category is briefly reviewed in this section.

1. Groundwater Production Monitoring

The early history of groundwater development in the Seaside Basin was not well documented. Prior to about 1950, the majority of groundwater extractions in the coastal area were assumed to be associated with small farming operations. The earliest recorded production dates to the mid-1950’s, when municipal wells were installed in the coastal area of the basin by several small water systems that were acquired in the mid-1960’s and subsequently consolidated into the main California American Water (Cal-Am) system that serves the Monterey Peninsula area. Other early metered production records were kept for wells in the coastal area supplying Fort Ord and the City of Seaside. A coordinated program of collecting and reporting groundwater production in the basin was established by the MPWMD in 1980. This program requires annual reporting of water production (surface water and groundwater) from all sources within the MPWMD’s boundary, which encompasses most of the Seaside Basin area. Currently, there is no surface water production from the Seaside Basin, and the only known groundwater production occurring within the basin outside of the MPWMD boundary is limited to production from Monterey County Parks Department wells at the eastern end of the Laguna Seca subarea of the Seaside Basin. In addition to the annual reporting requirement, MPWMD regulations require more comprehensive management for the Cal-Am water distribution system, as this system derives its supply from more than one hydrological management unit (i.e., the Carmel River Basin and Seaside Basin). This is accomplished under MPWMD regulations through the Quarterly Water Supply Budget Strategy program, in which projected production quantities for each of Cal-Am's production sources are developed on a quarterly basis, and actual production is tracked daily.

2. Groundwater Level Monitoring

The earliest groundwater level data collected in the Seaside Basin were from the municipal wells in the coastal area, beginning in the mid-1950's. The coverage was sparse, however, and limited to a small area of the basin. Water level data collection in the coastal area became more consistent when Cal-Am began operations in the mid-1960's, but the lack of long-term, spatially-distributed groundwater level data compromised the ability to rigorously assess the condition of the basin in studies conducted during the 1970's and 1980's. The Monterey County Water Resources Agency (MCWRA) periodically monitored several wells in the basin until that monitoring was curtailed due to budget constraints in the early 1990's. Basic groundwater data collection improved beginning at that same time as the MPWMD undertook a program of installing dedicated monitor wells in each aquifer at key locations in and near the coastal area of the basin. A network of dedicated monitor wells was preferable in that the water level data are more indicative of conditions outside of the direct influence of production wells. The dedicated monitor well network has been expanded since then, and is now comprised of 24 wells at 14 locations in and near the coastal and northern portions of the basin, and an additional 16 wells at 12 locations in and near the Laguna Seca subarea. The locations of monitor and production wells in and near the basin are shown on **Figure 2**. Presently, the MPWMD collects water level data monthly from 19 of the 24 monitor wells in and near the coastal subareas. Seven of these monitor wells are also equipped with automatic dataloggers (i.e., recording pressure transducer units) set to record hourly water levels to complement monitoring as part of the MPWMD Aquifer Storage and Recovery (ASR) program in the basin. The MPWMD collects water level data semi-annually (in Spring and Fall to correspond with anticipated seasonal high and low water levels) from 16 monitor wells in and near the Laguna Seca subarea. In addition to water levels collected by the MPWMD, Cal-Am currently collects and reports to MPWMD monthly water levels from 14 active and inactive production wells in the coastal subareas, and 7 wells in the Laguna Seca subarea. .

3. Groundwater Quality Monitoring

Historically, groundwater quality data were sparse and were not readily available to adequately support characterization of groundwater quality in the basin in the early resource studies conducted in the 1970's and 1980's. In the early 1990's, the MPWMD began a program to collect groundwater quality data from coastal monitor wells in the basin. This program has been expanded since then and now includes twelve (12) monitor wells at six (6) locations (**Figure 3**). Groundwater quality samples are currently collected annually and analyzed for a suite of inorganic parameters (i.e., general minerals) to assess long-term trends or changes that could indicate seawater intrusion. Based on the assessment of data from the MPWMD coastal monitor wells, there has been no indication of seawater intrusion into either of the basin's principal aquifers – the Paso Robles Formation or Santa Margarita Sandstone. In addition to the groundwater quality data collected by the MPWMD from its coastal wells, both the City of Seaside and Cal-Am collect complete general mineral groundwater quality data at least annually from their municipal production wells that serve water for potable use, as per requirements from the California Department of Health Services.

4. Surface Water Monitoring

Because dune sands cover much of the land area over the basin, precipitation falling on the basin does not produce appreciable surface runoff but directly infiltrates through the sandy soils. The exception is Arroyo Del Rey, which drains a portion of the Laguna Seca subarea. The U.S. Geological Survey measured discharge from this channel at Del Rey Oaks from 1966 to 1978, when this recording station was discontinued. The MPWMD re-established this as a recording station in 2002, and continuous streamflow records are currently maintained for this site.

5. Precipitation Monitoring

There are no long-term records of precipitation from monitoring stations within the Seaside Basin. Accordingly, basin precipitation estimates in previous water resources investigations have been based on records from nearby recording stations. The recent hydrogeologic assessment of the basin conducted for Cal-Am relied primarily on long-term records available from the National Oceanographic and Atmospheric Administration (NOAA) Station #045795 in Monterey (CH2M HILL, 2004, *Hydrogeologic Assessment of the Seaside Groundwater Basin*. Prepared for Somach, Simmons & Dunn and California American Water, January 2004. See page 2-2).

C. Basin Monitor Well Construction Program

1. Purpose

Notwithstanding the current groundwater monitoring efforts as described above, the Court recognizes that the present monitor well network is lacking adequate coverage in and near the Northern Coastal subarea of the basin, considered to be most vulnerable to seawater intrusion. Additionally, there are few existing monitor well control points to adequately define conditions along the northern basin boundary in the Northern Inland subarea. This section describes the Watermaster's planned exploratory drilling and monitor well construction activities that are designed to enhance the efficiency and utility of the existing basin monitoring network. This program is based on the description provided in Exhibit A of the *Decision*, attached as Appendix 1 of this program. Any proposed departures from that description and the basis for them are also described herein.

To ensure that the coastal area is adequately monitored to detect potential seawater intrusion, exploratory drilling, geophysical surveying and monitor well construction will be undertaken. Based on current knowledge of the availability of existing subsurface control points in and near the coastal area of the basin, monitor wells shall be initially constructed at a minimum of four (4) additional coastal "sentinel" monitor well sites ("*Sentinel" monitor well sites* refers to the network of monitor well sites closest to the coastline in and near the Seaside Basin, which can serve as a first line of defense in detecting potential seawater intrusion) at approximately 3,000 feet spacing, in the area along the coast northeast of existing monitor well "WMD-PCA-W". It is anticipated that the four coastal sites will be selected from the six potential target areas sites that are shown on **Figure 4**. Four sites are in a line near the coastline and two sites are slightly farther from the coastline and in between the most coastal sites, to provide secondary coverage if seawater intrusion should occur in narrow lobes or fingers. The actual locations for the new coastal "sentinel" well sites must be carefully selected based on nearness to the coastline, coastal erosion potential, site logistics, and long-term access constraints.

In addition, two (2) inland sites near the northern basin boundary shall be selected for exploratory drilling and monitor well construction. The recommended target areas for these sites are also shown on **Figure 4**. Information developed from these inland sites will support an improved understanding of the occurrence and nature of the aquifer systems and groundwater levels in the vicinity of the northern basin boundary where there are no existing monitor or production wells, and will support long-term monitoring in the basin.

As a planning goal, it is anticipated that these new monitor well installations can be completed within approximately 18 months of the Court's approval of this document, as shown in **Figure 5**. A breakdown of the proposed schedule by task is also included in Section V. Based on previous experiences by the MPWMD in installing similar coastal and inland monitor wells in the basin, land availability, authorization and access are key issues that must be overcome to successfully site and construct the monitor wells. The optimal locations for the new coastal monitor wells are along the coastal bluffs of the former Fort Ord military base, on land that is currently under the jurisdiction of the U.S. Army, but ultimately planned for transfer to the California Department of Parks and Recreation (CDPR). Accordingly, approval of such activity in this area of former Fort Ord will require the acquisition of a long-term easement, and will likely include authorizations from the Army Base Realignment And Closure (BRAC) office, the Fort Ord Reuse Authority (FORA), the County of Monterey, and the CDPR. As an alternate option, if land use approvals prove too difficult or lengthy for the coastal bluff locations, consideration will be given to siting the new coastal monitor wells along the inactive railroad alignment through the former Fort Ord coastal area. The Transportation Agency of Monterey County (TAMC) has recently acquired this property from the Union Pacific Railroad. Sites along the railroad alignment are less ideal in that they are approximately 500 to 1,500 feet farther from the coastline than the coastal bluff sites, but the approval process for use of these sites is anticipated to be less time consuming, and the MPWMD has already initiated discussions with TAMC on this issue. In any event, additional documentation from the Court endorsing its order to install the additional coastal monitor wells may be beneficial for the Watermaster to receive timely authorization for these monitor well installations.

As explained above, given the complexity of land use constraints and jurisdictional authority in the local setting, it is not likely that the exploratory drilling program can be conducted in the precise fashion described in Exhibit A of the *Decision*. Additionally, it is not envisioned that the exploratory drilling and geophysical surveys will be conducted as separate advance activities to facilitate subsequent siting of the new monitor well locations. Rather, monitor well clusters shall be installed at each of the carefully selected sites described above, with monitor well design and number of wells at each site guided by the lithologic and geophysical data to be collected in the manner described below. This is based on the MPWMD's past experience with exploratory drilling in the basin, wherein the actual occurrence of, and lithologic conditions within, each aquifer were variable from site to site, making it difficult to presume the monitor well designs and number of wells to be completed in advance. It is also noted that timely completion of the exploratory drilling and monitor well installation program described herein will require specialized drilling contractor services that may not be available locally, and could be limited by contractor availability.

2. Exploratory Borehole Drilling Program

A pilot borehole shall be constructed at each site, with the total depth targeted for the top of the Monterey Formation, which represents the effective base of the freshwater bearing formations at nearby locations in the basin. Total drilling depth at each site is anticipated to be 1,500 to 2,500 feet. Borehole lithologic samples (i.e., grab samples) shall be collected at ten-foot intervals (with the exception of any depths in the borehole at which continuous core samples can be collected). All collected lithologic samples shall be prepared and placed into labeled cases for storage and future inspection.

3. Geophysical Surveys

Upon completion of pilot drilling to the total depth, a complete suite of open borehole geophysical logs shall be run, including resistivity, spontaneous potential, caliper, temperature, gamma ray, and electromagnetic conductivity (EM) logs. These geophysical logs will provide a basis for describing the distribution of aquifers, occurrence of fine-grained interbeds and confining units between aquifers, water quality variations with depth, and the nature of groundwater flow and potential seawater intrusion, as was completed for a recent similar deep coastal monitor well construction project to the north of the Seaside Basin in the City of Marina (Hanson and others, 2002.

Geohydrology of a Deep-Aquifer System Monitoring-Well Site at Marina, Monterey County, California. U.S. Geological Survey Water-Resources Investigations Report 02-4003. Prepared in cooperation with the Monterey County Water Resources Agency (see page 12 for geophysical data description). In addition to the borehole geophysical logs, additional geophysical logging shall be conducted on the deepest cased well at each site and shall include gamma ray and EM logs. This additional logging will allow for comparisons with future annual geophysical logging surveys at each site as part of the ongoing monitoring program for early detection of salinity changes (i.e., potential seawater intrusion) into discrete zones within the aquifer system, that may otherwise go undetected by standard water quality sample collection.

5. New Monitoring Wells

Monitor well design shall be by multiple-well clusters at each site, either in the same or separate boreholes, unless an alternate well construction technique is authorized. Where present at each site, separate well casing strings shall be constructed with screened intervals within each recognized aquifer of the basin (e.g., Aromas Sand, Paso Robles, Santa Margarita) to provide a detailed vertical characterization of water levels and quality through the aquifer system. If observed conditions warrant, more than one well casing may be installed in each aquifer to more discretely characterize variable conditions in specific zones within the aquifer; however, this cannot be determined in advance of the exploratory drilling, as described above. For estimating purposes, it is assumed that four (4) wells will be installed at each well site cluster. The screened interval of each casing string shall be separated from other well completions by isolation seals if multiple wells are constructed in the same borehole. Each monitor well casing shall be a minimum two-inch inside diameter, and the deepest casing string at each well cluster shall be a minimum three-inch inside diameter to accommodate cased well geophysical logging tools.

D. Comprehensive Basin Production, Water Level and Water Quality Program

1. Purpose

The comprehensive monitoring program described herein is intended to guide ongoing data collection efforts in the basin to efficiently and economically provide the pertinent groundwater resource data that will establish a defensible basis for future decision-making by the Watermaster. Monitoring data collection tasks are described according to well location in or near the Seaside Basin. Coastal “sentinel” monitor wells refers to the closest monitor well sites to the coastline. Inland monitor wells refers to the monitor well locations in and near the Northern Inland and Laguna Seca subareas, and those monitor wells in the Southern and Northern Coastal subareas that are not included in the coastal sentinel monitor well network. “Production wells” refers to such wells in all four subareas of the basin.

2. Creation of Consolidated Basic Groundwater Resource Database

Currently, groundwater resource monitoring within the Seaside Basin is being conducted by several entities as described above in Section B. Basin Monitoring Background. A consolidated database will allow pertinent groundwater data to be more efficiently organized, managed and housed in a single location to facilitate: (a) ongoing data collection efforts, (b) data storage and retrieval, (c) distribution of basic data to Watermaster members and other interested parties, and (d) preparation of annual and periodic reports to the Watermaster. A database shall be created to contain all pertinent historical basic groundwater resource data (i.e., well production, level, quality) with proper annotations as to data sources, as well as all ongoing groundwater resource data collected on behalf of the Watermaster. The database will also include pertinent information on well type, location and construction details. In addition to the data organizational benefit, the consolidated database is intended to resolve any differences or discrepancies in existing datasets that have been compiled by separate entities. The MPWMD currently maintains a groundwater database that includes some of the features described herein. The Watermaster will need to determine if the MPWMD's database should be expanded or a new database should be created for this purpose. A breakdown of the proposed schedule by task is shown on Figure 5, and also is included in Section V.

