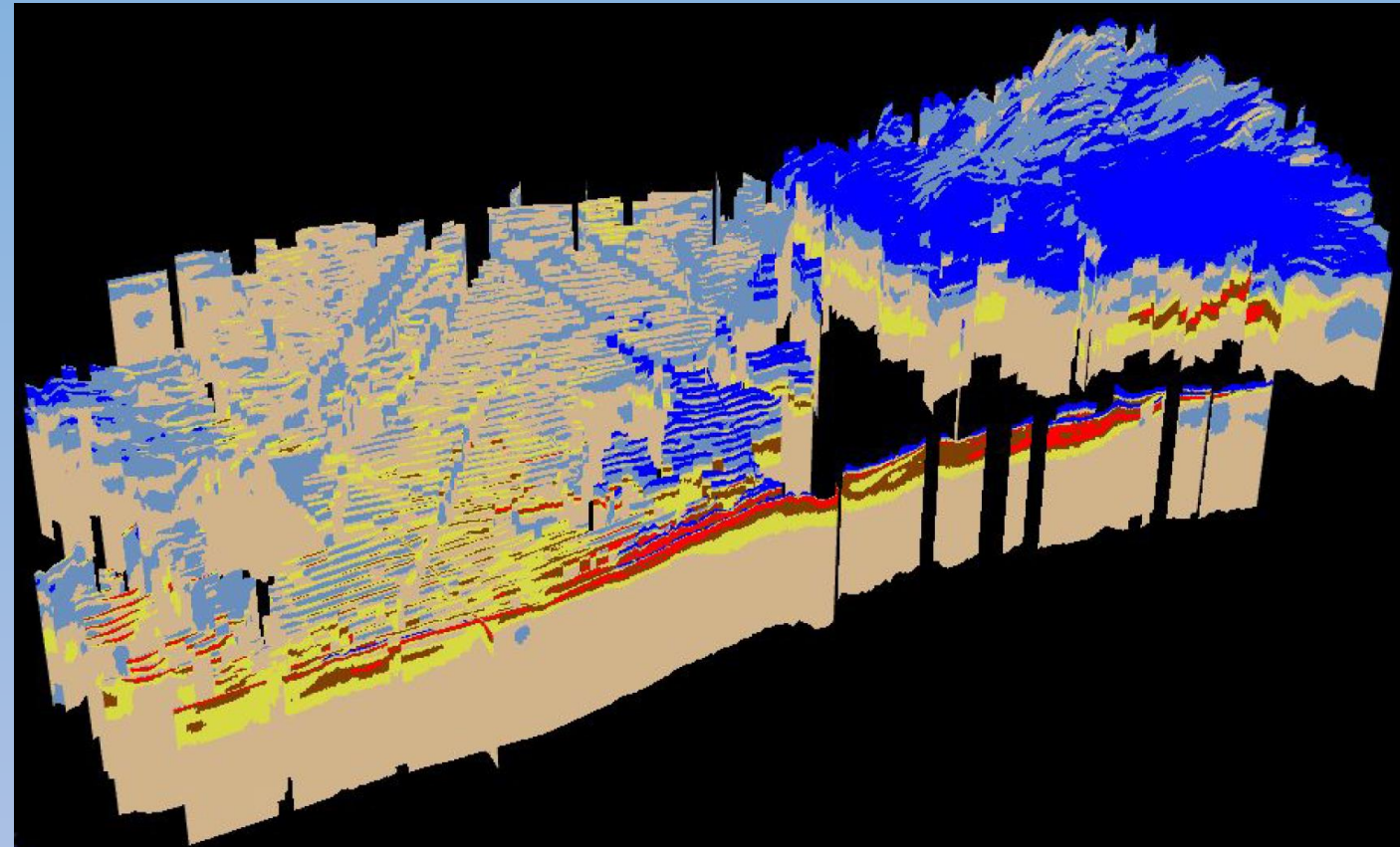


# Marina Coast Water District Board of Directors

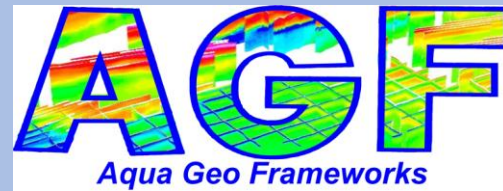
## 2017 & 2019 Airborne Geophysical Investigations for Marina Coast Water District



Theodore Asch, Ph.D., P.Gp.  
Jared Abraham, and James Cannia  
Aqua Geo Frameworks, LLC

February 25, 2020

25 February 2020



## 2017 MCWD AEM Investigation

AEM acquisition of  
635 line-km took 6  
flights over 3 days  
in mid-May 2017.

AEM acquisition design  
optimized for  
infrastructure

25 February 2020



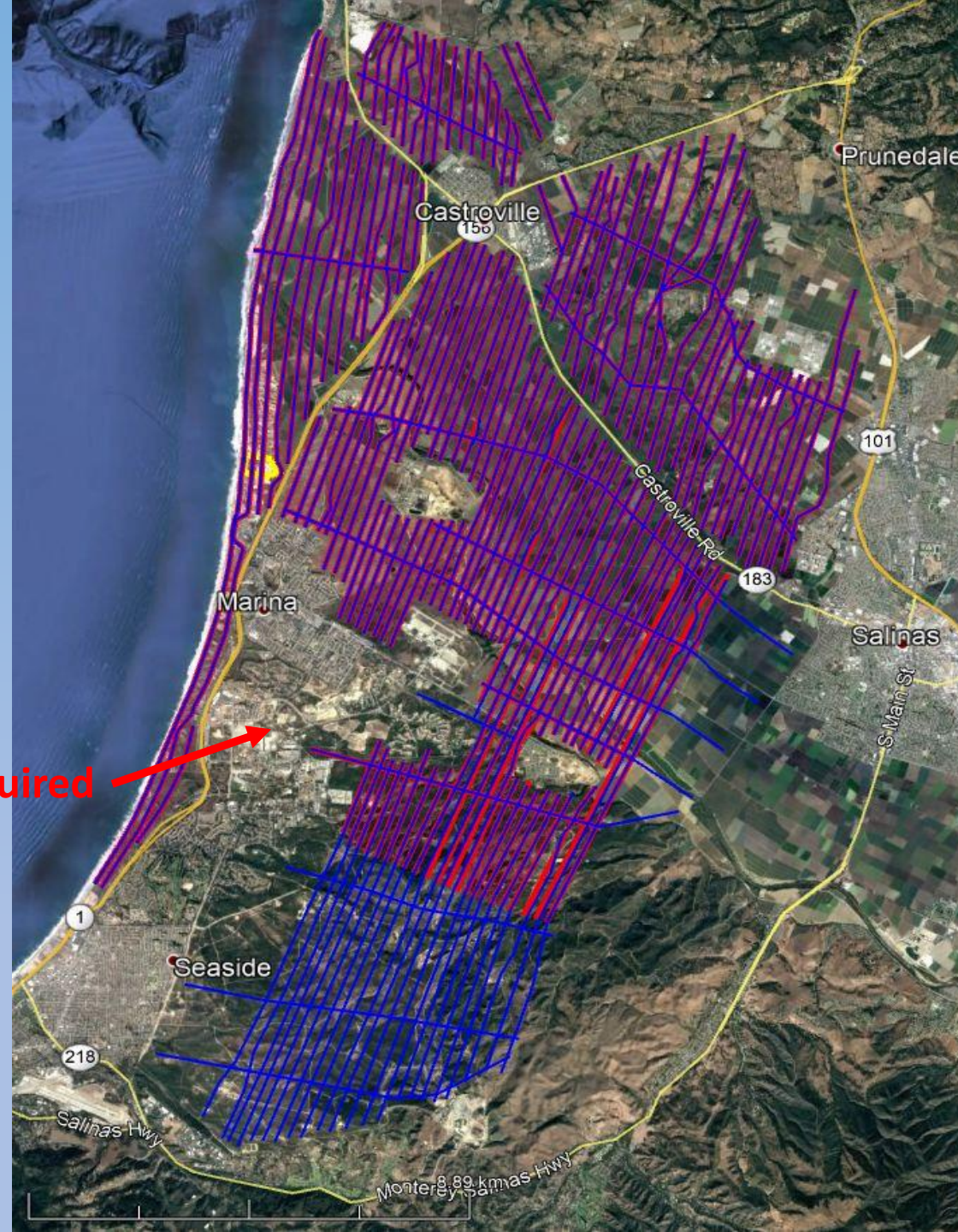
SkyTEM 304M  
used for  
acquisition

## 2019 MCWD AEM Investigation

AEM acquisition of  
881 line-km took 6  
flights over 3 days  
in late-April 2019.

AEM acquisition design  
optimized for  
infrastructure

25 February 2020



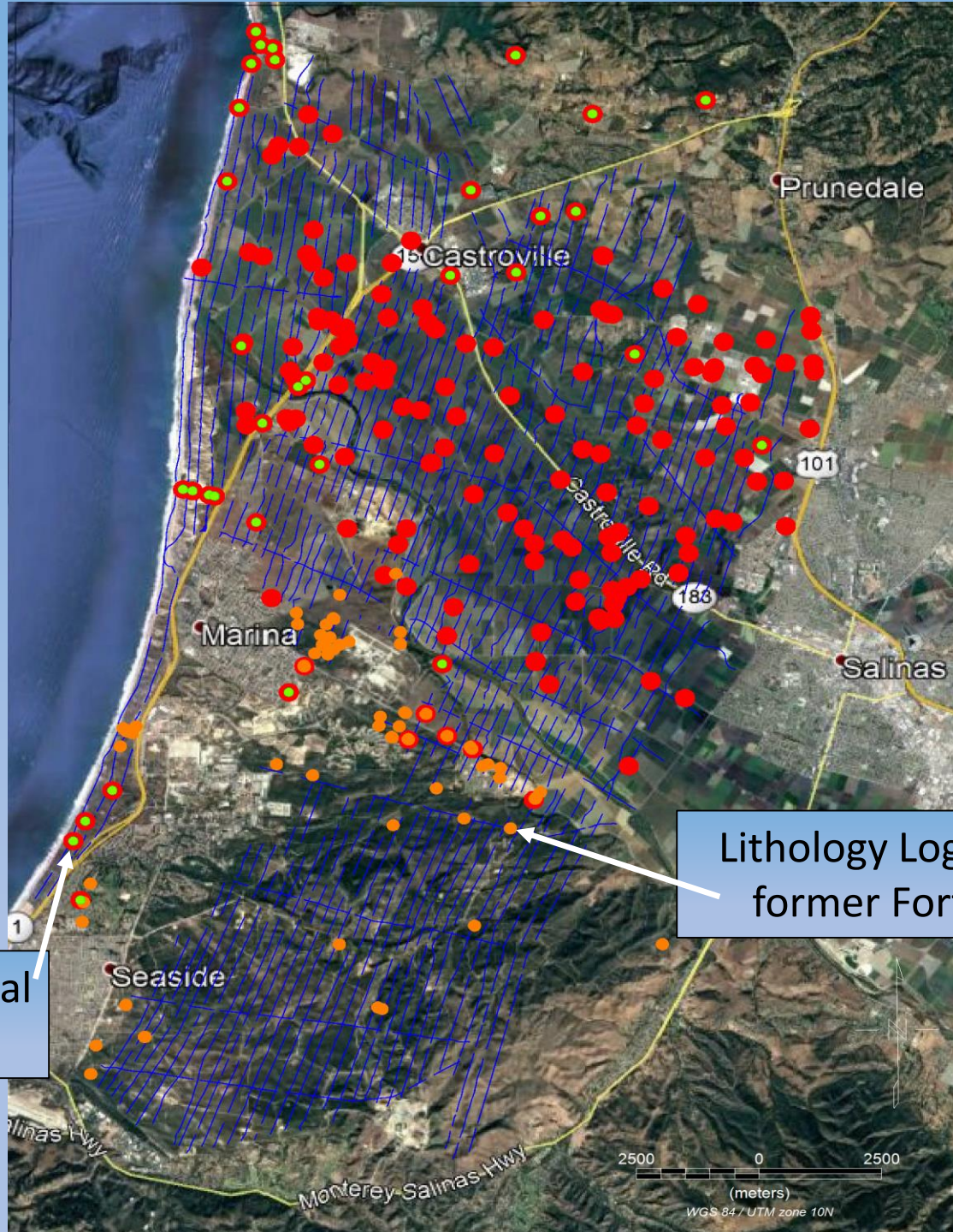
SkyTEM 312  
used for  
acquisition

# 2019 MCWD AEM Investigation

Lithology Logs,  
Geophysical Logs  
Used in Analysis

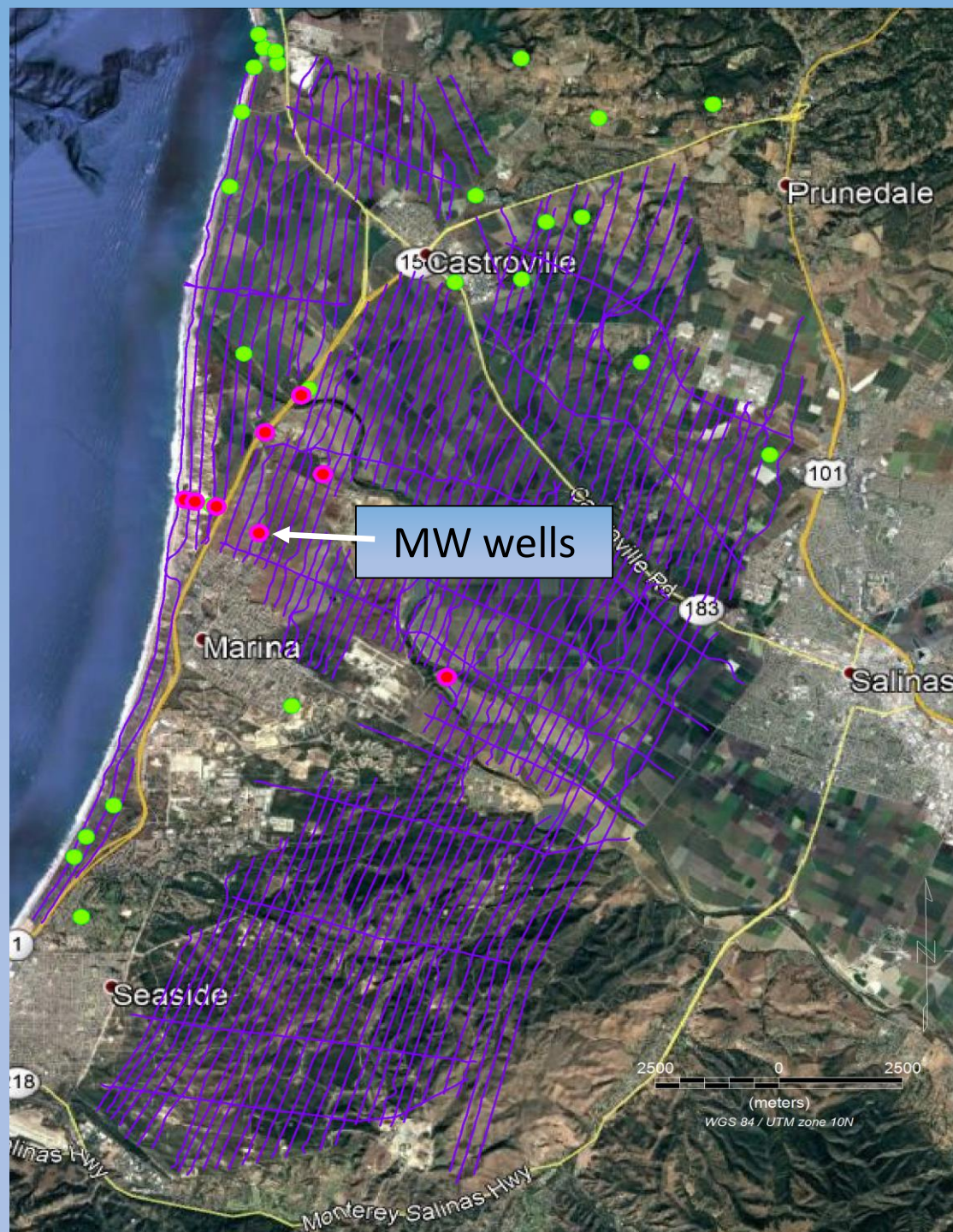
Geophysical  
Logs

Lithology Logs from  
former Fort Ord

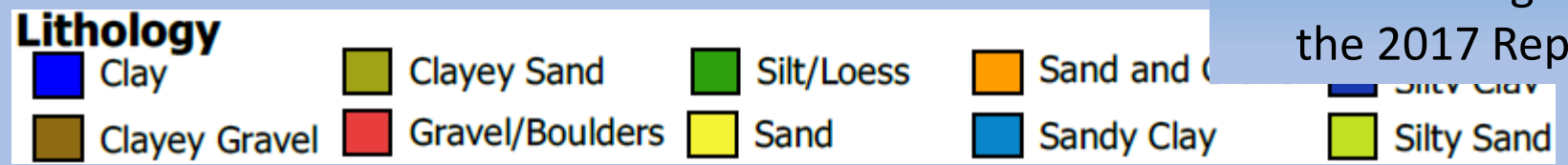
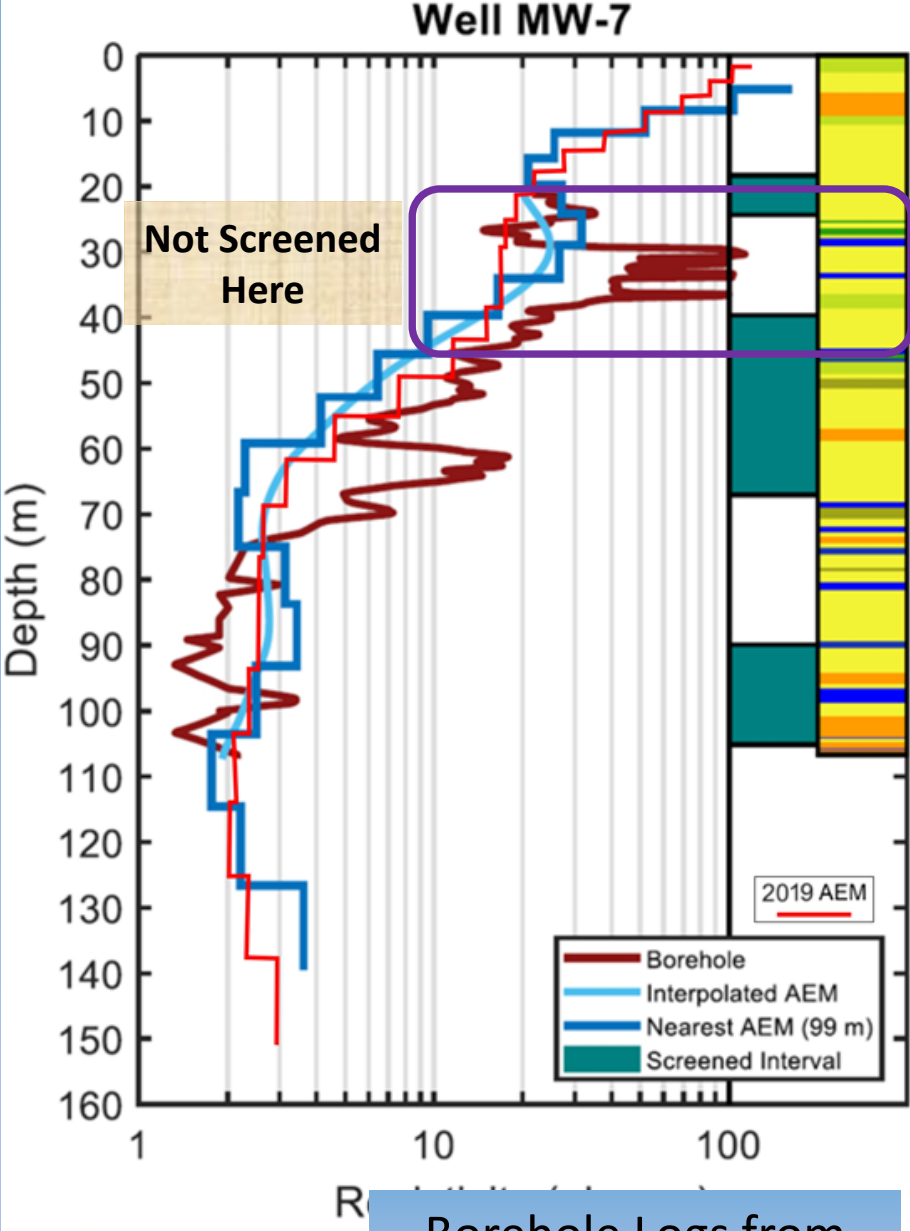
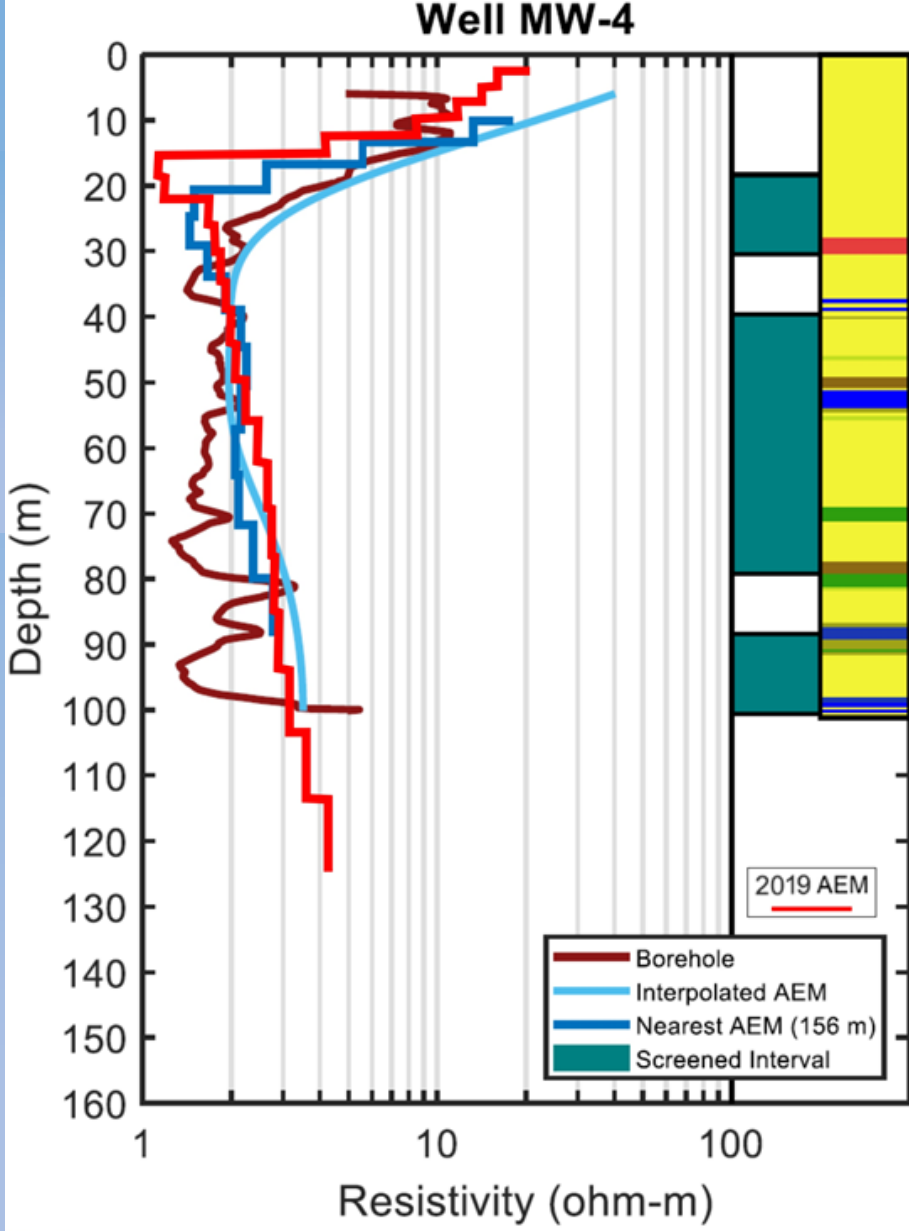
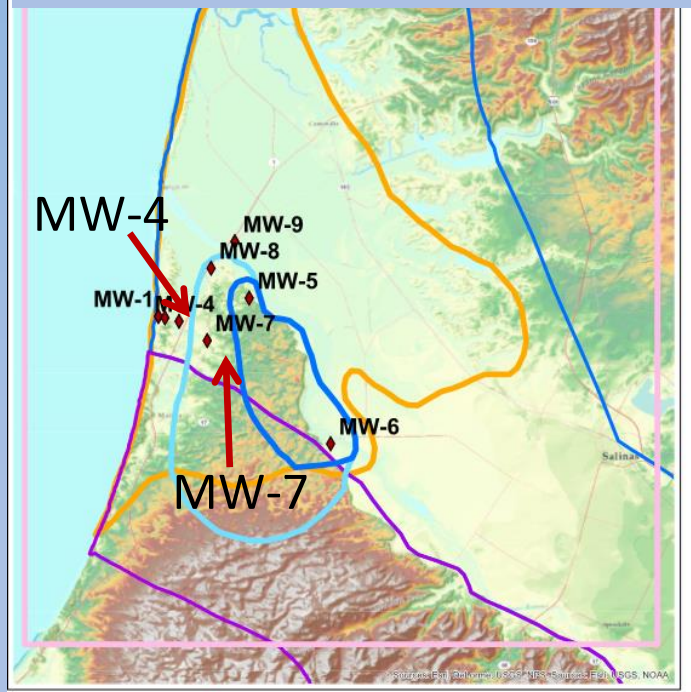


