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Technical Memorandum

Date: May 26, 2015

From: Spencer Harris, HG 633

To: Los Osos ISJ Group

SUBJECT: April 2015 Lower Aquifer Monitoring, Los Osos Groundwater Basin.

Lower aquifer groundwater monitoring in the Los Osos groundwater basin was performed by Cleath-Harris Geologists (CHG) in April 2015. Future monitoring events are planned on a semi-annual basis, and will implement monitoring recommendations included in the Los Osos Basin Plan. The purpose of groundwater monitoring is to collect and organize groundwater data on a regular basis for use in management of the basin, including the evaluation and mitigation of seawater intrusion.

Lower Aquifer Monitoring Program

Table 21 of the Updated Basin Plan (attached) lists 30 lower aquifer wells in the monitoring network, of which 20 are owned by the ISJ Parties (County of San Luis Obispo, S&T Mutual Water Company, Los Osos Community Services District and Golden State Water Company). Until agreements with the remaining ten private wells owners are in place, lower aquifer monitoring will be limited to wells owned by the ISJ Parties. Monitoring tasks are also listed in the attached Table 21 (with a few adjustments specific to seawater intrusion monitoring). Basin Plan monitoring network wells and tasks are also shown in the attached Figure 1.

Monitoring Results

Water levels for monitoring program wells are presented in the attached Table 1. The analytical results of groundwater samples collected from basin wells are presented in the attached Table 2, including the results of prior groundwater monitoring events. Chloride concentrations at lower aquifer monitoring wells are shown in the attached Figure 1.

One of the primary control points for the leading edge of the Lower aquifer Zone D isochlor is the LOCSD Palisades well (Basin Plan well LA15), which was out-of-service for a few months prior to the monitoring event. When this well is idle, upper aquifer water leaks down the annular space of the borehole and displaces lower aquifer water in the vicinity of the well. The April 2015 water quality result at Palisades is not representative of Lower aquifer conditions, and is therefore unsuitable for use in seawater intrusion interpretation.

Rate and Extent of Seawater Intrusion

As reported in the technical memorandum dated October 7, 2014, the estimated rate of Lower aquifer seawater intrusion since 2005 has been approximately 200-250 feet per year in Zone D, and approximately 100-170 feet per year in Zone E (the higher rate of intrusion occurring along a preferential pathway toward the LOCSD Palisades well). Based on the April 2015 monitoring event results, seawater intrusion in Zones D and E is continuing to advance inland, although the leading edge of seawater intrusion in Zone E along the preferential pathway is interpreted to have slowed or stalled at Palisades Avenue. Figure 1 presents the inferred extent of seawater intrusion in Zone D.

Continued inland advance of seawater intrusion in Zone D and Zone E is inferred based on groundwater levels and increasing chloride concentrations at the chloride metric wells (Table 1). As mentioned above, the April 2015 decline in Zone D chloride concentration at the LOCSD Palisades well was a result of upper aquifer borehole leakage which takes place when the well is idle for extended periods. The overall trend of increasing chlorides is expected to continue once the well resumes production.

Zone E Intrusion at Palisades

Production from Lower aquifer Zone E at the LOCSD Palisades well was permanently eliminated in 2013 through well modification. The only other purveyor well currently producing from Zone E is GSWC South Bay #1 (Basin Plan well LA20). A monitoring well constructed in Zone E at 10th Street (30S/11E-18K8; Basin Plan well LA18) lies between LOCSD Palisades and GSWC South Bay #1, and has not shown any significant increase in chlorides since first sampled 2005. This information indicates that when the accelerated Zone E intrusion along preferential pathways (permeable gravel lenses) reached the LOCSD Palisades well in 2004, it was essentially captured by the pumping depression created at the well. Now that Zone E production at the Palisades well has ceased, the accelerated intrusion into the area has slowed or stalled. Concurrently, however, the capture zone created by the Palisades well in Zone E has also subsided, which would allow existing intrusion in the area to begin moving east. No evidence of seawater intrusion has been observed at the Zone E well on 10th Street through April 2015.