3. Monitoring of Coastal "Sentinel" Monitor Wells

a) Water Level Monitoring

All coastal sentinel monitor wells (existing and proposed) shall be monitored on at least a monthly interval to record manual water level measurements. In addition, all coastal sentinel monitor wells shall be equipped with automatic dataloggers to continuously record groundwater levels in each aquifer measured. The dataloggers will be set to record no less frequently than a daily interval and will be downloaded at least quarterly. The dataloggers will be calibrated/confirmed initially and on at least a quarterly basis with the manual water level measurements. All collected data will be entered into the consolidated groundwater resource database on a quarterly basis.

b) Water Quality Monitoring

All coastal sentinel monitor wells (existing and proposed) shall be sampled on a quarterly interval by extraction of water samples (using standard sampling protocols) for chemical analysis by a state-approved laboratory. Parameters to be analyzed will at a minimum include the full general inorganic mineral suite. All collected water quality data will be entered into the consolidated groundwater resource database on a quarterly basis. Proposed new monitor wells may be sampled on a more frequent basis during the first year after construction to establish water quality variability at these locations. In addition, all coastal sentinel monitor wells (existing and proposed) shall be equipped with automatic dataloggers to continuously record groundwater quality (electrical conductivity and/or chloride) in each aquifer measured. The dataloggers will be set to record no less frequently than a daily interval and will be downloaded at least quarterly. The dataloggers will be calibrated/confirmed initially and at least quarterly with the chemical analysis data collected at each monitor well. On an annual basis, geophysical logs will be run at the deepest well at each of the new coastal sentinel monitor well sites. Also, an existing inactive Cal-Am production well in the Northern Coastal subarea, known as the “Del Monte Test” well, will be evaluated for possible inclusion with the coastal sentinel monitor well network.

4. Monitoring of Inland Monitor Wells

a) Water Level Monitoring

All inland monitor wells (existing and proposed) shall be monitored for water levels on at least a quarterly interval (This is an increased frequency from the semi-annual to annual water level monitoring recommended in the report: Yates and others, 2002, *Laguna Seca Subarea, Phase III Hydrogeologic Update*, prepared for MPWMD, November 2002 (see page 65)). In addition, at least two monitor well sites in the Laguna Seca subarea shall be equipped with automatic dataloggers to continuously record groundwater levels in each aquifer measured (This follows from a recommendation to instrument monitor wells to better understand water level variations in the report: Yates and others, 2002, *Laguna Seca Subarea, Phase III Hydrogeologic Update*, prepared for MPWMD, Novermber 2002. See page 65). The dataloggers will be set to record no less frequently than a daily interval and will be downloaded at least quarterly. The dataloggers will be calibrated/confirmed initially and on at least a quarterly basis with the manual water level measurements. All collected data will be entered into the consolidated groundwater resource database on a quarterly basis.

b) Water Quality Monitoring

Regularly scheduled water quality monitoring is not anticipated for the inland monitor wells, with the following exceptions: (a) the full general inorganic mineral suite of parameters shall be analyzed initially and quarterly for the first year, for any newly-constructed inland monitor wells to characterize background water quality at new locations, and (b) any water quality monitoring as part of special studies that may be directed by the Watermaster.

5. Monitoring of Production Wells

a) Water Level Monitoring

All active and inactive production wells in the basin owned and/or operated by a Watermaster member shall have static (i.e., non-pumping) water levels collected and recorded a minimum of once per month. It shall be the responsibility of each owner/operator of a Watermaster member production well to report monthly water level measurements to the Watermaster on an annual basis for inclusion of these data in the consolidated groundwater resource database.

b) Water Quality Monitoring

All active production wells in the coastal subareas of the basin owned and/or operated by a Watermaster member shall have a water quality sample from each well collected and analyzed by a state-approved laboratory for the full general inorganic mineral suite a minimum of once per year. It shall be the responsibility of each owner/operator of a Watermaster member production well to report water quality analytical results to the Watermaster on an annual basis for inclusion of these data in the consolidated groundwater resource database.

6. Reporting of Monitoring Data

It is anticipated that initially the Watermaster shall receive and distribute to members and interested parties a summary report of water resources data collected on behalf of the Watermaster on a quarterly basis. The quarterly reports shall include the reporting of water level and water quality data collected from the existing and proposed monitor wells as described herein. In addition, the monitor well data shall be summarized along with other information required in the Watermaster annual reports to be prepared and filed with the Court. Groundwater monitoring data will be prepared to conform to State Standards where appropriate or required.

E. Estimated Monitoring Program Costs

At this time only a preliminary "order of magnitude" estimate (*"Order of magnitude" cost estimates* refers to approximate costs with an estimated accuracy of +/- 40%.) of costs is available for the basin monitoring functions described in this Program. It is anticipated that refined costs will be available once proposals for exploration, monitoring and data management have been received, reviewed and authorized by the Watermaster. One-time costs for exploratory drilling, geophysical surveying and monitor well construction are estimated at $1,080,000. One-time costs for development of the basic groundwater database, and purchase and installation of water level/water quality dataloggers are estimated at $62,000. First year annual costs for groundwater database maintenance, and coastal and inland well monitoring are estimated at $61,680. A more detailed breakdown of estimated monitoring program costs is included in **Figure 6**. "Order of Magnitude" Cost Estimate Summary for Basin Monitoring Program Portion.

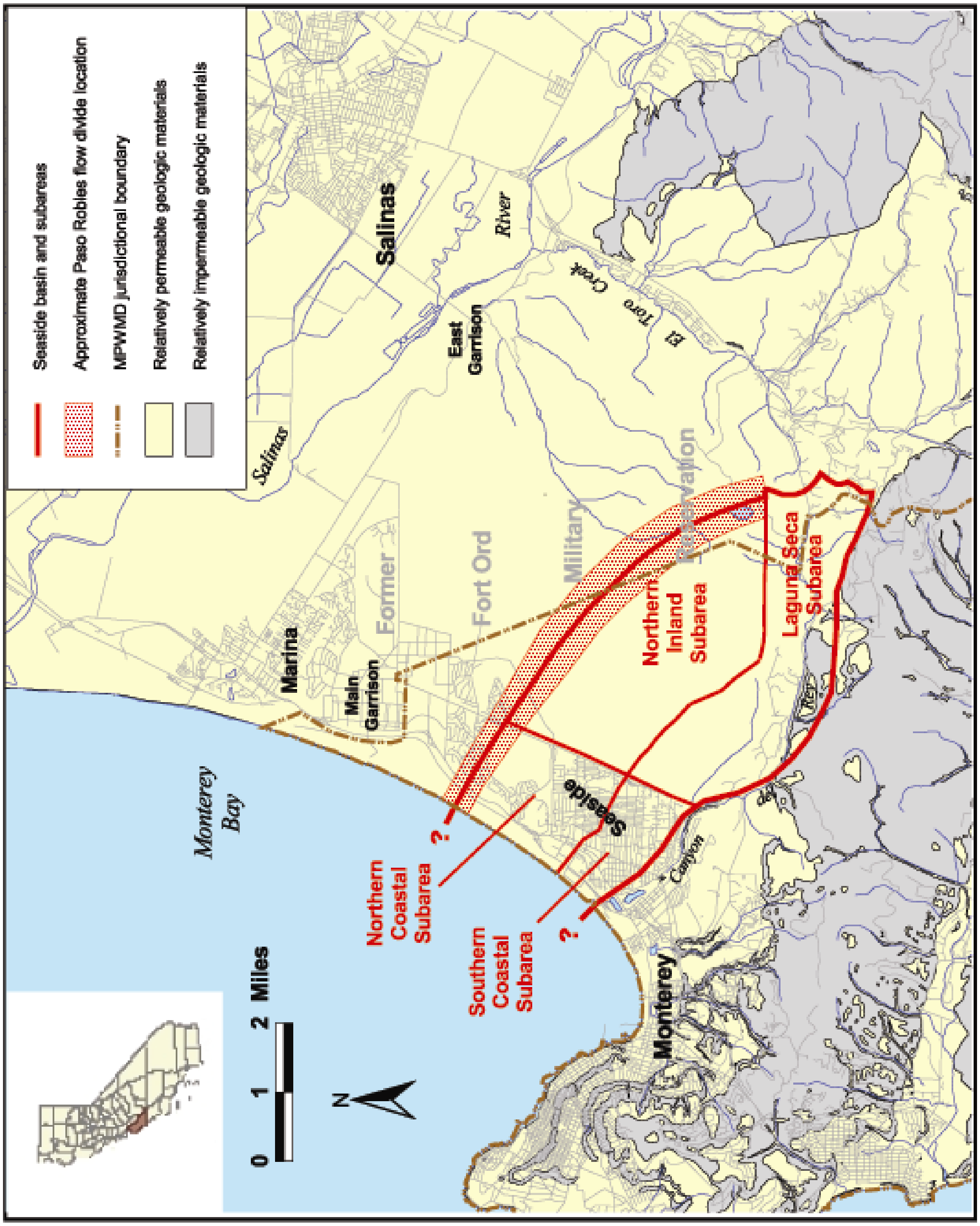


Figure 1. Location of the Seaside Groundwater Basin

Figure 2. Location of Production and Monitor Wells in and Near the Seaside Basin

Figure 3. Location of Existing Coastal Groundwater Quality Monitor Wells in an Near the Seaside Basin

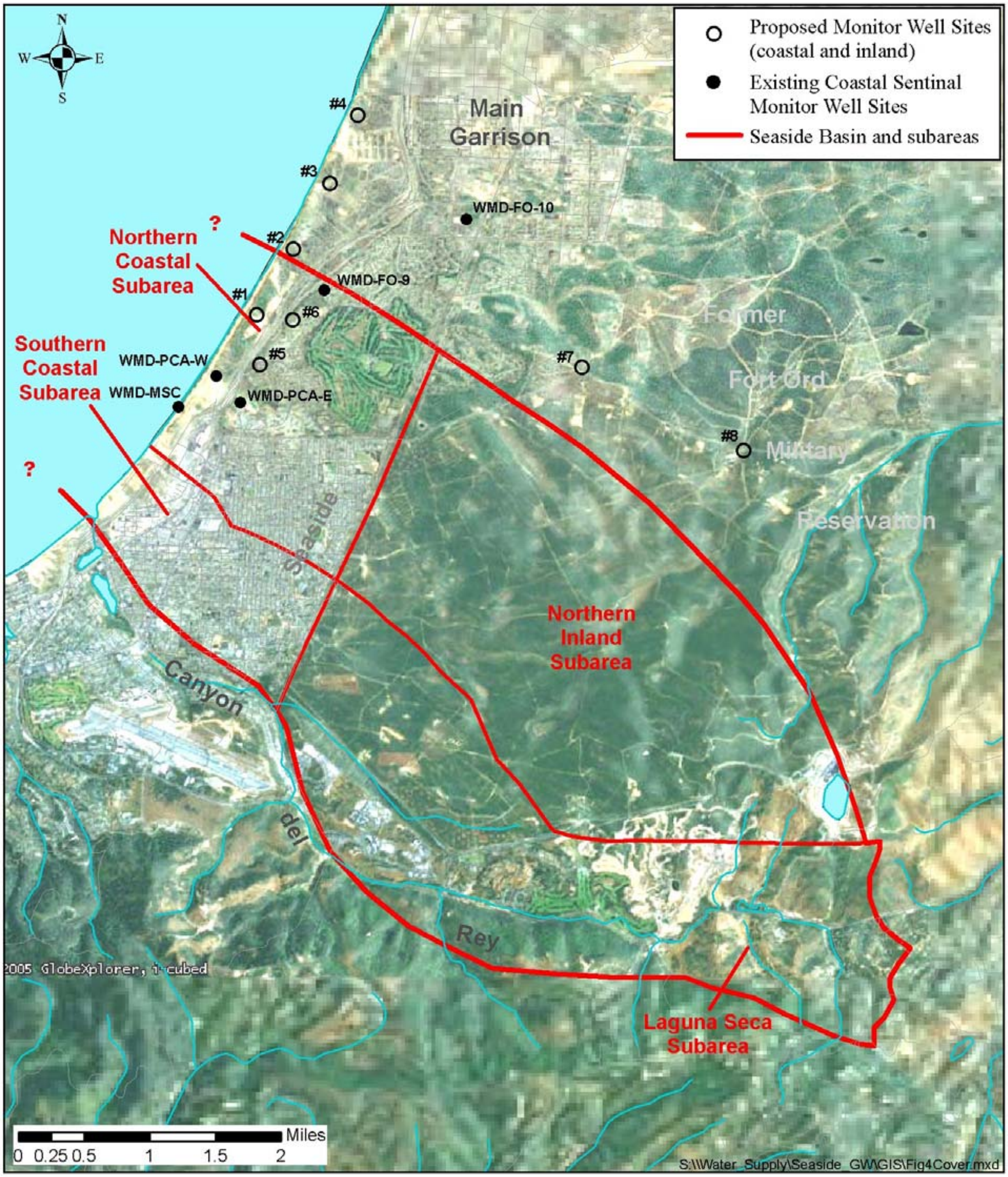


Figure 4. Location of Existing Coastal Sentinel Monitor Well Sites and Proposed Monitor Well Sites (Coastal and Inland) In and Near the Seaside Basin

Figure 5. Schedule by Task for Select Basin Monitoring Program Elements

No.	Task	Duration (Days)	Start	Finish
	Basin Monitor Well Construction Program			
1	Develop scope of services and RFP for consultant program oversight	60	7/1/2006	8/31/2006
2	Review proposals, secure oversight consultant contract	30	9/1/2006	9/30/2006
3	Oversight consultant completes site acquisition approvals	180	10/1/2006	3/31/2007
4	Develop scope of services and request bids for drilling/monitor wells	90	1/1/2007	3/31/2007
5	Review bids, secure contract(s)	30	4/1/2007	4/30/2007
6	Drill, equip and collect initial monitoring data	150	5/1/2007	9/30/2007
7	Prepare and submit completion report to Watermaster	60	9/1/2007	10/31/2007
	Creation of Consolidated Basic Groundwater Resource Database			
1	Develop database RFP	30	7/1/2006	7/31/2006
2	Review proposals, select consultant	30	8/1/2006	8/31/2006
3	Develop and approve database format	30	9/1/2006	9/30/2006
4	Populate database (historical data from all sources)	60	10/1/2006	11/30/2006
5	Populate database (current monitoring data)	30	12/1/2006	12/31/2006
6	Prepare database documentation report	30	1/1/2007	1/31/2007

Prepared for Seaside Basin Watermaster, May 2006

Figure 6. Seaside Basin Monitoring and Management Program “Order of Magnitude” Cost Estimate Summary for Basin Monitoring Program Portion

Task	Cost / Unit	# of Units	Cost / Site	# of Sites	One-Time Cost	Annual Cost
Exploratory drilling / geophysical surveying / monitor well construction						
Assume average TD = 1,800 feet; $100/ft lump sum	$100	1800	$180,000	6	$1,080,000	
Basic groundwater resource database						
Develop / populate: 200 hours	$70	200			$14,000	
Annual maintenance: 40 hours/quarter x 4/yr	$70	160				$11,200
Monitoring of coastal "sentinel" monitor wells						
Purchase/install WL/WQ dataloggers (6 existing wells; 16 new wells)	$2,000	22			$44,000	
Manual WL monitoring: 8 hrs/mo x 12 mo/yr	$70	96				$6,720
WQ sample collection: 3 hrs/pers/site x 2 pers x 4/yr	$70	24	$1,680	8		$13,440
WQ sample lab analyses: $200/sample gen. Minerals x 4/yr x 22 wells	$200	4		22		$17,600
Annual maintenance, WL/WQ dataloggers: 16 hrs/quarter x 4/yr	$70	64				$4,480
Annual geophysical surveys	$1,500			4		$6,000
Monitoring of inland monitor wells						
Manual WL monitoring: 8 hrs/quarter x 4/yr	$70	32				$2,240
Purchase/install WL/WQ dataloggers (2 existing wells)	$2,000	2			$4,000	
TOTAL ONE-TIME COST					**$1,142,000**	
TOTAL ANNUAL COST (first year)						**$61,680**

NOTES:

1. Cost estimates are at the preliminary “order of magnitude” level, with estimated accuracy of +/- 40%.

2. Cost estimates are subject to change as plans and scope are refined by Watermaster

III.