# 2019 MCWD AEM Investigation

## Geophysical Logs

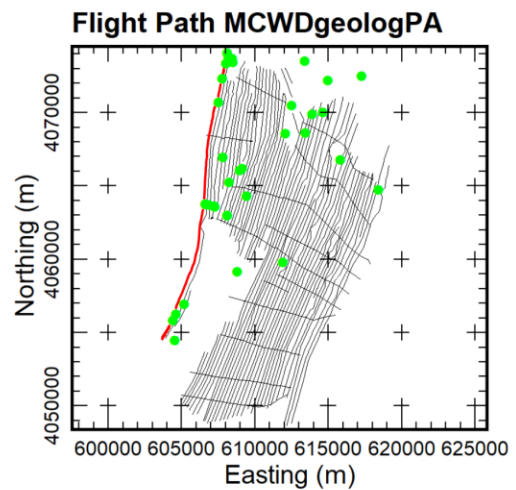


# Comparison of 2019 AEM Inversion Results to 2017 AEM & Borehole Geophysics



Borehole Logs from the 2017 Report

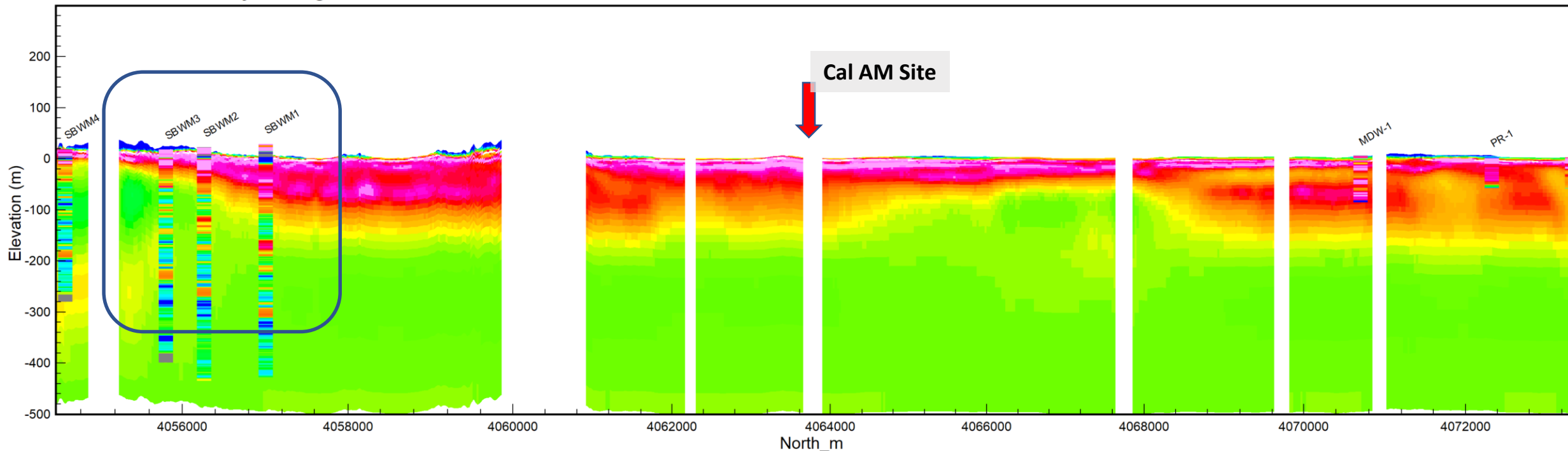
# Comparison of 2019 AEM Inversion Results to Borehole Geophysics



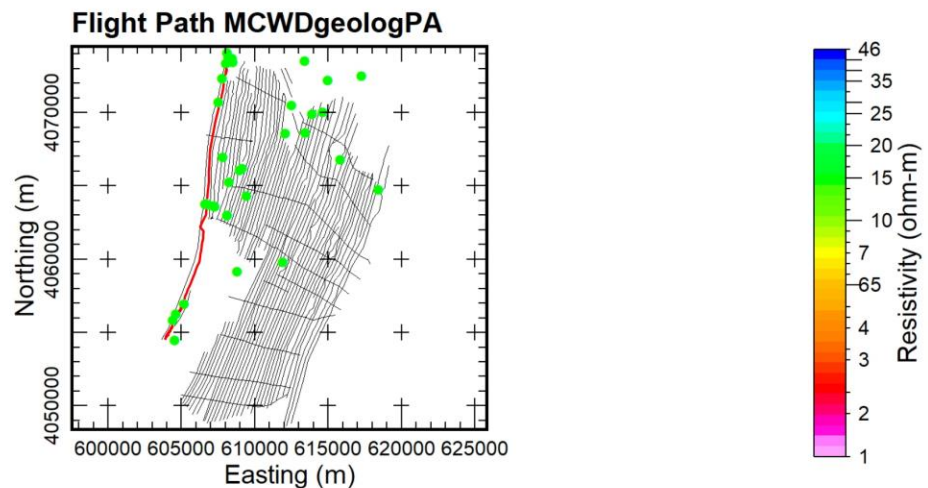
South

North

MCWD 2019 Resistivity & E-Log Profile - Line L200101



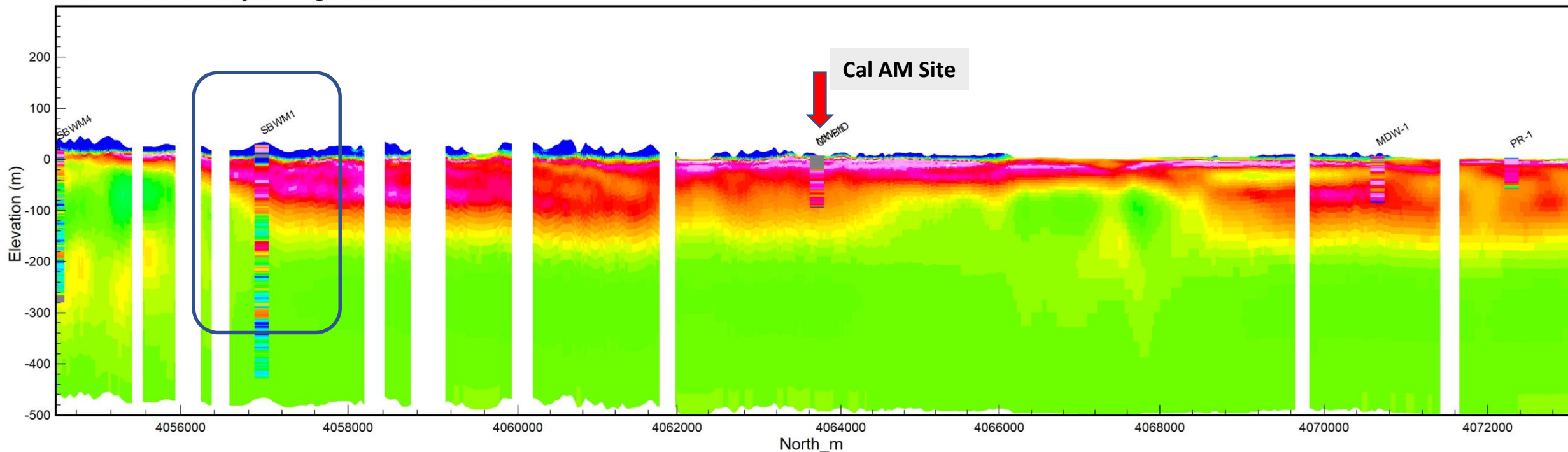
# Comparison of 2019 AEM Inversion Results to Borehole Geophysics



South

North

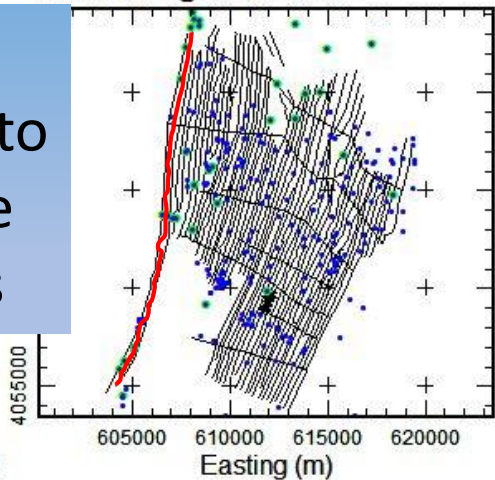
MCWD 2019 Resistivity & E-Log Profile - Line L200200



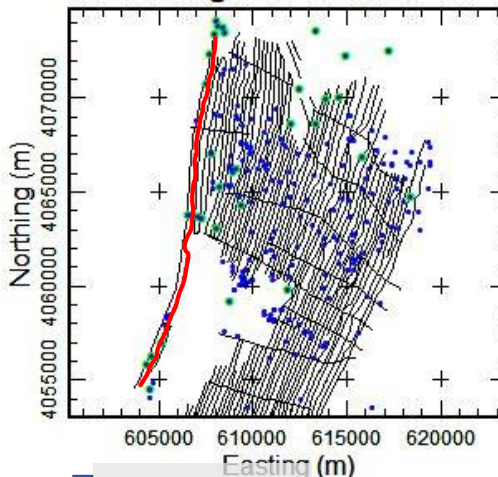


# Comparison of 2019 AEM Inversion Results to 2017 AEM & Borehole Lithology, Geophysics

MCWD Flight Path 2017



MCWD Flight Path 2019

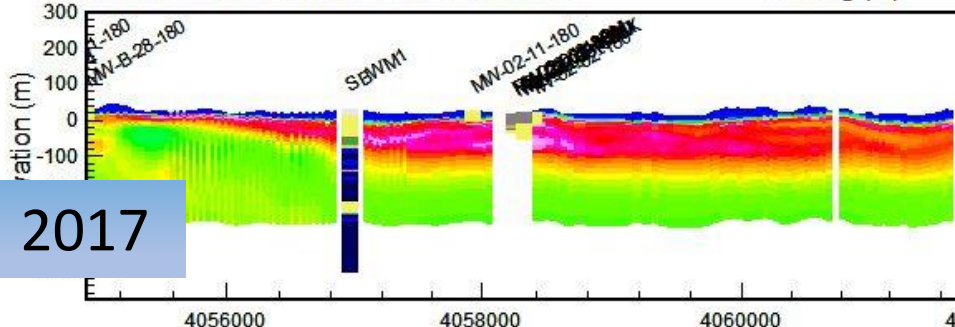


- MCWD Lithology
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Topsoil

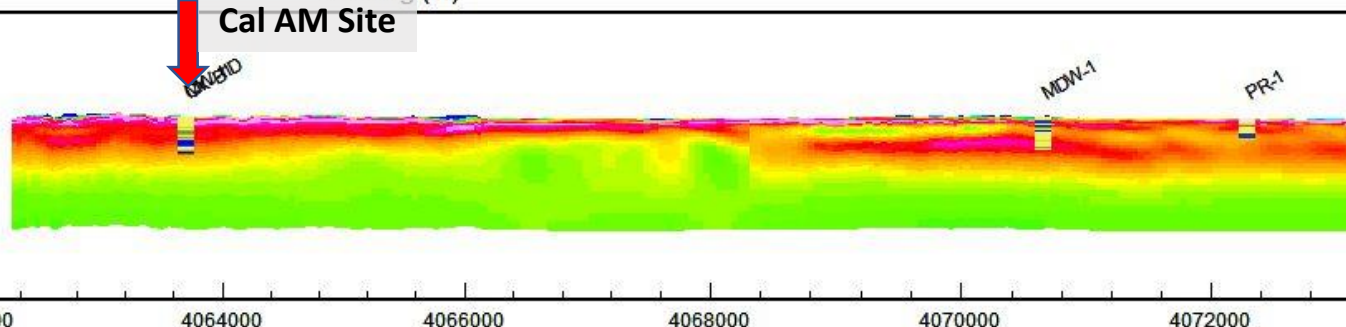
South

North

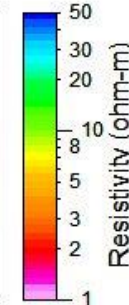
2017 MCWD Profile Line L200202



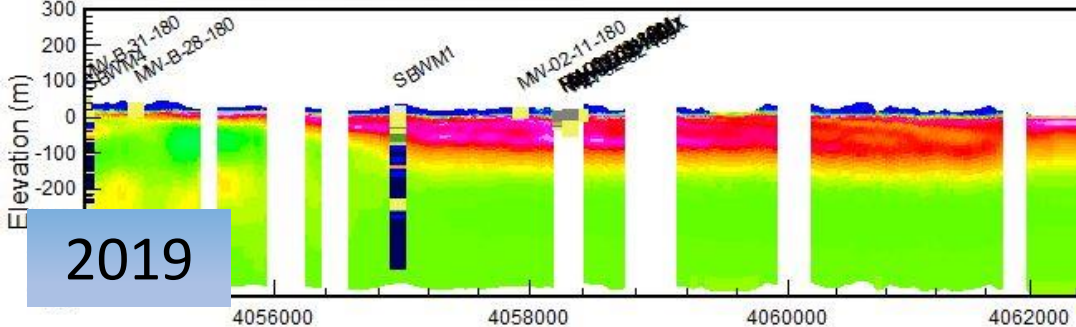
Cal AM Site



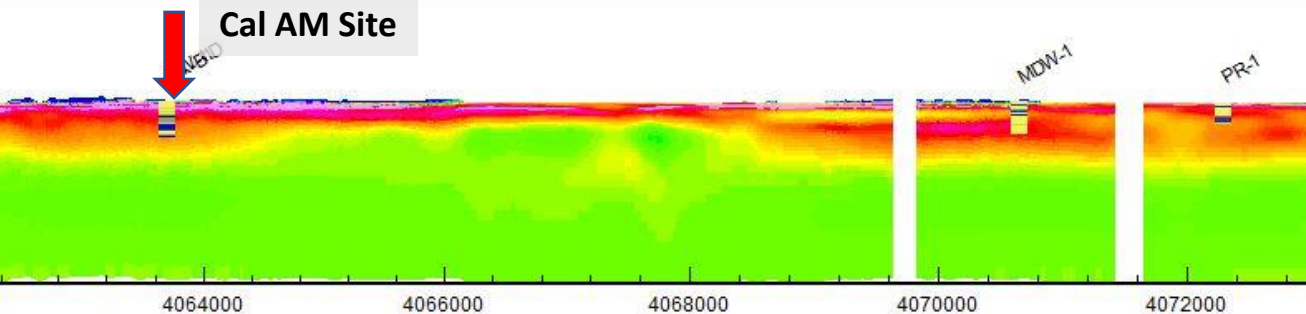
2017



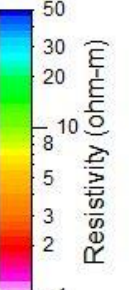
2019 MCWD Profile Line L200200



Cal AM Site

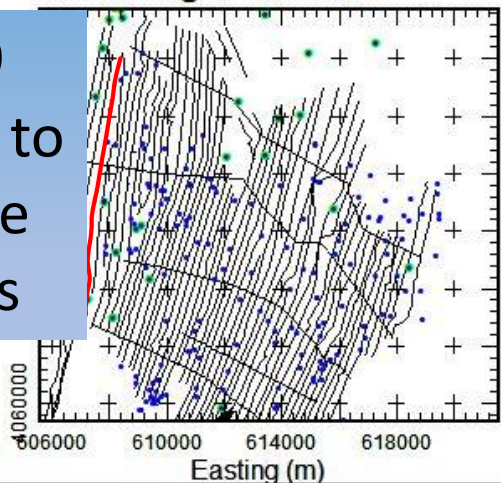


2019

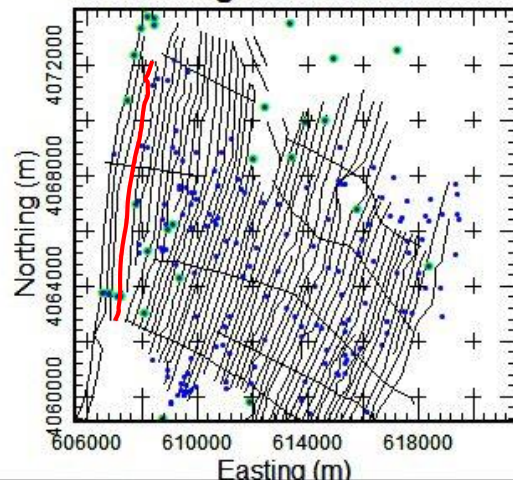


# Comparison of 2019 AEM Inversion Results to 2017 AEM & Borehole Lithology, Geophysics

MCWD Flight Path 2017



MCWD Flight Path 2019

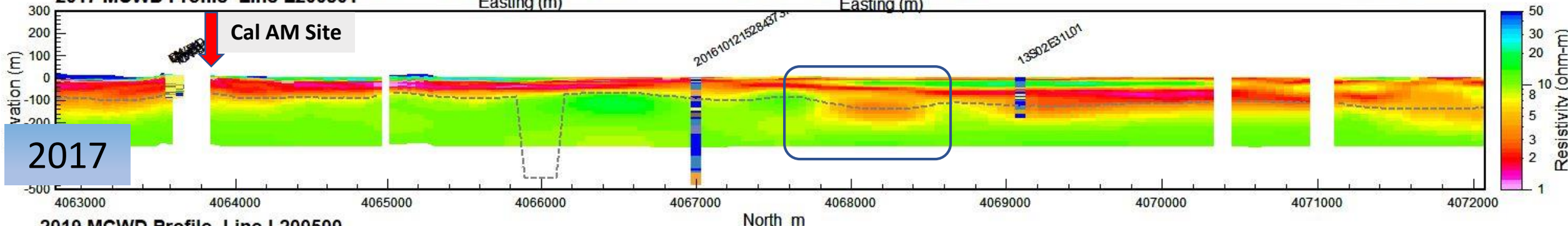


- MCWD Lithology
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Topsoil

South

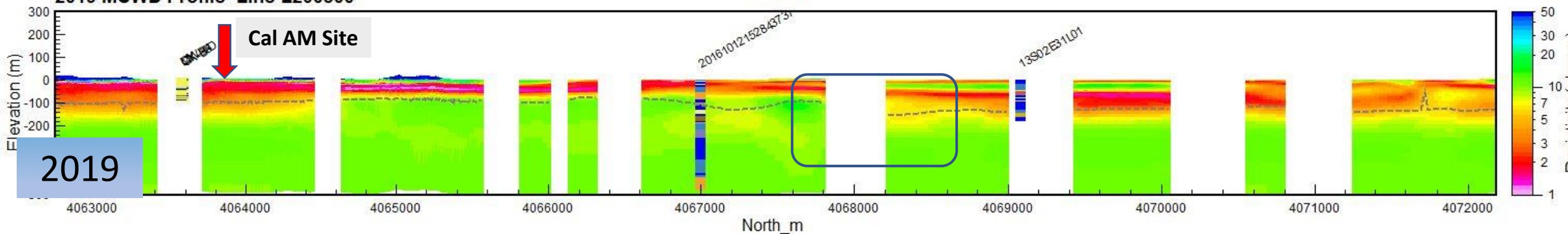
North

2017 MCWD Profile Line L200501



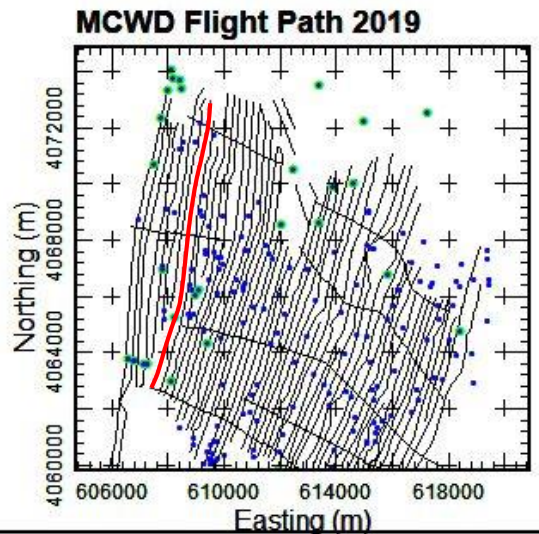
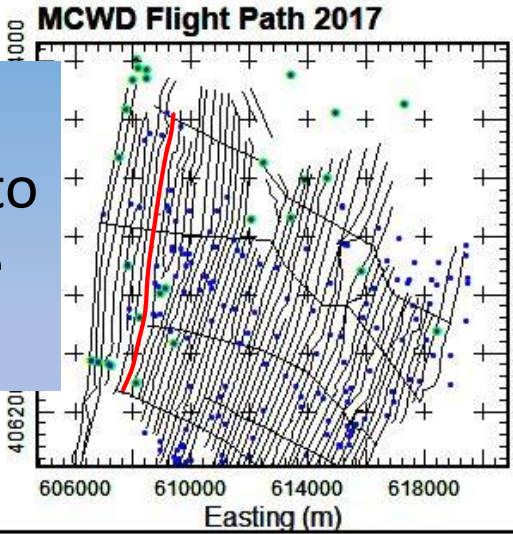
2017

2019 MCWD Profile Line L200500

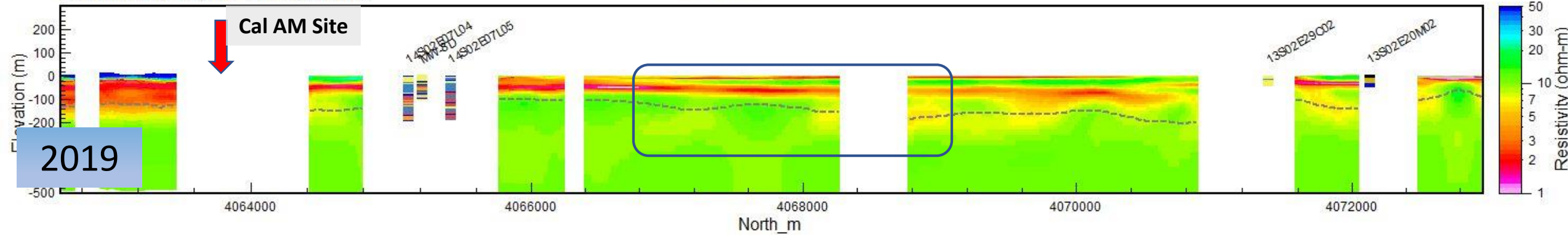
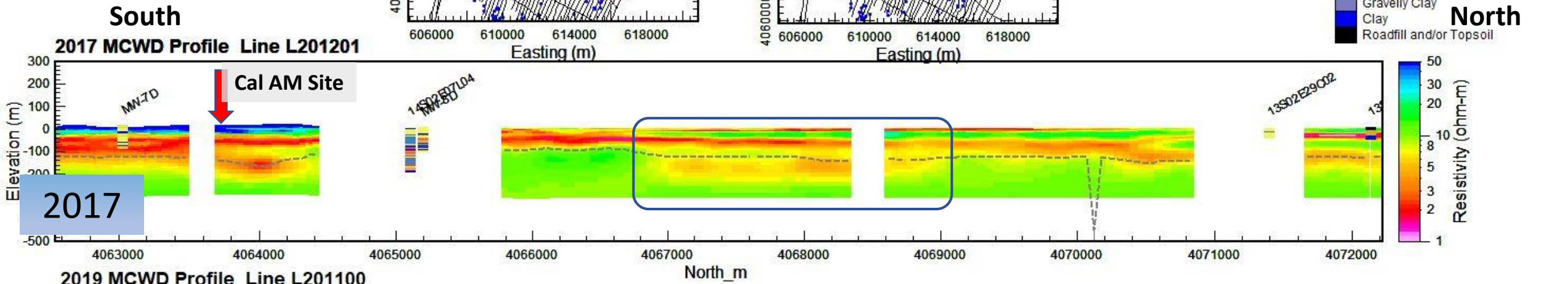