Chloride Metric

The chloride metric graph has been updated with the current monitoring results (Figure 2). The metric continues to rise, reaching 190 mg/l chloride in April 2015.

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. 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 3 shows the cumulative departure from mean precipitation curve for the Morro Bay Fire Department. The rainfall years corresponding to the four seawater intrusion monitoring events (2004, 2009, 2014, and 2015) are successively drier years when compared to each other.

The ISJ Group has initiated both April and October water quality monitoring due to critical drought conditions. 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.

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ATTACHMENTS

Table 21 from Updated Basin Plan
Table 1 - Groundwater levels April 2015
Table 2 - Water Quality Results
Figure 1 - Lower Aquifer Chloride Concentrations
Figure 2 - Chloride Metric
Figure 3 - Cumulative Departure from Mean Rainfall

Table 21. Lower Aquifer Monitoring Network				
Program ID	**Well Number**	**Area**	**Well Type**	**Monitoring***
LA1	30S/10E-2A1	Dunes and Bay	Monitoring	L
LA2	30S/10E-11A2	Dunes and Bay	Monitoring	L add G in Oct.
LA3	30S/10E-14B2	Dunes and Bay	Monitoring	L add G in Oct.
LA4	30S/10E-13M1	Western	Monitoring	L, GL
LA5	30S/10E-13L7	Western	Municipal	L
LA6	30S/10E-13L4	Western	Municipal	L, ~~G~~ remove G
LA7	Private	Western	Private	TL
LA8	30S/10E-13N	Western	Municipal	L, G
LA9	30S/10E-24C1	Western	Municipal	L add G
LA10	30S/10E-13J4	Western	Municipal	L, G
LA11	30S/10E-12J1	Central	Monitoring	L, G
LA12	30S/11E-7Q3	Central	Municipal	L, G
LA13	30S/11E-18F2	Central	Municipal	TL
LA14	30S/11E-18L6	Western	Monitoring	L
LA15	30S/11E-18L2	Western	Municipal	L, G
LA16	Private	Western	Private	L
LA17	30S/11E-24A2	Western	Monitoring	L
LA18	30S/11E-18K8	Central	Monitoring	L, G
LA19	30S/11E-19H2	Central	Monitoring	L
LA20	30S/11E-17N10	Central	Municipal	L, G
LA21	30S/11E-17E7	Central	Monitoring	L
LA22	30S/11E-17E8	Central	Monitoring	L add G
Private	LA23	~~30S/11E-17C1~~	Central	Monitoring	L, G
LA24	Private	Eastern	Private	L
LA25	Private	Eastern	Private	L
LA26	Private	Eastern	Private	L
LA27	Private	Eastern	Private	TL
LA28	Private	Eastern	Private	L, G
LA29	Private	Eastern	Private	L
LA30	Private	Eastern	Private	L, G

Legend: L = groundwater level; GL = geophysical logging; G = groundwater quality: general mineral suite; TL = transducer site for groundwater level.

Add groundwater sampling at mixed aquifer (C/D) wells: LOCSD 10th Street (18K9) and Sea Pines (13M2)

