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Technical Memorandum

Date: October 7, 2014

From: Spencer Harris, HG 633

To: Los Osos ISJ Group

SUBJECT: **2014 Seawater Intrusion Monitoring, Los Osos Valley Groundwater Basin.**

Water quality monitoring in the Los Osos Valley groundwater basin was conducted between July 23 and August 4, 2014. The purpose of monitoring is to update estimates of the rate and extent of seawater intrusion in the lower aquifer (Zones D and E). The analytical results of groundwater samples collected from basin wells are presented in the attached Table 1, including the results of prior groundwater monitoring events from 2004-05 and 2009-10.

Rate and Extent of Seawater Intrusion

The historical advance of seawater intrusion and associated intrusion rates are presented in Figure 1 (Zone D plan view) and Figure 2 (Zones D and E in cross-section with intrusion rates). The figures incorporate new information from depth-specific sampling and spinner testing at Palisades well 18L2 (reported in June 2013). The 2013 distribution of flow and salt loading contributions in the lower aquifer at the well 18L2 has been used to back-calculate historical water quality in Zones D and E (Figure 2). The estimated rates of intrusion are presented for the leading edge (toe) of the front in both Zone D and Zone E, and for intrusion moving along the preferential pathway toward well 18L2 in Zone E. The prior interpretation of 2009-10 monitoring data has been revised by removing the Zone D preferential pathway toward Palisades, based on the new information.

The estimated rate of seawater intrusion in Zone D has increased from an average of 60 feet per year between 1985 and 2005, to approximately 200-250 feet per year since 2005. Zone E intrusion has increased from an estimated 54 feet per year between 1977 and 2005, to approximately 100-125 feet per year since 2005. A separate, accelerated intrusion rate in Zone E along a preferential pathway toward Palisades well 18L2 is estimated to have averaged 170 feet per year between 1977 and 2004, when the intrusion front (250 mg/l isochlor) reached Palisades Avenue. The 250 mg/l isochlor is interpreted to have advanced west of Broderson Avenue in Zone D, and is approaching 10th Street in Zone E (Figure 2).

Chloride Metric

The chloride metric graph presented in the August 2013 Basin Plan public draft has been updated with the current monitoring results. The chloride metric has reached 175 mg/l as shown in the attached Figure 3.

Geophysics

Induction and natural gamma logs were performed at deep monitoring wells 13M1 (Sea Pines golf course) and 18L6 (north end of Palisades Avenue). The log at 13M1 indicates the top of seawater in Zone D has declined approximately 20 feet from a high in 2009 (Figure 4). A drop in the seawater elevation in Zone D is consistent with a general reduction in west side lower aquifer pumping since 2009. The chloride concentration in Sea Pines irrigation well 13M2, which includes the bottom of Zone C and top of Zone D, also declined slightly between 2009 and 2014.

Geophysics at deep monitoring well 18L6 shows no indication of intrusion, despite documented intrusion in Zone E at the nearby well 18L2, approximately 500 feet to the south. This is interpreted as an indication that Zone E intrusion toward well 18L2 was through a relatively narrow preferential pathway.

Comparing Monitoring Events

Rates of seawater intrusion are affected primarily by water levels (pressure gradients) and aquifer permeability. The rate of intrusion is typically not uniform over time, but varies seasonally according to pumping cycles, and is accelerated during drought periods. Intrusion may also not be uniform within the aquifer zones, but may follow preferential pathways along discrete sand and gravel layers being tapped by pumping wells.

The recommended method for indexing seawater intrusion monitoring events for comparison purposes is to perform monitoring in the fall (October) and to match events using cumulative departure from mean precipitation. Monitoring in October will minimize seasonal variations and is also when fall water level readings are collected. The 2014 monitoring event was performed in summer, out of sequence with the normal spring/fall readings. When two monitoring events are in similar positions on the cumulative departure from mean precipitation curve, they are more directly comparable for assessing long-term trends in seawater intrusion. Figure 5 shows the cumulative departure from mean precipitation curve for the Morro Bay Fire Department. The rainfall years corresponding to the three seawater intrusion monitoring events, 2004, 2009, and 2014, are successively drier years when compared to each other.