2019

# Comparison of 2019 AEM Inversion Results to 2017 AEM & Borehole Lithology, Geophysics

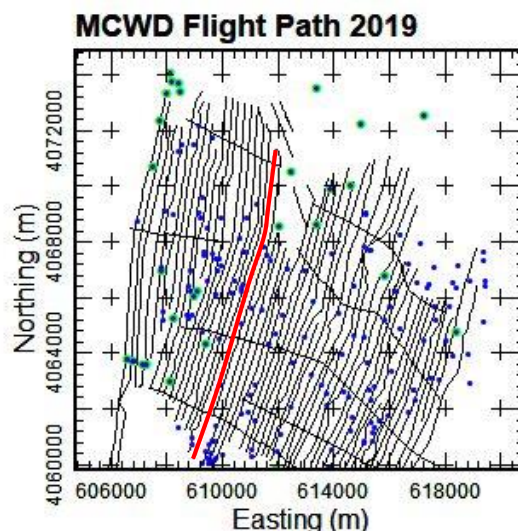
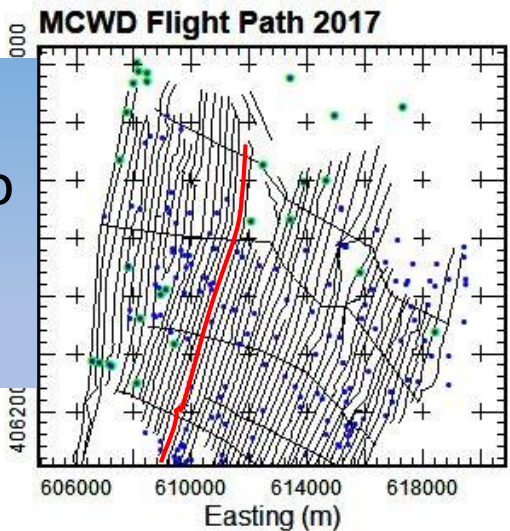


- MCWD Lithology**
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Topsoil



# Comparison of 2019 AEM Inversion Results to 2017 AEM & Borehole Lithology, Geophysics

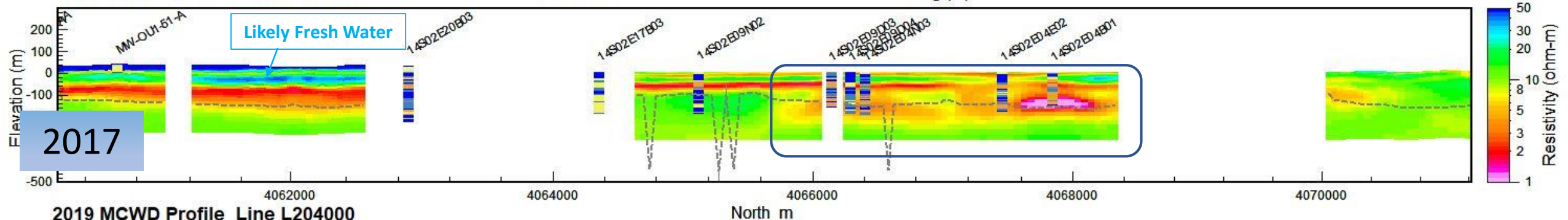
South



- MCWD Lithology
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Topsoil

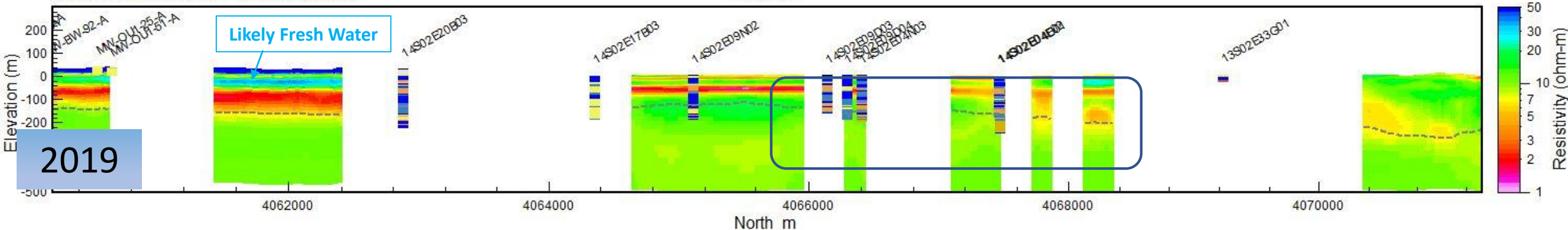
North

2017 MCWD Profile Line L204001



2017

2019 MCWD Profile Line L204000



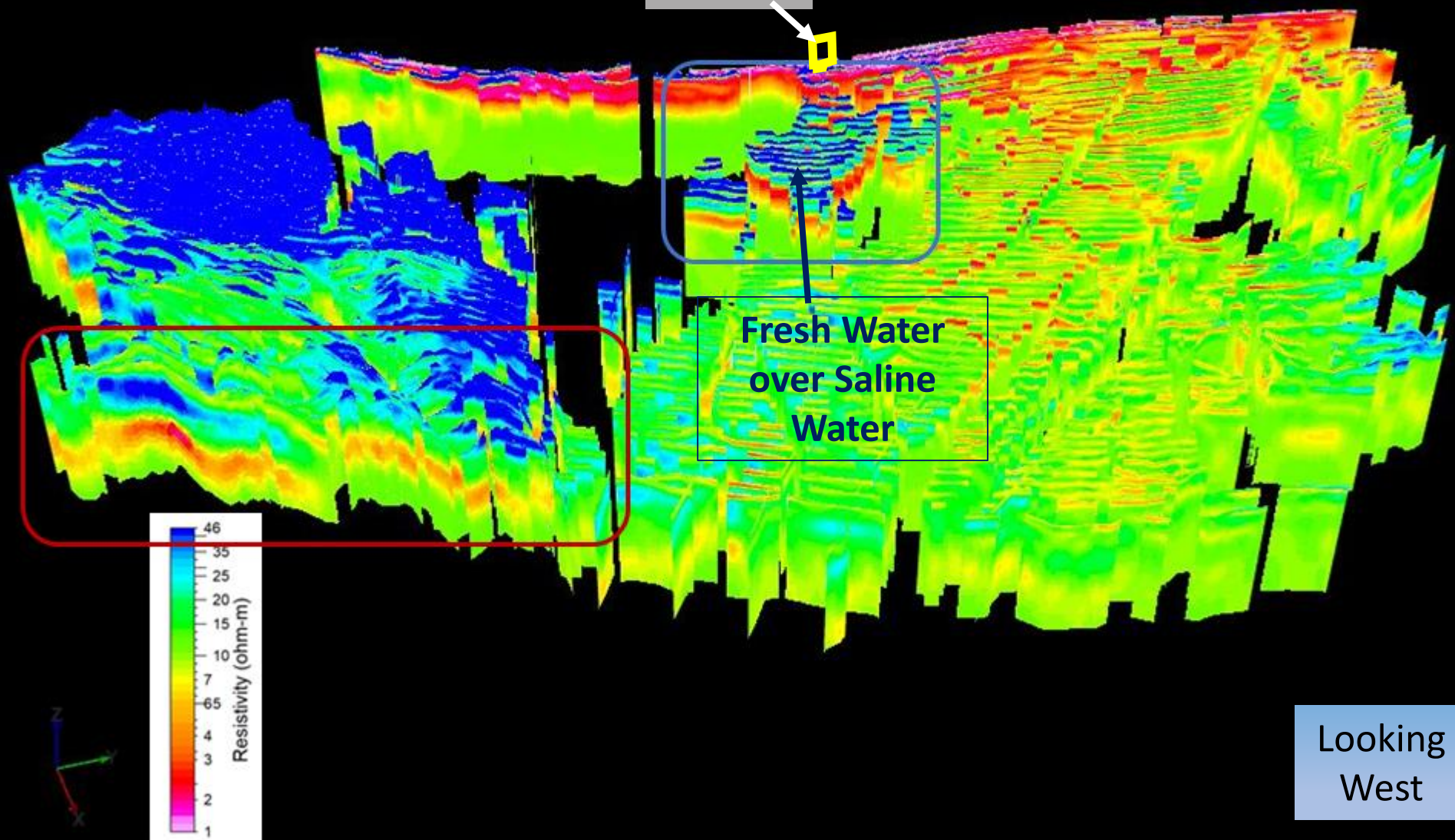
2019

2019

Cal AM Site

Fresh Water  
over Saline  
Water

Looking  
West

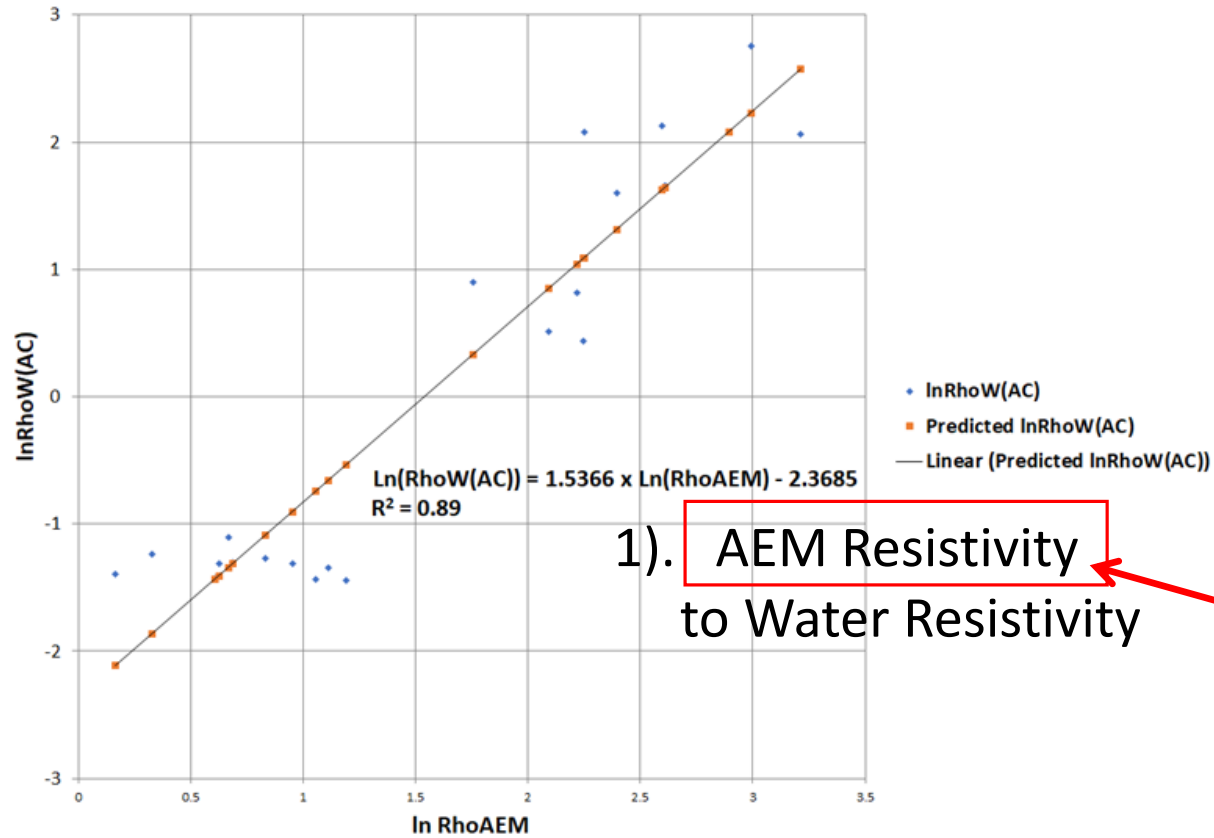


# AEM Bulk Resistivity to TDS Concentration Regression Relationship

HoleID	Screen Interval Lithology	Actual Conductivity $\mu\text{S}/\text{cm}$	Actual Conductivity (AC) $\text{S}/\text{cm}$	Actual Conductivity (AC) $\text{S}/\text{m}$	RhoW(AC) ohm-m	ln RhoW(AC)	Meas. Spec. Cond. $\mu\text{S}$ 4/24/2019 12PM	Ln(EC) $\mu\text{S}$	Ln(EC) S	TDS Conc mg/L	Salinity mg/L	AEM Mean Rho Ohm_m	CUT	Pred. Ln(Meas. EC)	Pred. EC	Pred TDS by EC (mg/L)	Pred TDS by RhoW (mg/L)
MW-1S	Sand	40172	0.040172	4.0172	0.2489	-1.3906	50221	10.82	1.6139	34150	32900	1.2		10.893	53809	58411	63981
MW-1M	Clayey Sand	41691	0.041691	4.1691	0.2399	-1.4277	51263	10.84	1.6344	34900	33700	1.8		10.732	45821	32747	33075
MW-1D	Clayey Sand	38218	0.038218	3.8218	0.2617	-1.3407	42936	10.67	1.4571	29200	27900	3.0		10.432	33922	16608	15252
MW-3S	Sand	34557	0.034557	3.4557	0.2894	-1.2400	40352	10.61	1.3950	27400	25900	1.4		10.845	51298	47859	50979
MW-3M	Clayey Sand	37029	0.037029	3.7029	0.2701	-1.3091	43257	10.67	1.4646	29400	28000	1.9		10.725	45465	32013	32231
MW-3D	Sand	41973	0.041973	4.1973	0.2382	-1.4344	46802	10.75	1.5433	31800	30700	2.9		10.471	35266	17827	16535
MW-4S	Sand	1751	0.001751	0.1751	5.7123	1.7426	2037	7.62	-1.5909	1400	1100	4.6	x, x	10.028	22653	9339	7912
MW-4M	Clayey Sand	30126	0.030126	3.0126	0.3319	-1.1028	34845	10.46	1.2483	23700	33200	2.0		10.705	44559	30246	30210
MW-4D	Clayey Sand	37219	0.037219	3.7219	0.2687	-1.3142	40848	10.62	1.4073	27800	26400	2.6		10.544	37934	20586	19482
MW-5S	x	2016	0.002016	0.2016	4.9596	1.6013	NA	NA	NA	NA	NA	11.0		8.434	4599	2905	2090
MW-5M	x	1254	0.001254	0.1254	7.9726	2.0760	NA	NA	NA	NA	NA	18.1		6.653	775	1480	968
MW-5D	Sand	6016	0.006016	0.6016	1.6622	0.5081	6450	8.77	-0.4386	4400	3600	8.1		9.158	9489	4388	3344
MW-6S	Sand	1901	0.001901	0.1901	5.2615	1.6604	2240	7.71	-1.4963	1500	1200	13.6		7.770	2367	2169	1498
MW-6M	Sand	1194	0.001194	0.1194	8.3780	2.1256	1412	7.25	-1.9579	1000	710	13.4		7.815	2477	2209	1529
MW-6D	Sand	4409	0.004409	0.4409	2.2681	0.8189	1833	7.51	-1.6965	3300	2600	9.2	x	8.886	7232	3704	2756
MW-7S	Sand	1268	0.001268	0.1268	7.8858	2.0651	1478	7.30	-1.9120	1000	800	24.9	x	4.933	139	958	589
MW-7M	x	6440	0.006440	0.6440	1.5528	0.4401	NA	NA	NA	NA	NA	9.5		8.813	6723	3551	2627
MW-7D	Sand	35728	0.035728	3.5728	0.2799	-1.2733	40180	10.60	1.3908	27300	25900	2.3		10.617	40805	24181	23407
MW-8S	Sand	635	0.000635	0.0635	15.7381	2.7561	762	6.64	-2.5751	500	400	19.9		6.185	485	1296	832
MW-8M	Sand	42505	0.042505	4.2505	0.2353	-1.4470	49993	10.82	1.6093	34000	32900	3.3		10.365	31731	14823	13397
MW-8D	Sand	1255	0.001255	0.1255	7.9707	2.0758	1375	7.23	-1.9841	900	700	9.5	x	8.806	6673	3535	2614
MW-9S	Silty Sand	4066	0.004066	0.4066	2.4594	0.8999	4805	8.48	-0.7329	3300	2600	5.8	x	9.741	17006	6934	5634
MW-9M	Sand	36792	0.036792	3.6792	0.2718	-1.3027	43607	10.68	1.4726	29700	28300	2.0		10.695	44113	29425	29277
MW-9D	Clayey Sand	550	0.000550	0.0550	18.1752	2.9001	295	5.69	-3.5237	405	300	12.1	x, x	8.144	3444	2538	1792

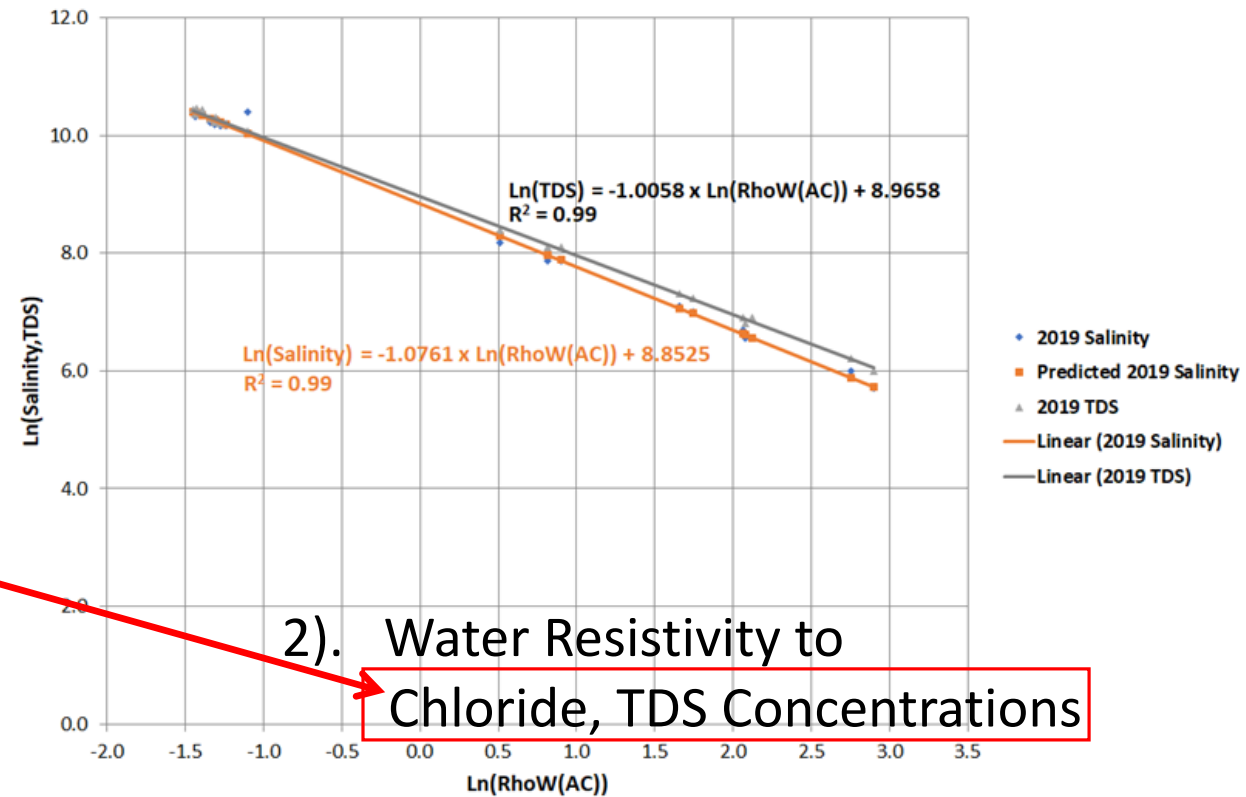
# 2019 AEM Bulk Resistivity to TDS Concentration Regression Relationships

RhoW(AC) vs RhoAEM Line Fit Plot



1). **AEM Resistivity to Water Resistivity**

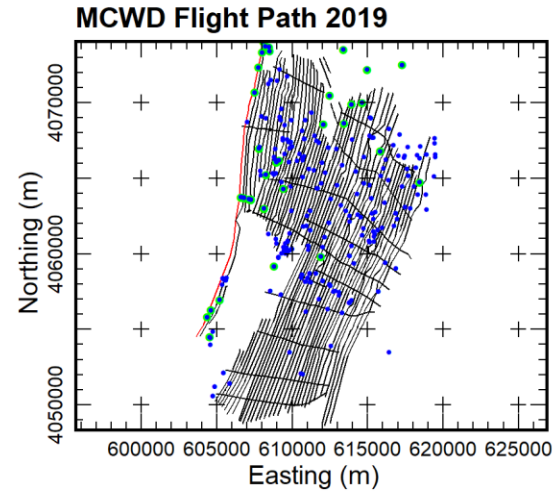
RhoW(AC) vs Salinity, TDS Line Fit Plot



2). **Water Resistivity to Chloride, TDS Concentrations**

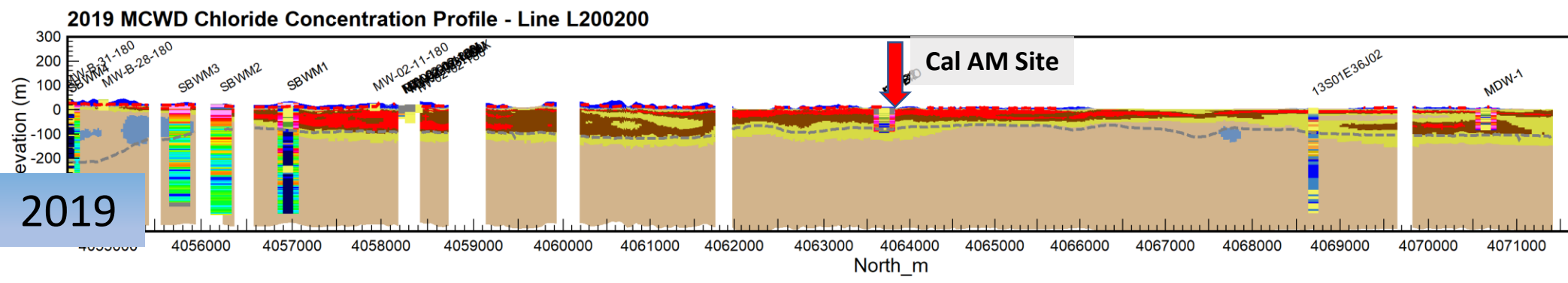
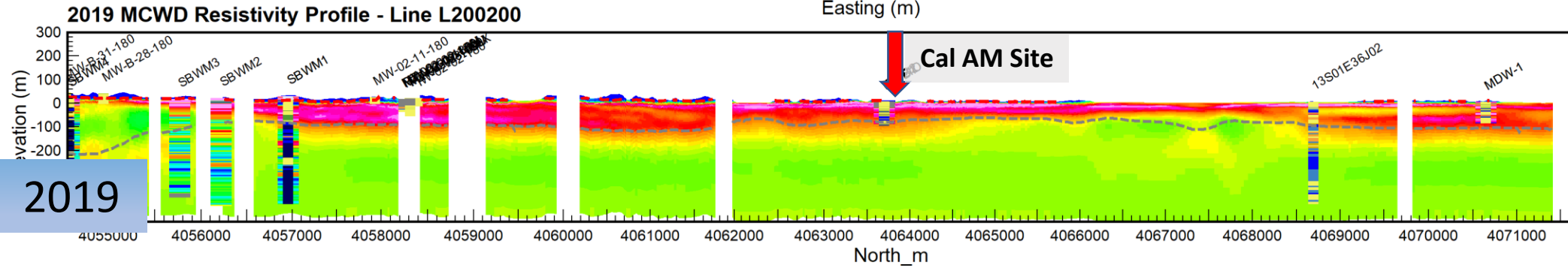
These relationships are used to examine the Chloride and TDS Concentrations in the MCWD AEM Survey Area

