Lake Elsinore & San Jacinto Watersheds Authority

City of Lake Elsinore • City of Canyon Lake • County of Riverside
Elsinore Valley Municipal Water District • Santa Ana Watershed Project Authority

LAKE ELSINORE & SAN JACINTO WATERSHEDS AUTHORITY

AGENDA

BOARD OF DIRECTORS MEETING

ELSINORE VALLEY MUNICIPAL WATER DISTRICT
31315 Chaney Street
Lake Elsinore, California 92531
951.674.3146 (EVMWD) / 951.354.4240 (LESJWA)

Thursday, April 21, 2016 – 4:00p.m.

CALL TO ORDER/PLEDGE OF ALLEGIANCE (Chair Robert Magee)

ROLL CALL: __SAWPA __EVMWD __CITY OF LAKE ELSINORE __CITY OF CANYON LAKE
__COUNTY OF RIVERSIDE

PUBLIC COMMENTS:

Members of the public may address the Board on any item that is within the Board's jurisdiction; however, no action may be taken on an item appearing on the agenda unless the action is otherwise authorized by Subdivision (b) Section 54954.2 of the Government Code. Members of the public are requested to provide a public comment notice card to the Board Clerk prior to the meeting in order to speak. The public is given a maximum of five minutes to speak on an issue following discussion of an agenda item.

Materials related to items on this Agenda submitted to the Board after distribution of the agenda packet, are available to the public during regular business hours at the Authority's office:11615 Sterling Avenue, Riverside, CA 92503.

Any person with a disability who requires accommodation in order to participate in this meeting may contact Dawna Munson at 951.354.4247, at least 48 hours prior to the meeting to request a disability-related modification.

CONSENT CALENDAR

Consent Calendar items are considered routine and non-controversial, to be acted upon by the Board at one time without discussion. If a Board member, staff member, or interested person requests that an item be removed from the Consent Calendar, the request will become the first item of business on the agenda.

1.0 MINUTES……………………………………………………………………………………………..3
RECOMMENDATION: Approve the Minutes of the Board of Directors meeting held December 17, 2015.

1.1 TREASURER'S REPORTS…………………………………………………………………….....7
RECOMMENDATION: Receive and file financial statements from December 2015, January and February 2016.

1.2 COMMITTEE STATUS REPORT…………………………………………………………….....25
RECOMMENDATION: Receive and file a status report from the Education and Outreach Committee meeting held on Feb. 1, 2016.

End of Consent Calendar

2.0 BOARD OFFICER ASSIGNMENTS (Memo 785)……………………………………………………….....27

RECOMMENDATION: Nominate and approve new LESJWA Board officer positions of Chair, Vice-Chair, and Treasurer/Secretary for the next two-year term.

3.0 LESJWA ANNUAL FY 2016-17 BUDGET (Memo 786)………………………………………………29

RECOMMENDATION: Approve the FY 2016-17 Budget, and invoice each LESJWA member agency at the start of the new fiscal year based on contribution levels as reflected in the budget.

4.0 FEDERAL LOBBYING (Memo 787)………………………………………………………………….....34

RECOMMENDATION: Receive and file a status report regarding possible joint efforts to secure outside Federal funding.

5.0 LESJWA WATER SUMMIT (Memo 788)…………………………………………………………..….48

RECOMMENDATION: Receive and file a status report regarding the April 27th LESJWA Water Summit.

6.0 LAKE ELSINORE & CANYON LAKE NUTRIENT TMDL INTERIM PROGRESS REPORT (Memo 789)………………………………………………………………………………….........60

RECOMMENDATION: Receive and file the draft Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report prepared by Tim Moore, Risk Sciences.

7.0 WATER QUALITY MODELING AND STUDIES FOR LAKE ELSINORE AND CANYON LAKE Memo 790)…………………………………………………………………………..………………….....86

RECOMMENDATION: Receive and file draft Lake Elsinore and Canyon Lake Water Quality Modeling and Study Report prepared by Dr. Michael Anderson, UCR.

8.0 LAKE ELSINORE/CANYON LAKE TMDL TASK FORCE (Memo 791)……………………….....174

RECOMMENDATION: Receive and file a status report on the Lake Elsinore and Canyon Lake TMDL Task Force.

9.0 ADMINISTRATOR'S COMMENTS

10.0 DIRECTORS' COMMENTS

11.0 ADJOURN

NEXT BOARD OF DIRECTORS MEETING: Thursday, June 16, 2016 at 4:00 p.m.

2016 Remaining Meetings

June 16
August 18
October 20
December 15

MINUTES OF THE
REGULAR BOARD OF DIRECTORS MEETING
OF THE
LAKE ELSINORE & SAN JACINTO WATERSHEDS AUTHORITY

December 17, 2015

DIRECTORS PRESENT	**REPRESENTING**
Robert Magee, Chair	City of Lake Elsinore
Phil Williams	Elsinore Valley Municipal Water District
Vicki Warren	City of Canyon Lake
Kevin Jeffries	County of Riverside
Brenda Dennstedt	Santa Ana Watershed Project Authority

OTHERS PRESENT	
Steve Horn	County of Riverside
Jason Uhley	Riverside County Flood Control & WCD
Liselle DeGrave	DeGrave Communications

LESJWA STAFF	
Karen Williams	LESJWA/ CFO -Finance
Mark Norton	LESJWA/Authority Administrator
Dawna Munson	LESJWA Board Clerk

The Regular Board of Directors meeting of the Lake Elsinore and San Jacinto Watersheds Authority was called to order at 4:01 p.m., by Chair Robert Magee at the Elsinore Valley Municipal Water District, located at 31315 Chaney Street, Lake Elsinore, California. Chair Magee asked for roll call. Representation from all five member agencies was duly noted by the Board Clerk.

Chair Magee asked if there were any comments from members of the public wishing to address the Board on matters within its jurisdiction. There were no public comments.

1.0: CONSENT CALENDAR

Chair Magee presented the Consent Calendar for review and approval. Upon Motion by Director Jeffries, seconded by Director Williams, the motion unanimously carried,

2015/12-1
MOVED, approval of the Consent Calendar including the Treasurer's Reports from June-August 2015, and the Minutes from the October 29, 2015 Board Meeting.

with the following vote:

Ayes:	Dennstedt, Jeffries, Magee, Warren, Williams
Noes:	None
Absent:	None
Abstain:	None

2.0: Report on Audit (Memo #779)

Mark Norton introduced SAWPA/LESJWA CFO Karen Williams to review LESJWA's audit for the fiscal year ending 2015. Ms. Williams said this is the third year of the audit contract with White Nelson Diehl Evans, LLP. LESJWA's financial statements contain no qualifications or reportable conditions. LESJWA's financial reporting meets the generally accepted accounting principles, it is compliant with applicable State and Federal laws, and its internal controls are sufficient to protect against material errors and fraud. It has been sent to the member agency staffs for review as well, and no comments were received.

Upon Motion by Director Williams, and seconded by Director Magee, motion unanimously carried;

2015/12-2
MOVED, receive and file the FY 2014-15 Report on Audit prepared by White Nelson Diehl Evans, LLP, and direct staff to file the Report on Audit with respective government agencies as required by law.

with the following vote:

Ayes:	Dennstedt, Jeffries, Magee, Warren, Williams
Noes:	None
Absent:	None
Abstain:	None

3.0: Lake Watershed Monitoring Program Change Order (Memo #780)

Mark Norton said this item is to recommend approval of a change order to the task order with AMEC Foster Wheeler (AMEC) who is conducting the monitoring program. This change order provides additional technical support to the Lake Elsinore/Canyon Lake TMDL Task Force. It includes 1) modification of the nutrient TMDL In-Lake Monitoring Design; 2) management of historical in-lake water quality monitoring data; and 3) interim TMDL compliance assessment report preparation. It had been agreed that more monitoring was needed monthly rather than every other month, which makes it eight months per year. The Task Force is providing additional data under this change order also to reflect changes requested by the State. The TMDL compliance report will be coming up in June and we want to be able to take the analysis and submit it to the Regional Board. AMEC has that expertise. This work is fully funded by the Lake Elsinore/Canyon Lake TMDL Task Force.

Upon motion by Director Williams, seconded by Director Dennstedt , the motion unanimously carried ,

2015/12-3
MOVED, approval of Change Order No. 1 to Task Order No. AMED160-01 with AMEC Foster Wheeler Environment & Infrastructure, Inc. for an amount not-to exceed $31,500, to provide additional technical support for the Lake Elsinore & Canyon Lake TMDL Task Force.

with the following vote:

Ayes:	Dennstedt, Jeffries, Magee, Warren, Williams
Noes:	None
Absent:	None
Abstain:	None

4.0: Lake Elsinore & Canyon Lake Nutrient TMDL Revision (Memo #781)

Mark Norton said this is a recommendation to authorize an Agreement for Services and a Task Order with CDM Smith for a not-to-exceed amount of $300,000 to initiate the revision and update of the TMDLs. This is a major effort that has been discussed in the past. The TMDL update will reflect the significant amount of new data that has emerged since the LE/CL TMDL was first enacted. Mr. Norton provided a brief background about the formation of the TMDLs; how land use has changed, nutrient loading has changed, policies and permits have changed, and the entire TMDL has been included now under the MS4 Permit. There is also a need for more specificity on compliance in supplying significant data and science.

An open and fair process for bids was conducted for this TMDL revision. Three of the four candidates were deemed qualified for interviews: CDM Smith, Larry Walker & Associates, and Tetra Tech. The review panel believed that CDM Smith is the most qualified, but also was very pleased with Tetra Tech, having much expertise in TMDLs with the EPA, although they didn't have the local expertise. It was determined that Tetra Tech could be the subconsultant to CDM Smith.

As shown in the task order, there is a level of detail associated with the specific tasks, and $300,000 has been budgeted over the next three years, but it will be divided among the three years' time. The work will include the technical documentation, the environmental documentation, and the economic analysis. Staff recommends approval.

Upon motion by Director Williams, seconded by Director Jeffries, the motion unanimously carried.

2015/12-4
MOVED, approval of the General Services Agreement and Task Order No. CDM160-01with CDM Smith, Inc. for an amount not-to-exceed $300,000 to initiate the effort to Revise and Update Lake Elsinore and Canyon Lake Nutrient TMDLs.

with the following vote:

Ayes: Dennstedt, Jeffries, Magee, Warren, Williams
Noes: None
Absent: None
Abstain: None

5.0: Lake Elsinore/Canyon Lake Nutrient TMDL Interim Progress (Memo #782)

Mark Norton said this item is for receive and file of the draft outline for the Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report. Everything that was needed and requested by the LESJWA Board was included. We want to be sure that the alum dosing is safe and effective for the future, and have asked Tim Moore to review the documents. Tim Moore of Risk Sciences is very qualified to put this together, and will be working with AMEC Foster Wheeler. The report will be completed under Risk Sciences' existing contract with LESJWA, and a draft report completed by March 30, 2016; this is a 2015 evaluation. It will help serve as a guide in the future process and also on progress to date. The report will meet the requirements of the LESJWA Board and also the Regional Board. Director Williams commented that he is pleased to see the response to some of the questions that were asked, and that we'll be able to access the information we're looking for.

Upon motion by Director Jeffries, seconded by Director Williams, the motion unanimously carried.

2015/12-5
MOVED, receive and file a Draft Outline for the Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report.

with the following vote:

Ayes: Dennstedt, Jeffries, Magee, Warren, Williams
Noes: None
Absent: None
Abstain: None

6.0: Future Canyon Lake Alum Application CEQA (Memo #783)

This is a recommendation to ratify the Canyon Lake City Council approval action on December 2, 2015 of the CEQA update for future alum dosing, and to file a Notice of Determination for implementation starting in 2016, with funding from Proposition 84 Round 2 Implementation Grant funds. The City of Canyon Lake serves as the lead agency while LESJWA serves as the responsible agency under this CEQA. The existing 2013 CEQA Mitigated Negative Declaration needed to be updated in order to continue the alum dosing. The work was done by Tom Dodson and Associates and paid for by the LE/CL TMDL Task Force. It included the extension of the pilot alum application program in Canyon Lake for ten more years, and expanded the area of alum treatment to include the area above the north causeway at the confluence between the San Jacinto River and Canyon Lake.

Preparing the CEQA documentation and then filing a Notice of Determination allows us to continue use of the grant funds. It is not an authorization to proceed with the alum application, but is a preparatory step.

Upon motion by Director Warren, seconded by Director Williams, the motion unanimously carried.

2015/12-6
MOVED, ratify the Dec 2, 2015 CEQA approval of future Canyon Lake alum applications, and file a Notice of Determination to continue alum dosing in Canyon Lake and continue to use Proposition 84 grant funds.

with the following vote:

Ayes:	Dennstedt, Jeffries, Magee, Warren, Williams
Noes:	None
Absent:	None
Abstain:	None

7.0 Lake Elsinore & Canyon Lake TMDL Task Force Update (Memo #784)

The Task Force met December 2nd and was fully supportive of hiring CDM Smith, Inc. to initiate the TMDL Revision and Update. They discussed moving into the TMDL revision, and one of the first actions was to look into the budget for the next three years so agencies can anticipate costs for their budgets.

Michael Anderson's work continues with the TMDLs – the analysis of both lakes and answering questions that will be important to the TMDL revision. He has had some delays, but is confident he will have the final report to us in January 2016, and we look forward to seeing that.

The Canyon Lake alum application evaluation phase of five applications over 2-1/2 years concluded in September 2015. SAWPA will continue to do the administration and support of the grant funding from DWR. With the upcoming El Nino, we want to do the alum application after the rains finish bringing all those nutrients in; most likely late spring.

Work is continuing on the Operations and Maintenance Agreement for the Lake Elsinore. Tim Moore is working out the nutrient credits and how to provide funding. It's all currently under discussion and it's hoped to be concluded in the next few months.

Upon motion by Director Williams, seconded by Director Dennstedt, the motion unanimously carried.

2015/12-7
MOVED, receive and file an update of the activities of the Lake Elsinore & Canyon Lake TMDL Task Force.

with the following vote:

Ayes:	Dennstedt, Jeffries, Magee, Warren, Williams
Noes:	None
Absent:	None
Abstain:	None

8.0: ADMINISTRATOR'S COMMENTS

None.

9.0: DIRECTORS' COMMENTS

Director Williams requested that in the future, if staff could post both the LESJWA Board minutes and the TMDL meeting notes on the LESJWA website. Chair Magee concurred and asked that the City of Lake Elsinore logo be updated as well.

As there was no further business, Chair Magee adjourned the meeting at 4:40 p.m.

APPROVED: April 21, 2016 ____
Robert Magee, Chair

ATTEST: April 21, 2016 ____
Dawna Munson, Board Clerk

LAKE ELSINORE & SAN JACINTO WATERSHEDS AUTHORITY
CASH FLOW STATEMENT
AS OF 02/29/16

Balance as of 01/31/16		$ 901,803.72
Funds Received		
Deposits:		
DWR - Prop 84 Grant - Inv 4		120,505.61
Open - Grant Invoices		
DWR - Prop 84 Grant - Inv 1 Retention	$ 6,502.99	
DWR - Prop 84 Grant - Inv 2 Retention	$ 2,019.94	
DWR - Prop 84 Grant - Inv 3 Retention	$ 546.38	
DWR - Prop 84 Grant - Inv 4	$ 6,342.64	
	$ 15,411.95	
Open - Member & Other Contributions		
	$ -	
Total Due LESJWA	$ 15,411.95	
Disbursement List - February 2016		(30,130.88)
Funds Available as of 02/29/16		**$ 992,178.45**

Funds Available:	
Checking	$ 156,083.75
LAIF	$ 836,094.70
Total	$ 992,178.45

Lake Elsinore San Jacinto Watersheds Authority
LE/CL TMDL Invoice History
FYE 2009 - 2016

Agency	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
March ARB	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	35,226.00	25,176.00
CalTrans	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	28,656.00	26,072.00
City of Beaumont	2,957.00	3,940.00	4,719.53	3,900.00	1,865.00	19,263.00	24,280.00	26,866.00
City of Canyon Lake	3,670.00	4,890.00	4,109.46	3,396.00	644.00	18,389.00	34,863.00	24,142.00
City of Hemet	22,308.00	29,723.00	27,460.77	22,696.00	6,286.00	18,175.00	25,510.00	27,958.00
City of Lake Elsinore	21,403.00	67,782.00	89,889.28	73,133.00	-	19,381.00	30,580.00	32,463.00
City of Menifee	-	-	24,752.77	20,458.00	23,649.00	44,155.00	55,821.00	23,584.00
City of Moreno Valley	50,638.00	67,469.00	63,546.31	52,520.00	15,425.00	103,565.00	113,058.00	17,750.00
City of Murrieta	2,006.00	2,673.00	786.96	650.00	-	12,426.00	24,280.00	26,866.00
City of Perris	15,000.00	19,985.00	20,060.94	16,580.00	5,752.00	18,869.00	26,739.00	29,050.00
City of Riverside	2,071.00	2,759.00	3,587.28	2,965.00	1,575.00	17,641.00	24,280.00	26,866.00
City of San Jacinto	9,565.00	12,744.00	13,470.59	11,133.00	4,315.00	19,487.00	24,280.00	26,866.00
City of Wildomar	-	-	4,668.93	3,859.00	4,461.00	8,307.00	19,528.00	26,460.00
County of Riverside	57,352.00	76,415.00	39,829.77	32,919.00	-	30,165.00	36,469.00	30,362.00
Dept of Fish and Game	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	18,435.00	28,840.00
Eastern Municipal Water District	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	16,225.00	23,525.00
Elsinore Valley Municipal Water District	13,656.00	57,460.00	75,294.20	61,070.00	-	12,500.00	16,225.00	23,525.00
March JPA	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	24,485.00	27,160.00
San Jacinto Agricultural Operators *	159,074.00	-	-	143,320.00	28,278.00	12,500.00	47,549.00	23,530.58
San Jacinto Dairy & CAFO Operators *	41,634.00	37,252.80	25,000.00	10,000.00	10,211.00	12,500.00	16,225.00	-
Total	451,334.00	433,092.80	447,176.79	508,599.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Paid Contributions	451,334.00	433,092.80	447,176.79	379,290.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Outstanding Contributions	-	-	-	**129,309.00**	-	-	-	-

Lake Elsinore/San Jacinto Watershed Authority
Statement of Net Assets
For the Eight Months Ending Monday, February 29, 2016

Assets	
Checking - US Bank	$156,083.75
L.A.I.F.	836,094.70
Accounts Receivable	15,411.95
Total Assets	$1,007,590.40
Liabilities	
Accounts Payable	107,396.10
Total Liabilities	$107,396.10
Retained Earnings	738,871.80
Excess Revenue over (under) Expenditures	$161,322.50
Total Net Assets	$900,194.30
Total Liabilities and Net Assets	$1,007,590.40

Lake Elsinore/San Jacinto Watershed Authority
Revenues, Expenses and Changes in Net Assets
For the Eight Months Ending Monday, February 29, 2016

	Period Actual	YTD Actual	Annual Budget	% Used	Budget Variance
Revenues					
State Grant Proceeds	$0.00	$126,848.25	$328,000.00	38.67%	$201,151.75
LAIF Interest	0.00	1,486.40	878.00	169.29%	(608.40)
Member Agency Contributions	0.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	0.00	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	***$0.00***	***$725,396.23***	***$970,378.00***	***74.75%***	***$244,981.77***
Expenses					
Salaries - Regular	4,541.48	40,637.43	58,286.86	69.72%	17,649.43
Payroll Burden	1,902.88	17,027.08	24,421.83	69.72%	7,394.75
Overhead	7,230.03	64,694.79	92,791.31	69.72%	28,096.52
Audit Fees	0.00	5,500.00	5,500.00	100.00%	0.00
Consulting - General	57,200.72	433,592.86	785,500.00	55.20%	351,907.14
Legal Fees	0.00	306.25	1,500.00	20.42%	1,193.75
Meeting & Conference Expense	0.00	101.20	100.00	101.20%	(1.20)
Shipping & Postage	0.00	20.29	50.00	40.58%	29.71
Office Supplies	0.00	0.00	60.00	0.00%	60.00
Other Expense	0.00	0.00	50.00	0.00%	50.00
Insurance Expense	0.00	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	0.00	31.83	50.00	63.66%	18.17
Total Expenditures	***$70,875.11***	***$564,073.73***	***$970,378.00***	***58.13%***	***$406,304.27***
Excess Revenue over (under) Expenditures	***($70,875.11)***	***$161,322.50***	***$0.00***	***0.00%***	***($161,322.50)***

Lake Elsinore San Jacinto Watersheds Authority
Revenues, Expenses and Changes in Net Assets by Project
For the Month Ending February 29, 2016

	JPA Administration	TMDL Task Force	Total	Budget	% Used	Budget Variance
Revenues						
State Grant Proceeds	$ -	$ 126,848.25	$ 126,848.25	$ 328,000.00	38.67%	$ 201,151.75
LAIF Interest	1,486.40	-	1,486.40	878.00	169.29%	(608.40)
Member Agency Contributions	100,000.00	110,492.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	-	386,569.58	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	$ 101,486.40	$ 623,909.83	$ 725,396.23	$ 970,378.00	74.75%	$ 244,981.77
Expenditures						
Salaries	$ 15,355.56	$ 25,281.87	$ 40,637.43	$ 58,286.86	69.72%	$ 17,649.43
Benefits	6,433.99	10,593.09	17,027.08	24,421.83	69.72%	7,394.75
G&A Allocation	24,446.06	40,248.73	64,694.79	92,791.31	69.72%	28,096.52
Audit Fees	5,500.00	-	5,500.00	5,500.00	100.00%	-
Consulting	17,641.88	415,950.98	433,592.86	785,500.00	55.20%	351,907.14
Legal Fees	306.25	-	306.25	1,500.00	0.00%	1,193.75
Meeting & Conference Expense	55.20	46.00	101.20	100.00	101.20%	(1.20)
Office Expense	-	-	-	110.00	0.00%	110.00
Other Expense	-	20.29	20.29	50.00	40.58%	29.71
Insurance Expense	2,162.00	-	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	31.83	-	31.83	50.00	63.66%	18.17
Total Expenditures	$ 71,932.77	$ 492,140.96	$ 564,073.73	$ 970,378.00	58.13%	$ 406,304.27
Excess Revenue over (under) Expenditures	$ 29,553.63	$ 131,768.87	$ 161,322.50	$ -	100.00%	$ (161,322.50)
Cash Balance @ 02/29/16	**$ 72,789.33**	**$ 919,389.12**	**$ 992,178.45**			

Lake Elsinore San Jacinto
Watersheds Authority
Disbursements
February 29, 2016

Check #	Check Date	Type	Vendor	Check Amount
* 01045	02/11/2016	Void	Amec Foster Wheeler Environment & Infrastructure	$0.00
1046	02/11/2016	CHK	Amec Foster Wheeler Environment & Infrastructure	$12,151.01
EFT037	02/05/2016	CHK	Santa Ana Watershed Project Authority	$10,965.24
EFT038	02/25/2016	CHK	Risk Sciences	$5,162.13
EFT039	02/25/2016	CHK	DeGrave Communications	$1,852.50

Total Disbursements February 2016	$ 30,130.88

LAKE ELSINORE & SAN JACINTO WATERSHEDS AUTHORITY
CASH FLOW STATEMENT
AS OF 01/31/16

Balance as of 12/31/15		$ 899,654.56
Funds Received		
Deposits:		
LAIF Interest 10/01 - 12/31/15		885.71
City of Menifee - TMDL Contribution		23,584.00
DWR - Prop 84 Grant - Inv 3		10,380.78
Open - Grant Invoices		
DWR - Prop 84 Grant - Inv 1 Retention	$ 6,502.99	
DWR - Prop 84 Grant - Inv 2 Retention	$ 2,019.94	
DWR - Prop 84 Grant - Inv 3 Retention	$ 546.38	
DWR - Prop 84 Grant - Inv 4	$ 126,848.25	
	$ 135,917.56	
Open - Member & Other Contributions		
	$ -	
Total Due LESJWA	$ 135,917.56	
Disbursement List - January 2016		(32,701.33)
Funds Available as of 01/31/16		**$ 901,803.72**

Funds Available:	
Checking	$ 65,709.02
LAIF	$ 836,094.70
Total	$ 901,803.72

Lake Elsinore San Jacinto Watersheds Authority
LE/CL TMDL Invoice History
FYE 2009 - 2016

Agency	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
March ARB	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	35,226.00	25,176.00
CalTrans	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	28,656.00	26,072.00
City of Beaumont	2,957.00	3,940.00	4,719.53	3,900.00	1,865.00	19,263.00	24,280.00	26,866.00
City of Canyon Lake	3,670.00	4,890.00	4,109.46	3,396.00	644.00	18,389.00	34,863.00	24,142.00
City of Hemet	22,308.00	29,723.00	27,460.77	22,696.00	6,286.00	18,175.00	25,510.00	27,958.00
City of Lake Elsinore	21,403.00	67,782.00	89,889.28	73,133.00	-	19,381.00	30,580.00	32,463.00
City of Menifee	-	-	24,752.77	20,458.00	23,649.00	44,155.00	55,821.00	23,584.00
City of Moreno Valley	50,638.00	67,469.00	63,546.31	52,520.00	15,425.00	103,565.00	113,058.00	17,750.00
City of Murrieta	2,006.00	2,673.00	786.96	650.00	-	12,426.00	24,280.00	26,866.00
City of Perris	15,000.00	19,985.00	20,060.94	16,580.00	5,752.00	18,869.00	26,739.00	29,050.00
City of Riverside	2,071.00	2,759.00	3,587.28	2,965.00	1,575.00	17,641.00	24,280.00	26,866.00
City of San Jacinto	9,565.00	12,744.00	13,470.59	11,133.00	4,315.00	19,487.00	24,280.00	26,866.00
City of Wildomar	-	-	4,668.93	3,859.00	4,461.00	8,307.00	19,528.00	26,460.00
County of Riverside	57,352.00	76,415.00	39,829.77	32,919.00	-	30,165.00	36,469.00	30,362.00
Dept of Fish and Game	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	18,435.00	28,840.00
Eastern Municipal Water District	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	16,225.00	23,525.00
Elsinore Valley Municipal Water District	13,656.00	57,460.00	75,294.20	61,070.00	-	12,500.00	16,225.00	23,525.00
March JPA	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	24,485.00	27,160.00
San Jacinto Agricultural Operators *	159,074.00	-	-	143,320.00	28,278.00	12,500.00	47,549.00	23,530.58
San Jacinto Dairy & CAFO Operators *	41,634.00	37,252.80	25,000.00	10,000.00	10,211.00	12,500.00	16,225.00	-
Total	451,334.00	433,092.80	447,176.79	508,599.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Paid Contributions	451,334.00	433,092.80	447,176.79	379,290.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Outstanding Contributions	**-**	**-**	**-**	**129,309.00**	**-**	**-**	**-**	**-**

Lake Elsinore/San Jacinto Watershed Authority
Statement of Net Assets
For the Seven Months Ending Sunday, January 31, 2016

Assets	
Checking - US Bank	$65,709.02
L.A.I.F.	836,094.70
Accounts Receivable	135,917.56
Total Assets	$1,037,721.28
Liabilities	
Accounts Payable	30,130.88
Total Liabilities	$30,130.88
Retained Earnings	738,871.80
Excess Revenue over (under) Expenditures	$268,718.60
Total Net Assets	$1,007,590.40
Total Liabilities and Net Assets	$1,037,721.28

Lake Elsinore/San Jacinto Watershed Authority
Revenues, Expenses and Changes in Net Assets
For the Seven Months Ending Sunday, January 31, 2016

	Period Actual	YTD Actual	Annual Budget	% Used	Budget Variance
Revenues					
State Grant Proceeds	$0.00	$126,848.25	$328,000.00	38.67%	$201,151.75
LAIF Interest	885.71	1,486.40	878.00	169.29%	(608.40)
Member Agency Contributions	0.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	0.00	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	***$885.71***	***$725,396.23***	***$970,378.00***	***74.75%***	***$244,981.77***
Expenses					
Salaries - Regular	3,638.47	36,095.95	58,286.86	61.93%	22,190.91
Payroll Burden	1,524.52	15,124.20	24,421.83	61.93%	9,297.63
Overhead	5,792.45	57,464.76	92,791.31	61.93%	35,326.55
Audit Fees	0.00	5,500.00	5,500.00	100.00%	0.00
Consulting - General	7,014.63	339,871.15	785,500.00	43.27%	445,628.85
Legal Fees	0.00	306.25	1,500.00	20.42%	1,193.75
Meeting & Conference Expense	0.00	101.20	100.00	101.20%	(1.20)
Shipping & Postage	0.00	20.29	50.00	40.58%	29.71
Office Supplies	0.00	0.00	60.00	0.00%	60.00
Other Expense	0.00	0.00	50.00	0.00%	50.00
Insurance Expense	0.00	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	9.80	31.83	50.00	63.66%	18.17
Total Expenditures	***$17,979.87***	***$456,677.63***	***$970,378.00***	***47.06%***	***$513,700.37***
Excess Revenue over (under) Expenditures	***($17,094.16)***	***$268,718.60***	***$0.00***	***0.00%***	***($268,718.60)***

Lake Elsinore San Jacinto Watersheds Authority
Revenues, Expenses and Changes in Net Assets by Project
For the Month Ending January 31, 2016

	JPA Administration	TMDL Task Force	Total	Budget	% Used	Budget Variance
Revenues						
State Grant Proceeds	$ -	$ 126,848.25	$ 126,848.25	$ 328,000.00	38.67%	$ 201,151.75
LAIF Interest	1,486.40	-	1,486.40	878.00	169.29%	(608.40)
Member Agency Contributions	100,000.00	110,492.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	-	386,569.58	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	$ 101,486.40	$ 623,909.83	$ 725,396.23	$ 970,378.00	74.75%	$ 244,981.77
Expenditures						
Salaries	$ 13,480.10	$ 22,615.85	$ 36,095.95	$ 58,286.86	61.93%	$ 22,190.91
Benefits	5,648.17	9,476.03	15,124.20	24,421.83	61.93%	9,297.63
G&A Allocation	21,460.33	36,004.43	57,464.76	92,791.31	61.93%	35,326.55
Audit Fees	5,500.00	-	5,500.00	5,500.00	100.00%	-
Consulting	15,095.00	324,776.15	339,871.15	785,500.00	43.27%	445,628.85
Legal Fees	306.25	-	306.25	1,500.00	0.00%	1,193.75
Meeting & Conference Expense	55.20	46.00	101.20	100.00	101.20%	(1.20)
Office Expense	-	-	-	110.00	0.00%	110.00
Other Expense	-	20.29	20.29	50.00	40.58%	29.71
Insurance Expense	2,162.00	-	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	31.83	-	31.83	50.00	63.66%	18.17
Total Expenditures	$ 63,738.88	$ 392,938.75	$ 456,677.63	$ 970,378.00	47.06%	$ 513,700.37
Excess Revenue over (under) Expenditures	$ 37,747.52	$ 230,971.08	$ 268,718.60	$ -	100.00%	$ (268,718.60)
Cash Balance @ 01/31/16	**$ 78,994.73**	**$ 822,808.99**	**$ 901,803.72**			

Lake Elsinore San Jacinto
Watersheds Authority
Disbursements
January 31, 2016

Check #	Check Date	Type	Vendor	Check Amount
1042	01/08/2016	CHK	Aklufi and Wysocki	$ 87.50
1043	01/08/2016	CHK	Amec Foster Wheeler Environm	$ 16,994.19
1044	01/28/2016	CHK	MWH Americas, Inc.	$ 2,807.08
EFT035	01/14/2016	CHK	Santa Ana Watershed Project	$ 12,487.56
EFT036	01/28/2016	CHK	DeGrave Communications	$ 325.00
			Total Disbursements January 2016	$ 32,701.33

LAKE ELSINORE & SAN JACINTO WATERSHEDS AUTHORITY
CASH FLOW STATEMENT
AS OF 12/31/15

Balance as of 11/30/15		$ 954,571.02
Funds Received		
Deposits:		
None		
Open - Grant Invoices		
DWR - Prop 84 Grant - Inv 1	$ 6,502.99	
DWR - Prop 84 Grant - Inv 2	$ 2,019.94	
DWR - Prop 84 Grant - Inv 3	$ 10,927.16	
DWR - Prop 84 Grant - Inv 4	$ 126,848.25	
	$ 146,298.34	
Open - Member & Other Contributions		
City of Menifee - TMDL Contribution	$ 23,584.00	
	$ 23,584.00	
Total Due LESJWA	$ 169,882.34	
Disbursement List - December 2015		(54,916.46)
Funds Available as of 12/31/15		**$ 899,654.56**

Funds Available:	
Checking	$ 14,445.57
LAIF	$ 885,208.99
Total	$ 899,654.56

Lake Elsinore San Jacinto Watersheds Authority
LE/CL TMDL Invoice History
FYE 2009 - 2016

Agency	FY 2008-09	FY 2009-10	FY 2010-11	FY 2011-12	FY 2012-13	FY 2013-14	FY 2014-15	FY 2015-16
March ARB	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	35,226.00	25,176.00
CalTrans	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	28,656.00	26,072.00
City of Beaumont	2,957.00	3,940.00	4,719.53	3,900.00	1,865.00	19,263.00	24,280.00	26,866.00
City of Canyon Lake	3,670.00	4,890.00	4,109.46	3,396.00	644.00	18,389.00	34,863.00	24,142.00
City of Hemet	22,308.00	29,723.00	27,460.77	22,696.00	6,286.00	18,175.00	25,510.00	27,958.00
City of Lake Elsinore	21,403.00	67,782.00	89,889.28	73,133.00	-	19,381.00	30,580.00	32,463.00
City of Menifee	-	-	24,752.77	20,458.00	23,649.00	44,155.00	55,821.00	23,584.00
City of Moreno Valley	50,638.00	67,469.00	63,546.31	52,520.00	15,425.00	103,565.00	113,058.00	17,750.00
City of Murrieta	2,006.00	2,673.00	786.96	650.00	-	12,426.00	24,280.00	26,866.00
City of Perris	15,000.00	19,985.00	20,060.94	16,580.00	5,752.00	18,869.00	26,739.00	29,050.00
City of Riverside	2,071.00	2,759.00	3,587.28	2,965.00	1,575.00	17,641.00	24,280.00	26,866.00
City of San Jacinto	9,565.00	12,744.00	13,470.59	11,133.00	4,315.00	19,487.00	24,280.00	26,866.00
City of Wildomar	-	-	4,668.93	3,859.00	4,461.00	8,307.00	19,528.00	26,460.00
County of Riverside	57,352.00	76,415.00	39,829.77	32,919.00	-	30,165.00	36,469.00	30,362.00
Dept of Fish and Game	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	18,435.00	28,840.00
Eastern Municipal Water District	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	16,225.00	23,525.00
Elsinore Valley Municipal Water District	13,656.00	57,460.00	75,294.20	61,070.00	-	12,500.00	16,225.00	23,525.00
March JPA	10,000.00	10,000.00	10,000.00	10,000.00	13,050.00	12,500.00	24,485.00	27,160.00
San Jacinto Agricultural Operators *	159,074.00	-	-	143,320.00	28,278.00	12,500.00	47,549.00	23,530.58
San Jacinto Dairy & CAFO Operators *	41,634.00	37,252.80	25,000.00	10,000.00	10,211.00	12,500.00	16,225.00	-
Total	451,334.00	433,092.80	447,176.79	508,599.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Paid Contributions	451,334.00	433,092.80	447,176.79	379,290.00	167,711.00	429,823.00	642,714.00	497,061.58
Total Outstanding Contributions	**-**	**-**	**-**	**129,309.00**	**-**	**-**	**-**	**-**

Lake Elsinore/San Jacinto Watershed Authority
Statement of Net Assets
For the Six Months Ending Thursday, December 31, 2015

Assets	
Checking - US Bank	$14,445.57
L.A.I.F.	885,208.99
Accounts Receivable	169,882.34
Total Assets	$1,069,536.90
Liabilities	
Accounts Payable	32,701.33
Total Liabilities	$32,701.33
Retained Earnings	738,871.80
Excess Revenue over (under) Expenditures	$297,963.77
Total Net Assets	$1,036,835.57
Total Liabilities and Net Assets	$1,069,536.90

Lake Elsinore/San Jacinto Watershed Authority
Revenues, Expenses and Changes in Net Assets
For the Six Months Ending Thursday, December 31, 2015

	Period Actual	YTD Actual	Annual Budget	% Used	Budget Variance
Revenues					
State Grant Proceeds	$0.00	$126,848.25	$328,000.00	38.67%	$201,151.75
LAIF Interest	0.00	600.69	878.00	68.42%	277.31
Member Agency Contributions	0.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	0.00	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	***$0.00***	***$724,510.52***	***$970,378.00***	***74.66%***	***$245,867.48***
Expenses					
Salaries - Regular	4,110.38	32,457.48	58,286.86	55.69%	25,829.38
Payroll Burden	1,722.25	13,599.68	24,421.83	55.69%	10,822.15
Overhead	6,543.73	51,672.31	92,791.31	55.69%	41,119.00
Audit Fees	0.00	5,500.00	5,500.00	100.00%	0.00
Consulting - General	3,132.08	320,705.51	785,500.00	40.83%	464,794.49
Legal Fees	87.50	306.25	1,500.00	20.42%	1,193.75
Meeting & Conference Expense	101.20	101.20	100.00	101.20%	(1.20)
Shipping & Postage	10.00	20.29	50.00	40.58%	29.71
Office Supplies	0.00	0.00	60.00	0.00%	60.00
Other Expense	0.00	0.00	50.00	0.00%	50.00
Insurance Expense	0.00	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	0.00	22.03	50.00	44.06%	27.97
Total Expenditures	***$15,707.14***	***$426,546.75***	***$970,378.00***	***43.96%***	***$543,831.25***
Excess Revenue over (under) Expenditures	***($15,707.14)***	***$297,963.77***	***$0.00***	***0.00%***	***($297,963.77)***

Lake Elsinore San Jacinto Watersheds Authority
Revenues, Expenses and Changes in Net Assets by Project
For the Month Ending December 31, 2015

	JPA Administration	TMDL Task Force	Total	Budget	% Used	Budget Variance
Revenues						
State Grant Proceeds	$ -	$ 126,848.25	$ 126,848.25	$ 328,000.00	38.67%	$ 201,151.75
LAIF Interest	600.69	-	600.69	878.00	68.42%	277.31
Member Agency Contributions	100,000.00	110,492.00	210,492.00	206,125.00	102.12%	(4,367.00)
Other Agency Contributions	-	386,569.58	386,569.58	435,375.00	88.79%	48,805.42
Total Revenues	$ 100,600.69	$ 623,909.83	$ 724,510.52	$ 970,378.00	74.66%	$ 245,867.48
Expenditures						
Salaries	$ 12,037.69	$ 20,419.79	$ 32,457.48	$ 58,286.86	55.69%	$ 25,829.38
Benefits	5,043.80	8,555.88	13,599.68	24,421.83	55.69%	10,822.15
G&A Allocation	19,164.01	32,508.30	51,672.31	92,791.31	55.69%	41,119.00
Audit Fees	5,500.00	-	5,500.00	5,500.00	100.00%	-
Consulting	13,242.50	307,463.01	320,705.51	785,500.00	40.83%	464,794.49
Legal Fees	306.25	-	306.25	1,500.00	0.00%	1,193.75
Meeting & Conference Expense	55.20	46.00	101.20	100.00	101.20%	(1.20)
Office Expense	-	-	-	110.00	0.00%	110.00
Other Expense	-	20.29	20.29	50.00	40.58%	29.71
Insurance Expense	2,162.00	-	2,162.00	2,068.00	104.55%	(94.00)
Interest Expense	22.03	-	22.03	50.00	44.06%	27.97
Total Expenditures	$ 57,533.48	$ 369,013.27	$ 426,546.75	$ 970,378.00	43.96%	$ 543,831.25
Excess Revenue over (under) Expenditures	$ 43,067.21	$ 254,896.56	$ 297,963.77	$ -	100.00%	$ (297,963.77)
Cash Balance @ 12/31/15	**$ 84,975.25**	**$ 814,679.31**	**$ 899,654.56**			

Lake Elsinore San Jacinto
Watersheds Authority
Disbursements
December 31, 2015

Check #	Check Date	Type	Vendor	Check Amount
1037	12/11/2015	CHK	Amec Foster Wheeler Environment and Infrastructure	$ 23,177.27
1038	12/17/2015	CHK	MWH Americas, Inc.	$ 3,780.04
1039	12/17/2015	CHK	Tom Dodson & Associates	$ 850.00
1040	12/17/2015	CHK	White Nelson Diehl Evans LLP	$ 1,350.00
1041	12/17/2015	CHK	Regents of the Univ of Calif	$ 8,673.26
EFT032	12/11/2015	CHK	Santa Ana Watershed Project Authority	$ 7,576.09
EFT033	12/17/2015	CHK	Risk Sciences	$ 7,991.05
EFT034	12/17/2015	CHK	DeGrave Communications	$ 1,518.75
			Total Disbursements December 2015	$ 54,916.46

LESJWA Education and Outreach Committee
Meeting Notes
February 1, 2016

Members Present:	Mark Norton, Chair, SAWPA Nicole Dailey, City of Lake Elsinore Bonnie Woodrome, EVMWD Vicki Warren, City of Canyon Lake
Others Present:	Liselle DeGrave, DeGrave Communications
Members Absent:	Steven Horn, County of Riverside

1. Call to Order

Mark Norton called the meeting to order at 12:10 pm at Elsinore Valley Municipal Water District (EVMWD), located at 31315 Chaney Street, Lake Elsinore, California.

2. Additions/Corrections to the Agenda

None.

3. Approval of the Meeting Notes

The meeting notes from November 3, 2015 were reviewed and deemed acceptable by the Committee.

4. Lake Levels

Lake Levels – The most current lake levels at Lake Elsinore are 1235.20 (January 25), and 1381.13’ at Canyon Lake (January 27). The lake levels from the last meeting at Lake Elsinore were 1235.00 (October 26) and Canyon Lake at 1378.34 (October 26).

5. Project Status

- **Dr. Anderson report – preliminary results –** Mr. Norton reported that a presentation was made at the last TMDL task force meeting by Dr. Michael Anderson about his preliminary results. Overall his models of Lake Elsinore show that recycled water provides a very positive impact on water quality in the long term with the exception of TDS. Further, his presentation showed that supplementation with recycled water on Lake Elsinore had limited effect on mean DO concentration in lake, but increased the range of average water column DO concentrations, with both increased supersaturation and greater episodes of anoxia; had negligible effects on average total N and total P concentrations; and will lower slightly chlorophyll a concentrations. More work is needed to address the other questions posed in his scope of work such as the estimated effects of removing carp and stocking hybrid game fish. Dr. Anderson is now working on the draft final reports, which should be completed in Feb. 2016.

  Nicole Dailey reported that the City of Lake Elsinore would like to get the recommendations. but still will be spending $25k from their budget this year for fish stocking - $10,000 now, $10,000 in April/May and the remainder in June. They will budget for more in 2016/2017 as well.

6. 2015-2016 PR Items

- **Infographic** Liselle DeGrave shared a draft 8 ½” x 11” inforgraphic for the review. Some edits suggested included changing the title to My Watershed(s), explaining CY, and correcting the title to box of San Jacinto Watershed to San Jacinto River Watershed. Mr. Norton said he felt that before releasing the document as final, he wants to be sure that the entire LE/CL TMDL Task Force and the LESJWA Board is okay with it and to provide any additional review comments. A deadline for the comments was set for the end of February.

- **LESJWA Summit Planning** Ms. DeGrave asked the Committee whether the April 2016 timeframe and EMWD Boardroom are still acceptable and desired. Since the last meeting, Nicole Dailey had offered up a city facility for the location.
    - **Date/time**: The Committee agreed that it was probably best to stick with a similar time frame as the last LESJWA Water Summit of holding it from 8:30 am – 11:30 am and not serve lunch
    - **Location:** The Committee agreed that the EMWD Boardroom would still work. Mr. Norton said he would direct the EMWD Boardroom staff coordinator to Liselle.
    - **Invite List:** Ms. DeGrave distributed the contact list. Corrections and additional contacts were suggested including the legislative officials.
    - **Agenda:** Mr. Norton said he would send the agenda from the last LESJWA Water Summit to Ms. DeGrave. Topics and speakers were discussed such as Dr. Anderson, the TMDL revision, a need for a Call to Action. Showing the latest LESJWA videos prepared by DeGrave Communications also was deemed appropriate.
- **Upcoming Events** Ms. DeGrave asked the Committee to share information on upcoming events that they would advise that LESJWA participate in. The following two events were included in the scope.
    - Splash Into Spring, March 12. The Committee agreed it made sense to attend this one.
    - OWOW Conference, date pending. Mr. Norton said he would check to see if SAWPA would be holding an OWOW Conference this year.

  Vicki Warren also recommended that a LESJWA booth be included in the Canyon Lake Fiesta Day on May 28th. Ms. DeGrave will follow up with Ms. Warren on details.

- **Media Outreach** – **Alum Results** Mr. Norton said that an effectiveness report, which is also called the Interim TMDL Compliance Report, will be developed by Mr. Tim Moore of Risk Sciences. The draft report reflecting all the pre- and post-water quality data to the alum application will be prepared by the end of March 2016.

- **Lake Watershed CAPIO Award Entry** Ms. Dailey indicated that she would be submitting a joint application for the California Association of Public Information Officers for the Lake Elsinore Storm Watch program. The submittal of the new LESJWA video also was suggested, but Ms. DeGrave suggested submitting that for consideration next year after she has an opportunity to use it for public outreach and allow time to determine its impact.

7. Next Meeting Date

The next LESJWA Education and Outreach Committee is scheduled for Monday, May 9, 2016 at 12 noon at EVMWD Conference room.

LESJWA MEMORANDUM NO. 785

DATE: April 21, 2016

SUBJECT: Election of Officers

TO: LESJWA Board of Directors

FROM: Mark Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors nominate and approve the officers of the LESJWA Board for a two-year term through December 31, 2017.

DISCUSSION

In accordance with the LESJWA Joint Powers Agreement Article, 5.2 the rotation of LESJWA Board officers is encouraged, and the elections are to be held every two years at the first meeting in January [February]. The current Board officers are City of Lake Elsinore – Chair, SAWPA – Vice Chair, and EVMWD – Secretary/Treasurer.

5.2 Elections.

> Elections of officers shall be conducted every two years in January, in the following order: Chair, Vice Chair, and Secretary-Treasurer. It shall be a policy of the Board to encourage the rotation of the offices among the Board members.

5.3 Installation and Term.

> Officers shall assume the duties of their offices after their election at the first meeting in January and shall hold office until their successors are elected and installed, except in the case of their earlier removal or resignation. Vacancies shall be filled by appointment of the Board, and such appointee shall hold office until the election and installation of his/her successor.

RESOURCES IMPACT

None at this time.

MN:dm

Page Intentionally Blank

LESJWA BOARD MEMORANDUM NO. 786

DATE: April 21, 2016

SUBJECT: FY 2016-2017 Budget

TO: LESJWA Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors approve the FY 2016-2017 LESJWA budget, and invoice each LESJWA member agency at the start of the new fiscal year based on contributions levels as reflected in the budget.

BACKGROUND

The attached budget covers activities of the Authority from July 1, 2016 to June 30, 2017. It also lists the existing projects, studies, and administrative costs associated with operating the agency and implementing TMDL projects. It includes the use of the remaining reserve revenue funding carried over from past member agency contributions for much of the LESJWA administrative activities and to balance the budget. Based on projections of costs for FY 2016-17, funding by member agencies and additional funding provided by the Lake Elsinore/Canyon Lake (LE/CL) TMDL Task Force will be sufficient to cover all projected JPA activities. With increased contributions from the LESJWA member agencies and funding from RCFCWCD, LESJWA's reserve funding is now gradually growing rather than becoming depleted as in past years.

The major activities planned for FY 2016-17 include administration and implementation of the many TMDL tasks for both lakes, including continuing the alum application at Canyon Lake for the water quality improvement project, implementing watershed and lake monitoring, and revision to the LE/CL nutrient TMDL.

In FY 2016-17, the main source of funding coming into LESJWA will continue to be from the TMDL parties that are supporting the TMDL implementation, as well as LESJWA's staff cost for Task Force administration. The source of this funding will be from the TMDL stakeholders; some are the LESJWA member agencies.

As indicated in the recently updated LESJWA Business Plan, one of the primary concerns with the long-term financial outlook for the organization is continued operation funding. With the increased funding from the LESJWA member agencies and the additional funding from RCFCWCD for a three year term between FYE 2015-17, sufficient funding is available for LESJWA to operate at its current operation level. The LESJWA Business Plan laid out the preferred options to deal with the future gap in the following fashion:

1. Pursue State and Federal Grant Funding
2. Decrease annual costs
3. Establish Lake Quality Improvement Contribution
4. Establish TMDL Task Force Contribution for LESJWA
5. Increase Cost Share Among LESJWA Agencies

Staff continues to monitor outside funding sources for future planning and projects that LESJWA can undertake. In the past, LESJWA was successful in obtaining a funding grant of $500,000 from SAWPA's One Water One Watershed application for State Proposition 84 Integrated Regional Water Management Implementation Round 2 Funding Program, which supports the TMDL compliance. The contract term for the grant continues through 2018, so it will be available to support future alum applications at Canyon Lake.