Three of the last four years have been drought years. The drought influence on lower aquifer seawater intrusion would be directly related to declining fresh water pressures due to less upper aquifer leakage and less creek valley recharge. The other main factor affecting water levels and seawater intrusion is lower aquifer well production, which has declined since the last monitoring event in 2009-10. Based on the cumulative departure from mean precipitation curve, potential reductions in seawater intrusion due to reduced groundwater production appear to have been offset by declining fresh water recharge to the lower aquifer since 2009.

The chloride metric (Figure 3) and water level metric are additional tools for evaluating trends in seawater intrusion. Data for updating the water level metric will be available in October.

Table 1
Water Quality Results - Sea Water Intrusion Monitoring
Los Osos ISJ Group

Station ID	Well Name	Aquifer Zone	Date	HCO3	Total Hardness	Cond	pH	TDS	Cl	NO3	SO4	Ca	Mg	K	Na
				mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
30S/10E-12J1	MBO5 DWR Obs.	E	2/14/2005	350	370	1300	8.1	840	77	ND	190	51	58	6.1	110
			11/20/2009	300	360	1150	7.5	732	83	ND	190	51	58	4.4	95
			7/24/2014	360	489	1290	7.7	780	**105**	ND	212	69	77	5	88
30S/10E-13J4*	GSWC Rosina	D	12/20/2004	72	230	720	7.1	410	150	7	14	38	33	1.4	29
			1/14/2010	35	260	778	6	435	200	7.1	13	41	38	1.5	33
			7/24/2014	80	418	1200	7.3	910	**303**	7.6	16	67	61	2	39
30S/10E-13L4	GSWC Pecho	D	12/20/2004	82	340	1000	7	590	230	9.7	27	56	47	1.9	48
			11/20/2009	85	550	1610	7	979	460	10	48	91	78	2.1	69
			not sampled during 2014 monitoring event - well not operational												
30S/10E-13L7**	S&T #4	C,D	1/10/2005	64	110	410	7.2	270	44	55	14	19	15	1.5	36
			11/19/2009	60	110	410	6.9	270	49	59	14	18	15	1.4	38
			not sampled during 2014 monitoring event - upper aquifer influence												
30S/10E-13M2	Howard East	C,D	11/22/2004	51	810	2900	7.3	1500	810	2.4	140	130	120	4.7	210
			12/9/2009	55	1100	3740	7.1	2170	1100	2.2	220	160	160	4.8	370
			8/4/2014	60	757	3340	7.1	2450	**990**	2.5	178	117	113	5	382
30S/10E-13N	S&T #5	D	11/23/2004	42	80	390	6.9	200	67	26	9.2	13	12	1.7	38
			11/19/2009	41	89	386	6.8	267	73	27	11	15	13	1.4	38
			7/24/2014	50	100	438	7.4	270	**76**	31	10	17	14	2	38
30S/10E-24C1	GSWC Cabrillo	D	12/20/2004	64	130	610	7	310	110	20	19	22	19	1.6	50
			11/20/2009	60	150	611	7.1	347	130	18	22	23	22	1.6	52
			7/24/2014	40	69	339	7.6	240	**46**	37	6	11	10	1	32
30S/11E-7Q3	LOCSD 8th St.	D	11/18/2004	250	270	790	7.5	410	73	ND	39	44	40	2.3	48
			11/19/2009	220	290	782	7.4	465	92	ND	46	46	42	1.9	53
			7/23/2014	290	303	876	7.6	460	**91**	ND	43	49	44	2	54
30S/11E-17E7***	So. Bay Obs. Deep	E	1/14/2005	150	180	690	8.8	440	75	ND	41	33	25	13	78
			11/19/2009	ND	100	1100	11.2	427	110	6.1	54	39	1	8.7	110
			7/23/2014	ND	62	1200	10.8	520	**179**	ND	81	25	ND	9	176
30S/11E-17E8	So. Bay Obs. Middle	D	1/14/2005	150	150	440	7.5	290	34	9.7	11	24	22	1.4	28
			11/20/2009	120	160	455	7.3	255	42	19	12	25	23	1.3	29
			7/23/2014	150	166	500	7.6	270	**43**	28	10	27	24	2	28
30S/11E-17N10	GSWC So. Bay #1	C,D,E	Jan 2003	250	--	510	7.1	290	37	ND	21	41	25	1.3	35
			11/20/2009	230	220	638	7.3	357	41	2.4	30	35	33	1.7	37
			7/24/2014	280	232	646	7.7	370	**37**	2.3	24	37	34	2	41
30S/11E-18K8	10th St. Obs. East (Deep)	E	1/19/2005	260	290	650	7.5	370	33	ND	38	62	33	2.5	28
			11/20/2009	230	220	620	7.5	378	32	ND	40	51	24	1.8	23
			7/24/2014	290	271	647	7.5	380	**28**	ND	34	56	32	2	27
30S/11E-18K9	LOCSD 10th St.	C,D	May 2002	250	--	550	6.9	320	37	1	26	31	32	--	39
			11/20/2009	180	160	539	7.2	307	36	4.6	27	27	24	1.3	32
			7/23/2014	220	190	546	7.7	300	**32**	4.3	20	30	28	1	35
30S/11E-18L2	LOCSD Palisades	D,E	11/18/2004	220	330	880	7.3	420	120	ND	31	54	48	2.2	40
		D,E	11/19/2009	200	590	1460	7.2	890	360	1.8	39	94	86	2	44
		D	7/23/2014	250	293	783	7.8	390	**90**	1.8	26	48	42	2	40
30S/11E-18L6	Palisades Obs.Deep	D,E	1/18/2005	300	380	860	7.4	560	63	ND	77	72	48	2.4	36
			12/9/2009	270	380	856	7.5	528	68	ND	85	70	50	2.2	36
			7/30/2014	340	418	945	7.4	580	**71**	ND	81	75	56	3	38