Basin Management Program

A. Development of a Seaside Basin Management Plan

1. Program Objectives

The objectives of the Basin Management Program, as stated in the Court's *Decision*, are to optimize groundwater pumping, control seawater intrusion, and return the Basin to equilibrium through implementation of conservation methods, through the importation of supplemental water for direct use and Basin replenishment. The Program will serve as the technical roadmap for future basin management decisions to achieve the management objectives in a cost-effective manner while balancing potential socio-economic impacts to users of Seaside Basin groundwater. The Program will be developed in a way that provides flexibility in the future to respond to changing conditions in the basin and new information that becomes available as the basin monitoring program is implemented.

2. Program Development

The Watermaster will oversee the development of the plan, utilizing member agency staff expertise and/or consultants where appropriate to conduct detailed technical analyses and investigations. The Watermaster should seek available grants and loans for plan development through the California Department of Water Resources or from other resources available to assist in alternative regional solutions that support the plan.

3. Key Program Elements

The Seaside Basin Management program will consist of the following key elements:

a) Development and implementation of a program for collecting and analyzing data related to groundwater production, water levels, water use, land use, rainfall, and other pertinent information useful in managing the basin. The Plan will outline the criteria and protocol to be used in triggering basin management actions. The MPWMD currently has an extensive data collection and management system that includes much of the data that will be required as part of the Seaside Basin Management Program. The MPWMD program will be evaluated during Plan development for use as a base upon which necessary data collection and storage enhancements can be made.

b) Development of an enhanced Seaside Basin groundwater model to be used in developing improved estimates of natural and secondary basin recharge, Total Useable Storage Space for the Seaside Basin, Operating Safe Yield, Natural Safe Yield, and basin management strategies. Technical consultants will be utilized for the task of developing a model and modifying existing groundwater models wherever possible. Existing models that will be evaluated for modification include but are not limited to: Laguna Seca Phase III Report (Yates et. al 2002), Sand City Desalination studies (Feeney & Williams, 2004), and Seaside Basin adjudication trial model (Durbin, 2005). No model development cost estimates have been provided in this document. A formal technical review of the models will be conducted in order to develop a scope of work and budget for the project.

c) Development of recommendations regarding implementation of strategies to import supplemental water supplies into the basin, including:
   - Substitution of alternative supplies for Basin groundwater (including in-lieu recharge).
   - Direct aquifer replenishment of pumping in exceedence of basin Natural Safe Yield.

   Potential water sources for the above strategies include reclaimed water for irrigation of large turf areas and/or direct recharge, surplus Carmel River Water for aquifer replenishment during the winter months, and local desalination projects such as that proposed by Sand City and regional desalination project, such as that proposed by California American Water. Supplemental supplies will be evaluated with regard to cost and environmental constraints to implementation. Plan recommendations will include concrete steps for project implementation over specific time periods, including near-term and long-term actions.

d) Development of strategies for redistribution of pumping to avoid various adverse impacts within the basin.

IV.

Seawater Intrusion Contingency Program

A. Objective

If seawater intrusion is detected in a coastal production or monitoring well, it is imperative that pumping stresses be reduced so that the seawater is not pulled further inland or otherwise spread into a larger area of the Basin where it may contaminate additional wells. Accordingly, the objective of the Seawater Intrusion Contingency Program is to set forth the actions that will be undertaken if seawater intrusion is detected in a coastal well to prevent the seawater from contaminating larger portions of the Basin. The purpose of this section is describe how the presence and extent of seawater intrusion will be determined by the analysis of the existing and the future enhanced coastal seawater intrusion water quality monitoring program. The seawater intrusion contingency planning process to address the detection and presence of seawater intrusion will then be discussed.

B. Seawater Intrusion Analysis

In order to detect and determine the extent of seawater intrusion, the mechanism of seawater intrusion must first be defined and then described. The analysis of the water quality monitoring data and mapping of the extent of seawater intrusion will follow.

1. Seawater Intrusion – Description of Problem and Process

Intensification of water use on ground water resources can cause the depletion of groundwater storage and lower groundwater levels in a basin. Declining groundwater levels to an elevation below mean sea level may eventually cause inflow of seawater into aquifers along coastal areas. As seawater moves inland, ground water chloride values increase over time.

2. Seawater Intrusion - Definition

For the purposes of defining when actions described in Section C of the program will be taken, the seaside groundwater basin aquifers will be defined as seawater intruded when the chloride concentrations in a coastal monitor well reach approximately 100 mg/l and 250 mg/l for the Paso Robles and Santa Margarita formations respectively. For a coastal production well, the standard will be when chloride concentrations reach 250 mg/l, given that some production wells have multiple aquifer completions with water quality that reflects a blend from these sources. These standards will be used until more comprehensive standards based on historical water quality data at individual monitor and production wells can be developed. Each monitoring well and production well in the groundwater network will be evaluated on site-specific criteria. In addition, the Watermaster will institute interim standards for notice of potential seawater intrusion so that appropriate preventative actions may be taken. Interim notice for seawater intrusion will be defined as a 50 percent increase above ambient chloride concentrations for any specific monitoring well location. Generally accepted laboratory protocols and hydrogeologic methods will be employed for the determinations of seawater intrusion.

3. Description of Water Quality Related to Seawater Intrusion

The California Safe Drinking Water Secondary Standard for chloride ranges from the recommended maximum for drinking water of 250 mg/L chloride and an upper limit of 500mg/L chloride. By the time chlorides reach the latter concentration, many times the wells are abandoned or destroyed due to unacceptable aesthetic qualities such as taste due to mineralization. The standards mentioned above dictate that, for drinking water purposes, chloride concentrations will be the primary water quality indicator for the determination of seawater intrusion. Other complementary inorganic parameter concentrations will also provide supplemental data for water quality trend analysis and aquifer water quality characterization (calcium, magnesium, sodium, potassium, sulfate, and nitrate) called “fingerprinting”. The analysis of these combined parameters will determine aquifer impacts by seawater intrusion.

Background chloride values may vary by aquifer depending on aquifer characteristics. For this reason, chloride values generated from the water quality monitoring program will be referenced to the 100mg/L and 250 mg/L chloride concentrations to determine aquifer impacts by seawater intrusion. In the coastal Salinas Valley, the agricultural community recognizes chloride values under 100mg/L as excellent to good irrigation quality. After determining if seawater intrusion is present, the observance of increasing chloride trends from the baseline up to 250mg/L chloride will be analyzed to determine the advancement of seawater intrusion. It must be noted that seawater intrusion is a gradual process due to the chemical interactions between the geologic formations in the aquifers and seawater. It is critical that the Watermaster Board is kept informed whenever chloride levels reach levels in excess of the interim standard so that appropriate action can be taken.

4. Data Analysis Tools and Data Analysis

The water quality data analysis exercise requires certain tools. These tools include different types of computer software to digitally identify the location of wells, to quality check data, and to generate graphs, diagrams, and chloride contour lines. Before a thorough analysis of the water quality data can begin, the following software will be required:

- Geographic Positioning System (GPS) equipment to provide latitude/longitude location for study wells
- Excel to graph chloride trends for each well
- Water quality graphing software to represent water quality data in “stiff” and “trilinear” diagrams
- ArcView GIS 3.3 to generate chloride contour lines

Once the software is obtained and personnel are trained, immediate evaluation of the existing monitoring data can begin. Compilation of the data in a central database will be required along with data checking for correctness and GPS digital locations for all wells must be obtained. If the exiting study wells have historical data, the first step is to graph the chloride values for each well to determine any increasing trends over time. The next step is to determine the "fingerprint" or the water quality characteristics for each well with the use of stiff diagrams. Stiff diagrams show the complete inorganic suite of water quality data concentrations represented on a graph. This provides instant recognition the "fingerprint" of water being pumped from each of the aquifers. Like aquifer wells will have similar water quality fingerprints. The next water quality graphing step, prior to contouring the well chloride data, is to create a trilinear diagram for multiple wells. The inorganic water quality concentrations for each well will be represented on one graph in comparison to the same constituent concentrations of seawater. This graph enables the analyst to determine inorganic parameter concentration trends toward varying degrees of seawater intrusion. Using generally accepted standards, it must be confirmed whether elevated chloride concentrations are an anomaly or are due to seawater intrusion. The last step in the water quality data analysis is to contour the chloride data for each of the coastal monitoring wells on a map to compare and contrast chloride values. To contour, the following protocol will be followed utilizing ArcView GIS 3.3:

- Create a .dbf file that includes facility codes, chloride values and sampling dates information
- Import .dbf file into Arc-View
- In Arc-View, open a new view
- In the menu bar, under View choose the add Theme button and add the shape file with wells to be contoured
- In the View window, "open the tables of active themes", which will bring up the attributes table
- Open both the .dbf file and the study wells shape file, join the tables
- Choose create contours under Surface in the view window
  - Create contours, select Output Grid Extent option
  - Choose spline method to interpolate surface type field
  - Choose chloride for "Z" value field
  - Choose appropriate weight and number of points (hint: start with default values to see what the default contour looks like)
- Classify quantiles using Legend Editor menu
  - Choose chloride value for value field. Classify according to chloride concentration e.g. 100 mg/L, 250 mg/L, or 500 mg/L
  - Assign line type according to chloride concentrations

After the draft chloride contour map is generated, multiple technical review sessions must take place by all entities, MPWMD, Cal Am, and MCWRA, to evaluate the data representation. This will enable the entities to determine if the data are correctly being represented on the map, and if so, lead to the implementation of an action program. Well production amounts, seasonal precipitation, and water conservation efforts in each of the geographic areas will be useful in interpreting the chloride contour map. Once this first step is completed to determine the baseline chloride contours, a more thorough evaluation will be accomplished once the data is generated from the new coastal dedicated monitoring wells.

Take note that there are other, less routinely used, data analysis tools available to further delineate seawater intrusion and its advancement. Some tools, among others, include water quality stable isotope analysis and periodic well borehole geophysics.

The data analysis of seawater intrusion will be performed on an annual basis beginning January 2007 after the period of monitoring during heavy pumping is completed from May through November 2006.

C. Actions to be Taken Subsequent to Detection of Seawater Within in a Coastal Well

The following actions are to be taken in accordance with Exhibit A of the *Decision (Case No. M66343)*

1. If seawater intrusion is detected in a coastal production or monitoring well ("Contaminated Well"), the Contaminated Well will discontinue pumping and all other wells that produce groundwater from the intruded aquifer that are within one-half mile of the affected monitoring well ("Threatened Wells") will immediately reduce their monthly production to the equivalent of one-half of their average monthly production[1] within the previous five years upon notification from Watermaster of the detection of seawater intrusion within the Contaminated Well.

2. Watermaster shall increase monitoring of groundwater levels within the one-half mile radius of the Contaminated Well to determine if the requisite pumping reductions sufficiently affect groundwater gradients to prevent the further spread of seawater intrusion toward the Threatened Wells. This increased monitoring effort will include installing at least one new monitoring well as a sentinel well between the Contaminated Well and the nearest down-gradient active Threatened Well.

3. After six months of reduced pumping of the Threatened Wells, the threat of further seawater intrusion will be re-evaluated. If the requisite pumping reductions have failed to sufficiently affect groundwater gradients to prevent the further spread of seawater intrusion toward the Threatened Wells, those wells will further reduce their monthly production to the equivalent of one-third of their average monthly production within the previous five years upon notification by Watermaster that such further reductions are required.

4. After another six months of monitoring, the direction of groundwater gradients will again be evaluated. If there continues to be a groundwater gradient that would pull the detected seawater towards the Threatened Wells, then the Threatened Wells shall discontinue pumping, unless in Watermaster's determination, doing so would create a public health and/or safety risk.

5. If, after the initial discovery of the initial seawater intrusion, seawater is encountered

---

> in an additional monitoring or production well, pumping reductions will be required for nearby threatened production wells (i.e., production wells within one half mile of the recently contaminated well) in the same manner as set forth above for first Contaminated Well.

If the implementation of the procedures set forth above cause a production well to reduce its pumping or to cease pumping altogether, all reasonable efforts shall be undertaken by the Watermaster and all other Parties that Produce Groundwater from the Basin to insure that the lost production capacity and associated water supply for that well owner/operator will be replaced by redistributing pumping, or provision of replacement water from other sources.

D. Efforts to Redistribute or Replace Water Lost Because of Seawater Intrusion Contingency Plan

The Monterey Peninsula has faced the constant specter of water shortage for decades. The Monterey Peninsula Water Management District has developed an *Expanded Conservation and Standby Rationing Plan* (included in the program as Appendix 2) that responds to a number of water supply shortage scenarios. Saltwater intrusion and subsequent management of an event will require planning and coordination of all Seaside Basin users

In the event that supplies cannot immediately be replaced with supplies from other Seaside Basin wells or from outside sources, the Monterey Peninsula Water Management District would, in conjunction with California American Water, implement the appropriate actions called for in the *Expanded Conservation and Standby Rationing Plan* (MPWMD Regulation XV, Rules 160 – 175) for the Cal Am service area. The plan will be amended by January 2007 as needed to use detected seawater intrusion episodes as a trigger for the implementation of the plan to also include the Seaside Water Main System.