Annual costs for operating LESJWA have been reduced based on past Board direction including a reduced work scope for education and outreach consulting support, the elimination of Board compensation (stipends), and cost reductions incurred by SAWPA staff in support of LESJWA. The need for additional revenue funding arising from adding additional LESJWA member agencies continues to be explored.

Attachment 1, shown as additional information, reflects the final FY 2016-17 LE/CL TMDL Task Force Budget approved by the Task Force on March 22, 2016. Their budget revenue is reflected as "TMDL stakeholder contributions" under Revenue, and "TMDL-Administration" and "TMDL studies and monitoring" under Expenditures.

Staff recommends continuance of the member agency funding contribution amount of $10,000 for the City of Canyon Lake and SAWPA, and $20,000 each from EVWMD, the City of Lake Elsinore, and the County of Riverside. Additional funding of $20,000 for FY 2016-17 from RCFCWCD also is budgeted as agreed to by the joint funding agreement.

RESOURCES IMPACT

SAWPA is conducting a strategic assessment of its Roundtable support activities including LESJWA and the LE/CL TMDL Task Force. The outcome will be shared at the next LESJWA Board meeting. At this time, SAWPA remains supportive of providing staff to serve as administrator for LESJWA. Funding of SAWPA staff time for LESJWA activities will be provided by TMDL stakeholder funding, grant administration funding, and local contributions from LESJWA member agencies.

MN:dm

Attachment:
1. Draft FY 2016-17 LESJWA Budget
2. LE/CL TMDL Task Force Budget FY 2016-17

DRAFT FY 16-17 BUDGET

	FY 15-16 Budget Total	FY 15-16 Actual thru 2/29/16	FY 15-16 Expected Total	FY 16-17 Budget Total
Operating Revenue				
JPA Reserve Transfer				3,570
JPA LAIF Interest	878	1,486	1,486	1,500
Member & Other Agency Contributions*	100,000	100,000	100,000	100,000
JPA Adm Sub Total	100,878	101,486	101,486	105,070
TMDL stakeholder contributions totals	541,500	497,062	497,062	988,406
Member Agency TMDL contributions	106,125	110,492	110,492	179,233
Other TMDL Agency TMDL contributions	435,375	386,570	386,570	809,173
Grant Proceeds				
Canyon Lake Hybrid Project - Alum	328,000	321,400	321,400	172,000
LESJWA Total	970,378	919,948	919,948	1,265,476
Operating Expenditures				
JPA Administration				
Salaries, burden & OH (SAWPA)	71,500	46,236	71,500	71,500
Legal	1,500	306	500	500
Audit	5,500	5,500	5,500	5,500
Insurance	2,068	2,162	2,162	2,260
Meetings and Conference	100	55	100	100
Office Expense	60		60	60
Shipping Postage	50		50	50
Board Compensation				
Other Expense	50		300	50
Interest Expense	50	32	50	50
Public Relations Program	20,000	17,642	20,000	25,000
JPA Adm Subtotal	100,878	71,933	100,222	105,070
TMDL Task Force				
TMDL - Administration (SAWPA)	104,000	76,124	104,000	104,000
TMDL studies & monitoring	565,500	270,162	343,561	816,406
Canyon Lake Lake Treatment	200,000	145,789	232,500	240,000
Total	970,378	564,008	780,283	1,265,476
JPA Reserves Remaining	14,948	72,789	44,500	40,930
TMDL Reserves Remaining	518,020	539,574	351,588	351,588
* Member agency allocation - City of LE	$20,000	$20,000	$20,000	$20,000
* Member agency allocation - EVMWD	$20,000	$20,000	$20,000	$20,000
* Member agency allocation - Co of Riv	$10,000	$20,000	$20,000	$20,000
* Member agency allocation - City of CL	$10,000	$10,000	$10,000	$10,000
* Member agency allocation - SAWPA	$10,000	$10,000	$10,000	$10,000
* Other agency contribution - RCFCWCD		$20,000	$20,000	$20,000

Page Intentionally Blank

Approved FY 2016-17 Budget: Lake Elsinore & Canyon Lake TMDL Task Force

Summary Task Force Expenditures

		Approved Budget 2016-17
	Part A: Task Force Regulatory/Administrative Budget	
1.	**Task Force Administration**	**$ 80,000**
	Task Force Administrator (LESJWA)	
	Annual Water Quality Reporting and Database Management	
	Grant Preparation/Administration	
2.	**TMDL Compliance Expert**	**$ 50,000**
	Risk Sciences	
3.	**Update of Watershed and In-Lake Nutrient Monitoring Program Plans**	**$ -**
	Watershed Monitoring	$ -
	in-lake Monitoring	$ -
3.	**Update of Watershed and In-Lake Nutrient Models**	**$ -**
	Watershed Modeling	$ -
	in-lake Modeling	$ -
3	**Phase 2 Projects**	**$ 50,000**
	Supplemental Project Reserve Fund	$ 50,000
4	**Revise TMDL**	**$ 300,000**
5	**Contingency (10% of budgeted project expenses)**	**$ 48,000**
	TMDL Task Force Regulatory/Administrative Budget	**$ 528,000**
	Part B: TMDL Implementation Project Budget	
1.	**TMDL Compliance Monitoring**	**$ 162,806**
	Watershed-wide Nutrient Monitoring Program	**$ 67,268**
	Watershed-wide Nutrient Monitoring & Report Preparation	$ 67,268
	Wet Year Watershed-wide Monitoring (weather dependent) (RCFC&WCD)	$ -
	Lab Analysis, Watershed-wide Monitoring	$ -
	Lake Elsinore Nutrient Monitoring Program	**$ 46,280**
	Lake Elsinore Nutrient Monitoring & Lab Analysis	$ 46,280
	Real-time Water Quality Monitoring in LE using Existing Data Sondes	$ -
	Canyon Lake Nutrient Monitoring Program	**$ 49,258**
	Canyon Lake Nutrient Monitoring & Lab Analysis	$ 49,258
	Blue Water Satellite Imagery Mapping	$ -
	Special Study: Impact of Salinity on Zooplankton and In-lake water Quality	
	Annual Water Quality Monitoring Program Reporting	$ -
2.	**Lake Elsinore Project Alternatives**	**$ 205,600**
	Aeration & Destratification System O&M (to be handled by separate agreement)	$ 180,600
	LEAMS O&M	
	Fishery Management O&M	$ 25,000
	Carp Removal Program	
3.	**Canyon Lake Project Alternatives**	**$ 92,000**
	Chemical Additions - Alum Dosing (2 applications annually)	$ 200,000
	Prop 84 Grant reimbursement	$ (172,000)
	Effectiveness Monitoring	$ 40,000
	Project Administration (10% of budgeted expenses)	$ 24,000
	TMDL Task Force Implementation Budget	**$ 460,406**

Prop 84 Round 2 IRWM Funding

	Approved Budget 2016-17
Canyon Lake Hybrid Treatment process - Phase 1 (year reimbursement expected)	
Total Grant Funding	

TMDL Task Force Budget Total:	**$ 988,406**

A

Task Force Agency Contributions Summary

1. **Task Force Agency Allocation**

		Approved Budget 2016-17 Total
MS4 Co-Permittees (Total)	**$**	**531,487**
Riverside County	$	68,931
City of Beaumont	$	37,421
City of Canyon Lake	$	37,421
City of Hemet	$	40,178
City of Lake Elsinore	$	37,421
City of Moreno Valley	$	58,014
City of Murrieta	$	37,421
City of Perris	$	45,697
City of Riverside	$	37,421
City of San Jacinto	$	37,421
City of Menifee	$	62,099
City of Wildomar	$	32,042
Elsinore Valley Municipal Water District (EVMWD)	**$**	**30,361**
San Jacinto Agricultural Operators	**$**	**45,785**
San Jacinto Dairy & CAFO Operators	**$**	**-**
CA Department of Transportation	**$**	**37,421**
CA DF&G - San Jacinto Wetlands	**$**	**35,121**
Eastern Municipal Water District	**$**	**27,789**
March Air Reserve Base Joint Powers Authority	**$**	**37,421**
US Air Force (March Air Reserve Base)	**$**	**37,421**
Total Funding Required	**$**	**782,806**

Notes:

Task Force Administration

a. Organize and facilitate TMDL TASK FORCE and TAC meetings,
b. Perform secretarial, clerical and administrative services, including providing meeting summaries to TMDL TASK FORCE members,
c. Manage TMDL TASK FORCE funds and prepare annual reports of TMDL TASK FORCE assets and expenditures,
d. Serve as the contracting party, for the benefit of the TMDL TASK FORCE, for contracts with all consultants, contractors, vendors and other entities,
e. Seek funding grants to assist with achieving goals and objectives of the TMDL TASK FORCE.
f. Coordinate with other agencies and organizations as necessary to facilitate TMDL TASK FORCE work.
g. Administer the preparation of quarterly and annual reports, as required by the TMDL Implementation Plan, and submit them as required by the TMDL Implementation Plan on behalf of the TMDL TASK FORCE.
h. Possible administrator of future pollutant trading (water quality trading) agreements.

Task Force Agency Contributions Detailed Tables

Approved Budget 2016-17

Part A: Task Force Regulatory/Administrative Budget

Task Force Regulatory/Administrative Expenses

	Allocation
MS4 Co-Permittees	**$ 333,474**
Riverside County	$ 27,789
City of Beaumont	$ 27,789
City of Canyon Lake	$ 27,789
City of Hemet	$ 27,789
City of Lake Elsinore	$ 27,789
City of Moreno Valley	$ 27,789
City of Murrieta	$ 27,789
City of Perris	$ 27,789
City of Riverside	$ 27,789
City of San Jacinto	$ 27,789
City of Menifee	$ 27,789
City of Wildomar	$ 27,789
Elsinore Valley Municipal Water District (EVMWD)	**$ 27,789**
San Jacinto Agricultural Operators	**$ 27,789**
San Jacinto Dairy & CAFO Operators	
CALTRANS - freeway	**$ 27,789**
CA DF&G - San Jacinto Wetlands	**$ 27,789**
Eastern Municipal Water District	**$ 27,789**
March Air Reserve Base Joint Powers Authority	**$ 27,789**
US Air Force (March Air Reserve Base)	**$ 27,789**
Funding Required	**$ 528,000**

Part B: TMDL Implementation Project Budget

TMDL Compliance Monitoring Expenses

Watershed-wide Nutrient Monitoring Program **

			Allocation
MS4 Co-Permittees			**$ 55,839**
Riverside County			$ 16,028
City of Beaumont			$ 1,682
City of Canyon Lake			$ 1,682
City of Hemet			$ 1,682
City of Lake Elsinore			$ 1,682
City of Moreno Valley			$ 9,894
City of Murrieta			$ 1,682
City of Perris			$ 4,916
City of Riverside			$ 1,682
City of San Jacinto			$ 1,682
City of Menifee			$ 11,547
City of Wildomar			$ 1,682
Elsinore Valley Municipal Water District (EVMWD)			
San Jacinto Agricultural Operators			**$ 4,702**
San Jacinto Dairy & CAFO Operators			
CALTRANS - freeway			**$ 1,682**
CA DF&G - San Jacinto Wetlands			**$ 1,682**
Eastern Municipal Water District			
March Air Reserve Base Joint Powers Authority			**$ 1,682**
US Air Force (March Air Reserve Base)			**$ 1,682**
Funding Required			**$ 67,268**

** Watershed Monitoring Normalized % Max TP or TN Load (based on load to both lakes projected in 2015)

*Lake Elsinore Nutrient Monitoring Program + Blue Water Satellite Imagery Mapping ***

	Allocation
MS4 Co-Permittees	**$ 30,853**
Riverside County	$ 2,571
City of Beaumont	$ 2,571
City of Canyon Lake	$ 2,571
City of Hemet	$ 2,571
City of Lake Elsinore	$ 2,571
City of Moreno Valley	$ 2,571
City of Murrieta	$ 2,571
City of Perris	$ 2,571
City of Riverside	$ 2,571
City of San Jacinto	$ 2,571
City of Menifee	$ 2,571
City of Wildomar	$ 2,571
Elsinore Valley Municipal Water District (EVMWD)	**$ 2,571**
San Jacinto Agricultural Operators	**$ 2,571**
San Jacinto Dairy & CAFO Operators	$ -
CALTRANS - freeway	**$ 2,571**
CA DF&G - San Jacinto Wetlands	**$ 2,571**
Eastern Municipal Water District	$ -
March Air Reserve Base Joint Powers Authority	**$ 2,571**
US Air Force (March Air Reserve Base)	**$ 2,571**
Funding Required	**$ 46,280**

*Canyon Lake Nutrient Monitoring Program ****

	Allocation
MS4 Co-Permittees	**$ 33,865**
Riverside County	$ 3,079
City of Beaumont	$ 3,079
City of Canyon Lake	$ 3,079
City of Hemet	$ 3,079
City of Lake Elsinore	$ 3,079
City of Moreno Valley	$ 3,079
City of Murrieta	$ 3,079
City of Perris	$ 3,079
City of Riverside	$ 3,079
City of San Jacinto	$ 3,079
City of Menifee	$ 3,079
City of Wildomar	
Elsinore Valley Municipal Water District (EVMWD)	
San Jacinto Agricultural Operators	**$ 3,079**
San Jacinto Dairy & CAFO Operators	
CALTRANS - freeway	**$ 3,079**
CA DF&G - San Jacinto Wetlands	**$ 3,079**
Eastern Municipal Water District	
March Air Reserve Base Joint Powers Authority	**$ 3,079**
US Air Force (March Air Reserve Base)	**$ 3,079**
Funding Required	**$ 49,258**

Lake Elsinore Project Alternatives

Aeration & Destratification System O&M (to be handled by separate agreement)

	Allocation
MS4 Co-Permittees	
Riverside County	
City of Beaumont	
City of Canyon Lake	
City of Hemet	
City of Lake Elsinore	
City of Moreno Valley	
City of Murrieta	
City of Perris	
City of Riverside	
City of San Jacinto	
City of Menifee	
City of Wildomar	
Elsinore Valley Municipal Water District (EVMWD)	
San Jacinto Agricultural Operators	
San Jacinto Dairy & CAFO Operators	
CALTRANS - freeway	
CA DF&G - San Jacinto Wetlands	
Eastern Municipal Water District	
March Air Reserve Base Joint Powers Authority	
US Air Force (March Air Reserve Base)	
Funding Required	**$ -**

*Fishery Management O&M ***

	Allocation
MS4 Co-Permittees	**$ -**
Riverside County	$ -
City of Beaumont	$ -
City of Canyon Lake	$ -
City of Hemet	$ -
City of Lake Elsinore	$ -
City of Moreno Valley	$ -
City of Murrieta	$ -
City of Perris	$ -
City of Riverside	$ -
City of San Jacinto	$ -
City of Menifee	$ -
City of Wildomar	$ -
Elsinore Valley Municipal Water District (EVMWD)	**$ -**
San Jacinto Agricultural Operators	**$ -**
San Jacinto Dairy & CAFO Operators	**$ -**
CALTRANS - freeway	**$ -**
CA DF&G - San Jacinto Wetlands	**$ -**
Eastern Municipal Water District	**$ -**
March Air Reserve Base Joint Powers Authority	**$ -**
US Air Force (March Air Reserve Base)	**$ -**
Funding Required	**$ -**

** based upon Watershed Monitoring Normalized % Max TP or TN Load (based on load to both lakes projected in 2015)

Canyon Lake Project Alternatives

Alum Addition ***			**Allocation**
MS4 Co-Permittees			**$ 77,456**
Riverside County			$ 19,464
City of Beaumont			$ 2,300
City of Canyon Lake			$ 2,300
City of Hemet			$ 5,057
City of Lake Elsinore			$ 2,300
City of Moreno Valley			$ 14,680
City of Murrieta			$ 2,300
City of Perris			$ 7,342
City of Riverside			$ 2,300
City of San Jacinto			$ 2,300
City of Menifee			$ 17,113
City of Wildomar			
Elsinore Valley Municipal Water District (EVMWD)			
San Jacinto Agricultural Operators			**$ 7,644**
San Jacinto Dairy & CAFO Operators			
CALTRANS - freeway			**$ 2,300**
CA DF&G - San Jacinto Wetlands			
Eastern Municipal Water District			
March Air Reserve Base Joint Powers Authority			**$ 2,300**
US Air Force (March Air Reserve Base)			**$ 2,300**
		Funding Required	**$ 92,000**

*** Normalized Multi Criteria Offset Demand or Min Buy in (Alum Project % Need) (based on need projected for 2015)

1) presumes actual CNRP/AGMNP offset demand estimates projected for 2015

2) Negative numbers are shown as "0", Jurisdictions with zero offset demand are not funding partners

3) Proposes 2.5% minimum project buy-in for those with minor offset demands

4) For those entities that have not developed nutrient management plans, offset demand is the load to Canyon Lake in excess of the WLA. WLA is determined by converting the TMDL WLAs into per acre values and then applying to the acreage of these jurisdictions

Task Force Agency Contributions Detailed Tables

	Approved Budget 2016-17 Allocation
MS4 Co-Permittees (Total)	**$ 531,487**
Task Force Regulatory/Administrative Expenses	$ 333,474
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 55,839
Lake Elsinore Nutrient Monitoring Program	$ 30,853
Canyon Lake Nutrient Monitoring Program	$ 33,865
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 77,456
Riverside County *	**$ 68,931**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 16,028
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 19,464
City of Beaumont *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
City of Canyon Lake *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
City of Hemet *	**$ 40,178**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 5,057

City of Lake Elsinore *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
City of Moreno Valley *	**$ 58,014**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 9,894
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 14,680
City of Murrieta *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
City of Perris *	**$ 45,697**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 4,916
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 7,342
City of Riverside *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300

City of San Jacinto *	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
City of Menifee *	**$ 62,099**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 11,547
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 17,113
City of Wildomar *	**$ 32,042**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ -
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ -
Elsinore Valley Municipal Water District (EVMWD)	**$ 30,361**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ -
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ -
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ -
San Jacinto Agricultural Operators	**$ 45,785**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 4,702
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 7,644

San Jacinto Dairy & CAFO Operators	**$ -**
Task Force Regulatory/Administrative Expenses	$ -
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ -
Lake Elsinore Nutrient Monitoring Program	$ -
Canyon Lake Nutrient Monitoring Program	$ -
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ -
CALTRANS - freeway	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300
CA DF&G - San Jacinto Wetlands	**$ 35,121**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ -
Eastern Municipal Water District	**$ 27,789**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ -
Lake Elsinore Nutrient Monitoring Program	$ -
Canyon Lake Nutrient Monitoring Program	$ -
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ -
March Air Reserve Base Joint Powers Authority	**$ 37,421**
Task Force Regulatory/Administrative Expenses	$ 27,789
TMDL Compliance Monitoring Expenses	
Watershed-wide Nutrient Monitoring Program	$ 1,682
Lake Elsinore Nutrient Monitoring Program	$ 2,571
Canyon Lake Nutrient Monitoring Program	$ 3,079
Lake Elsinore Project Alternatives	
Aeration & Destratification System O&M	$ -
Fishery Management O&M	$ -
Canyon Lake Project Alternatives	$ 2,300

US Air Force (March Air Reserve Base)		**$ 37,421**
Task Force Regulatory/Administrative Expenses		$ 27,789
TMDL Compliance Monitoring Expenses		
Watershed-wide Nutrient Monitoring Program		$ 1,682
Lake Elsinore Nutrient Monitoring Program		$ 2,571
Canyon Lake Nutrient Monitoring Program		$ 3,079
Lake Elsinore Project Alternatives		
Aeration & Destratification System O&M		$ -
Fishery Management O&M		$ -
Canyon Lake Project Alternatives		$ 2,300
Total:		**$ 782,806**

footnote: (*) designates MS4 co-permittees

LESJWA BOARD MEMORANDUM NO. 787

DATE: April 21, 2016

SUBJECT: Federal Lobbying

TO: LESJWA Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors discuss and provide direction to staff regarding a proposal from the City of Lake Elsinore to request that LESJWA help secure federal funding for projects benefiting Lake Elsinore in the future.

BACKGROUND

On February 29, 2016, LESJWA staff was contacted to participate in a conference call with the City of Lake Elsinore regarding the possibility of securing federal lobbying assistance. When asked what projects might benefit the Lake, staff referred the group to the Lake Elsinore & San Jacinto Watersheds Authority Business Plan that outlines several proposed water quality projects including ongoing maintenance and capital costs. See pages 18-20.

In addition to this plan, Nicole Dailey of the City of Lake Elsinore also shared some other projects that may benefit the lake as follows:

1. New Ag Pipeline to drop recycled water directly into the lake
2. Needed infrastructure including sewer lines along areas on the east side of our lake where there are no sewer lines
3. Future C-Walls and/or projects to make it easier and encourage development along the lake
4. Clearing the tamarisk and other invasive species on the shorelines, private property areas that create places for the homeless to live and threaten the water quality of the lake.

Another possible project discussed with the City of Lake Elsinore and EVMWD staff included a natural additive product called WatrSavr that could reduce evaporation on the lake. This product could offset the costs of adding recycled water to the lake and help maintain lake levels. Strong interest has been expressed in taking advantage of funding through MWDSC Innovative Conservation Program, but the grant would require a local project commitment of funding for the project to detail the evaporative loss for a test period. With lake levels so low and all EVWMD/City of Lake Elsinore funds for recycled water needed for treatment and delivery of recycled water, no upfront funds are available at this time.

A proposal for Federal lobbying services by David Turch & Assoc. was forwarded from the City of Lake Elsinore for information. See attached. The City staff estimated that the cost for their services would be $24,000-$36,000/year.

RESOURCES IMPACT

Due to very limited LESJWA resources and reserves, no additional funding is readily available from LESJWA to support federal funding unless funding contributions for this purpose were increased.

MN:dm

Page Intentionally Blank

David Turch and Associates

Information Packet For:

Lake Elsinore San Jacinto Watershed Authority

April 15, 2016

David Turch and Associates
517 2nd St NE
Washington, DC 20002
202.543.3744

David Turch and Associates

April 15, 2016

Mark Norton
LESJWA Administrator
11615 Sterling Ave
Riverside, CA 92503
Phone: (951) 354-4220

Dear Mr. Norton:

The fiscal climate in Washington offers fresh sources for federal assistance in areas that interest the Lake Elsinore San Jacinto Watershed Authority (LESJWA) and the regulatory environment requires close monitoring on your behalf.

We have put together an informational packet based on your request and our discussions. We understand many of your needs and desires, including lake remediation, water quality, and economic development. For these reasons and others, it is important that LESJWA have a place at the federal table. We will provide the representation in Washington that you deserve.

Sincerely,

David Turch

Contents

Background on the Firm

David Turch and Associates is a successful, experienced and well respected federal government relations firm. Since 1987, we have provided comprehensive strategic planning, legislative goal setting, intergovernmental liaison and political analysis. We provide these services to a wide range of public sector entities across the country, and to small and large corporations in the United States and abroad.

We maintain close relationships with those we represent. Members of the governing boards of our clients know us personally. We make frequent visits to your area. We listen. We work hard to understand your current needs and your plans for the future. We appreciate the role everyone plays in this essential team effort. Working closely with you and the decision-makers in Washington, D.C. brings success.

David Turch and Associates know Southern California. This offers several advantages to LESJWA. We combine the efforts of local government associations, transportation commissions, water and flood control boards, states, counties, cities and economic development agencies to make all these entities function for you. Clients, elected officials and the media know of and acclaim our work:

"... proven, effective assistance in dealing with [agencies of the federal government]." *San Bernardino Sun* editorial.

"... Turch's company has done a good job for Rialto, bringing millions in federal money to the city through grants and legislations (sic)." *Daily Bulletin* editorial, Ontario, California.

"... Turch has been instrumental in getting... a $5 million appropriation as part of the Intermodal Surface Transportation and Efficiency Act...." *The Californian,* Temecula, California.

"…you guys [David Turch and Associates] make it easy to be welcoming because you are great advocates for communities." a senior EPA official

We bring our knowledge, proven experience and manpower to LESJWA. We have strong personal and professional relationships with the most powerful decision-makers in Washington, D.C. We can link this political force to that of your congressional delegation to form a cooperative effort, providing the best possible chance to achieve your goals.

Next Steps

Members of the firm will travel to you to conduct a workshop. We will meet with the LESJWA Board, staff, and others, at your behest. We will gather and exchange information to develop a better understanding of your needs, interests, and priorities. Together we will develop a strategic plan to achieve your legislative goals and a project list that will help guide our search for appropriate federal resources.

Following this visit, we will begin working with you to prepare the materials necessary to promote your legislative agenda. We will help you draft testimony for use before congressional committees and prepare handouts for Congress. We will be systematic and exhaustive in our search through the executive branch for programs and funding opportunities that meet your priorities.

We will work with you to develop a strategy to win political support and pursue funding for your various priorities. We will flag all relevant grant opportunities and guide you through the application process. We will draft letters of support and whip up signatures on Capitol Hill. We will do what it takes to bring about the results you expect and deserve.

We are already aware of important projects LESJWA that could benefit from an infusion of federal funds and regulatory monitoring.

Restoration of the Lake

A multi-agency, multi-jurisdictional approach may have the best chance of success. It is important to have all the federal, state, and local governments involved in the restoration of Lake Elsinore. The sooner they are engaged in the process, the greater our chance of success. They should be involved in the research and planning for the remediation and restoration of the Lake. The Executive branch of the federal government places an emphasis on these cross agency collaborative efforts.

Water

Urban Waters Small Grants Program, Environmental Protection Agency

The mission of EPA's Urban Waters Program is to help local residents and their organizations, particularly those in underserved communities, restore their urban waters in ways that benefit community and economic revitalization. The Urban Waters Small Grants Program recognizes that healthy and accessible urban waters can help grow local businesses and enhance educational, recreational, social, and employment opportunities in nearby communities.

Source Reduction Assistance Program, Environmental Protection Agency

This funding will be awarded through the EPA's regional offices to support projects that prevent pollution and conserve resources. These projects must focus on the reduction of sources of pollution and should support the national environmental strategies to reduce pollution.

Clean Water Rule, Environmental Protection Agency

The Clean Water Rule has been offered as clarification for aspects of the Clean Water Act. As it is currently drafted, this rule will expand the EPA's enforcement authority under the Clean Water Act by redefining navigable waters to include streams, wetlands, and tributaries. This will offer coverage to approximately sixty percent of the nation's streams and millions of acres of wetlands with the purpose of protecting downstream water quality. It also seeks to regulate water that had previously been under the sole authority of the states and as a result, it is currently being litigated in over twenty states.

Economic Development

Economic Development Administration, U.S. Department of Commerce (EDA)

EDA can be used for a wide variety of activities based on a locally developed comprehensive economic development strategy. The program helps distressed communities to revitalize, expand, and upgrade their physical infrastructure to attract new industry, encourage business expansion, diversify local economies, and generate or retain long-term, private sector jobs and investment. Technical assistance and planning is available also through EDA. EDA applications are currently open and will be accepted on a rolling basis.

As you will see in the following pages, no two projects are alike. We have the knowledge and the relationships to navigate the federal government and deliver wins for our clients.

A Record of Success

David Turch and Associates has successfully represented our clients' needs across a broad range of issues. Projects have spanned from transportation/infrastructure to water/flood control to law enforcement/homeland security. Here are samples of our successes.

Water

On water related projects, we have worked with a number of clients including the cities of Rialto and Colton in the Inland Empire. In this capacity, we worked with Senators Barbara Boxer and Dianne Feinstein and Representatives Joe Baca, Jerry Lewis, Grace Napolitano, and Gary Miller to secure both federal funding and legislative solutions.

Perchlorate Remediation

We have secured over $23 million for perchlorate groundwater remediation in the Rialto-Colton Basin in San Bernardino County. In advocating for our clients, in this particular case for Rialto and Colton, we worked closely with the Department of Defense and the U.S. Environmental Protection Agency (EPA). In addition to helping secure federal funding for treatment wells, we worked to get a 160-acre site in northern Rialto listed on the EPA's National Priorities List (NPL) as a Superfund site. In advancing this issue in Washington, DC, we advocated before House and Senate committees including the Senate Environment and Public Works Committee and the House Natural Resources Committee. We drafted committee testimony and worked with key members of Congress in establishing an authorized groundwater cleanup program under the Department of Interior's Bureau of Reclamation. We have worked as part of a larger coalition of water purveyors in San Bernardino County in successfully advancing our clients' water-related interests.

Los Angeles River Ecosystem Restoration Study

We are working with the City of South Gate, California and the US Army Corps of Engineers in developing park/recreational space along the Los Angeles River that will complement the Corps work on the Los Angeles River Ecosystem Restoration Project. The proposed LA River Ecosystem Restoration Project involves restoring 11 miles of the Los Angeles River from approximately Griffith Park to downtown Los Angeles, while maintaining existing levels of flood risk management. Restoration measures considered include creation and reestablishment of historic riparian strand and freshwater marsh habitat to support increased populations of wildlife and enhance habitat connectivity within the study area, as well as to provide opportunities for connectivity to ecological zones, such as the Santa Monica Mountains, Verdugo Hills, Elysian Hills, and San Gabriel Mountains. Restoration includes the reintroduction of ecological and physical processes, such as a more natural hydrologic and hydraulic regime that reconnects the river to historic floodplains and tributaries, reduced flow velocities, increased infiltration, improved natural sediment processes, and improved water quality. The proposed Project also includes opportunities for passive recreation that is compatible with the restored environment.

USACE and Prado Basin Ecosystem Restoration Project

We worked with the City of Ontario, the US Army Corps of Engineers' Los Angeles District Office and a host of other stakeholders in securing funding for the restoration of the Prado Basin ecosystem project. The project is designed to create a wetland ecosystem for a variety of plants and wildlife within the Prado Basin, with feed waters from Mill Creek in the City of Ontario. The wetland will be comprised of a series of treatment ponds fitted into the existing topographic features of the Prado Regional Park area. The wetland is envisioned to be a regional amenity providing opportunities for habitat enhancement, recreations, and public education. The wetland will also provide a natural treatment system for storm water and urban runoff entering into the Middle and Upper Santa Ana River watershed.

EPA

We have assisted Fallon County, Montana with EPA mandated wetlands restoration efforts on Baker Lake. The County was required to develop a plan to restore 7.58 acres of wetlands in Lower Baker Lake and to mitigate potential disruption to 1.83 acres in Upper Baker Lake subject to EPA approval. We are currently working closely with EPA Officials in Washington and Montana, and with the County to secure the necessary approvals so that work can commence before the close of 2016.

Through our advocacy work with EPA in 2015, we were able to help the City of Rialto partner with the agency to establish a job training program aimed at helping prepare young adults in Rialto for employment opportunities in the hazardous waste cleanup industry. The Superfund Job Training Initiative (SuperJTI) program combines extensive classroom instruction with hands-on training exercises for each participant. SuperJTI graduates have the technical skills to work on a broad range of construction, environmental remediation, and cleanup projects at Superfund sites. EPA offers SuperJTI training through its Technical Assistance Services for Communities (TASC) contract, which provides training and independent technical assistance to communities. TASC provides assistance to communities affected by hazardous waste sites regulated by the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), commonly known as Superfund, and the Resource Conservation and Recovery Act (RCRA). Rialto's first SuperJTI class was graduated this past summer and participants have already begun accepting job offers.

Economic Development

On behalf of the City of Imperial, California, we have been diligently holding meetings over the past couple of years with officials from the Commerce Department's Economic Development Administration (EDA), both here in Washington, D.C. and with their regional office in southern California.

Our work with EDA was successful in 2013 when the City of Imperial secured a $3,000,000 EDA grant to fund the extension of water, wastewater, and the construction of surface road and other improvements along Neckel Road. This project supports the development of the Alliance and Innovative Regional Center, an USCIS approved EB-5 green card investment regional center, which will include a hotel, retail center, and office park. This project supports foreign direct investment and global competitiveness. This investment is part of a $3,828,375 project that will create an estimated 642 jobs and leverage $22.25 million in private investment.

.

Staff Biographies: Our Firm; Your Team

David Turch and Associates has the right people. Our bipartisan firm has the institutional and relational knowledge to expertly navigate the legislative labyrinth of Washington. Our whole advocacy team will work to promote and advance your federal agenda.

David Turch

David Turch served more than fifteen years as a legislative aide with Members of both the U.S. House and Senate and both major political parties. A former Division Director for two of the nation's largest independent public relations firms, David achieved substantial expertise in the development of successful government marketing strategies. In August of 1987 he founded David Turch and Associates at its present location on Capitol Hill. David was graduated from Saint John's University with majors in economics and business administration.

The Honorable Elton Gallegly (R-CA)

Elton Gallegly is a consultant for the firm. He served as a Member of Congress from California from 1987 to 2013. Mr. Gallegly was a member of the Committee on Foreign Affairs, rising to the position of Vice Chair. He was also on the powerful Judiciary panel. In this capacity he oversaw US policies on courts, commerce, administrative law, and immigration. He was Chairman of the Subcommittee on Immigration Policy and Enforcement. Having served in the US House for twenty-six years, Mr. Gallegly maintains a robust network of contacts in the Congress.

The Honorable Gary Condit (D-CA)

We have a close working relationship with Mr. Condit. He was a Member of Congress from California from 1993 to 2003, where he rose to a senior position on the House Intelligence Committee. Since leaving the House of Representatives, Mr. Condit moved to Arizona, where he has been successful in business. He is also the President of the Phoenix Institute of Desert Agriculture.

Marilyn Campbell

Marilyn Campbell is our chief operating officer. A native Washingtonian, Marilyn brings extensive management and political experience including staff service on the House Rules Committee, the most powerful committee in Congress. Ms. Campbell also served as a staff member to the Senate Committee on Energy and Natural Resources and the Senate Committee on the Judiciary. Subsequently, Marilyn managed some of Washington's top law firms and the Washington office of Ferranti International of the United Kingdom, one of the world's leading defense contractors.

Jamie Jones

Jamie Jones worked for twelve years in the U.S. House of Representatives. As a senior level staffer for a member from Southern California, Jamie managed the legislative operations of the office and worked closely with both the Republican and Democratic leadership of the House. Jamie worked as a consultant/advance representative on a congressional campaign in New York. He was also a senior associate for a New York-based financial institution. Jamie holds an advanced degree in International Affairs from The American University.

Victor Tambone, Col, USAF (Ret.)

Victor Tambone served the country as an Air Force officer for twenty-four years, rising to the rank of colonel. In addition to being a pilot, staff officer, and commander, he served with distinction in the Office of Legislative Liaison for the Secretary of the Air Force. Tambone also served as a program manager for aircraft acquisition, an Advance Agent for Presidential Flight Support, and the military aide to Secretary Henry Kissinger. President George W. Bush appointed Mr. Tambone as the first Chief of Staff, Science and Technology Directorate, U.S. Department of Homeland Security, where he served as special advisor to the members of the Under Secretary's immediate staff and also as a liaison to other components of the Department, the Administration, and the US Congress. Victor Tambone attended the Virginia Military Institute, and graduated from the United States Air Force Academy. He earned a Bachelor of Science degree in aeronautic engineering and a minor in astronautic engineering. He also holds a Masters degree in international politics from Webster University and is a graduate of the Harvard University, Kennedy School of Government, National Preparedness Leadership Institute.

Kodiak Hill-Davis

Kodiak Hill-Davis brings experience in both the legislative and regulatory process. Ms. Hill-Davis initially joined David Turch & Associates in 2007 after serving on the staff of Congresswoman Nancy L. Johnson. She has worked extensively on behalf of both public and private sector clients on a wide range of initiatives. Whether standing up a judicial program specifically to combat domestic violence or negotiating a land release with the Veterans Administration, Ms. Hill-Davis has been instrumental in helping our clients succeed. Ms. Hill-Davis earned dual degrees in Political Science and History from Smith College and a J.D. from George Mason University where she focused on regulatory law and analysis.

Kevin Bosch

Kevin Bosch is the director of legislative research; he monitors the activities of Congressional committees and agencies of the Executive Branch. Mr. Bosch provides the firm with a solid business perspective from his work as manager of Georgetown Pipe and Tobacco, an internationally renowned firm. Mr. Bosch holds an advanced degree in Comparative Politics from The American University.

Page Intentionally Blank

LESJWA BOARD MEMORANDUM NO. 788

DATE: April 21, 2016

SUBJECT: 2016 LESJWA Water Summit

TO: LESJWA Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors receive and file this status report for the upcoming LESJWA Water Summit scheduled for Wednesday, April 27th at EVMWD's Boardroom.

BACKGROUND

The LESJWA Water Summit has been held annually since 2012, although the 2015 Summit was deferred to 2016. The last Summit was held on April 23, 2014 at Eastern Municipal Water District's (EMWD) Board Room. The Summit provides an opportunity to invite elected officials and staff of the Lake Elsinore and Canyon Lake TMDL Task Force parties to provide important background and support about LESJWA's role, the nutrient TMDLs, and implementation projects like the Canyon Lake alum application. Costs for the event have decreased significantly over time due to the use of a public facility, and ending the event before the lunch hour. The location of the Summit originally was scheduled again for EMWD similar to previous years, but due to remodeling being conducted at EMWD, the location of the LESJWA Summit was moved to the recently remodeled EVMWD. The budget costs for this event were included in the DeGrave Public Relations' contract. Approximately 50 people have attended in the past.

The 2016 LESJWA Summit has been scheduled for April 27, 2016 from 8:30 am – 11:30 am at the EVMWD Boardroom in the City of Lake Elsinore. Attached is an agenda for the event showing the speakers and topics as recommended by the LESJWA Board and the LESJWA Education and Outreach Committee. The invitation (attached) to the event included a short message from the Riverside County Supervisors encouraging participants to attend. The Summit invite list also is attached.

RESOURCES IMPACT

Sufficient funding was provided in the approved LESJWA FY 2015-16 Budget under the Education and Outreach program for the LESJWA Summit.

MN:dm

Lake Elsinore & San Jacinto Watersheds Authority

City of Lake Elsinore • City of Canyon Lake • County of Riverside
Elsinore Valley Municipal Water District • Santa Ana Watershed Project Authority

LESJWA WATER SUMMIT

April 27, 2016, 8:30 a.m. – 11:30 a.m.

Elsinore Valley Municipal Water District
31315 Chaney Street, Lake Elsinore, CA 92530

Continental Breakfast
8 a.m. - 8:30 a.m.

Welcome
LESJWA Chair
8:30 a.m. - 8:45 a.m.

Lake-Watershed Connections, Lake Challenges and LESJWA Accomplishments
Mark Norton, LESJWA Authority Administrator
8:45 a.m. - 9:00 a.m.

Lake Elsinore History and Plan Forward
Nicole Dailey, City of Lake Elsinore
9:00 a.m. - 9:15 a.m.

Quail Valley Prohibition, Nutrient TMDLs & Revisions, and Task Force Benefits
Kurt Berchtold, Santa Ana Regional Water Quality Control Board
9:15 a.m. - 9:35 a.m.

MS4 Stormwater Permit and TMDL Costs & Savings
Jason Uhley, Riverside County Flood Control and Water Conservation District
9:35 am- 10:00 am

Break
10:00 a.m. - 10:15 a.m.

Agricultural and Dairy Operator Nutrient Reduction in the San Jacinto Watershed
Pat Boldt, Western Riverside County Agricultural Coalition
10:15 a.m. - 10:40 a.m.

Canyon Lake Operations and Drought Impacts
Brian Dickinson, Elsinore Valley Municipal Water District
10:40 a.m. - 11:05 a.m.

Canyon Lake Alum Application Video Presentation
11:05 a.m. - 11:10 a.m.

Canyon Lake and Lake Elsinore: Past, Present & Future
Dr. Michael Anderson, University of California Riverside
11:10 a.m. - 11:30 a.m.

Close

LESJWA Summit RSVP as of April 13, 2016

First Name:	Last Name:	Company:	Job Title:	
Dr. Michael	Anderson	University of California Riverside	Associate Dean	
Kurt	Berchtold	Santa Ana Regional Water Quality Control Board	Executive Officer	
Pat	Boldt	Western Riverside County Agricultural Coalition	Executive Director	
George	Cambero	Elsinore Valley Municipal Water District	Board Director	
Nicole	Dailey	City of Lake Elsinore	Senior Management Analyst	
Brian	Dickinson	Elsinore Valley Municipal Water District	District Operations Manager	
Maryann	Edwards	Office of Senator Jeff Stone / City of Temecula	District Director, Southwest / Mayor Pro Tem	
Mike	Emberton	City of San Jacinto	Former Asst. City Manager	
Cynthia	Gabaldon	CG Resource Management and Engineering, Inc.	Principal Engineer	
Kyle	Gallup	RCFC&WCD	Engineering Project Manager	
Jeffrey	Giba	City of Moreno Valley-City Council Office	Mayor Pro Tem	
Jennifer	Hemmert	CDFW	Environmental Scientist (Fish Biologist)	
Steve	Horn	Riverside County Executive Office	Sr. Managament Analyst	
Nancy	Horton	Elsinore Valley Municipal Water District	Board Director	
Jonathan	Ingram	City of Murrieta	Council Member	
Kristen	Jensen	City of Hemet	Deputy Public Works Director	
Lynn	Merrill	City of San Jacinto	Public Works Consultant	
Alex	Meyerhoff	City of Hemet	City Manager	
Andy	Morris	Elsinore Valley Municipal Water District	Board Member	
Linda	Nixon	City of Hemet Public Works Department	Environmental Services Manager	
Mark	Norton	Santa Ana Watershed Project Authority	Water Resources & Planning Manager	
Nem	Ochoa	Elsinore Valley Municipal Water District	Assistant General Manager - Engrg. and Operations	
James	Ozouf	City of Murrieta	Associate Civil Engineer	
Steven	Pastor	Riverside County Farm Bureau	Executive Director	
Harry	Ramos	City of Murrieta	Council Member	
K. Paul	Raver	City of Hemet & SJ Water Master	Mayor Pro Tem	
Harvey	Ryan	Elsinore Valley Municipal Water District	Board Member	
Scott	Sewell	California Department of Fish and Wildlife	WHS II	
Lesa	Sobek	City of Menifee	City Councilwoman	
Rita	Thompson	City of Lake Elsinore	Senior Engineering Technician - NPDES	
Jason	Uhley	Riv. County Flood Control and Water Conservation	Assistant Chief Engineer	
John	Vega	Elsinore Valley Municipal Water District	General Manager	
Phil	Williams	Elsinore Valley Municipal Water District	Board Member	
Bonnie	Woodrome	Elsinore Valley Municipal Water District	Public Affairs Representative	
Bonnie	Wright	City of Hemet	Mayor	
Bruce	Yarbrough	Canyon Lake Poa	President	
Brenda	Dennstedt	LESWJA Board Director	Santa Ana Watershed Project Authority	Board Director, Div. 3
Kevin	Jeffries	LESWJA Board Director	County of Riverside	Supervisor, First District
Vicki	Warren	LESWJA Board Director	City of Canyon Lake	City Council Member
Robert	Magee	LESWJA Board Director	City of Lake Elsinore	Mayor Pro Tem
Phil	Williams	LESWJA Board Director	Elsinore Valley Municipal Water District	Board Director, Div. 4

LESJWA WATER SUMMIT INVITE FINAL

Name	Position	Email	NOTES	RSVP
Santa Ana Regional Water Quality Control Board				
William P. von Blasingame	Board Member		Email	
James Famiglietti	Board Member	jfamigli@uci.edu		
William Ruh	Chair	bruh@ci.montclair.ca.us		
Linda Ackerman	Vice Chair	lackerman@waterboards.ca.gov		
Tom Rivera	Board Member	trivera@waterboards.ca.gov		
Susan Longville	Board Member	slongville@waterboards.ca.gov		
Kurt Berchtold	Executive Officer	kberchtold@waterboards.ca.gov		
Eastern Municipal Water District				
Joseph Kuebler	Board Treasurer	joe.kuebler@pkckuebler.com		
Philip E. Paule	Board Director	Philip.Paule@bos.sbcounty.gov		
Randy A. Record	Board President	rrecord@att.net		
David Slawson	Board Vice President	slawson@wai-eng.com		
Ronald Sullivan	Board Director	boardmember@emwd.org		
Paul D. Jones II, P.E.	General Manager	jonesp@emwd.org		
City of Beaumont				
Dr. Delia Condon	Council Member	dellamayc@gmail.com		
Mark Orozco	Council Member	mark@markorozco.com		
Lloyd White	Mayor Pro Tem	ourfocusourkids@gmail.com		
Brenda Knight	Council Member	brendajoy4u@gmail.com		
Mike Lara	Mayor	bmtcouncilmembermikelara@yahoo.com		
Elizabeth Gibbs-Urtiaga	Acting City Manager	elizabethu@beaumontcares.com		
Kyle Warsinski	Development Services Director	kwarsinski@ci.beaumont.ca.us		
City of San Jacinto				
Mark Bartel	Mayor Pro Tem	mbartel@sanjacintoca.us		
Crystal Ruiz	Council Member	cruiz@sanjacintoca.us		
Andrew Kotyuk	Council Member	akotyuk@sanjacintoca.us		
Scott Miller	Mayor	smiller@sanjacintoca.us		

LESJWA WATER SUMMIT INVITE FINAL

Alonso Ledezma	Council Member	aledezma@sanjacintoca.us		
Tim Hults	City Manager	thults@sanjacintoca.us		
Mike Emberton	Public Works Director	MEmberton@sanjacintoca.us		
City of Murrieta				
Rick Gibbs	Mayor Pro Tem	rgibbs@murrieta.org		
Jonathan Ingram	Council Member	jingram@murrieta.org		
Randon Lane	Mayor	rlane@murrieta.org		
Alan Long	Council Member	along@murrieta.org		
Harry Ramos	Council Member	hramos@murrieta.org		
Rick Dudley	City Manager	rdudley@murrieta.org		
Kim Summers	Assistant City Manager	ksummers@murrieta.org		
Bill Woosley	Civil Engineer Associate, Land Dev	wwoolsey@murrieta.org		
City of Hemet				
Robert Youssef	Council Member	ryoussef@cityofhemet.org		
Paul Raver	Mayor Pro Tem	praver@cityofhemet.org		
Shellie Milne	Council Member	smilne@cityofhemet.org		
Bonnie Wright	Mayor	bwright@cityofhemet.org		
Linda Krupa	Council Member	lkrupa@cityofhemet.org		
Alexander Meyerhoff	City Manager	ameyerhoff@cityofhemet.org		
Steven Latino	City Engineer	slatino@cityofhemet.org		
Ron Proze	Water/ Waste Water Superintend	rproze@cityofhemet.org		
Linda Nixon	Environmental Services Manager	lnixon@cityofhemet.org		
City of Moreno Valley				
Jeffrey Giba	Mayor Pro Tem	jeffg@moval.org		
Dr. Yxstian Gutierrez	Mayor	yxstiang@moval.org		
Jesse Molina	Council Member	jessem@moval.org		
George Price	Council Member	georgep@moval.org		
D. LaDonna Jempson	Council Member	ladonnaj@moval.org		
Michelle Dawson	City Manager	cmoffice@moval.org		

LESJWA WATER SUMMIT INVITE FINAL

Ahmad Ansari	Public Works Director/City Engine	ahmada@moval.org		
Allen Brock	Community Development Directo	allenb@moval.org		
Hoang Nguyen	Storm Water Protection	hoangn@moval.org		
City of Perris				
Daryl Busch	Mayor	dbusch@cityofperris.org		
David Starr Rabb	Council Member	dstarrrabb@cityofperris.org		
Tonya Burke	Council Member	tburke@cityofperris.org		
Rita Rogers	Mayor Pro Tem	rrogers@cityofperris.org		
Mark Yarbrough	City Council	Myarbrough@cityofperris.org		
Ron Carr	Assistant City Manager	rcarr@cityofperris.org		
Richard Belmudez	City Manager	rbelmudez@cityofperris.org		
City of Menifee				
Scott Mann	Mayor	smann@cityofmenifee.us		
John Denver	Council Member	jdenver@cityofmenifee.us		
Greg August	Council Member	gaugust@cityofmenifee.us		
Matt Liesemeyer	Council Member	mliesemeyer@cityofmenifee.us		
Lesa Sobek	City Council	lsobek@cityofmenifee.us		
Robert Johnson	City Manager	rjohnson@cityofmenifee.us		
Rudy Luna	Public Works Supervisor	rluna@cityofmenifee.us		
Steve Glynn	Public Works Manager	sglynn@cityofmenifee.us		
Dennis Bechter	Consultant on LE/CL TMDL TF	dbechter@cityofmenifee.us		
City of Wildomar				
Timothy Walker	Mayor Pro Tem	twalker@cityofwildomar.org		
Marsha Swanson	Council Member	mswanson@cityofwildomar.org		
Bob Cashman	Council Member	bcashman@cityofwildomar.org		
Bridgette Moore	Mayor	bmoore@cityofwildomar.org		
Ben Benoit	Council Member	bbenoit@cityofwildomar.org		
Gary Nordquist	City Manager	gnordquist@cityofwildomar.org		
Dan York	Public Works Director/City Engine	dyork@cityofwildomar.org		

