

November 24, 2015

TO:

LOCSD Board of Directors

FROM:

Robert Miller, District Engineer

SUBJECT:

Agenda Item 12A – 12/3/2015 Board Meeting
October 2015 Seawater Intrusion Monitoring Report

President R. Michael Wright

Vice President Marshall E. Ochvlski

Directors

Charles A. Cesena Jon-Erik E. Storm Louis G. Tornatzky

General Manager Kathy A. Kivley

District Accountant Michael L. Doyel

Fire Chief Robert Lewin

Battalion Chief Phill Veneris

Mailing Address:

P.O. Box 6064 Los Osos, CA 93412

Offices:

2122 9th Street, Suite 102 Los Osos, CA 93402

Phone: 805/528-9370 FAX: 805/528-9377

www.losososcsd.org

DESCRIPTION

Cleath Harris Geologists (CHG) recently completed a draft report summarizing the findings of a semi-annual lower aquifer monitoring event. During the October, 2015 monitoring event, data was collected from the lower aquifer for both water levels and water quality.

SUMMARY OF STAFF RECOMMENDATION

Staff recommends that the Board receive the draft report and provide any comments or questions.

DISCUSSION

Lower aquifer groundwater monitoring in the Los Osos groundwater basin was performed by CHG in October, 2015. The purpose of groundwater monitoring is to collect and organize groundwater data on a periodic basis for use in management of the basin, including the evaluation of seawater intrusion. A total of 30 lower aquifer wells were included in the monitoring event. The draft report is included for review by the Board and public. Key findings from the report are as follows:

- 1. The water level and chloride metrics improved compared to April, 2015.
- 2. Chlorides at the District's Palisades Well increased to 104 mg/l, compared to 90 mg/l in July, 2014 and 43 mg/l in April, 2015.
- 3. The District's Water Shortage Contingency Plan includes a chloride trigger for the District's 8th and 10th Street Wells. The Stage III trigger for chloride was previously set at 150 mg/l. Chloride levels in the 8th and 10th Street Wells were measured and determined to be 91 mg/l and 31 mg/l, respectively. These values remain essentially unchanged from July, 2014, and slightly lower compared to April, 2015.

Staff will be available to answer questions, and feedback will be conveyed to CHG so that the draft report can be finalized.

FINANCIAL IMPACT

No financial impacts are anticipated. It should be noted that the District previously committed to paying its pro rata share of monitoring costs.

Cleath-Harris Geologists, Inc.

71 Zaca Lane, Suite 140 San Luis Obispo, California 93401 (805) 543-1413



Technical Memorandum

Date:

November 19, 2015

From:

Spencer Harris, HG 633

To:

Los Osos ISJ Group

SUBJECT:

October 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 October 2015. 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). 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 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.

Chloride Metric

The chloride metric had been rising at a rate of close to 7 mg/l per year since 1995, but did not increase between April and October 2015. The metric is currently 188.2 mg/l (slightly lower than the April 2015 value of 190.4 mg/l). Figure 2 shows the updated chloride metric.

Chloride measurements at the key metric wells were available approximately every five years through August 2014, and have been monitored semi-annually since then. The current short-term stabilization of the chloride metric may be a delayed response to the water conservation efforts and lower purveyor groundwater production over the last several years, which has also resulted in a rising water level metric. Additional monitoring events will be needed to confirm this.



The LOCSD Palisades well was removed as a key metric well following its modification in 2013 due to the resulting decline in chloride concentrations. Since modification, the chloride concentrations at Palisades representing Zone D have increased from 91 mg/l in July 2014 to 104 mg/l in October 2015, therefore, continued movement of the seawater intrusion front in Zone D toward Palisades is inferred. Historical chloride concentrations in Zone D and Zone E at the Palisades well have been calculated using the information obtained during well modification (see Figure 1), which would enable the well to be reinserted into the chloride metric. Only two representative post-modification data sets are available for Zone D, due to the upper aquifer influence from borehole leakage during the April 2015 monitoring event (the well had been out of service for several months). Additional monitoring data would be recommended prior to reinstating LOCSD Palisades well back into the chloride metric.