A contingency planning program will enable quick action to take place to address any seawater intrusion scenario that may arise from the annual analysis of the seawater intrusion water quality.

V. Basin Monitoring and Management Program Implementation Schedule

					2006						2007									
No.	Task	Duration (Days)	Start	Finish	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
	Groundwater Modeling for Seaside Basin Through Consultant:																			
1	Review (E) groundwater models, select best model for enhancement	61	07/01/2006	08/31/2006	🟦	🟦														
2	Develop scope of services & budget for model enhancement project	29	08/01/2006	08/30/2006		🟦														
3	Advertise, select consultant, execute contract	59	09/01/2006	10/30/2006			🟦	🟦												
4	Complete model development & calibration, run scenario evaluations, develop improved estimates of basin recharge and safe-yield	180	10/01/2006	03/30/2007				🟦	🟦	🟦	🟦	🟦	🟦							
5	Provide training in use of model to Watermaster Technical Committee	29	04/01/2007	04/30/2007										🟦						
	Seaside Basin Management Program:																			
1	Develop scope of services & budget for consultant	60	07/01/2006	08/30/2006	🟦	🟦														
2	Advertise, select consultant, execute contract	90	09/01/2006	11/30/2006			🟦	🟦	🟦											
3	Develop Basin Monitoring Plan, Seaside Basin Watermaster Database & data collection & analysis protocol	180	12/01/2006	05/30/2007						🟦	🟦	🟦	🟦	🟦	🟦					
4	Evaluate options for importation of supplemental water supplies into the Seaside Basin, develop action plan	89	12/01/2006	02/28/2007						🟦	🟦	🟦								
5	Using groundwater model from task above, analyze & develop strategies for improved basin management	122	04/30/2007	08/30/2007											🟦	🟦	🟦	🟦		
6	Develop action plan to avoid adverse impacts on the basin	152	02/28/2007	07/30/2007									🟦	🟦	🟦	🟦	🟦	🟦		
7	Draft Seaside Basin Management Plan Report for Watermaster review	121	06/01/2007	09/30/2007												🟦	🟦	🟦	🟦	
8	Produce Final Seaside Basin Management Plan	29	10/01/2007	10/30/2007																🟦
	Basin Monitor Well Construction Program:																			
1	Develop scope of services and RFP for consultant program oversight	60	07/01/2006	08/31/2006	🟦	🟦														
2	Review proposals, secure oversight consultant contract	30	09/01/2006	09/30/2006			🟦													
3	Oversight consultant completes site acquisition approvals	180	10/01/2006	03/31/2007				🟦	🟦	🟦	🟦	🟦	🟦							
4	Develop scope of services and request bids for drilling/monitor wells	90	01/01/2007	03/31/2007							🟦	🟦	🟦							
5	Review bids, secure contract(s)	30	04/01/2007	04/30/2007										🟦						
6	Drill, equip and collect initial monitoring data	150	05/01/2007	09/30/2007											🟦	🟦	🟦	🟦	🟦	
7	Prepare and submit completion report to Watermaster	60	09/01/2007	10/31/2007															🟦	🟦
	Creation of Consolidated Basic Groundwater Resource Database:																			
1	Develop database RFP	30	07/01/2006	07/31/2006	🟦															
2	Review proposals, select consultant	30	08/01/2006	08/31/2006		🟦														
3	Develop and approve database format	30	09/01/2006	09/30/2006			🟦													
4	Populate database (historical data from all sources)	60	10/01/2006	11/30/2006				🟦	🟦											
5	Populate database (current monitoring data)	30	12/01/2006	12/31/2006						🟦										
6	Prepare database documentation report	30	01/01/2007	01/31/2007							🟦									

Appendix 1

Exhibit A of the *Decision* in the Superior Court of the State of California in and for the County of Monterey, Case No. M66343

Principles and Procedures of the Seaside Basin Monitoring and Management Plan

Introduction

This document sets forth the criteria that will guide the Watermaster in creating the Seaside Basin Monitoring and Management Plan. It also establishes a procedure for dealing with seawater intrusion, should the same occur, during the time the Watermaster is developing its plan of action to deal with such an eventuality.

Plan Criteria

Within sixty days of entry of the Judgment by the Court, the Watermaster will submit for the Court's approval a Monitoring and Management Plan containing details for implementation of the following actions:

a. *Exploratory borehole drilling program.* About four exploratory boreholes shall be drilled along the shoreline and the northern boundary of the Basin to depths ranging from 500 to 1500 feet, the depth being controlled by the depth of the Monterey formations. Lithologic samples shall be collected and classified for every one foot of drilling. A full suite of geophysical logs shall be collected. The data collected as part of this program shall be compared to other well data in the Seaside Basin to further refine the hydrogeologic conceptual model in the areas between the production wells and saline groundwater.

b. *Geophysical surveys.* Geophysical surveys shall be performed along the shoreline and the northern boundary of the Basin, intersecting the test borehole locations. The results of the geophysical surveys shall be calibrated against the test borehole data. The borehole data and the surveys shall be analyzed to characterize the near shore hydrology and to locate and design new monitoring wells.

c. *New monitoring wells.* About four to six monitoring well clusters shall be drilled and installed along the shoreline and the northern boundary of the Basin. Each cluster shall consist of at least four to five wells to provide a detailed vertical characterization of head and water quality through the aquifer system. The Watermaster shall coordinate the placement of the wells with MPWMD, which already has some monitoring wells in place with plans to drill more, to avoid duplication of effort and cost inefficiencies.

d. *Design and implementation of a piezometric and water quality monitoring program.* Pressure transducers and ionic probes (EC and C1) shall be installed in each well at each cluster. These probes will record water levels and water quality on a frequent interval (every 15 minutes for water levels, and every day for water quality). Where possible, similar probes will be installed in the pumping wells to record water levels and on/off cycles. Grab samples will be obtained periodically to true up the ionic probes. These data will be analyzed to assess the state of seawater

Exhibit A

intrusion, reveal groundwater barriers within the aquifer system, and more accurately estimate aquifer system parameters.

e. *Development and implementation of a management program.* The objectives of the management program will be to optimize pumping, halt seawater intrusion, and return the Basin to equilibrium through implementation of conservation methods; replacement of water drawdown by substitution of reclaimed water, where appropriate, infusion of imported water into the aquifer; and utilization of controlled pumping schedules through analysis of real-time monitoring.

f. *Develop criteria for use by the Watermaster in determining any modification of the Operating Yield.*

The management program will include periodic review of monitoring information and the use of this review to guide near-term and long-term groundwater pumping. If seawater is detected by the MPWMD monitoring wells currently in place, or by pumping wells, or by the monitoring well system contemplated by this document, the Watermaster shall follow the procedures developed pursuant to the mandate of the following paragraph. If it is detected before such procedures are in place, the Watermaster shall follow the procedure set forth in the *Interim Contingency Procedure to Contain Seawater Intrusion*, infra.

Within one year after entry of the Judgment by the Court, the Watermaster will:
(a) develop improved estimates of the natural and secondary recharge within the Seaside Basin; (b) develop and implement a program for collecting groundwater production, water use, and land use data for the Seaside Basin and appropriate adjacent areas;
(c) develop a suitable groundwater model of the Seaside Basin and appropriate adjacent areas; (d) develop a plan of action to be implemented to avoid various adverse effects in the Basin, including seawater intrusion; and (e) develop a plan of action to contain seawater intrusion, should it occur. The plan of action to avoid adverse effects in the Basin shall include a timeline for the importation of Non-Native water for spreading or injection into the Basin, and for acquisition of recycled water in lieu of Native Water production, and shall outline concrete steps to be taken to secure both Non-Native Water and recycled water.

Interim Contingency Procedure to Contain Seawater Intrusion

If Seawater intrusion is detected in the Basin during the development of the Watermaster's Management Plan, the following contingency plan will be set in motion to prevent seawater from contaminating larger portions of the Basin:

a. *Detection in a coastal monitoring well.* If seawater intrusion is detected in a coastal monitoring well, it is imperative that pumping stresses be reduced so that seawater is not pulled inland to producing wells. To accomplish this, all wells that produce from the intruded aquifer that are within one-half mile of the affected monitoring well will reduce their production to the equivalent of one-half their previous five-year pumping average. Monitoring of groundwater levels within the one-half mile radius of the affected well will be increased to determine if groundwater gradients following reductions in pumping have been modified sufficiently to prevent further seawater intrusion. This increase in monitoring effort will include installing at least one new monitoring well as a sentinel between the affected monitoring well and the nearest down-gradient active production well. After six months of reduced pumping, the threat of further seawater intrusion will be re-evaluated. If there continues to be a groundwater gradient that would pull the detected seawater toward producing wells, the pumping wells within one-half mile of the affected monitoring well will further reduce pumping to one-third of their previous five-year pumping average. After another six months of monitoring, the direction of groundwater gradients will again be evaluated. If there continues to be a groundwater gradient that would pull the detected seawater towards producing wells, then the wells with reduced pumping will discontinue pumping. If, after the initial discovery of intrusion, seawater is encountered in an additional monitoring well, pumping reductions will be required for nearby producing wells in the same manner as for the first intruded monitoring well.

b. *Detection in a production well.* If seawater intrusion is encountered in a production well, that well will discontinue pumping. In addition, all wells that produce from the intruded aquifer that are within one-half mile of the affected well will reduce their production to the equivalent of one-half of their previous five-year pumping average. The sequence of threat evaluation, subsequent pumping reductions, and installation of new monitoring wells will be the same as for that in subparagraph a.

f the implementation of the procedures set forth above causes a production well to educe its pumping or to cease pumping altogether, all reasonable efforts must be ndertaken by the Watermaster to insure that lost production will be replaced by edistributing pumping, further conservation efforts on the part of all parties, or provision f replacement water from other sources.

Appendix 2

Expanded Conservation and Standby Rationing Plan, by the Monterey Peninsula Water Management District

REGULATION XV. EXPANDED WATER CONSERVATION AND STANDBY RATIONING PLAN

RULE 160 - GENERAL PROVISIONS

A. All water users within the Monterey Peninsula Water Management District shall be subject to the District's water waste and non-essential water use prohibitions.

B. Prohibitions against water waste and non-essential water use shall be enforced by the District and its designated agents in accordance with Rule 171 (Water Waste Fees).

C. Stage 1 Water Conservation shall be implemented upon the effective date of this regulation.

D. Stage 1 Water Conservation parallels Cal-Am's Phase IV Mandatory Water Conservation program that was designed to meet the Carmel Valley water production limits set by the SWRCB and approved by the Public Utilities Commission. Stages 1 through 3 Water Conservation is intended to achieve the Carmel Valley water production limits set by the State Board. Stage 4 Water Rationing through Stage 7 Water Rationing are intended to respond to limitations in supply caused by inadequate system inflow and storage.

E. Stage 1 Water Conservation through Stage 3 Water Conservation shall apply to water users of the Cal-Am water distribution system where that system derives its source of supply from the Monterey Peninsula Water Resources System (MPWRS) for as long as Cal-Am is subject to water production goals and limitations enforced by the SWRCB.

F. Stage 4 Water Rationing through Stage 7 Water Rationing may apply to all water distribution system users and water users within the Monterey Peninsula Water Resources System as a response to limited water supply. These stages shall also serve as responses to emergency situations where immediate reductions in water use are necessary to ensure public health, safety or welfare. This regulation authorizes the Board of Directors to, from time to time, determine by Resolution that any water distribution system or set of water users within the Monterey Peninsula Water Management District shall be subject to Stages 4 Water Rationing through Stage 7 Water Rationing as provided in this ordinance.

G. As to water derived from the MPWRS, Cal-Am shall maintain unaccounted for water use in its MPWRS distribution system at or below seven (7) percent. Average losses of more than seven (7) percent during the most recent twelve-month period shall be considered water waste. This limitation shall not affect any Cal-Am system east of, and including, the Ryan Ranch subunit.

H. Cal-Am shall amend its Urban Water Management Plan to conform to the policies and procedures described in this ordinance. A copy of the plan and amendment shall be filed with the District within 180 days of the effective date of this ordinance. The plan shall comply with the California Water Code, Division 6, Part 2.6.

Amended by Ordinance No. 119 (3/21/2005)

RULE 161 - STAGE 1 WATER CONSERVATION

A. Stage 1 Water Conservation is defined as the first stage in the District's Expanded Water Conservation and Standby Rationing Plan that takes action to maintain Cal-Am water derived from the MPWRS below regulatory constraints by increasing conservation activities and preparing for further stages of conservation and rationing. During Stage 1 Water Conservation, Cal-Am shall have the goal of maintaining its annual (October 1 through September 30) water production from the Carmel Valley below 11,285 acre-feet. This quantity may be modified by the SWRCB. Assuming a maximum annual production of 4,000 acre-feet from the Seaside Coastal Basin, this equates to a Cal-Am system production limit of 15,285 acre-feet. Each water user deriving water from the Cal-Am system that derives its source of supply from the MPWRS shall comply with District water waste and non-essential water use prohibitions and shall participate to the extent possible in voluntarily reducing water use.

B. All water users with the Monterey Peninsula Water Management District shall comply with water waste and non-essential water use prohibitions.

Rule added by Ordinance No. 92 (1/29/99)

RULE 162 - STAGE 2 WATER CONSERVATION

A. Stage 2 Water Conservation is defined as the second stage in the District's Expanded Water Conservation and Standby Rationing Plan that takes action to maintain Cal-Am water use from the MPWRS below regulatory constraints by requiring implementation of Landscape Water Budgets for large irrigators of three acres or more, large residential water users and water users with dedicated landscape water meters.

B. Stage 2 Water Conservation shall be enforced when Cal-Am production from the MPWRS has exceeded the year-to-date at month-end target as displayed in Table 1.

The monthly distribution of water production shown in Table 1 between sources in the Carmel River Basin and in the coastal subareas of the Seaside Groundwater Basin shall be approved by the Board of Directors as part of the Quarterly Water Supply Strategy and Budget process. The Board shall hold public hearings to consider the water supply budgets for Cal-Am's main system during the Board's regular meetings in September, December, March, and June, at which time the Board may modify Table 1 by Resolution.