ND = Not Detected

Chloride Metric Wells in Green (13J4 weighted x2); current chloride concentrations in red

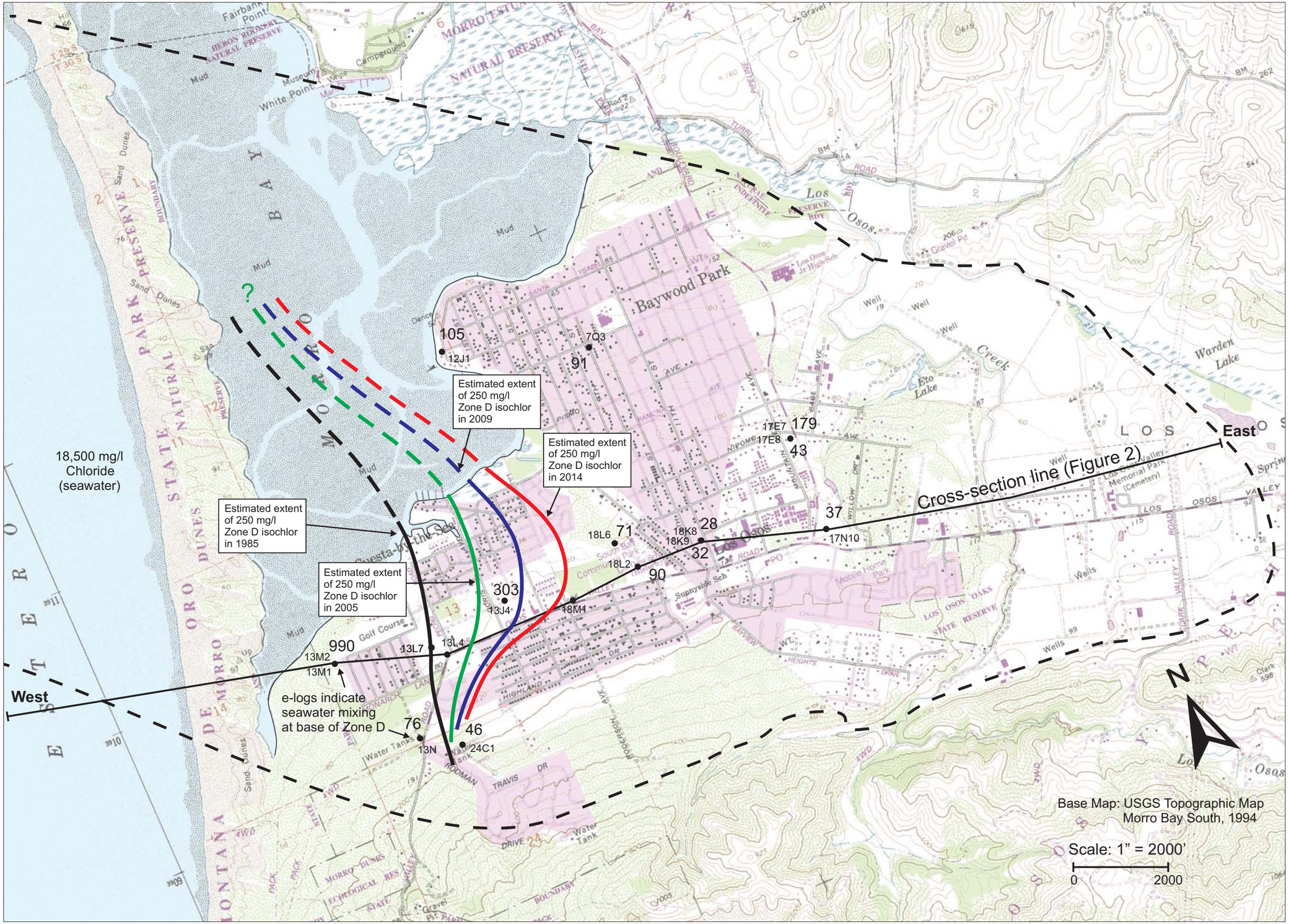
*Chloride concentrations at 13J4 have varied seasonally by 100+ mg/l, and are affected by well production, so fluctuations are expected.