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Table 1

Groundwater Levels - April 2015

Program ID	Well Number	Date	Depth to Water	Reference point elevation (ft)*	Groundwater elevation (ft)*	Monitoring data source
LA1	30S/10E-2A1			16.0*		COUNTY (pending)
LA2	**30S/10E-11A2**			16.4*		COUNTY (pending)
LA3	**30S/10E-14B2**			16.8*		COUNTY (pending)
LA4	30S/10E-13M1	4/21/2015	45.32	41.2	-4.1	CHG
(none)	30S/10E-13M2	4/21/2015	39.41	40.2	0.8	CHG
LA5	30S/10E-13L7	4/23/2015	33			S&T
LA6	30S/10E-13L4	4/13/2015	63.7	68	4.3	GSWC
LA7	30S/10E-13P2	Private well - program participation to be determined				
LA8	30S/10E-13N	4/23/2015	133			S&T
LA9	30S/10E-24C1	4/14/2015	176	178.3	2.3	GSWC
LA10	30S/10E-13J4	4/2/2015	98	95.3	-2.7	GSWC
LA11	**30S/10E-12J1**	4/22/2015	7.65	8.4*	0.75*	CHG
LA12	30S/11E-7Q3	4/14/2015	36.7	24	-12.7	LOCSD
LA13	30S/11E-18F2	4/29/2015	105.5	100	-5.5	LOCSD
LA14	**30S/11E-18L6**			76		COUNTY (pending)
LA15	30S/11E-18L2	4/14/2015	92.55	85	-7.6	LOCSD
LA16	**30S/11E-18M1**	Private well - program participation to be determined				
LA17	30S/10E-24A2			210.4		COUNTY (pending)
LA18	30S/11E-18K8	4/21/2015	146.1	135.7	-10.4	CHG
(none)	30S/11E-18K9	4/14/2015	156.6	135	-21.6	LOCSD
LA19	30S/11E-19H2			256.2		COUNTY (pending)
LA20	30S/11E-17N10	4/23/2015	144			GSWC
LA21	30S/11E-17E7	4/21/2015	115.54	105.9	-9.6	CHG
LA22	30S/11E-17E8	4/21/2015	124.62	105.9	-18.7	CHG
LA23	30S/11E-17C1	Private well - program participation to be determined				
LA24	30S/11E-17J2	Private well - program participation to be determined				
LA25	30S/11E-20Aa	Private well - program participation to be determined				
LA26	30S/11E-20G2	Private well - program participation to be determined				
LA27	30S/11E-16Ma	Private well - program participation to be determined				
LA28	30S/11E-16Mb	Private well - program participation to be determined				
LA29	30S/11E-21E3	Private well - program participation to be determined				
LA30	30S/11E-21H1	Private well - program participation to be determined				

Water Level Metric Wells in Blue

*Elevations with astrix are reported in NAVD 88. All others are reported in NAVD 29.

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Table 2
Water Quality Results - Lower Aquifer Monitoring

Station ID	Well Name	Basin Plan Well ID	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.	LA11	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
				4/22/2015	360	475	1290	7.8	810	**112**	ND	189	65	76	5	88
30S/10E-13J4*	GSWC Rosina	LA10	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
				4/22/2015	80	431	1230	7.1	750	**331**	8.3	20	69	63	2	39
30S/10E-13M2	Howard East	none	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
				4/21/2015	60	739	3430	7.3	1930	**950**	2.5	178	117	113	5	382
30S/10E-13N	S&T #5	LA8	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
				4/21/2015	50	98	445	6.9	280	**77**	33.9	11	16	14	2	38
30S/10E-24C1	GSWC Cabrillo	LA9	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
				4/22/2015	70	117	530	7.3	320	**95**	24.2	16	19	17	2	45
30S/11E-7Q3	LOCSD 8th St.	LA12	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
				4/21/2015	290	305	897	7.7	500	**101**	ND	55	48	45	2	59
30S/11E-17E8	So. Bay Obs. Middle	LA22	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
				4/21/2015	150	157	481	7.6	270	**49**	31.4	13	25	23	1	28
30S/11E-17N10	GSWC So. Bay #1	LA20	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
				4/22/2015	290	234	653	7.4	360	**43**	2.5	27	36	35	2	42
30S/11E-18K8	10th St. Obs. East (Deep)	LA18	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
				4/21/2015	290	265	634	7.7	400	**33**	ND	39	55	31	2	27
30S/11E-18K9	LOCSD 10th St.	none	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
				4/21/2015	190	108	504	7.6	270	**38**	7	20	17	16	1	27
30S/11E-18L2**	LOCSD Palisades	LA15	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
			D	4/29/2015	80	78	348	7.4	230	**43**	22	10	13	11	ND	30

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 18L2 affected by borehole leakage/upper aquifer influence when inactive