Amended by Ordinance No. 119 (3/21/2005)

Table 1

REGULATORY WATER PRODUCTION TARGETS FOR CALIFORNIA AMERICAN WATER MAIN SYSTEM FROM SOURCES WITHIN THE MONTEREY PENINSULA WATER RESOURCES SYSTEM

Month	Monthly Target	Year-to-Date At Month-End Target
October	1,379	1,379
November	1,113	2,492
December	984	3,476
January	958	4,434
February	894	5,328
March	1,047	6,375
April	1,209	7,584
May	1,405	8,989
June	1,527	10,516
July	1,628	12,144
August	1,649	13,793
September	1,492	15,285
TOTAL	15,285	

C. Requirements imposed by implementation of the Expanded Water Conservation and Standby Rationing Plan through Stage 1 Water Conservation shall remain in force. Requirements may be modified or superseded by actions taken in future stages of the Expanded Water Conservation and Standby Rationing Plan.

D. Implementation of Landscape Water Budgets: All water users required to obtain a Landscape Water Budget under District Rule 172 are required to manage outdoor irrigation within the Landscape Water Budget assigned to the property.

E. Water use in excess of the established Landscape Water Budget shall be considered Water Waste and shall be subject to District Rule 171.

F. Sunset of Stage 2 Water Conservation: Without further action of the Board of Directors, the provisions of Stage 2 Water Conservation shall be rescinded and revert to Stage 1 Water Conservation upon compliance with the year-to-date at month-end production goal for two consecutive months in the subsequent water year.

G. Notice: Cal-Am shall provide an annual reminder notice to MPWRS users with Landscape Water Budgets to report modifications in landscaping which could alter an existing budget.

H. Monthly Consumption Reports: During any Stage 2, 3, 4, 5, 6, or 7, Cal-Am shall provide the District with monthly consumption reports in a format approved by the District. Reports shall be provided within fifteen (15) days of the close of the preceding month.

Rule added by Ordinance No. 92 (1/28/99); Ordinance No. 119 (3/21/05)

RULE 163 - STAGE 3 WATER CONSERVATION

A. Stage 3 Water Conservation is defined as the third stage in the District's Expanded Water Conservation and Standby Rationing Plan that takes action to maintain Cal-Am water use in the MPWRS below regulatory constraints. It is triggered when the year-to-date at month-end production target for Cal-Am from the MPWRS is exceeded twice by the average of Cal-Am's year-to-date production from the MPWRS for each month during the October through March period or exceeded once by the average of Cal-Am's year-to-date production from the MPWRS for each month during the April through September period. It provides a procedure to enable emergency temporary increases in the upper block volume rates and requires increased action by Cal-Am to reduce unaccounted-for water and monthly reporting of actions taken. Stage 3 Water Conservation may also be triggered upon Resolution of the Board of Directors when there is a need for an immediate water use reduction in response to an unexpected water production increase.

Upon implementation of Stage 3 Water Conservation, Cal-Am shall immediately submit a plan to the General Manager to reduce unaccounted for water uses to seven (7) percent or less measurered by the most recent twelve-month rolling average and shall immediately act on such plan. Cal-Am shall provide a progress report to the Board of Directors monthly until Stage 3 is sunset.

B. Regulatory Trigger: Stage 3 Water Conservation shall be enforced when any of the following criteria has been met: 1) the average of Cal-Am's year-to-date production from the MPWRS for each month has exceeded the year-to-date at month-end production target for Cal-Am from the MPWRS as displayed in Table 1 for a second time during the period from October 1 through March 31 in any water year, or 2) the average of Cal-Am's year-to-date production from the MPWRS for each month has exceeded the year-to-date at month-end production target for Cal-Am from the MPWRS as displayed in Table 1 once during the period from April 1 through September 30 in any water year, or 3) a Resolution has been adopted by the Board in accord with Section C below.

C. Emergency Trigger: Stage 3 Water Conservation shall be implemented upon Resolution of the Board of Directors when there is need for an immediate water use reduction requirement in response to an unexpected water production increase.

D. Sunset of Stage 3 Water Conservation: Without further action by the Board of Directors, the provisions of Stage 3 Water Conservation shall be rescinded upon compliance with the year-to-date at month-end production goal for two consecutive months in the subsequent water year. Water users of Cal-Am when that water system derives water from the MPWRS shall revert to Stage 1 Water Conservation.

Regulatory compliance during a period of Stage 4 Water Rationing shall not cause a sunset of this provision.

E. Notice: Cal-Am shall provide notice of mandatory water conservation with each bill prepared for water users of the Cal-Am system

F. Cal-Am Emergency Use Rates: Cal-Am shall implement the California Public Utilities Commission (CPUC) approved emergency rate schedule to respond to Stage 3 water reduction requirements. Cal-Am shall file an Advice Letter with the CPUC to implement Emergency Use Rates, however, only after it has first met and conferred with the District at least five days in advance of that filing. The General Manager may waive this time period for good cause.

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 164 - STAGE 4 WATER RATIONING

A. Stage 4 Water Rationing is defined as the fourth stage in the District's Expanded Water Conservation and Standby Rationing Plan that responds to a drought situation or emergency water supply shortage with a 15 percent reduction goal from system production limits for non-Cal-Am water users. Fifteen percent reductions in the Cal-Am system are achieved through Stage 3 Water Conservation.

B. Trigger.

1. Water Supply Limitation Trigger. Stage 4 Water Rationing shall apply to all water users whose source of supply is derived from the MPWRS. Stage 4 Water Rationing shall become effective on June 1 or such earlier date as may be set by the Board following the District's May Board meeting if total usable storage in the MPWRS on May 1 is less than 27,807 acre-feet and greater than 21,802 acre-feet. If total usable storage is equal to or greater than 27,807 acre-feet on May 1, no water rationing shall be imposed.

2. Emergency Trigger. Stage 4 Water Rationing shall be implemented upon Resolution of the Board of Directors when there is need for an immediate water use reduction requirement in response to an unexpected water supply shortage.

C. Requirements previously imposed by implementation of the Expanded Water Conservation and Standby Rationing Plan shall remain in force. Requirements may be modified or superseded by actions taken in this or future stages of the Expanded Water Conservation and Standby Rationing Plan.

D. The provisions of Stage 3 Water Conservation shall be implemented for all water users of the Cal-Am water distribution system, unless specifically exempt from Stage 4 Water Rationing by action of the Board of Directors.

E. Sunset of Stage 4 Water Rationing.

1. Water Supply Availability. Stage 4 Water Rationing shall continue to have force and effect until rescinded by Resolution of the Board of Directors upon a determination that the total usable storage in the MPWRS is greater than 27,807 acre-feet. This determination will normally be made at the Board's May meeting. However, a determination to rescind Stage 4 Water Rationing as early as the following January Board meeting can be made if the total usable storage in the MPWRS is equal to or greater than 27,807 acre-feet on January 1.

2. In the event total usable storage is greater than 27,807 acre-feet, the General Manager shall review Cal-Am's year-to-date production. Upon compliance with the monthly year-to-date goals specified in Table 1 of

Rule 162 and, unless otherwise specified in the Resolution rescinding Stage 4 Water Rationing, water users shall revert to Stage 1 Water Conservation. If Cal-Am's year-to-date production exceeds the year-to-date goal specified in Table 1 of Rule 162, Cal-Am water users shall revert to Stage 2 Water Conservation.

3. Emergency. Upon correction of a water supply limitation caused by an emergency, Stage 4 Water Rationing shall sunset without action by the Board.

F. Notice.

1. Upon direction of the General Manager, all water distribution system operators affected by Stage 4 Water Rationing shall notify water users of the system that reductions in water use are necessary and that stricter water rationing may be imminent. Water distribution system operators shall ensure that notices provided or required by the District shall be distributed to the system water users.

2. As appropriate, Cal-Am shall notify its water users that excessive use rates will be imposed upon the effective date of Stage 4 Water Rationing.

3. The District shall contact all water users of private wells not supplying water to a distribution system within the MPWRS. Contact shall be via first class mail and shall explain the restrictions placed on the use of private wells during Stage 4 Water Rationing and shall provide and/or request additional information from the private well owner as deemed necessary for the efficient operation of the program.

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 165 - STAGE 5 WATER RATIONING

A. Stage 5 Water Rationing is defined as the fifth stage in the District's Expanded Water Conservation and Standby Rationing Plan that responds to a drought situation or emergency water supply shortage with a 20 percent reduction goal from the system production limit. Reductions are achieved by water use cutbacks by user category and by per-capita water rations and a moratorium on water permits that intensify water use.

B. Implementation.

1. Water Supply Limitation Trigger. Stage 5 Water Rationing shall apply to all water users whose source of supply is derived from the MPWRS. Stage 5 Water Rationing shall become effective on June 1 or such earlier date as may be set by the Board following the District's May Board meeting if total usable storage in the MPWRS on May 1 is less than 21,802 acre-feet and greater than 15,615 acre-feet. If total usable storage is equal to or greater than 27,807 acre-feet on May 1, no water rationing shall be imposed.

   The General Manager may delay implementation of Stage 5 Water Rationing to ensure adequate operation of the program. Delays authorized by the General Manager shall not exceed 90 days.

2. Emergency. Implementation shall also occur following urgency action by Resolution of the Board of Directors declaring that an emergency situation exists and immediate 20 percent reductions in water use from a distribution system's production limit are necessary to ensure public health, safety or welfare.

C. Sunset of Stage 5 Water Rationing.

1. Water Supply Availability. Stage 5 Water Rationing shall continue to have force and effect until rescinded by Resolution of the Board of Directors upon a determination that the total usable storage in the MPWRS is greater than 21,802 acre-feet. This determination will normally be made at the Board's May meeting. However, a determination to rescind Stage 5 Water Rationing as early as the following January Board meeting can be made if the total usable storage in the MPWRS is equal to or greater than 27,807 acre-feet on January 1.

2. In the event total usable storage is greater than 27,807 acre-feet, the General Manager shall review Cal-Am's year-to-date production. Upon compliance with the monthly year-to-date goals specified in Table 1 of Rule 162 and, unless otherwise specified in the Resolution rescinding Stage 5 Water Rationing, water users shall revert to Stage 1 Water Conservation. If Cal-Am's year-to-date production exceeds the year-to-date goal specified in Table 1 of Rule 162, Cal-Am water users shall revert

to Stage 2 Water Conservation.

If Cal-Am production exceeds the year-to-date at month's end production goal as shown in Rule 162, Table 1, Cal-Am water users shall revert to Stage 2 Water Conservation.

D. Affected Water Users. Stage 5 Water Rationing shall apply to all water users within the MPWRS. As necessary to ensure adequate water supplies, the Board of Directors may act within its discretion to authorize activation of Stage 5 Water Rationing within one or more water distribution systems in the District.

E. Requirements imposed by implementation of the Expanded Water Conservation and Standby Rationing Plan through Stage 4 Water Conservation shall remain in force. Requirements may be modified or superseded by actions taken in this or future stages of the Expanded Water Conservation and Standby Rationing Plan.

F. Moratorium. On October 1 following implementation of Stage 5 Water Rationing, the District shall suspend the issuance of water permits associated with intensification in use. This provision shall not suspend the issuance of water permits that utilize public or private Water Use Credits or where issuance of a permit is required by prior agreement of the District.

G. Reduction Goal. Stage 5 Water Rationing achieves water use reductions of 20 percent of the Cal-Am and non-Cal-Am system production limits in each user category as follows: Residential single-family and multi-family, commercial/industrial, public authority, golf course, "other," non-revenue metered uses, and reclaimed water users.

H. Notice.

1. Cal-Am shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the Cal-Am system via first-class mail at least thirty (30) days before the first day of rationing. Further, Cal-Am shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, Cal-Am shall provide each responsible party with a survey form upon request.

2. All water distribution system operators affected by Stage 5 Water Rationing shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the water distribution system via first-class mail at least thirty (30) days before the first day of rationing. Further, the distribution system operator shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, the water distribution system operator shall provide each responsible party with a survey form

at least once each calendar year. Water distribution system operators shall ensure that notices provided or required by the District shall be distributed to the system water users.

3. The District shall contact all water users of private wells not supplying water to a distribution system within the MPWRS at least thirty (30) days before the first day of Stage 5 Water Rationing. Contact shall be via first class mail and shall explain the restrictions placed on the use of private wells during Stage 5 Water Rationing and shall provide and/or request additional information from the private well owner as deemed necessary for the efficient operation of the program.

I. Rations by Category. Water rations shall be determined by user category. Each water user within the Monterey Peninsula Water Resources System shall be classified in one of the following groups: Residential Single-Family and Multi-Family, Commercial/Industrial, Public Authority, Golf Course, "other," Non-Revenue Metered Use, and Reclaimed Water Users.

J. Reduced Annual Cal-Am Annual Production During Stage 5 Water Rationing. The Cal-Am annual production limit shall be reduced by 20 percent during Stage 5 Water Rationing. The resulting production limit shall be further reduced by a water rationing contingency determined by the Board. Seven (7) percent of the remainder shall be the maximum Cal-Am unaccounted for water use ration. The remaining water shall be the Cal-Am annual production limit for all user categories.

K. Non-Cal-Am Annual Production Limits During Stage 5 Water Rationing. Available production for other water distribution systems subject to Stage 5 Water Rationing shall be determined using the same methodology as for Cal-Am without including a deduction for unaccounted for water uses. The non-Cal-Am annual production limit for the Monterey Peninsula Water Resources System shall be used as the maximum production limit.

L. Establishing the Rations. Rations for each user category shall be determined by the General Manager by dividing the reduced available production by the percentage of use. The percentage of use for each user group shall be determined by the most recent unrationed reporting year (July 1 through June 30) data provided by Cal-Am for water users of that portion of Cal-Am that derives water from the MPWRS, and by data provided by the District from its annual well reporting program for non-Cal-Am distribution systems.

1. Residential Water Users. Each residential water user either served by a water meter reported as "single-family residential" by the water distribution system or served by a private well shall have an equal portion of the water available to the single-family residential category based upon the number of residents reported on the survey form.

2. Multi-Family Residential Water Users. Each multi-family residential water user either served by a water meter reported as "multi-family residential" by the water distribution system or served by a private well shall have an equal portion of the water available to the multi-family residential category based upon the number of residents reported on the survey form with the following exception:

    a. Multi-family residential sites with common laundry facilities on a separate water meter shall receive a one-unit water ration for each dwelling unit that has access to the facility. Each dwelling unit located on the multi-family residential site that has access to the common laundry facility shall have the dwelling unit ration reduced by one unit of water.

3. Commercial/Industrial Water Users. Each commercial/industrial water user either served by a water meter reported as "commercial" or "industrial" by the water distribution system shall have a base ration determined by applying the current commercial water use factors.

    a. Mixed Use Water Users. Mixed-use water users shall be classified as commercial uses for the purposes of this program.