Water Level Metric

After historical declines in the water level metric during the 1970's and 1980's, there was a brief recovery in the late 1990's with stabilization of the metric at sea level between 2000 and 2010. Since 2010, the water level metric has been rising at a rate of 0.4 feet per year through 2015. Given the exceptional drought conditions, a rise in lower aquifer water levels at the key metric wells is interpreted to be due to reduced purveyor production. Figure 2 shows the updated water level metric, which is based on spring water levels.

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 15 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.

Geophysics at deep monitoring well 18L6 continues to show no indication of intrusion, despite documented intrusion in Zone E at the nearby LOCSD Palisades well, approximately 500 feet to the south. This is interpreted as an indication that Zone E intrusion toward the Palisades well was through a relatively narrow preferential pathway. Production from Zone E at the Palisades well was permanently eliminated through well modification in 2013.

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. Seawater intrusion was continuing to advance inland through April 2015, although the leading edge of seawater intrusion in Zone E along the preferential pathway was interpreted to have slowed or stalled at Palisades Avenue.



The October 2015 monitoring results indicate a reduced rate of advance of the seawater intrusion front between April and October 2015. Zone D intrusion toward the LOCSD Palisades is inferred to be approximately 100-150 feet per year. Figure 1 shows the approximate location of the toe of the intrusion front, defined by the 250 mg/l chloride concentration contour.

Stabilization of the chloride metric and a reduced intrusion rate may be a delayed response to the water conservation efforts and lower purveyor groundwater production over the last several years, which has also resulted in a rising water level metric. Additional monitoring events will be needed to confirm this.

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

Data Interpretation

Seawater intrusion mitigation will result in a rising water level metric and a declining chloride metric. The rising water level metric since 2010 indicates that declines in purveyor production over the last several years have offset the drought impacts to lower aquifer pressure. The chloride metric, however, did not show any response to the lower purveyor production or rising water level metric until the October 2015 monitoring event.

There was a delay of 15-20 years between the onset of water level metric declines in the 1970's and chloride metric increases in the 1990's. If the current short-term stabilization of the chloride metric continues through future October events (supporting a long-term trend), then the current delay between the onset of a water level metric rise and a chloride metric response would be on the order of five years. This shorter response period under current conditions would be expected, given that



part of the historical delay period was movement of the intrusion front into the area monitored by the key wells.

The October 2015 monitoring results indicate a decreased rate of the seawater intrusion. This is only the third semi-annual monitoring event, however, with prior monitoring events being closer to five years apart. Additional monitoring events will be needed before a change in the long term intrusion trends can be confirmed.



ATTACHMENTS

Table 21 from Updated Basin Plan

Table 1 - Groundwater levels October 2015

Table 2 - Water Quality Results

Figure 1 - Lower Aquifer Chloride Concentrations

Figure 2 - Chloride and Water Level Metric

Figure 3 - Geophysics at 30S/10E-13M1

Figure 4 - Cumulative Departure from Mean Rainfall

SOURCE: 2015 UPDATED LOS OSOS BASIN PLAN (CHG Adjustments in RED)

CHAPTER 7: GROUNDWATER MONITORING PROGRAM

		er Aquifer Monito		
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
LA3	30S/10E-14B2	Dunes and Bay	Monitoring	L add G
LA4	30S/10E-13M1	Western	Monitoring	L, GL
LA5	30S/10E-13L7	Western	Municipal	L
LA6	30S/10E-13L4	Western	Municipal	L,& remo
LA7	Private	Western	Private	TL
LA8	30S/10E-13N	Western	Municipal	L, G
LA9	30S/10E-24C1	Western	Municipal	L
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
LA23	808\xxx\xxx\x	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

Private

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)