Table 1 Legend and Detection Limits

Constituent	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

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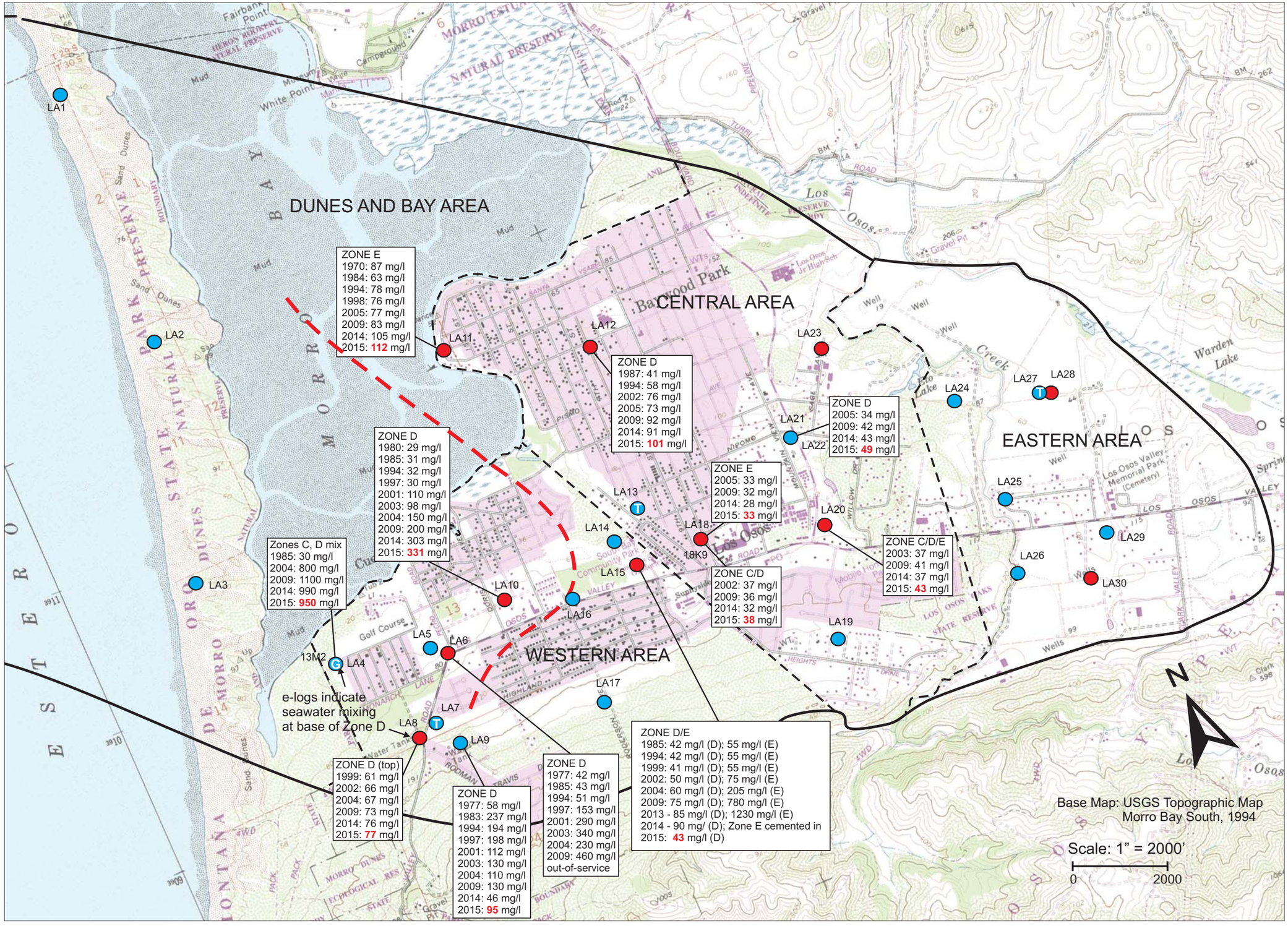

Explanation

Basin Plan Monitoring Tasks:

- Water level only
- T Water level transducer
- G Water level with geophysics
- Water level and water quality

101 April 2015 chloride concentration in mg/l shown in red

Well location

LA11

Inferred 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
April 2015 Groundwater Monitoring
Los Osos ISJ