## Conversion of Rho AEM to Chloride Concentration



- MCWD Lithology**
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Tops

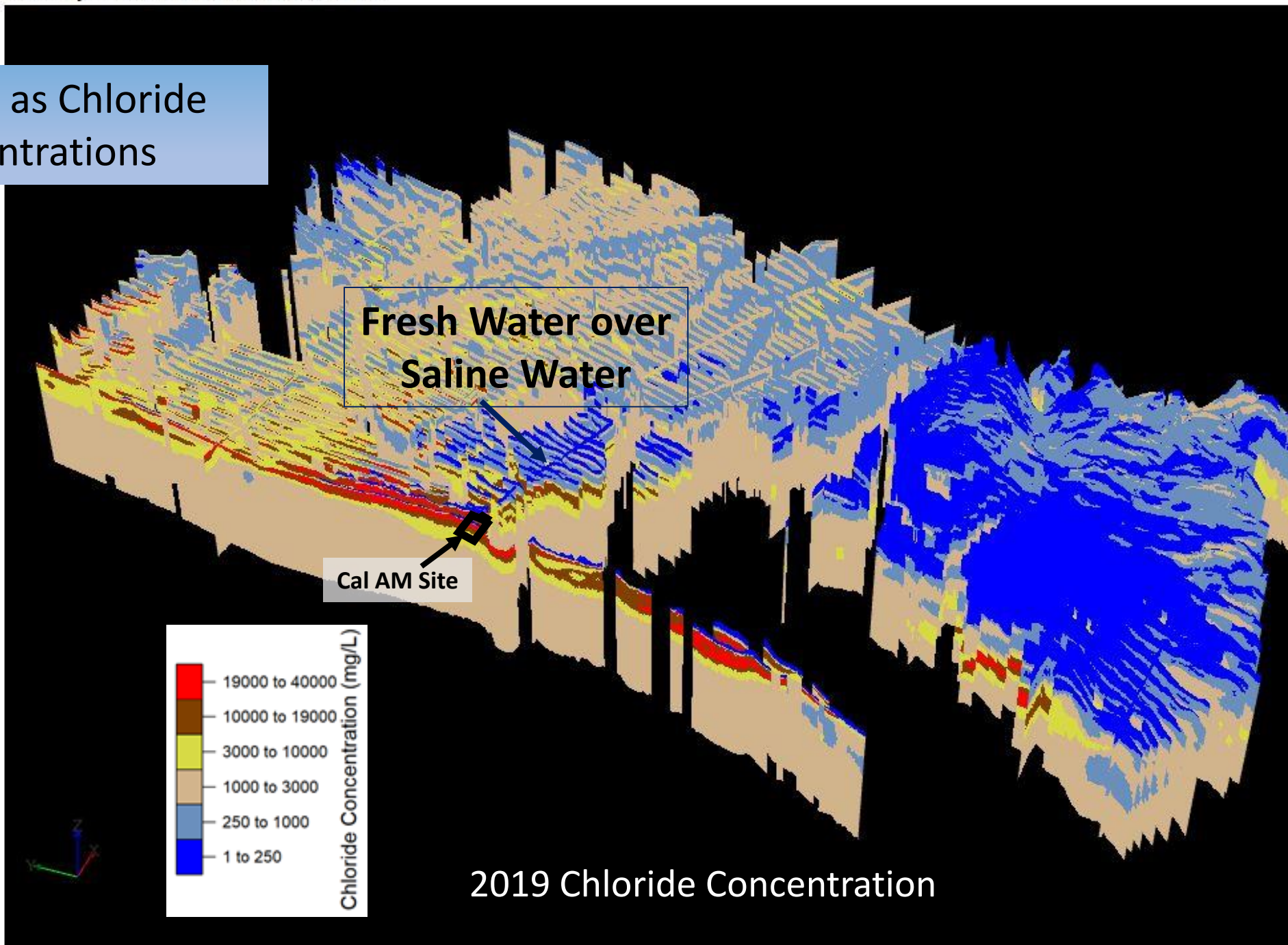
North



- Chloride Concentration (mg/L)**
- 19000 to 40000
  - 10000 to 19000
  - 3000 to 10000
  - 1000 to 3000
  - 250 to 1000
  - 1 to 250

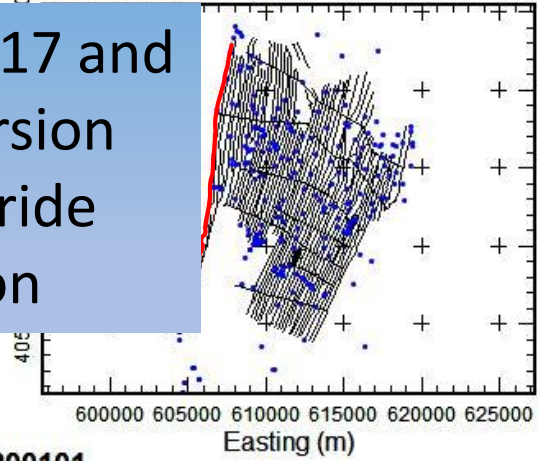


# Rho AEM as Chloride Concentrations

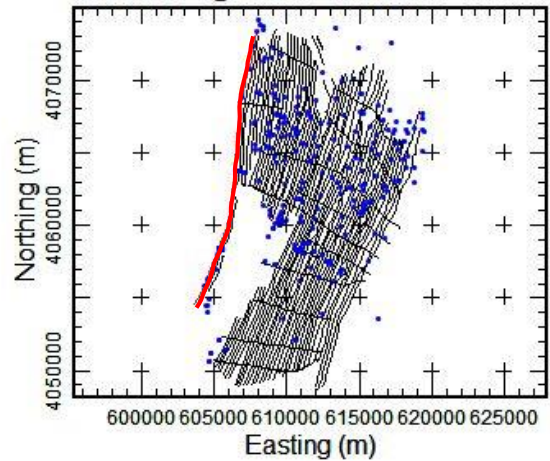


# Comparison of 2017 and 2019 AEM Inversion Results in Chloride Concentration

MCWD Flight Path 2017



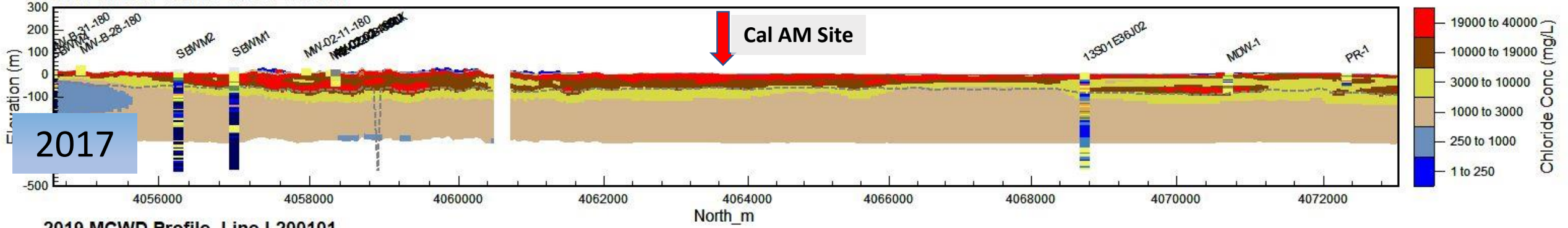
MCWD Flight Path 2019



- MCWD Lithology
- No Sample
  - Igneous/Metamorphics
  - Decomposed Granite
  - Clayey Shale Claystone
  - Chert
  - Gravel/Boulders
  - Sand and Gravel
  - Sand
  - Mixed
  - Clayey sand
  - Clayey Gravel
  - Silty Sand
  - Silt/Loess
  - Silty Clay
  - Sandy Clay
  - Gravelly Clay
  - Clay
  - Roadfill and/or Topsoil

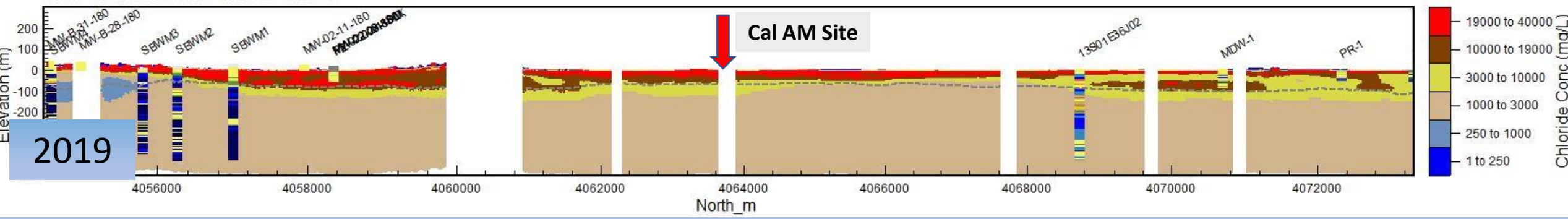
North

2017 MCWD Profile Line L200101

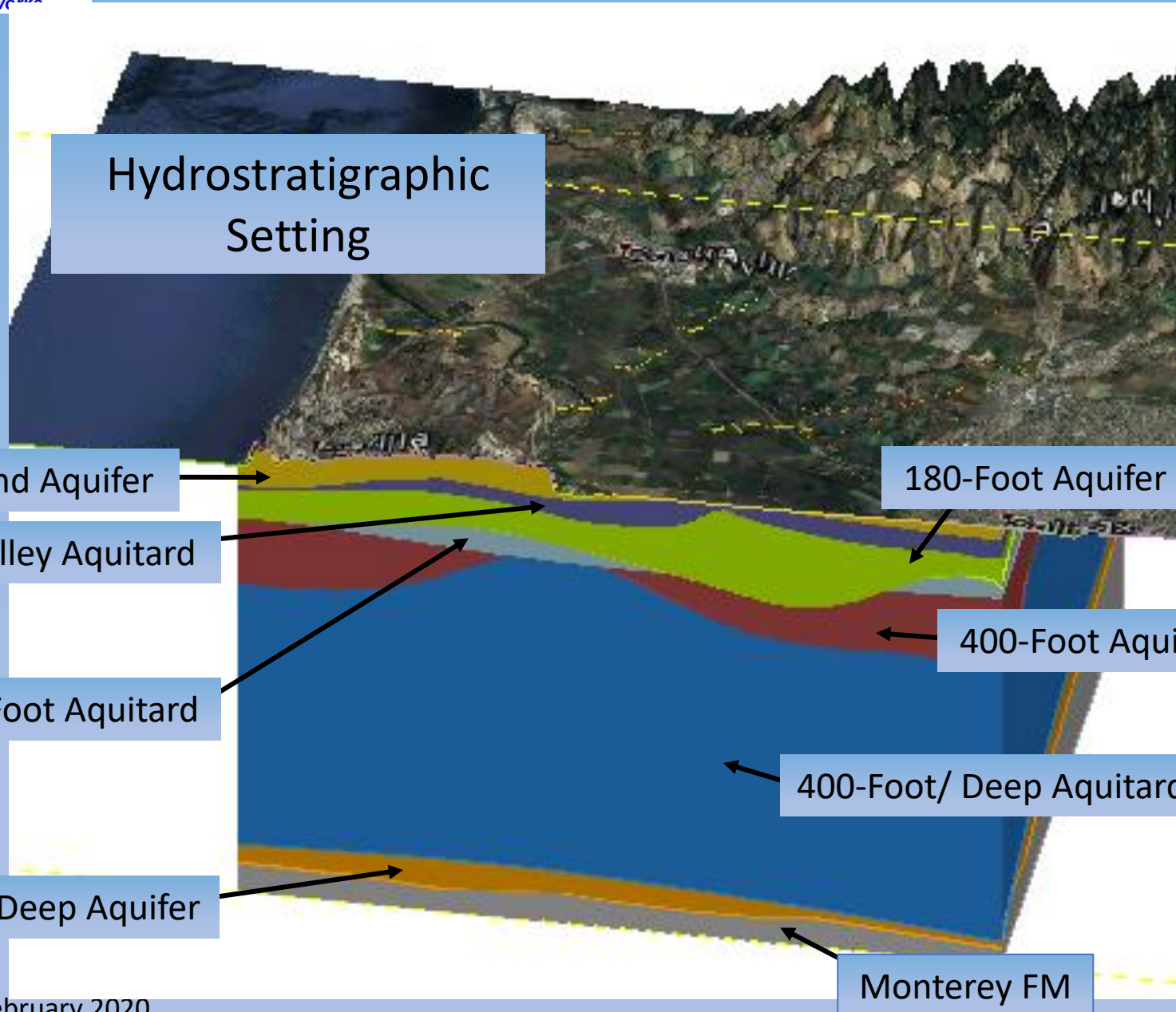


2017

2019 MCWD Profile Line L200101



2019



Hydrostratigraphic Setting

Dune Sand Aquifer

Salinas Valley Aquitard

180/400-Foot Aquitard

Deep Aquifer

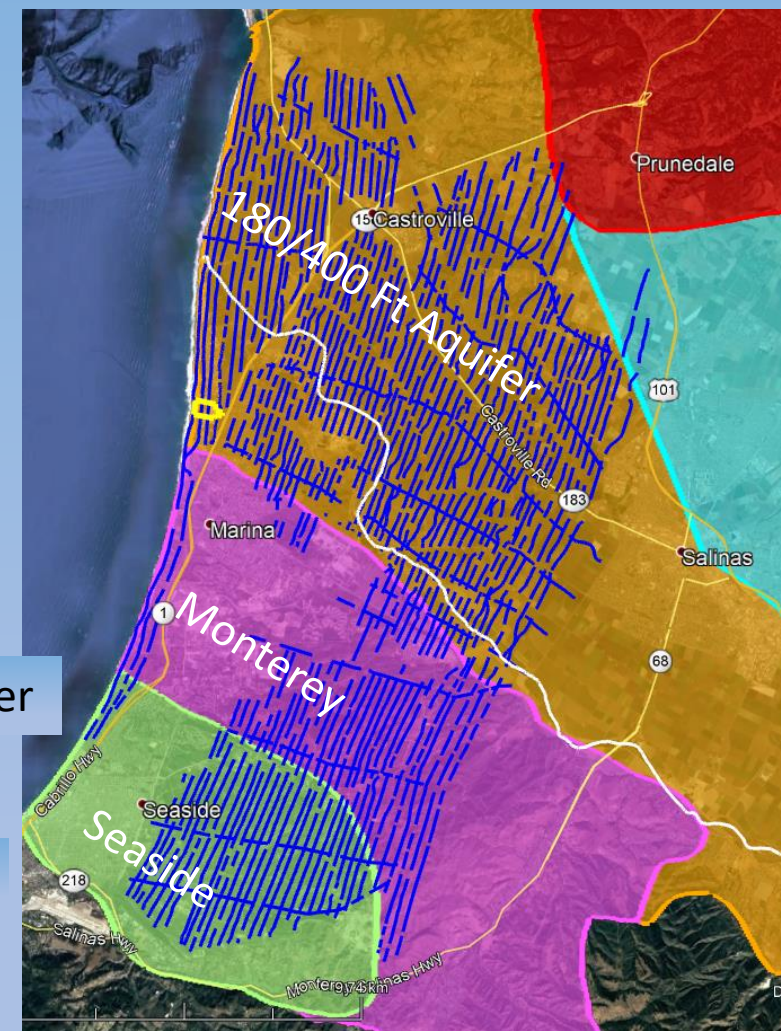
180-Foot Aquifer

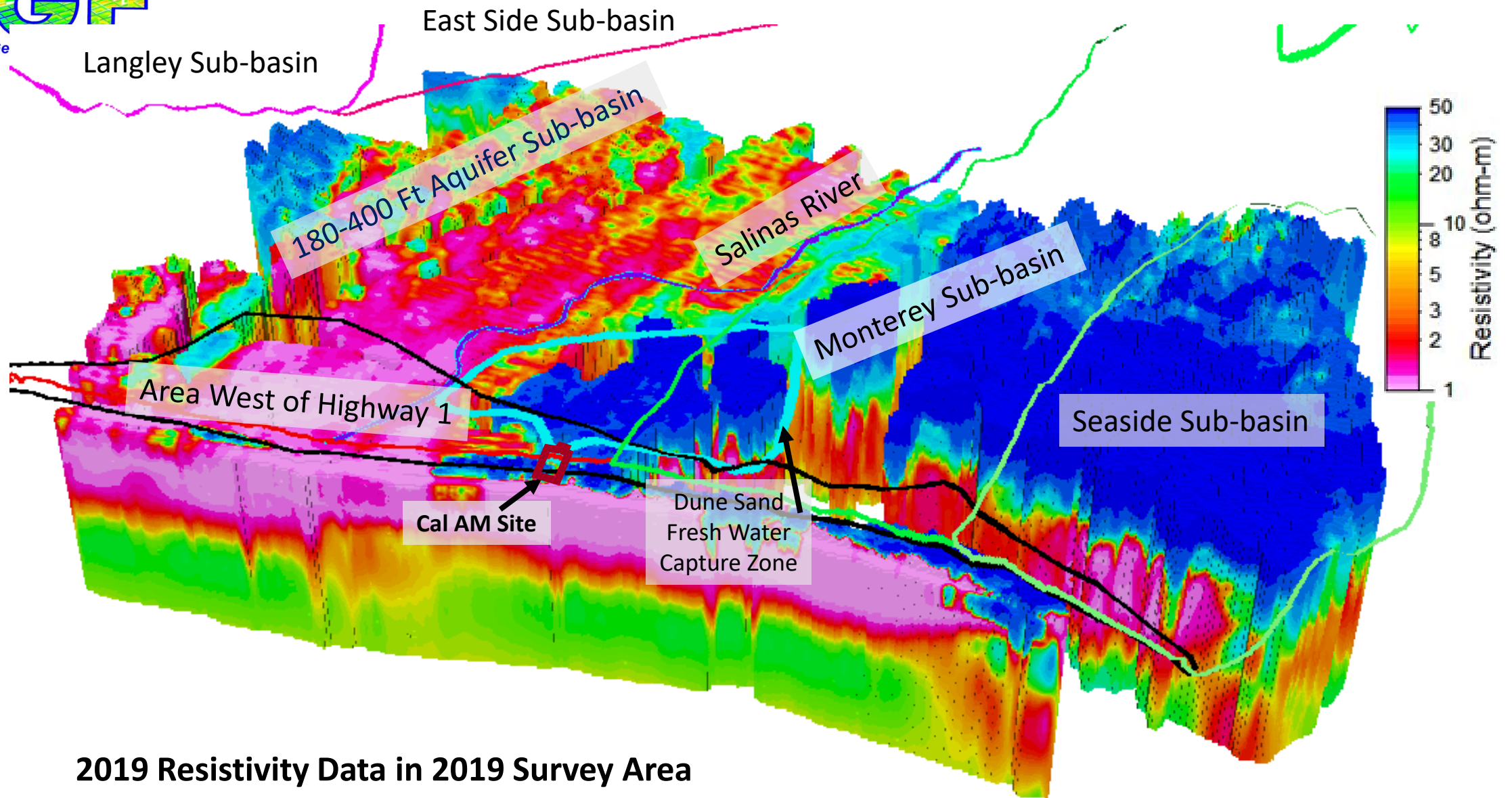
400-Foot Aquifer

400-Foot/ Deep Aquitard

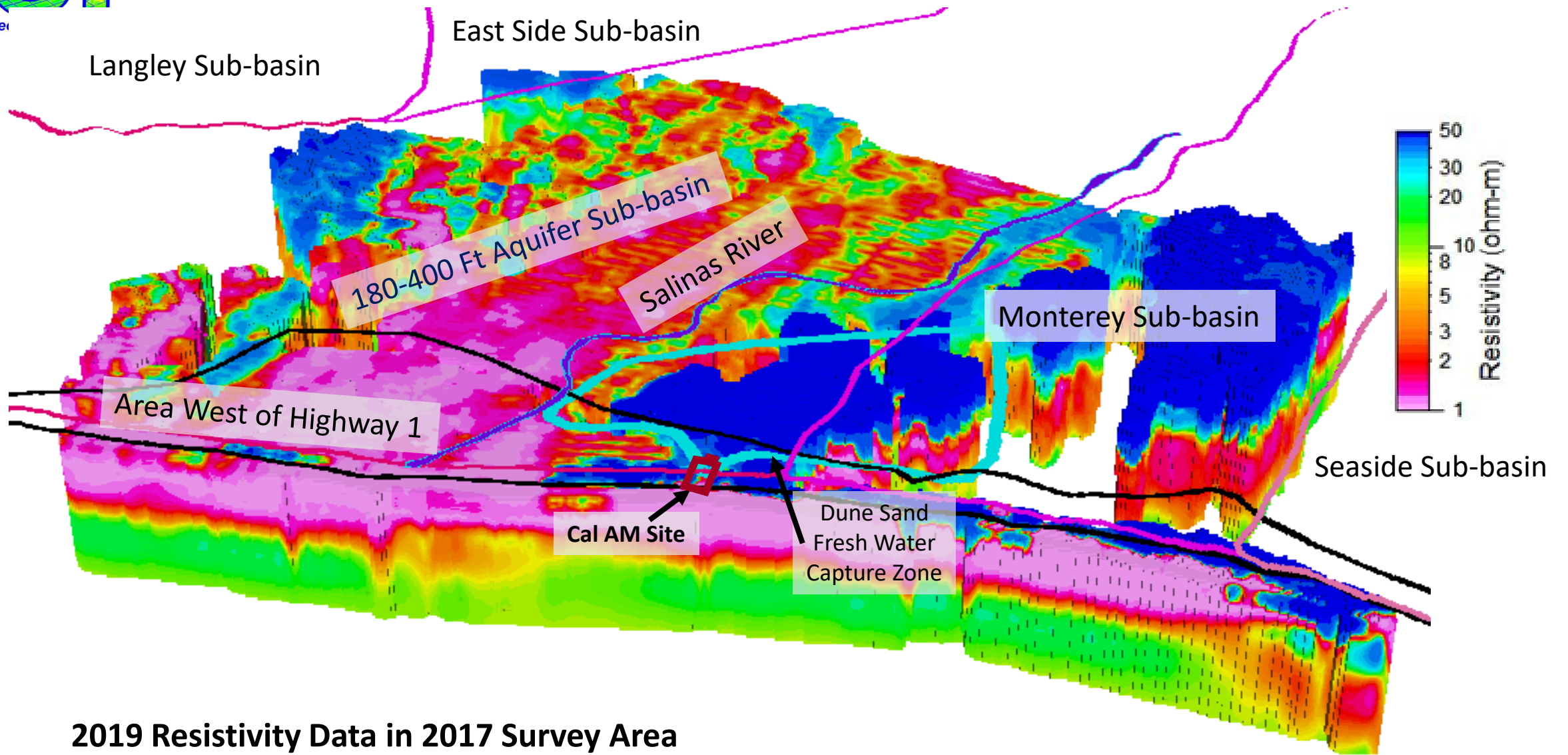
Monterey FM

Local Sub-Basins



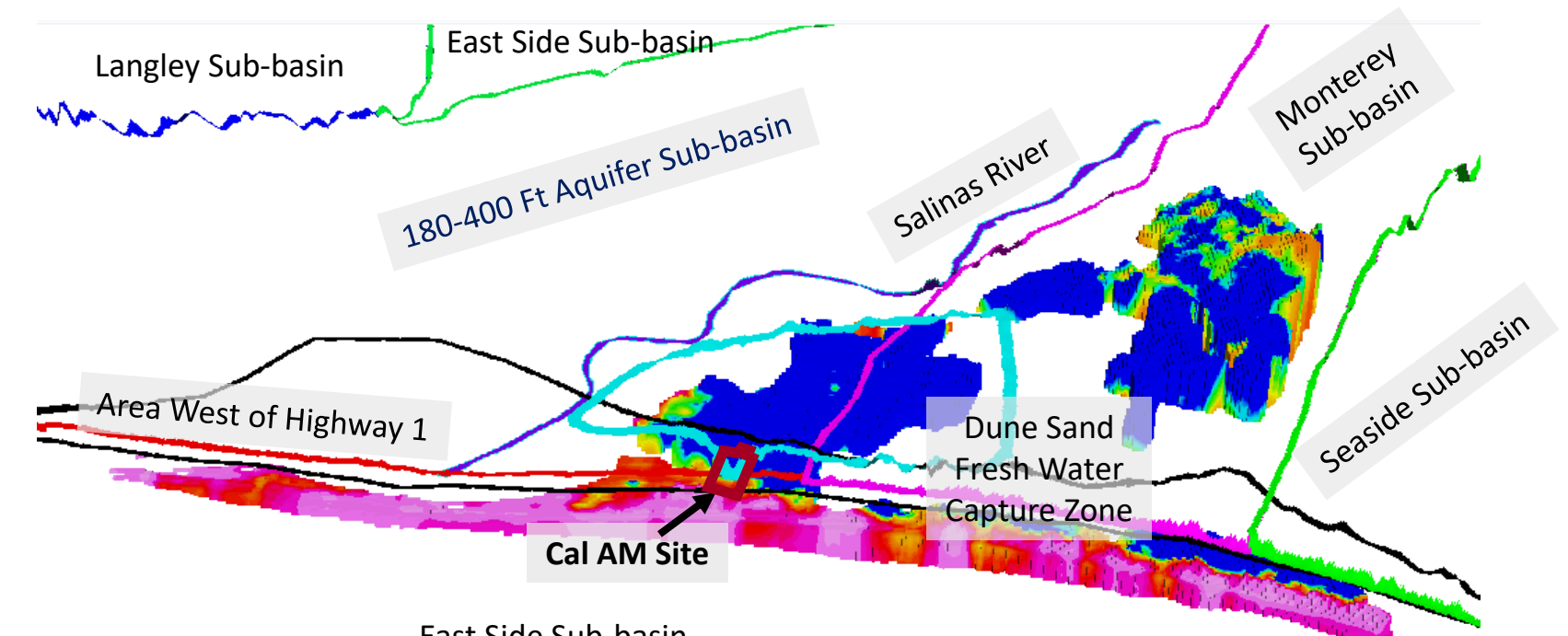
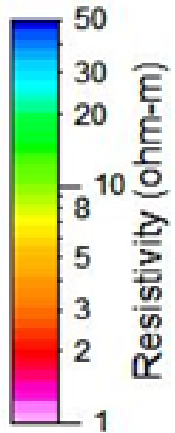