LESJWA WATER SUMMIT INVITE FINAL

Craig McKenzie, Chairman	Wildomar Chamber of Commerce	admin@wildomarchamber.org		
March Joint Powers Authority				
Daryl Busch	Chairman	dbusch@cityofperris.org		
Marion Ashley	Commissioner	mashley@rcbos.org		
Mike Gardner	Commissioner	mgardner@riversideca.gov		
Rita Rogers	Commissioner	rrogers@cityofperris.org		
Kevin Jeffries	Commissioner	district1@rcbos.org		
Dr. Yxstian Gutierrez	Commissioner	yxstiang@moval.org		
Andy Melendrez	Past Chairman	asmelendrez@riversideca.gov		
Jeffrey Giba	Vice Chairman	jeffg@moval.org		
Danielle Wheeler	Executive Director	wheeler@MarchJPA.com		
City of Canyon Lake				
Dawn Haggerty	Mayor Pro Tem	dhaggerty@cityofcanyonlake.com		
Vicki Warren	Council Member	vwarren@cityofcanyonlake.com		
John Zaitz	Council Member	jzaitz@cityofcanyonlake.com		
Tim Brown (LESJWA Alt. Dire	Mayor	tbrown@cityofcanyonlake.com		
Jordan Ehrenkranz	Council Member	jehrenkranz@cityofcanyonlake.com		
Ariel Hall	Interim City Manager	amhall@cityofcanyonlake.com		
Larry Cressy	President, Canyon Lake Chamber	admin@canyonlakechamber.net		
Chris Mitchell	General Manager, Canyon Lake P	chrismitchell@canyonlakepoa.com		
Bruce Yarbrough	Board President, Canyon Lake PO	byarbrough@canyonlakepoa.com		
City of Lake Elsinore				
Robert Magee (Chair, LESJW	Mayor Pro Tem	rmagee@lake-elsinore.org		
Natasha Johnson	Council Member	njohnson@lake-elsinore.org		
Daryl Hickman (Alt. Director,	Council Member	dhickman@lake-elsinore.org		
Steve Manos	Council Member	smanos@lake-elsinore.org		
Brian Tisdale	Mayor	btisdale@lake-elsinore.org		
Grant Yates	City Manager	gyates@lake-elsinore.org		
Rita Thompson	Senior Engineering Technician	rthompson@lake-elsinore.org		

LESJWA WATER SUMMIT INVITE FINAL

Rick De Santiago	Public Works Superintendent	rdesantiago@lake-elsinore.org		
City of Riverside				
Rusty Bailey	Mayor	RBailey@Riversideca.gov		
Mike Gardner	Ward 1	mgardner@riversideca.gov		
Andy Melendrez	Ward 2	asmelendrez@riversideca.gov		
Mike Soubirous	Ward 3	msoubirous@riversideca.gov		
Paul Davis	Ward 4	pdavis@riversideca.gov		
Chris Mac Arthur	Ward 5	cmacarthur@riversideca.gov		
Jim Perry	Ward 6	jperry@riversideca.gov		
John Burnard	Ward 7	jburnard@riversideca.gov		
County of Riverside				
Kevin Jeffries (Director, LESJV	Supervisor, 1st District	district1@rcbos.org		
Chuck Washington	Supervisor, 3rd District	district3@rcbos.org		
John Tavaglione	Supervisor, 2nd District	District2@rcbos.org		
John J. Benoit	Supervisor, 4th District, Chairman	District4@rcbos.org		
Marion Ashley (Alt. Director,	Supervisor, 5th District	District5@rcbos.org		
Jay Orr	Deputy County Executive Officer	ceo@rceo.org		
Steven Horn	Senior Management Analyst	shorn@rceo.org		
Elsinore Valley Municipal Water District				
Nancy Horton	Director	nhorton@evmwd.net		
Phil Williams (Director, LESJW	President	pwilliams@evmwd.net		
Andy Morris	Treasurer	amorris@evmwd.net		
George Cambero	Director	gcambero@evmwd.net		
Harvey R. Ryan	Vice President	hryan@evmwd.net		
SAWPA Commission				
Terry Catlin	Commissioner	tcatlin@ieua.org		
Brenda Dennstedt (Director,	Alternate Commissioner	BDennstedt@wmwd.com		
Phil Anthony	Commissioner	panthony@ocwd.com		
Ron Sullivan	Secretary- Treasurer	Rsullivan888@verizon.net		

LESJWA WATER SUMMIT INVITE FINAL

David Slawson	Alternate Commissioner	slawson@wai-eng.com		
Ed Kilgore	Vice Chair	mr7ebk@aol.com		
Tom Evans	Commissioner	evanswmwd@gmail.com		
Celeste Cantú	General Manager	ccantu@sawpa.org		
***LESJWA Key Staff**				
Mark Norton	LESJWA Authority Administrator	mnorton@sawpa.org		
Karen Williams	LESJWA Finance Officer	kwilliams@sawpa.org		
Dawna Munson	LESJWA Board Secretary	dmunson@sawpa.org		
Rick Whetsel	TMDL Task Force Project Manage	rwhetsel@sawpa.org		
***LESJWA Board Member Support Staff**				
Jeff Greene	Chief of Staff, Supv Jeffries	jtgreene@rcbos.org		
Susie Evans	EVMWD Administrative Assistant	sevans@evmwd.net		
Joyce McCarthy	EVMWD Administrative Assistant	jmccarthy@evmwd.net		
Ariel Hall	Interim City Manager	amhall@cityofcanyonlake.com		
Terese Quintanar	EVMWD Board Secretary	terese@evmwd.net		
Kristen Huyck	Executive Assistant, Supv Jeffries	KHuyck@RCBOS.org		
Diana Giron	Acting City Clerk, Lake Elsinore	dgiron@lake-elsinore.org		
Lake Elsinore School District Board				
Heidi Matthies Dodd	Board Member	heidi.dodd@leusd.k12.ca.us		
Juan Saucedo	President	Juan.Saucedo@leusd.k12.ca.us		
Stan Crippen	Clerk	Stan.crippen@leusd.k12.ca.us		
Susan E. Scott	Board Member	sue.scott@leusd.k12.ca.us		
Harold Stryker	Board Member	harold.stryker@leusd.k12.ca.us		
Western Riverside County Regional Conservation Authority				
Marion Ashley	Vice Chairperson, County of Riverside Fifth District Supervisor	district5@rcbos.org		
George Moyer	Board Member, City of Banning	gmoyer@ci.banning.ca.us		
Brenda Knight	Board Member, City of Beaumont	brendajoy4u@gmail.com		

LESJWA WATER SUMMIT INVITE FINAL

Jeffry Hewitt	Board Member, City of Calimesa	jhewitt@cityofcalimesa.net		
Tim Brown	Board Member, City of Canyon La	tbrown@cityofcanyonlake.com		
Eugene Montanez	Chairperson, City of Corona	emontanez@ci.corona.ca.us		
Andy Melendrez	Board Member, City of Riverside	asmelendrez@riversideca.gov		
Maryann Edwards	Board Member, City of Temecula	maryann.edwards@citycouncil.org		
Kevin Jeffries	Board Member, County of Riversid	district1@rcbos.org		
Chuck Washington	Board Member, County of Riverside Third District Supervisor	district3@rcbos.org		
John Benoit	Board Member, County of Riversi	District4@rcbos.org		
John Tavaglione	Chairperson County of Riverside S	District2@rcbos.org		
Clint Lorimore	Board Member, City of Eastvale	CLorimore@Eastvaleca.gov		
Linda Krupa	Board Member, City of Hemet	council@cityofhemet.org		
Verne Lauritzen	Board Member, City of Jurupa Val	VLauritzen@JurupaValley.org		
Natasha Johnson	Board Member, City of Lake Elsin	njohnson@Lake-Elsinore.org		
Matt Liesemeyer	Board Member, City of Menifee	mliesemeyer@cityofmenifee.us		
D. LaDonna Jempson	Board Member, City of Moreno V	ladonnaj@moval.org		
Jonathan Ingram	Board Member, City of Murrieta	jingram@murrieta.org		
Kevin Bash	Board Member, City of Norco	kbash@ci.norco.ca.us		
Crystal Ruiz	Board Member, City of San Jacint	cruiz@sanjacintoca.us		
Ben Benoit	Board Member, City of Wildomar	bbenoit@cityofwildomar.org		
Mark Yarbrough	Board Member, City of Perris	ryarbrough@cityofperris.org		
Charles Landry	Executive Director	clandry@wrcra.org		
US Army Corps of Engineers				
Eileen Takata	Watershed Program Manager	Eileen.k.takata@usace.army.mil		
City of Lake Elsinore Planning Commission				
Lance Ray	Commissioner	lray@lake-elsinore.org		
Tim Fleming	Commissioner	tfleming@lake-elsinore.org		
Shelly Jordan	Chairman	sjordan@lake-elsinore.org		

Adam Armit	Vice Chairman	aarmit@lake-elsinore.org		
John Gray	Commissioner	jgray@lake-elsinore.org		
Kim Joseph Cousins, Presiden	Lake Elsinore Chamber of Comme	kim@lakeelsinorechamber.com		
Mark Piascik, Commander	LEMSAR	mpiascik@verizon.net		
Other TMDL Key Participants				
Hope Smythe	Division Chief, Regional Water Qu	hsmythe@waterboards.ca.gov		
Mark Smythe	Chief of Basin Planning, Regional \	msmythe@waterboards.ca.gov		
Jason Uhley	Riverside Co FC&WCD	juhley@rcflood.org		
Tim Moore	Risk Sciences	tmoore@risk-sciences.com		
Pat Boldt	Western Riverside County Agr Coa	mpboldt@aol.com		
Steve Pastor	Riverside County Farm Bureau	pastor@riversidecfb.com		
Yung Nguyen	March Air Reserve Base	Yung.Nguyen@march.af.mil		
Bruce Scott	Chairman, Western Riverside Cou	bruce@sbdfarms.com		
Albert Martinez	Riverside County Flood Control &	amart@rcflood.org		
Kyle Gallup	Watershed Planning Section Man	KWGallup@rcflood.org		
Bill Sapp	US Forest Service	billsapp@fs.fed.us		
Adam Collier	March JPA	collier@marchjpa.com		
Eddy Konno	Department of Fish & Game	ekonno@dfg.ca.gov		
Gian Villarreal	RBF for CalTrans	gvillarreal@rbf.com		
Jason Jimenez	US Forest Service	jjimenez@fs.fed.us		
Kevin Street	City of Riverside	kstreet@riversideca.gov		
Stuart McKibbin	Chief of Watershed Protection, Ri	SMcKibbi@rcflood.org		
Scott Sewell	Wildlife Habitat Supervisor II Area	ssewell@dfg.ca.gov		
Western Riverside County Agricultural Coalition				
Pat Boldt	Executive Director	**Mpboldt@aol.com**		
Bruce Scott	Chairman	bruce@sbdfarms.com		
Brad Scott	Treasurer	brad@sbdfarms.com		
Essie Bootsma	Secretary	Mrsdairylady@aol.com		
John Oostdam	Board Member	oostdam@earthlink.net		

LESJWA WATER SUMMIT INVITE FINAL

David McElroy	Board Member	dmcelroy@mwdh2o.com		
Soboba Band of Luiseno Indians				
Kenneth McLaughlin	Director of Public Works	kmclaughlin@soboba-nsn.gov		
Steve Estrada	Environmental Manager	sestrada@soboba-nsn.gov		
Andrea De Leon	Public Affairs and Government Re	andrea@inlandstrategiesgroup.com		
Inland Empire Waterkeeper				
Megan Brousseau	Program Director	megan@iewaterkeeper.org		
WRCOG				
Rick Bishop	Executive Director	bishop@wrcog.cog.ca.us		
Department of Fish & Wildlife				
Jennifer Hemmert		Jennifer.Hemmert@wildlife.ca.gov		
Mike Giusti		Mike.Giusti@wildlife.ca.gov		
State Senate				
Senator Richard Roth	District 31	trish.fontana@sen.ca.gov		
Senator Jeff Stone	District 28	brittny.garcin@sen.ca.gov		
State Assembly				
Assemblyman Jose Medina	District 61	karin.means@asm.ca.gov		
Assemblywoman Melissa Me	District 67	donda.scholl@asm.ca.gov		

LESJWA BOARD MEMORANDUM NO. 789

DATE: April 21, 2016

SUBJECT: Lake Elsinore & Canyon Lake Nutrient TMDL Interim Compliance Report

TO: Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors receive and file a draft Lake Elsinore and Canyon Lake Nutrient TMDL Interim Compliance Report.

BACKGROUND

The attached pre-release draft Lake Elsinore and Canyon Lake Nutrient TMDL Interim Compliance Report summarizes the efforts of the Lake Elsinore and Canyon Lake Nutrient TMDL Task Force and provides an evaluation of the overall effectiveness of all prior projects in addressing the LE&CL Nutrient TMDLs. It will address the requirement of the MS4 Permittees Comprehensive Nutrient Reduction Plan for Lake Elsinore and Canyon Lake requiring that a Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report be submitted to the Regional Board by June 30, 2016. This document is also a requirement of the Agricultural Nutrient Management Plan and is tied to the TMDL compliance affecting the Lake Elsinore and Canyon Lake Nutrient TMDL Task Force.

In addition, due to concerns raised by the LESJWA Board, this Report also will include discussion of a number of issues relating to the effects of alum applications to Canyon Lake.

The attached draft Report includes the most important substantive material regarding the key projects implemented by the Task Force and responses to the key questions raised by the LESJWA Board.

Items yet to be completed include:

1) Additional details regarding the Ag BMPs implemented since the TMDL was adopted.
2) Additional charts and graphs regarding DO trends in Canyon Lake.
3) Final conclusions and recommendations.

An official draft of the Report is expected to be released to the Task Force at the end of April 2016.

RESOURCES IMPACT

All staff time associated with the Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report has been budgeted under the LE/CL TMDL Task Force budget that also is shown within the LESJWA budget.

MN/dm

Attachment:
1. Draft Lake Elsinore and Canyon Lake Nutrient TMDL Interim Progress Report

Page Intentionally Blank

1.0 Background

In 1994, Lake Elsinore was added to EPA's list of impaired waterbodies due to excessive algae levels and low dissolved oxygen (DO) concentrations. The poor water quality is principally the result of elevated nitrogen and phosphorus pollution in the lake. In 1998, Canyon Lake was deemed to be impaired for the same reasons and also added to EPA's 303(d) list.

In 2004, the Santa Ana Regional Water Quality Control Board ("Regional Board") adopted a Total Maximum Daily Load (TMDL) to reduce nutrient loads to both lakes.[1] The TMDL restricts the amount of nitrogen and phosphorus that can be discharged by wastewater treatment facilities, municipal stormwater systems and commercial agriculture operations.[2]

The TMDL specifies a number of targets that should be met by the end of 2015 in order to assure progress toward meeting the water quality standards presently at-risk in Canyon Lake and Lake Elsinore. The purpose of this Interim Compliance Report is to summarize the status for each of these milestones.

1.1 TMDL Water Quality Targets

Table 1 describes the interim numeric targets for Chlorophyll-a (algae) and Dissolved Oxygen that are *"to be attained no later than 2015"* in both lakes.[3]

Table 1: Interim Response Targets[4]

Water Quality Metric	Lake Elsinore	Canyon Lake
Chlorophyll-a	Summer average no greater than 40 ug/L	Annual average no greater than 40 ug/L
Dissolved Oxygen	Depth average no less than 5 mg/L	Minimum of 5 mg/L above the thermocline

---

[1] California Regional Water Quality Control Board - Santa Ana Region Res. No. R8-2004-0037 (Dec. 20, 2004); subsequently approved by the State Water Resources Control Board on May 19, 2005 and by the California Office of Administrative Law (OAL) on July 26, 2005. The TMDL became effective upon final approval by U.S. EPA on September 30, 2005.

[2] For Elsinore Valley MWD, compliance with the TMDL is required by NPDES Permit No. CA8000392). For the Riverside County Stormwater Program compliance with the TMDL is required by NPDES Permit No. CAS618033 and described in the Comprehensive Nutrient Reduction Program (CNRP) approved as Regional Board Res. No. R8-2013-0044 (July 19, 2013). For Commercial Agriculture Operations compliance with the TMDL is governed by a Conditional Waiver of Waste Discharge Requirements and an Ag Nutrient Management Plan (both are pending Regional Board approval).

[3] The TMDL also specifies several additional FINAL targets, wasteload allocations and load allocations that must be met by 2020. These final threshold values are not addressed in this Interim Compliance Report.

[4] Table 1 is excerpted from Table 5-9n in Res. No. R8-2004-0037 (Dec. 20, 2004).

1.2 TMDL Task Force

To assure rapid and cost-effective compliance with the numerous TMDL requirements, stakeholders throughout the San Jacinto River watershed formed a voluntary Task Force to coordinate implementation efforts. The Task Force is comprised of nearly all dischargers named in the TMDL and is managed by the Lake Elsinore San Jacinto Watershed Authority (LESJWA).[5] The Task Force meets monthly and staff from the Regional Board regularly attend and participate in these meetings.

Collectively, the Task Force manages an annual budget of more than $1 million and is responsible for:

a) Implementing the watershed-wide water quality monitoring program.[6]

b) Implementing the water quality monitoring program for both lakes.[7]

c) Updating the watershed runoff model used to estimate nutrient loads.[8]

d) Conducting special studies to aid in selection of mitigation projects.[9]

e) Implementing the Lake Elsinore Sediment Nutrient Reduction plan.[10]

f) Implementing the Canyon Lake Nutrient Reduction plan.[11]

g) Revising and updating the TMDL (incl. targets and allocations).[12]

In the 10 years since it commenced operation, the Task Force has implemented several large-scale water quality improvement projects to reduce nutrient loads released by lake bottom sediments. In addition, individual Task Force agencies have implemented a wide array of new Best Management Practices (BMPs) designed to reduce nitrogen and phosphorus pollution in the stormwater runoff that originates from urban and agricultural areas.

The remainder of this report will describe both the in-lake projects and watershed BMPs and summarize the effectiveness of these efforts at improving water quality. Special emphasis will be given to the question of whether the lakes are meeting the aforementioned Interim Response Targets. The status of each lake is addressed separately.

---

[5] The U.S. Forest Service and the U.S. Fish and Wildlife Service are not active members of the Task Force.

[6] Approved in Regional Board Res. No R8-2006-0031 (March 3, 2006). Revised plan (2015) pending approval.

[7] Modified by Regional Board Res. No. R8-2011-0023 (March 4, 2011). Revised plan (2015) pending approval.

[8] TetraTech, Inc. San Jacinto Watershed Model Update - Final (2010). Completed Oct. 7, 2010

[9] See: http://www.sawpa.org/collaboration/projects/lake-elsinore-canyon-lake-tmdl-task-force/

[10] Approved in Regional Board Res. No. R8-2007-0083 (Nov. 30, 2007).

[11] See: http://www.sawpa.org/task-10-cl-in-lake-sediment-reduction-plan/

[12] The TMDL review and revision process was initiated in January of 2016. All proposed changes will be submitted to the Regional Board for formal consideration in the fall of 2018 and the regulatory approval process and is expected to be complete two years later.

2.0 Canyon Lake

2.1 Principal Water Quality Improvement Programs

2.1.1 Alum Application Pilot Demonstration Project

After reviewing a variety of potential water quality improvement projects, the TMDL Task Force determined that large-scale application of alum was likely to produce the best results in Canyon Lake.[13] A pilot project was developed to demonstrate the efficacy of this strategy.[14]

CEQA evaluation and review was completed in the summer of 2013 and the first of five alum applications commenced in September that same year. Alum was also applied in February and September of 2014 and 2015.[15]

Altogether, a total of 840 tons of alum was sprayed as a liquid slurry across the surface of Canyon Lake.[16] Two-thirds of the alum was applied to the main body of the lake and the remaining third was applied to the East Bay. Although less alum was dispersed the effective dose was more than two times higher in the East Bay than in the main body of the lake. This is due to the fact that the main body holds 7 times more water than the East Bay.[17]

Routine water quality monitoring is performed at four lake stations before and after each alum application. Two of the sampling sites are located in the main body of Canyon Lake and two are located in the East Bay. Figure 1 shows how phosphorus concentrations declined at all stations immediately following each alum application. Figure 1 also shows how phosphorus levels rose in response to local storm events.

Since December of 2014, samples collected in the main body of Canyon Lake show that phosphorus concentrations are consistently at or below 0.1 mg/L - a final TMDL target the stakeholders were not required to meet until 2020. By June of 2015, phosphorus concentrations in the East Bay were also less than 0.1 mg/L and meeting the final TMDL target five years ahead of schedule.

---

[13] Dr. Michael Anderson (U.C.-Riverside); Technical Memorandum - Task 6: Predicted Water Quality in Canyon Lake with In-Lake Alum Treatments and Watershed BMPs. Nov., 27, 2012. Also: Dr. Michael Anderson; Technical Memorandum - Task 3: Evaluation of Alum, Phoslock and Modified Zeolite to Sequester Nutrients in Inflow and Improve Water Quality in Canyon Lake. May 17, 2012. Also: Dr. Michael Anderson; Technical Memorandum - Task 2: Evaluation of Long-Term Reduction of Phosphorus Loads from Internal Recycling as a Result of Hypolimnetic Oxygenation in Canyon Lake. April 22, 2012.

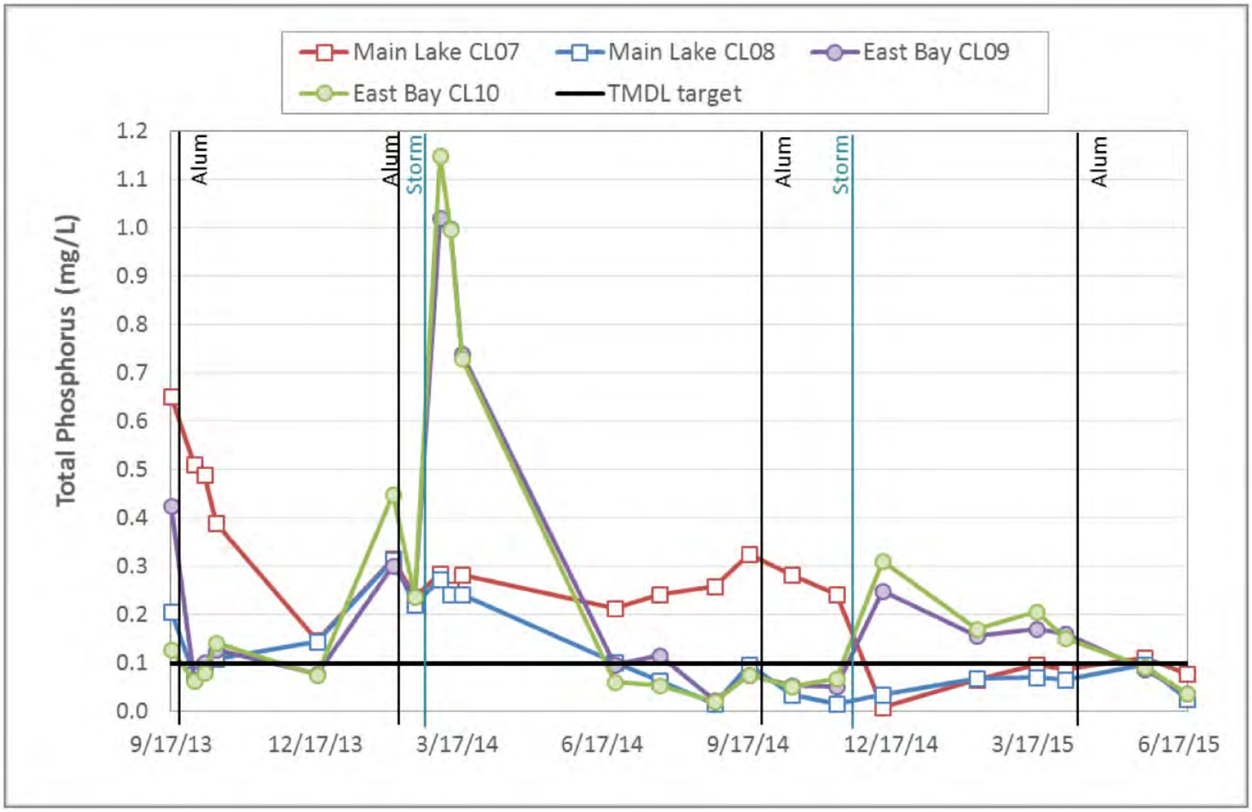
[14] The alum demonstration project was partially funded by a state Prop-84 grant.

[15] Alum was not applied to the main body of Canyon Lake in February of 2015 because water quality was already very good (e.g. low chlorophyll-a and low phosphorus concentrations.

[16] A total of 311,000 gallons of liquefied alum was applied to Canyon Lake between Sept., 2013 and Sept., 2015.

[17] Riverside County MS4 Permittees CNRP Implementation Summary FY 2014-15; see Table 2 on pg. 2.

Fig. 1: Total Phosphorus Concentrations in Canyon Lake[18]



To date, the alum application project has neutralized more than 7,600 pounds of phosphorus - an amount equal to the total average load contributed to Canyon Lake by 3 years of urban runoff. Dr. Michael Anderson (U.C. Riverside) estimates that, so far, the demonstration project has sequestered approximately 30% of the bioavailable phosphorus in the lake bottom sediments.[19]

An odd problem was encountered the first time alum was applied during the winter season (February, 2014). Initially, the alum formed floc that floated on the surface for a few days. Eventually, the floc sank to the bottom of the lake as it is supposed to. Analysis of the data gathered during the event indicates that two factors led to this atypical result. First, the alum tended to form a floc with the large concentration of algae present in the lake. Second, the cold water was supersaturated with oxygen which help the algae-alum floc stay afloat. To avoid this problem in the future, subsequent alum applications were timed to occur before the algae bloom occurs in early Spring or after that bloom has dissipated.

---

[18] Riverside County MS4 Permittees CNRP Implementation Summary FY 2014-15. Fig. 1 on pg. 2.

[19] Dr. Michael Anderson (U.C.-Riverside). Presentation to the residents of Canyon Lake. Sept. 9, 2015.

2.1.2 Sediment Dredging Pilot Demonstration Project

According to the TMDL adopted by the Regional Board 34% of the annual phosphorus load to Canyon Lake originates from the bottom sediments.[20] To address this problem the Canyon Lake Property Owners Association (CLPOA) began dredging nutrient-enriched sediments from the East Bay.[21]

In the 9 month period commencing in July of 2006 and ending in March of 2007, the dredging project removed nearly 15,000 cubic yards of sediment from the East Bay. Table 2 provides a more detailed summary by month.

Table 2: Sediment Dredged from the East Bay of Canyon Lake[22]

Month	Volume	Mass
July, 2006	980 cu. yds.	1,323 tons
August, 2006	1,320 cu. yds.	1,782 tons
September, 2006	2,110 cu. yds.	2,849 tons
October, 2006	1,740 cu. yds.	2,349 tons
November, 2006	1,070 cu. yds.	1,444 tons
December, 2006	1,865 cu. yds.	2,518 tons
January, 2007	2,160 cu. yds.	2,916 tons
February, 2007	1,465 cu. yds.	1,878 tons
March, 2007	2,225 cu. yds.	3,003 tons
Total	**14,935 cu. yds.**	**20,162 tons**

---

[20] California Regional Water Quality Control Board - Santa Ana Region. Supplemental Staff Report: Proposed Basin Plan Amendment - Incorporation of Total Maximum Daily Loads for Nutrients for Lake Elsinore and Canyon Lake. Dec. 20, 2004. See Attachment - Table 1: Revised TMDL Allocation for Lake Elsinore and Canyon Lake to meet the revised final TP and TN targets.

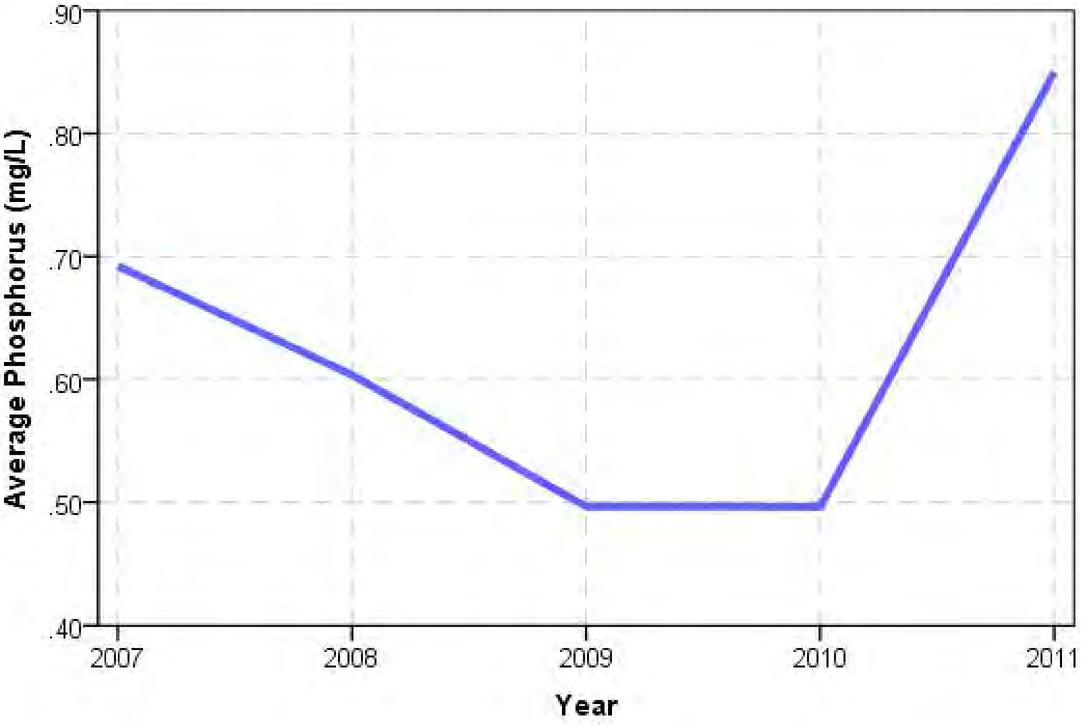
[21] The dredging project was operated in accordance with NPDES Permit No. CA8000405 approved by the Regional Board as Order No. R8-2004-0046 on June 4, 2004 and was partially funded by a state Prop-13 grant.

[22] Dredge volumes reported to the Regional Board as required by the Monitoring and Reporting Program for NPDES Permit No. CA8000405 (Res. No. R8-2004-0046). Copies of the monthly Discharge Monitoring Reports (DMR) are on-file and available for review at the Regional Board's main office in Riverside, CA.

Laboratory analysis of core samples showed that sediment from the East Bay contained an average phosphorus concentration of 519 mg/kg.[23] Thus, about 9,493 kilograms of phosphorus was also removed or about 1 pound of phosphorus for each ton of sediment dredged.

Routine water quality monitoring indicates that the average phosphorus concentration in the East Bay declined from 0.70 mg/L to 0.50 mg/L (a 40% improvement) in the two years following the conclusion of the dredging project (see Fig. 2). Phosphorus concentrations in the East Bay began to rise again as stormwater runoff transported new sediment loads to the lake during the wet winters of 2010 and 2011).

Fig. 2: Average Annual Phosphorus Concentration in East Bay of Canyon Lake[24]



The pilot dredging project was discontinued in the spring of 2007 when the CLPOA lost access to a nearby fill site for the de-watered sediment materials and legal complications arose regarding proper application of prevailing wage laws under the state grant program

---

[23] HDR, Inc. Canyon Lake East Bay Sedimentation Characterization. Report to the Lake Elsinore & San Jacinto Watersheds Authority. August, 2002 (based on samples of East Bay sediments collected and analyzed by Dr. Michael Anderson of U.C. Riverside on May 29, 2002).

[24] Based on analysis of data collected as part of the routine water quality monitoring program sponsored and supervised by the TMDL Task Force. All of this data was previously submitted to the Regional Board as part of the Annual Report on Water Quality in Lake Elsinore and Canyon Lake.

2.1.3 Watershed Best Management Practices

The TMDL established a Waste Load Allocation (WLA) of only 306 kg/year total phosphorus for "Urban" stormwater discharges to Canyon Lake.[25] To demonstrate direct compliance with this WLA, the Regional Board estimated that MS4 permittees would need to reduce their existing phosphorus loads by approximately 73%.[26]

In order to reduce nitrogen and phosphorus loads in urban stormwater to the Maximum Extent Practicable (MEP), the MS4 agencies developed a Comprehensive Nutrient Reduction Plan (CNRP).[27] The NPDES permit obligates these agencies to implement the pollution control strategies described in the CNRP.[28]

The NPDES permit also requires the MS4 agencies to develop and implement a Water Quality Management Plan (WQMP) for Urban Runoff from areas undergoing new development or significant redevelopment.[29] The NPDES permit specifies the amount runoff that must be infiltrated, filtered or treated prior to discharge from these development areas.[30]

In the several years since the NPDES permit was adopted and the related CNRP was approved, the MS4 agencies have implemented a wide range of Best Management Practices (BMPs) to reduce urban runoff in general and nutrient loads in particular. Many of these same cities are also engaged in an active program to repair and replace defective septic systems that may also be exacerbating the pollution problems observed in Canyon Lake and Lake Elsinore.

And, each year the co-permittees summarize their implementation efforts in a report to the Regional Board (see Table 3). A similar report, summarizing the BMPs implemented by the commercial agriculture operators will soon be required when the Conditional Waiver of Waste Discharge Requirements is authorized by the Regional Board.[31] However, the ag and dairy operators began implementing BMPs several years ago and long before the Conditional Waiver required them to do so (see Table 5).

---

[25] California Regional Water Quality Control Board - Santa Ana Region Res. No. R8-2004-0037 (Dec. 20, 2004); See Table 5-9q: Canyon Lake Nitrogen and Phosphorus Wasteload and Load Allocation. The WLA is expressed as a 10-year running (annualized) average. Compliance with the final WLA must be achieved no later than December 31, 2020.

[26] California Regional Water Quality Control Board - Santa Ana Region. Supplemental Staff Report: Proposed Basin Plan Amendment - Incorporation of Total Maximum Daily Loads for Nutrients for Lake Elsinore and Canyon Lake. Dec. 20, 2004. See Attachment - Table 1: Revised TMDL Allocation for Lake Elsinore and Canyon Lake to meet the revised final TP and TN targets.

[27] California Regional Water Quality Control Board - Santa Ana Region Res. No. R8-2013-0044 (July 19, 2013)

[28] NPDES Permit No. CAS618033; see §VI-D-2-f @ pg. 67 of 117 (Order No. R8-2010-0033; Jan. 29, 2010).

[29] NPDES Permit No. CAS618033; see §XII-D (Order No. R8-2010-0033; Jan. 29, 2010).

[30] NPDES Permit No. CAS618033; see §XII-D-4-a & §XII-D-4-b (Order No. R8-2010-0033; Jan. 29, 2010).

[31] This Conditional Waiver is scheduled for Regional Board consideration at their meeting on April 22, 2016.

Table 3: Summary of MS4 Implementation Efforts (FY 2014-15)[32]

Best Management Practice	Effectiveness
Septic Systems Managed	2,140 systems
Stormwater Infiltration	949 acres treated
Extended Detention	4,163 acres treated
Hydrodynamic Separator	1,058 acres treated
Vegetated Swale	288 acres treated
Media Filters	458 acres treated
Street Sweeping	16,168 metric tons collected
Debris in MS4 Facilities	758 metric tons removed

Table 4 shows the nutrient load reductions estimated to result from all the BMPs implemented by the MS4 agencies by mid-2015.

Table 4: Load Reductions to Canyon Lake from Urban Stormwater & Septic Systems[33]

Nutrient	Mass Reduction	% of Existing Load
Phosphorus	559 kg/yr	34%
Nitrogen	3,827 kg/yr	30%

[PLACEHOLDER FOR TABLE 5: SUMMARY OF BMP IMPLEMENTATION AND EFFECTIVENESS FOR THE AG AND DAIRY DISCHARGERS]

---

[32] Riverside County MS4 Permittees CNRP Implementation Summary FY 2014-15. Table 3 (above) is a meta-summary of the data shown in Table 3 (pg. 4) and Table 4 (pg. 5) of the original report. Table 3 includes BMPs in the local Lake Elsinore watershed that do no flow to or thru Canyon Lake. Note: values shown are incomplete because some cities are just beginning to develop systems to track and quantify the effectiveness of their BMP efforts and other cities have not yet reported their results.

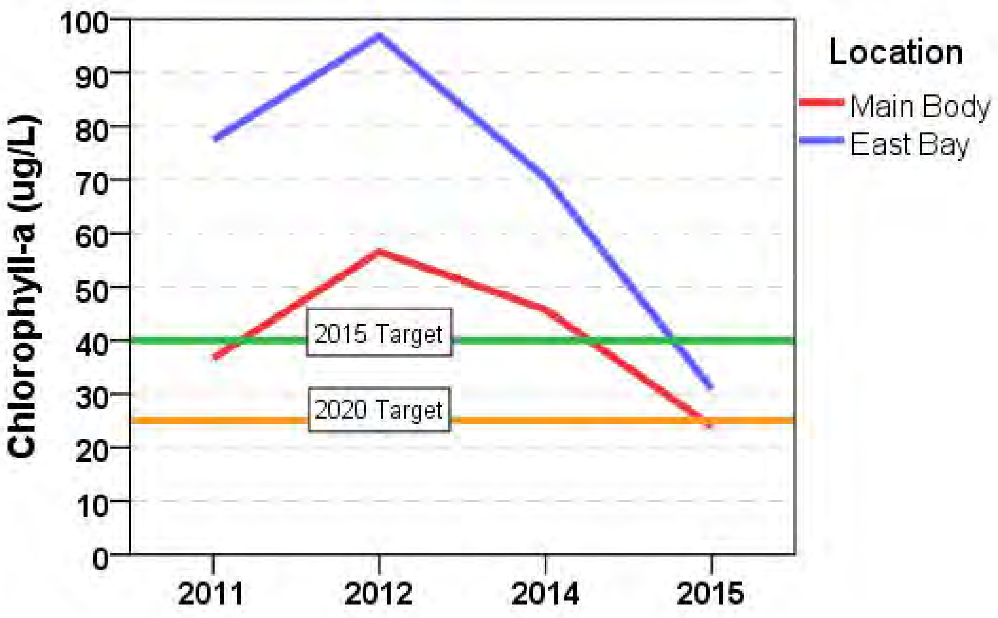
[33] Spreadsheet analysis of BMP effectiveness provided by Steve Wolosoff (CDM-Smith) on March 18, 2016. Existing load is based on the values reported by the Regional Board in the adopted TMDL (see footnote 26).

2.2 Interim Response Targets

2.2.1 Chlorophyll-a (algae)

Data from the routine water quality monitoring program shows that the average annual Chlorophyll-a concentration is meeting the interim TMDL target of <40 ug/L (see Fig. 3). This is true for both the main body of Canyon Lake as well as the East Bay.[34]

Fig. 3: Average Annual Concentrations of Chlorophyll-a in Canyon Lake[35]



It should be noted that actual Chlorophyll-a concentrations measured at each of the four separate sampling stations varies greatly over the course of a year and sometimes exceeds 40 ug/L at some locations (see Fig. 4 and Fig. 5). Nevertheless, the interim response target for Chlorophyll-a is specified as an annual average and, at present, Canyon Lake is meeting that target. In fact, the average annual concentration of Chlorophyll-a in the main body of Canyon Lake is now meeting the final 2020 response target of 25 ug/L five years ahead of the TMDL deadline.

---

[34] The TMDL specifies a the response target for Chlorophyll-a as an annual average for "Canyon Lake." Although the TMDL does not distinguish between the Main Body and the East Bay, doing so provides a more meaningful representation of water quality throughout the lake.

[35] There was very little in-lake monitoring done in the first 8 months of 2013 prior to the first alum application. Therefore, no average value if computed for 2013.

Fig. 4: Chlorophyll-a and Phosphorus Concentrations in Main Body of Canyon Lake[36]

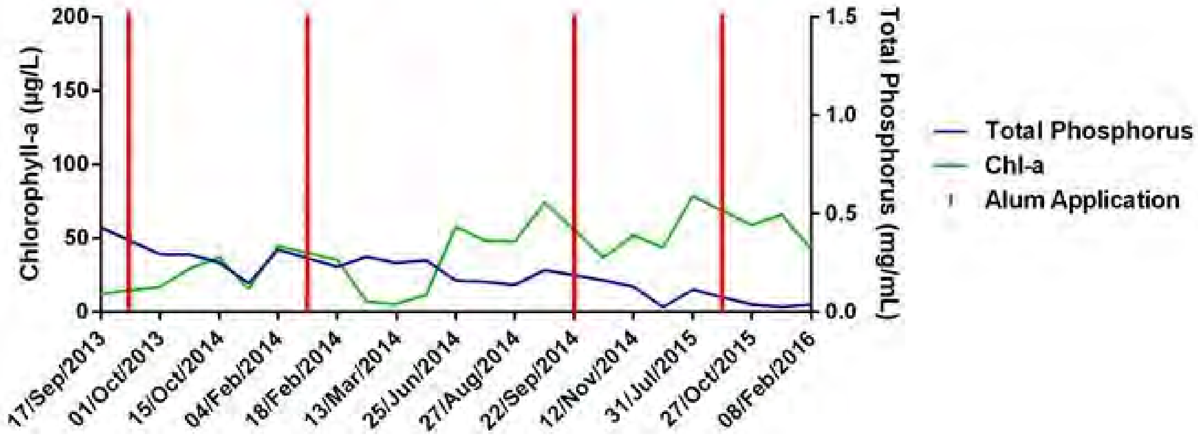
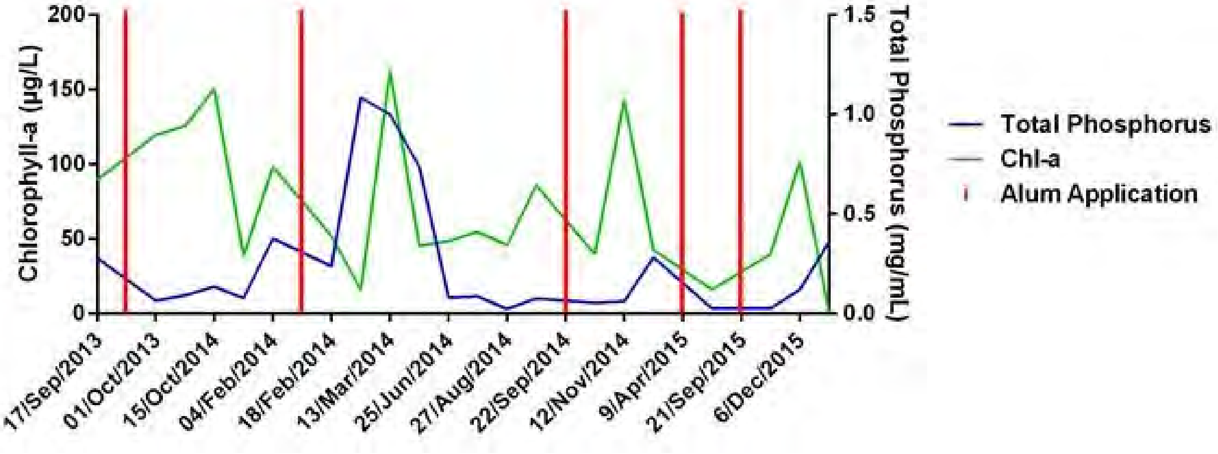


Fig.5: Chlorophyll-a and Phosphorus Concentrations in East Bay of Canyon Lake[37]



It is important to note that algae concentrations have been declining since 2012 despite a prolonged drought during which evaporation would normally increase the average phosphorus concentration. The TMDL Task Force believes the alum application project, coupled with increased implementation of upstream BMPs throughout the watershed, have kept phosphorus levels relatively low despite the drought conditions which have prevailed for the last 4 years.

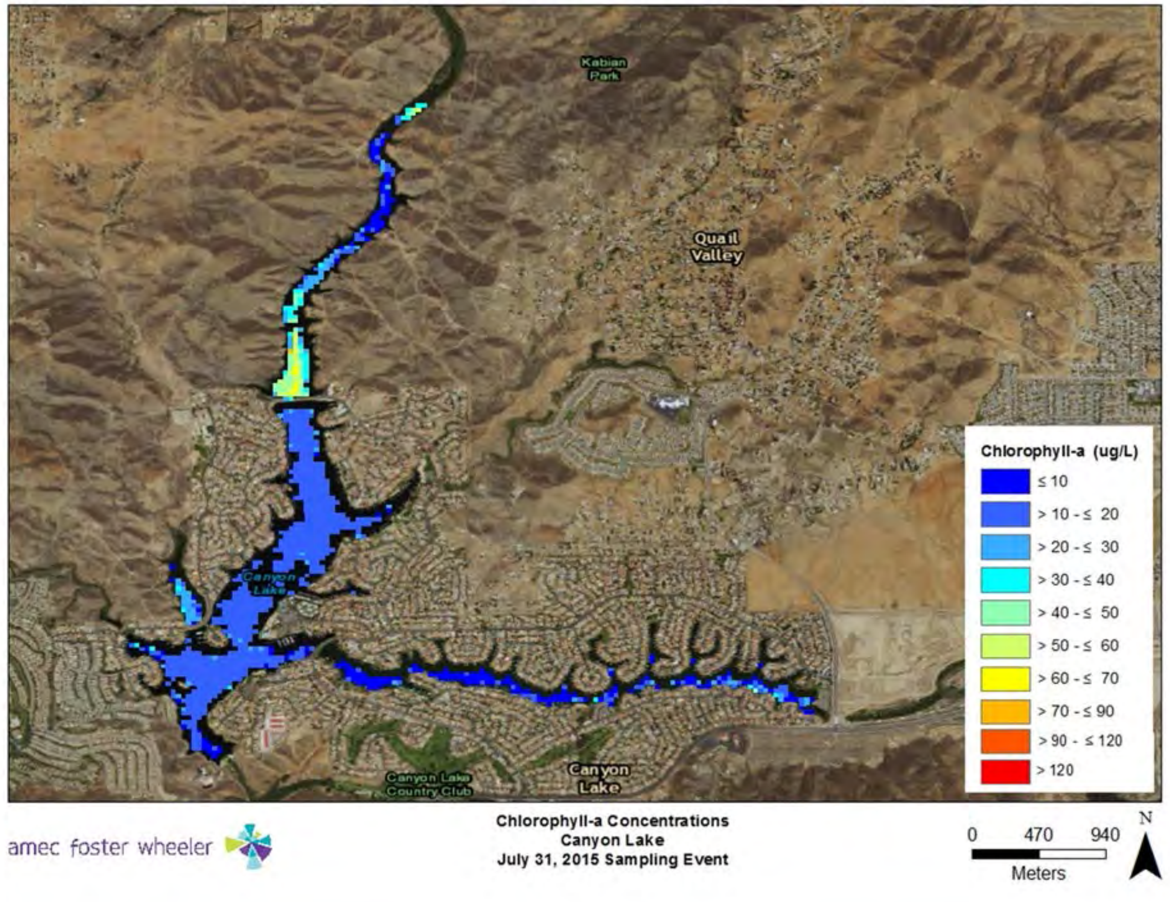
---

[36] Graph for Main Body prepared by AMEC Foster Wheeler using Task Force monitoring data (Apr. 5, 2016)

[37] Graph for East Bay prepared by AMEC Foster Wheeler using Task Force monitoring data (Apr. 5, 2016)

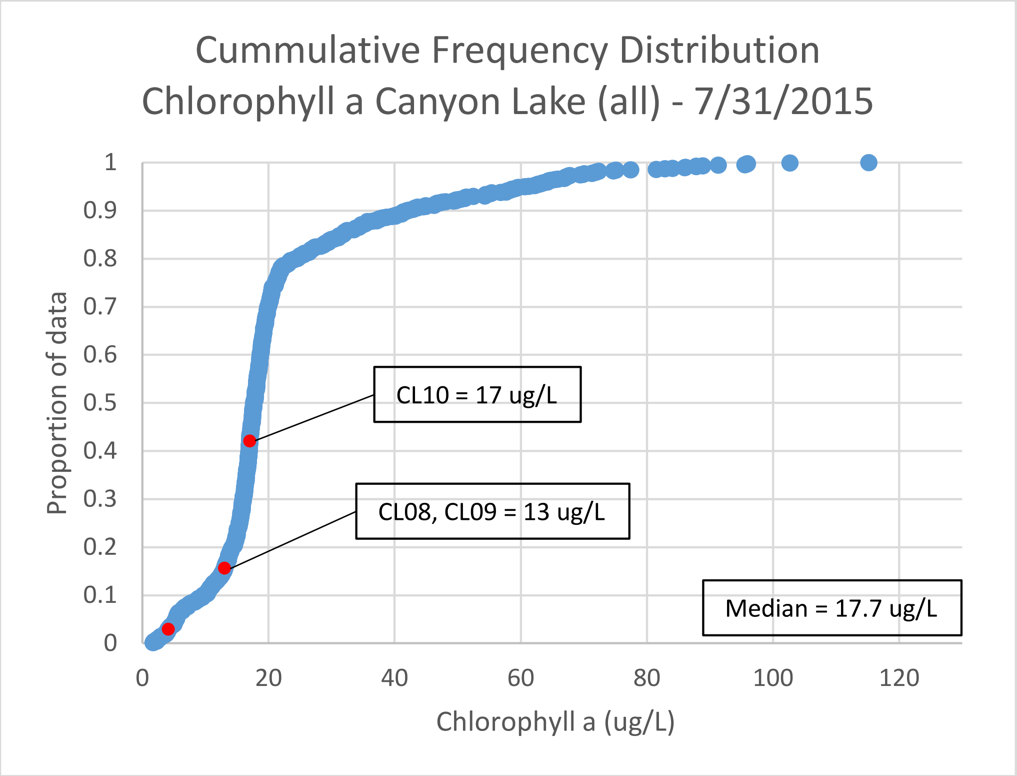
A specialized analysis of images collected by NASA's Landsat satellite shows that Chlorophyll-a concentrations were generally low throughout Canyon Lake on July 31, 2015 (see Fig. 6). The sole exception was the area above the north causeway where the San Jacinto River merges with the lake. During summer months, the water level rarely rises high enough to flow through the culverts beneath the causeway and remains trapped in the shallow area north of the main body of Canyon Lake.