**Water from 13L7 affected by borehole leakage/upper aquifer influence when inactive

***Water from 17E7 affected by high pH from sea shell zone. Alkalinity 90 mg/l as carbonate and hydroxide. Not seawater intrusion.

Table 1 Legend and Detection Limits

General Mineral	Description	Practical Quantitation Limit (2014)
HCO3	Bicarbonate Alkalinity in mg/L CaCO3	10.0
Total Hardness	Total Hardness in mg/L CaCO3	--
Cond	Electrical Conductance in μmhos/cm	1.0
pH	pH in pH units	--
TDS	Total Dissolved Solids in mg/L	20.0
Cl	Chloride concentration in mg/L	1.0
NO3	Nitrate concentration in mg/L	0.4
SO4	Sulfate concentration in mg/L	0.5
Ca	Calcium concentration in mg/L	1.0
Mg	Magnesium concentration in mg/L	1.0
K	Potassium concentration in mg/L	1.0
Na	Sodium concentration in mg/L	1.0



Explanation

105 July - Aug 2014 chloride concentration in mg/l

12J1 Well location

Estimated extent of 250 mg/l Zone D isochlor

NOTE: the isochlor lines are interpreted from water quality and geophysical data, and include consideration of well construction and use.

approx. basin limits

Figure 1

Lower Aquifer
Chloride Concentrations
and Zone D Intrusion Front
Seawater Intrusion
2014 Update