**2019 Resistivity Data in 2019 Survey Area  
Full Voxel  
Depth: Surface to -375 m (1,230 ft)**

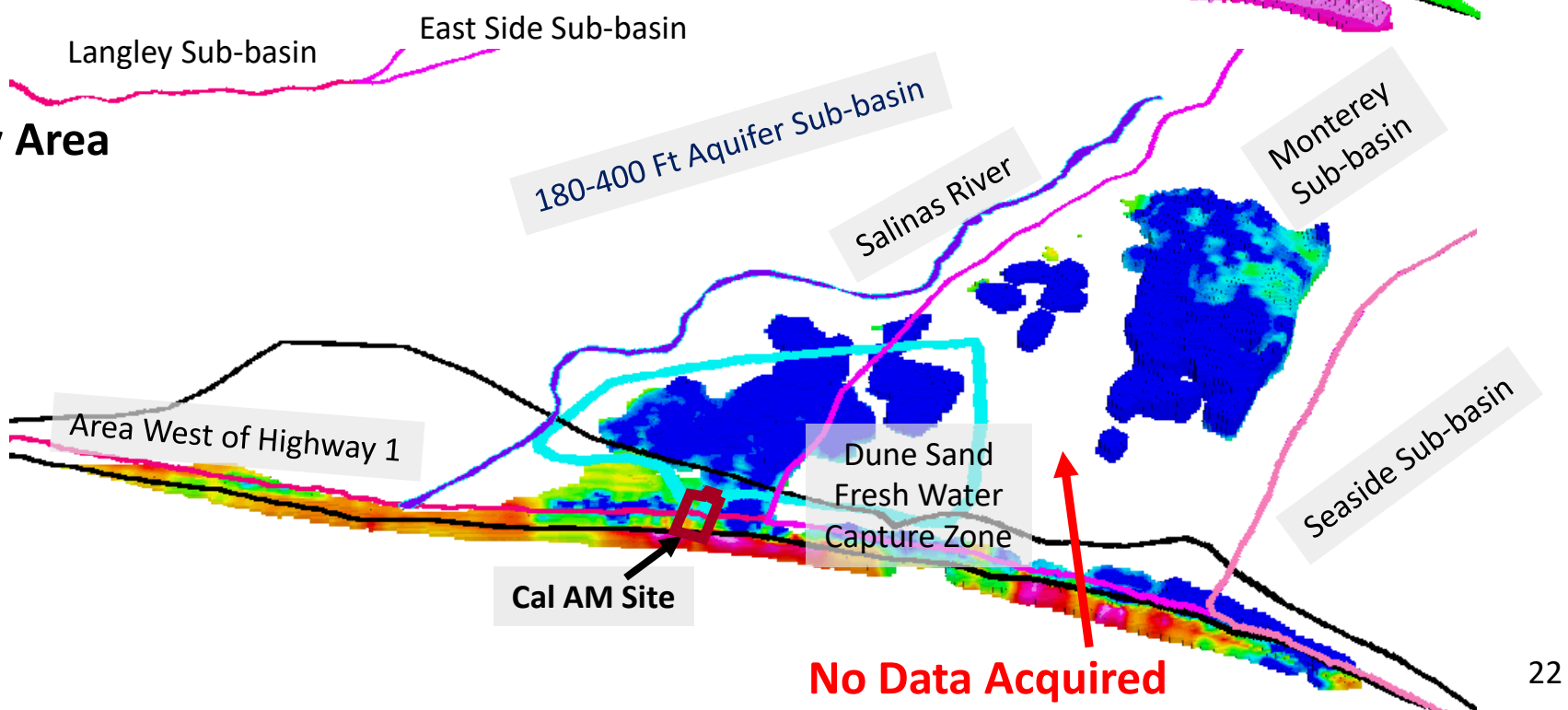


**2019 Resistivity Data in 2017 Survey Area  
Full Voxel  
Depth: Surface to -375 m (1,230 ft)**

## 2017 Resistivity Data Dune Sand Aquifer



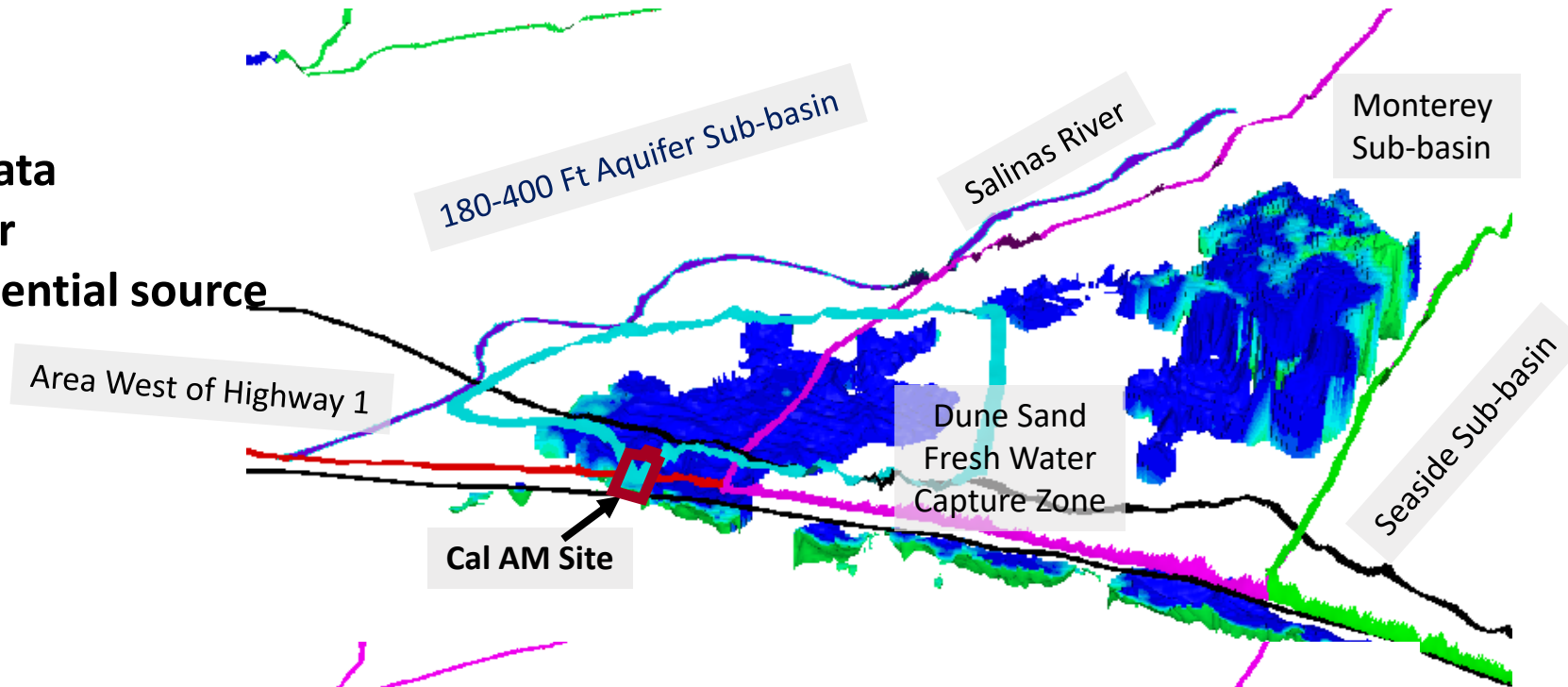
## 2019 Data - 2017 Survey Area Dune Sand Aquifer



**2017 Resistivity Data**

**Dune Sand Aquifer**

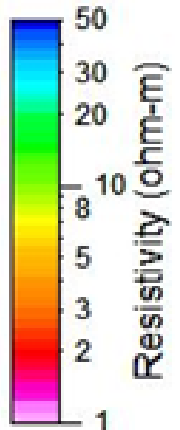
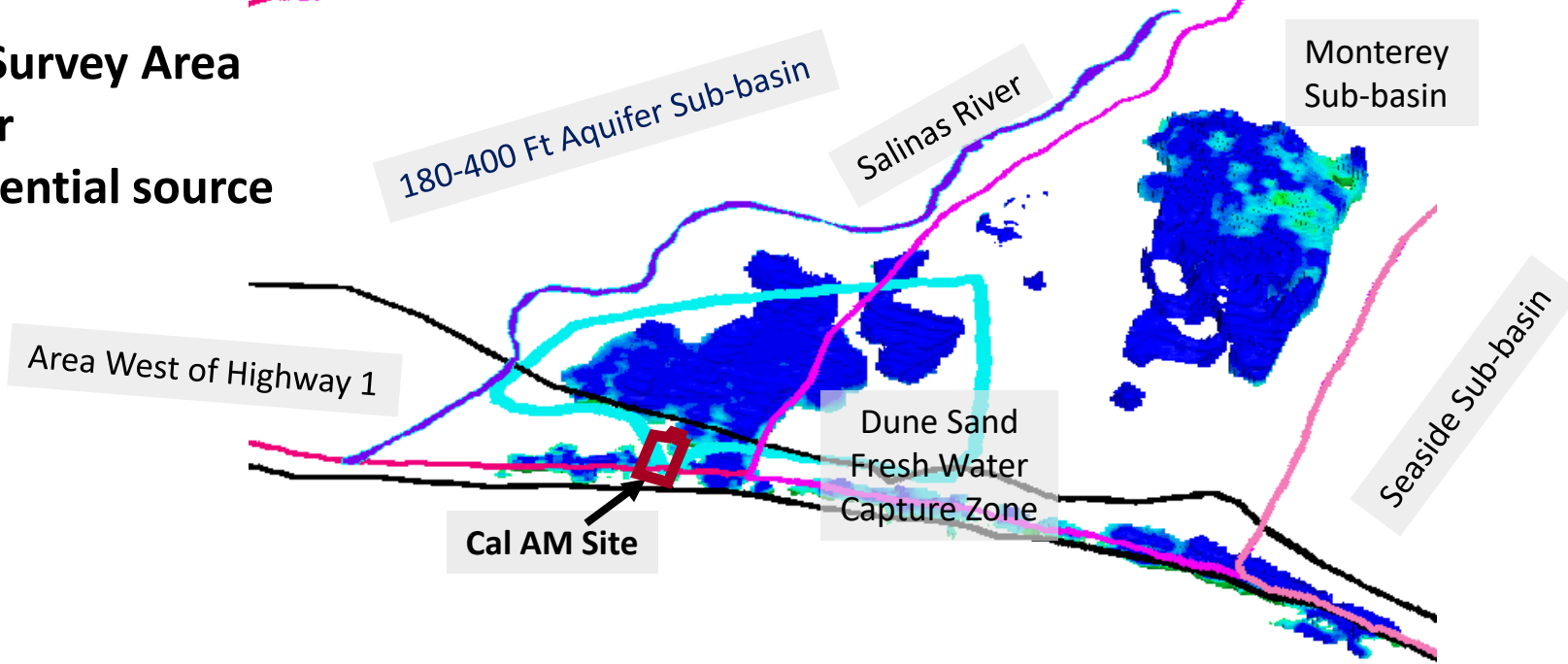
**20-75 ohm-m (Potential source of drinking water)**



**2019 Data - 2017 Survey Area**

**Dune Sand Aquifer**

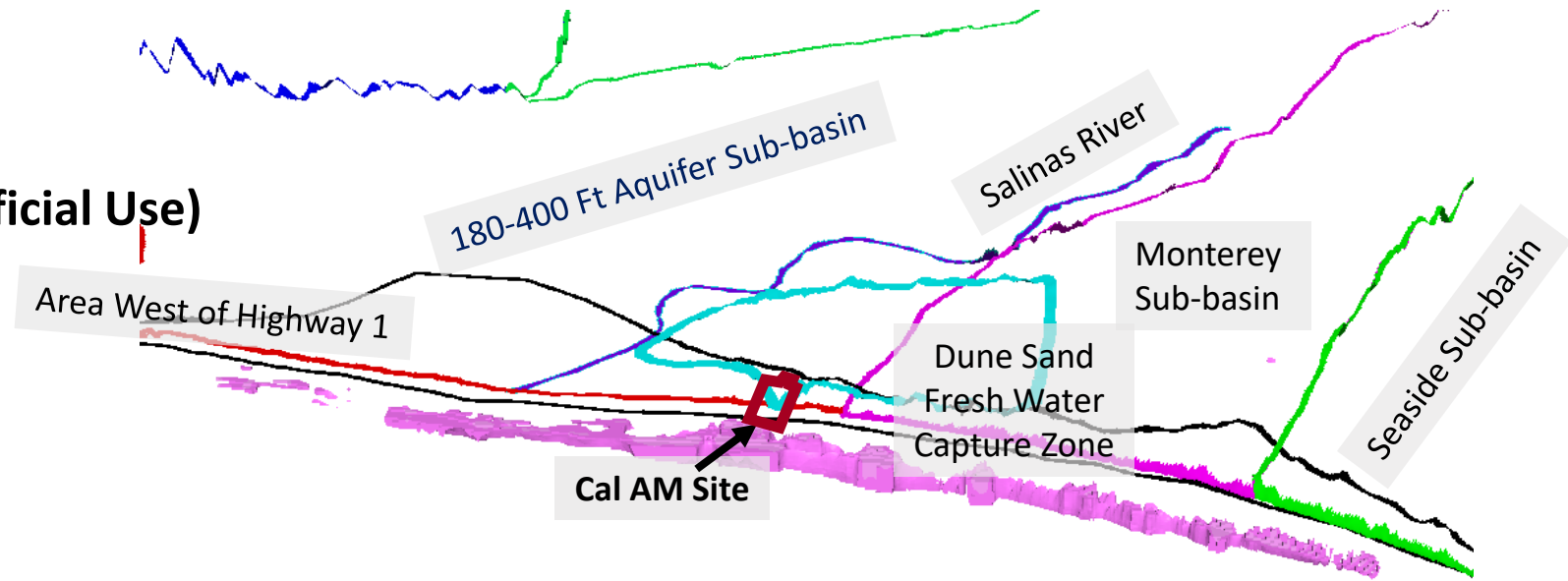
**20-75 ohm-m (Potential source of drinking water)**



## 2017 Resistivity Data

### Dune Sand Aquifer

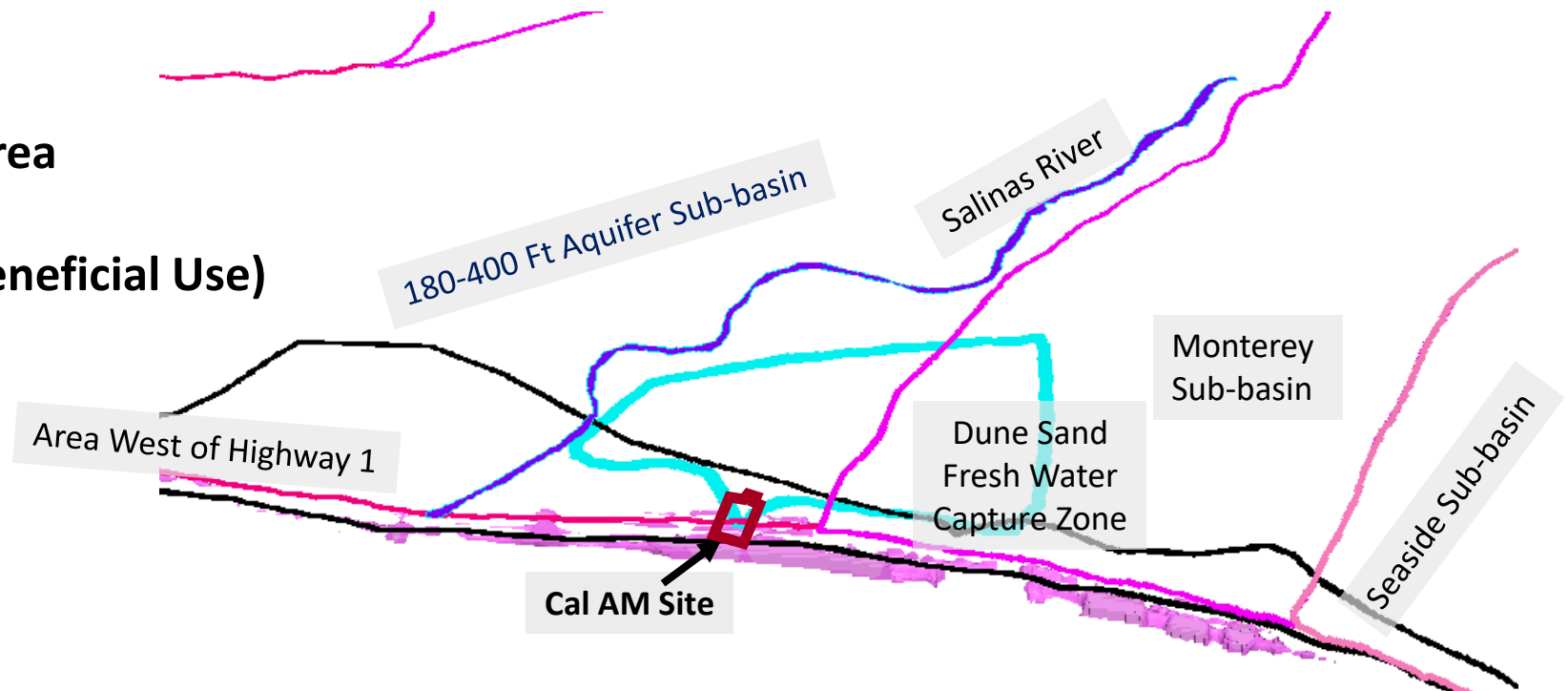
0.01 - 3 ohm-m (Limited Beneficial Use)



## 2019 Data - 2017 Survey Area

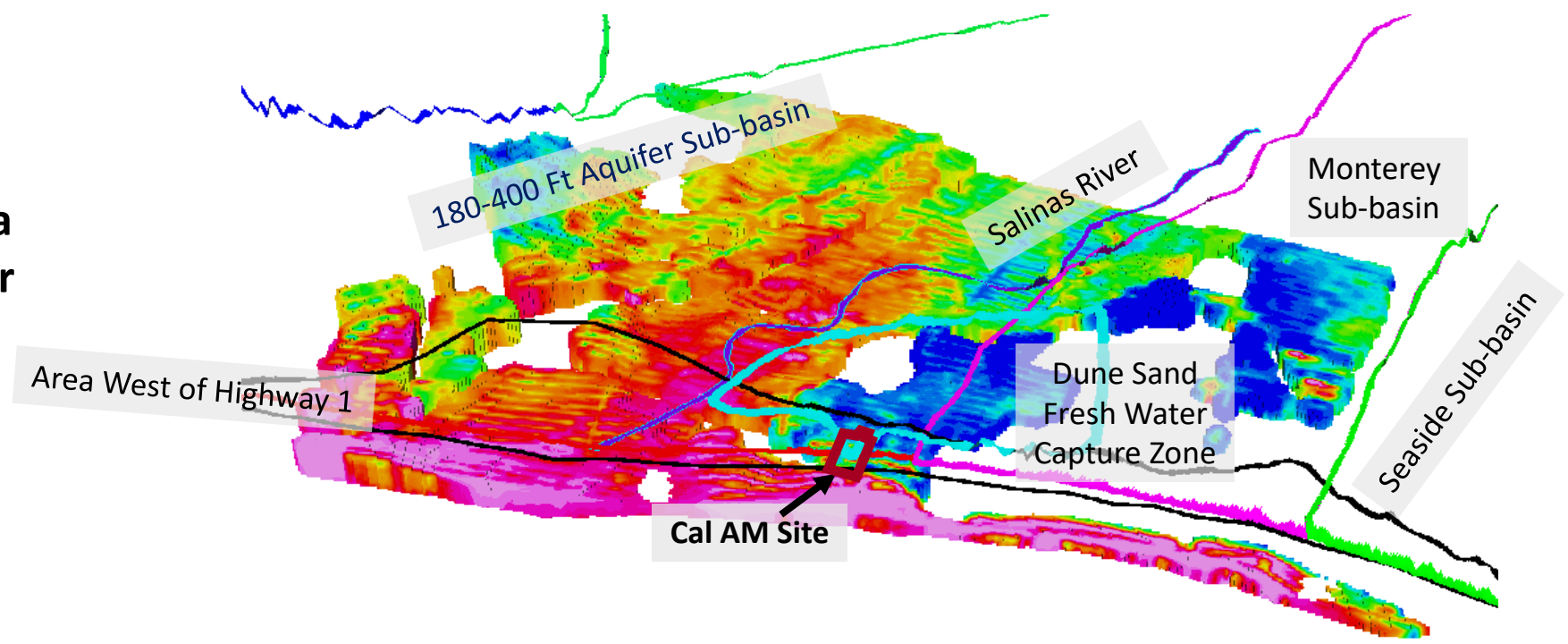
### Dune Sand Aquifer

0.01 - 3 ohm-m (Limited Beneficial Use)