Fig. 6: Satellite Assessment of Chlorophyll-a Concentration on 7/31/2015



The satellite image provides five pixels for every surface acre of the lake. Each pixel represents an independent e estimate of Chlorophyll-a concentrations at that specific point. Thus, the satellite image provides approximately 1,500 data points to supplement the laboratory analysis of samples collected at the 4 field locations. Figure 7 shows how the Chlorophyll-a concentration varied across these 1,500 pixel locations. On July 31, 2015 nearly 90% of the pixels registered a Chlorophyll-a concentration less than 40 ug/L. And, the median Chlorophyll-a concentration for all 1,500 pixels was 17.7 ug/L.

Fig. 7: Cumulative Distribution Function for Chlorophyll-a Concentrations on 7/31/2015



Satellite images have also been analyzed for December 18, 2015 and February 8, 2016. Table 6 provides a summary of the Cumulative Frequency Distribution Analyses for all three satellite images.

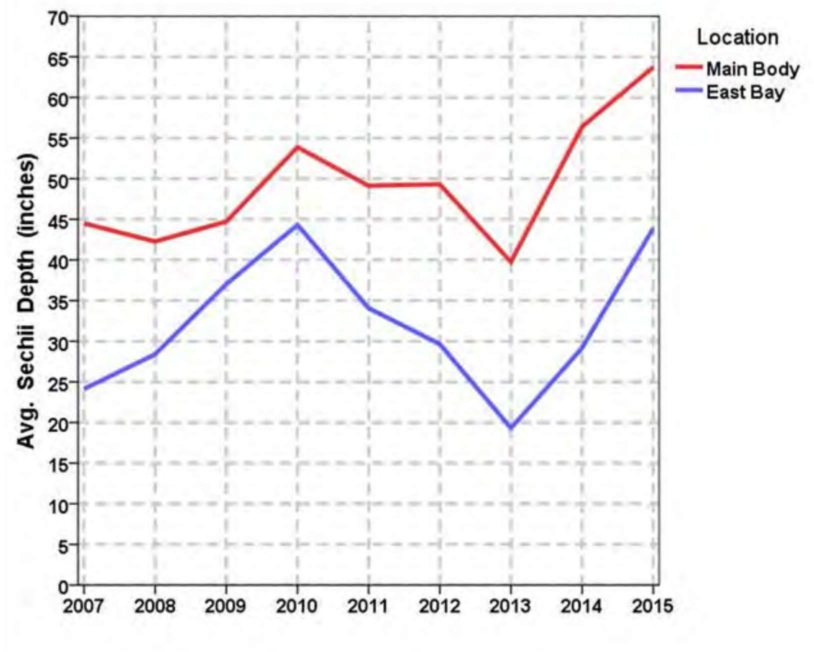
Table 6: Cumulative Distribution Function Analysis of Satellite Images for Canyon Lake

Chlorophyll-a	July 31, 2015	Dec. 18, 2015	Feb. 8, 2016
Median Value	17.7 ug/L	59 ug/L	18.9 ug/L
% <40 ug/L	≈90%	≈30%	≈75%
% <25 ug/L	≈80%	≈10%	≈70%

The Task Force is working on a method to provide a robust estimate of the annual average Chlorophyll-a concentration using data from multiple satellite images. Landsat takes approximately 20 pictures of the lake each year. Collectively, that would provide nearly 30,000 data points from which to calculate the annual average.

Back on Earth, long-term monitoring data shows that water clarity in Canyon Lake has also improved dramatically since the alum application began in late 2013 (see Fig. 8). Water clarity is measured at each of the four sampling stations using the traditional Sechii disk method.

Fig. 8: Long-term Trend for Water Clarity in Canyon Lake



In 2015, average water clarity in the main body of Canyon Lake was more than 60% better than it was two years earlier. And, average water clarity in the East Bay improved by more than 100% during the same period. The Sechii disk data appears to corroborate the previous findings from the water quality monitoring samples and the satellite data: Chlorophyll-a concentrations in Canyon Lake have improved markedly in the last few years. This is most likely due to lower average phosphorus concentrations in the lake.

In late spring of 2015, a large bloom of brownish-colored algae occurred in the East Bay. Test samples showed that the algae, which appears brown to the naked eye, is actually a species called *Pseudoanabaena*, from the Blue-Green (cyanobacteria) classification.[38] Some residents questioned whether the unusual bloom was caused by the prior alum applications. This is unlikely as a similar bloom of *Pseudoanbaena* also occurred at the same time in Lake Elsinore which receives no alum treatment. The Canyon Lake bloom dissipated in May and was followed by some of the lowest summer concentrations of Chlorophyll-a ever measured in the East Bay.

---

[38] SePRO Research and Technology Campus. SeSCRIPT Analysis Report. Prepared by AquaTechnex for a sample collected in June of 2015. *Pseudoanabaena* sp. density = 13,400 cells/mL. A

2.2.2 Dissolved Oxygen

Through the process of photosynthesis, algae produces oxygen during daylight hours. But, algae consumes oxygen after the sun goes down. Consequently, excessive algae concentrations can significantly depress DO levels in the water column. Extreme algae infestations can lead to major fish kills. There was such a fish kill in Canyon Lake in 2009.

Now that algae concentrations are declining, it is reasonable to expect that DO levels should be improving. The best evidence to support this conclusion is the fact that there have been no significant fish kills in Canyon Lake in the last 6 years. This roughly corresponds with the period where stakeholders throughout the watershed have been aggressively implementing BMPs and supporting the alum application project to reduce phosphorus loads released from lake-bottom sediments.

Water quality monitoring data also indicates that the DO concentrations in Canyon Lake are improving in response to the TMDL implementation efforts.

[PLACEHOLDER FOR ADDITIONAL ANALYSIS RELATED TO DO DATA]

[NEED TO DEVELOP CUMULATIVE DISTRIBUTION FUNCTION GRAPHS TO CALCULATE THE VOLUME-WEIGHTED AVERAGE DAILY DO CONCENTRATION ABOVE THE THERMOCLINE]

3.0 Lake Elsinore

3.1 Principal Water Quality Improvement Programs

3.1.1 Lake Level Stabilization Project

Lake Elsinore is a terminal take with a very high rate of evaporation. Consequently, under natural conditions, the lake would periodically go dry (see Fig. 9 & Fig. 10). In 1996 a levee was constructed to reduce the surface area of Lake Elsinore by 50%. Nevertheless, annual water losses due to evaporation are still greater than 12,000 acre-feet/year.

Fig. 9: Lake Elsinore, Riverside County, CA (circa 1965)

In 2002-3, a pilot project to stabilize the lake level using high quality recycled water was initiated.[39] The project proved successful and a permanent permit to discharge treated municipal effluent into Lake Elsinore was issued to the Elsinore Valley Municipal Water District (EVMWD).[40]

---

[39] The pilot demonstration project included recycled water from both EVMWD and Eastern MWD. Today, only EVMWD has a valid NPDES permit to discharge recycled water to Lake Elsinore.

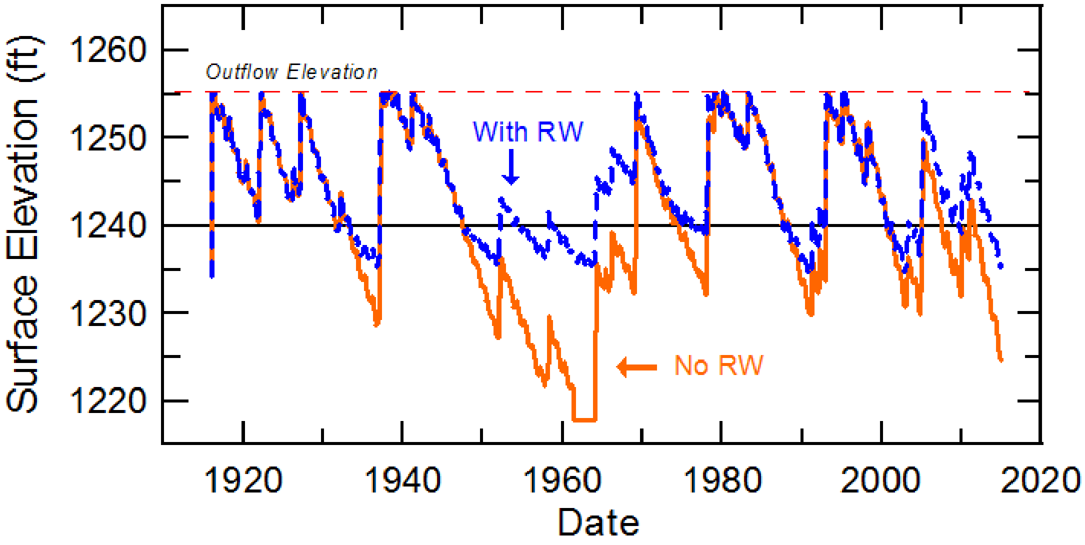
[40] EVMWD's current NPDES permit (CA8000392) was reauthorized by the Regional Board in 2013 (R8-2013-0017) and expires on Sept. 30, 2018.

The NPDES permit limits the average phosphorus and nitrogen concentrations of the effluent to no more than 0.5 mg/L and 1.0 mg/L, respectively. EVMWD installed advanced treatment technology to comply with these restrictions. EVMWD also joined with the City of Lake Elsinore and the County of Riverside to build an in-lake aeration and mixing system to "offset" any excess nutrient loads in the recycled water (see Section 3.1.2, below).

Using recycled water to stabilize the level of Lake Elsinore is a key part of the Sediment Nutrient Reduction Plan developed by the Task Force and approved by the Regional Board.[41] Since 2007, EVMWD had discharged more than 5 million gallons-per-day (>6,700 acre-feet/year) of high quality recycled water to Lake Elsinore.

Currently, recycled water makes up for only half of all that is lost to evaporation each year. Without the recycled water that EVMWD has been discharging for the last 7 years, Lake Elsinore would be more than 12 feet lower than it already was in 2015 (see Fig. 10).

Fig. 10: Estimated Historic Level of Lake Elsinore With and Without Recycled Water[42]



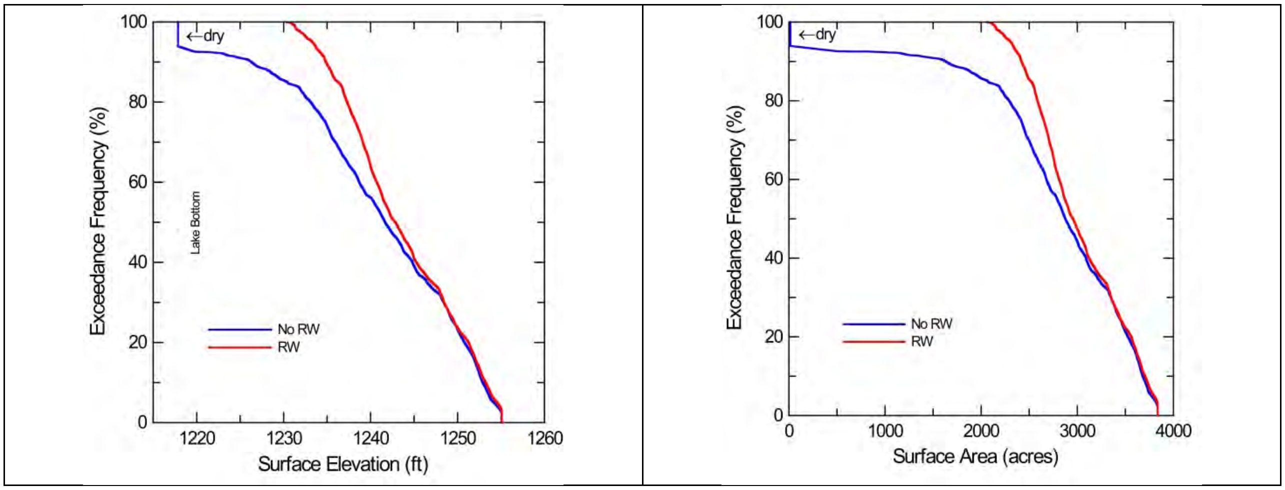
As the area continues to develop, EVMWD will eventually generate approximately 9 million gallons-per-day (≈12,000 acre-feet/year). If the additional volume of recycled water is also discharged, the level of Lake Elsinore will be very close to achieving long-term balance. If this lake stabilization strategy had been in place 50 years ago, the Lake Elsinore would not have gone dry as it did in the early 1960's. In fact, with recycled water, the lake elevation is not expected to fall below 1,230' and the lake area is not expected to be less than 2,000 acres (see Fig. 11).

---

[41] Regional Board Res. No. R8-2007-0083 (November 30, 2007).

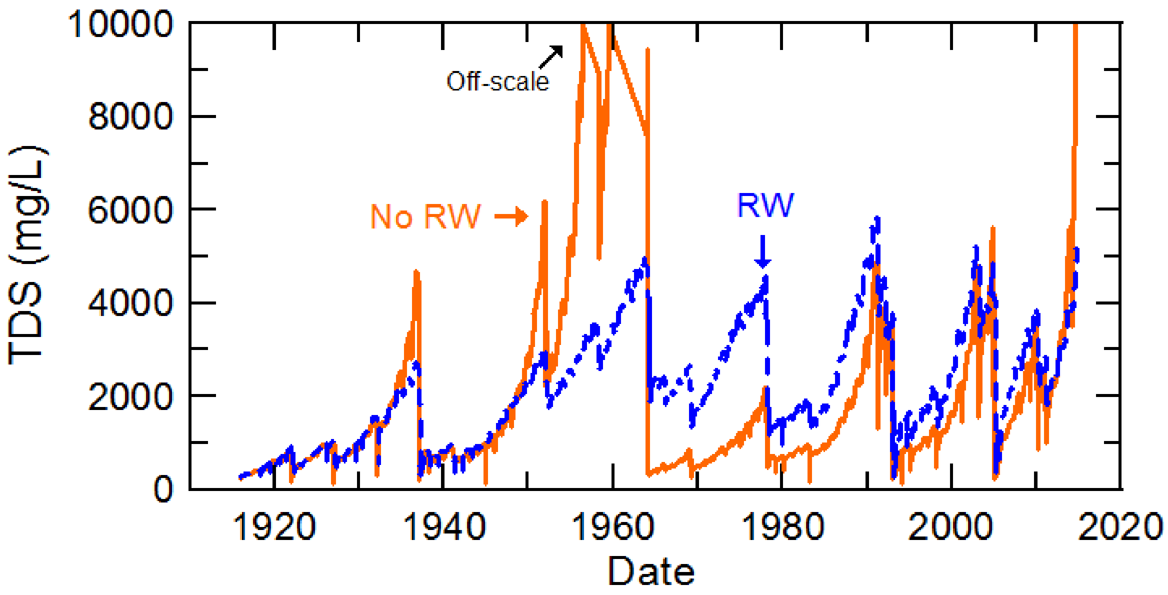
[42] Dr. Michael Anderson (U.C.-Riverside). Technical Memorandum for Task 1.2: Water Quality in Lake Elsinore Under Selected Scenarios - Model Predictions for 1916-2014 with Current (post-LEMP) Basin. Feb. 21, 2016.

Fig. 11: Elevation and Surface Area of Lake Elsinore With & Without Recycled Water[43]



Discharging recycled water to Lake Elsinore also provides significant water quality benefits. Under natural conditions, as evaporation slowly dried-up the lake, salt concentrations would gradually rise in response. Eventually, the average salinity in Lake Elsinore would reach levels that greatly exceed that normally found in the nearby Pacific Ocean (see Fig. 12).

Fig. 12: Comparative Salinity Concentrations in Lake Elsinore[44]



---

[43] Dr. Michael Anderson (U.C.-Riverside). Technical Memorandum for Task 1.2: Water Quality in Lake Elsinore Under Selected Scenarios - Model Predictions for 1916-2014 with Current (post-LEMP) Basin. Feb. 21, 2016.

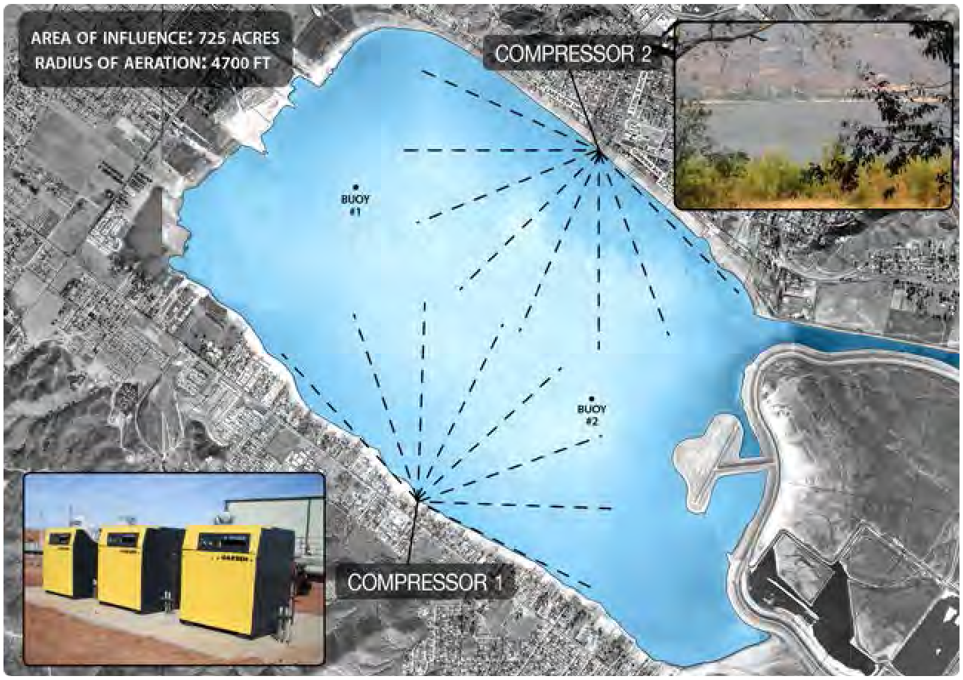
[44] Dr. Michael Anderson (U.C.-Riverside). Technical Memorandum for Task 1.2: Water Quality in Lake Elsinore Under Selected Scenarios - Model Predictions for 1916-2014 with Current (post-LEMP) Basin. Feb. 21, 2016.

However, with recycled water, the total dissolved solids (TDS) concentrations are not expected to exceed to 6,000 mg/L. That is 90% lower than the maximum expected salt concentration under natural conditions and without supplemental recycled water discharges to Lake Elsinore. Keeping salinity concentrations in-check is important because the existing water quality objective for Lake Elsinore is 2,000 mg/L. TDS concentrations greater than this are too high to support most lake species.[45] By offsetting some of the adverse effects of natural evaporation, recycled water helps preserve the freshwater aquatic habitat of Lake Elsinore even during prolonged drought conditions.

3.1.2 Lake Elsinore Aeration and Mixing System Project

The Lake Elsinore Aeration and Mixing System (LEAMS) was constructed in 2006-7 as a joint project sponsored by EVMWD, the City of Lake Elsinore and the County of Riverside, CA.[46] LEAMS relies on a combination of slow-turning propellers submerged in the lake, and shoreline compressors that disperse air from pipelines anchored to the bottom of the lake, to circulate water in Lake Elsinore (see Fig. 13).

Fig. 13: Aeration Distribution Pipelines Submerged in Lake Elsinore



---

[45] [ADD REFERENCE CITATION FROM AMEC WORK]

[46] A large state grant, awarded under Prop-13, paid for most of the capital cost of this project. Historically, all O&M expenses (≈$450k/year) have been shared equally among the three cost-sharing partners.

Water near the bottom of the lake is low in dissolved oxygen. LEAMS is designed to push this bottom water toward the surface where it will be re-aerated, naturally. Higher DO levels are essential to support fish and other aquatic organisms living in the lake. However, stirring the lake to increase DO concentrations also helps improve water quality.

Higher DO concentrations help convert ammonia and nitrate to nitrogen gas. Higher DO concentrations also helps sequester nutrients by aiding the chemical process whereby phosphorus bonds with iron to form harmless mineral sediments.

A comprehensive analysis of water quality data collected since the aeration system began full-time operations in 2008 shows that each hour of LEAMS operation converts more than 22 kg of total nitrogen into nitrogen gas.[47] Consequently, the system removes approximately 44,000 kg of nitrogen from the water column every year. This is more than the total annual average nitrogen load contributed by all anthropogenic sources, including recycled water and stormwater runoff from urban and agricultural areas.

Before LEAMS was built, laboratory tests indicated that aeration would reduce phosphorus released from lake bottom sediments by at least 35%. This conservative estimate was accepted by the Regional Board and used when the Load Allocation was calculated in the TMDL.[48] LEAMS is expected to reduce the existing phosphorus load from sediment by 11,600 kg/year. That, too, is enough to offset 100% of the incremental increase in phosphorus loads contributed by runoff from all anthropogenic sources in the watershed above Lake Elsinore.

The estimated effect of LEAMS on other water quality indicators (e.g. Chlorophyll-a and DO concentrations) are discussed in Section 3.2, below.

3.1.3 Fishery Management Project

Common carp are bottom-feeding fish that forage for food by wagging their tail fins in the sediment to stir up macroinvertebrates. This tail-wagging behavior also re-suspends nutrients from the sediment back to the water column. As a result, large carp populations can have a significant adverse effect on water quality. Experts estimate that reducing the total number of carp in Lake Elsinore by 75% would result reduce the average phosphorus concentration from 0.38 mg/L to 0.26 mg/L (a 31% improvement). Even reducing the total number of carp by only 50% is expected to provide a 12% improvement in average phosphorus concentrations.[49]

---

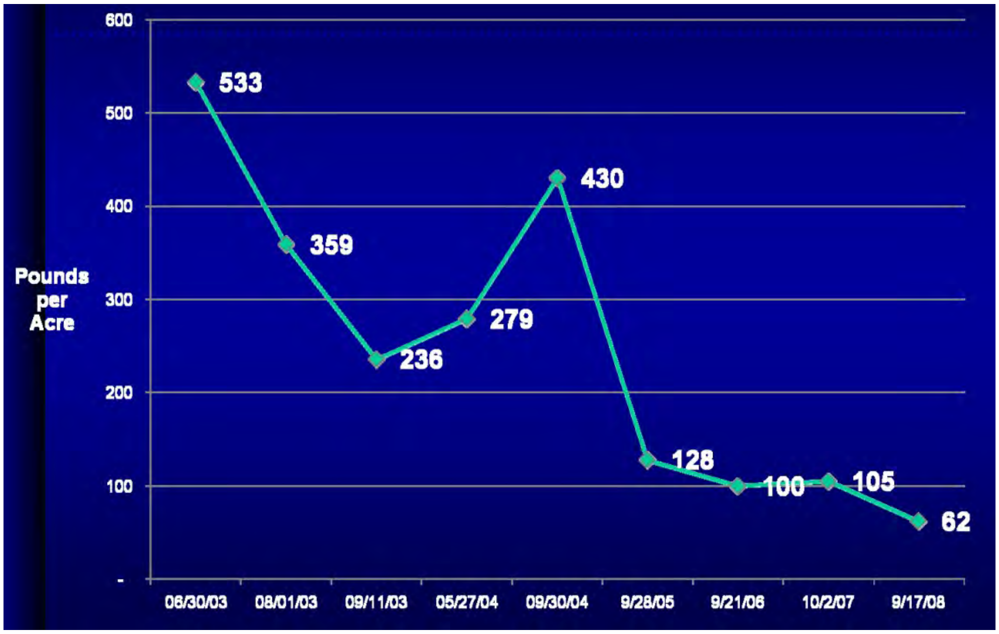
[47] Dr. Alex Horne (U.C. - Berkeley). Nitrogen Offsets Produced by Artificial Water Column Mixing by Aeration Bubble Plumes in Lake Elsinore, CA. Dec. 3, 2012. Note: estimated nitrogen conversion/removal efficiency assumes that LEAMS operates a minimum of 2,000 hours/year. This is now a requirement in EVMWD's NPDES discharge permit.

[48] California Regional Water Quality Control Board - Santa Ana Region Res. No. R8-2004-0037 (Dec. 20, 2004).

[49] Dr. Michael Anderson (U.C. - Riverside). Predicted Effects of Restoration Efforts on Water Quality in Lake Elsinore: Model Development and Results. March 12, 2006; see pg. 26.

In 2002, the City of Lake Elsinore initiated a multi-year demonstration project to reduce the carp population in Lake Elsinore.[50] From 2002 to 2008, a total of 1,316,650 pounds of carp was removed from the lake. And, the carp population declined from 250-500 fish per acre to only 138 fish per acre (45-72%; see Fig. 14).[51]

Fig. 14: Estimated Reduction in Carp Density *(pounds of fish per seine netting area)*



The carp removal effort was suspended at the end of 2008 because the program had been so successful that there were now too few carp to capture efficiently. In the early years, the cost or removing carp was only about 20-cents per pound. By 2008, the cost was over a dollar a pound (a 500% increase).

Since 2008, the Task Force has conducted periodic fish surveys to determine whether the carp population has, once again, expanded to the point where it makes sense to re-start the removal program. The most recent lake assessment shows that, in 2015, the number of fish >20 cm in length (principally carp) is less than 6 per acre.[52] This is 90% fewer fish than there were when the carp removal program was suspended years earlier. Thus, the original program has been shown to produce effective long-term results as well.

---

[50] A total of $600,000 was spent on the demonstration project. State grant funding (under Prop-13) reimbursed approximately 20% of the project cost.

[51] City of Lake Elsinore. Lake Elsinore Fishery Assessment and Carp Removal Program. Report to the LESJWA Board. Nov. 20, 2008.

[52] Dr. Michael Anderson (U.C.-Riverside). Technical Memorandum for Task 2.2: Fishery Hydroacoustic Survey and Ecology of Lake Elsinore in the Spring of 2015. Draft Report dated Feb. 21, 2016.

3.2 Interim Response Targets

3.2.1 Chlorophyll-a (algae)

Long-term water quality monitoring data indicates that Chlorophyll-a concentrations in Lake Elsinore have been rising slowly since the last major El Niño event in the winter of 2004-5 (see Fig. 15). And, it appears that the average phosphorus concentrations have been rising as well (see Fig. 16).

Fig. 15: Measured Chlorophyll-a Concentrations at 3 Sampling Sites in Lake Elsinore[53]

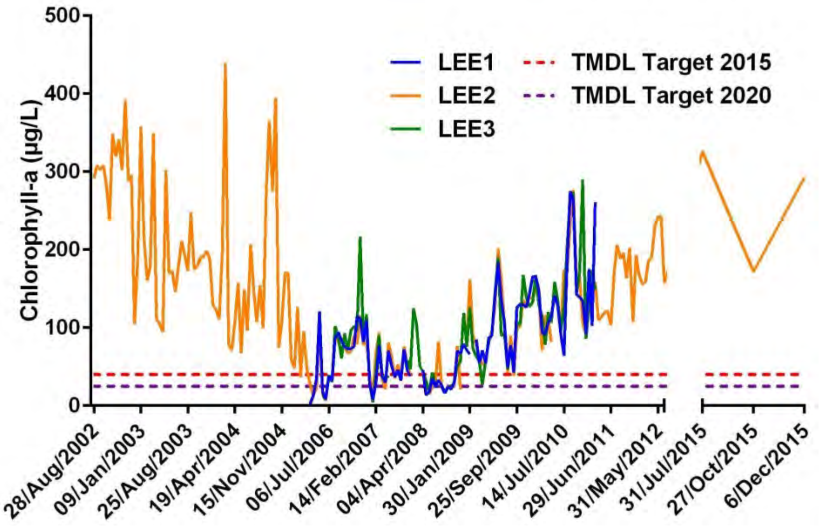
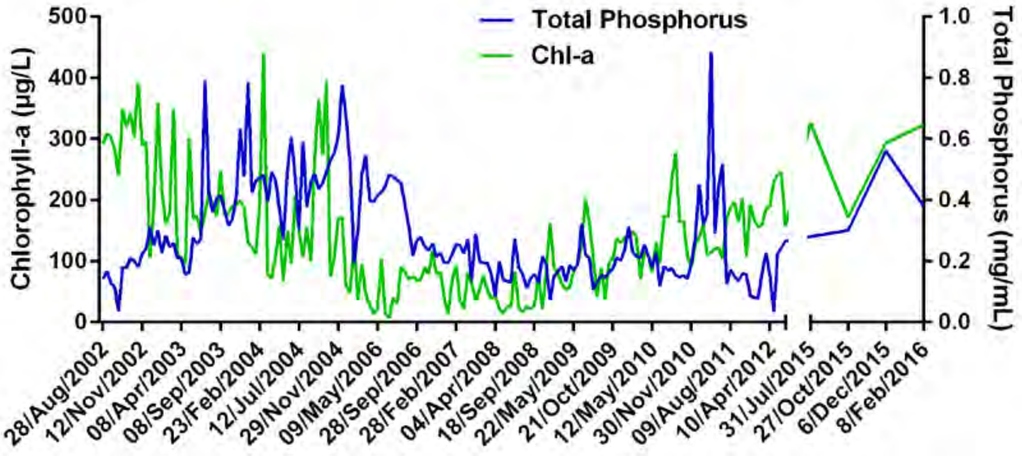


Fig. 16: Long-term Trends for Phosphorus and Chlorophyll-a Concentration in Lake Elsinore



---

[53] AMEC Foster Wheeler. Lake Elsinore Canyon Lake Historic Data Figures. Draft dated April 5, 2016.

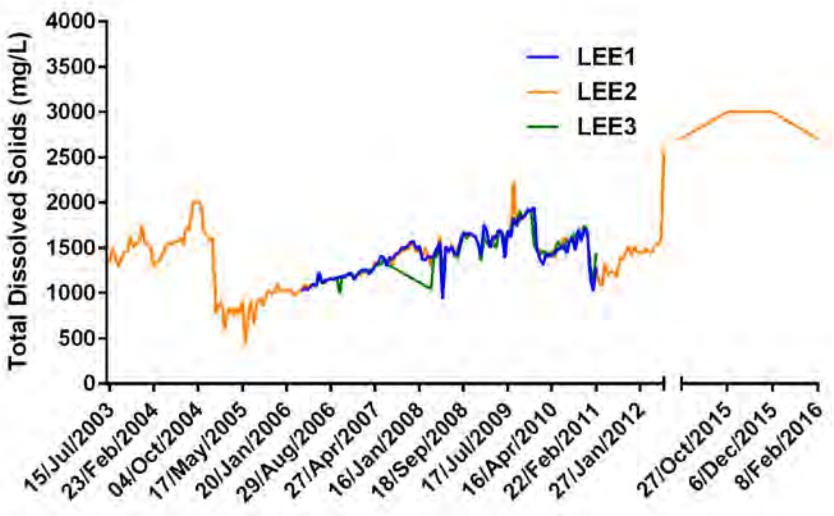
Analysis of satellite images collected in July and December of 2015 and February of 2016 also confirm that Lake Elsinore is not meeting the Interim Response Target for Chlorophyll-a that is specified in the TMDL. These results are admittedly discouraging in light of the considerable investment the stakeholders have made in water quality improvement projects over the last 10 years. However, this data does not mean prior efforts are failing or were made in vain.

Since 2006, the entire San Jacinto watershed has been in a protracted and extreme drought. The lake continues to evaporate and an alarming and Lake Elsinore is starting to approach historic low levels. Were it not for the addition of enormous quantities of recycled water over the last decade, the Lake Elsinore would be less than 5 feet deep on average and would likely dry up completely in the next 12-18 months without a huge new El Niño winter like that experienced in 1993 or 2005.

It should be noted that, during the prolonged drought, very little runoff has been transferred from Canyon Lake to Lake Elsinore. So, the poor current water quality in Lake Elsinore cannot be ascribed to nutrient loads originating from urban or agricultural areas. In fact, these stakeholders are presently in-compliance with the applicable waste load allocations and load allocations proscribed by the TMDL.

Cumulative evaporation is concentrating both salts and nutrients to levels that cannot be overcome by the various mitigation projects previously implemented by the stakeholders. But, the situation would be much worse if these efforts have never been undertaken. Average TDS concentrations, which are presently over 3,000 mg/L would be more than 3x higher if recycled water were not helping to support the lake (see Fig. 17). Such high salinities would be lethal to all freshwater species found in Lake Elsinore.

Fig. 17: Long-Term Trend for Salinity Concentrations in Lake Elsinore[54]



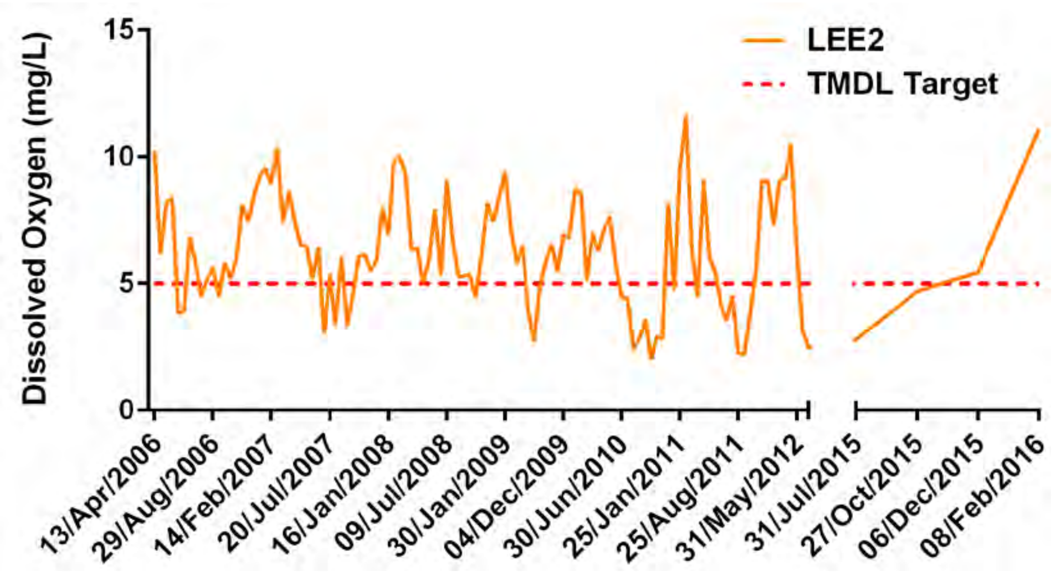
---

[54] AMEC Foster Wheeler. Lake Elsinore Canyon Lake Historic Data Figures. Draft dated April 5, 2016.

3.2.2 Dissolved Oxygen

Long-term monitoring data shows that the interim target for dissolved oxygen is being met most of the time in Lake Elsinore (see Fig. 18). The TMDL Task Force has asked Dr. Michael Anderson (U.C.-Riverside) to prepare a new analysis, using the validated water quality model for Lake Elsinore, to determine whether current DO conditions are likely better or worse than what would have otherwise occurred if recycled water was not being added to the lake.

Fig. 18: Depth-Integrated Daily Average for Dissolved Oxygen in Lake Elsinore[55]



If there is any silver-lining to the recent low lake levels observed in Lake Elsinore, it is that the aeration and mixing system become even more effective under such conditions. There is simply less water to mix and the system is able to circulate what is available more efficiently.

That last major fish kill in Lake Elsinore occurred in 2009. And, based on past experience, local stakeholders have been expecting another one to occur as lake levels fell and temperatures rose. However, while there was a modest fish kill in the summer of 2015, it fell far short of those observed during previous long-lasting droughts. This suggests that LEAMS is probably mitigating some of the problems associated with extremely low DO concentrations that have occurred under similar lake-level conditions in the past.

IV. Conclusions and Recommendations

---

[55] AMEC Foster Wheeler. Lake Elsinore Canyon Lake Historic Data Figures. Draft dated April 5, 2016.

Page Intentionally Blank

LESJWA BOARD MEMORANDUM NO. 790

DATE: April 21, 2016

SUBJECT: Water Quality Modeling and Focused Studies for Lake Elsinore and Canyon Lake in Support of Nutrient TMDL and Assessment

TO: LESJWA Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Receive and file Lake Elsinore and Canyon Lake Water Quality Modeling and Study Report prepared by Dr. Michael Anderson, UCR.

BACKGROUND

In March 2016, Dr. Michael Anderson, University of California, Riverside (UCR) completed water quality modeling and focused studies for Lake Elsinore and Canyon Lake. This modeling evaluated not only seasonal or annual conditions, but decadal and multi-decadal trends and conditions. This longer term perspective was needed to establish the appropriate reference condition for Lake Elsinore and Canyon Lake, and understand longer term responses to watershed and in-lake management efforts.

The results of these analyses have been presented to the LE&CL TMDL Task Force and are described in detail in the attached Technical Memorandums (TM) as listed below:

TM 1.0: Surface Elevation and Salinity in Lake Elsinore: 1916-2014

TM 1.1: Influence of Recycled Water Supplementation on Surface Elevation and Salinity in Lake Elsinore: Model Predictions for 1916-2014 with Current (post-LEMP) Basin

TM 1.2: Water Quality in Lake Elsinore Under Selected Scenarios: Model Predictions for 1916-2014 with Current (post-LEMP) Basin

TM 2.1: Stable Isotope, Elemental and Mobile-P Measurements in Lake Elsinore Sediments

TM 2.2: Fishery Hydroacoustic Survey and Ecology of Lake Elsinore: Spring 2015

TM 2.3: Bathymetric Survey and Sediment Hydroacoustic Study of Canyon Lake

TM 2.4: Mobile-P and Internal Phosphorus Recycling Rates in Canyon Lake

Please note: Dr. Anderson will be presenting the modeling results at the April 27th LESJWA Water Summit.

BUDGET IMPACT

All staff time associated with the Water Quality Modeling and Focused Studies for Lake Elsinore and Canyon Lake in Support of Nutrient TMDL and Assessment has been budgeted under the LE/CL TMDL Task Force budget that also is shown in the LESJWA budget.

MN:RW:dm

Attachment:

1. Draft Water Quality Modeling and Focused Studies for Lake Elsinore and Canyon Lake in Support of Nutrient TMDL and Assessment Technical Memorandums

Page Intentionally Blank

Lake Elsinore/Canyon Lake TMDL Task Force

Technical Memorandums 2015-16

Michael Anderson, Ph.D.
University of California, Riverside

Water Quality Modeling and Focused Studies for Lake Elsinore and Canyon Lake in Support of Nutrient TMDL and Assessment

List of Technical Memorandums:

Task 1.0:	Surface Elevation and Salinity in Lake Elsinore: 1916-2014
Task 1.1:	Influence of Recycled Water Supplementation on Surface Elevation and Salinity in Lake Elsinore: Model Predictions for 1916-2014 with Current (post-LEMP) Basin
Task 1.2:	Water Quality in Lake Elsinore Under Selected Scenarios: Model Predictions for 1916-2014 with Current (post-LEMP) Basin
Task 2.1:	Stable Isotope, Elemental and Mobile-P Measurements in Lake Elsinore Sediments
Task 2.2:	Fishery Hydroacoustic Survey and Ecology of Lake Elsinore: Spring 2015
Task 2.3:	Bathymetric Survey and Sediment Hydroacoustic Study of Canyon Lake
Task 2.4:	Mobile-P and Internal Phosphorus Recycling Rates in Canyon Lake

Technical Memorandum

Task 1.0: Surface Elevation and Salinity in Lake Elsinore: 1916-2014

Objective

The objective of this initial task was to develop and calibrate a 1-D hydrodynamic model for Lake Elsinore to simulate volume, surface elevation and salinity in Lake Elsinore for the period 1916-2014, and compares model-predicted values with available observations.

Approach

The DYRESM model was used to simulate conditions in Lake Elsinore under the 1-D assumption, *i.e.*, that lateral differences in water column properties are small and that the primary gradients in properties occur in the vertical dimension. The 1-D assumption is appropriate given the lake's relatively simple basin shape and the long time horizon of interest. Specifically, this assessment evaluated the time period from 1916-2014 (99 yrs). This time interval was selected because of availability of flow, rainfall and air temperature data for this full period.

Daily flows of the San Jacinto River into Lake Elsinore at USGS gage #11070500 were downloaded from USGS. Daily rainfall records were provided by RCFCD for the Quail Valley, (1958-2014), San Jacinto (1940-2014) and Hemet (1916-2014) rain gauges to estimate runoff from the local 13,340 acre watershed not captured by gaged San Jacinto River flows (Anderson, 2006). The available Quail Valley rainfall data were used for the 1958-2014 period without any correction. Regression equations developed between measured Quail Valley precipitation and that at San Jacinto (r^2=0.70) and Hemet r^2=0.52) were used to predict rainfall at Quail Valley for 1940-1958 and 1916-1940, respectively. Daily average air temperature, relative humidity/vapor pressure, shortwave radiation, and windspeed for 1985-2014 were taken from CIMIS station #057 at UC Riverside. Air temperature records for 1916-1985 were downloaded from the NOAA National Climatic Data Center for the Corona station that provided the longest nearby continuous record. Average shortwave solar radiation, vapor pressure and windspeed from CIMIS station #057 for each calendar day were used for the earlier part of the record when measurements of these meteorological attributes were not available (pre 1985).

The elevation-area data for the natural lake basin was used from the 1916-1995 period (*i.e.*, pre-LEMP), while the current reconfigured basin (*i.e.*, post-LEMP) was used for the period 1996-2014. A 10-minute time-step was used for the simulations.

Meteorological and Flow Records

Analysis of meteorological and flow data over the past 99 years highlights the inter-annual variability present in the region. Annual rainfall within the local watershed of Lake Elsinore ranged from 2.04 inches in 2006 (based on water year) to 26.97 inches in 1977 (Fig. 1). Precipitation averaged 10.1 inches over this period, while the median was 8.89 inches. As suggested in Fig. 1, precipitation was not normally-distributed about the mean value; precipitation was found to be log-normally distributed however (mean log rainfall 0.96±0.21).

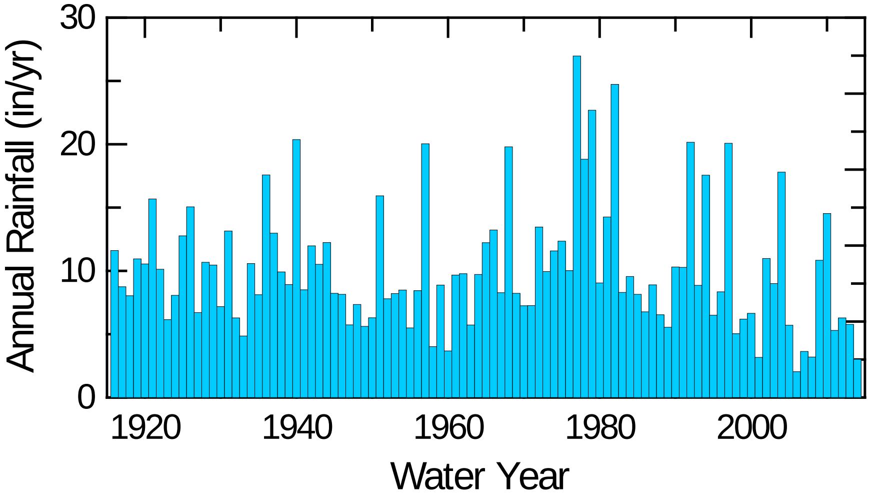


Fig. 1. Annual rainfall to local watershed adjacent to Lake Elsinore.

The mean annual air temperature has also varied over the past 99 years (Fig. 2). Temperature has averaged 17.08±0.81 °C over this interval, with a minimum value of 15.4 in 1934 and a maximum temperature of 19.5 °C in 1984, with a statistically significant increase ($p<0.001$) in average annual air temperature at a mean rate of 0.016°C/yr, or an increase of almost 1.6°C over the study period. This rate of change is larger than the global mean surface temperature increase of approximately 1.0°C over this same time period.

Annual runoff to Lake Elsinore measured at the USGS gage exhibited even more dramatic variation (Fig. 3). There were 5 years where virtually no flow was recorded at the gage, and 25% of the time, annual flow was <100 AF/yr. At the other end of the spectrum, 22 years were found to have flows >10,000 AF/yr, supporting the general notion of an El Nino-type event on average every 4-5 years. Low flows are difficult to see on this figure due to the periodic very large flows (e.g., water years 1916 and 1980).

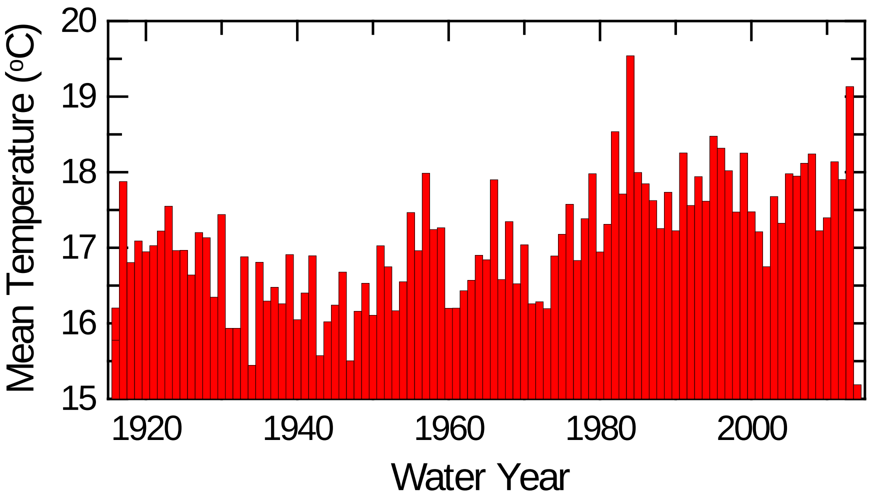


Fig. 2. Mean annual temperature at Corona (NOAA)

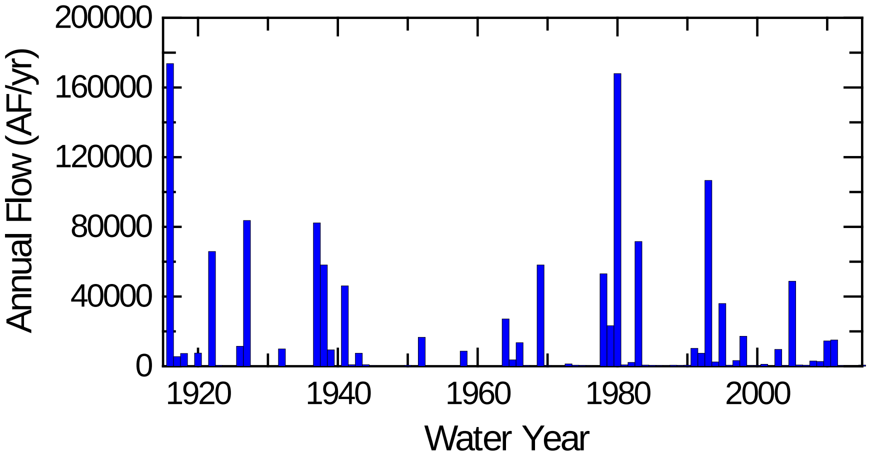


Fig. 3. Annual flow at USGS gage #11070500 (San Jacinto River near Lake Elsinore)

Local rainfall values (Fig. 1) were used to estimate local runoff flows to the lake (i.e., runoff from the land areas surrounding the lake and not captured by the USGS gage) (Fig. 4, orange bars). Previous measurements at the lake suggested a local runoff coefficient of about 0.3, or about 30% of precipitation contributed to runoff (Anderson, 2006), while 70% was on average retained by the soil through infiltration and storage within the porosity of the soil and weathered bedrock. Since runoff in urban and suburban-type watersheds is strongly influenced by the amount of impermeable surfaces (roads, parking lots, driveways and rooftops), an assumption was made that the runoff coefficient measured a few years ago adequately reflects current levels of development, but that the runoff coefficient would likely have been lower earlier in the study period. Specifically, a runoff coefficient of 0.2 was assumed from 1916-1960, 0.25 for 1961-

1980, and 0.3 for 1981-present. Local runoff averaged 2813 AF/yr. Recycled water was also recently added over a number of years (Fig. 4, green bars).