4. Public Authority. Public Authority Uses shall be rationed by jurisdiction. Each Public Authority water user may combine multiple accounts or connections when the accounts are located within one jurisdiction.

5. Golf Courses. Golf Courses supplied water exclusively by the Cal-Am or non-Cal-Am water distribution systems or wells may be rationed individually or, upon request to the General Manager, as a group.

6. Other. Water users utilizing portable water meters or hydrant meters shall be required to employ Best Management Practices. Cal-Am shall be required to report monthly to the District the location and responsible party for all portable water meters and the amount of use from those meters. As deemed necessary to achieve the imposed reduction in use, the District may condition use of temporary connections.

7. Non-Revenue Metered Users. Non-Revenue Metered Uses shall be rationed as a group with the following exception:

    a. Irrigation required by the Mitigation Program adopted when the Water Allocation Program Environmental Impact Report was adopted in 1990, and as required by SWRCB Order No. WR 95-10, shall not be subject to reductions in use. Required irrigation of the riparian corridor shall be identified and reported separately from other non-revenue metered uses.

8. Non-Cal-Am Wells. Regulations for rationing non-Cal-Am wells located within the MPWRS that are not supplying water to a distribution system shall be considered by the Board prior to implementation of Stage 5 Water Rationing.

9. Recycled Water Users. Recycled Water Irrigation Areas receiving water from the CAWD/PBCSD Wastewater Reclamation Project shall be subject to Stages 5 Water Rationing and higher for potable water used during an interruption or emergency, in accordance with contractual agreements between the District and the respective owners of the Recycled Water Irrigation Areas.

    a. Before Project Expansion Is Completed. Under the agreements operative before the Project Expansion is Completed (as the capitalized terms are defined in Rule 23.5), the owners of the Recycled Water Irrigation Areas shall have the respective irrigation requirements thereof satisfied to the same degree as any non-Project golf course or open space which derive their source of supply from the Cal-Am system. The irrigation requirements of the Recycled Water Irrigation Areas will be determined based on the most-recent non-rationed four-year average irrigation water demand, including both Recycled Water and potable water, for each Recycled Water Irrigation Areas. The use of Recycled Water, when available in sufficient quantities to satisfy the irrigation requirements of the Recycled Water Irrigation Areas, shall not be restricted by this requirement.

       Each Recycled Water Irrigation Area shall be entitled to receive the average irrigation requirement determined above, reduced by the percentage reduction required by the current stage of rationing. If the quantity of Recycled Water that is available is less than the quantity of water that the Recycled Water Irrigation Area is entitled to, potable water shall be provided to make up the difference and satisfy the irrigation requirements of the Recycled Water Irrigation Area to the same degree that the irrigation requirements of non- Project golf course and open space users are being satisfied.

       The District shall ensure that the water provided during water rationing is of adequate quality. If the quality does not satisfy the contractual agreement operative before the Project Expansion is deemed Completed (as the capitalized terms are defined in Rule 23.5), potable water shall be provided in sufficient quantities to improve the quality of the reclaimed water.

This Subsection L.9.a shall cease to be operative once the Project Expansion is deemed to be Completed (as the capitalized terms are defined in Rule 23.5), and shall thereafter be of no force or effect.

b. When Project Expansion Is Completed. Under the agreements operative once the Project Expansion is deemed Completed (as the capitalized terms are defined in Rule 23.5), the owners of the Recycled Water Irrigation Areas shall have the respective irrigation requirements thereof satisfied to the same degree as any non-Project golf course or open space which derives its source of supply from the Cal-Am system. The irrigation requirements of the Recycled Water Irrigation Areas will be determined based on the most-recent non-rationed four-year average irrigation water demand, including both Recycled Water and potable water, for each respective Recycled Water Irrigation Area.

Each Recycled Water Irrigation Area shall be entitled to receive the average irrigation requirement determined above, reduced by the percentage reduction required by the current stage of rationing. If the quantity of Recycled Water that is available is less than the quantity of water that the Recycled Water Irrigation Area is entitled to, potable water shall be provided to make up the difference and satisfy the irrigation requirements of the Recycled Water Irrigation Areas to the same degree that the irrigation requirements of non-Project golf course and open space users are being satisfied.

The preceding sentence shall not apply to the extent that the irrigation requirements of any Recycled Water Irrigation Area are met with water legally available to Buyer from any source other than the Carmel River System or the Seaside Groundwater Basin, including percolating ground water underlying Buyer's Property, to make up any such difference.

When Recycled Water (as defined in Rule 23.5) is available in sufficient quantities to satisfy the irrigation requirements of the Recycled Water Irrigation Areas, such irrigation shall not be subject to Stages 5 Water Rationing and higher, and neither potable water nor any water described in the preceding sentence (whether or not it is potable) shall be used for irrigation of the Recycled Water Irrigation Areas except to the extent allowed in the circumstances described in the next two sentences.

If there is an Interruption in Recycled Water deliveries to any Recycled Water Irrigation Area(as the capitalized terms are defined in Rule 23.5), the temporary use of potable water for irrigating each such Recycled Water Irrigation Area is authorized in the manner described in Rule 23.5, Subsection F.

If MPWMD has adopted an ordinance in response to any emergency caused by drought, or other threatened or existing water shortage pursuant to section 332 of the Monterey Peninsula Water Management Law, said ordinance shall prevail over contrary provisions of this Rule. Notwithstanding the preceding sentence, potable water shall be made available for irrigating tees and greens of the Recycled Water Irrigation Areas in sufficient quantities to maintain them in good health and condition during an Interruption, without any limitation on the duration.

The District shall have no obligation to furnish potable water for irrigation of the Recycled Water Irrigation Areas except in the circumstances set forth above in this Subsection L.9.b.

If (1) an emergency or major disaster is declared by the President of the United States, or (2) a "state of war emergency," "state of emergency," or "local emergency," as those terms are respectively defined in Government Code section 8558, has been duly proclaimed pursuant to the California Emergency Services Act, with respect to all or any portion of the territory of MPWMD, the provisions of this Subsection L.9.b shall yield as necessary to respond to the conditions giving rise to the declaration or proclamation.

This Subsection L.9.b shall be of no force or effect until the Project Expansion is deemed Completed (as the capitalized terms are defined in Rule 23.5), and shall thereafter be operative and of full force and effect.

Added by Ordinance No. 119 (3/21/2005)

RULE 166 - STAGE 6 WATER RATIONING

A. Stage 6 Water Rationing is defined as the sixth stage in the District's Expanded Water Conservation and Standby Rationing Plan that responds to a drought situation or emergency water supply shortage with a 35 percent reduction goal from system production limits. Reductions are achieved by water use cutbacks by user category and by per-capita water rations and a moratorium on water permits that utilize water credits.

B. Implementation.

1. Water Supply Limitation Trigger. Stage 6 Water Rationing shall apply to all water users whose source of supply is derived from the MPWRS. Stage 6 Water Rationing shall become effective on June 1 or such earlier date as may be set by the Board following the District's May Board meeting if total usable storage in the MPWRS on May 1 is less than 15,615 acre-feet and greater than 9,610 acre-feet. If total usable storage is equal to or greater than 27,807 acre-feet on May 1, no water rationing shall be imposed.

2. Implementation shall also occur following urgency action by Resolution of the Board of Directors declaring that an emergency situation exists and immediate 35 percent reductions in water use from a distribution systems production limit are necessary to ensure public health, safety or welfare.

C. Sunset of Stage 6 Water Rationing.

1. Water Supply Availability. Stage 6 Water Rationing shall continue to have force and effect until rescinded by Resolution of the Board of Directors upon a determination that the total usable storage in the MPWRS is greater than 15,615 acre-feet. This determination will normally be made at the Board's May meeting. However, a determination to rescind Stage 6 Water Rationing as early as the following January Board meeting can be made if the total usable storage in the MPWRS is equal to or greater than 27,807 acre-feet on January 1.

2. In the event total usable storage is greater than 27,807 acre-feet, the General Manager shall review Cal-Am's year-to-date production. Upon compliance with the monthly year-to-date goals specified in Table 1 of Rule 162 and, unless otherwise specified in the Resolution rescinding Stage 6 Water Rationing, water users shall revert to Stage 1 Water Conservation. If Cal-Am's year-to-date production exceeds the year-to-date goal specified in Table 1 of Rule 162, Cal-Am water users shall revert to Stage 2 Water Conservation.

D. Affected Water Users. Stage 6 Water Rationing shall apply to all water users within the Monterey Peninsula Water Resources System. As necessary to ensure adequate water supplies, the Board of Directors may act within its discretion to authorize activation of Stage 6 Water Rationing within one or more water distribution systems in the District.

E. Requirements imposed by implementation of the Expanded Water Conservation and Standby Rationing Plan through Stage 5 Water Rationing shall remain in force. Requirements may be modified or superseded by actions taken in this or future stages of the Expanded Water Conservation and Standby Rationing Plan.

F. Moratorium. On October 1 following implementation of Stage 6 Water Rationing, the District shall suspend the issuance of water permits that utilize a public or private Water Use Credit.

G. Reduction Goal. Stage 6 Water Rationing achieves water use reductions of 35 percent of the Cal-Am and non-Cal-Am system production limits in each user category as follows: Residential single-family and multi-family, commercial/industrial, public authority, golf course, "other," non-revenue metered uses, and reclaimed water users.

H. Notice

1. Cal-Am shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the Cal-Am system via first-class mail at least thirty (30) days before the first day of rationing. Further, Cal-Am shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, Cal-Am shall provide each responsible party with a survey form upon request.

2. All water distribution system operators affected by Stage 6 Water Rationing shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the water distribution system via first-class mail at least thirty (30) days before the first day of rationing. Further, the distribution system operator shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, the water distribution system operator shall provide each responsible party with a survey form at least once each calendar year. Water distribution system operators shall ensure that notices provided or required by the District shall be distributed to the system water users.

3. The District shall contact all water users of private wells not supplying water to a distribution system within the MPWRS at least thirty (30) days before the first day of Stage 6 Water Rationing. Contact shall be via first class mail and shall explain the restrictions placed on the use of

private wells during Stage 6 Water Rationing and shall provide and/or request additional information from the private well owner as deemed necessary for the efficient operation of the program.

I. Rations by Category. Water rations shall be determined by user category. Each water user within the Monterey Peninsula Water Resources System shall be classified in one of the following groups: Residential Single-Family and Multi-Family, Commercial/Industrial, Public Authority, Golf Course, "other," Non-Revenue Metered Use, and Reclaimed Water Users.

J. Reduced Annual Cal-Am Annual Production During Stage 6 Water Rationing. The Cal-Am annual production limit shall be reduced by 35 percent during Stage 6 Water Rationing. The resulting production limit shall be further reduced by a water rationing contingency determined by the Board. Seven (7) percent of the remainder shall be the maximum Cal-Am unaccounted for water use ration. The remaining water shall be the Cal-Am annual production limit for all user categories.

K. Non-Cal-Am Annual Production Limits During Stage 6 Water Rationing. Available production for other water distribution systems subject to Stage 6 Water Rationing shall be determined using the same methodology as for Cal-Am without including a deduction for unaccounted for water uses. The non-Cal-Am annual production limit for the Monterey Peninsula Water Resources System shall be used as the maximum production limit.

L. Establishing the Rations. Rations for each user category shall be determined by the General Manager by dividing the reduced available production by the percentage of use and by taking into consideration residential water needs to ensure health, safety and welfare. The percentage of use for each user group shall be determined by the most recent unrationed reporting year (July 1 through June 30) data provided by Cal-Am for water users of that portion of Cal-Am that derives water from the MPWRS, and by data provided by the District from its annual well reporting program for non-Cal-Am distribution systems.

1. All water users shall be rationed by user category as outlined in Rule 165 (Stage 5 Water Rationing).

M. The Board shall consider adopting restrictions on non-residential outdoor water use that may include any or all of the following: Limit outdoor watering to one day per week, one day every other week, or prohibit outdoor irrigation with water from the effected water resource system(s); prohibit irrigation of non-turf areas with water from the affected water resource system(s); reduce golf course irrigation from the effected water distribution system(s) to a percentage of the amount required to water tees, greens and landing areas only. The use of reclaimed water, when available, shall not be restricted by this requirement.

N. Elimination or modification of commercial/industrial variances for Best Management Practices. The General Manager shall be authorized to require a percentage reduction of all commercial/industrial water users granted a variance for complying with BMPs for the type of use. The amount of the percentage reduction shall be determined by the General Manager following review of the success of commercial/industrial rationing during Stage 5 Water Rationing prior to Stage 6 Water Rationing.

O. All water users shall cease operation and maintenance of all ornamental water uses (fountains, ponds, etc.) that use water from the effected water supply system(s). Ornamental water uses supplied with water from other sources shall clearly display information about the source of water on or immediately adjacent to the use;

P. Prohibition on Use of Water for Dust Control. The use of water from the Monterey Peninsula Water Resources System shall be prohibited for dust control purposes, except by prior approval of the General Manager. Decisions of the General Manager shall be final.

Rule added by Ordinance No. 92 (1/29/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 167 - STAGE 7 WATER RATIONING

A. Stage 7 Water Rationing is defined as the seventh stage in the District's Expanded Water Conservation and Standby Rationing Plan that responds to a drought situation or emergency water supply shortage with a 50 percent reduction goal from system production limits. Reductions are achieved by water use cutbacks by user category and by per-capita water rations and a moratorium on water permits that utilize water credits.

B. Implementation.

1. Water Supply Limitation Trigger. Stage 7 Water Rationing shall apply to all water users whose source of supply is derived from the MPWRS. Stage 7 Water Rationing shall become effective on June 1 or such earlier date as may be set by the Board following the District's May Board meeting if total usable storage in the MPWRS on May 1 is less than 9,610 acre-feet. If total usable storage is equal to or greater than 27,807 acre-feet on May 1, no water rationing shall be imposed.

2. Implementation shall also occur following urgency action by Resolution of the Board of Directors declaring that an emergency situation exists and immediate 50 percent reductions in water use from a distribution system's production limit are necessary to ensure public health, safety or welfare.

C. Sunset of Stage 7 Water Rationing.

1. Water Supply Availability. Stage 7 Water Rationing shall continue to have force and effect until rescinded by Resolution of the Board of Directors upon a determination that the total usable storage in the MPWRS is greater than 9,610 acre-feet. This determination will normally be made at the Board's May meeting. However, a determination to rescind Stage 7 Water Rationing as early as the following January Board meeting can be made if the total usable storage in the MPWRS is equal to or greater than 27,807 acre-feet on January 1.