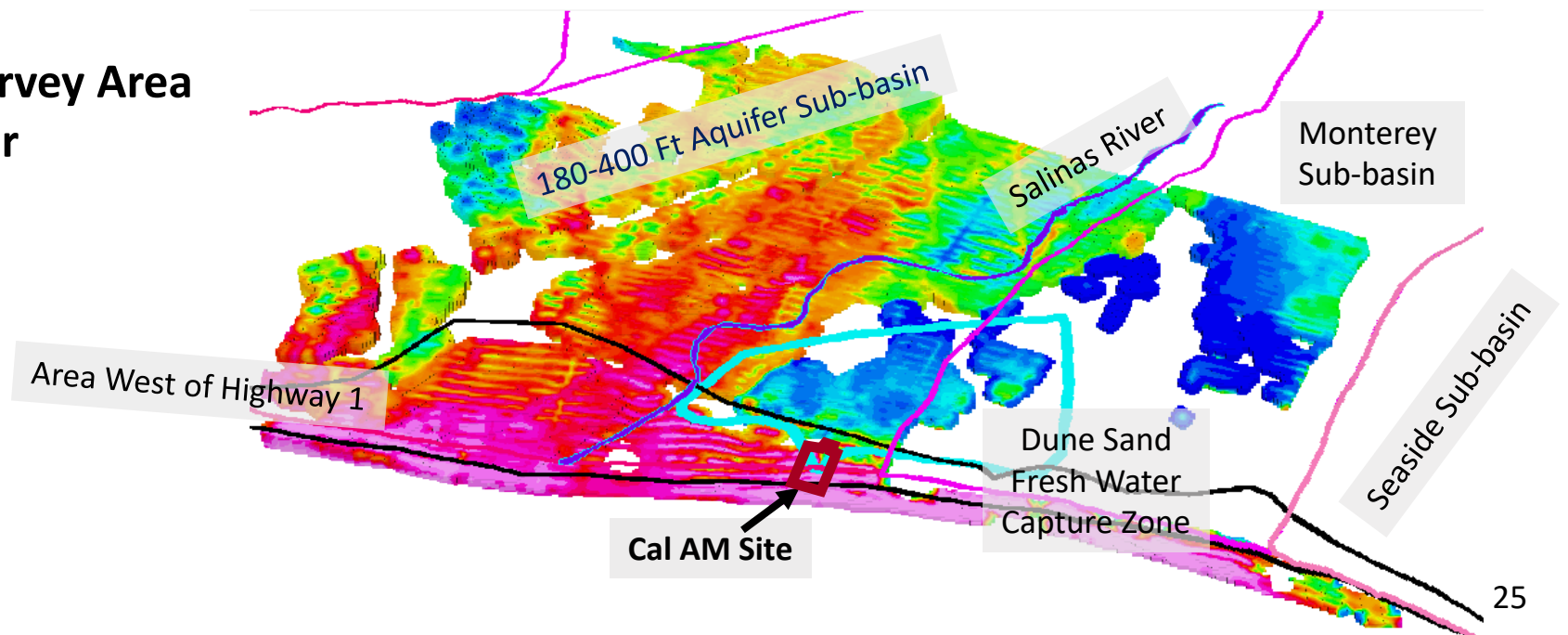
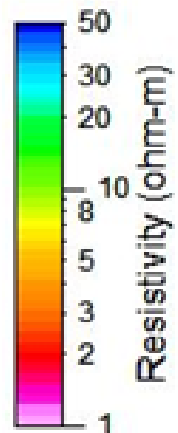




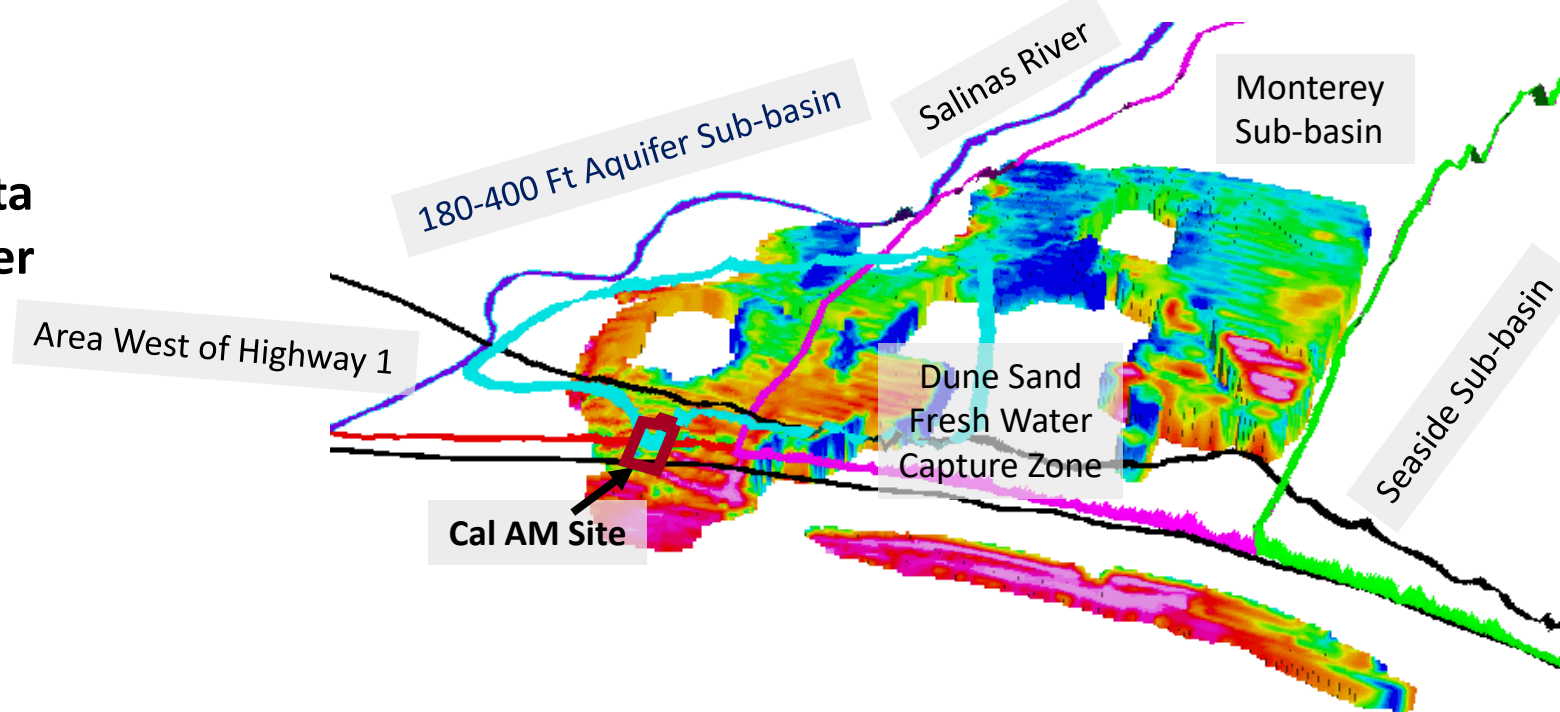
## 2017 Resistivity Data Upper 180 Ft Aquifer



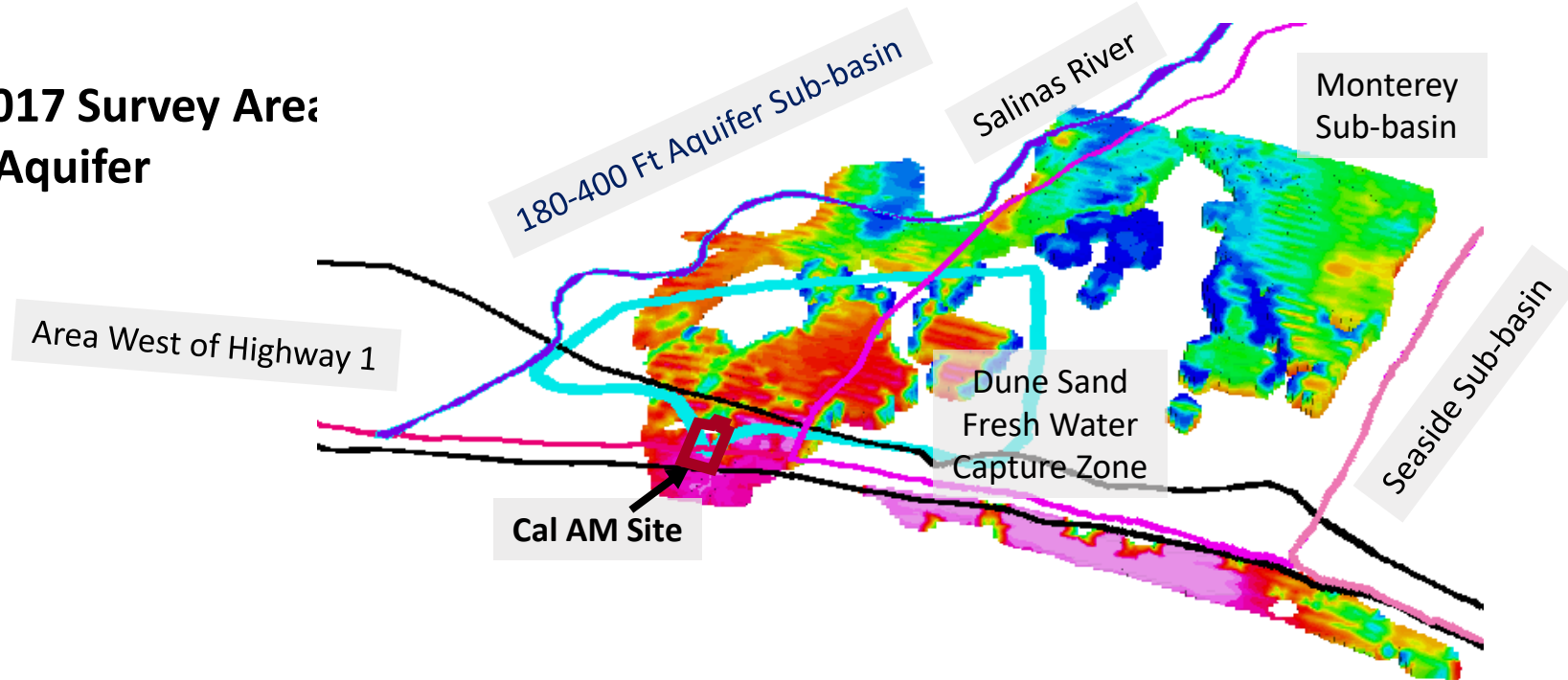
## 2019 Data - 2017 Survey Area Upper 180 Ft Aquifer



**2017 Resistivity Data  
Lower 180 Ft Aquifer**



**2019 Data - 2017 Survey Area  
Lower 180 Ft Aquifer**



# Estimated Volumes Based on 2017 Resistivity Data

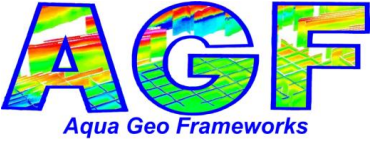
Stanford Rept Table 5, p.62, Revised 12/23/2019		2017 Total Volume "Limited Beneficial Use" (m <sup>3</sup> x10 <sup>8</sup> )	2017 Total Volume "Limited Beneficial Use" (acre-ft x10 <sup>3</sup> )	2017 Total Volume Potential source of drinking water (m <sup>3</sup> x10 <sup>8</sup> )	2017 Total Volume Potential source of drinking water (acre-ft x10 <sup>3</sup> )	2017 Net Volume potential source of drinking water, 20% porosity (m <sup>3</sup> x10 <sup>8</sup> )	2017 Net Volume potential source of drinking water, 20% porosity (acre-ft x10 <sup>3</sup> )
<b>By Aquifer</b>							
	Perched A/Shallow Aquifer	0.04	3	0.05	4	0.01	1
	Dune Sand Aquifer	1.48	120	13.11	1062	2.62	212
	Salinas Valley Aquitard	0.70	56	1.64	133	0.33	27
	Upper 180-Foot Aquifer	1.40	113	9.24	749	1.85	150
	Intermediate 180 Aquitard	0.14	11	0.59	48	0.12	10
	Lower 180-Foot Aquifer	1.51	123	2.08	169	0.42	34
	180-400 Ft Aquitard	0.31	25	0.30	24	0.06	5
	400-Foot Aquifer	1.19	96	0.45	36	0.09	7
	400-Foot Aquitard	0.19	15	0.00	0	0.00	0
	<b>Total</b>	<b>6.94</b>	<b>562</b>	<b>27.47</b>	<b>2226</b>	<b>5.49</b>	<b>445</b>
<b>2017 Vol.</b>							
<b>By Region</b>							
	Monterey Subbasin	4.55	369	12.83	1039	2.57	208
	180/400 Aquifer Subbasin	12.94	1048	18.12	1468	3.62	294
	West of HW 1	10.41	844	0.84	68	0.17	14
	<b>Total</b>	<b>27.91</b>	<b>2261</b>	<b>31.79</b>	<b>2575</b>	<b>6.36</b>	<b>515</b>

**445,000  
acre-feet  
Net Vol.**

# Estimated Volumes Based on 2019 Resistivity Data in 2017 Survey Bounds

Stanford Rept Table 5, p.62, Revised 12/23/2019		2019: 2017 Area - Total Volume "Limited Beneficial Use" ( $m^3 \times 10^8$ )	2019: 2017 Total Volume "Limited Beneficial Use" (acre-ft $\times 10^3$ )	2019: 2017 Total Volume Potential source of drinking water ( $m^3 \times 10^8$ )	2019: 2017 Total Volume Potential source of drinking water (acre-ft $\times 10^3$ )	2019: 2017 Net Volume potential source of drinking water, 20% porosity ( $m^3 \times 10^8$ )	2019: 2017 Net Volume potential source of drinking water, 20% porosity (acre-ft $\times 10^3$ )
<b>By Aquifer</b>							
	Perched A/Shallow Aquifer	0.02	1	0.04	3	0.01	1
	Dune Sand Aquifer	1.16	94	13.57	1100	2.71	220
	Salinas Valley Aquitard	0.45	37	1.44	117	0.29	23
	Upper 180-Foot Aquifer	1.68	136	8.07	654	1.61	131
	Intermediate 180 Aquitard	0.14	12	0.82	66	0.16	13
	Lower 180-Foot Aquifer	1.28	104	2.38	193	0.48	39
	180-400 Ft Aquitard	0.36	30	0.24	19	0.05	4
	400-Foot Aquifer	0.42	34	0.44	36	0.09	7
	400-Foot Aquitard	0.00	0	0.04	3	0.01	1
	<b>Total</b>	<b>5.52</b>	<b>447</b>	<b>27.05</b>	<b>2191</b>	<b>5.41</b>	<b>438</b>
<b>2017 Vol.</b>		<b>2019 Data, 2017 Bounds</b>					
<b>By Region</b>	Monterey Subbasin	2.90	235	11.41	924	2.28	185
	180/400 Aquifer Subbasin	12.06	977	13.39	1084	2.68	217
	West of HW 1	9.92	803	0.64	52	0.13	10
	<b>Total</b>	<b>24.88</b>	<b>2015</b>	<b>25.43</b>	<b>2060</b>	<b>5.09</b>	<b>412</b>

**438,000  
acre-feet  
Net Vol.**



# Estimated Volumes Based on 2019 Resistivity Data

		2019 Area - Total Volume "Limited Beneficial Use" (m <sup>3</sup> x10 <sup>8</sup> )	2019 Total Volume "Limited Beneficial Use" (acre-ft x10 <sup>3</sup> )	2019 Total Volume Potential source of drinking water (m <sup>3</sup> x10 <sup>8</sup> )	2019 Total Volume Potential source of drinking water (acre-ft x10 <sup>3</sup> )	2019 Net Volume potential source of drinking water, 20% porosity (m <sup>3</sup> x10 <sup>8</sup> )	2019 Net Volume potential source of drinking water, 20% porosity (acre-ft x10 <sup>3</sup> )
<b>By Aquifer</b>							
	Perched A/Shallow Aquifer	0.02	1	0.04	3	0.01	1
	Dune Sand Aquifer	1.19	97	20.19	1636	4.04	327
	Salinas Valley Aquitard	0.45	37	2.09	170	0.42	34
	Upper 180-Foot Aquifer	1.69	137	9.39	761	1.88	152
	Intermediate 180 Aquitard	0.15	12	0.96	78	0.19	16
	Lower 180-Foot Aquifer	1.29	104	2.52	204	0.50	41
	180-400 Ft Aquitard	0.37	30	0.59	47	0.12	9
	400-Foot Aquifer	0.44	36	1.06	86	0.21	17
	400-Foot Aquitard	0.11	9	0.06	5	0.01	1
	<b>Total</b>	<b>5.71</b>	<b>463</b>	<b>36.89</b>	<b>2989</b>	<b>7.38</b>	<b>598</b>
<b>2019 Vol. By Region</b>							
	Monterey Subb	3.18	258	24.08	1951	4.82	390
	180-400 Ft Aq Subb	12.10	980	16.28	1319	3.26	264
	Hwy 1	9.93	804	0.64	52	0.13	10
	Seaside	6.88	557	20.67	1675	4.13	335
	Langley	0	0	0.26	21	0.05	4
	East Side	0	0	0.10	8	0.02	2
	<b>Total</b>	<b>32.09</b>	<b>2599</b>	<b>62.02</b>	<b>5024</b>	<b>12.40</b>	<b>1005</b>

**598,000  
acre-feet  
Net Vol.**

### 2017 TDS Thickness Dune Sand Aquifer < 500 mg/L

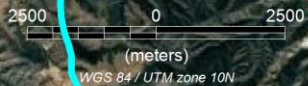
### 2019 TDS Thickness Dune Sand Aquifer < 500 mg/L

Cal AM Site

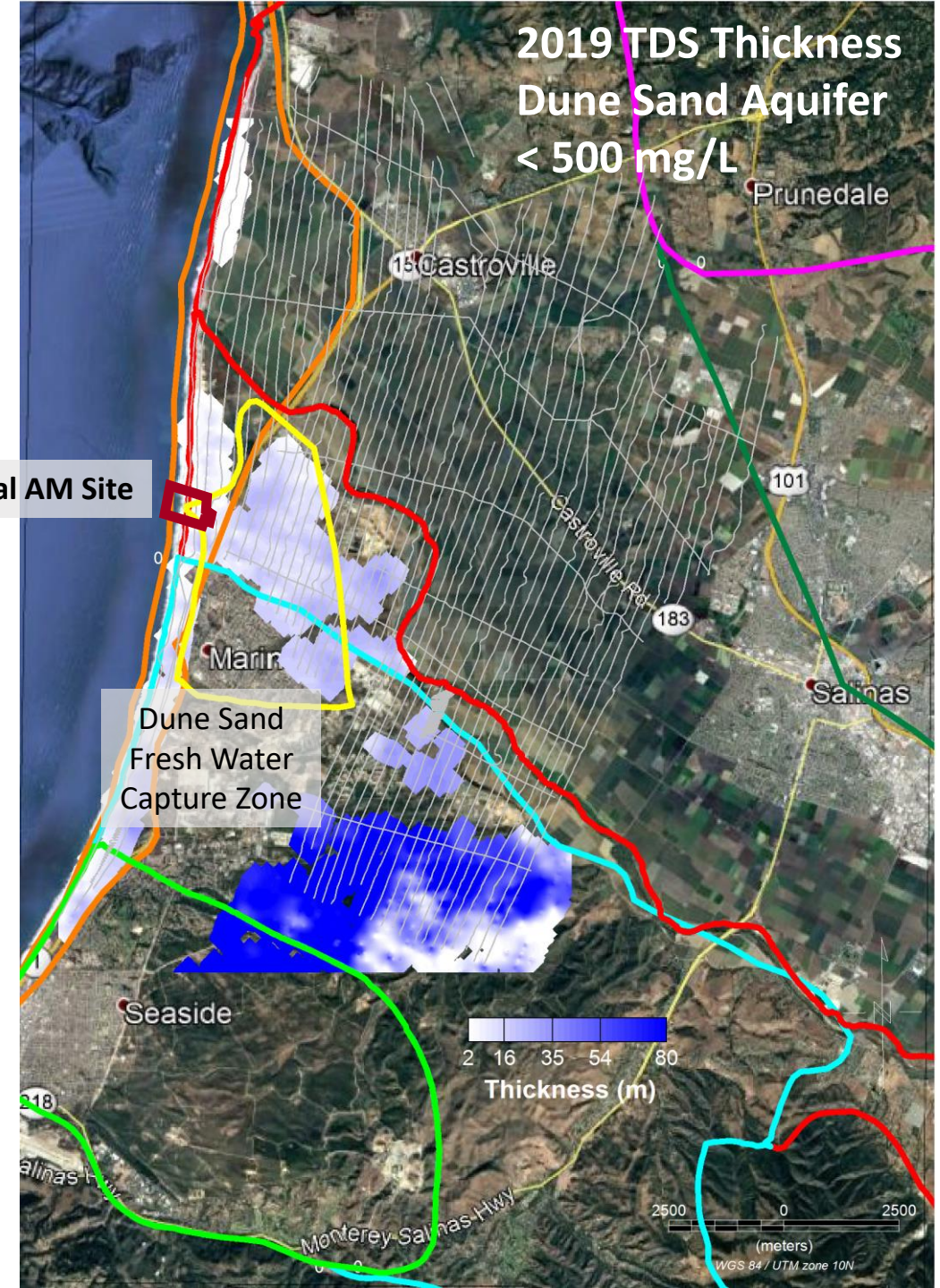
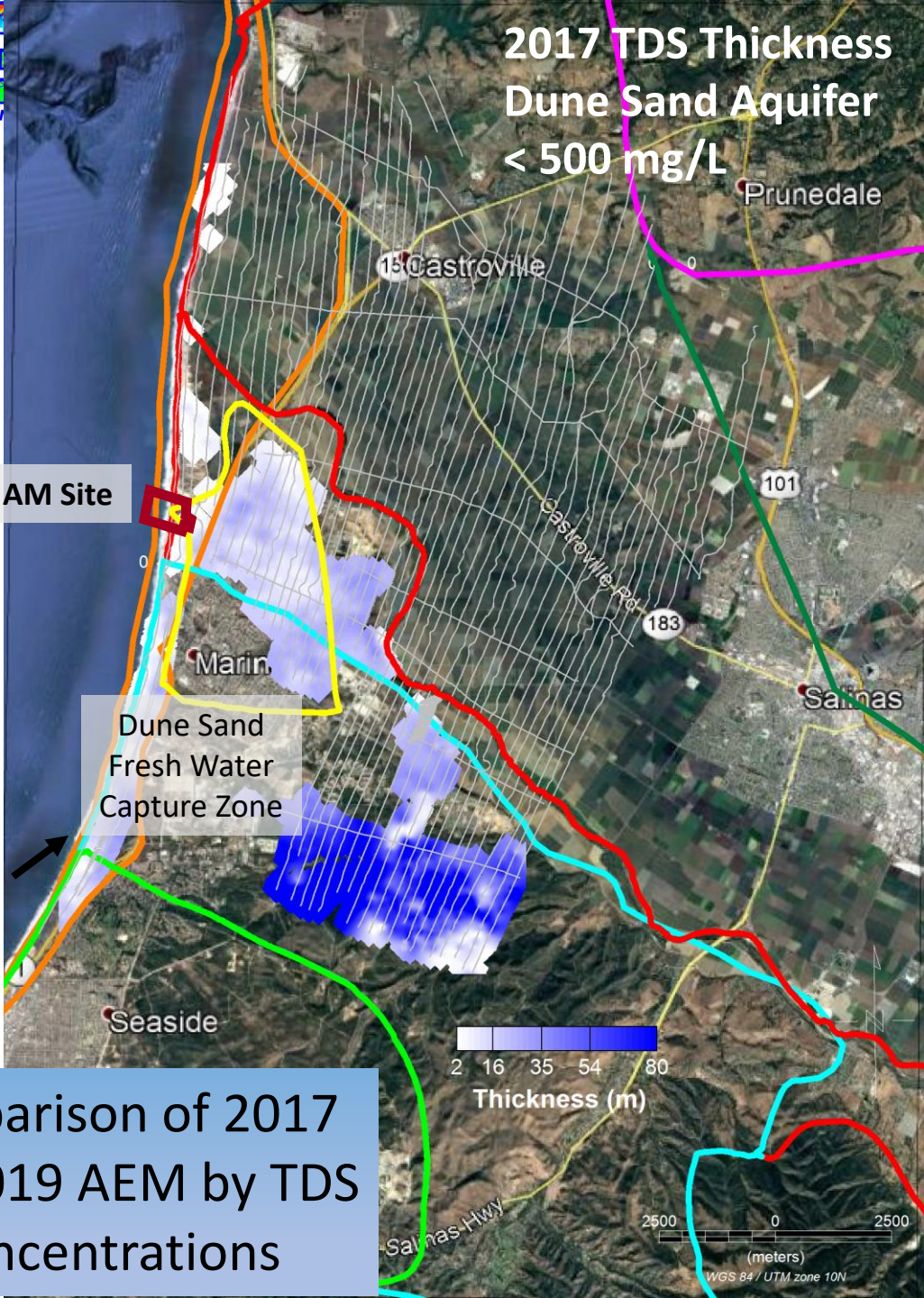
Cal AM Site