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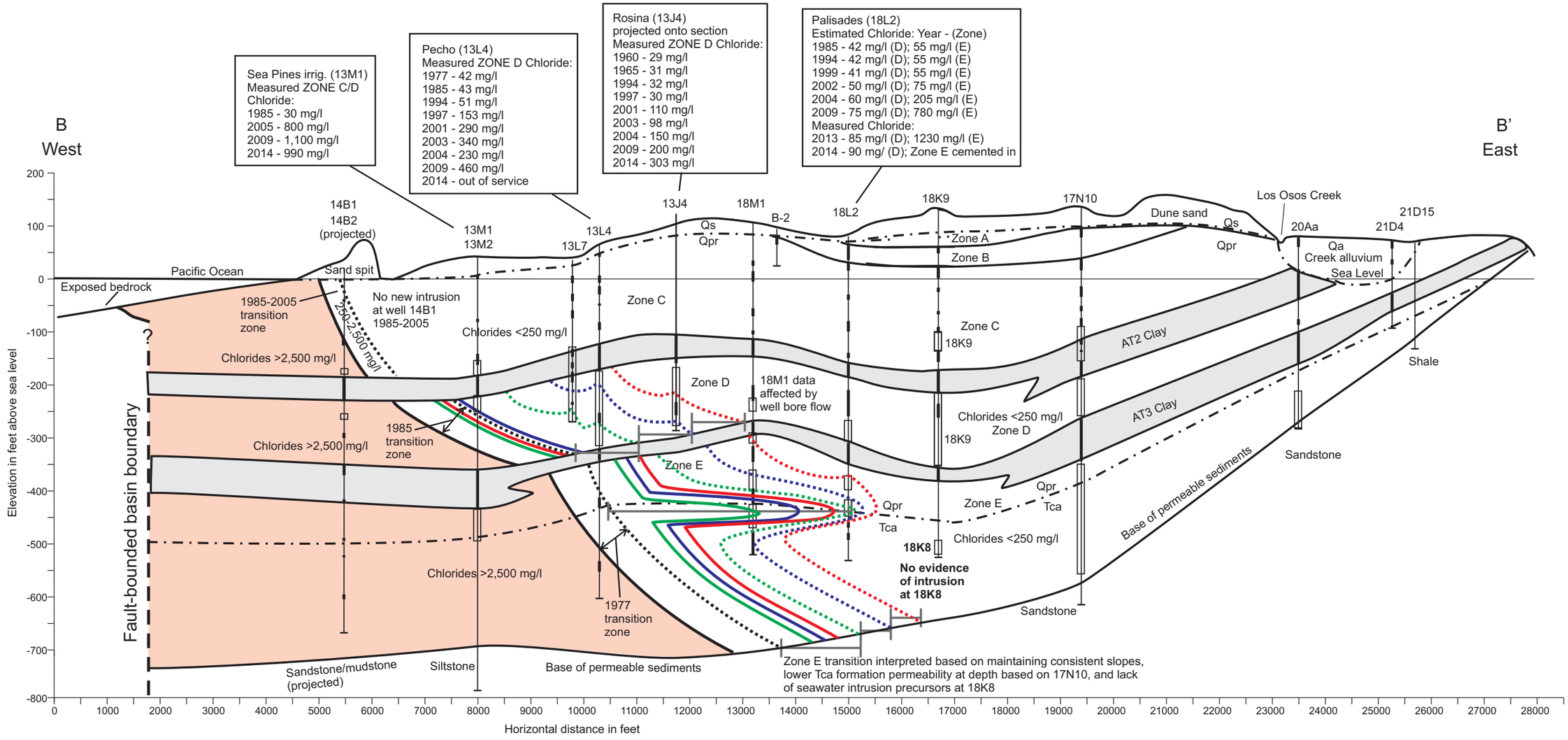

Aquifer Zones:
Zone A - Perched Aquifer
Zone B - Transitional Aquifer
Zone C - Upper Aquifer
Zone D - Lower Aquifer (shallow)
Zone E - Lower Aquifer (deep)

Well data point
18M1 Well ID
Clay layer
Well screen

Formation:
Qa - alluvium
Qs - dune sand
Qpr - Paso Robles Formation
Tca - Careaga Formation

NOTE: the transition zone lines are interpreted from available water quality and geophysical data, and include consideration of well construction and use. Intrusion rates are estimates based on interpreted advance of toe of transition zone. Rates within zones can vary based on preferential pathways. The generalized slopes of the transition zones were based on geophysical logs and water quality obtained during the 2005 study and have been maintained for consistency.

ZONE D Intrusion rates

1,200 ft — 20 yr — 1985 — 2005 — 60 ft/yr
1,000 ft — 5 yr — 2010 — 200 ft/yr
1,000 ft — 4 yr — 2014 — 250 ft/yr

ZONE E Intrusion rates

1,500 ft — 28 yr — 1977 — 2005 — 54 ft/yr
500 ft — 5 yr — 2010 — 100 ft/yr
500 ft — 4 yr — 2014 — 125 ft/yr