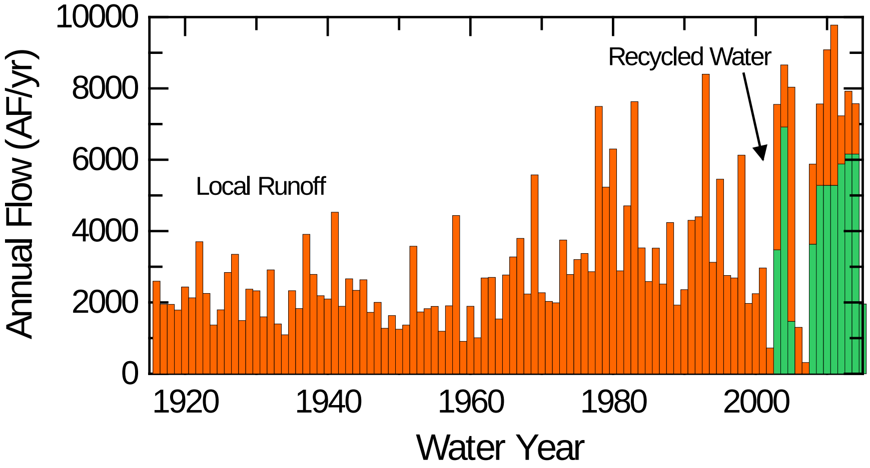


Fig. 4. Annual flows to Lake Elsinore due to local runoff (orange bars) estimated from precipitation and runoff coefficient and recycled water additions (green bars).

<u>Model Calibration: 1964-2014</u>

Lake Level

Daily average values for meteorological parameters were used in conjunction with daily flow data to predict volume, surface elevation, and salinity in Lake Elsinore over time. Lake surface elevation has been recorded regularly by Elsinore Valley Municipal Water District staff since 1964, following the dry lake bed from approximately 1954-1964 and beginning with importation and delivery of Colorado River Aqueduct water. Recorded lake level data were provided by Jesus Gastelum and used to calibrate the model with respect to the water budget.

Preliminary simulations used January 1, 1964 as the starting point with the introduction of Colorado River water beginning on February1, 1964 with model default parameter values; the model was found to over-predict water levels and surface water temperatures. More detailed analysis indicated that the model was under-predicting evaporation when compared with theoretical ET_0 values measured at UCR CIMIS station #057. This appears to be due to use of daily average values for air temperature, vapor pressure and windspeed, which do not adequately reflect the warm dry afternoon winds that result in much of the evaporative heat flux and water loss that occurs at the lake. To account for this, the bulk aerodynamic transport coefficient was lowered from $1.3\text{x}10^{-3}$ to $0.3\text{x}10^{-3}$ and non-neutral atmospheric stability was assumed; this was found to yield an annual evaporation rate from the lake that matched the rate of 1.47 m/yr reported at the UCR CIMIS station. Using these parameter values, predicted lake surface elevations from simulations matched much more closely measured values over the 1964-2014 period, except immediately following a large runoff event that dramatically increased lake level and wetted lake area. This discrepancy was attributed to rapid infiltration into dry lake bed sediment and surrounding soils and potential groundwater recharge. This was especially evident in 1964 when water was introduced in the lake basin following an approximately decade-long dry lake bed, and in 1970 and 1980 when large volumes of runoff was delivered to the lake (Fig. 3). Following the major runoff event in 1980, about 40% of the runoff delivered to the lake was estimated to have saturated soils and recharged groundwater as a result of rewetting more than 2000 acres of the lake's approximately 6000 acre natural basin. Infiltration rates were estimated to be 0.7 cm/d. Subject to these corrections, the model predicted lake surface elevations that very closely followed measured values (Fig. 5). Note that the natural 6000 acre basin was assumed to be in place through 1995, at which time the LEMP project was completed which reduced lake area and increased mean depth.

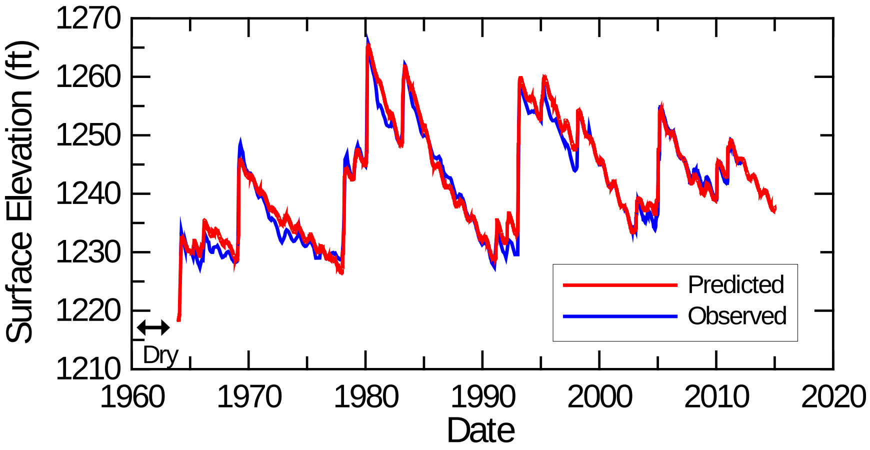


Fig. 5. Surface elevation of Lake Elsinore: 1964-2014 (blue line represents measured values; red line represents predicted values).

The model quite reasonably reproduced lake level in the post-LEMP basin (1996-2014) without any corrections for infiltration so none were applied over this interval (Fig. 5). This is thought to be a result of the tight clay layer present across much of the lower part of the lake basin that limits deep percolation and minimizes loss to unsaturated soil or groundwater. The reconfiguration of the basin as a result of LEMP thus not only reduced evaporative loss but all quite substantially reduced losses to unsaturated soils and groundwater. Root-mean square error (RMSE) of model-predicted surface elevations was 0.0047 ft.

Salinity

Salinity in the lake is a function of runoff volumes, salinities of those flows, and evapoconcentration. Based upon available measurements and reports, average TDS values for the San Jacinto River, local runoff and recycled water were taken as 300, 150 and 700 mg/L. TDS levels would also vary markedly as a result of rewetting of a dry evaporite lake bed, and during episodes of evapoconcentration as well as large runoff events. The amount of salt deposited during the approach to and subsequent decade-long dessication period of 1954-1964 is not known, but local accounts do report frequent episodes of intense blowing dust and salt. It is likely that wind erosion was a mechanism by which a significant amount of salt was exported from the lake basin. Based upon water budget calculations (Fig. 5) and other factors, initial salinity was varied and model results were compared with observed values. Reasonable agreement was found when initial salinity was set at 7,500 mg/L TDS with a maximum water depth of 18 cm. Importantly, this TDS value was in good agreement with the TDS value of 8,000 mg/L measured in sediment porewater above the clay dessication layer from a core collected from the deepest part of the lake (unpublished data). (The model requires at least 18 cm of water be present in the lake and also requires that the salinity of the water remain below about 42,000 mg/L based upon the UNESCO equation of state for water that governs vapor pressure, specific heat and other thermodynamic properties of water.) The model predicted wide swings in TDS, with extended periods of evapoconcentration and increasing salinity followed by rapid declines as a result of large runoff events (Fig. 6). Model predicted TDS levels were in good overall agreement with measured TDS values available over the past 15 years when studies began in earnest at the lake (Fig. 6). RMSE of model-predicted TDS concentrations was 203 mg/L.

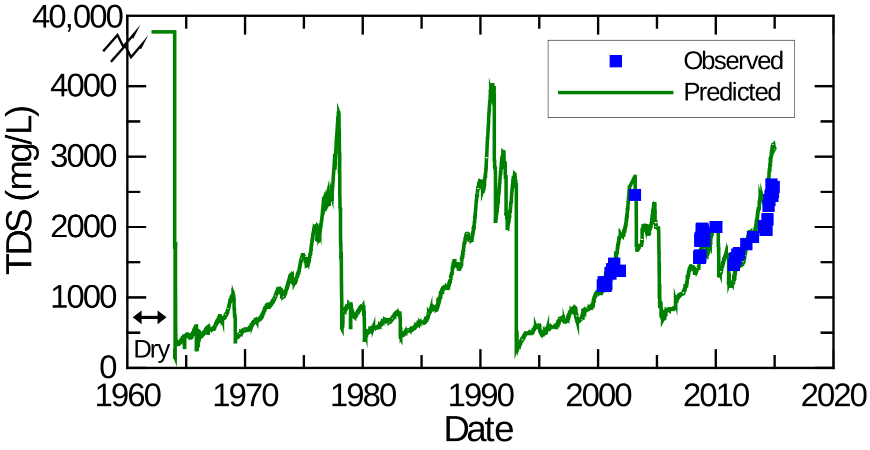


Fig. 6. Total dissolved solids (TDS) concentration in Lake Elsinore: 1964-2014 (blue symbols represents measured values; green line represents predicted values).

The model accurately reproduced measured lake surface elevations (Fig. 5) and also reasonably reproduced measured TDS concentrations (Fig. 6). The model was thus deemed suitable for predicting water balances and salt balances in Lake Elsinore over the longer 1916-2014 time period, and also serves as an appropriate starting point for simulations of water quality over the past century.

1916-2014

The period from 1916-1964 was then simulated and appended to 1964-2014 model results (Fig. 7). The initial condition for the lake on January 1, 1916 was not precisely known, but the average depth of 5 m, temperature of 12°C and TDS of 250 mg/L was assumed based upon historical accounts of lake levels in the late 1930s and 1950s. To account for loss to unsaturated soils and groundwater following large runoff events into the large shallow natural basin, flows were reduced by an average value of 30% based upon detailed water accounting over the 1964-1995 period previously described. The results from 1916-1950's should thus be considered provisional; notwithstanding, this period also demonstrated considerable variation in lake level (Fig. 7).

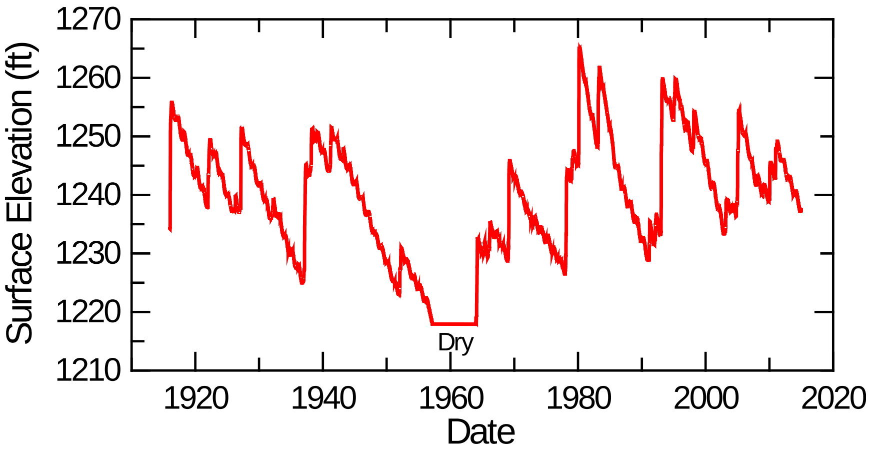


Fig. 7. Model-predicted surface elevations of Lake Elsinore: 1916-2014.

The model predicted low lake levels in 1935, with a minimum surface elevation of 1225.3 ft and depth of 2.3 m in December 1936 before spring rains in 1937 increased lake level to 1245.2 ft and depth of 8.34 m (Fig. 7). Rainfall and runoff the following spring (1938) further increased lake level to 1251.3 ft. The surface area of the lake increased from 1450 to 4895 acres over this time period (Fig. 8). The model predicted the lake level to decline through much of the 1940's, fully dry out by early 1957 and remain essentially dry until February 1964 (Figs. 7, 8). Historical accounts suggest the lake dried out somewhat earlier than that, potentially by 1954 or 1955.

Salinity varied inversely with surface elevation and lake area, with very large increases in TDS present as a result of evapoconcentration at low lake levels (Fig. 9). Values exceeding 3000 mg/L were predicted in the 1930s, 1940s-1964, 1978 and 1990 (Fig. 9). The TDS was predicted to exceed that of seawater upon complete dessication in the late 1950s.

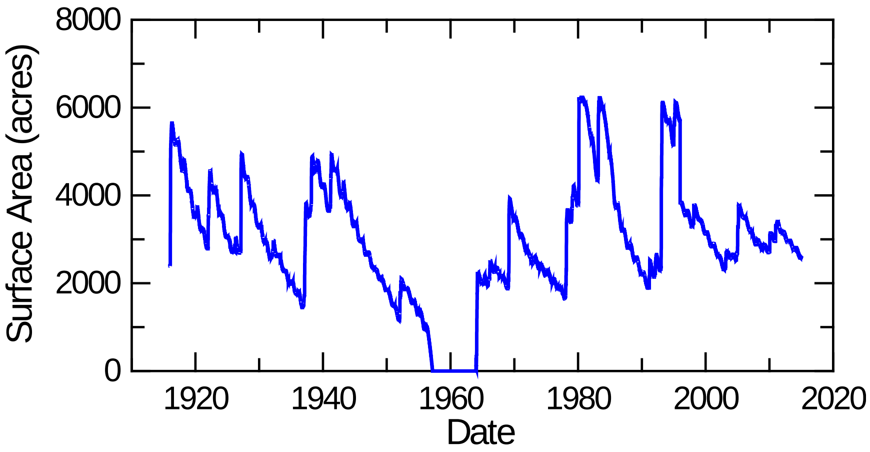


Fig. 8. Model-predicted surface area of Lake Elsinore: 1916-2014.

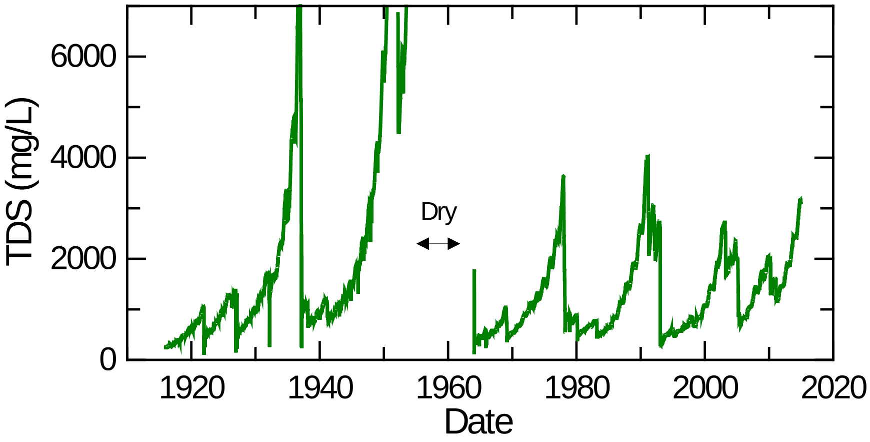


Fig. 9. Model-predicted TDS concentrations in Lake Elsinore: 1916-2014.

The simulation results presented in Fig. 9 can also be used to track salt accumulation within the lake basin. While it is difficult to visually track salinity given the highly dynamic lake level that concentrates and then dilutes the salt load, TDS concentrations at a common surface elevation, and thus also lake volume, provides a straightforward way to estimate of the rate of salt accumulation within the lake. At a constant lake level of 1240 ft, TDS concentration was observed to increase at a rate of 39 mg/L/yr between 1920-1950 (r^2=1.00) for the large shallow natural lake basin (Fig. 10). The rate of salt accumulation at constant elevation was similar for the period 1970-2002 (30 mg/L/yr) even though the post-LEMP data point shifted the slope of the line down somewhat. Most notably, addition of recycled water at rates shown in Fig. 4 approximately quadrupled the rate of salt accumulation, to 136 mg/L/yr (r^2=1.00), despite the smaller deeper (post-LEMP) lake basin that would be expected to reduce the rate of evapoconcentration of salts relative to the natural basin (Fig. 4). This provides the first quantitative estimate of effect of recycled water addition on salt load in Lake Elsinore.

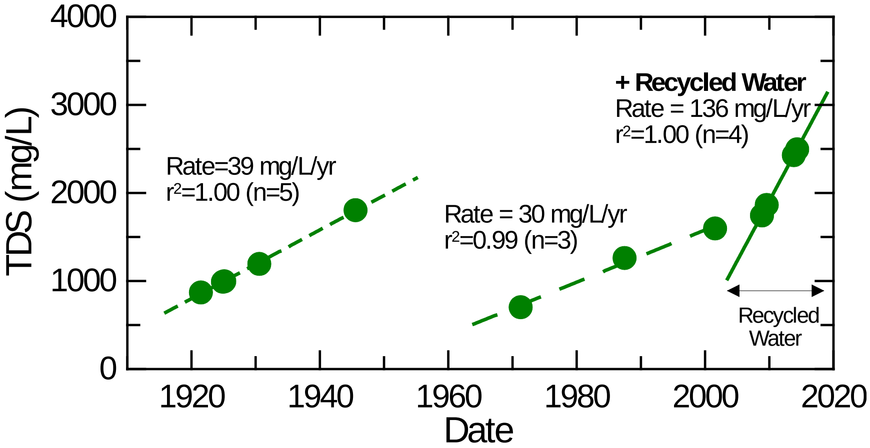


Fig.10. Model-predicted TDS concentrations in Lake Elsinore at constant lake elevation of 1240 ft showing marked increase in rate of salt accumulation since recycled water additions began in late 2002.

Part of the interest in simulating the early part of the past century was to include this longer record in a probabilistic description of the range of conditions in the lake and the frequency of low lake levels and high salinities that would have profoundly negatively affected its beneficial uses. The results from Figs. 7-9 were used to develop cumulative distribution functions that describe the exceedance frequency of a given condition, *e.g.*, frequency over the past 99 years that the lake level was below 1240 ft, or salinity exceeded some critical biological threshold (Fig. 11).

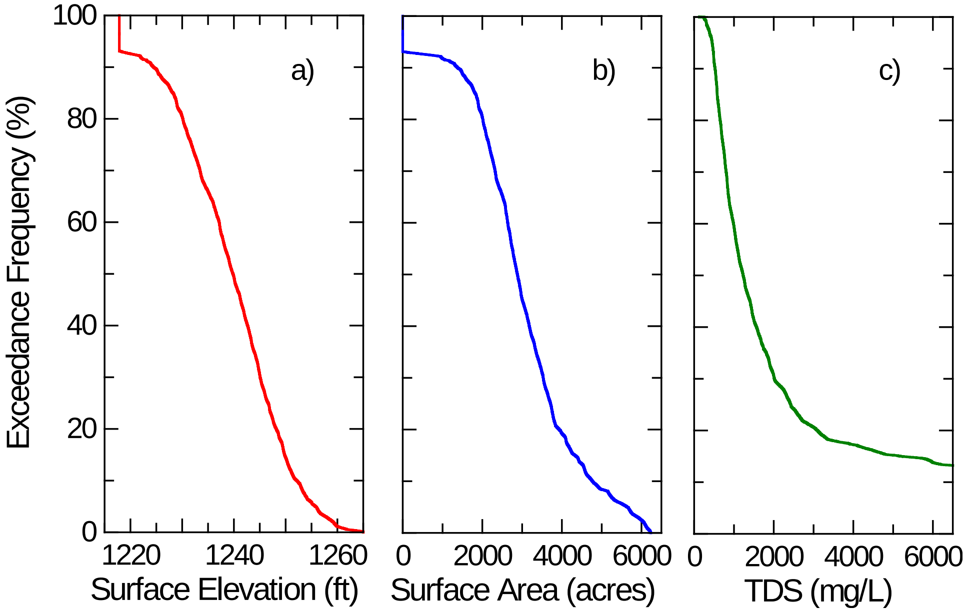


Fig. 11. Exceedance frequencies for a) lake surface elevation, b) lake surface area, and c) TDS concentration.

Based upon model predictions, the lake was dry 6.8 of the past 99 years, with a surface elevation <1218 ft and no wetted surface area (Fig. 11). The frequency of exceeding a given lake elevation and area decreased with increasing values. Selected exceedance frequencies are provided in Table 1. The lake property at an exceedance frequency of 50% corresponds to the median value over the simulated period; thus, the median lake level was at 1239.8 ft, surface area was 2881.4, and TDS was 1232 mg/L (Table 1). Values higher than these were found less frequently, e.g., 5% of the time, the TDS was predicted to exceed that of ocean water (when the lake was essentially dry).

Table 1. Values of surface elevation, area and TDS concentration in Lake Elsinore at selected exceedance frequencies based upon simulations for 1916-2014..

Exceedance Freq (%)	**Elevation (ft)**	**Area (acres)**	**TDS (mg/L)**
90	1224.5	1380.2	524
50	1239.8	2881.4	1232
10	1252.1	4766.7	13,786
5	1255.8	5641.7	>42,000
1	1260.4	6137.6	>42,000

It is worth noting that a 90% exceedance frequency for a lake surface elevation of 1224.5 ft or surface area of 1380.2 acres (Table 1), also corresponds to a 10% frequency of being *less* than these values. Thus using the 99 year record as an index, 10 years out of the past 99 years would yield elevations and areas below these values.

Conclusions

Results from these initial simulations indicate:

(i) the model accurately predicted measured lake surface elevations and available TDS concentrations;

(ii) significant loss of water to unsaturated soil and groundwater occurred in the large shallow natural basin (i.e., pre-LEMP) following large runoff events;

(iii) losses to unsaturated soils and groundwater were not apparent for the reconfigured (post-LEMP) basin;

(iv) over the past 99 years, the model predicts that the lake was dry for 6.8 years, with salinity near or exceeding that of sea water when the lake approached dessication;

(v) salt has accumulated in Lake Elsinore at a predicted rate of 30-39 mg/L/yr at a surface elevation of 1240 ft for much of the past century;

(vi) addition of recycled water has accelerated the predicted rate of salt accumulation at 1240 ft elevation to 136 mg/L/yr since addition of recycled water began in late 2002.

Next Step

The next step will be to simulate Lake Elsinore using the reconfigured (post-LEMP) basin for the entire 1916-2014 period, with and without recycled water additions, to compare effects of recycled water on lake surface elevation, area and salinity. Comparison will also be made with the results reported herein for the natural basin (1916- 1995) and transition to the reconfigured basin (1996-2014).

References

Anderson, M.A. 2006. *Predicted Effects of Restoration Efforts on Water Quality in Lake Elsinore: Model Development and Results.* Final Report to LESJWA. 33 pp.

Page Intentionally Blank

Technical Memorandum

Task 1.1: Influence of Recycled Water Supplementation on Surface Elevation and Salinity in Lake Elsinore: Model Predictions for 1916-2014 with Current (post-LEMP) Basin

Objective

The objective of this task was to simulate Lake Elsinore using the current (post-LEMP) basin for the entire 1916-2014 period, with and without recycled water additions, to compare effects of recycled water on lake surface elevation, area and salinity.

Approach

The calibrated DYRESM model used in Tech Memo 1.0 that simulated lake level and salinity in Lake Elsinore under conditions present at the lake from 1916-2014 (Anderson, 2015) will be used with the current (post-LEMP) basin. The lake will be simulated (i) assuming San Jacinto River flow and local runoff with TDS concentrations of 300 and 150 mg/L, respectively, and (ii) water supplemented with up to 5000 acre-feet of recycled water with a TDS concentration of 700 mg/L when the lake level drops below 1240 ft. Crest elevation was set to 1255 feet; the model assumes that the discharge capacity when the lake reaches crest elevation is effectively unlimited. All other model parameters will remain unchanged from those described in Tech Memo 1.0. The reader is referred to that document for details.

Results

Runoff from the San Jacinto River and local watershed into Lake Elsinore (with post-LEMP basin) for the 1916-2014 period were predicted to yield wide swings in lake surface elevation (Fig. 1, solid orange line). The model predicted that the lake level would remain above 1240 ft from early 1916 -1931, with water flowing out of the lake in 1916, 1922, and 1927. The water surface elevation decreased to about 1229 ft above MSL in 1936 before rainfall and runoff increased the lake level sufficient for water to again flow out of the lake in 1937 (Fig. 1, orange line). Limited runoff from 1943-1964 failed to meet evaporative losses and resulted in the lake level declining and eventually going dry in 1961-1964. Importantly then, while LEMP has a pronounced benefit helping maintain water level relative to the natural basin (Anderson, 2013), the re-engineered smaller basin is nonetheless unable to maintain water in the lake during periods of prolonged drought (Fig. 1, orange line).

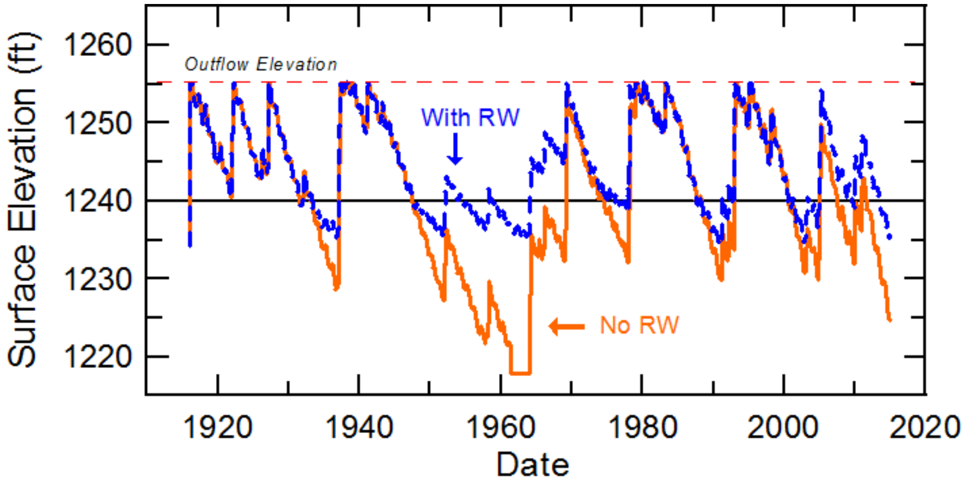


Fig. 1. Lake surface elevation with LEMP basin and natural flows (solid orange line) and supplemented inflows with recycled water (dashed blue line).

Supplementation of natural inflows with recycled water when the lake level declined below 1240 ft helped support higher lake levels and was predicted to maintain surface elevations above 1234.5 ft throughout the entire 99-yr period (Fig.1, dashed blue line). The re-engineered basin together with supplementation with recycled water helps prevent extremely low lake levels.

The increased lake surface elevations resulting from recycled water additions also had a marked effect on lake surface area (Fig. 2).The lake area rarely dropped below 2500 acres (range 2372 – 3844 acres) and averaged 3088 acres with recycled water supplementation. In contrast, a much wider range of surface areas were predicted with natural flows, from 0 acres (i.e., dry lake bed) in early 1960s to 3844 acres (full pool) during strong El Nino events (Fig. 2). The lake averaged 2772 acres over the duration of the simulation. Recycled water additions thus help ensure greater recreational opportunities and provide more substantial habitat when compared with natural inflows only.

The re-engineered basin also resulted in lake surface elevations that periodically reached the crest elevation of 1255 ft, resulting in overflows and some flushing of the lake (Fig. 3). The DYRESM model assumes no limits on outflow rates when surface elevations exceed crest elevation, so the predicted daily outflow rates in many cases exceed the capacity of the outflow channel. In the short-term then, lake surface elevations and volumes would exceed those predicted by the model, although values would approach model-predicted values as water is discharged downstream.

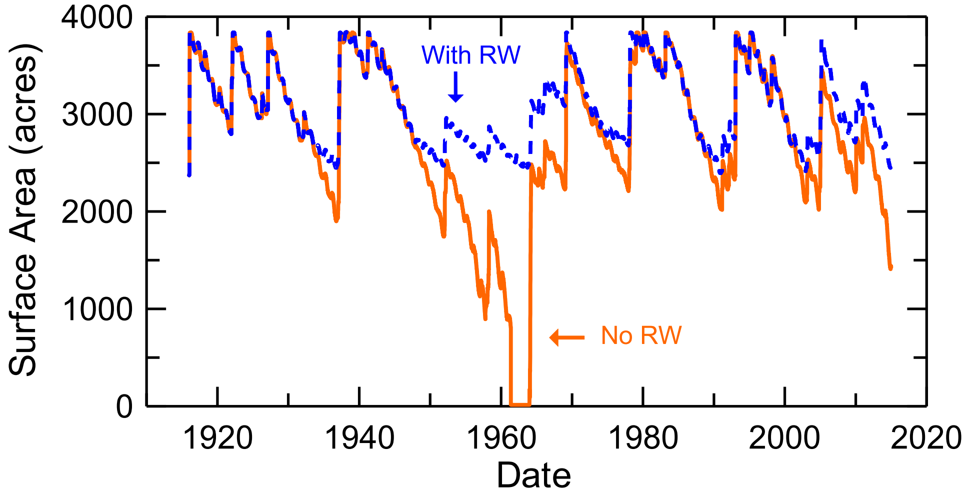


Fig. 2. Lake surface area with LEMP basin and natural flows (solid orange line) and supplemented inflows with recycled water (dashed blue line).

While it is difficult to discern from Fig. 3, outflows often occurred for several weeks or more, with the duration governed by the intensity and duration of runoff events (i.e., features in Fig 3 represent many days, rather than a single day). Also not necessarily evident, supplementation with recycled water increases the amount of water discharged to the outflow and Temescal Creek on similar dates, especially evident in late 1969 and 1979. For example, outflow occurred for an additional 53 days in winter 1969 with recycled water added, at a flow rate up to more than 5000 af/d and resulting in a cumulative additional outflow of 29,071 af (Fig. 4).

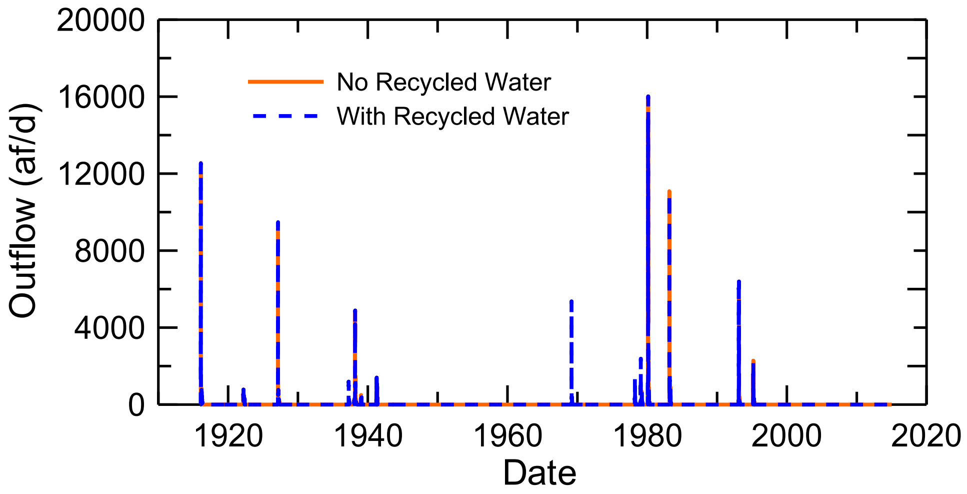


Fig. 3. Daily lake outflow from LEMP basin with natural flows (solid orange line) and inflows supplemented with recycled water (dashed blue line).

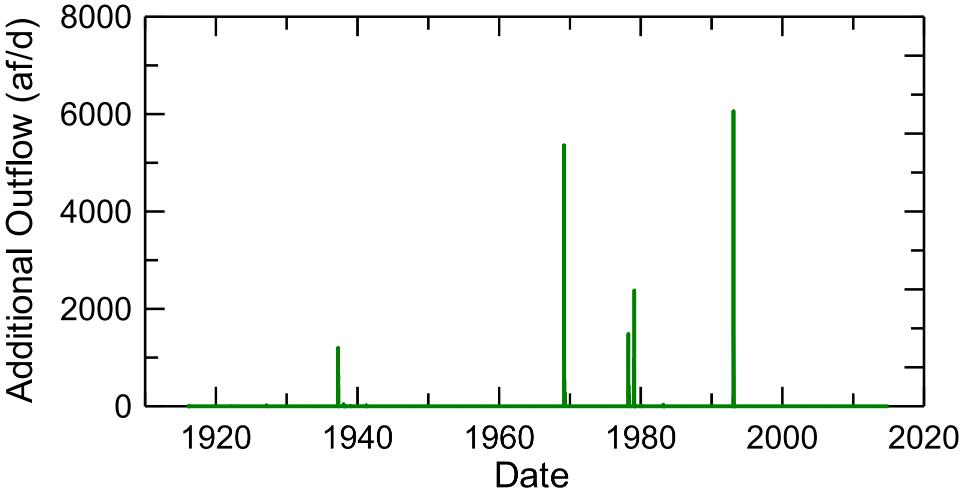


Fig. 4. Additional daily outflow from LEMP basin beyond that predicted for natural flows resulting from supplementation with recycled water.

Supplementation with recycled water also had a clear effect on total dissolved solids (TDS) concentrations in the lake (Fig. 5). Most notably, addition of recycled water eliminated the extreme TDS values (>10,000 mg/L) predicted for mid- to late-1950's through 1964 when lake surface elevation dropped to very low levels (Fig. 1) and eventually went dry (Fig. 2). Since supplementation with recycled water helps maintain water in the lake, TDS concentrations do not reach the extreme values present when the lake levels drops to exceedingly low values, thus providing a ceiling to TDS levels that is a function of TDS concentration in recycled water and the frequency and intensity of outflow-flushing events (Fig. 5).

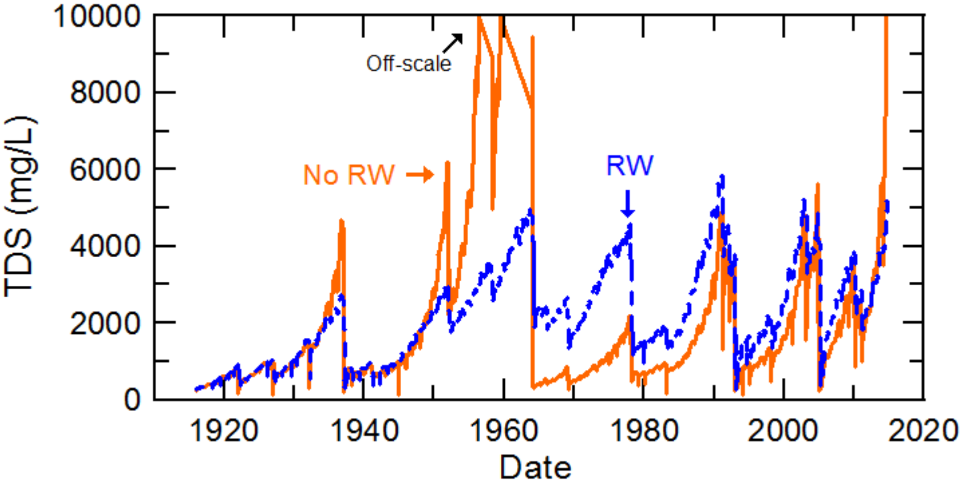


Fig. 5. TDS concentrations over time with LEMP basin and natural flows (solid orange line) and inflows supplemented with recycled water (dashed blue line).

The addition of recycled water also constrains the lower range of TDS predicted in the lake (Fig. 5). For the simulated interval since about 1960, recycled water supplementation yielded TDS levels that rarely dropped below 1,000 mg/L and were more typically predicted to be 2,000-4,000 mg/L (Fig. 5, blue line). Minimum TDS concentrations were much lower without recycled water additions (Fig. 5, orange line).

This can be seen from a cumulative distribution function for TDS with and without recycled water additions (Fig. 6). One notes that the exceedance probabilities differ significantly for the 2 scenarios, with lower TDS values predicted over 80% of the time for natural inflows relative to those with recycled water supplementation, although TDS values were dramatically higher without recycled water supplementation about 15% of the simulation period (Fig. 6). On no day was TDS predicted to exceed 6,000 mg/L with recycled water additions, while TDS values with only natural flows exceeded 6,000 mg/L 9.3% of the time (over 3300 days or >9 yrs out of 99). The median TDS value for the 99-yr simulation period under natural flows was 1,163 mg/L while the value increased to 2,055 mg/L with recycled water supplementation. Recycled water supplementation thus constrained TDS values to <6,000 mg/L, but also increased TDS levels much of the time. If we assume that TDS values >2,000 mg/L negatively impact the ecology of the lake, some salinity-impairments would be expected about 52% of the time with recycled water additions and 32% of the time with natural flows.

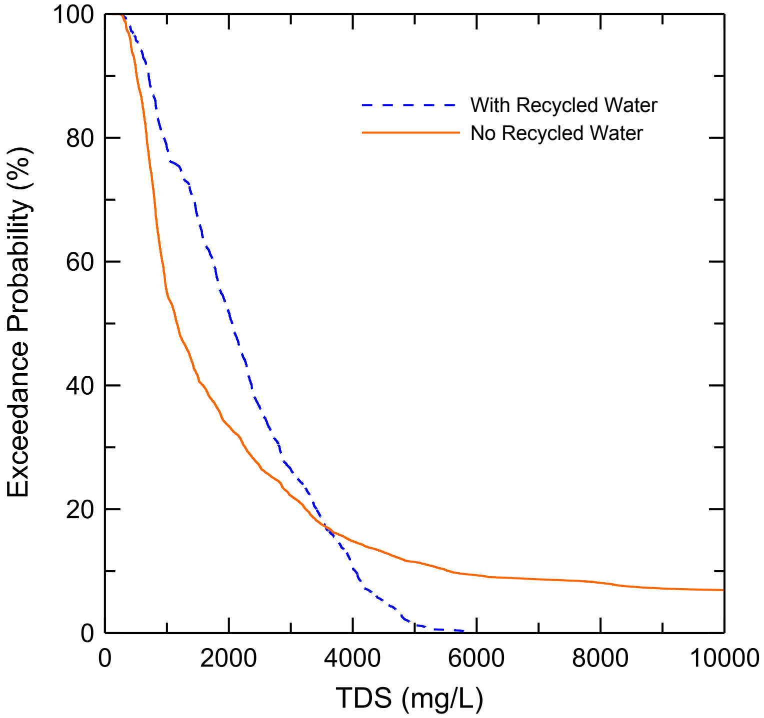


Fig. 6. Cumulative distribution function showing exceedance probability for TDS concentrations for the LEMP basin with natural flows (solid orange line) and inflows supplemented with recycled water (dashed blue line).

Of course, far less extreme conditions are predicted with recycled water (Fig. 6); most would probably agree that moderate lake levels (>1235 ft) (Fig. 1) and TDS values below 6,000 mg/L (Figs. 5 and 6) are preferable to very low lake levels, limited lake area, sea-water salinities or dry lake bed conditions predicted periodically with only natural inflows.

Importantly, the LEMP basin allows for periodic outflow and export of salt from the lake (Table 1). Natural flows delivered 1.55 MAF to the lake over the 1916-2014 simulation period, with 0.51 MAF (33%) flowing out in a limited number of years (Fig. 3). Supplementation with recycled water increased inflows to 1.77 MAF and outflows by 76,940 acre-feet to 0.58 MAF (Table 1). These outflows also exported salt; nearly 41% of the salt delivered to the basin with natural flows was removed with outflow, while a smaller fraction of a larger salt load, associated with recycled water inputs, was exported (35%) (Table 1). The 200,000 metric ton larger salt load to the lake with recycled water results from the higher salinity of that water relative to natural flows.

Table 1. Predicted total flows and salt budget for LEMP basin (99-yr simulation).

Scenario	**Total Flow In (af)**	**Total Flow Out (af)**	**Total Salt In (tonnes)**	**Total Salt Out (tonnes)**
No Recycled H_2O	1,546,230	506,982	535,972	219,245
+ Recycled H_2O	1,771,860	583,922	735,858	258,121

Conclusions

Simulations for Lake Elsinore using meteorological and runoff records from the past 99 yrs (1916-2014) with and without recycled water supplementation indicate:

(i) recycled water supplementation significantly increases lake surface elevation and lake area compared with natural inflows into the lake during periods of limited precipitation and runoff;

(ii) recycled water supplementation maintained predicted lake elevations >1234.5 ft and lake areas >2370 acres, while natural inflows resulted in complete desiccation of the lake for almost 3 yrs during the extreme drought that began in the late 1950s and continued into the early 1960s;

(iii) recycled water supplementation prevented extreme TDS levels from developing in the lake (keeping TDS concentrations <6000 mg/L) but also increased average TDS concentrations by about 900 mg/L, from 1,163 mg/L to 2,055 mg/L over the 99-yr (1916-2014) simulation period;

Next Step

The next step will be to extend this comparison of natural inflows with recycled water supplementation beyond lake level and salinity, and assess impacts of recycled water on concentrations of nutrients, dissolved oxygen, chlorophyll and other properties.

References

Anderson, M.A. 2015. *Technical Memorandum Task 1.0: Surface Elevation and Salinity in Lake Elsinore: 1916-2014.* Draft Technical Memorandum to LESJWA. 13 pp.

Anderson, M.A. 2013. *Predicted Effects of Lake Elsinore Management Project (LEMP) on Lake Level and Water Quality of Lake Elsinore.*

Page Intentionally Blank

Technical Memorandum

Task 1.2: Water Quality in Lake Elsinore Under Selected Scenarios: Model Predictions for 1916-2014 with Current (post-LEMP) Basin

Objective

The objective of this task was to simulate water quality in Lake Elsinore using the current (post-LEMP) basin for the entire 1916-2014 period, comparing predicted water quality in the lake under selected conditions and management scenarios. For this assessment, the current (post-LEMP) basin will be used for the entire 99-yr simulation period.

Approach

The Computational Aquatic Ecosystem Dynamics Model (CAEDYM v.3) was linked to the 1-D Dynamic Reservoir Simulation Model (DYRESM v.4) model used in Tech Memos 1.0 and 1.1 that simulated lake level and salinity in Lake Elsinore for the period 1916-2014 (Anderson, 2015a,b). The CAEDYM model is a highly complex ecosystem model capable of simulating a vast array of water quality and ecological parameters. In addition to the daily average meteorological conditions and runoff-streamflow volumes required by DYRESM, CAEDYM requirements information or assumptions about the structure of the food web, dynamics within the food web, rates of reactions for photosynthesis, nutrient uptake, excretion, mineralization, and transformations, as well as nutrient concentrations in runoff and streamflow and a large number of other parameters and variables. The reader is referred to the CAEDYM Science Manual v.3.2 for additional details (Hipsey et al., 2014). For these simulations, 3 algal groups (blue-green algae, green algae and freshwater diatoms), 2 zooplankton groups (copepods and cladocerans), and 2 fish groups (approximating threadfin shad and larger piscivores such as bass and crappie) were represented. Consistent with the TMDL developed for Lake Elsinore, this study focused on 4 key water quality parameters: total N, total P, dissolved oxygen (DO) and total chlorophyll a, and systematically evaluated their response to different external conditions and management scenarios for the lake.

Model Calibration: 2000-2014

Key Input Parameters

The coupled DYRESM-CAEDYM model was calibrated against available data for 2000-2014. Meteorological conditions that drive the hydrodynamics in the 1-D DYRESM model were taken from the CIMIS station #44 at UCR (Fig. 1). Key forcing factors driving the heating, cooling and mixing of Lake Elsinore include the shortwave solar heat flux (300-3000 nm) that includes photosynthetically available radiation (PAR, 400-700 nm), as well as near-UV (300-400 nm) and near-IR and IR (700-3000 nm) (Fig. 1a), air temperature (Fig. 1b) and windspeed (Fig. 1c). Values are represented as daily average values. The strong seasonal trend in solar shortwave heat flux is evident in the figure, with daily average shortwave flux values of about 350 W/m^2 in the summer and 50-100 W/m^2 during the winter (Fig. 1a). Daily average air temperatures exhibit a similar seasonal pattern, with daily-averaged summer temperatures near 30°C and daily average winter temperatures generally 7-10°C (Fig. 1b).

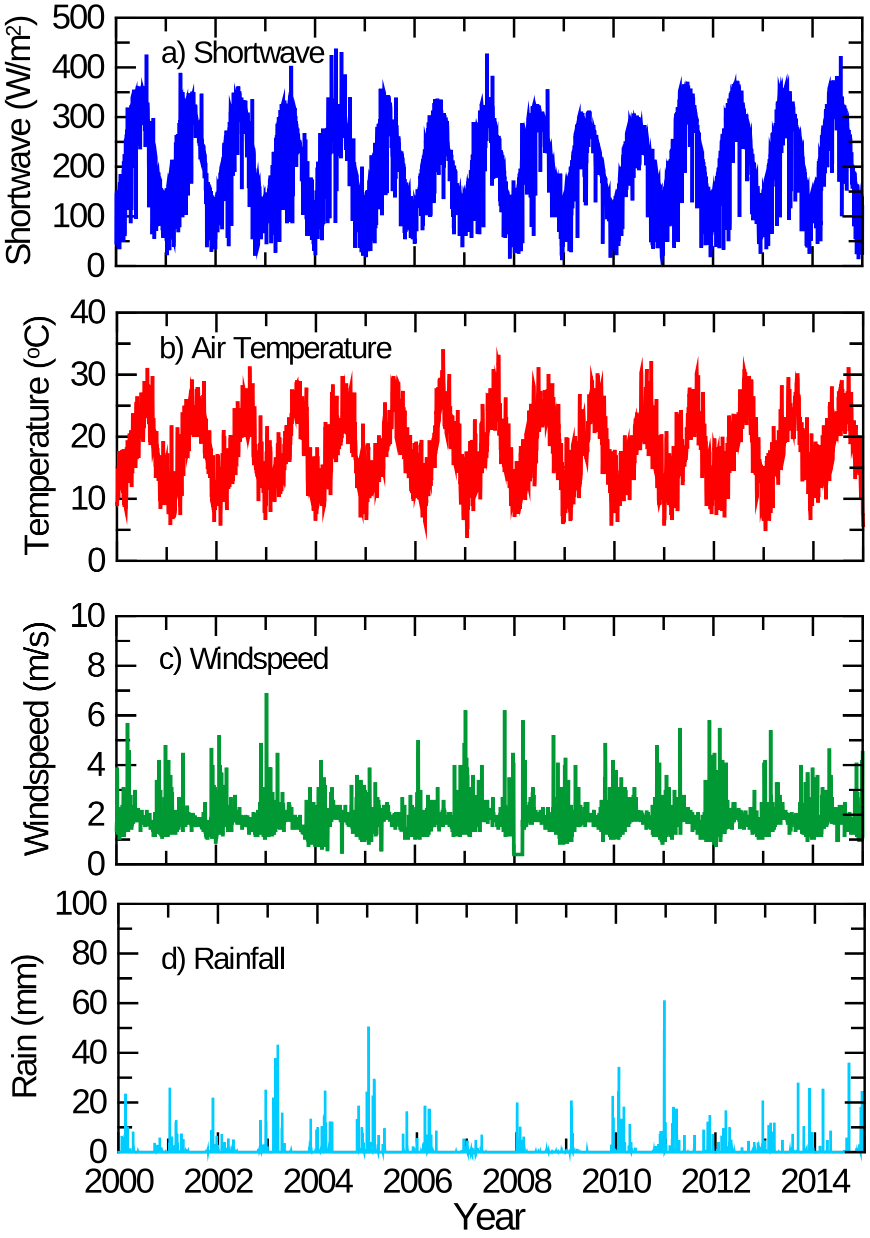


Fig. 1. Daily average a) shortwave radiation, b) air temperature, c) windspeed and d) rainfall used in model simulations for the calibration period 2000-2014.

Daily average windspeeds averaged near 2 m/s and exhibited some seasonality as did daily rainfall rates that also showed annual variability (Fig. 1c,d).

In addition to direct precipitation on the lake surface, water delivered to the lake included San Jacinto River flows (as recorded at the USGS gage #11070500), runoff from the local watershed (Anderson, 2015a), and supplemental water that included recycled water from EVMWD as well as recycled water from EMWD and water pumped from island wells in 2003-2004 (collectively represented as recycled water) (Fig. 2).

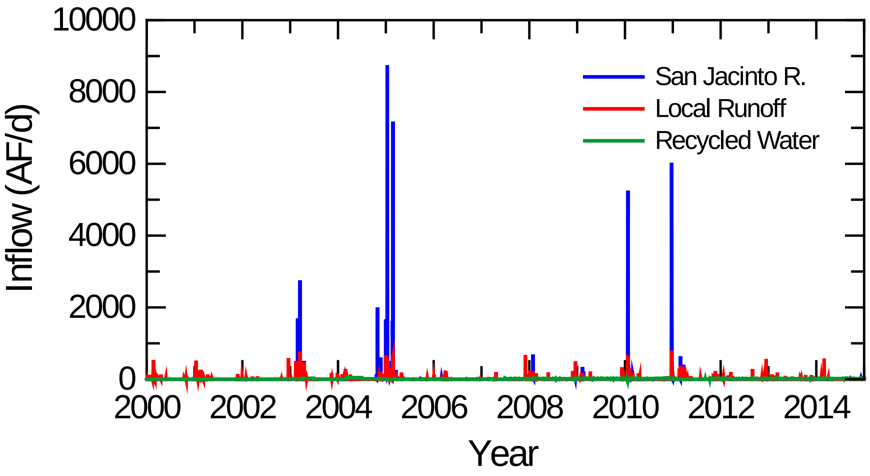


Fig. 2. Daily inflows to Lake Elsinore for the calibration period 2000-2014.

External loading of nutrients was derived from inflows from the San Jacinto River, local runoff and recycled water (Fig. 2). A limited number of large runoff events delivered most of the flows from the San Jacinto River during this time period, including the very large runoff events at the beginning of 2005, that included daily flow exceeding 8,000 acre-feet (Fig. 2, blue line). Shorter duration high flow runoff events were also present in January 2010 and December 2011. Precipitation generated runoff from the local watershed as well, although daily flows were much smaller than the very large runoff events noted in 2005, 2010 and 2011 (Fig. 2). Recycled water flows were much lower than runoff volumes and barely perceptible on Fig. 2 (green line). Presented as cumulative flows however, we see that recycled water inputs exceeded that of local runoff and contributed about 50,000 acre-feet since inputs began in late 2002 (Fig. 3). Based upon these values, a total of 187,926 acre-feet of water was delivered to Lake Elsinore over this 2000-2014 period, with approximately 53% derived from San Jacinto River flows, 20% from local runoff and 27% from recycled water (Fig. 3).