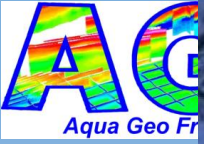
Dune Sand  
Fresh Water  
Capture Zone

Dune Sand  
Fresh Water  
Capture Zone



Comparison of 2017  
and 2019 AEM by TDS  
Concentrations





# 2017 TDS Thickness Dune Sand Aquifer 500-1,000 mg/L

# 2019 TDS Thickness Dune Sand Aquifer 500-1,000 mg/L

Cal AM Site

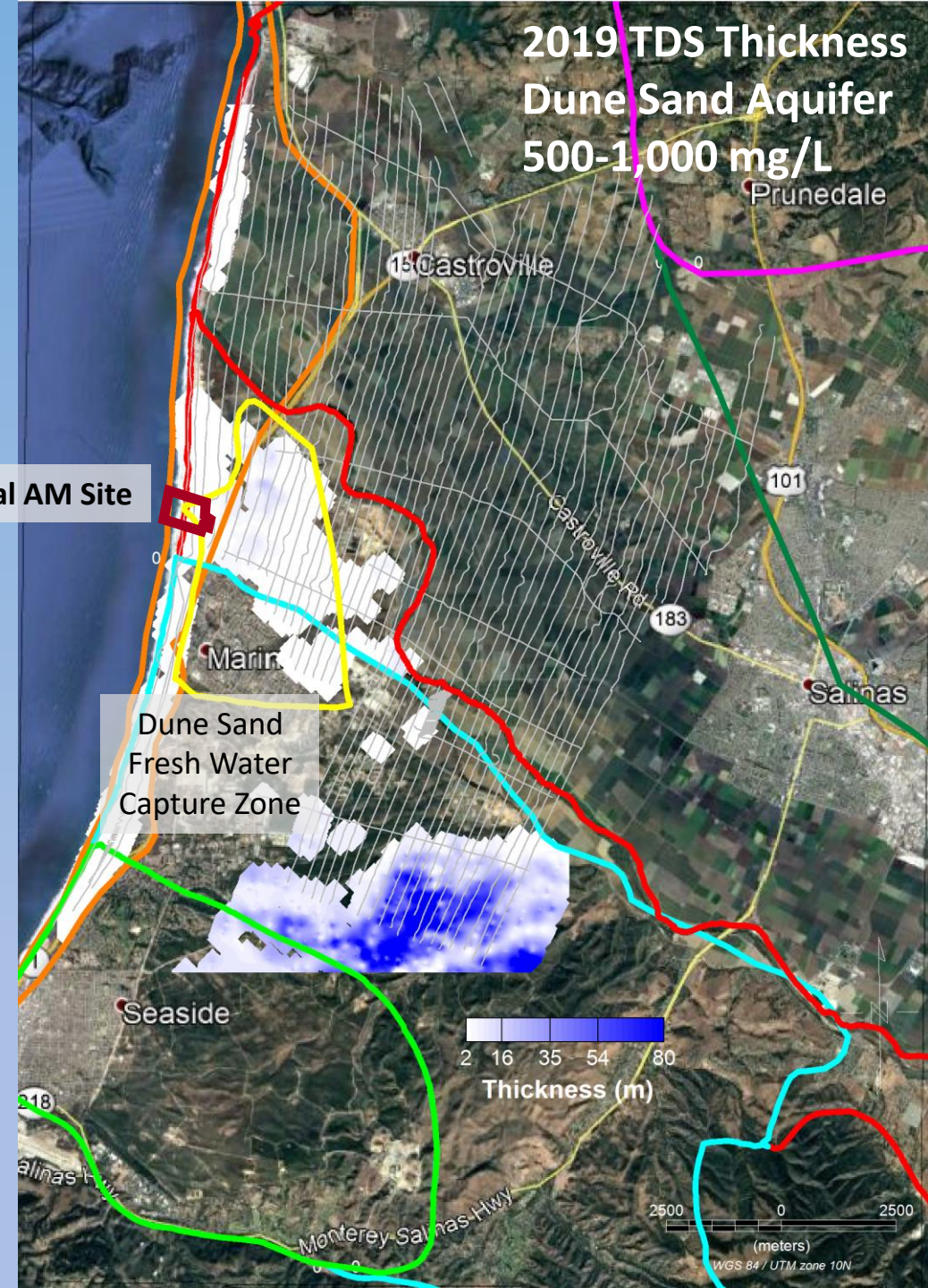
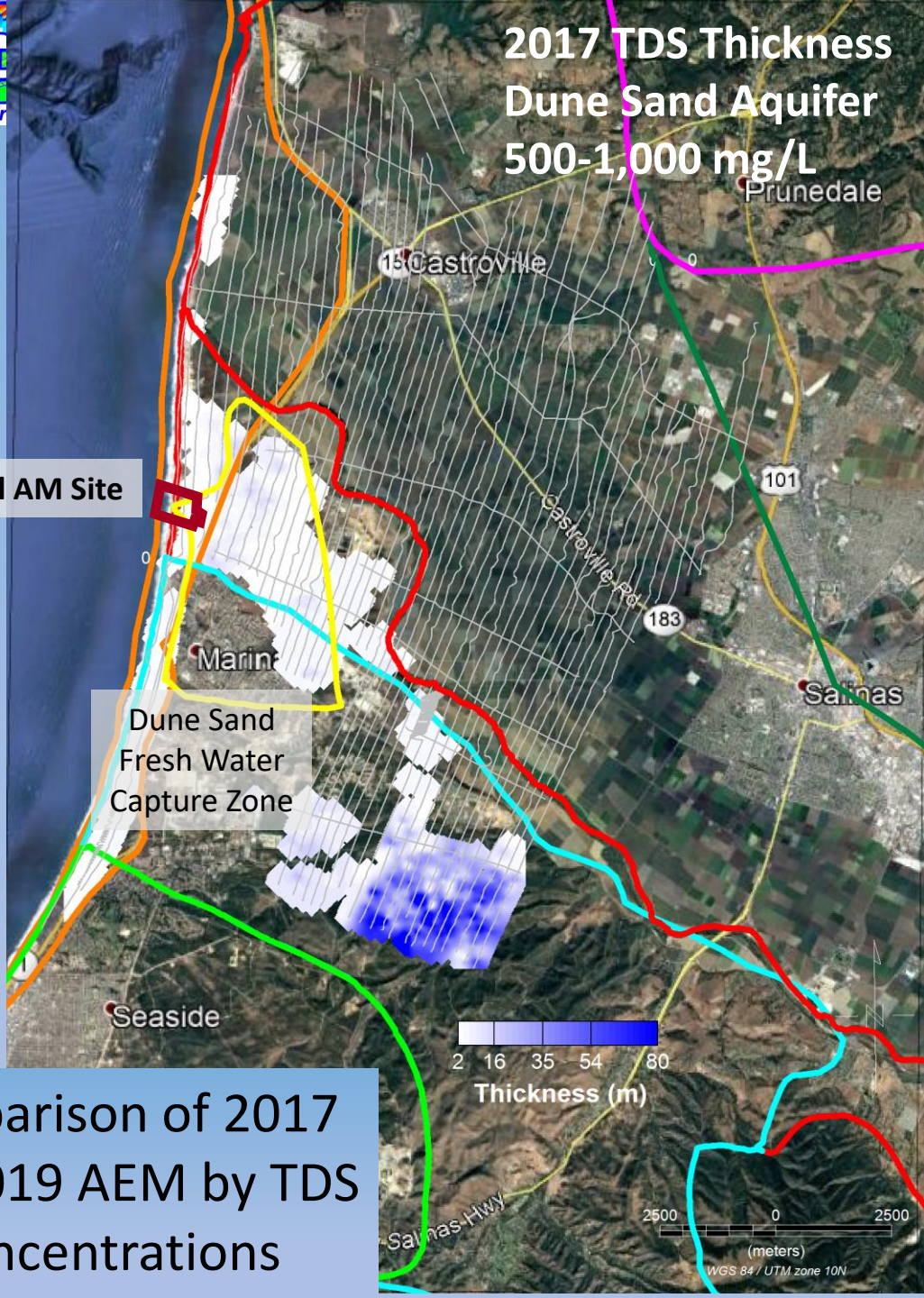
Cal AM Site

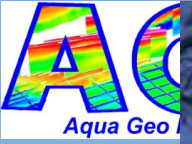
Dune Sand  
Fresh Water  
Capture Zone

Dune Sand  
Fresh Water  
Capture Zone

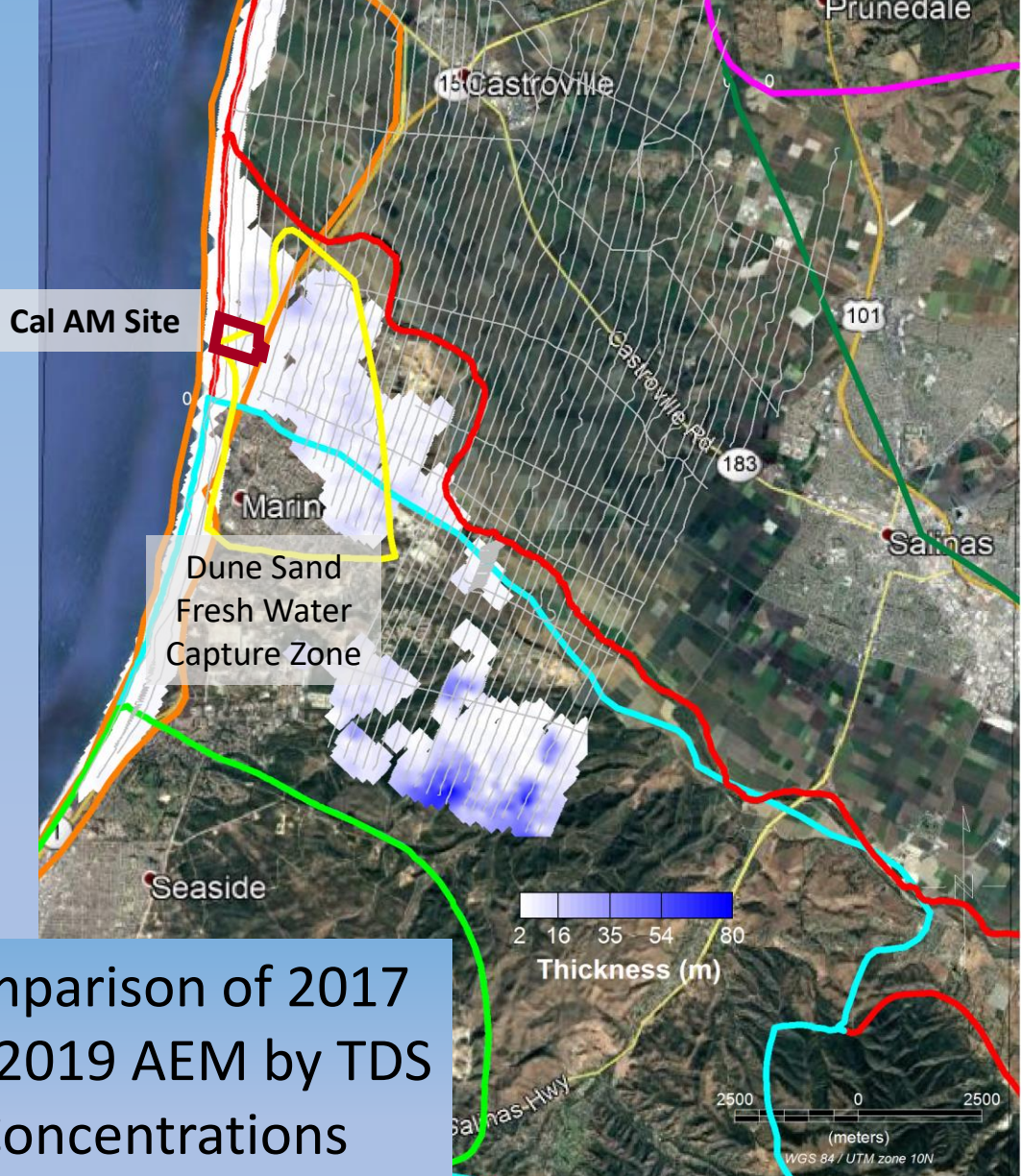


## Comparison of 2017 and 2019 AEM by TDS Concentrations

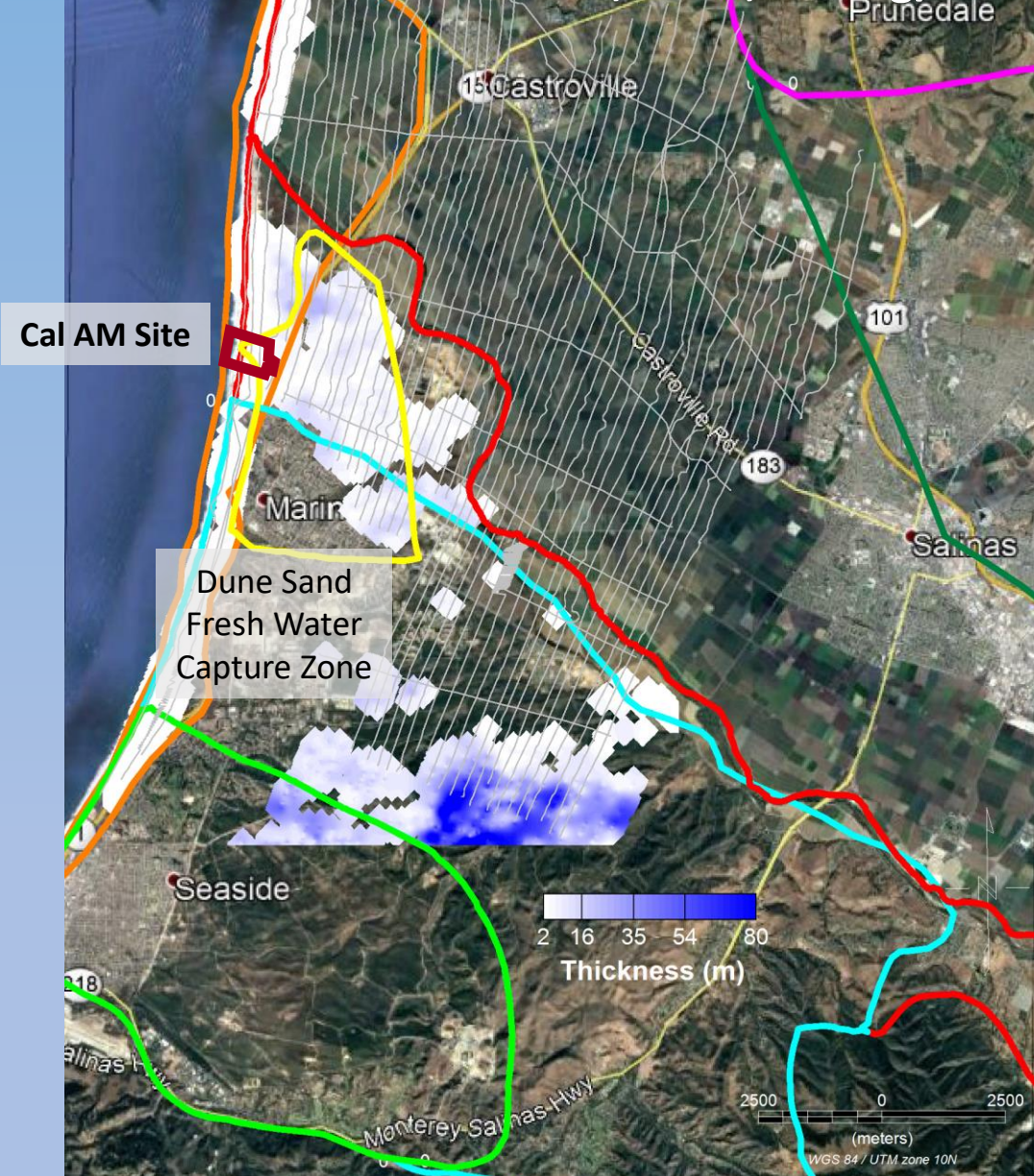




### 2017 TDS Thickness Dune Sand Aquifer 1,000-3,000 mg/L

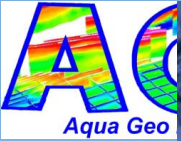


### 2019 TDS Thickness Dune Sand Aquifer 1,000-3,000 mg/L



Comparison of 2017  
and 2019 AEM by TDS  
Concentrations

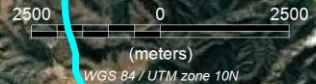




### 2017 TDS Thickness Dune Sand Aquifer 3,000-10,000 mg/L

Cal AM Site

Dune Sand  
Fresh Water  
Capture Zone



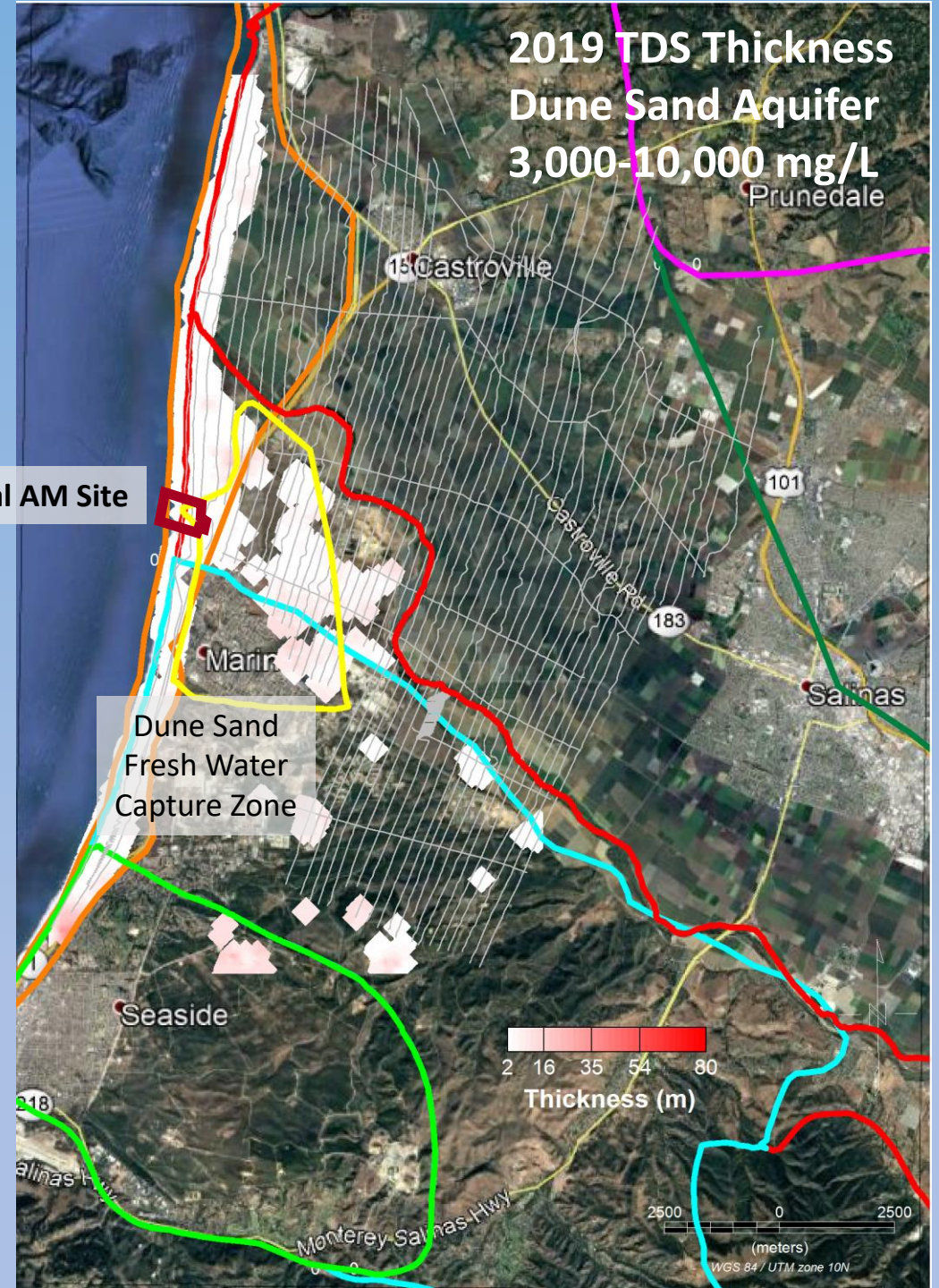
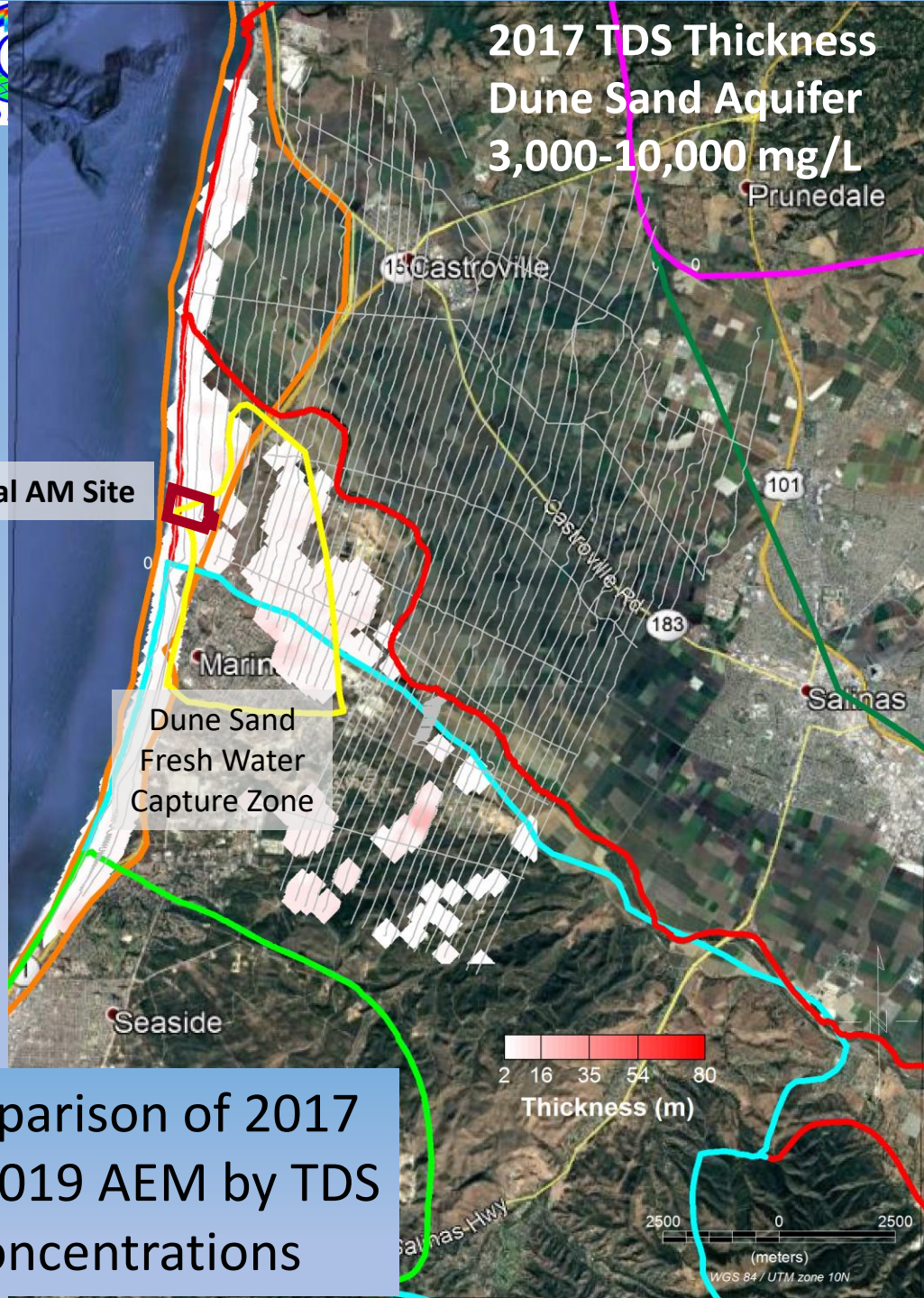
### 2019 TDS Thickness Dune Sand Aquifer 3,000-10,000 mg/L

Cal AM Site

Dune Sand  
Fresh Water  
Capture Zone



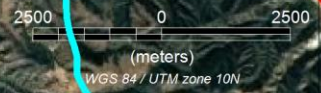
Comparison of 2017  
and 2019 AEM by TDS  
Concentrations