ZONE E preferential pathway

4,600 ft / 27 yr
170 ft/yr
1977 — 2004

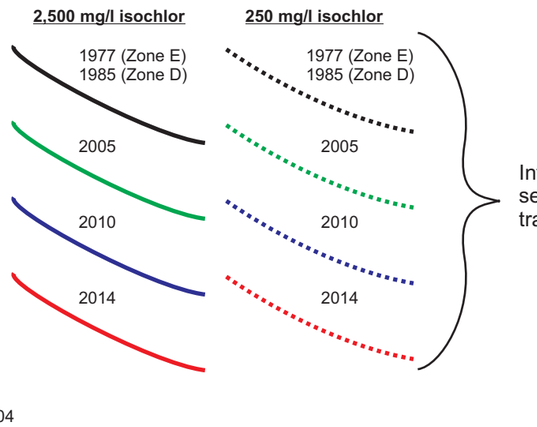

Figure 2

Lower Aquifer
Seawater Intrusion - 2014 Update
Los Osos Valley Groundwater Basin

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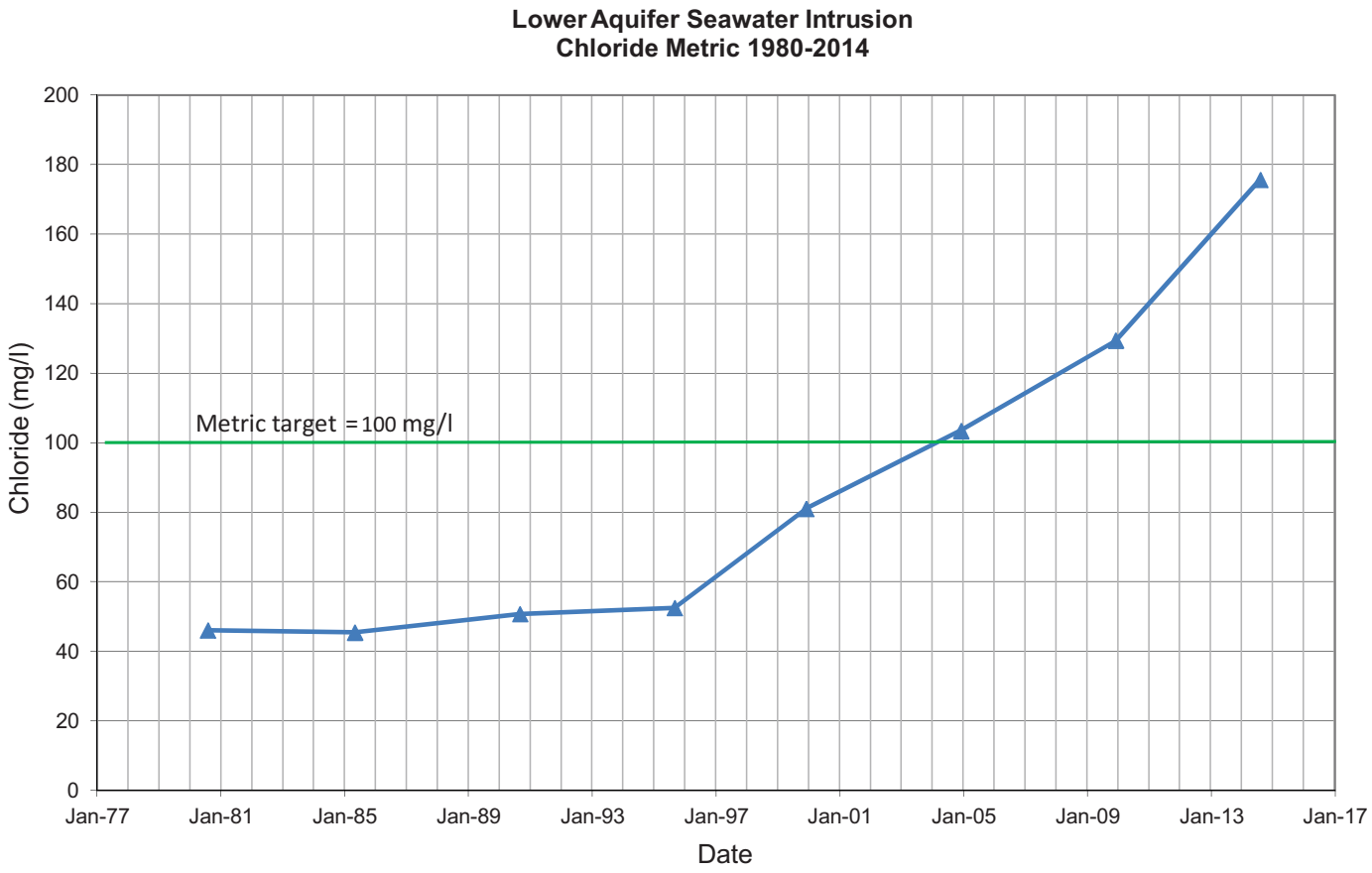