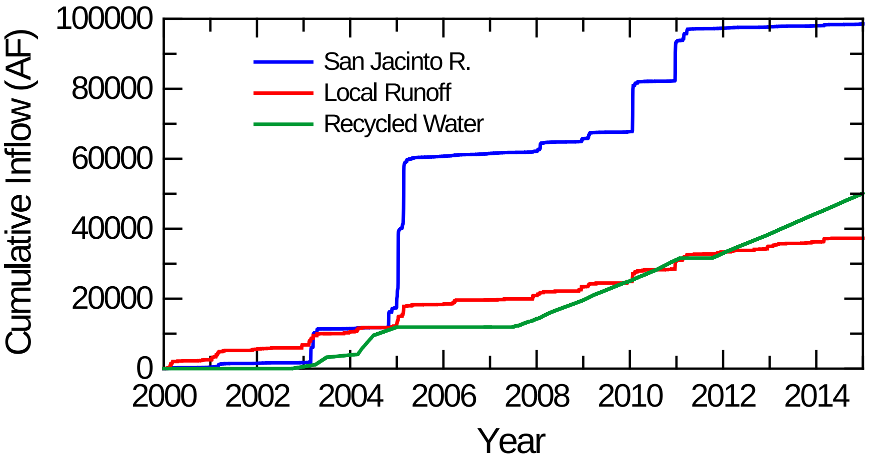


Fig. 3. Cumulative inflow to Lake Elsinore from the San Jacinto River, local runoff and recycled water for the calibration period 2000-2014.

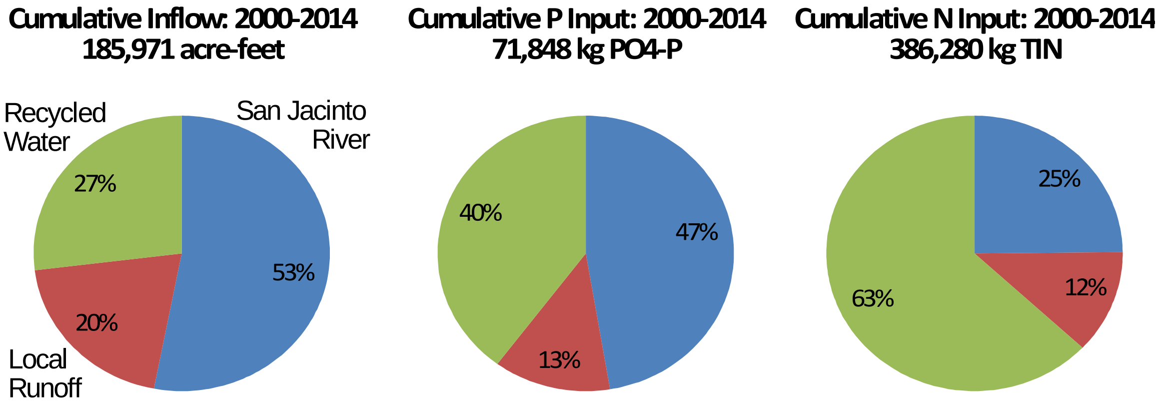
Concentrations of nutrients in these inflows vary depending upon a number of factors, including intensity and duration of storms, interval of time between storms and other factors (including treatment plant operation for recycled water inputs). Average concentration values derived from runoff sampling within the watershed and treatment plant data were used in model simulations (Table 1).

Table 1. Nutrient concentrations of inflows to Lake Elsinore used in model simulations.

Source	PO_4-P	Total P	NH_4-N	NO_3-N	Total N
San Jacinto R.	0.28	0.50	0.22	0.57	1.62
Local Runoff	0.20	0.48	0.22	0.80	1.82
Recycled H2O[a]	0.32	0.41	0.36	1.62	2.87

[a]Recycled water concentrations for EVMWD 2007-present.Higher concentrations of PO_4-P, NH_4-N and NO_3-N were present for the 2002-2004 period which included significant volumes of island well and EMWD flows (concentrations for this period of 0.82, 0.24 and 10 mg/L, respectively).

Total external nutrient loading over the calibration period was calculated from flow data (Fig. 2) and nutrient concentrations (Table 1). Flows from the San Jacinto River delivered 47% of the total external load of PO_4-P (71,848 kg) added between 2000-2014, with 40% from recycled water supplementation, and 13% from local watershed runoff (Fig. 4). Recycled water contributed 63% of the total TIN load, while San Jacinto River and local runoff contributed 25 and 12%, respectively. From Fig. 4, we note that the contributions of PO_4-P from the 3 sources are broadly comparable to their volumetric flow contributions owing to fairly similar PO_4-P concentrations, while recycled water contributes a disproportionately large amount of TIN owing to its larger NO_3-N concentration (Table 1).



a) b) c)

Fig. 4. Total inflow, P and N inputs to Lake Elsinore for the calibration period 2000-2014.

Calibration Results

Lake Elevation

The first step in assessing the model effectiveness in reproducing conditions in Lake Elsinore was to compare measured lake surface elevations with predicted values (Fig. 5). Measured and predicted values are in very good agreement, showing synchronous marked declines from 2000-2003, dramatic increase at the end of 2004 and in early 2005, and subsequent declines through 2010 (Fig. 5). Modest differences were occasionally found (e.g., in 2004), but given the tremendous range in rainfall, runoff and surface elevations witnessed over this time period, agreement is thought to be quite good.

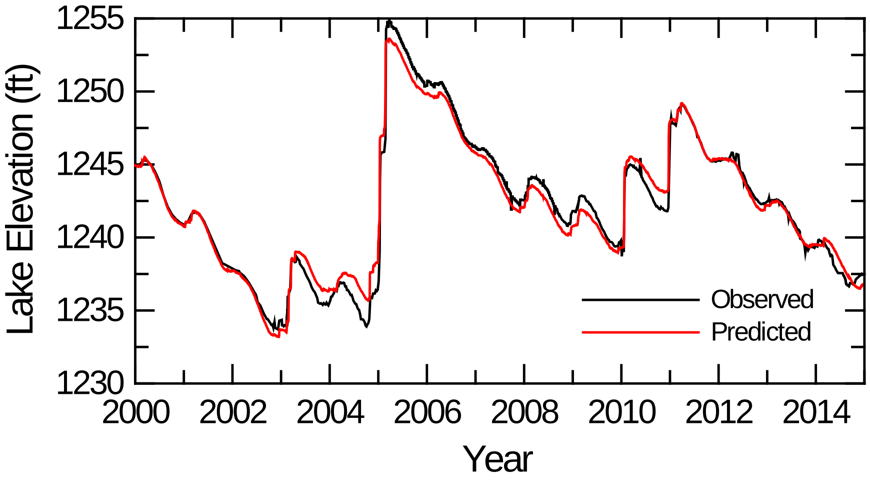


Fig. 5. Predicted and observed lake surface elevation for the calibration period 2000-2014.

Lake Salinity

Salinity in the lake varied from approximately 700 - 2600 mg/L TDS, with low concentrations following the very large runoff in winter 2015 (Fig. 6, solid circles). The model captured trends in TDS reasonably well, including the high TDS concentrations measured in late fall 2002 and the marked decline in TDS in 2015 (Fig. 6, line). The only discrepancy was found in 2014, when the model over-predicted TDS in the lake.

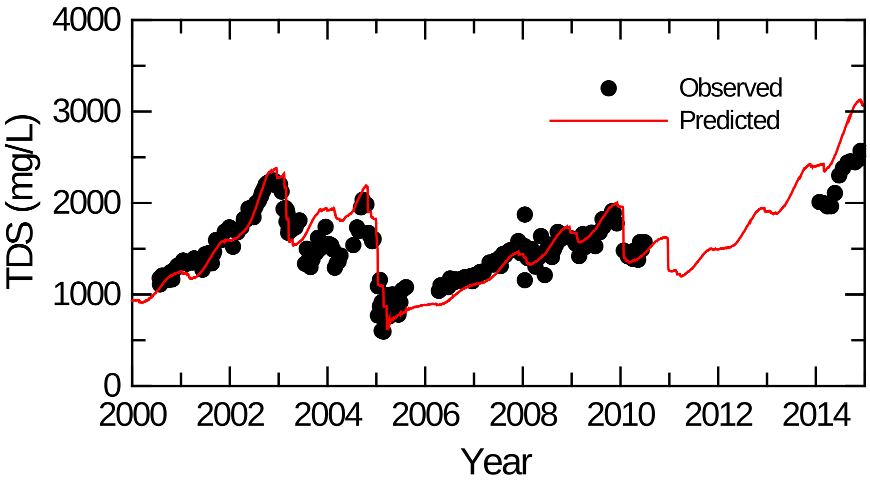


Fig. 6. Predicted and observed TDS concentrations for the calibration period 2000-2014.

Temperature

The model reasonably captured measured temperature values in Lake Elsinore (Fig. 7). The model correctly predicted strong seasonal trends in water column temperature that reflects seasonal trends in solar shortwave heat flux (Fig. 1a) and air temperature (Fig. 1b). The model predicted summer values near 27°C and winter minimum values near 10°C, with little difference between depths reflecting weak stratification or mixed conditions commonly present in the lake (Fig. 7).

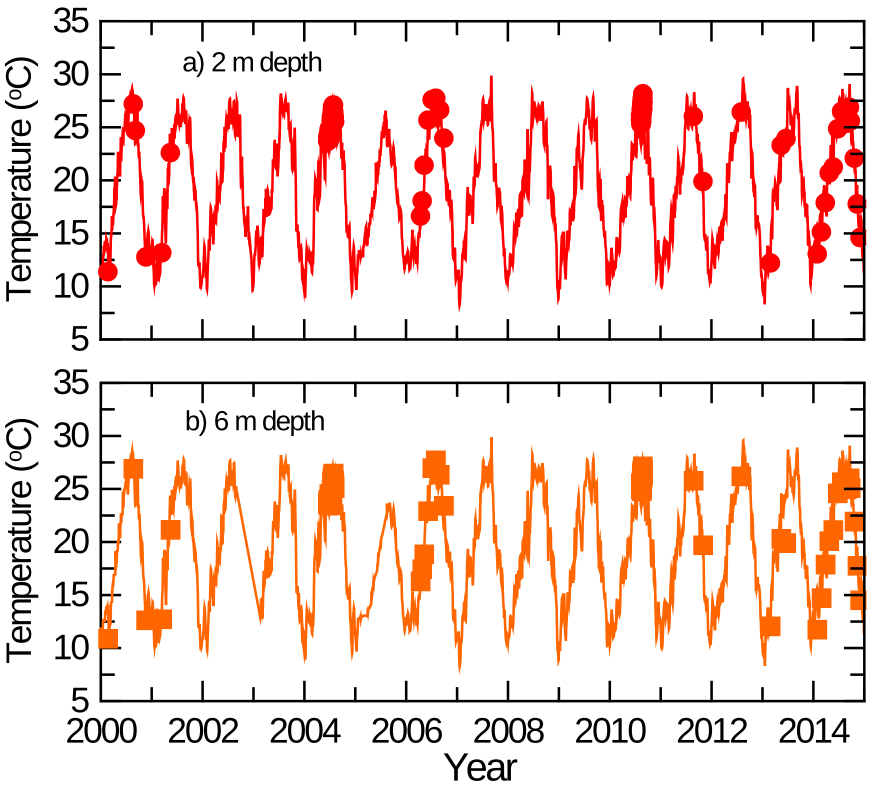


Fig. 7. Predicted and observed temperature at a) 2 m depth and b) 6 m depth for the calibration period 2000-2014.

Dissolved Oxygen

Dissolved oxygen (DO) in the lake varied seasonally and with depth (Fig. 8). The temperature effect on oxygen solubility was evident in model predictions for the 2 m depth, with DO values generally near 10 mg/L in the winter and 7-8 mg/L in the summer (Fig. 8a). At the same time, supersaturation was periodically predicted (e.g., in spring 2011 when concentrations reached 17 mg/L). The model predicted DO concentrations deeper in the water column to be often quite similar to near-surface values, but did also correctly predict periods of anoxia in the summer of 2003, 2004, 2006 and 2010 (Fig. 8b).

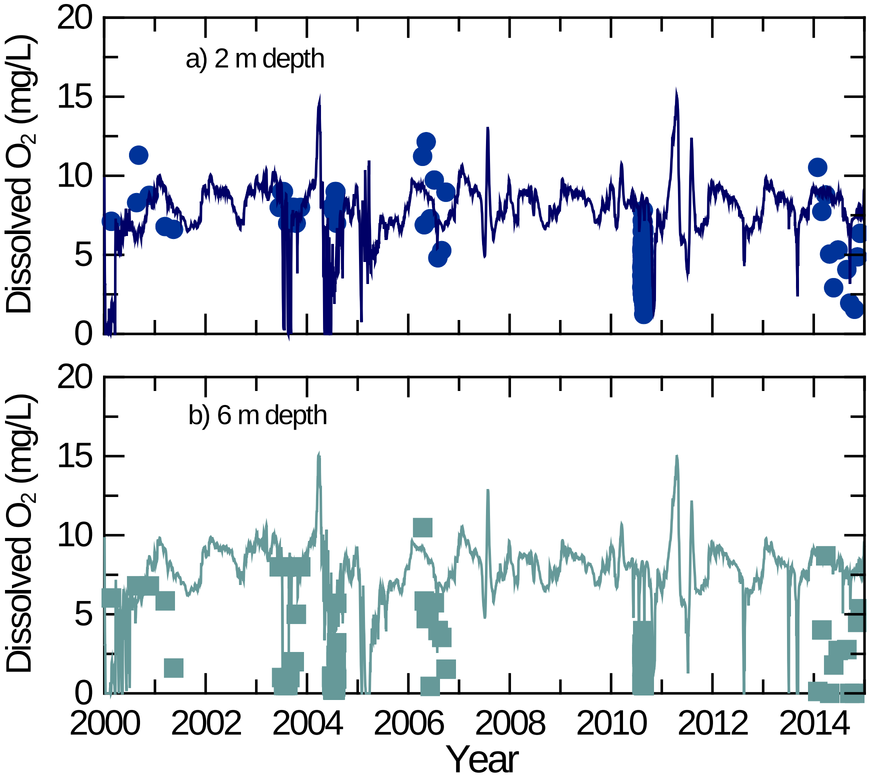


Fig. 8. Predicted and observed dissolved oxygen concentrations at a) 2 m depth and b) 6 m depth for the calibration period 2000-2014.

Total N

The model did a fair job of capturing the dramatic trends in concentrations of total N in the lake between 2000 and 2020 (Fig. 9). Concentrations increased from about 2 mg/L in 2000 to greater than 8 mg/L by late 2004, and then declined sharply with the very large runoff volumes delivered in winter of 2005 that quadrupled the volume of the lake. Total N concentrations then edged up over several years before declining slightly in 2010 (Fig. 9). While the model captured trends reasonably well, it did not reproduce the more significant apparent swings observed, e.g., in 2008, when reported concentrations over the period of a few months ranged from <1 to >8 mg/L. It may be that sampling bias or analytical challenges crept into the time series data, exaggerating short term trends.

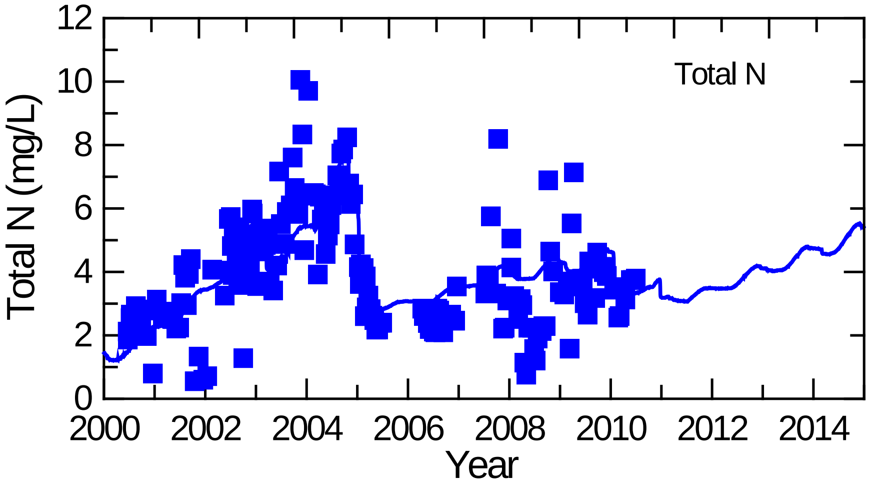


Fig. 9. Predicted and observed total N concentrations for the calibration period 2000-2014.

Total P concentrations also varied quite dramatically over this calibration period, from about 0.1 mg/L in 2000 to >0.6 mg/L in late 2004 before declining to a value near 0.2 mg/L (Fig. 10). The model generally captured trends but under predicted concentrations somewhat in 2003-2004, although it did predict a maximum value of about 0.6 mg/L in late 2004 (Fig. 10).

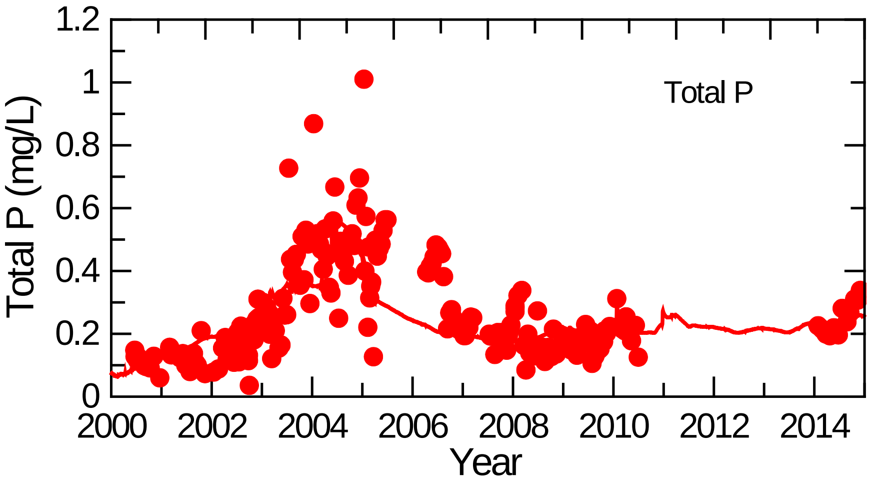


Fig. 10. Predicted and observed total P concentrations for the calibration period 2000-2014.

Chlorophyll a

Measured chlorophyll a concentrations exhibited pronounced seasonal and interannual variability, ranging from <10 µg/L in some winters to >300 µg/L in 2002, 2004 and 2014 (Fig. 11, solid symbols). The model did a fair job overall in reproducing these complex trends and corrected predicted summer maximum chlorophyll a concentrations in 2000-2004 (Fig. 11, line). The model did not do as well predicting the winter minimum values however, and also missed the particularly high concentrations observed in 2014

(Fig. 11). Notwithstanding, the agreement between predicted and observed concentrations was considered passable given the highly dynamic algal community in the lake and the complex dependence of chlorophyll a concentrations on nutrient availability and ecosystem structure.

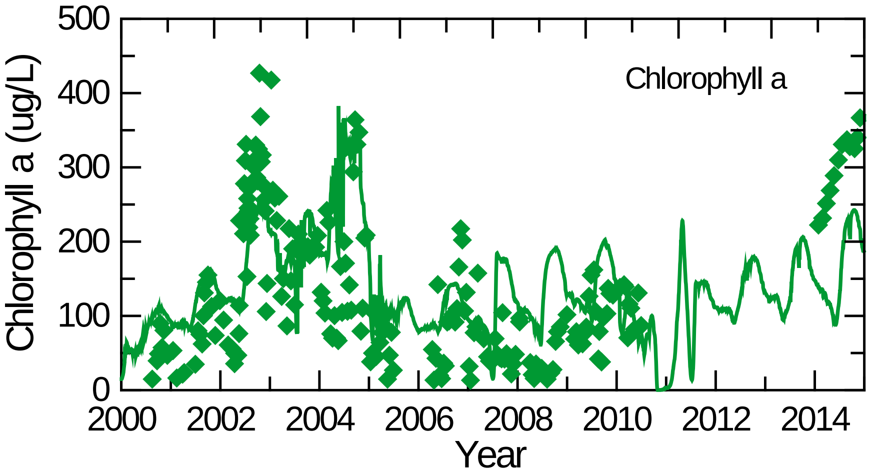


Fig. 11. Predicted and observed chlorophyll a concentrations for the calibration period 2000-2014.

The overall goodness of fit of the model results to measured concentrations of total N, total P and chlorophyll a was assessed using the relative percent error between predicted and observed average concentrations (Table 2). Total N averaged 3.98 mg/L over this period, while the model yielded an average value of 3.88 mg/L, representing a 2.5% underestimate (Table 2). The average observed total P concentration over this period was 0.265 mg/L while the predicted average concentration was 0.235 mg/L, an 11.3% underestimate. Predicted and observed chlorophyll a concentrations were 130 and 137 µg/L, corresponding to a relative % error of 5.4%. Given the extreme range in conditions experienced at the lake over this 2000-2014 period, the model was considered to reasonably predict water quality in Lake Elsinore under a wide range of hydrologic, chemical and ecological conditions, allowing for comparison of water quality under different conditions and scenarios.

Table 2. Mean observed and predicted values of key water quality parameters for calibration period (2000-2014).

	Observed	**Predicted**	**% Error**
Total N	3.98	3.88	-2.5
Total P	0.265	0.235	-11.3
Chlorophyll a	130	137	+5.4

99-yr Simulations Using Current (LEMP) Basin

With reasonable agreement between measured and predicted water quality for the 2000-2014 calibration period, simulations were conducted for the much wider 99-yr period from 1916-2014. The goal of these simulations was to understand how water quality in Lake Elsinore might be expected to vary under a wide range of meteorological and hydrologic conditions. Water quality was predicted for the lake using the current (post-LEMP) basin and the 99-year meteorological and flow record for the period 1916-2014 (Anderson, 2015). These calculations are not simulating actual conditions in the lake for the period 1916-2014 since the natural lake basin was much larger than currently configured for most of this period of time; rather, the goal is to evaluate water quality in the current lake basin under the natural range of meteorological and runoff conditions previously witnessed in the watershed and at the lake, thus extending the previous approach that used high-, average- and low-runoff conditions develop the TMDL for Lake Elsinore. The advantage of this more comprehensive simulation approach is that it provides more thorough understanding of dynamic conditions in the lake, allows for more statistical power and a probabilistic presentation of results, and more clearly demonstrates accrued impacts on water quality of multi-year droughts and extreme runoff events. The following section on meteorological and flow records is excerpted from Anderson (2015a) and provided here to highlight major features for this extended 99-yr simulation period.

Meteorological and Flow Records: 1916-2014

Daily flows of the San Jacinto River into Lake Elsinore at USGS gage #11070500 were downloaded from USGS as previously noted. Daily rainfall records were provided by Riverside County Flood Control District for the Quail Valley, (1958-2014), San Jacinto (1940-2014) and Hemet (1916-1940) rain gauges to estimate runoff from the local 13,340 acre watershed not captured by gaged San Jacinto River flows (Anderson, 2006). The available Quail Valley rainfall data were used for the 1958-2014 period without any correction. Regression equations developed between measured Quail Valley precipitation and that at San Jacinto (r^2=0.70) and Hemet r^2=0.52) were used to predict rainfall at Quail Valley for 1940-1958 and 1916-1940, respectively. Daily average air temperature, relative humidity/vapor pressure, shortwave radiation, and windspeed for 1985-2014 were taken from CIMIS station #057 at UC Riverside. Air temperature records for 1916-1985 were downloaded from the NOAA National Climatic Data Center for the Corona station that provided the longest nearby continuous record. Average shortwave solar radiation, vapor pressure and windspeed from CIMIS station #057 for each calendar day were used for the earlier part of the record when measurements of these meteorological attributes were not available.

Meteorological and flow data over the past 99 years highlight the inter-annual variability present in the region. Annual rainfall within the local watershed of Lake

Elsinore ranged from 2.04 inches in 2006 (based on water year) to 26.97 inches in 1977 (Fig. 12). Precipitation averaged 10.1 inches over this period, while the median was 8.89 inches. As suggested in Fig. 12, precipitation was not normally-distributed about the mean value; precipitation was found to be log-normally distributed however (mean log inches of rainfall 0.96±0.21).

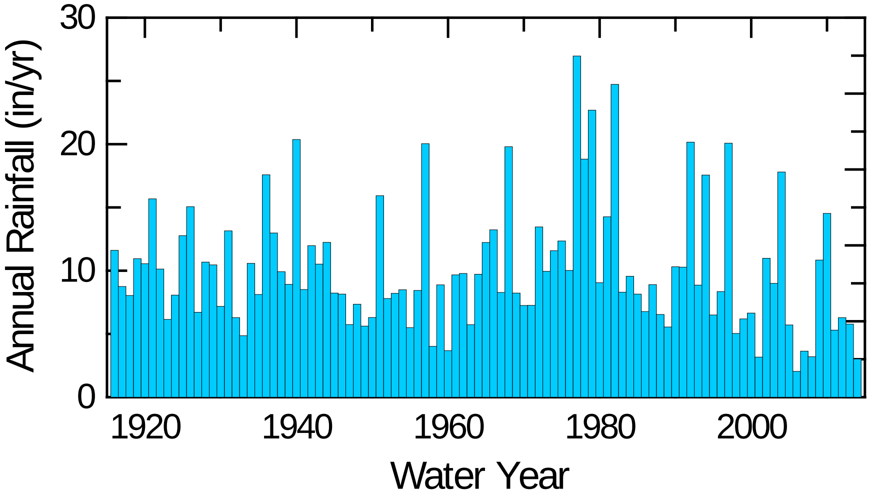


Fig. 12. Annual rainfall to local watershed adjacent to Lake Elsinore.

The mean annual air temperature has also varied over the past 99 years (Fig. 13). Temperature has averaged 17.08±0.81 °C over this interval, with a minimum value of 15.4 in 1934 and a maximum temperature of 19.5 °C in 1984, with a statistically significant increase ($p<0.001$) in average annual air temperature at a mean rate of 0.016°C/yr, or an increase of almost 1.6°C over the study period. This rate of change is larger than the global mean surface temperature increase of approximately 1.0°C over this same time period.

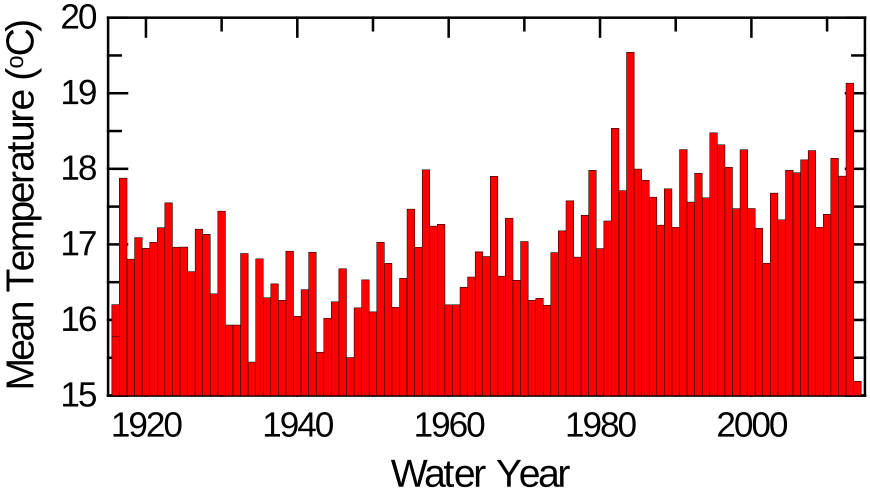


Fig. 13. Mean annual temperature at Corona (NOAA)

Annual runoff to Lake Elsinore measured at the USGS gage exhibited even more dramatic variation (Fig. 14). There were 5 years where virtually no flow was recorded at the gage, and 25% of the time, annual flow was <100 AF/yr. At the other end of the spectrum, 22 years were found to have flows >10,000 AF/yr, supporting the general notion of an El Nino-type event on average every 4-5 years. Low flows are difficult to see on this figure due to the periodic very large flows (e.g., water years 1916 and 1980).

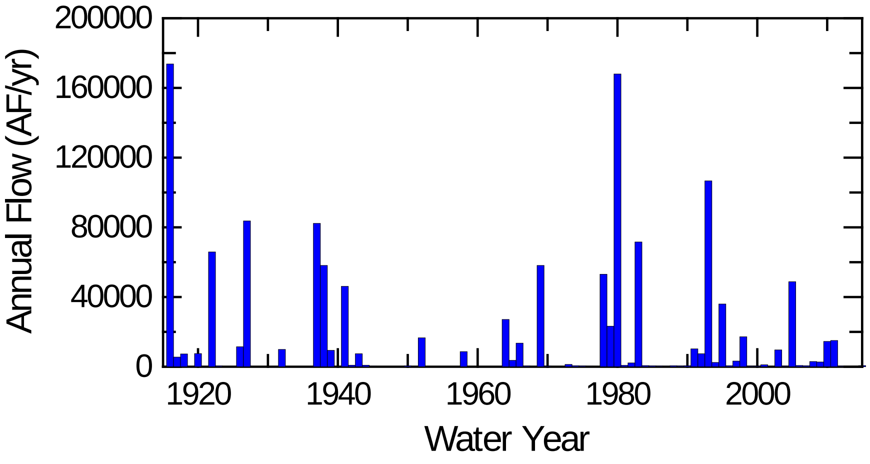


Fig. 14. Annual flow at USGS gage #11070500 (San Jacinto River near Lake Elsinore)

Local rainfall values (Fig. 12) were used to estimate local runoff flows to the lake (i.e., runoff from the land areas surrounding the lake and not captured by the USGS gage) (Fig. 15). Previous measurements at the lake suggested a local runoff coefficient of about 0.3, or about 30% of precipitation contributed to runoff (Anderson, 2006), while 70% was on average retained by the soil through infiltration and storage within the porosity of the soil and weathered bedrock.

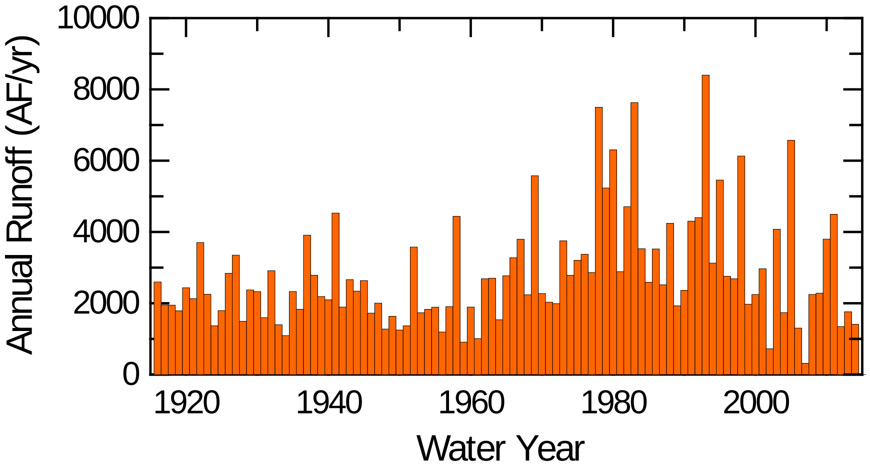


Fig. 15. Annual flows to Lake Elsinore due to local runoff estimated from precipitation and runoff coefficient.

Since runoff in urban and suburban-type watersheds is strongly influenced by the amount of impermeable surfaces (roads, parking lots, driveways and rooftops), an assumption was made that the runoff coefficient measured a few years ago adequately reflects current levels of development, but that the runoff coefficient would likely have been lower earlier in the study period. Specifically, a runoff coefficient of 0.2 was assumed from 1916-1960, 0.25 for 1961-1980, and 0.3 for 1981-present. Local runoff averaged 2813 AF/yr.

In addition to direct precipitation on the lake (Fig. 12), flows from the San Jacinto River (Fig. 3) and runoff from the local watershed (Fig. 15), recycled water represents an important additional water source for the lake, especially during year of limited rainfall and runoff. In an agreement between the EVMWD and the City of Lake Elsinore, EVMWD provides up to 5,000 acre-feet of recycled water annually when the lake level drops below 1240' above MSL.

<u>Scenarios</u>

The model was subsequently used to evaluate water quality under a number of different conditions and management actions. Specifically, the following scenarios were simulated:

1. Pre-development - using natural rainfall and runoff with (low) concentrations of nutrients (based upon TetraTech estimates)

2. Natural runoff - with natural rainfall and runoff with (higher) concentrations of nutrients (based chiefly upon watershed sampling results)

3. Recycled water – rainfall and runoff supplemented with recycled water when lake level drops below 1240' above MSL

4. Recycled water + Aeration – rainfall and runoff supplemented with recycled water, and daytime operation of diffused aeration system

5. Recycled water + Aeration (no Zooplankton, no Fish) - rainfall and runoff supplemented with recycled water, and daytime operation of diffused aeration system; altered food web such that no zooplankton or fish are present (phytoplankton only)

6. Recycled water + Aeration (Zooplankton only) – rainfall and runoff supplemented with recycled water, and daytime operation of diffused aeration system; food web limited to phytoplankton and zooplankton (no fish)

7. Recycled water + Aeration (no Carp) – rainfall and runoff supplemented with recycled water, and daytime operation of diffused aeration system; no bioturbation or enhanced release of nutrients from sediments (achieved via carp removal)

8. Recycled water (0.1 mg/L PO_4-P) + Aeration – rainfall and runoff supplemented with recycled water at reduced PO_4-P concentration (0.1 mg/L), and daytime operation of diffused aeration system

Results

Key results from 99-yr simulations for each of the 8 scenarios are presented below.

Scenario 1. Pre-Development

Pre-development conditions were simulated using the current (LEMP) basin with the meteorological and runoff conditions reported for 1916-2014 (e.g., Figs. 12-15). Under natural flows (i.e., no recycled water inputs), extreme variations in lake level were predicted, e.g., with the lake going dry by late 1958 (Fig. 16a).

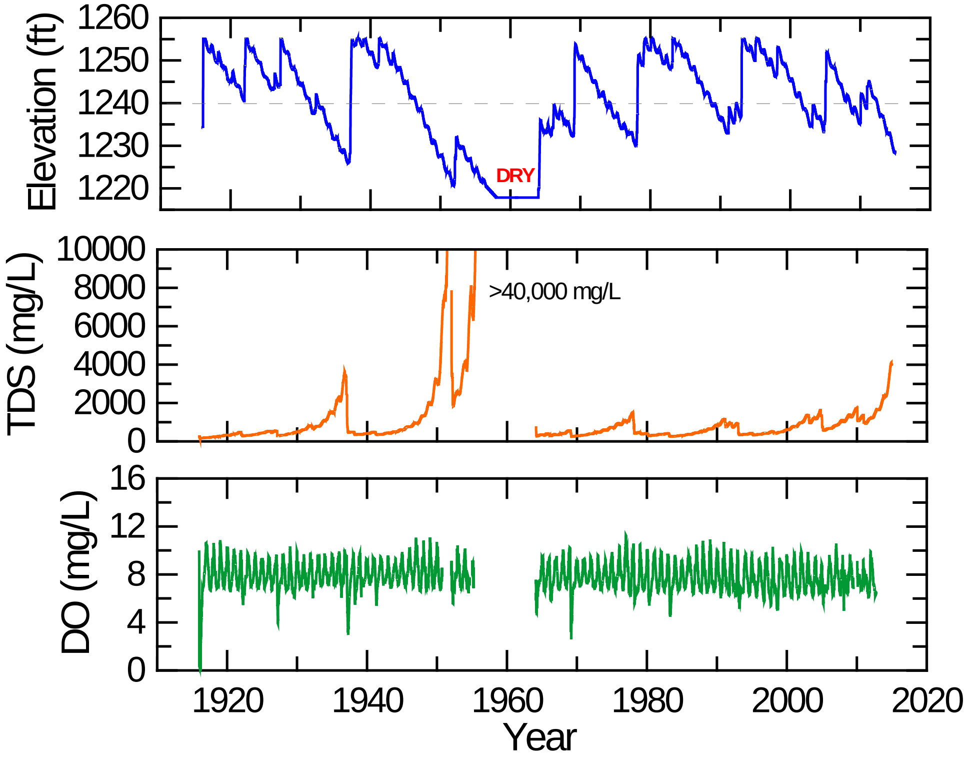


Fig. 16. Predicted lake surface elevation, TDS and dissolved oxgyen concentrations in Lake Elsinore: Pre-development scenario.

The simulation predicts that the lake was dry for 6 years (1959-1964) during this 99-year period, with lake levels below 1240' predicted 45% of the time (Fig. 16a). Decliining lake levels corresponded to increasing salinity values as a result of evapoconcentration of salts (Fig. 16b). Salinities exceeding that of ocean water were present preceding dessication in 1958, although concentrations near or above 4000 mg/L TDS were also present in late 1930's, early 1950's and near the end of the simulation (Fig. 16b).Dissolved oxygen (DO) concentrations were generally between 7-11 mg/L and followed the temperature dependence of Henry's law constant, with lower concentrations when the water is warm during the summer, and higher concentrations during the cool winter months (Fig. 16c).

Water quality was generally very good, with typically very low concentrations of total N, total P and, as a result, chlorophyll a (Fig. 17). Notwithstanding, during very low lake levels, high concentrations of nutrients and chlophyll a were predicted, with total N, total P and chlorophyll a reaching concentrations >10 mg/L, 0.3 mg/L and 300 µg/L, respectively (Fig. 17).

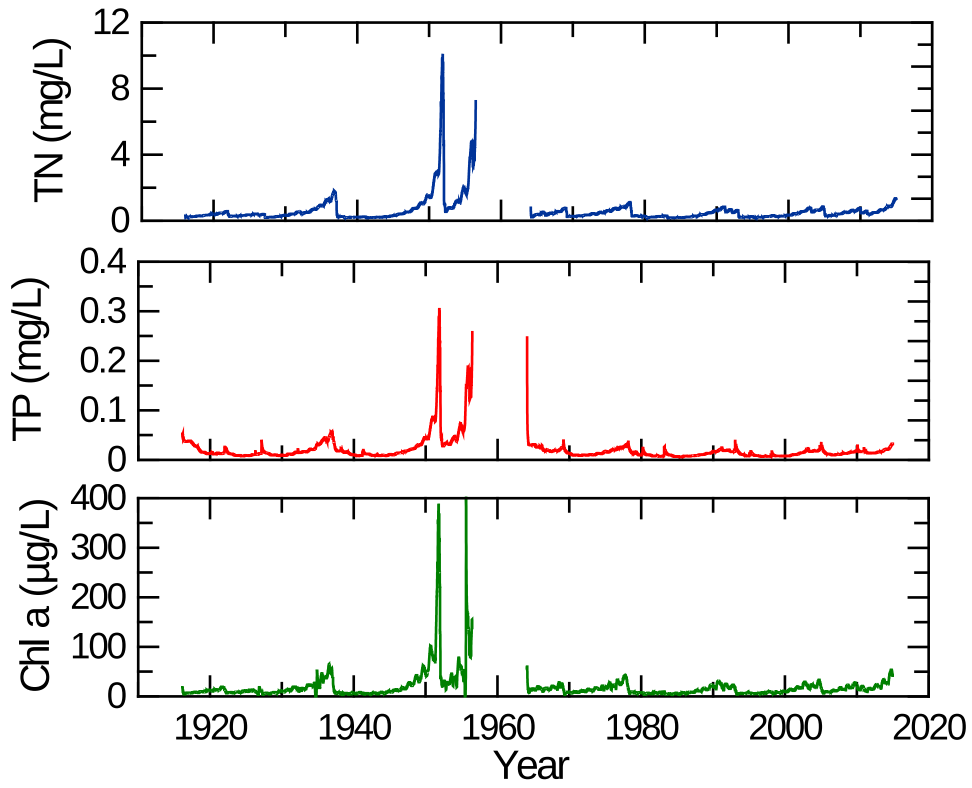


Fig. 17. Predicted lake total N, total P anc chlorophyll a concentrations in Lake Elsinore: Pre-development scenario.

Scenarios 2 and 3. Natural Runoff and Supplementation with Recycled water.

Addition of recycled water significantly alters the hydrologic and nutrient budgets for the lake. To highlight the effects of recycled water addition, scenario 2 (natural runoff without any supplementation) and scenario 3 (with recycled water supplementation) will be graphed and discussed together.

The lake surface elevation under current conditions (Fig. 18, blue line) does not differ from the pre-development scenario previously discussed (Fig. 16a), as the only difference is in the nutrient concentrations in the local runoff and San Jacinto River flow. As a result, the lake (still) goes dry in late 1950's and into 1960's (Fig. 18, blue line). Supplementation with recycled water protected the lake from extremely low (or dry) conditions, with the lake level generally above 1232' and in all instances above 1230.3'. This is a key finding; even in an extended drought such as witnessed in 1950's-1960's, addition of recycled water, at rates up to 5,000 acre-feet per year when the lake level drops below 1240', ensures a reasonable lake level.

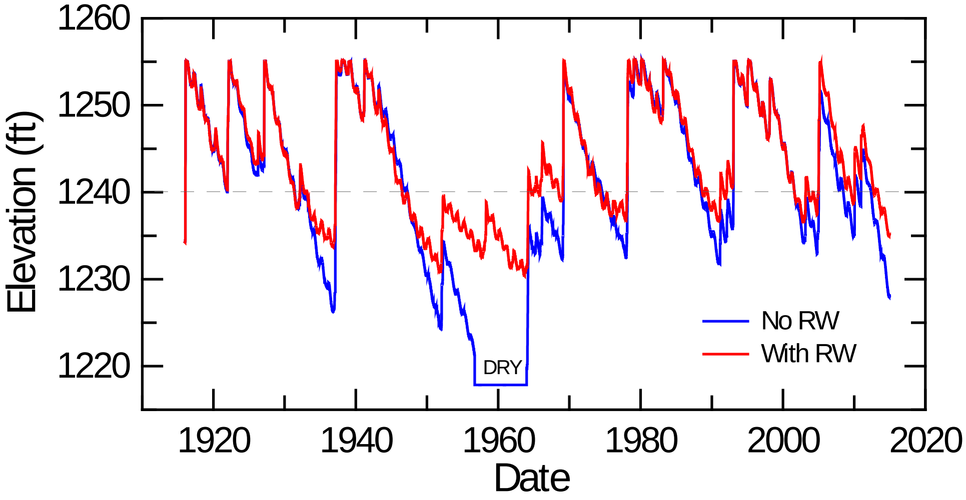


Fig. 18. Predicted lake surface elevations with natural runoff (no RW) and when supplemented with recycled water (with RW).

The addition of recycled water also protects the lake from extreme salinity events (Fig. 19). For example, natural rainfall and runoff yielded a lake level of 1226.5' in 1936 (Fig. 18, blue line) with a salinity of about 9,000 mg/L TDS (Fig. 19, blue line); supplementation with recycled water supported a lake level of 1234.2' and TDS near 3,500 mg/L. Addition of recycled water also prevented the hypersaline brine from forming as the lake approached desiccation in the late 1950's. Interestingly, TDS levels were much higher in the 1960's-1970's with recycled water inputs compared with natural flows; this results from desiccation and wind-blown salt transport out of the lake basin (estimated that 85% of dried salt in basin was exported) (Fig. 19). The extreme runoff event in 1978-1979 (Fig. 14) flushed out a substantial amount of salt that remained with recycled water, such that subsequent salinity levels were similar in subsequent years

(Fig. 19). Salt is thus periodically exported from the lake with large runoff inputs and downstream discharge events. At least some water was discharged downstream and some salt exported in 15 years out of 99 with recycled water supplementation (compared with 12 years under natural flows) (Fig. 18).

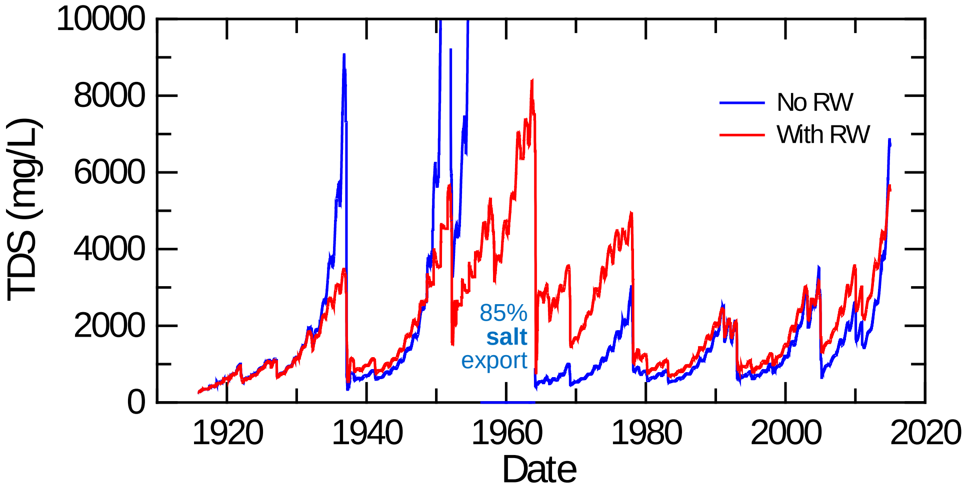


Fig. 19. Predicted TDS concentrations with natural runoff (no RW) and when supplemented with recycled water (with RW).

Nutrient concentrations also exhibited some meaningful similarities as well as differences. Total N concentrations without recycled water inputs varied in response to watershed inputs and evapoconcentration. Collectively, nitrogen fixation and denitrification did not appear to have a dramatic effect on total N concentrations. Recycled water inputs prevented the very high concentrations of total N found during low lake levels from occuring in the lake; thus, for example, total N reached only about 7 mg/L with recycled water, compared with 17 mg/L with only natural flows in 1936 (Fig. 20). Beyond these low lake level events where evapoconcentration resulted in higher total N concentrations under natural flows compared with recycled water inputs, concentrations of total N tended to track quite closely under both conditions (Fig. 20). This is due in part to the not dissimilar total N concentrations in runoff and San Jacinto River flows (1.82 and 1.62 mg/L, respectively), and recycled water (2.87 mg/L) (Table 1), and to periodic flushing events that tended to normalize concentrations.

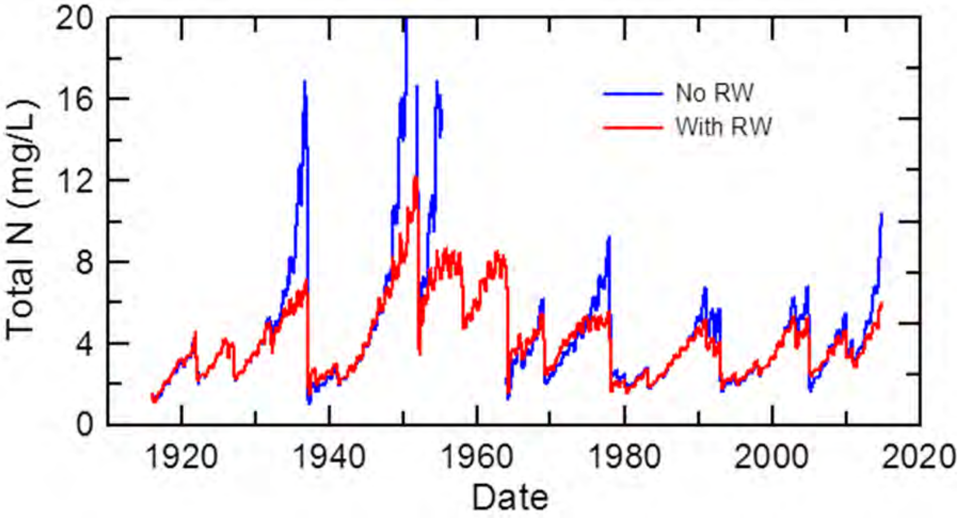


Fig. 20. Predicted total N concentrations with natural runoff (no RW) and when supplemented with recycled water (with RW).

Trends in total P concentrations followed total N, with similar concentrations in the lake both with and without recycled water additions except during strong divergences in lake surface elevations, when recycled water inputs markedly decreased total P (Fig. 21). The reductions resulted from dilution during periods of otherwise strong evapoconcentration, and incorporation into foodweb and subsequent settling.