### 2017 TDS Thickness Upper 180 Ft Aquifer 500-1,000 mg/L

Cal AM Site

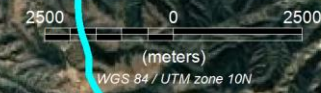
Dune Sand  
Fresh Water  
Capture Zone



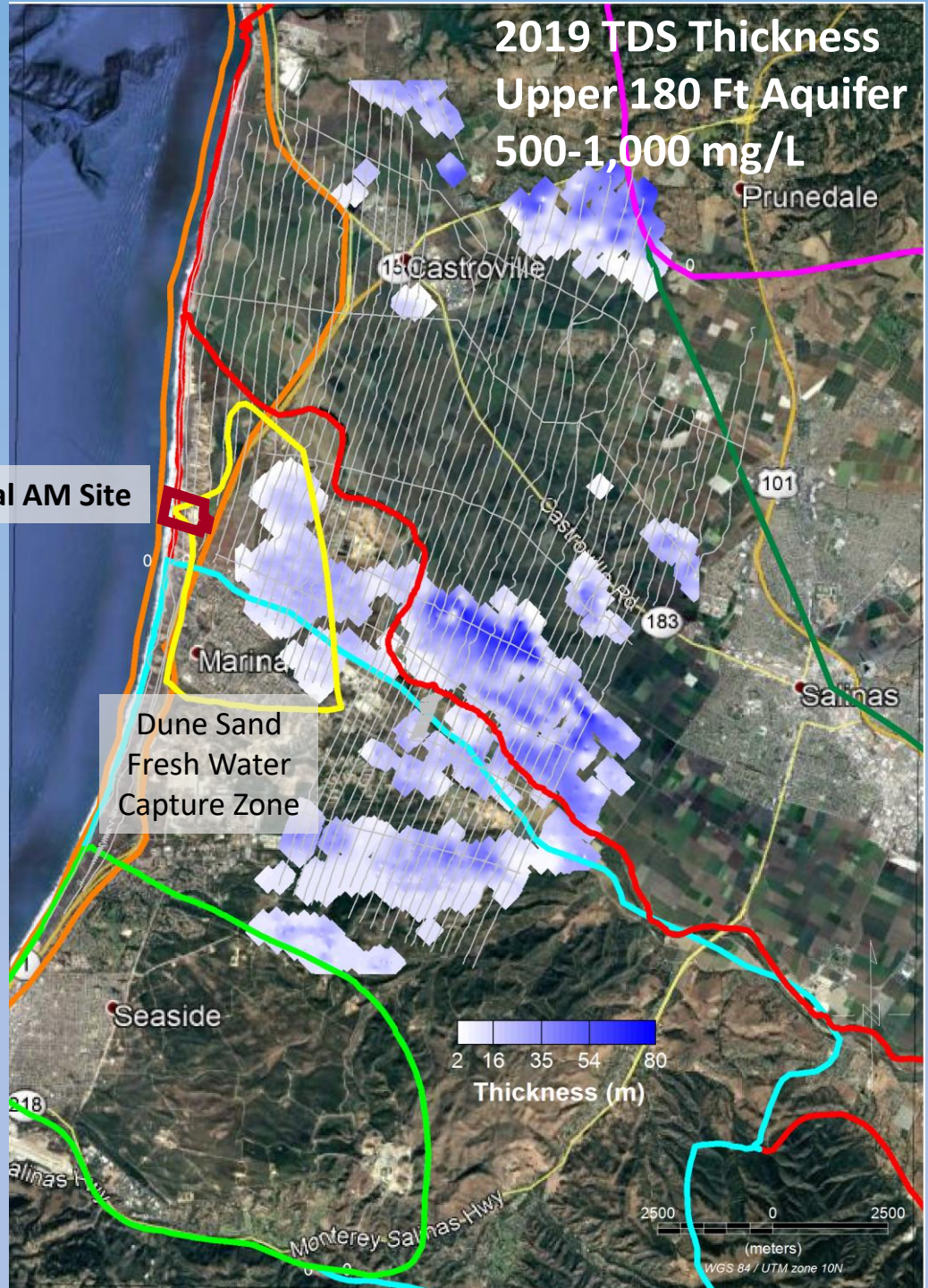
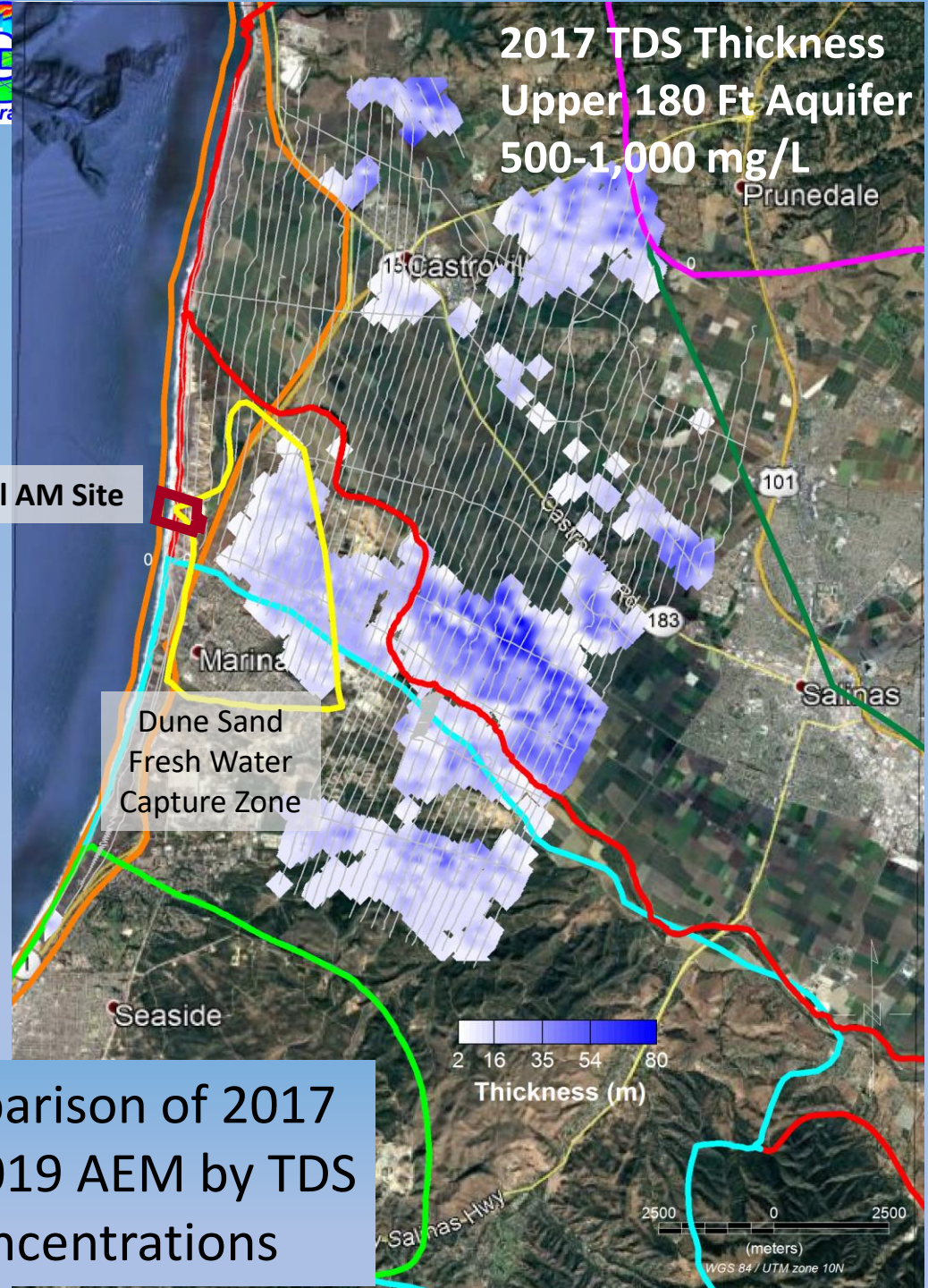
### 2019 TDS Thickness Upper 180 Ft Aquifer 500-1,000 mg/L

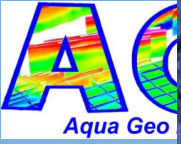
Cal AM Site

Dune Sand  
Fresh Water  
Capture Zone



Comparison of 2017  
and 2019 AEM by TDS  
Concentrations





2017 TDS Thickness  
Upper 180 Ft Aquifer  
>10,000 mg/L

2019 TDS Thickness  
Upper 180 Ft Aquifer  
>10,000 mg/L

Cal AM Site

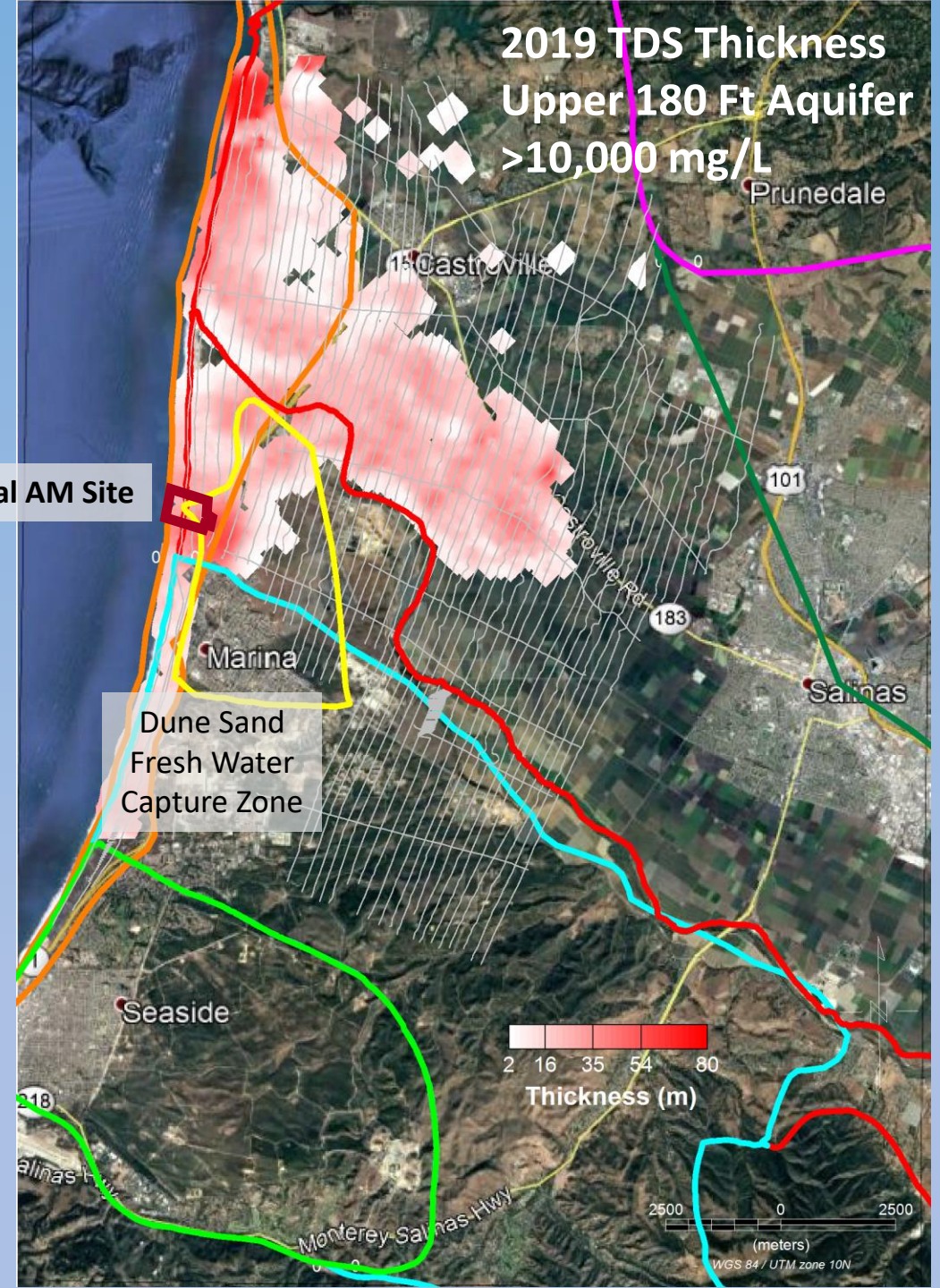
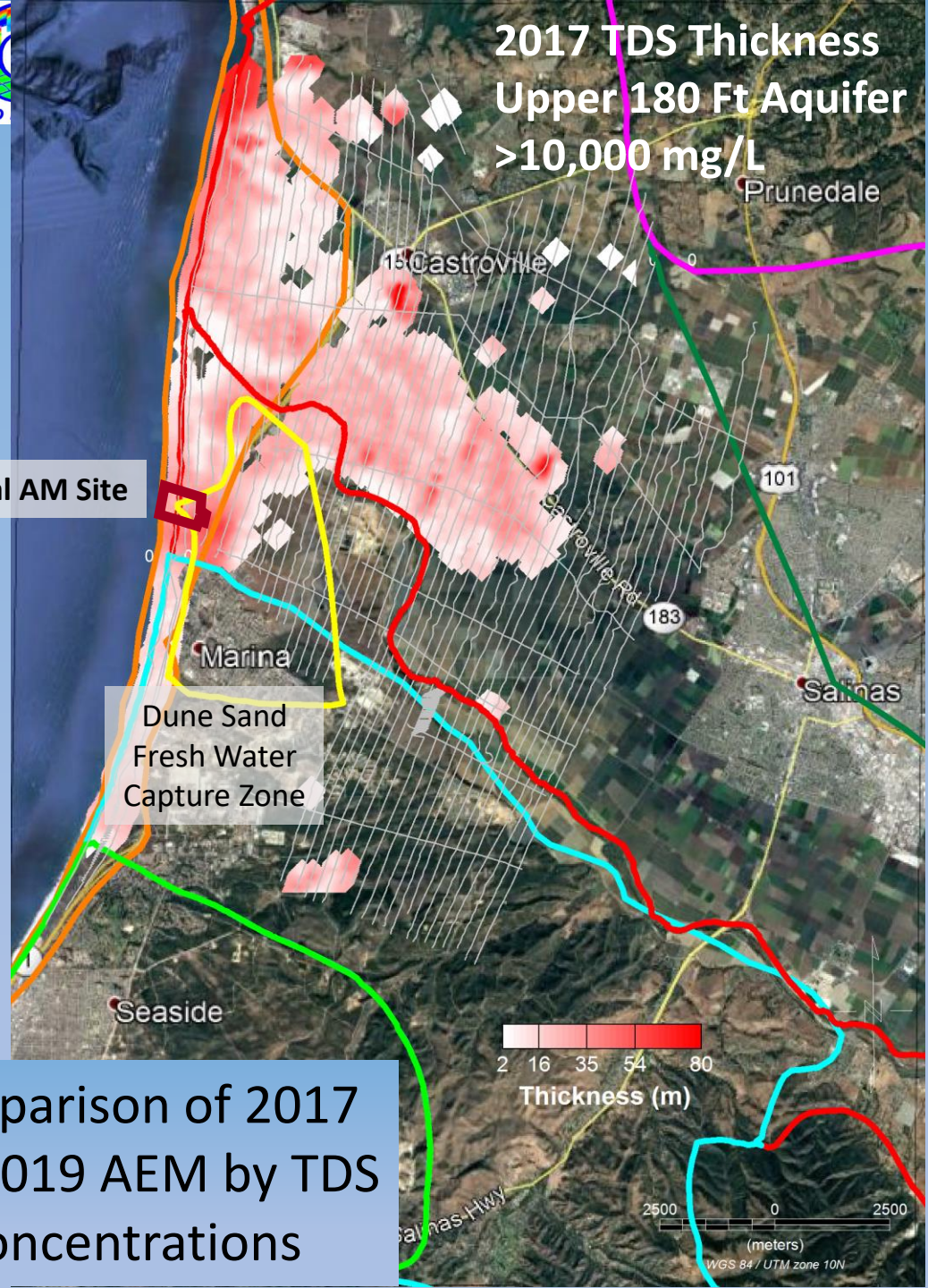
Cal AM Site

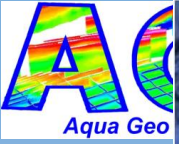
Dune Sand  
Fresh Water  
Capture Zone

Dune Sand  
Fresh Water  
Capture Zone



Comparison of 2017  
and 2019 AEM by TDS  
Concentrations





2017 TDS Thickness  
Lower 180 Ft Aquifer  
>10,000 mg/L

2019 TDS Thickness  
Lower 180 Ft Aquifer  
>10,000 mg/L

Cal AM Site

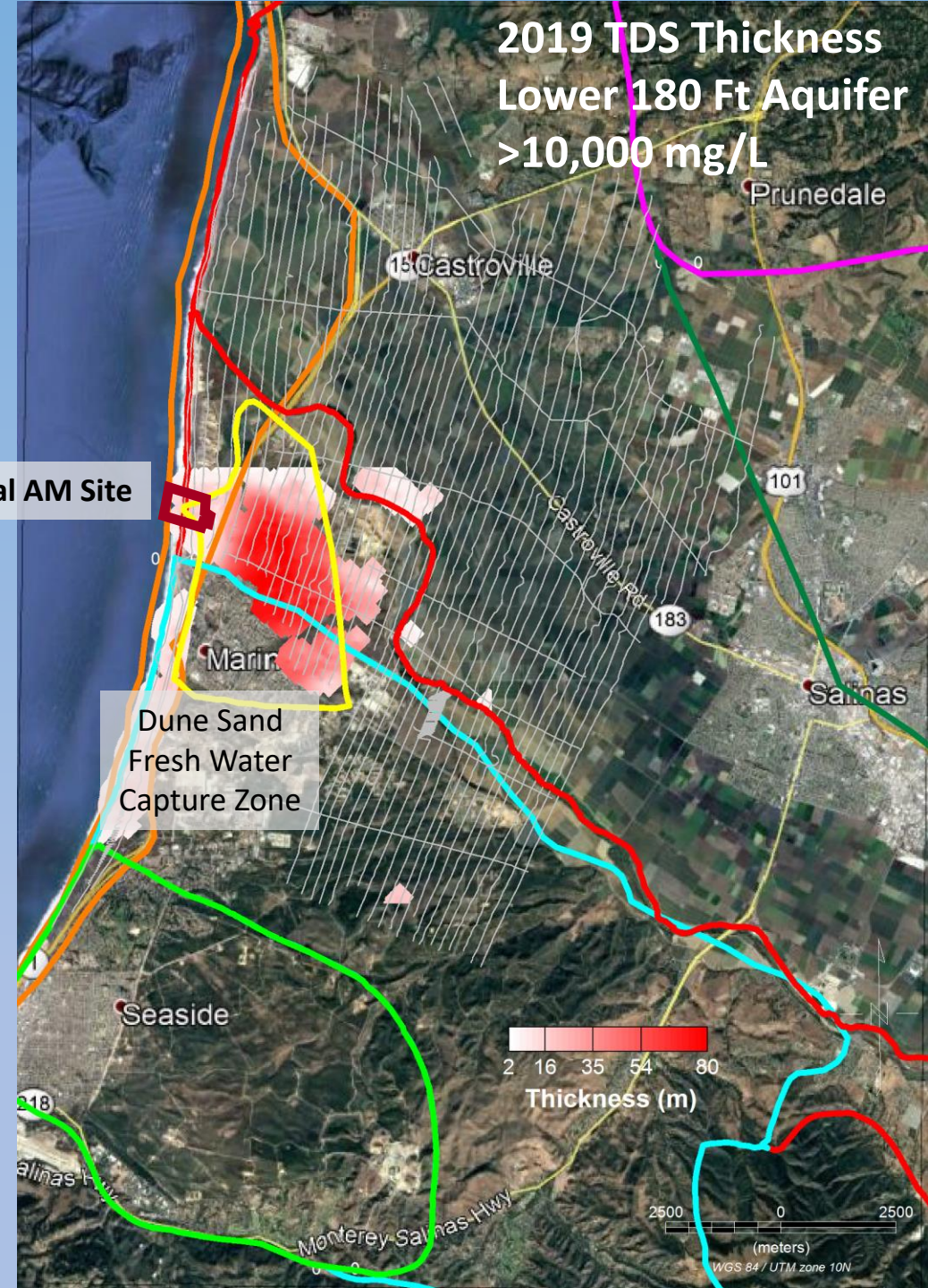
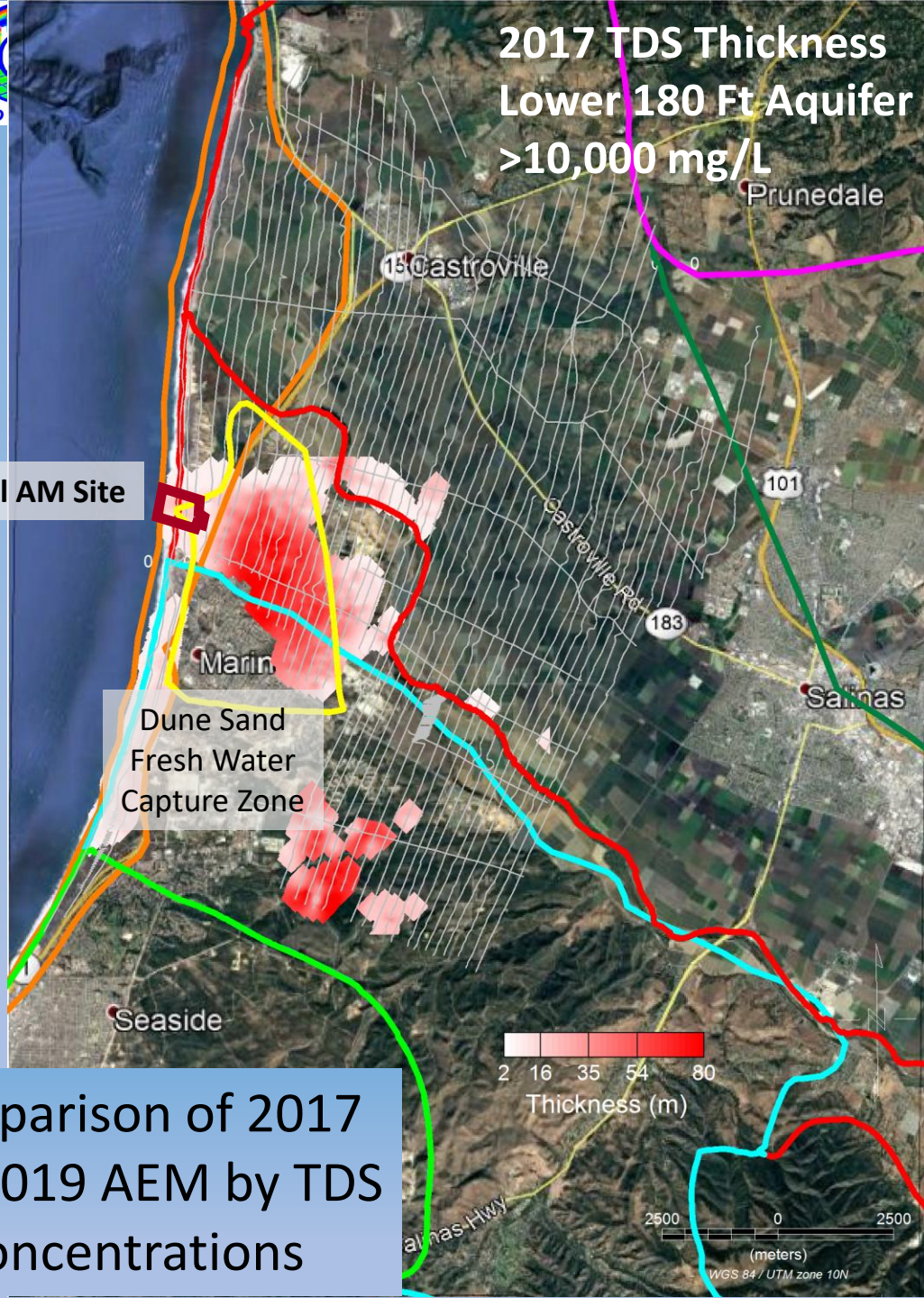
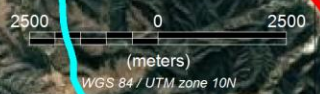
Cal AM Site

Dune Sand  
Fresh Water  
Capture Zone

Dune Sand  
Fresh Water  
Capture Zone



Comparison of 2017  
and 2019 AEM by TDS  
Concentrations



Questions?  
Comments?



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