Figure 3
Chloride Metric
Seawater Intrusion 2014 Update
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Well 30S/10E-13M1

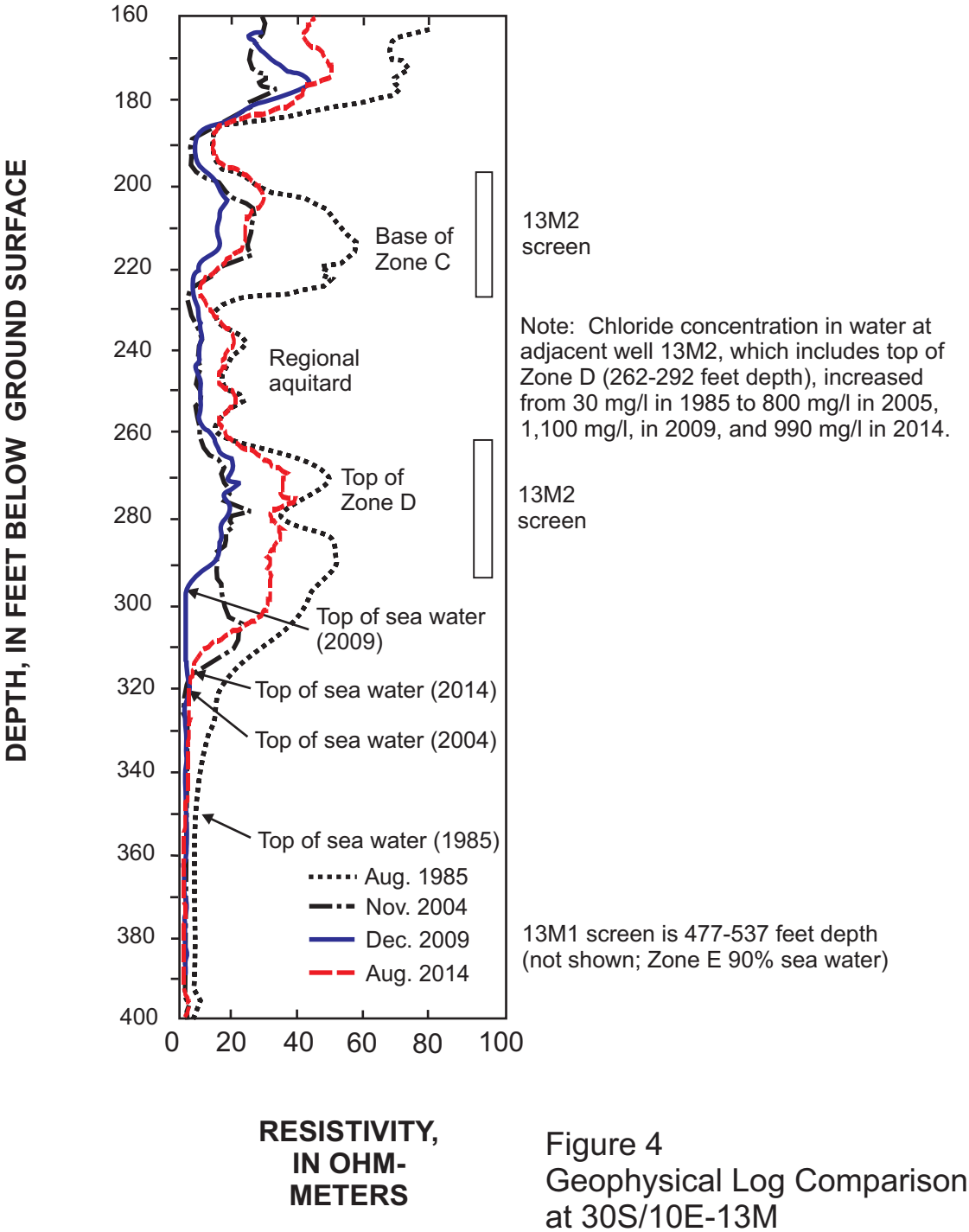

Figure 4
Geophysical Log Comparison
at 30S/10E-13M
Seawater Intrusion 2014 Update