January 2015

Table 1
Groundwater Levels - October 2015

Program ID	Well Number	Date	Depth to Water	Reference point elevation (ft)*	Groundwater elevation (ft)*	Monitoring data source
LA1	30S/10E-2A1	10/21/2015	8.45	16.0*	7.6*	COUNTY
LA2	30S/10E-11A2	10/21/2015	10.33	16.4*	6.1*	COUNTY
LA3	30S/10E-14B2	10/21/2015	13.59	16.8*	3.2*	COUNTY
LA4	30S/10E-13M1	10/24/2015	44.84	41.2	-3.6	CHG
(none)	30S/10E-13M2	10/24/2015	39.2	40.2	1	CHG
LA5	30S/10E-13L7					S&T (pending)
LA6	30S/10E-13L4			68		GSWC (pending)
LA7	30S/10E-13P2		Priv	ate well - program parti	icipation to be determine	ed
LA8	30S/10E-13N	10/6/2015	134	no survey		S&T
LA9	30S/10E-24C1			178.3		GSWC (pending)
LA10	30S/10E-13J4			95.3		GSWC (pending)
LA11	30S/10E-12J1	10/26/2015	5.22	8.4*	3.18*	CHG
LA12	30S/11E-7Q3	pending	34.9	24	-10.9	LOCSD
LA13	30S/11E-18F2			100		LOCSD (pending)
LA14	30S/11E-18L6	10/26/2015	83.6	76		COUNTY
LA15	30S/11E-18L2	pending	96	85	-11	LOCSD
LA16	30S/11E-18M1		Priv	ate well - program parti	cipation to be determine	ed
LA17	30S/10E-24A2	no access		210.4	×	COUNTY
LA18	30S/11E-18K8	10/19/2015	141.27	135.7	-5.6	CHG
(none)	30S/11E-18K9	pending	156.2	135	-21.2	LOCSD
LA19	30S/11E-19H2	10/27/2015	275.85	256.2	-19.7	COUNTY
LA20	30S/11E-17N10					GSWC (pending)
LA21	30S/11E-17E7	10/27/2015	118.51	105.9	-12.6	CHG
LA22	30S/11E-17E8	10/1/2015	129.19	105.9	-23.3	CHG
LA23	30S/11E-17C1		Priv	ate well - program parti	cipation to be determine	ed
LA24	30S/11E-17J2		Priv	ate well - program parti	cipation to be determine	ed
LA25	30S/11E-20Aa		Priv	ate well - program parti	cipation to be determine	ed
LA26	30S/11E-20G2		Priv	ate well - program parti	cipation to be determine	ed
LA27	30S/11E-16Ma		Priv	ate well - program parti	cipation to be determine	ed
LA28	30S/11E-16Mb		Priv	ate well - program parti	cipation to be determine	ed
LA29	30S/11E-21E3		Priv	ate well - program parti	cipation to be determine	ed
LA30	30S/11E-21H1		Priv	ate well - program parti	cipation to be determine	ed

Water Level Metric Wells in Blue

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



Water Quality Results - Lower Aquifer Monitoring

30S/10E-12J1	Station ID	Well Name	Basin Plan Well ID	Aquifer Zone	Date	нсоз	Total Hardness	Cond	рН	TDS	CI	NO3	SO4	Са	Mg	К	Na
2005/10E-12J1 MB05 DWR Obs. LA11 East LA2 D 1002/12Q15 150 6840 1770 07.4 13100 630 MB 74 01030 690 33 33 34 37 38 38 38 38 39 39 39 39			vveirio	Zone		mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/
Beast	30S/10F-11A2	Sand Spit #1	1.42	D	3/14/2005	180	4600		7.3	8900	5400	ND	430	770	640	20	130
30S/10E-13.14* Obs. LA11 E 17/20/2009 300 300 1150 7.5 732 83 NO 190 51 58 44 17/24/2015 360 3475 1290 7.8 61 112 NO 189 65 76 52 18/22/2015 360 475 1290 7.8 61 112 NO 189 65 76 75 19/22/2015 360 475 1290 7.8 61 112 NO 189 65 76 75 19/22/2015 360 475 1290 7.8 61 112 NO 189 65 76 75 19/22/2015 360 475 1290 7.8 61 112 NO 189 65 76 75 19/22/2015 520 486 1280 7.3 340 117 NO 189 65 76 76 19/22/2015 520 486 1280 7.3 340 117 NO 189 65 76 76 19/22/2015 520 486 1280 7.3 340 117 NO 189 65 76 76 19/22/2015 570 480 1280 7.3 510 303 7.6 16 67 61 61 19/22/2015 580 431 1230 7.1 510 331 302 69 63 32 19/22/2016 580 431 1230 7.1 510 331 303 7.6 16 67 61 61 19/22/2016 580 431 1230 7.1 510 331 300 37 61 61 61 61 19/22/2016 580 431 1230 7.1 510 331 350 310 20 41 61 19/22/2016 580 431 1230 7.1 510 331 500 310 22 220 160 61 44/21/2015 580 431 230 7.3 350 310 22 220 160 61 44/21/2015 580 431 230 7.3 350 310 22 230 160 61 44/21/2015 530 768 337 7.1 2450 990 2.5 178 117 113 50 19/22/2016 530 768 337 7.1 2450 990 2.5 178 117 113 50 19/22/2016 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530 530	000/102 11/12	East	D 12		10/21/2015	150	6640	17700	7.4	13100	6300	ND	740	1030	990	31	156
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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.