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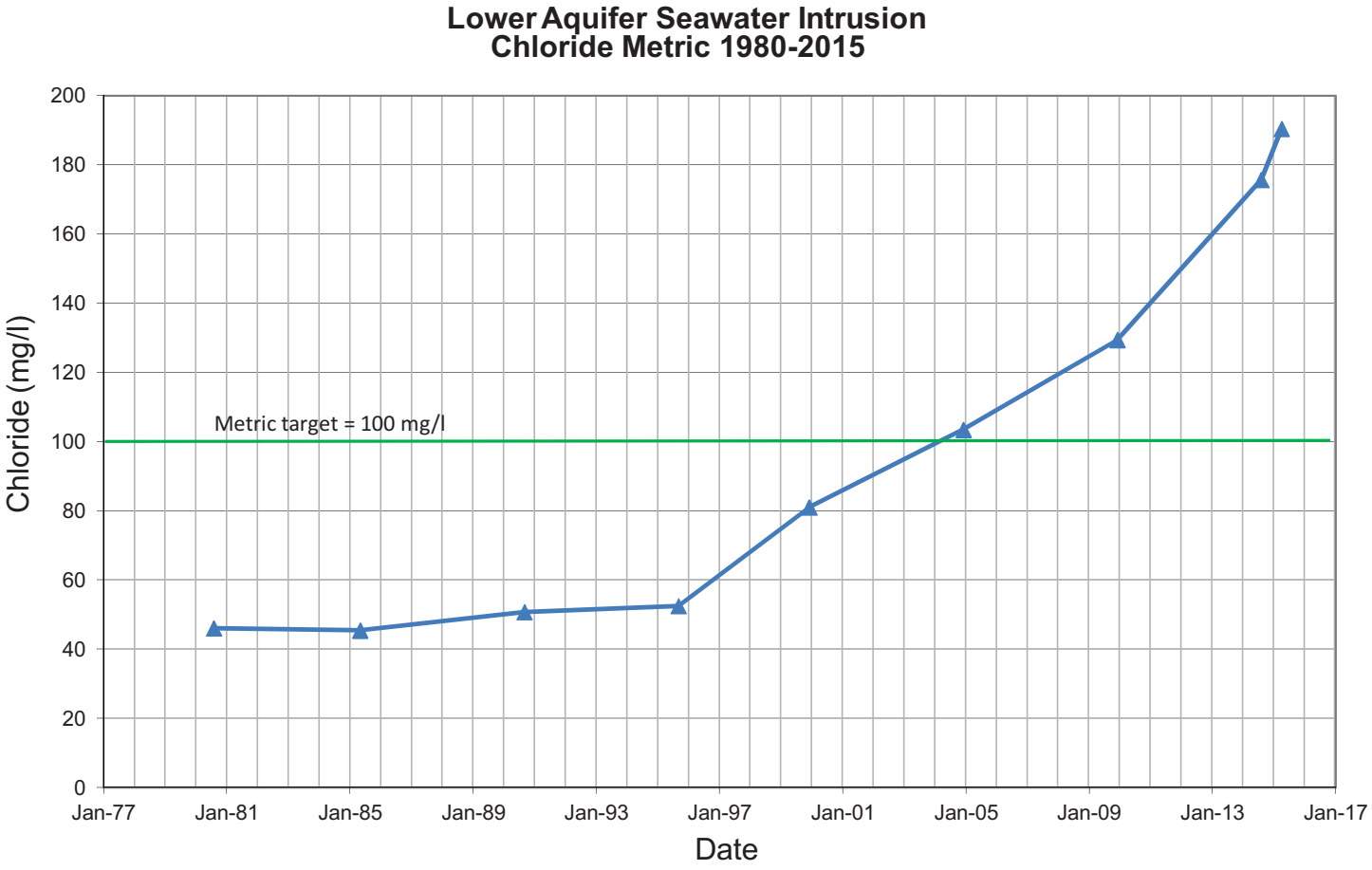