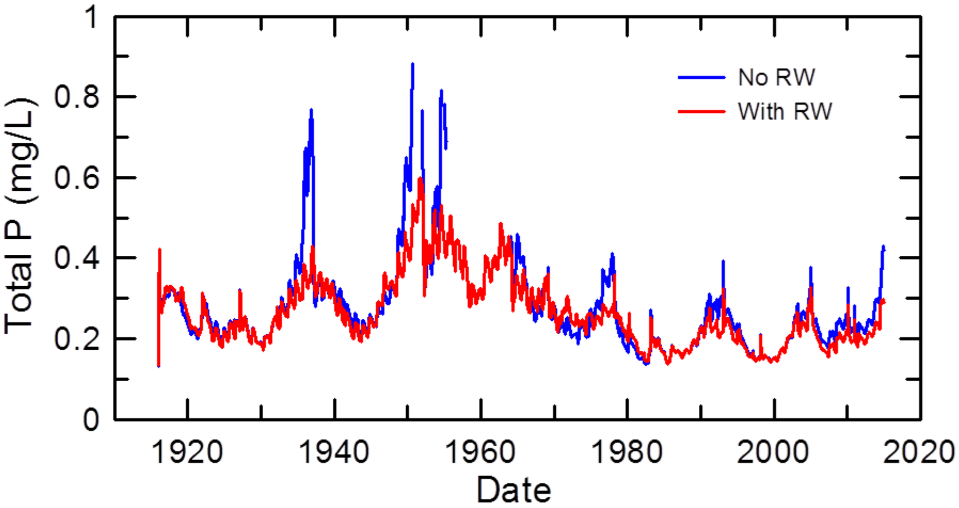


Fig. 21. Predicted total N concentrations with natural runoff (no RW) and when supplemented with recycled water (with RW).

Concentrations of chlorophyll a exhibited much greater variability, including variability over short (week-month) time scales, than the other water quality parameters (Fig. 22). Predicted concentrations reached 1000 µg/L in 1950 and again in 1957-58 when lake levels were very low (Fig. 18) and nutrient concentrations were very high

(Figs. 20,21). Concentrations were also often very low (<10 µg/L). Recycled water addtions had little effect on chlorophyll a concentrations owing to the similar nutrient concentrations (especially total P) in runoff and recycled water (Table 1).

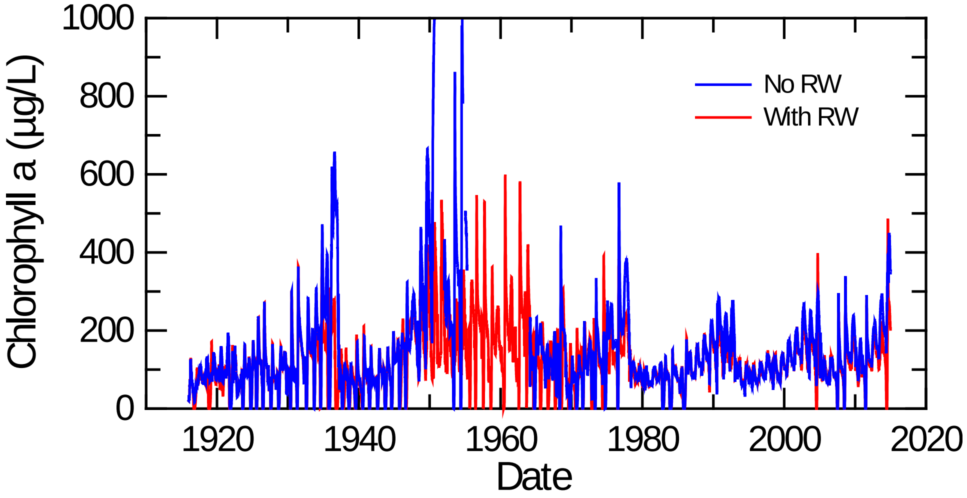


Fig. 22. Predicted chlorophyll a concentrations with natural runoff (no RW) and when supplemented with recycled water (with RW).

Statistical Analysis of Scenarios

A key feature of this study is the very long period of time over which conditions were simulated, necessitated by the complex hydrology of the region that includes extnded droughts and extreme El Nino events. This very long period of time allowed for statistical representations of conditions in Lake Elsinore under different management strategies. In particular, probabilistic representations are useful because they allow us to understand the probability and frequency of a given set of conditions. Thus, while time-series graphs could be developed for each of the additional scenarios, results henceforth will be presented using cumulative distribuiton functions and other statistical representations, focusing on the following key attributes of Lake Elsinore:

- lake surface elevation
- lake area
- TDS
- total P
- total N
- DO
- chlorophyll a

Lake Surface Elevation

As evident from Fig. 18, surface elevation can vary dramatically at Lake Elsinore. Presented using cumulative distribution functions (CDFs), we see that under natural flows (without addition of recycled water), the lake surface elevation exceeded the minimum bottom elevation of 1217.8 ft on 93.9% of the simulation days for the 1916-2014 simulation period (i.e., the lake was dry for 6 years or 6.1% of the time) (Fig. 23, blue line). In contrast, with recycled water added when the lake level dropped below 1240 ft, the lake level always exceeded 1230.3 ft above MSL (Fig. 23, red line). The two water management alternatives thus yielded dramatically different CDFs, especially below 1240 ft. Little difference was found above approximately 1245 ft, however, with natural flow and with recycled water supplementation scenarios both yielding these higher lake levels about 40% of the time. Under the rules of the water transfer agreement, recycled water would not be a part of the water budget at these higher lake levels, so levels would be controlled by flows from the San Jacinto River and local runoff. As previously noted, the model assumes outflow is rapid when the lake level exceeds the outlet/spillway elevation, so lake level does not substantively exceed 1255 ft above MSL. A 3-D model of the lake could more readily accommodate filling of the back basin and other, more complex hydraulic conditions.

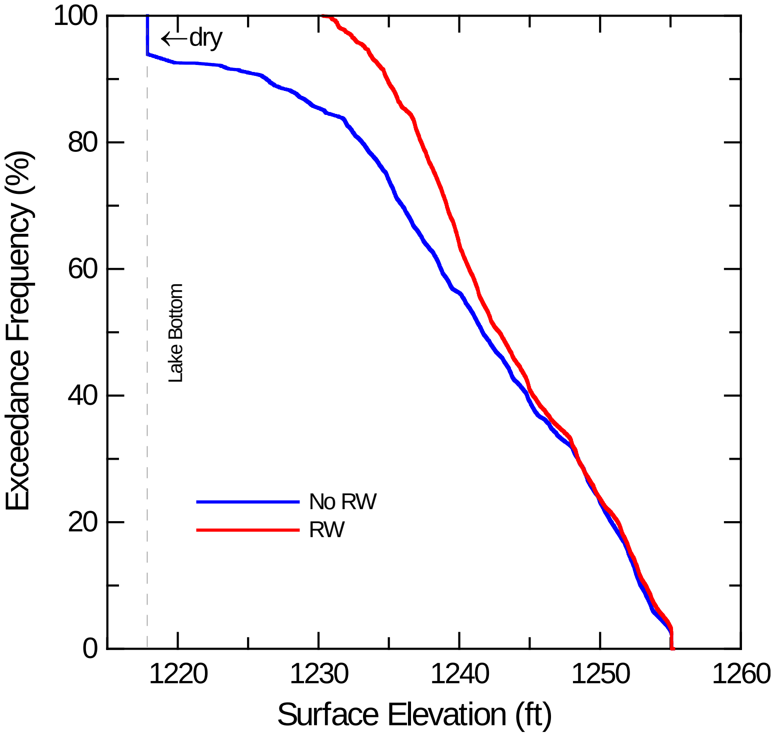


Fig. 23. Cumulative distribution functions showing lake surface elevation under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Lake Surface Area

A 3rd-order polynomial used to represent the hypsography of Lake Elsinore allowed surface area (Fig. 24) to be calculated from predicted lake surface elevation (Fig. 23). As indicated in Fig. 23, the lake was dry (lake area essentially 0 acres) for 6.1% of the 99-year period, while the lake was never smaller than 2060 acres with recyclced water supplementation (Fig. 24). With only natural flow, lake levels were below the minimum level maintained with recycled water (2060 acres) for 15 years. While substantial differences were present at lower surface areas, the median (50% exceedance frequency) values with and without recycled water supplementation were not dramatically different (2956 vs. 2875 acres, respectively, for a difference of 81 acres). As noted with lake surface elevation, differences in lake area were effectively absent at exceedance frequencies <40%, which is to say that recycled water supplementation did not increase the frequency of very high lake surface areas due in part to the model assumption of rapid discharge when the lake exceeded the outlet/spillway elevation (Fig. 24).

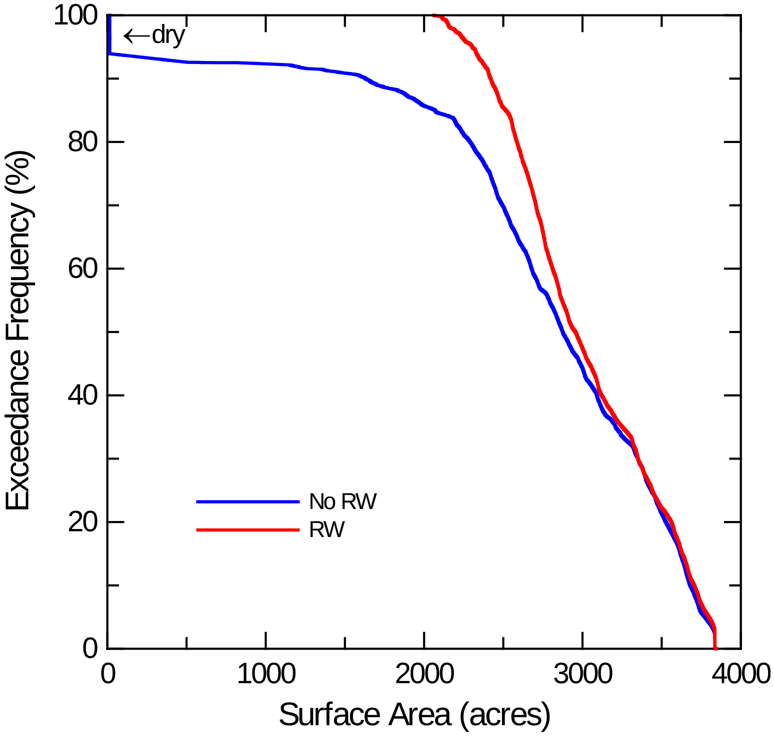


Fig. 24. Cumulative distribution functions showing lake surface area under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Total Dissolved Solids (TDS)

Recycled water supplementation did alter TDS concentrations in the lake across the full range of conditions, however, with distinct TDS-frequency relationships (Fig. 25).

Minimum TDS values of about 250 mg/L were present both with and without recycled water supplementation (Fig. 25), with >99.95% probability that TDS values in the lake will exceed this minimum value. The two CDFs diverged quickly, with TDS values with natural flows to the lake (no recycled water supplementation) lower than values present in the lake with recycled water addition 80.3% of the time (the cross-over point on the curves, occurring at 3345 mg/L TDS) (Fig. 25). By extension, natural flows would have yielded had a greater lake TDS value than that with recycled water supplementation 19.7% of the time the lake. The maximum TDS value with recycled water reached 8400 mg/L, while this TDS value was exceeded 11.7% of the 1916-2014 simulation period and reached very high levels (greater that that of sea water at very low lake levels, before becoming a salt encrusted playa upon complete dessication). Salinity-induced mortality can occur at higher TDS values which vary depending upon the individual species, as well as temperature and other factors.

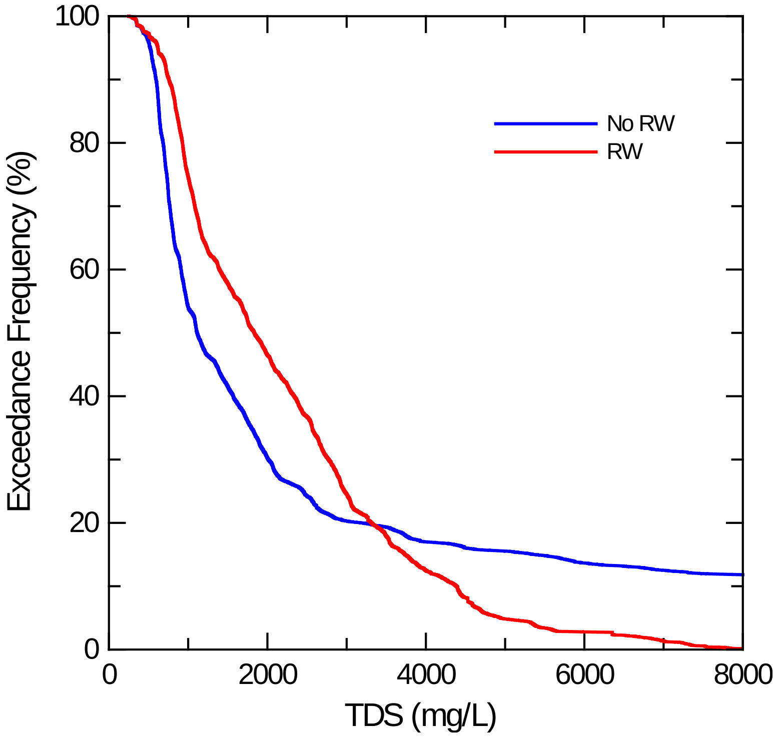


Fig. 25. Cumulative distribution functions showing TDS concentrations under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Approximate maximum salinity values for important species in Lake Elsinore were taken from available references. Black crappie appear to be the species most sensitive to salinity, with an upward limit of about 2,000 mg/L (Table 3). This threshold is shown by the dashed line; from the intercept of the two curves with this 2,000 mg/L line, we see that with recycled water additions, TDS exceeds this value 46.5% of the time (indicating that suitable salinity conditions are expected to be present in the lake 53.5%

of the time). With natural flows, TDS levels in the lake exceeded this value less frequently (30.3%), yielding suitable salinity conditions 69.7% of the time. Largemouth bass can tolerate a higher level of salinity than black crappie, with values exceeding the threshold of 4,000 mg/L 12.5% of the time with recycled water supplementation and 17.0% with natural flows (Table 3). Hybrid striped bass and common carp are more tolerant of high salinity, with threshold values of approximately 8,000 and 7,300 mg/L, respectively. Lake Elsinore is expected to support these species under essentially all conditions (<1% exceedance probability) with recycled water supplemention, while salinities would have exceeded these threshold values about 12% of the time under natural flows (Table 3). Notwithstanding, complete extirpation of all fish in Lake Elsinore would have occurred upon dessication under natural flow conditions in 1958-1964. The upper limit of salinity for *Daphnia pulex* has been reported in literature (e.g., Latta et al., 2012) to be approximately 4,000 mg/L, indicating that widespread mortality of this important cladocern would occur 17% of time under natural flow conditions to the lake which is reduced to 12.5% with recycled water additions (Table 3). Reproduction and recruitment are inhibited at salinity values below those reported in Table 3, although well-defined values are not available.

Table 3. Salinity tolerances and threshold exceedances as percentage of total simulation time (1916-2014).

	Max Salinity (mg/L)	Threshold Exceedance (%)	
		No RW	RW
Daphnia pulex	4,000	17.0	12.5
Threadfin Shad	15,000	10.0	0
Bluegill	3,600	18.9	16.2
Black Crappie	2,000	30.3	46.5
Largemouth Bass	4,000	17.0	12.5
Striped bass	8,000	11.8	0.1
Common carp	7,300	12.2	0.9

Lake elevation, area and salinity levels differ only between scenarios comparing natural flows and those with recycled water supplementation; these properties are not affected by operation of diffused aeration, alteration of the food web, or other management actions or scenarios. This is not the case with concentrations of nutrients, DO and chlorophyll a concentrations. As a result, more complex CDFs were developed for these water quality parameters that included a wide range of scenarios.

Cumulative distribution functions for these key water quality parameters are presented for scenarios that include (i) no recycled water added (No RW), (ii) supplementation with recycled water (RW), (iii) supplementation with recycled water and daytime operation of the diffused aeration system (RW+Aeration), and (iv) supplementation with recycled water with 0.1 mg/L PO_4-P and aeration (RW (0.1 mg/L P)+Aeration). In each of these 4 scenarios, the full food web (with cladocerans, copepods, threadfin shad, and piscivores) is operating. Although carp are not explicitly simulated, their effect on bioturbation and enhanced release of NH_4^+ and PO_4-P from bottom sediments was also included based upon Anderson (2006). Three additional scenarios explored food-web effects explicitly, with (vi a simulation that removed zooplankton, threadfin shad and piscivores (RW+Aeration, no Zoo, no Fish), (vi) a simulation with only zooplankton grazing and no fish (RW+Aeration+Zoo), and (vii) a simulation that explored effect of complete carp control that eliminated bioturbation-enhanced sedimebnt nutrient flux (RW+Aeration, no Carp).

Total N

Across this set of scenarios and over the 99-yr simulation period, total N concentrations varied from about 1 mg/L to >10 mg/L (Fig. 20). This was also shown in Fig. 20, which presented the total N time-series comparing No RW and RW scenarios. Notable in this figure is that for all scenarios, including aeration and food web alterations, at no time did total N concentration meet the final TMDL target of 0.75 mg/L (i.e., 100% exceedance frequency for total N concentration was > 1 mg/L) (Fig. 26). Comparatively little difference across the scenarios was seen at low TN concentrations (<3 mg/L) (Fig. 20) associated with high lake levels following large runoff events (Fig. 18). This makes sense since the conditions in the lake are driven to a large extent by external hydrologic forcing with comparatively little opportunity for extensive management effects on nutrient concentrations. The CDFs deviate at higher concentrations however, as evapo-concentration, ecological and management actions exert a greater effect (Fig. 26). For example, removal of carp and corresponding reductions in internal nutrient loading had a noticeable benefit, shifting the CDFf to lower total N concentration between 20-60% exceedance frequency (Fig. 26, light blue dashed line). At the other end of the spectrum, elimination of algal grazing by zooplankton and food web effects shifted the CDF to higher total N concentrations at a given exceedance frequency (Fig. 26, orange line).

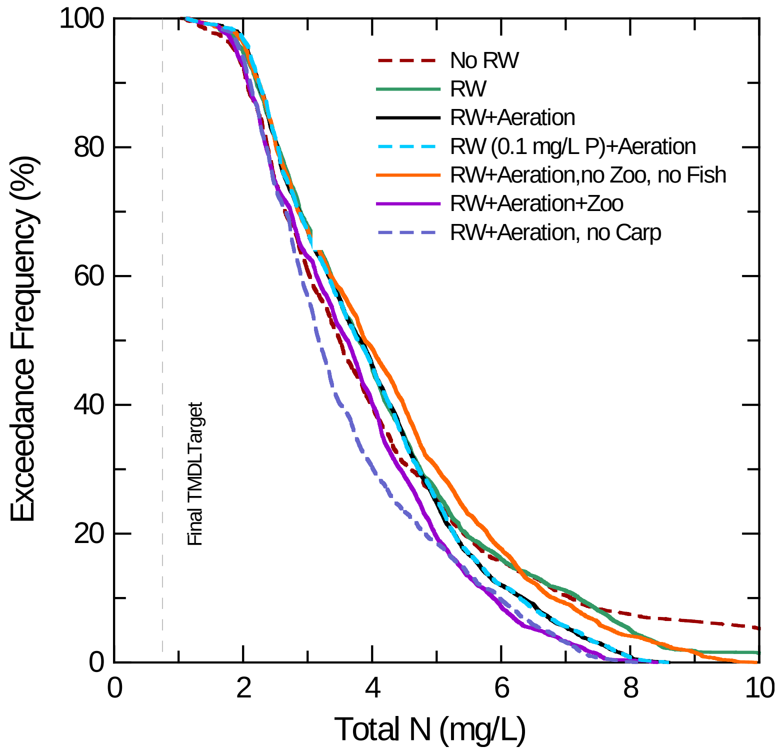


Fig. 26. Cumulative distribution functions showing total N concentrations under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Key values were pulled off the CDF and are presented in Table 4. The arithmetic mean concentrations of total N for the scenarios ranged from 3.6 mg/L for the scenario in which carp have been removed, to 4.27 mg/L for the scenario with no recycled water addition (Table 4). Median concentrations, corresponding to the 50% exceedance frequencies, were lower than mean values, indicating a non-Gaussian distribution in concentrations that are skewed to higher values, as demonstrated in the CDFs. Median values were again lowest for the no carp scenario, but in this case highest for the no zooplankton/no fish scenario in which top-down control of algal production was excluded (Table 4). Maximum concentration varied most dramatically, as very high total N concentrations were predicted for the natural flow scenario (no RW) at low lake levels, exceeding 24 mg/L as the lake approached dryness. Aeration (RW+Aeration) was shown to reduce total N concentrations compared with recycled water addition alone (No RW), with maximum concentrations reduced from 12.25 to 8.60 mg/L, and 10% exceedance frequency concentrations reduced from 7.20 to 6.33 mg/L (Table 4). At the 10% exceedance frequency, zooplankton grazing without fish pressures yielded the lowest predicted concentration of total N for all evaluated scenarios.

Table 4. Total N concentrations for Lake Elsinore simulation scenarios.						
Scenario	Mean	Median	Min	Max	90%	10%
No RW	4.27	3.50	1.05	>24.0	2.06	7.08
RW	4.20	3.80	1.10	12.25	2.21	7.20
RW+Aeration	4.01	3.82	1.14	8.60	2.24	6.33
RW(0.1 mg/L P)+Aeration	4.01	3.78	1.14	8.58	2.25	6.29
RW+Aeration, no Zoo, no Fish	4.23	3.89	1.16	9.95	2.24	6.81
RW+Aeration+Zoo	3.77	3.62	1.15	8.41	2.08	5.88
RW+Aeration, no Carp	3.60	3.17	1.13	8.10	2.11	5.97

Total P

Results for total P differ in some interesting ways from total N. Beyond much lower concentrations than total N, greater separation in CDFs was witnessed between the different scenarios. As with total N, predicted total P concentrations exceeded the TMDL target of 0.1 mg/L (Fig. 27), although it bears noting that while model calibration reasonably captured average concentrations and trends, the model tended to over-predict observed low concentrations and under predict somewhat the observed high values (despite considerable effort) (Fig. 10). On that basis, the CDFs for total P are somewhat "steeper" than might be expected, with reduced tails (that would represent low probability events) at both low concentrations and high concentrations (Fig. 27). Notwithstanding, the main features of the CDFs, including mean and median concentrations, as well as relative trends for the different scenarios are well represented.

Lowest predicted concentrations across all scenarios were predicted for recycled water supplementation with reduced (0.1 mg/L) PO_4-P concentrations with aeration (and full food web) (Fig. 27, light blue dashed line). Somewhat lower predicted total P concentrations were also predicted for the RW+Aeration, No Zoo, No Fish scenario, attributed to slightly lower dissolved organic P levels that results from reduced processing by zooplankton and greater proportion of particulate organic P that settled more quickly through the water column. The other simulations tended to track somewhat more closely, although natural flows (No RW) yielded higher concentrations than most of the other scenarios at low exceedance frequencies (Fig. 27). Somewhat surprisingly, recycled water with aeration also yielded high total concentrations at low exceedance frequencies that would be associated with low lake levels and high evapoconcentration, underscoring the complexity of controls and uptake, processing and loss of P in the lake.

Median total P concentrations ranged from 0.21 – 0.26 mg/L, with carp removal yielding the lowest predicted median value and RW+Aeration+Zoo (i.e., no fish predation) yielding the highest value (Table 5). Reduced PO4-P concentrations in recycled water coupled with aeration yielded the consistently lowest predicted total P concentrations (Fig. 27, Table 5).

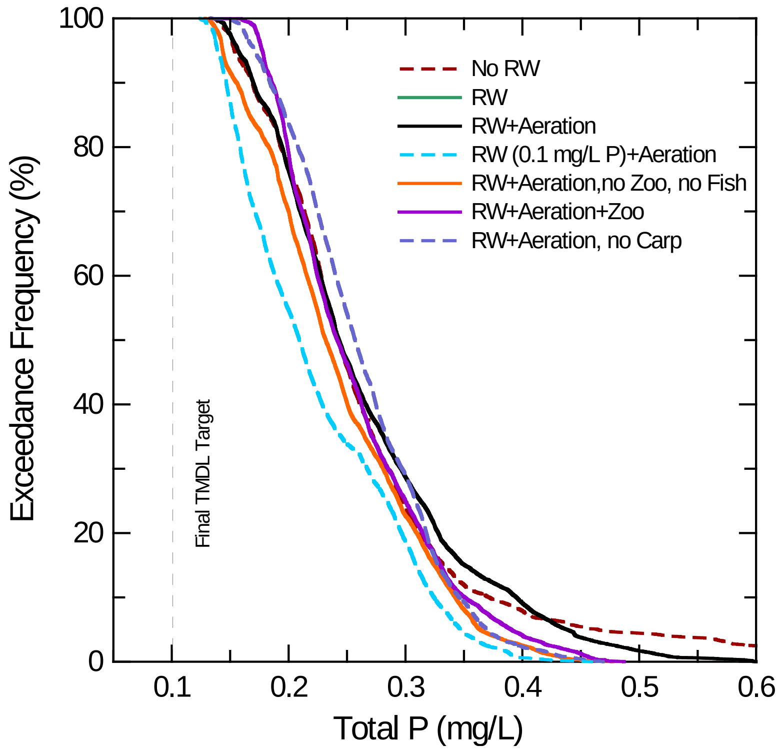


Fig. 27. Cumulative distribution functions showing total P concentrations under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Table 5. Total P concentrations for Lake Elsinore simulation scenarios.

Scenario	Mean	Median	Min	Max	90%	10%
No RW	0.27	0.24	0.13	0.88	0.17	0.37
RW	0.26	0.24	0.13	>0.60	0.17	0.39
RW+Aeration	0.24	0.23	0.13	0.48	0.17	0.39
RW(0.1 mg/L P)+Aeration	0.23	0.22	0.13	0.42	0.15	0.32
RW+Aeration, no Zoo, no Fish	0.26	0.24	0.13	0.49	0.16	0.34
RW+Aeration+Zoo	0.26	0.26	0.13	0.47	0.19	0.35
RW+Aeration, no Carp	0.22	0.21	0.12	0.46	0.18	0.35

Chlorophyll a

Cumulative distribution functions for predicted chlorophyll a concentrations exhibited trends different from either total N or total P (Fig. 28). The effect of no zooplankton grazing or other food web effects yielded dramatically higher chlorophyll a concentrations than any other scenario except at very low exceedance frequency when the No RW scenario overtook it at nearly 300 µg/L, and occurring at about or less than 10% exceedance frequency (Fig. 28). This observation highlights the control on algal abundance in Lake Elsinore that zooplankton grazing and higher food web effects exert.

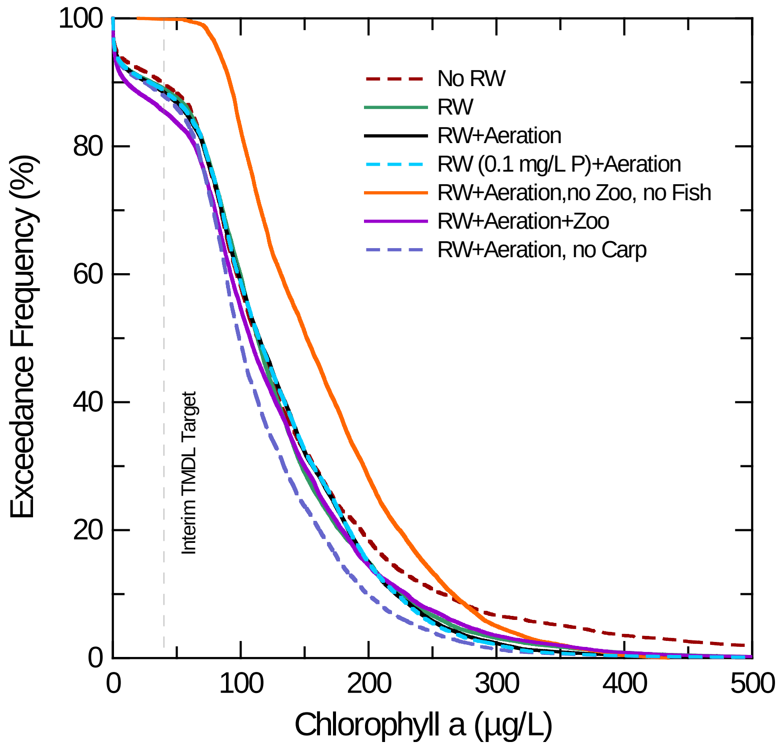


Fig. 28. Cumulative distribution functions showing chlorophyll a concentrations under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Zooplankton grazing alone yielded slightly lower chlorophyll a concentrations compared with the other scenarios between approximately 80-90% exceedance frequencies, suggesting some subtle food web effects under low nutrient/low carbon conditions. Carp removal yielded lower predicted chlorophyll a levels at lower exceedance frequencies (<60%) than most of the other scenarios (Fig. 28). Included in this figure is the interim TMDL target of summer-averaged chlorophyll a concentration of 40 µg/L, although CDFs were developed using daily data from the entire 99-yr simulation period, and thus can not be directly compared with the summer-average target value.

These trends in chlorophyll a concentrations can also been seen in Table 6, where complete carp removal yielded lowest mean and median chlorophyll a concentrations, followed by zooplankton grazing with no fish predation. The no-food web effects scenario (RW+Aeration, no Zoo, No Fish) yielded universally and dramatically higher concentrations for all metrics excluding the maximum concentration predicted at very low lake levels as the lake evapoconcentrated and approached desiccation (Table 6).

Table 6. Chlorophyll a concentrations for Lake Elsinore simulation scenarios.

Scenario	Mean	Median	Min	Max	90%	10%
No RW	140	113	<1	>1400	38	258
RW	125	113	<1	599	30	224
RW+Aeration	125	114	<1	647	27	222
RW(0.1 mg/L P)+Aeration	125	114	<1	666	29	222
RW+Aeration, no Zoo, no Fish	167	152	20	434	92	266
RW+Aeration+Zoo	122	107	<1	716	11	230
RW+Aeration, no Carp	111	99	<1	568	25	199

Dissolved Oxygen

Dissolved oxygen concentrations demonstrated less variation across the different scenarios than the other key water quality parameters. Unlike the other parameters where higher concentrations for a given scenario and exceedance frequency represented poorer water quality conditions, higher values for DO indicates improved conditions. The upper portions of the CDFs thus are of particular interest. Recycled water supplementation without aeration yielded the lowest water column-averaged DO concentrations of the scenarios, with anoxic (<1 mg/L) conditions present on 4.9% of all days in the 1916-2014 simulation period (Fig. 29, green line). In contrast, aeration with recycled water addition limited anoxia to 0.4% of the simulation period (Fig. 29, black line); under natural flow (no RW) (and no aeration), whole-water column anoxia was present 1.4% of the time (Fig. 29). The no Zoo/no Fish scenario (Fig. 29, orange line) provided the lowest amount of anoxia (0.2%), and also minimized conditions of extreme supersaturation present at low exceedance frequencies for the other scenarios. This suggests that grazing and resulting production of ammonia and oxidizable organic matter plays a greater role in DO dynamics that simply algal photosynthesis and respiration.

The frequency in which the 5 mg/L water column-averaged interim TMDL target was not met varied from 13.3% for recycled water addition without aeration (RW), to 5.6% for recycled water with aeration (RW+Aeration), and 2.3% without food web effects (RW+Aeration, no Zoo, no Fish) (Fig. 29).

Recycled water addition without aeration (RW) yielded the lowest mean and median DO concentrations, while RW+Aeration yielded the highest values (Table 7). All scenarios were predicted to produce whole-water column DO concentrations <0.01 mg/L at least 22 days out of the 99-year simulation period, and RW without aeration over 1300 days. Such conditions would be expected to produce widespread fish kills. Strongly supersaturated conditions associated with very high chlorophyll a concentrations were also predicted to occur for almost all scenarios with some frequency as well; DO levels exceeded 15 mg/L about 3% of the simulation days (Fig. 29).

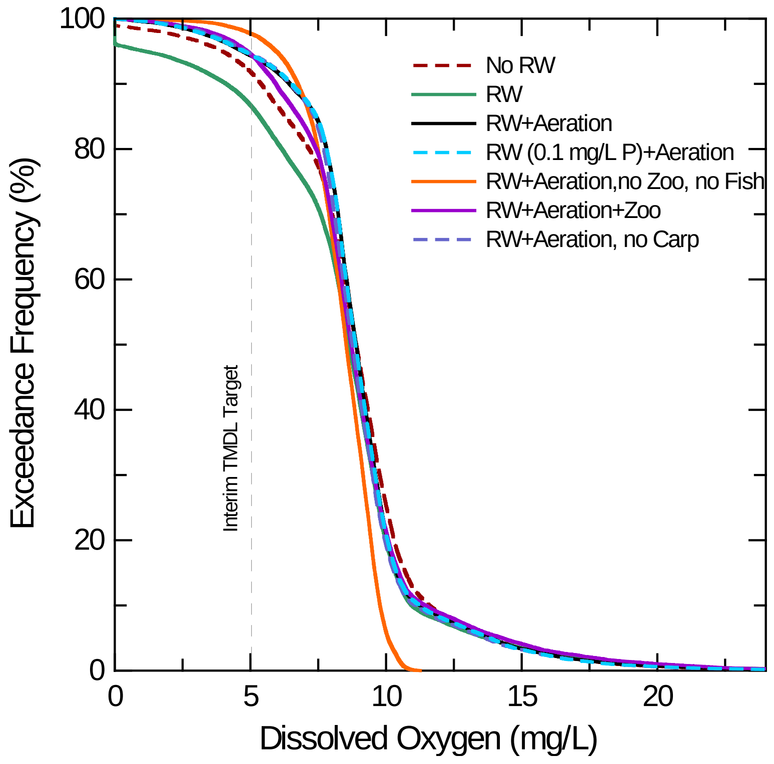


Fig. 29. Cumulative distribution functions showing dissolved oxygen concentrations under natural flow (No RW) and with recycled water supplementation (RW) scenarios.

Table 7. Dissolved oxygen concentrations for Lake Elsinore simulation scenarios.

Scenario	Mean	Median	Min	Max	90%	10%
No RW	8.85	8.90	<0.01	34.0	5.39	11.6
RW	8.30	8.64	<0.01	31.7	4.10	11.0
RW+Aeration	9.03	8.90	<0.01	28.1	6.45	11.3
RW(0.1 mg/L P)+Aeration	9.02	8.87	<0.01	29.4	6.51	11.2
RW+Aeration, no Zoo, no Fish	8.36	8.53	<0.01	11.3	6.75	9.78
RW+Aeration+Zoo	8.94	8.72	<0.01	30.0	5.94	11.4
RW+Aeration, no Carp	8.93	8.76	<0.01	29.6	6.46	11.1

Conclusions

Simulations for Lake Elsinore under a number of different scenarios indicate:

(i) water quality in Lake Elsinore varies dramatically over time;

(ii) water quality under pre-development conditions is substantially improved relative to current conditions, although under natural runoff, Lake Elsinore is nonetheless predicted to go dry for a number of years, with resultant poor water quality at very low lake levels;

(iii) recycled water supplementation significantly increases lake surface elevation and lake area compared with natural inflows into the lake during periods of limited precipitation and runoff, preventing drying up of the lake and extreme salinities seen under natural flow conditions;

(iv) recycled water supplementation did not substantively increase total N or total P concentrations in the lake, in large part since nutrient concentrations are not dramatically different than levels in runoff;

(v) aeration lowered slightly the mean and maximum concentrations of total N and total P, increased DO concentrations and reduced frequency of anoxia, although average chlorophyll a levels were not altered;

(vi) reduction in the PO_4-P concentration in recycled water to 0.1 mg/L reduced slightly total P in the lake but did not alter predicted chlorophyll a or dissolved oxygen concentrations;

(vii) removal of carp to reduce internal nutrient loading via bioturbation by carp yielded the lowest predicted average nutrient and chlorophyll a concentrations of all the scenarios evaluated, although reductions were modest;

(viii) elimination of food-web effects had a strong effect on predicted chlorophyll a concentrations, underscoring the value of zooplankton grazing and its beneficial effect on water quality in Lake Elsinore;

(ix) with the exception of the pre-development scenario, all scenarios yielded nutrient, chlorophyll a and DO concentrations that were routinely well-above current TMDL targets.

References

Anderson, M.A. 2006. *Predicted Effects of Restoration Efforts on Water Quality in Lake Elsinore: Model Development and Results.* Final Report to LESJWA. 33 pp.

Anderson, M.A. 2015. *Technical Memorandum Task 1.0: Surface Elevation and Salinity in Lake Elsinore: 1916-2014.* Draft Technical Memorandum to LESJWA. 13 pp.

Anderson, M.A. 2015. *Technical Memorandum Task 1.1:* **:** *Influence of Recycled Water Supplementation on Surface Elevation and Salinity in Lake Elsinore: Model Predictions for 1916-2014 with Current (post-LEMP) Basin.* Draft Technical Memorandum to LESJWA. 7 pp.

Hipsey, M.R., J.P. Antenucci and D. Hamilton. 2014. *Computational Aquatic Ecosystem Dynamics Model: CAEDYM v3. Science Manual v3.2 (Draft)*. Center for Water Research, University of Western Australia. 112 pp.

Latta, L.C., L.J. Weider, J.K. Colbourne, and M.E. Pfrender. 2012. The evolution of salinity tolerance in Daphnia: a functional genomics approach. *Ecol. Lett.* 15:794-802.

http://www.fishbase.org/summary/Dorosoma-petenense.html

Page Intentionally Blank

Technical Memorandum

Task 2.1: Stable Isotope, Elemental and Mobile-P Measurements in Lake Elsinore Sediments*

Objective

The objectives of this task were to quantify properties of Lake Elsinore sediments over time and correlate observed properties with hydrologic conditions, management actions and other factors.

Approach

Sample Collection

Two replicate cores were collected from profundal sediment ("Site 6", 33.66879° N, 117.35127° W) in Lake Elsinore on July 17, 2014 with a 1 meter polycarbonate tube with a 6.5 cm diameter. Water was carefully siphoned off the top of each core and the sediment was sectioned into 1 cm (for the top 10 cm) or 2 cm (for sediment deeper than 10 cm) intervals. Each section was homogenized and stored at 4°C under N_2 (g) in 50 mL polypropylene centrifuge tubes. A subsample from each interval was used for water content determination. To calculate water content, the wet sediment was pre-weighed into small aluminum pans and oven-dried at 105°C until reaching a constant weight (1-2 days).

Water was collected from 0.5 m depth at Site 6 on September 17, 2014 and June 18, 2015 and analyzed for isotopic composition of suspended organic matter (mainly phytoplankton). The water was stored in 20 L Nalgene jugs at 4°C until later filtration. The water collected in 2014 was stored for six months, over which it experienced an unknown period of time at 25°C, due to technical issues. Therefore suspended organic matter (SOM) experienced some decay over this period of time, but is thought to reflect, to at least some degree, natural decomposition processes operating within the lake.

Elemental Composition (XRF)

Bulk elemental composition was determined on sediment samples using a Spectro XEPOS HE Benchtop X-ray Fluorescence Spectrometer flushed with 85 L hr^{-1} of helium gas (EPA Method 6200). Approximately 5 g of wet sediment from sediment core interval was dried at 50°C and ground with a mortar and pestle prior to X-ray fluorescence analysis. Four different source energies/excitation targets were utilized per sample at count times of 200 seconds: excitation energy of 40 kiloelectron volts (kV) and 1 mA current; 60 kV and 0.66 mA; 25 kV and 1.6 mA; 20 kV and 2 mA.

**This technical memorandum was developed from Chapter 2 of the M.S. thesis of Simone Boudreau (2015).*

Phosphorus Forms

Forms of P in bottom sediment were extracted using the fractionation scheme described in Pilgrim et al. (2007). 0.2-0.25 grams of wet sediment was added to 50 mL polycarbonate centrifuge tubes, followed by a sequential phosphate extraction which utilized different reagents to measure the amount of phosphate in three different fractions within the sediment. The reagent solutions were 1M ammonium chloride (NH_4Cl) which extracts pore-water and loosely-sorbed P, followed by bicarbonate buffered dithionite solution (0.11M $NaHCO_3$/0.11M NaS_2O_4) to extract redox-sensitive P bound to iron and manganese hydroxides (Fe-P), and lastly 0.1M sodium hydroxide, NaOH, to extract non-reducible, aluminum-bound P (Al-P). The sum of the phosphate extracted in the first two steps represents mobile phosphorus, or phosphorus that can be re-released to the water column under low DO conditions. Aluminum-bound phosphate is generally considered to be a recalcitrant form that will not be re-released. 10 mL of each extract was added to the centrifuge tube. After each sequential reagent addition, the samples were placed on a shaker table for varying amounts of time: two hours for loosely-sorbed P, one hour for Fe-P, and 16 hours for Al-P (Pilgrim et al., 2007). Subsequent to each reagent addition and mixing, samples were centrifuged at 3,000 rpm for 20 minutes. The supernatant was decanted, filtered through 0.45 μm membrane filters, and stored in 20 mL HDPE scintillation vials in the freezer until analysis. The residual sediment continued on in the procedure after the supernatant from each step was decanted. One out of every 10 samples was replicated and 2 method blanks per core were used (no sediment, just reagent and centrifugation). Soluble reactive phosphorus was determined colorimetrically for each supernatant on a Seal AQ2 discrete analyzer following the automated ascorbic acid reduction method 4500-P F (Standard Methods for the Examination of Water and Wastewater, 20th edition). Absorbance was measured at 880 nm. Calibration control blank and calibration control verifications were used to verify accuracy.

Stable Isotopic Composition

Sediment subsamples were dried at 50°C and ground to a homogenous mixture with a mortar and pestle. The dried sediment was fumigated with concentrated HCl (12N) in a desiccator for 24 hours in order to remove inorganic C. Replicate samples were analyzed without fumigation to ensure all $CaCO_3$ had been removed. Suspended organic matter from epilimnetic water was filtered through 47 mm Whatman glass microfiber filters and then oven-dried at 50°C. Stable C and N isotope compositions as well as %OC (weight percent) and %N were analyzed on a Costech elemental analyzer coupled to a Delta V Advantage Isotope Ratio Mass Spectrometer at the Facility for Isotope Ratio Mass Spectrometry (FIRMS) at University of California, Riverside. One in every ten samples was replicated.

Results

Using the sedimentation rate of 1.27 cm/year previously determined by Byrne et al. (2004), the dates corresponding to given sediment depths were calculated using the formula shown below and plotted on each depth profile as a secondary y-axis to allow comparison of sediment properties over time and with lake management activities.

$$t = t_0 - (z/1.27\ cm\ yr^{-1}) \tag{1}$$

where t = date (decimal year) at sediment depth z

t_0 = date at time of sediment collection (2014.5)

z = sediment depth (cm)

Historical lake management activities are summarized in Fig. 1 for reference. Prior to the completion of the Lake Elsinore Management Project (LEMP) in 1995, Lake Elsinore was larger and shallower with presumably greater mixing and circulation. The completion of the project in 1995 marks the transition to a deeper lake with a reduced surface area. Addition of supplemental recycled wastewater began in 2002 and continued through 2004 and from 2008-present. Lake level varied strong over this period due to periodic drought and El Nino events.

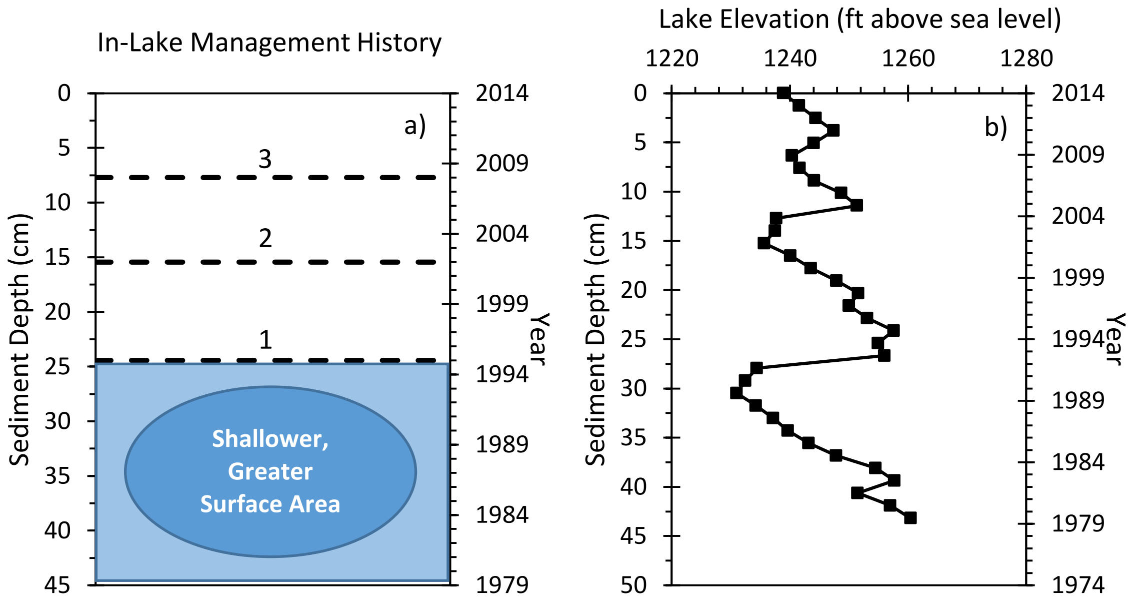


Fig. 1. Lake Elsinore: a). historical lake management: 1=Completion of LEMP, 1995. 2=Supplemental recycled wastewater begins, 2002. 3=Aeration system begins operating, 2008; b) lake surface elevation in feet above sea level.

Water Content

Water content of sediment increased with decreasing depth (and time), from about 70% to 90%, with the exception of a decrease in water content (which is reflected in both replicates) from depth of 22 cm to 10-16 cm in cores 6-A and 6-B (Fig. 2).

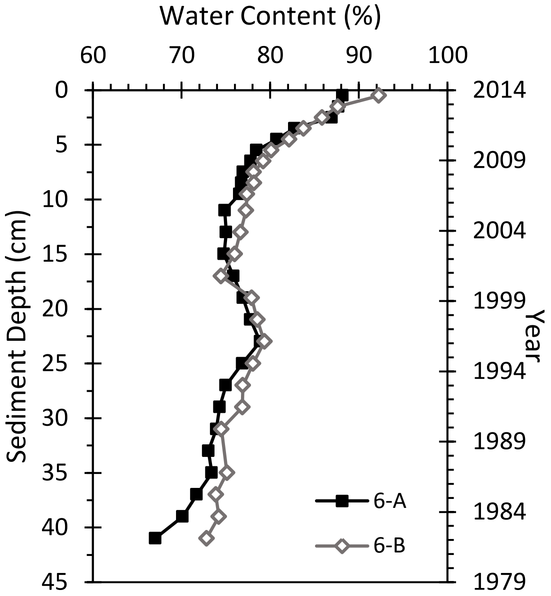


Fig. 2. Water content (%) with sediment depth at Site 6.

Elemental Composition

Organic carbon increases by 5% (from approximately 2% to 7%) from the bottom to the top of the cores (representing freshly deposited sediment). Organic carbon and total nitrogen concentrations reflect an increase from 30 cm to 25 cm as well as an increase up-core in the top 10 cm. Nitrogen increases from 0.25 to 0.75% throughout the length of the cores. Organic carbon and nitrogen are significantly correlated in both cores (r=0.97) (Table 1). The gradual increase in OC in the top 10 cm reflects an exponential increasing trend with decreasing depth, as the data better fit an exponential function (average r^2=0.77) than a linear function (average r^2=0.70). Similarly, the up-core increase in N in the top 10 cm better fits an exponential function (r^2=0.70) than a linear function (r^2=0.62). OC:N remains relatively constant with depth in both cores, at a value of 10, with minor fluctuations. OC:N of suspended organic matter collected in June 2015 was 6.9±0.2. Total phosphorus increases from 0.1% at the bottom of the core to 0.15% at the top of the core. TP exhibits an up-core exponential increase in the top 10 cm (r^2 =0.74 vs r^2 =0.71 for linear fit). The depth profiles for silicon and aluminum reveal an increase between 25 and 30 cm after which the concentrations return to background levels and remain relatively constant to the top of the cores. Silicon and aluminum are significantly correlated (r =0.99), and their stoichiometric ratios suggest the presence of alumino-silicate minerals such as montmorillonite (Wetzel, 2001) which has a 2:1 molar ratio of Si to Al. Calculation of the ratio of moles of Si per gram (0.006) to moles Al per gram (0.003) in Lake Elsinore sediments resulted in a value of 2. Sulfur (S) increases from 6000 µg/g in 1989 to 2000 µg/g in 1994 after which it remains constant with sediment depth. Calcium (Ca) increases from 4% at the bottom of the core to 10% at the top. The increase is not a gradual, constant increase. Instead calcium increases from the bottom of the core to 25 cm (1994). It remains constant from 1994 to 10 cm (2007), after which it increases exponentially to the top of the core (r^2 = 0.86 for exponential fit, vs. r^2 =0.83 for linear fit).