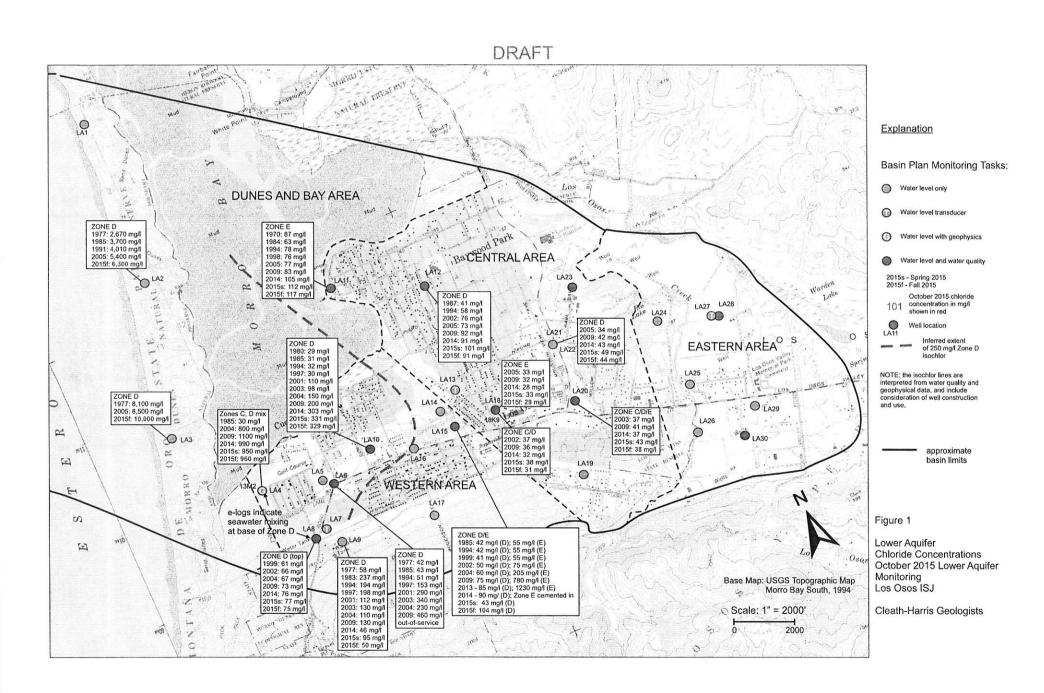
**Alkalinity 140 mg/l as carbonate (ND as bicarbonate) due to high pH, possibly associated with shell zone.

^{***}Water from 18L2 affected by borehole leakage/upper aquifer influence when inactive

Table 2 Legend and Detection Limits

Constituent	Description	Practical Quantitation Limit*				
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				
рН	pH in pH units					
TDS	Total Dissolved Solids in mg/L	20.0				
CI	Chloride concentration in mg/L	1.0				
NO3	Nitrate concentration in mg/L	0.5				
SO4	Sulfate concentration in mg/L	2.0				
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				