2. In the event total usable storage is greater than 27,807 acre-feet, the General Manager shall review Cal-Am's year-to-date production. Upon compliance with the monthly year-to-date goals specified in Table 1 of Rule 162 and, unless otherwise specified in the Resolution rescinding Stage 7 Water Rationing, water users shall revert to Stage 1 Water Conservation. If Cal-Am's year-to-date production exceeds the year-to-date goal specified in Table 1 of Rule 162, Cal-Am water users shall revert to Stage 2 Water Conservation.

D. Affected Water Users. Stage 7 Water Rationing shall apply to all water users within the Monterey Peninsula Water Resources System. As necessary to ensure adequate water supplies, the Board of Directors may act within its discretion to authorize activation of Stage 7 Water Rationing within one or more water distribution systems in the District.

E. Requirements imposed by implementation of the Expanded Water Conservation and Standby Rationing Plan through Stage 6 Water Rationing shall remain in force. Requirements may be modified or superseded by actions taken in this or future stages of the Expanded Water Conservation and Standby Rationing Plan.

F. Reduction Goal. Stage 7 Water Rationing achieves water use reductions of 50 percent of the Cal-Am and non-Cal-Am system production limits in each user category as follows: Residential single-family and multi-family, commercial/ industrial, public authority, golf course, "other," non-revenue metered uses, and reclaimed water users.

G. Notice.

1. Cal-Am shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the Cal-Am system via first-class mail at least thirty (30) days before the first day of rationing.

   Further, Cal-Am shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, Cal-Am shall provide each responsible party with a survey form upon request.

2. All water distribution system operators affected by Stage 7 Water Rationing shall provide written notice of mandatory water rationing to every residence and to every non-residential business or water user within the water distribution system via first-class mail at least thirty (30) days before the first day of rationing. Further, the distribution system operator shall send monthly reminders of water rationing in the water bill along with information showing the water ration and the quantity of the water ration consumed by the responsible party. Finally, the water distribution system operator shall provide each responsible party with a survey form at least once each calendar year. Water distribution system operators shall ensure that notices provided or required by the District shall be distributed to the system water users.

3. The District shall contact all water users of private wells not supplying water to a distribution system within the MPWRS at least thirty (30) days before the first day of Stage 7 Water Rationing. Contact shall be via first class mail and shall explain the restrictions placed on the use of private wells during Stage 7 Water Rationing and shall provide and/or request additional information from the private well owner as deemed necessary for the efficient operation of the program.

H. Rations by Category. Water rations shall be determined by user category. Each water user within the Monterey Peninsula Water Resources System shall be classified in one of the following groups: Residential Single-Family and Multi-Family, Commercial/Industrial, Public Authority, Golf Course, "other," Non-Revenue Metered Use, and Reclaimed Water Users.

I. Reduced Annual Cal-Am Annual Production During Stage 7 Water Rationing. The Cal-Am annual production limit shall be reduced by 50 percent during Stage 7 Water Rationing. The resulting production limit shall be further reduced by a water rationing contingency determined by the Board. Seven (7) percent of the remainder shall be the maximum Cal-Am unaccounted for water use ration. The remaining water shall be the Cal-Am annual production limit for all user categories.

J. Non-Cal-Am Annual Production Limits During Stage 7 Water Rationing. Available production for other water distribution systems subject to Stage 7 Water Rationing shall be determined using the same methodology as for Cal-Am without including a deduction for unaccounted for water uses. The non-Cal-Am annual production limit for the Monterey Peninsula Water Resources System shall be used as the maximum production limit.

K. Establishing the Rations. Rations for each user category shall be determined by the General Manager by dividing the reduced available production by the percentage of use and by taking into consideration residential water needs to ensure health, safety and welfare. The percentage of use for each user group shall be determined by the most recent unrationed reporting year (July 1 through June 30) data provided by Cal-Am for water users of the Cal-Am distribution system that derives water from the MPWRS, and by data provided by the District from its annual well reporting program for non-Cal-Am distribution systems.

1. All water users shall be rationed by user category as outlined in Rule 165 (Stage 5 Water Rationing).

L. The Board shall reconsider adopting restrictions on non-residential outdoor water use that may include any or all of the following not adopted during Stage 6 Water Rationing: Limit outdoor watering to one day per week, one day every other week, or prohibit outdoor irrigation with water from the effected water resource system(s); prohibit irrigation of non-turf areas with water from the effected water resource system(s); reduce golf course irrigation from the effected water distribution system(s) to a percentage of the amount required to water tees, greens and landing areas only. The use of reclaimed water, when available, shall not be restricted by this requirement.

M. Elimination or modification of commercial/industrial variances for Best Management Practices. The General Manager shall be authorized to require a percentage reduction of all commercial/industrial water users granted a variance for complying with BMPs for the type of use. The amount of the percentage reduction shall be determined by the General Manager following review of the success of commercial/industrial rationing during Stage 6 Water Rationing prior to Stage 7 Water Rationing.

N. Prohibition On The Use of Portable Water Meters and Hydrant Meters. Water users utilizing portable water meters or hydrant meters shall be required to cease use of water from the effected water supply system(s). Each water user reporting as "other" by the distribution system shall be notified by the distribution system operator of this requirement. Portable water meters shall be returned to the water company at least 30 days before the implementation of Stage 7 Water Rationing.

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 168 - WATER BANKS

A. Water banks shall be available to each water user during Stages 5 through 7 Water Rationing. A water bank shall allow each water user to accrue the unused portion of a monthly ration for use in the current calendar year.

B. Water banks shall be reset to zero on January 1 of each year. Ten (10) percent of the remaining water bank on December 31 shall be credited to the following year's water bank for three months to allow the establishment of a new bank.

C. On April 1, each water bank shall be reduced by the amount of banked water carried over on January 1. Water banks may not carry less than a zero balance.

Rule added by Ordinance No. 92 (1/28/99)

RULE 169 - WATER RATIONING VARIANCE

A. The General Manager shall assign additional water beyond the ration established in Stage 4 Water Rationing through Stage 7 Water Rationing in the following circumstances upon submittal of the appropriate variance request form and fees.

B. The following variances shall be considered for additional water during Stages 4 through 7 Water Rationing.

1. Medical and/or sanitation needs certified by a doctor;

2. Hospital and/or health care facilities that have achieved all Best Management Practices for those uses;

3. Drinking water for large livestock;

4. Commercial/Industrial users that can demonstrate compliance with all BMPs appropriate for the type of use and where there is minimal exterior water use on the water meter or water supply serving the use;

5. Leaks, when an invoice is provided by a licensed plumber or contractor;

6. Commercial Laundromats with signs advising full loads only;

7. Business in a home on a case-by-case basis;

8. Riparian irrigation when required as a condition of a riverbank restoration permit issued by the District or as a condition of a riverbank erosion protection permit issued by the District.

9. Emergency, extreme, or unusual situations on a case-by-case basis;

C. No Variance. The following categories of water use shall not qualify for special consideration under the provisions of this regulation:

1. Visitors other than those occupying short-term residential housing as defined in Rule 11 (Definitions) when the property owner has submitted a completed survey form with the applicable information about the occupancy of the site;

2. Irrigation, other than variances allowed by Rule 169 of this regulation.

3. Filling spas, ponds, fountains, etc.;

4. Long-term leaks that are not repaired after reasonable notice.

D. Waiver of Excess Fees by Variance Application. Any qualifying water user may seek to have all or part of the water waste fee for excess water use waived or forgiven through the Rationing Variance process set forth in this Rule. Any water user may seek relief from the water waste fee upon substantial evidence that the excess water use was beyond the user's control, and was not reasonably correctable in a timely fashion due to special and unique circumstances. Due diligence must be shown to forgive any water waste caused by a leak; under no circumstance shall a leak justify the forgiveness of an excess use fee for more than three billing periods. The applicant shall further demonstrate that all reasonable means have been taken to conserve water and minimize future water use.

1. The General Manager or his agent may grant any application to waive water waste fees upon submittal of the appropriate evidence to warrant a variance. All applicants for variance shall submit the appropriate Variance Request Form and processing fee of $60. Any action to waive a water waste fee shall be recorded in writing and include a written explanation to substantiate and justify the waiver;

2. Although inspections shall not be required in all cases, District staff shall use spot or random inspections as necessary to verify an applicant's eligibility for a water rationing variance.

3. Each person making written application for a variance shall be notified in writing of the disposition of their application. Decisions of the General Manager are final.

Rule added by Ordinance 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 170 - WATER USE SURVEY

A. Stage 1 Water Conservation Survey

1. Cal-Am shall conduct a confidential survey of all water users of the Cal-Am system that derive their source of supply from the MPWRS. This survey shall be required upon the effective date of this regulation. The survey shall request information to determine the number of permanent residents in each dwelling unit and the lot size of each residential site with permitted water service; the types of uses and amount of water use on non-residential sites; and the number of users and types of use(s) served by each water meter. Only information deemed appropriate for the effective operation of this program will be requested.

   Cal-Am shall conduct the survey within 45 days of the effective date of Stage 1 Water Conservation. Survey forms shall be completed by the responsible party and returned to Cal-Am within 30 days of mailing. The District shall have visual access to this data during Stages 1 through 3 Water Conservation and shall be provided with a summary of the results of the survey by census tract within 105 days of the effective date of Stage 1 Water Conservation. Cal-Am shall maintain survey information by census tract and shall provide unrestricted access to individual water use records when the District is actively investigating a variance, appeal or other rationing program action.

B. Stage 4 Water Rationing Survey.

1. The General Manager shall conduct a survey of MPWRS water users not deriving their source of supply from Cal-Am prior to effective date of Stage 5 Water Rationing. The survey shall request information to determine the number of permanent residents in each dwelling unit and the lot size of each residential site with permitted water use; the types of uses and amount of water use on non-residential sites; and the number of users and types of use(s) served by each water meter or connection. Only information deemed appropriate for the effective operation of this program will be requested.

2. The District shall mail the survey form to water users not supplied water by Cal-Am. Survey forms shall be completed by the responsible party and returned to the District within 30 days of mailing. The District shall preserve the confidentiality of this survey data.

C. Administration of Survey Data.

1. Cal-Am Water Users. Cal-Am shall maintain survey data for all MPWRS water users supplied water by Cal-Am and shall provide the District with access to all data. Cal-Am shall provide the District with an annual

summary of survey information, or more frequently as required by the General Manager. Cal-Am shall preserve the confidentiality of survey data.

2. Non-Cal-Am Water Users. During Stage 5 Water Rationing through Stage 7 Water Rationing, the District shall maintain survey data for all water users supplied water from non-Cal-Am sources subject to those stages.

3. A full or partial survey may be conducted as deemed necessary by the District to maintain accurate data.

4. District staff shall maintain the confidentiality of Cal-Am and non-Cal-Am residential customer survey data. Violations of this provision shall be enforced as a misdemeanor under District law.

D. Reporting.

1. Responsibility of Water User.

a. Each responsible party shall be responsible for accurately reporting the number of permanent residents in the dwelling unit or units or other information deemed appropriate for the effective operation of the program as requested on the survey form.

b. Upon activation of a water meter, each responsible party shall complete a survey form.

i. Cal-Am Water Users. The completed survey form shall be submitted to Cal-Am by customers of that distribution system.

ii. Non-Cal-Am Water Users. The completed survey form shall be submitted to the District or its agent by all other distribution systems users required to complete a survey form during Stage 5 Water Rationing through Stage 7 Water Rationing.

c. All responsible parties shall submit revised survey forms whenever there is a change in the number of permanent residents in a residential dwelling unit or whenever there is a change in a water user category in non-residential uses. Revised survey forms should be submitted to the appropriate party as indicated in Rule 170, D, 1, b.

d. Property owners of short-term residential housing rentals shall provide information about the average number of annual occupants and the average rate of occupancy to the appropriate party as indicated in Rule 170, D, 1, b.

2. Misrepresentation Violation. Any water user intentionally over-reporting the number of permanent residents in a dwelling unit or other information pertinent to establishing a water ration during Stages 4, 5, 6 and 7 Water Rationing may be charged with a misdemeanor punishable as an infraction as provided by Section 256 of the Monterey Peninsula Water Management District Law, Statutes of 1981, Chapter 986. Violations carry a maximum penalty of up to $250 for each offense. Each separate day or portion thereof during which any violation occurs or continues without a good-faith effort by the responsible water user to correct the violation, may be deemed to constitute a separate offense, and upon conviction thereof, may be separately punishable.

3. Penalties for Misreporting. In addition to any charge for misrepresenting information as provided in Rule 170, D-2, any or all of the following may be further imposed by the General Manager or his agent during Stages 4, 5, 6 and 7 Water Rationing where the violation occurs and continues without a good-faith effort by the responsible water user to correct the violation. Decisions pursuant to this rule are appealable under Rule 70 (Appeals).

    a. Intentional misrepresentation may be considered a violation of the water waste provisions and shall subject the water user to a fee for water waste; and/or

    b. Intentional misrepresentation may cause the loss of any water bank accrued and shall cause the responsible party to be ineligible to accrue a water bank for a period of sixty (60) months; and/or

    c. Intentional misrepresentation may cause the assignment of a reduced water ration that may be as low as a ration for one person for a period of twelve (12) months following implementation of Stages 4, 5, 6 or 7 Water Rationing.

4. Audit. The District may periodically audit the survey data for accuracy. Upon question, the District may request additional evidence of residency to demonstrate the number of permanent residents at that site as defined in Rule 11 (Definitions).

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 171 - WATER WASTE FEES

A. Each occurrence of Water Waste or Non-Essential Water Use, as those terms are defined by Rule No. 11 (Definitions), which continues after the water user has had reasonable notice to cease and desist that type of water use shall constitute a flagrant occurrence.

B. A $50 fee per day or portion thereof shall be assessed for each flagrant occurrence of Water Waste or Non-Essential Water Use. The fee shall accumulate daily until the occurrence is corrected.

C. A $150 fee per day or portion thereof shall be imposed for each subsequent occurrence (including multiple occurrences) of Water Waste or Non-Essential Water Use which occurs within 18 months of the first occurrence. The fee shall accumulate daily until the occurrence is corrected.

D. All fees shall be paid within 30 days.

E. Within the 30 day period, a water user may seek waiver or forgiveness of all or part of the Water Waste fees on the basis of hardship. The water user must provide the District with a written explanation as to why the fees should not be collected. Staff shall be authorized to determine whether or not fees should be waived in full or in part, with the final decision resting with the General Manager.