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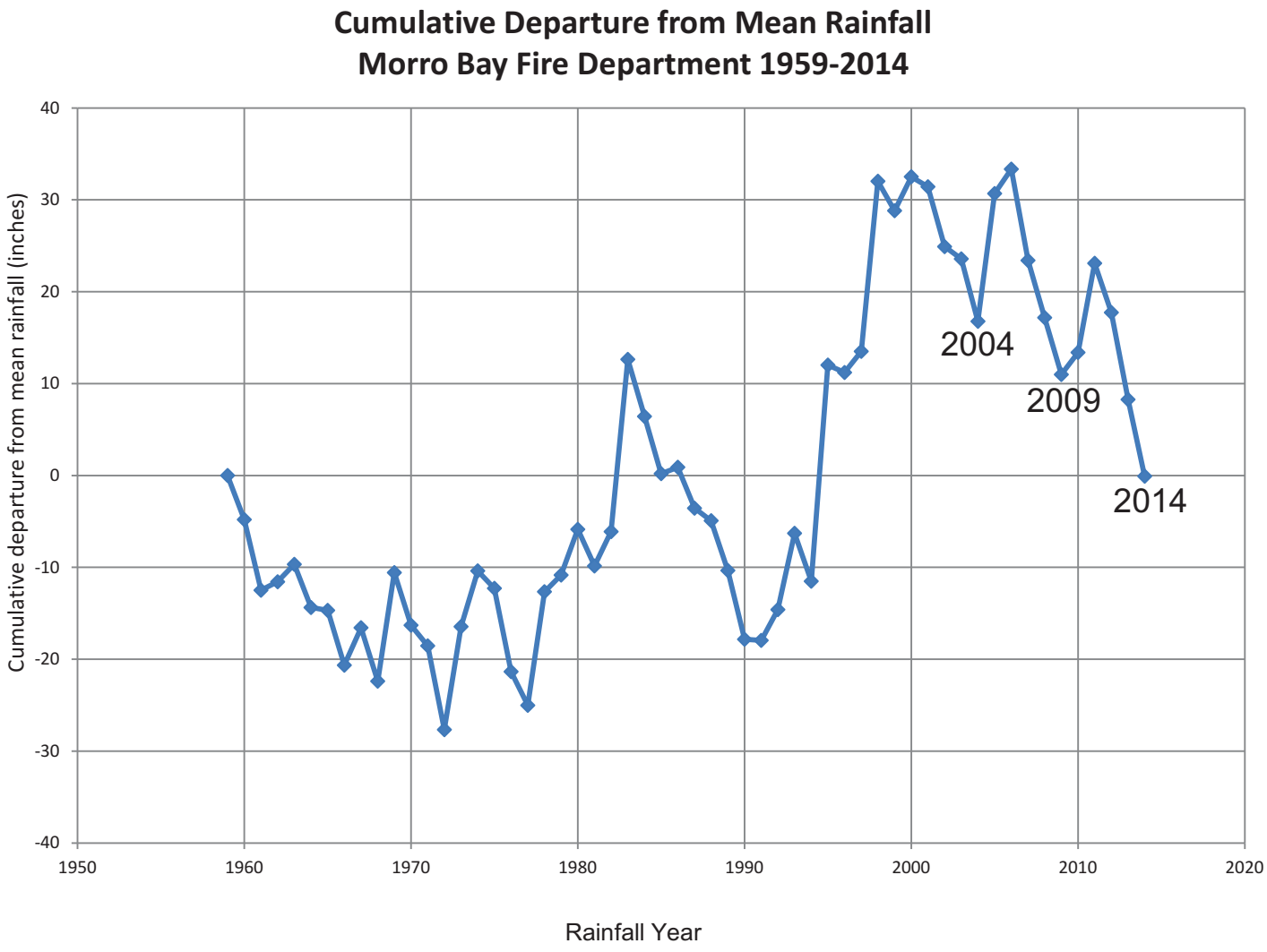

Figure 5
Cumulative Departure from Mean Rainfall at Morro Bay
Seawater Intrusion 2014 Update
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