^{*}where dilution not required



Chloride and Water Level Metric Lower Aquifer Composite Values

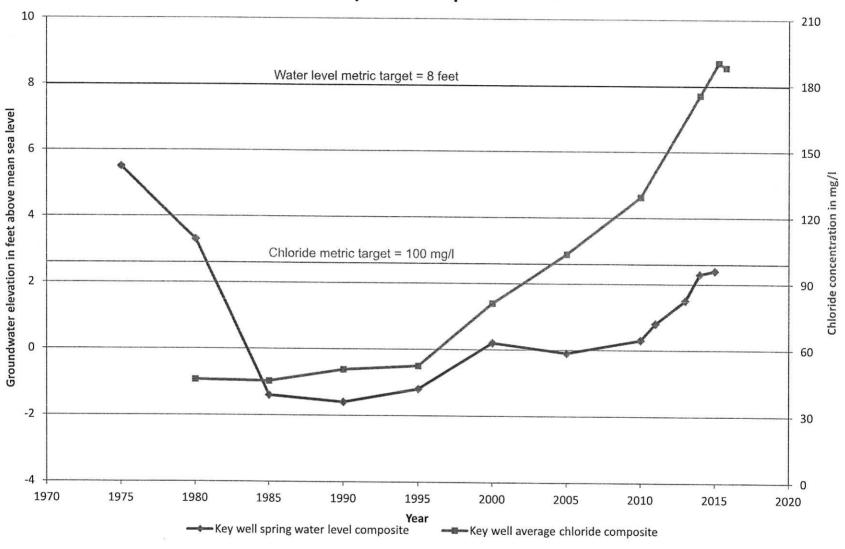
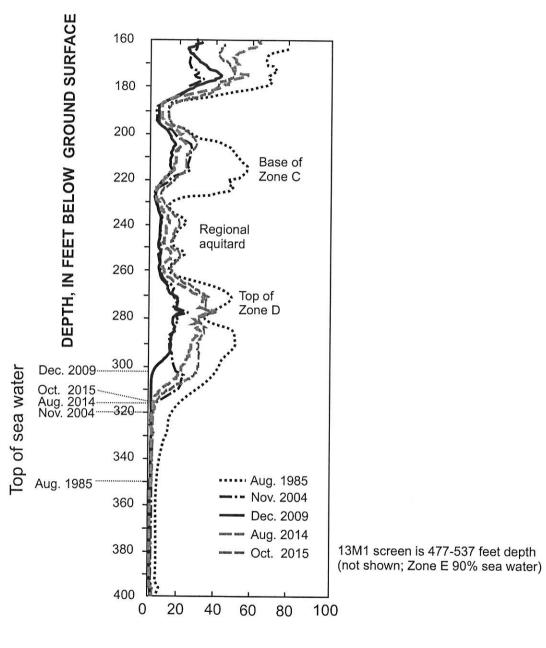


Figure 2 Chloride and Water Level Metric October 2015 Lower Aquifer Monitoring Los Osos ISJ

Cleath-Harris Geologists

Well 30S/10E-13M1



RESISTIVITY, IN OHM-METERS

Figure 3
Geophysical Log Comparison at 30S/10E-13M1
October 2015
Lower Aquifer Monitoring Los Osos ISJ

Cleath-Harris Geologists

Cumulative Departure from Mean Rainfall Morro Bay Fire Department 1959-2015

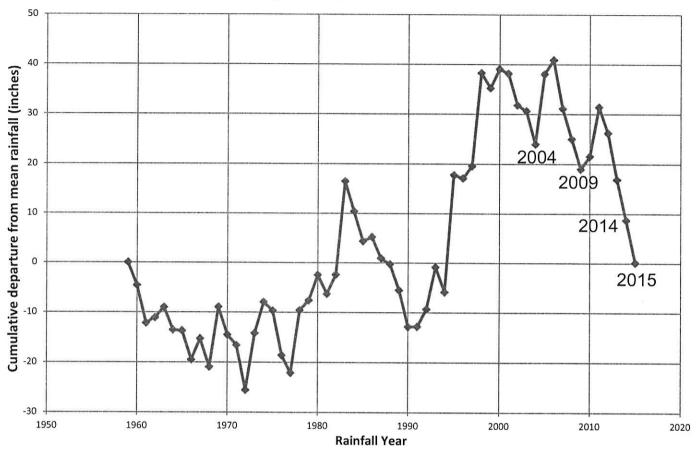


Figure 4
Cumulative Departure from
Mean Rainfall at Morro Bay
October 2015 Lower Aquifer Monitoring
Los Osos ISJ

Cleath-Harris Geologists