F. After 30 days, fees which have not been paid or waived may result in a lien being placed on the property served by the water account.

G. Repeated occurrences or Water Waste or Non-Essential Water Use, which continue or occur after the water user has had a reasonable notice to cease and desist that type of water use, or which continues or occurs after the water user has had a reasonable opportunity to cure any defect causing that type of water use, shall provide cause for the placement of a flow restrictor within the water line or water meter.

H. Decisions pursuant to this rule are appealable under Rule 70 (Appeals).

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 172 - LANDSCAPE WATER AUDITS

A. Landscape Water Audits shall be conducted under the supervision of an individual who has been certified by the Irrigation Association to conduct audits and establish Landscape Water Budgets. Each audit shall be signed by that person, who shall attest that the audit was performed under his/her direction.

B. Landscape Water Audits and Landscape Water Budgets shall be offered by the District and/or Cal-Am or their agent free of charge to all water users of Cal-Am with dedicated landscape meters, large irrigated areas over three acres, and large residential water users. Water use records shall be reviewed annually to identify new water users required to establish a Landscape Water Budget by this rule. Cal-Am shall provide the District with copies of all completed Landscape Water Audits and Landscape Water Budgets.

1. Cal-Am water users shall be required to obtain Landscape Water Audits and establish Landscape Water Budgets if the property:

   a. Has a dedicated landscape water meter; or

   b. Is an irrigated area of greater than three acres; or

   c. Is a large residential water user.

2. All Landscape Water Budgets must be prepared by an individual certified by the Irrigation Association.

3. All water users required to complete a Landscape Water Audit and establish a Landscape Water Budget shall have the option of obtaining a Landscape Water Audit and Landscape Water Budget from Landscape Irrigation Auditor of their choice at their own expense if the auditor is certified by the Irrigation Association.

4. Landscape Water Audits not conducted by the District and/or Cal-Am shall be reported on a Landscape Water Budget Application. Landscape Water Budget Applications shall be submitted to Cal-Am. Cal-Am shall forward a copy to the District within ten (10) days. Landscape Water Audits not performed by the District or Cal-Am are subject to review and acceptance by the District. Landscape Water Audits and Landscape Water Budgets rejected by the District may be appealed to the Board of Directors pursuant to Rule 70 (Appeals).

5. Landscape Irrigation Auditors shall arrange on-site visits to compile water records to review historic use, measure irrigated sites, identify plant materials by general groups, determine irrigation water requirements, and estimate potential dollar and water savings. Landscape Irrigation Auditors shall also develop system testing strategies, check pressure and flow rates, and conduct water application distribution tests. Data shall

be collected to determine irrigation uniformity and efficiency. Soil samples shall be examined to determine soil types and root zone depths. Landscape Irrigation Auditors shall observe system operations, locate irrigation zones, prepare site audit maps and visually identify broken or misaligned equipment. All data from field tests shall be summarized and this information used to generate monthly irrigation base schedules. A copy of the Landscape Water Budget Application shall be provided to the water user. One copy of the Landscape Water Budget Application shall be submitted to Cal-Am. Cal-Am shall forward a copy to the District within ten (10) days.

6. Cal-Am shall provide quarterly compliance status notices to each water user required to follow a mandatory Landscape Water Budget.

C. Modifications To Audited Landscapes. Following significant modification to an existing audited landscape, a new Landscape Water Audit shall be conducted to establish an appropriate Landscape Water Budget. It shall be the responsibility of the property owner to ensure that a Landscape Water Audit is conducted within 60 days of any such change and to submit a new Landscape Water Budget Application to Cal-Am.

D. Reporting and Analysis. Cal-Am shall preserve water use records and budgets for water users subject to this provision of law for such time as the Expanded Water Conservation and Standby Rationing Plan remains effective. Updated Landscape Water Budgets shall supersede previous data. Quarterly, a report shall be compiled by Cal-Am and provided to the District showing the account information and comparing the Landscape Water Budget with actual consumption. During Stages 2 and 3, Cal-Am shall provide the District with monthly consumption reports for all customers with Landscape Water Budgets.

E. Landscape Irrigation Restrictions in the Cal-Am system that derives its source of supply from the MPWRS. Unless watering is by drip irrigation, through a hand-held hose with a positive action shut-off nozzle, or performed by a professional gardener or landscaper, the following schedule shall apply:

1. Odd Numbered Properties shall water after 5 p.m. or before 9 a.m. on Saturdays and Wednesdays only. This schedule shall also apply to properties located on the South or West side of the street in cities where no street address is available.

2. Even Numbered Properties shall water after 5 p.m. or before 9 a.m. on Sundays and Thursdays only. This schedule shall also apply to properties located on the North or East side of the street in cities where no street address is available.

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

RULE 173 - REGULATION OF MOBILE WATER DISTRIBUTION SYSTEMS

A. No person, extractor, owner or operator shall operate a mobile water distribution system without first securing a written permit from the District. In accordance with Monterey County Code (e.g., Title 15.20), no applications will be accepted or permitted for bulk hauled water for permanent potable use. Applications for establishment of a mobile water distribution system shall be made pursuant to Rule 22 (Action On Application For Permit To Create/Establish A Water Distribution System) and shall be investigated, considered, determined, and acted upon on the same terms and conditions as provided for the approval, conditional approval or denial of a creation establishment permit as stated in that rule. The application shall identify each source of supply and the location of each use. For any subpotable mobile water distribution system within the California-American Water Company (Cal-Am) service area, a condition of approval shall require that Cal-Am be notified so that a back-flow protection device can be installed pursuant to Monterey County Code Title 17.

B. In the event prior authorization is not obtained by reason of an emergency or health related situation, authorization for the Mobile Water Distribution System permit shall be sought from the District by submittal of a complete application compliant with Rule 21, within five working days following commencement of the emergency or health related event.

C. Delivery and/or receipt of water from an unpermitted Mobile Water Distribution System shall be deemed water waste, and shall be subject to fine, restriction, and cease and desist order as set forth in Rule 171.

Rule added by Ordinance No. 92 (1/28/99); amended by Ordinance No. 96 (3/19/2001)

RULE 174 - REGULATION OF WELL OWNERS/OPERATORS AND EXTRACTORS

A. During a water supply emergency, each owner/operator or extractor of a private water well or other water-gathering facility shall comply with the provisions of this regulation, as they relate to such well.

Rule added by Ordinance No. 92 (1/28/99)

RULE 175 - WATER RATIONING ENFORCEMENT

A. Enforcement During Stages 4 through 7 Water Rationing.

1. Courtesy Notice. For the first instance of excess water use beyond the ration in Stages 4 through 7 Water Rationing, a water user shall be given written notice by the water system operator of the excess use and shall be notified that such violation constitutes water waste and a water waste fee of $50 per day shall be collected in the event the water user again exceeds that user's water ration during any future billing cycle under Stages 4 through 7 Water Rationing. If the water user complies with all water rationing and water waste and non-essential water use requirements during the next month following the first instance of excess use, the excess use fee shall be deferred.

   If the water user again exceeds that user's water ration during any following month, the water waste fee of $50 per day shall be imposed immediately and shall accumulate daily until the occurrence is corrected.

2. Second Offense. Upon the second occurrence of excess water use (including any prior excess water use during any prior stage) a water user shall be charged with water waste and assessed a fee of $150 per day for the second offense, plus the previously deferred $50 first offense fee, by the District or its agent. The $150 fee shall accumulate daily until the occurrence is corrected.

3. Third Offense.

   A third occurrence of excess water use (including any prior excess water use during any prior stage) shall result in an excess water use charge equivalent to the Cal-Am per unit water charge at the water user's level of use multiplied by the number of units over a water ration, plus $150 per day as provided in Rule 171 (Water Waste Fees). A third occurrence of excess water use shall provide cause for the installation of a flow restrictor in the water meter or water supply providing water to the property where the over-use occurred. Restrictors shall remain in place until conditions are reduced to Stage 2 Water Conservation or a less restrictive stage. All costs for the installation and removal of a flow restrictor shall be charged to the property owner of the site subjected to this action.

4. Fourth Offense. A fourth occurrence of water use in excess of the water ration shall result in fees and charges listed for a third offense and shall result in the installation of a flow restrictor by the system operator in the water meter or water supply providing water to the property where the over-use occurred. Restrictors shall remain in place until conditions are reduced to Stage 3 Water conservation or to a less restrictive stage. All costs for the installation and removal of a flow restrictor shall be charged to the property owner of the site subjected to this action.

B. Flow Restrictor Exemption. Exemptions to the installation of a flow restrictor as a means to enforce the water ration shall occur when there are provable risks to the health, safety and/or welfare of the water user. An exemption shall be made for water meters serving three or more multi-family dwelling units by substituting an excess water use charge of $150 times the number of dwelling units located on the meter during each month in which a violation of the water ration occurs. The responsible party shall be liable for payment of all excess water use charges.

C. All notices and assessments of water waste and/or excess water use charges made by a water distribution system operator shall be reported to the District.

Rule added by Ordinance No. 92 (1/28/99); Amended by Ordinance No. 119 (3/21/2005)

Appendix 7F

List of Water Quality Monitoring Network Monitoring Sites

Appendix 7-F. List of Water Quality Monitoring Network Monitoring Sites

Site Name	Water System Name	Well Screen Information			Coordinates (NAD 83)		Monitoring Data Range	
		Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)	Screen Length (ft)	Latitude	Longitude	First Year	Last Year
2700536-002	CORRAL DE TIERRA ESTATES WC	-	-	-	36.570	-121.726	6/9/2002	10/24/2017
2700536-004	CORRAL DE TIERRA ESTATES WC	120	250	130	36.570	-121.726	9/8/2002	12/26/2019
2700775-001	TIERRA VERDE MWC	200	356	156	36.568	-121.731	8/7/1986	5/31/2015
2700775-002	TIERRA VERDE MWC	100	440	340	36.567	-121.731	2/26/2004	12/19/2019
2701142-001	HORN WS	54	100	46	36.587	-121.712	8/7/1986	1/8/2019
2701227-001	SAN BENANCIO SCHOOL WS	320	460	140	36.578	-121.717	6/23/2006	5/30/2012
2701367-002	TIERRA MEADOWS HOA WS	220	260	40	36.565	-121.734	3/24/2006	12/6/2012
2701681-001	EXXON STATION WS	40	200	160	36.578	-121.727	12/28/2005	9/13/2019
2701740-001	BLUFFS WS	271	309	38	36.639	-121.705	4/6/1987	12/10/2019
2701740-012	BLUFFS WS	-	-	-	36.626	-121.687	6/25/2008	3/7/2018
2701822-001	ROBLEY PROPERTY MWS	335	585	250	36.557	-121.741	9/11/1986	12/16/2019
2701822-002	ROBLEY PROPERTY MWS	320	390	70	36.557	-121.744	9/3/2003	12/16/2019
2701935-001	MOUNT TORO RANCHOS MWA	-	-	-	36.544	-121.670	4/28/2003	3/26/2018
2701935-002	MOUNT TORO RANCHOS MWA	550	830	280	36.544	-121.670	6/23/2003	12/17/2019
2701959-001	TIERRA VISTA MWC	230	250	20	36.555	-121.696	6/5/1997	12/31/2019
2702030-001	CYPRESS COMMUNITY CHURCH WS	370	430	60	36.582	-121.728	3/30/2011	10/2/2019
2702315-001	CORRAL DE TIERRA COUNTRY CLUB WS	180	440	260	36.568	-121.727	3/25/2004	12/10/2019
2710006-004	CAL AM WATER COMPANY - AMBLER PARK	160	360	200	36.575	-121.725	7/2/1984	12/11/2019
2710006-005	CAL AM WATER COMPANY - AMBLER PARK	160	420	260	36.574	-121.727	6/19/1990	12/4/2018
2710006-006	CAL AM WATER COMPANY - AMBLER PARK	160	460	300	36.575	-121.725	4/7/1994	12/11/2019
2710006-009	CAL AM WATER COMPANY - AMBLER PARK	-	-	-	36.576	-121.716	9/13/2011	12/11/2019
2710012-007	CWSC SALINAS HILLS	260	540	280	36.606	-121.699	10/20/1986	10/11/2018
2710017-008	MARINA COAST WATER DISTRICT	160	1540	1380	36.672	-121.782	9/19/1984	12/17/2019
2710017-009	MARINA COAST WATER DISTRICT	970	1170	200	36.677	-121.779	1/6/1986	12/17/2019
2710017-026	MARINA COAST WATER DISTRICT	-	-	-	36.662	-121.755	11/5/1985	12/17/2019
2710017-027	MARINA COAST WATER DISTRICT	-	-	-	36.667	-121.751	8/7/1985	12/17/2019
2710017-028	MARINA COAST WATER DISTRICT	-	-	-	36.662	-121.746	8/7/1985	12/17/2019
2710017-033	MARINA COAST WATER DISTRICT	-	-	-	36.660	-121.741	5/4/2011	12/17/2019
2710017-034	MARINA COAST WATER DISTRICT	-	-	-	36.649	-121.727	12/7/2011	12/17/2019

Site Name	Water System Name	Well Screen Information			Coordinates (NAD 83)		Monitoring Data Range	
		Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)	Screen Length (ft)	Latitude	Longitude	First Year	Last Year
2710021-003	CAL AM WATER COMPANY - TORO	-	-	396	36.571	-121.745	9/15/1987	10/8/2019
2710021-004	CAL AM WATER COMPANY - TORO	-	-	200	36.571	-121.744	11/10/1987	12/11/2019
AGC100000001-CCGC_0108	-	-	-	-	36.645	-121.717	3/10/2014	3/10/2014
AGC100000001-CCGC_0132	-	-	-	-	36.659	-121.736	3/13/2014	3/13/2014
AGC100000001-CCGC_0615	-	-	-	-	36.664	-121.736	8/25/2015	8/25/2015
AGL020003793-DOM	-	-	-	-	36.569	-121.736	12/30/2017	12/30/2017
AGL020003810-CCGC_0108	-	271	309	38	36.645	-121.717	6/1/2017	5/1/2019
AGL020003815-HOME_BM	-	-	-	-	36.631	-121.709	6/1/2017	5/1/2019
AGL020003815-HOME_KG	-	-	-	-	36.630	-121.704	6/1/2017	5/1/2019
AGL020003815-HOME_SM	-	-	-	-	36.632	-121.717	6/1/2017	5/1/2019
AGL020028240-RIVER1_I	-	-	-	-	36.622	-121.684	11/28/2017	9/23/2019
AGL020028240-RIVER2_I	-	-	-	-	36.623	-121.682	11/28/2017	9/23/2019