Figure 2
Chloride Metric
April 2015 Groundwater Monitoring
Los Osos ISJ

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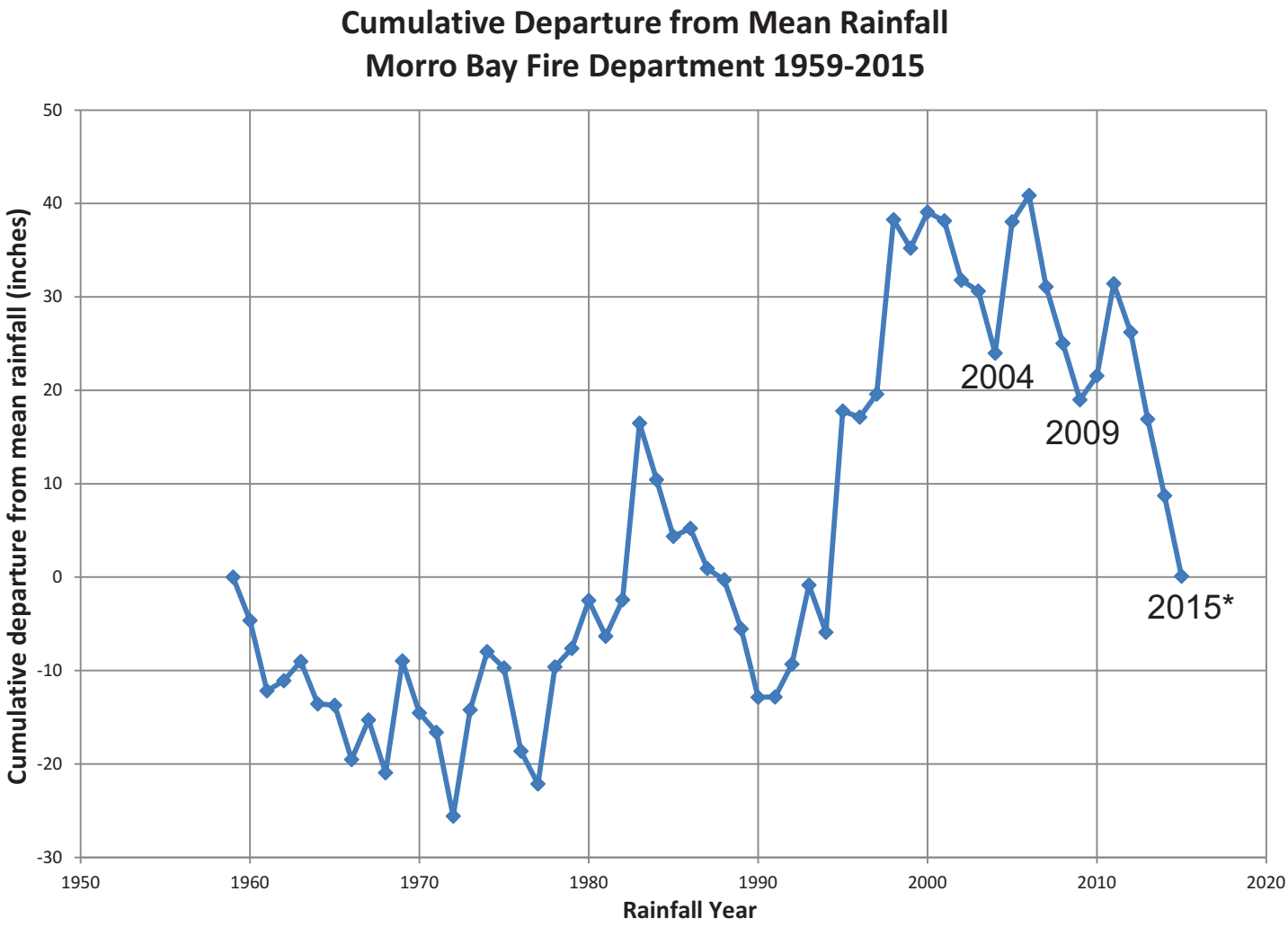

*NOTE: 2015 rainfall year provisional (year ends June 30, 2015)

Figure 3
Cumulative Departure from
Mean Rainfall at Morro Bay
April 2015 Groundwater Monitoring
Los Osos ISJ

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