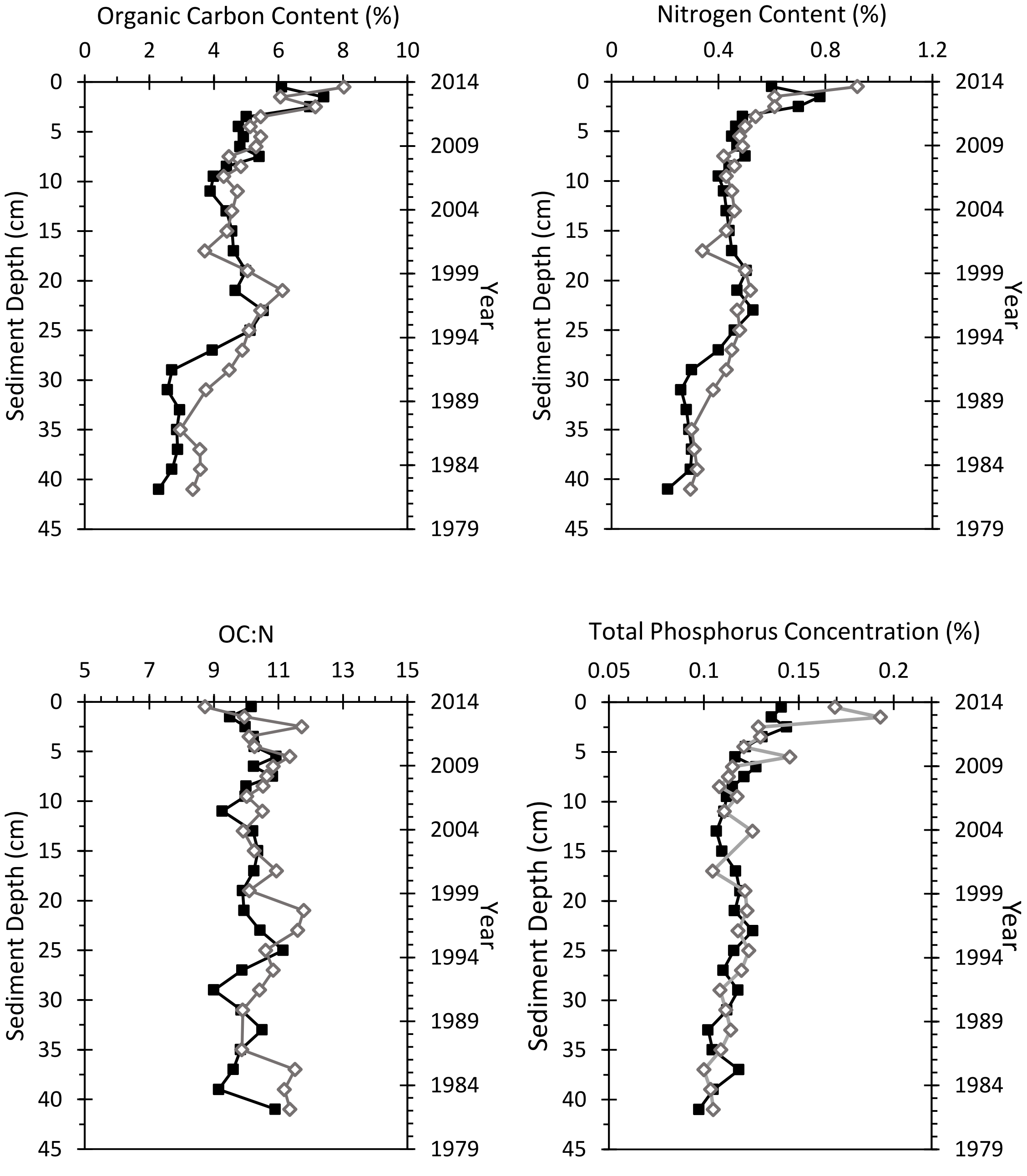


Fig. 3. Organic carbon content, total nitrogen content, OC:N ratio, and total phosphorus concentration in Lake Elsinore sediment. Solid squares represent data points in core 6-A. Open diamonds represent data points in core 6-B.

Calcium also exhibits a significant correlation with OC and N (Table 1). Iron shows a similar but opposite trend as calcium, decreasing until 1994, remaining relatively constant until 2006, then decreasing to the top of the core. The overall decline in concentration is 6.25 to 5%. Iron and calcium are significantly negatively correlated (Table 1).

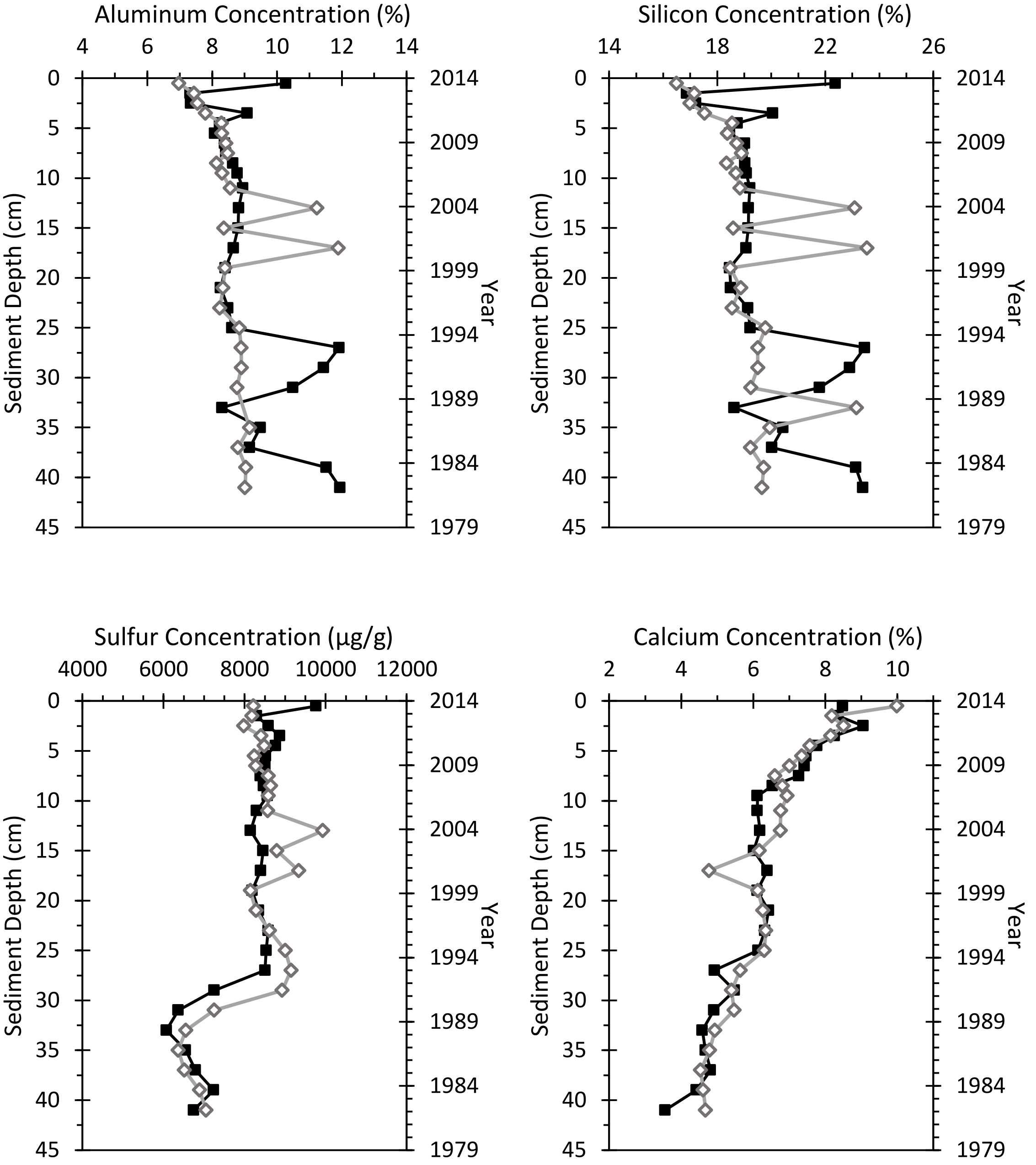


Fig. 4. Aluminum, silicon, sulfur, and calcium depth profiles of Lake Elsinore sediment. Solid squares represent data points in core 6-A. Open diamonds represent data points in core 6-B.

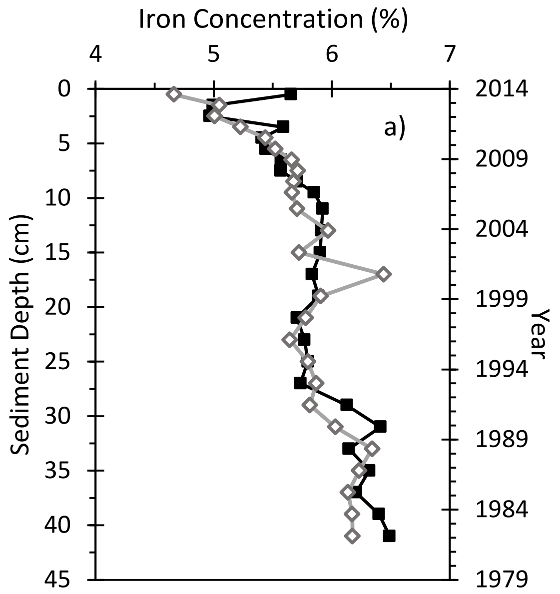


Fig. 5. Iron concentration profiles for Lake Elsinore sediment. Solid squares represent data points in core 6-A. Open diamonds represent data points in core 6-B.

Table 1. Correlation table showing r values for bulk elemental properties in Lake Elsinore sediment. With n=26, an r value of 0.51 is statistically significant at p=0.001.

	Depth	Water	%OC	%N	Al	Si	P	S	K	Ca	Ti	Fe
Depth	1.00											
Water	-0.79	1.00										
%OC	-0.75	0.89	1.00									
%N	-0.75	0.91	0.97	1.00								
Al	0.48	-0.56	-0.62	-0.59	1.00							
Si	0.48	-0.53	-0.60	-0.57	0.99	1.00						
P	-0.57	0.72	0.63	0.68	-0.39	-0.35	1.00					
S	-0.67	0.49	0.58	0.57	-0.04	-0.02	0.43	1.00				
K	0.91	-0.79	-0.86	-0.85	0.58	0.58	-0.58	-0.73	1.00			
Ca	-0.90	0.94	0.88	0.90	-0.60	-0.58	0.70	0.56	-0.88	1.00		
Ti	0.88	-0.87	-0.87	-0.87	0.50	0.50	-0.65	-0.66	0.95	-0.93	1.00	
Fe	0.81	-0.89	-0.89	-0.90	0.70	0.69	-0.66	-0.49	0.91	-0.93	0.94	1.00

Phosphorus Forms

Redox-sensitive phosphate is the least abundant fraction, averaging about 75 µg/g dry weight (dw) throughout the length of the cores and remaining constant with depth (Fig. 6, open diamonds). Loosely-sorbed and pore-water phosphate represents the majority of the mobile-P (~60%) (Fig. 6, solid triangles). With the exception of two noticeable increases at 20 and 35 cm, loosely-sorbed/pore-water P remains at about 150 µg/g dw below 10 cm depth. In the upper 10 cm, the fluctuations stabilize, and smaller variations center around 125 µg/g dry weight. This signifies a shift to lower pore-water P concentrations in more recently deposited sediment. Aluminum-bound P was the most abundant of the fractions measured using the sequential extraction procedure, with concentrations ~135 µg/g dw at the bottom of the core (Fig. 6, solid squares). The concentration exhibits a large increase to ~200 µg/g dw at about 25 cm, followed by a shift to greater concentrations in depths <25 cm, averaging 150-160 µg/g dw. The increase and subsequent shift to greater mean concentrations occurred in 1994, around the same time the Lake Elsinore Management Project was completed (Figs. 1, 6).

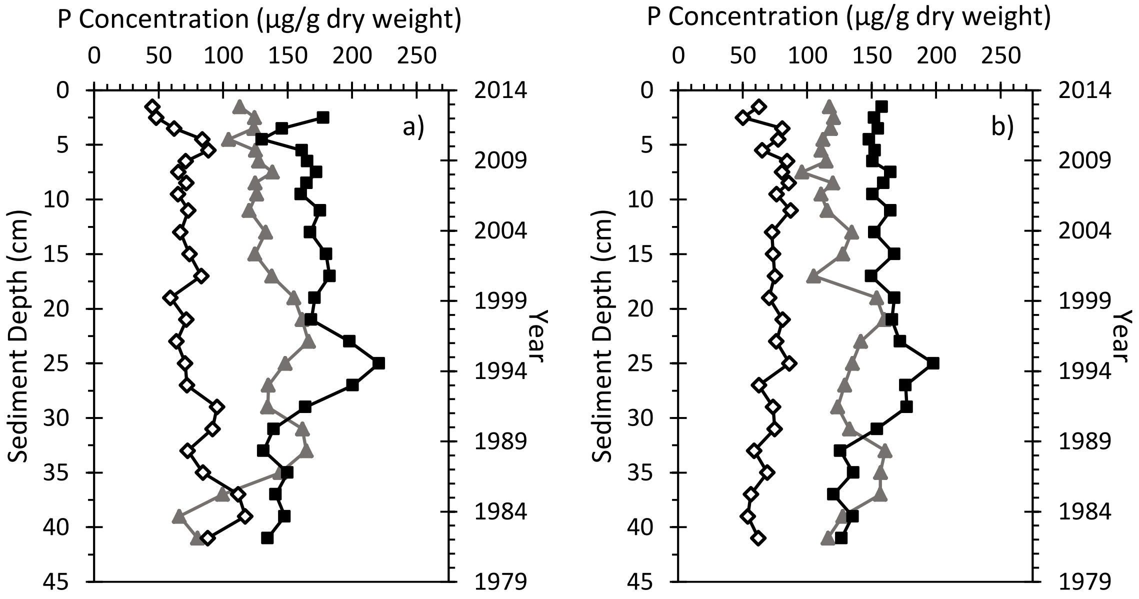


Fig. 6. Phosphorus concentrations in three different sediment forms. Panel a shows core 6-A. Panel b shows core 6-B. Open diamonds=Fe-P. Solid triangles= loosely-sorbed/pore-water P. Solid squares=Al-P. Mobile-P is taken as the sum of loosely-sorbed/pore-water P and Fe-P.

Stable Isotopic Composition

Stable isotopic composition results are presented in delta notation relative to Vienna Pee Dee Belemnite Standard (for C) and Air N_2 standard (for N) and calculated using the equation, exemplified below for ^{13}C:

$$\delta^{13}C = \left[\left(\frac{{}^{13}C/{}^{12}C_{sample}}{{}^{13}C/{}^{12}C_{standard}}\right) - 1\right] * 1000 \qquad (2)$$

The filters exhibited suspended organic matter (SOM) with δ^{13}C values of -20.2±0.6‰ and -23.7±0.4‰ in the fresh and decomposed samples, respectively (Table 2). The measured δ^{15}N of the SOM was 5.8±0.2‰ and 10.2±1.6‰ in the fresh and decomposed samples, respectively. The decomposed SOM exhibited about a 3‰ higher δ^{15}N than the top of the sediment core and about a 4‰ more negative δ^{13}C than the top sediment. Fresh SOM reflected the same δ^{13}C values as the top sediment and slightly lower (0.7‰ difference) δ^{15}N.

δ^{13}C values are gradually increasing in both cores from approximately -24‰ at 29 cm to -20‰ at the top of the cores (Fig. 7). In core 6-A, δ^{13}C increases from -25‰ at the bottom of the core to -20‰ at the top of the core. This gradual 5‰ increase towards the top of the core represents a significant change with depth (r^2=0.72).

The δ^{15}N depth profiles reflect three distinct periods which have significantly different mean values. From 41 to 35 cm (the bottom section of the core), mean δ^{15}N values are 6.2±0.4‰ and 6.5±0.4‰ for cores 6-A and 6-B, respectively. This section represents the time frame from approximately 1982 to 1988, when the lake was shallow, prior to completion of the Lake Elsinore Management Project. After 1988, during the transition from a shallower, larger surface area lake to a deeper lake with a smaller surface area, δ^{15}N shifts to lower, more variable values with means 5.3±0.5‰ and 5.8±0.4‰. This period lasts from 31 cm to 17 cm (1990-2001), after which point the signatures increase to 7.1±0.4‰ and 6.9±0.6‰ in cores 6-A and 6-B, respectively. In the top layer of sediment, δ^{15}N values vary little and the high values extend to the top of the cores.

Table 2. Stable isotopic composition of suspended organic matter (SOM)

Suspended Organic Matter	δ^{13}C (‰ vs. VPDB)	δ^{15}N (‰ vs. Air N_2)
Fresh	-20.2±0.6	5.8±0.2
Decayed	-23.7±0.4	10.2±1.6

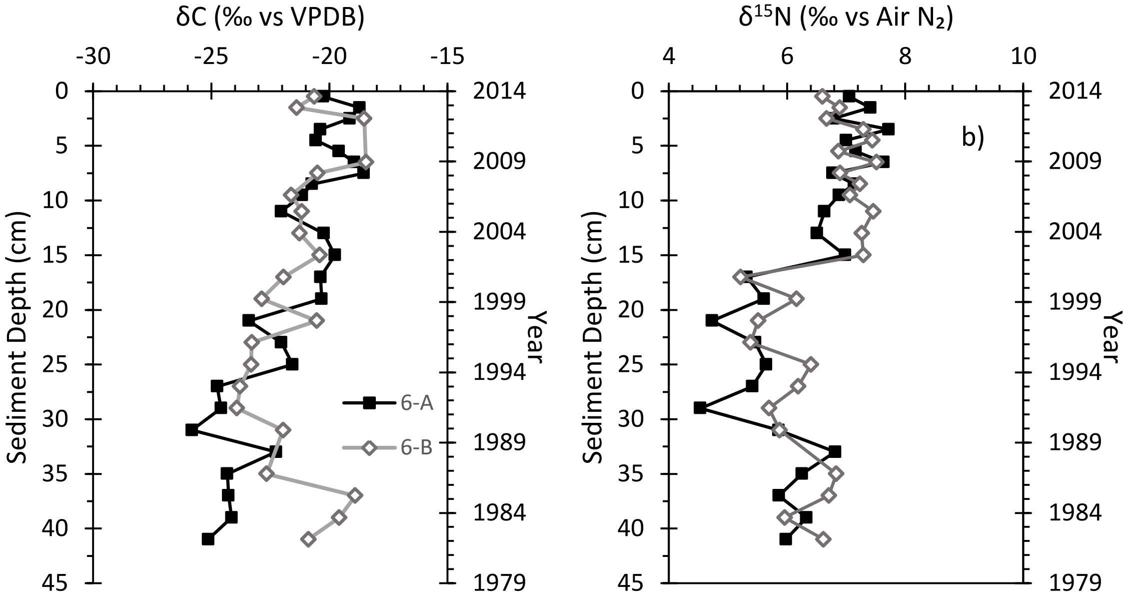


Fig. 7. Stable carbon (panel a) and nitrogen (panel b) isotopic composition of Lake Elsinore sediment relative to standards. Solid squares represent data points in core 6-A. Open diamonds represent data points in core 6-B.

Discussion

Elemental Composition

The organic carbon and total nitrogen concentrations (Fig. 3) increase around the same time that the Lake Elsinore Management Project was completed, surface areas was reduced and mean lake depth increased (Fig. 1b). A greater water depth would have resulted in enhanced organic matter preservation due to increased stratification, less mixing and, thus, more frequent depleted oxygen levels. Another possible explanation for the increase is the amount of organic matter delivered to a given surface area of sediment would have increased when the lake surface area decreased and depth increased. An exponential decrease with depth in the top sediments of organic carbon and nitrogen profiles is generally representative of decomposition (Wetzel, 2001). Sediment at the top of the core has experienced less diagenetic degradation than sediment at 10 cm depth and therefore will contain more organic matter. The fact that OC and N are significantly correlated (Table 1) is further evidence that the decrease is due to decomposition because N is utilized by bacteria during respiration and conversion of organic carbon into CO_2, and N typically decomposes at a similar rate as OC (DiToro, 2001). In addition, water column total N data do not indicate higher concentrations over the past 8-10 years; concentrations vary with no significant trend (Fig. 8). Anderson (2010) indicated that total N content in sediment grab samples (top 10 cm) from fine-textured profundal sediment collected in 2000 and 2010 did not significantly change. This observation further supports the argument that the exponential increase in N toward the top of the sediment is due to degradation processes rather than differences in concentration or loading (Fig. 8).

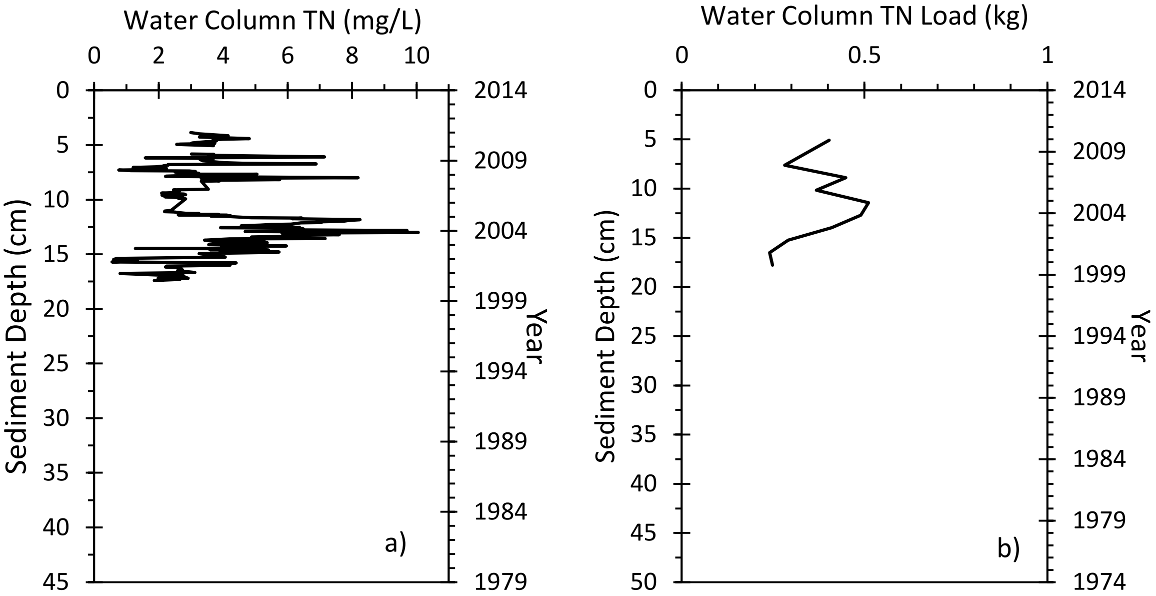


Fig. 8. Average water column total nitrogen concentrations (a) and total nitrogen load (b) in Lake Elsinore.

It is common for C:N of organic matter to increase with depth in the sediment as N is preferentially utilized (Lehman et al., 2002). The fact that OC:N in Lake Elsinore sediment remains approximately constant with depth (Fig. 3) suggests that OM is already highly mineralized in the water column, before it reaches the sediment. The OC:N of suspended organic matter was 6.9, which is 3.1 lower than the sediment, indicating N is selectively recycled as organic matter is settling and/or resuspended. These results are similar to those detected in 2003 in which C and N content of sediment traps was compared to that of the sediment. C and N both decreased from the sediment trap to the sediment and C:N increased from 7.7 to 8.6, indicating greater recycling of N relative to C, although both elements showed evidence of recycling in the water column. From the results of the study, it was concluded that there is substantial recycling occurring on settling particles in the water column (Anderson, 2011). In a study on Lake Simcoe, Canada, in 2011, the deepest bay, Kempenfelt Bay, exhibited constant C:N with sediment depth and this was attributed to the OM being highly recycled in the water column prior to sedimentation (Hiriart-Baer et al., 2011).

Average total TP concentration in Lake Elsinore sediment (0.125% or 1,250 µg/g) (Fig. 3) is consistent with concentrations quantified on other eutrophic lake sediments, which typically range from 1,000 to 1,900 µg/g in surficial sediments (Rydin, 2000; Kapanen, 2012; Dittrich et al., 2013). The depth profile for total phosphorus also reflects an exponential decrease in concentration with sediment depth in the top 10 cm. This exponential decrease in total phosphorus is typical for eutrophic lakes and generally represents mineralization of organic phosphorus (Carey and Rydin, 2011). Fitting an exponential equation to total P concentration in the top 10 cm results in r^2=0.72 and 0.63 for cores 6-A and 6-B respectively, verifying the exponential trend. We assume that this trend is in fact due to the decomposition of organic matter and not due to increased total phosphorus loading to the lake because organic carbon and TP are significantly correlated in the top 10 cm and the decrease in OC with sediment depth is assumed to be the result of decomposition (see above).

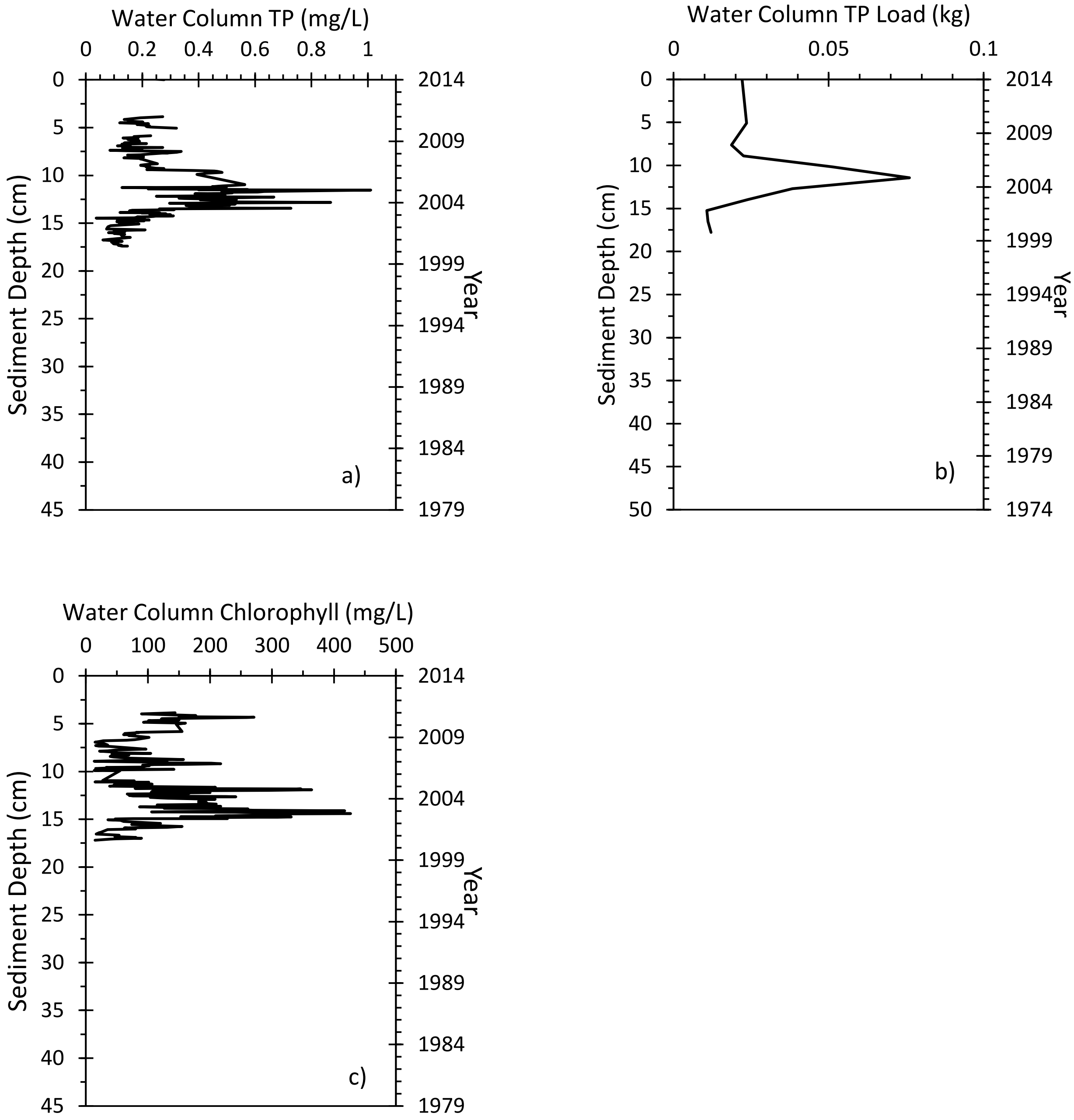


Fig. 9. Average water column a) total phosphorus concentration, b) total phosphorus load, and c) chlorophyll concentrations in Lake Elsinore.

Correlation of total P to OC could in some cases reflect increasing chlorophyll biomass (OC) due to increase in total P loading. However, water column chlorophyll a concentrations in Lake Elsinore do not reflect similar trends (Fig. 9c). Also, external P loading has not been increasing in the past 8-10 years as revealed in the water column TP concentrations from 2000 to 2014 (Fig. 9a). Total phosphorus concentration and load in the water column peaked in 2005 and has been variable since then, rather than exponentially increasing (Anderson, 2010). Anderson (2010) measured a decrease in mean TP concentrations in sediment grab samples from 916 mg/kg in 2000 to 785 mg/kg in 2010, although the difference was not statistically significant. These results further demonstrate that the strongest diagenetic processes are occurring in the surficial sediment. If the increase in TP toward the top of the sediment reflected increased TP concentrations, TP in the grab samples would be expected to increase from 2000 to 2010, not decrease or remain the same. He also concluded that pore-water P concentrations were significantly correlated with organic carbon ($r^2 = 0.87$). A study on a core collected from Lake Elsinore in 2001, however, found that TP was unchanged with depth but that organic P showed an exponential decrease. This difference is interesting, in that it suggests a greater contribution of other P forms to total P in 2001 compared to 2014 (CNRP, 2013).

Calcium and organic carbon are significantly correlated in both cores (Table 1). This correlation suggests calcium carbonate ($CaCO_3$) co-precipitation with organic matter. This process occurs in the epilimnion, when primary production raises the pH, enabling calcite precipitation, and organic matter serves as nuclei for the precipitation (Wetzel, 2001). Anderson (2010) attributed the increase in $CaCO_3$ of sediment grab samples collected from Lake Elsinore from 2000 to 2010 to increased precipitation of calcite in the water column due to erosion of Ca from the watershed in El Niño year 2005 as well as increased productivity and TDS in 2003 and 2004 (Anderson, 2010). The decrease of Ca concentration with depth in the top 10 cm, as well as the correlation with organic carbon, suggests this decrease is due to $CaCO_3$ dissolution coupled to organic matter decomposition (Fig. 4). Respiration leads to increasing carbon dioxide in pore-water which lowers the pH and causes dissolution of $CaCO_3$. Considerable CO_2 concentrations were measured in Lake Elsinore sediments in 2010 (concentrations reaching 3.8±0.6%) which is about 100x atmospheric concentrations, confirming the presence of elevated amounts of CO_2 in pore-water that can contribute to $CaCO_3$ dissolution, the proposed mechanism for decline in Ca with depth (Anderson, 2010). Similar to OC and N (Fig. 3), calcium concentrations increase around the year 1994 due to increased preservation of OC, which is precipitated with Ca, resulting in increased preservation of Ca as well (Fig. 4).

In order to confirm that diagenesis is the driving force for the decreasing trends in the top 10 cm of OC, N, TP, and Ca profiles, the data was fit to an exponential function, because organic matter decomposition is an (exponential) first order decay process (Wetzel, 2001).

$$C_t = C_0 e^{-kt} \tag{3}$$

Fitting the data to an exponential function also enables the calculation of the rate constants, depicting the rate of mineralization, or loss of the element. In the equation above, k is the slope of the function and represents rate change per depth in the sediment with units of

cm^{-1}. To calculate the rate per time, k_r, the k is multiplied by sedimentation rate. Once k is calculated, half-life can be calculated following the equation below. Rate constants for the exponential decline in OC, N, and TP concentrations in the top 10 cm with depth were calculated to confirm diagenesis is the driving force for these trends. Rate constants for each element were averaged between the two replicate cores and that average was used to calculate half-life, using the equation:

$$t_{1/2}= 0.693/k_r \tag{4}$$

The exponential fit to OC was statistically significant at p=0.001 with r^2=0.73 and 0.76. The exponential fit to N was statistically significant at 0.01 but the goodness of fit wasn't as strong, with r^2=0.68 and 0.72 (for 6-B p=0.001). TP fit the exponential function at p=0.001 with r^2=0.79 and 0.64 (p=0.01). This discrepancy may have skewed the TP average half-life. For 6-A the calculated half-life was 21.5 years and for 6-B the half-life was 12.16 years, yielding an average of 15.4 years (Table 1), although it may be a little longer than that, due to 6-A (half-life 21.5 years) demonstrating a better fit to the exponential function. The exponential fit to calcium in Lake Elsinore sediment was significant at 0.001 with r^2=0.9 and 0.81. The goodness of fit for calcium was greater than the other three elements. The significance of the goodness of fit of each element to an exponential function indicates that the decrease in depth can be attributed to sedimentary diagenesis, or decomposition.

The rate constants for OC an N were slightly greater than those for TP and Ca, suggesting that OC and N mineralize at about 1.5x the rate than TP and Ca, indicating that OC and N do not remain bioavailable for as long as TP and Ca. OC and N had very similar rate constants and therefore very similar half-lives, of about 10 years (Table 3). These values are lower from the half-life for OC and N determined on a core collected in 2001, which were calculated to be 24 and 30 years, respectively, using a 1-phase model, but similar to the half-lives calculated using a 2-phase model (Anderson, 2011). In the present analysis, the uppermost 10 cm was fitted, while the 2-phase model represented labile recently deposited material as well as an older less reactive phase. The 95% upper and lower confidence intervals represent the error in fitting the data to an exponential curve (Table 3). The half-lives calculated for the upper and lower rate constants confidence intervals were about 18 and 6.5.

The half-lives for calcium and total phosphorus were similar, at around 15 years. This similarity further corroborates the concept of $CaCO_3$ dissolution with increasing sediment depth due to decreasing pH and subsequent SRP and Ca^{2+} release to pore-water. The average half-life for total phosphorus was 15.4 years, but the error was greater than that for OC and N. Similar to the results from calculations for organic phosphorus from 2001, TP had a rate constant that was lower than those for OC and N, indicating slower mineralization and longer period of recycling of P in the sediment. However, taking error estimates into consideration, the half-life for TP calculated in this study (15.4 yrs, with upper confidence interval of 37.2 yrs) is about half of that calculated for organic P in 2001 using a 2-phase model (29.7 years) (Anderson, 2011). Notwithstanding, the large uncertainty in the calculated half-life for total P (95% CI of 7.8 – 37.2 yrs) and comparison between values calculated for total P in this study and organic-P in Anderson (2001) make it difficult to draw any firm conclusions between sediment cores collected in 2001 and 2014.

Table 3. Rate constants and half-lives for organic carbon, total nitrogen, total phosphorus, and calcium.

	k_r (yr^{-1})	$t_{1/2}$ (yr^{-1})	Upper 95% C.I.	Lower 95% C.I.
Organic Carbon	0.066±0.003	10.5	18.8	6.9
Total Nitrogen	0.073±0.0	9.5	17.8	6.3
Total Phosphorus	0.045±0.018	15.4	37.2	7.8
Calcium	0.046±0.003	15.1	24.9	11.5

The iron content of sediments decreases from 6.2% prior to 1990 to 5.8% by about 1994 and then is constant until about 2006, before declining more recently (Fig. 5). Similarly, sulfur (S) increases in 1994 and is constant to the top of the core (Fig. 4). Following completion of LEMP in 1994/1995, lake depth increased and presumably there was less circulation and less DO reaching the sediment surface and hypolimnion. This would lead to chemical reduction of iron and sulfate and cause precipitation of FeS, which may explain why the two elements exhibit similar trends during this time. Prior to this time, the redox conditions may have resulted in iron reduction and release to the water column but the redox conditions were not low enough to enable sulfate reduction until the lake deepened. Iron increases with depth in the top 10 cm due to increasing precipitation of FeS with depth, as more and more sulfate is reduced during organic matter decomposition. According to Wakefield (2001), sulfate concentrations in Lake Elsinore pore-water decreased with depth and sulfide concentrations increased which she attributed to increased FeS precipitation with depth as sulfate reduction takes place (greater with depth because DO in sediment decreases with depth). This iron then becomes locked up and is no longer able to bind to P.

The increase in silicon and aluminum concentrations between 25 and 30 cm in core 6-A corresponds to the time period when the Lake Elsinore Management Project was in progress (Fig. 4). Levee construction and construction of a new inlet and outlet channel would have resulted in increased erosion and dredging, causing a large influx of inorganic particles (silt and clay minerals) to the sediment, although this was not observed in core 6-B. The transition from a large and shallow mean depth lake to a deeper mean depth lake, however, did not result in lasting changes to these elements' concentrations in the sediment, as after 1995, concentrations returned to background levels.

Correlation analysis comparing sediment properties with sources of inflow and physical hydrologic characteristics of the lake revealed a few notable significant relationships at $p<0.05$ (Table 4; Table 5). The correlation between local runoff and aluminum, silicon, potassium, titanium, and iron reflects erosional inputs to the lake from the surrounding watershed during precipitation events (Table 4). The significant negative correlation of organic carbon, nitrogen, and calcium with local runoff suggests dilution of organic constituents corresponding to an influx of large amounts of inorganic elements in local runoff (Table 4). In comparison, inflow from the San Jacinto River exhibits weaker, non-significant relationships with elements, which can be attributed to sediment trapping in upstream Canyon Lake (Table 4). Recycled water inputs appear to be significantly correlated with OC and N, suggesting contribution to organic matter production in the lake through increased nutrient inputs in wastewater, although diagenetic processes operating over this same timeframe complicate interpretation of these r-values. Given the small n-size and importance of diagenesis, no clear conclusion can be drawn from this simple statistical calculation.

Table 4. Correlation table showing r values for hydrologic properties and inflows to Lake Elsinore for period 1981-2014 (entire core length). With n=26, an r value of 0.38 is statistically significant at $p<0.05$, and 0.51 is statistically significant at $p<0.001$. USGS data from gage #11070500.

Property	Avg. Area	SJ Inflow	Local Runoff	Recycled H_2O	Avg. Elev.
δ 13C	-0.14	-0.19	-0.30	0.50	-0.07
δ15N	-0.24	-0.23	-0.55	-0.63	-0.16
%OC	-0.22	-0.16	-0.42	0.89	0.01
%N	-0.27	-0.16	-0.44	0.82	-0.06
Al-P	0.04	0.22	0.16	-0.08	0.08
Mobile-P	-0.10	-0.05	0.14	-0.12	-0.25
Al	0.20	0.36	0.43	-0.16	-0.48
Si	0.22	0.36	0.43	-0.15	-0.48
P	-0.30	-0.22	-0.39	0.27	-0.76
S	-0.21	0.12	-0.18	-0.07	-0.26
K	0.38	0.12	0.49	-0.41	0.61
Ca	-0.41	-0.29	-0.62	0.55	0.78
Ti	0.33	0.11	0.50	-0.55	-0.81
Fe	0.30	0.17	0.49	-0.46	-0.71

Phosphorus Forms

The average concentration of loosely-sorbed/pore-water P in Lake Elsinore (125 µg/g) is greater than many other studied eutrophic lakes, including Lake Peipsi, Estonia (11 µg/g) and Lake Erken, Sweden (53 µg/g) (Rydin, 2000; Kapanen, 2012). Generally in eutrophic lakes, mobile P (specifically loosely-sorbed/pore-water P) will increase toward the sediment surface which indicates diffusion toward the water column (Rydin, 2000). However, in such a shallow lake as Lake Elsinore, with bioturbation and strong bottom shear during periods of high wind speeds, diffusion may be very rapid, such that a concentration gradient toward the sediment surface is not depicted in the profiles (Fig. 6). In addition, the ebullition of CH_4 gas bubbles generated by microbes can stimulate the diffusion of P toward the water column (Wetzel, 2001, Kapanen, 2012). Martinez and Anderson (2013) measured elevated levels of CH_4 gas in the sediment and ebullition at numerous sites on Lake Elsinore, including site 6 where cores were collected.

The high concentrations of loosely-sorbed (NH_4Cl-extractable) P and relatively low concentrations of iron-bound P in Lake Elsinore sediment are unusual compared to other lakes in the region (Table 5), and eutrophic lakes more generally which exhibit very little contribution of loosely-sorbed phosphate to mobile P (Pilgrim et al., 2007). In the Lake Elsinore sediment cores, NH_4Cl-P averaged about 120 µg/g and 63% of the mobile-P in the upper 10 cm, while Fe-P averaged about 70 µg/g (Table 5). In Big Bear Lake, a mesotrophic lake also located in the San Bernardino mountains, only 1 µg/g NH4Cl-extractable P was present in the sediments, with essentially all (99%) of the mobile-P of surface sediments there present as a reducible Fe-P phase. Canyon Lake, the reservoir located upstream from Lake Elsinore, contains 5x greater Fe-P (average of 386 µg/g and 87% of mobile-P) than Lake Elsinore and one-half the amount of NH_4Cl-extractable P (Table 5). The disparity between Fe-P in Lake Elsinore compared with other lakes in the region and with many other eutrophic lakes may be explained by a low influx of iron to the lake due to sedimentation of particulate iron within Canyon Lake.

Table 5. Comparison of concentrations of P in different forms within sediments of selected lakes in Southern California.

Lake	**Mean Phosphorus Fractionation in Sediments (µg g^{-1} dw)**			
(n=# sites)	**NH_4Cl-P**	**Fe-P**	**Mobile-P**	**NaOH (Al)-P**
Big Bear L. (n=15)	1 (1%)	129 (99%)	130	191
Canyon L. (n=5)	59 (13%)	386 (87%)	459	890
L. Elsinore (n=2)	120 (63%)	70 (37%)	190	150
Diamond Valley L (n=20)	1 (1%)	91 (99%)	92	268

The increased amount of Al-P in lake sediment around a depth of 25 cm is reflected in aluminum and silicon profiles and corresponds approximately to 1994 which is around the time of completion of the LEMP. The construction involved in the project likely increased suspension, erosion and deposition of inorganic particles to the sediment and increased precipitation of aluminum-bound phosphate (see Elemental Composition discussion above).

Stable Isotopic Composition

The gradual increase in $\delta^{13}C$ toward the top of the sediment core (Fig. 7) may result from either diagenetic processes or from increasing eutrophic conditions in the lake. Diagenetic processing of organic matter in the sediment typically accounts for a decrease of 1.6-1.8‰ due to selective decomposition of enriched carbohydrates and proteins, which are easier to degrade, as well as the addition of depleted microbial biomass (Lehmann et al., 2002). A study on Lake Lugano found that sediment was depleted by 1.5‰ compared to sediment traps corresponding to the same time (Lehmann et al., 2002). However, suspended organic matter bore a $\delta^{13}C$ of -20‰, which is the same as the sediment. If OC is being degraded in the water column, as evidenced in Anderson (2010), then this indicates that at least during early diagenesis, there is very little fractionation effect or change on δ^{13}C values. The decomposed suspended organic matter resulted in a δ^{13}C of -23.7‰, which indicates a -3.7‰ shift during diagenesis. However, because this SOM spent an unknown amount of time incubating under room temperature, it may have undergone more decomposition than SOM typically would in Lake Elsinore before sedimentation and permanent burial (less prone to decay with increased burial).

Increasing eutrophication has also been determined to lead to increases in δ^{13}C of sediment. A study of three Florida lakes of different trophic levels reported that δ^{13}C was lowest in the oligotrophic lake and highest in the eutrophic lake and that in the hypereutrophic lake, Lake Apopka, δ^{13}C increased up-core from -23 to -18 (Torres et al., 2012), which is approximately the same magnitude increase as in the Lake Elsinore sediment (Fig. 7). A study on Lake Ontario found a progressive increase in δ^{13}C of organic matter with increasing phosphorus loading and water column P concentrations, which also supports the hypothesis that δ^{13}C reflects lacustrine productivity. In that study, δ^{13}C increased from -27 to -25. A significant correlation between organic carbon and calcium carbonate was observed in Lake Ontario as well, which suggests photosynthesis generated calcite co-precipitation increases the sedimentation of organic matter and enhances its preservation in the sediment (Hodell and Schelske, 1998). If this is the case in Lake Elsinore, diagenesis may only be affecting δ^{13}C for a short period of time before permanent burial preserves the δ^{13}C signature of organic matter. Without water quality data dating back to the early 1980s, it is difficult to determine whether the increasing trend in δ^{13}C toward the top of the core is due to increasing primary production or simply reflects sedimentary diagenesis.

The δ^{15}N results reflect three distinct periods in Lake Elsinore's recent history. The section at bottom of the core from 41 to 35 cm corresponds to the period of time when the lake was shallow, with presumably greater circulation and mixing. The transition to a deeper lake with the completion of the Lake Elsinore Management Project resulted in a decrease in sedimentary δ^{15}N. The reason for this decline lies predominantly in the fact that increased lake depth led to a decrease in circulation and increase in stratification and anoxia. With the completion of the Lake Elsinore Management Project and resulting increase in lake depth, nitrate-nitrogen would have been less available than ammonium, and increasing incorporation of ammonium by phytoplankton could have resulted in the decrease in δ^{15}N. During assimilation, phytoplankton fractionate ammonium by about -10‰ and nitrate by -1 to -3.4‰, so increased ammonium uptake relative to nitrate-nitrogen would result in a decline in δ^{15}N of algal biomass (Teranes and Bernasconi, 2000; Lu et al., 2010). Also, the majority of NH_4 is generated from organic matter mineralization in which ^{14}N is preferentially mineralized over ^{15}N during organic matter hydrolysis so ammonium is more depleted in ^{15}N than nitrate even before uptake by phytoplankton (Torres et al., 2012; Lehmann et al., 2002).

In addition to an increased utilization of ammonium over nitrate, during oxic decomposition of algal biomass, there is typically very little change in δ^{15}N, but during anoxic decay (in the sediments or anoxic bottom water), δ^{15}N typically decreases by 2.5 to 4‰ due to the input of depleted microbial biomass (Lehmann et al., 2002). Bacterial growth and consumption of the depleted ammonium from decomposition in addition to fractionation during bacterial excretion of ammonia which preferentially excretes ^{15}N leads to the depletion of $\delta^{15}N$ of bacterial biomass (Lehmann et al., 2002). When there is a large amount of bacterial growth and activity in the sediment, as is usually the case in stratified lakes with anoxic bottom water, it can cause a reduction in the $\delta^{15}N$ of sediment (Lehman et al., 2002).

Increasing autochthonous productivity can lead to increases in sedimentary $\delta^{15}N$ signatures when phytoplankton become more enriched in ^{15}N. However, this only occurs if surface waters become depleted in N, which typically only happens if a lake is nitrogen-limited (Torres et al., 2012; Teranes et al., 2000). Analysis of sedimentary $\delta^{15}N$ in Lake Simcoe, a eutrophic lake in Canada, revealed an up-core increase from 4.5‰ to 7.3‰ due to increasing productivity (Hiriart-Baer et al., 2011). The N:P in the water column in Lake Elsinore (17.4) indicates that Lake Elsinore is generally not N-limited and water column concentrations of TN do not wane in recent years, therefore the increase to higher $\delta^{15}N$ values around 2002 cannot be attributed to changes in N loading and availability in the water column (Fig. 8) (CNRP, 2013).

The shift to higher $\delta^{15}N$ values around the year 2002 is more likely due to the input of supplemental wastewater. Sewage, composed of human and animal waste, has nitrate with $\delta^{15}N$ between 10 and 20‰. Nitrate input from soils and terrestrial organic matter in the watershed has values between 2-5‰ while fertilizers exhibit lower $\delta^{15}N$, approximately 3‰ (Teranes and Bernasconi, 2000; Machiwa, 2010; Torres et al., 2012). Assuming a $\delta^{15}N$ value of 3‰ for nitrate input from local runoff and San Jacinto River inflow and a value of 15‰ for nitrate input from recycled wastewater, one can calculate predicted $\delta^{15}N$ values of Lake Elsinore sediment. Using assumed N isotope signatures for each source of water to the lake as well as average annual inflow (2008-present) of 10,000 acre-feet from local runoff/San Jacinto River and 5,600 acre-feet from recycled wastewater, the predicted $\delta^{15}N$ value is calculated as 7.37‰. The actual $\delta^{15}N$ at site 6 in Lake Elsinore was on average 7.12‰ from 2001 to present which is very similar to the predicted value with a 3.5% error.

Denitrification in the water column also results in $\delta^{15}N$ enrichment of the sediment because denitrification preferentially reduces ^{14}N over ^{15}N, leaving residual nitrate enriched in ^{15}N (Teranes and Bernasconi, 2000; Lu et al., 2010). In Lake Ontario, Canada, an increase in $\delta^{15}N$ of 0.3‰ over a period of ten years, and subsequent stabilization of $\delta^{15}N$ were attributed to denitrification (Hodell and Schelske, 1998). Prior to wastewater additions, denitrification rates in the water column were fairly low due to low concentrations of nitrate (Horne, 2009). Therefore, wastewater input may be enabling denitrification by providing NO_3 for the reaction. Denitrification is likely occurring in the water column near the sediment-water interface because sedimentary denitrification does not result in a fractionation effect and $\delta^{15}N$ of suspended organic matter (5.8‰) was lower than the surficial sediment values, indicating that denitrification is occurring in the benthic boundary layer or bottom of the water column prior to permanent sedimentation (Terranes and Bernasconi, 2000). Another reason that suspended organic matter is more depleted in $\delta^{15}N$ than sediment is that as it is settling, OM degradation results in enrichment of residual OM as ^{14}N ammonium is preferentially released (Torres et al., 2012;

Lehmann et al., 2002). The suspended organic matter sample that experienced decomposition resulted in a $\delta^{15}N$ of 10‰, which is greater than the top sediment isotopic signature. This discrepancy suggests that the algal biomass experienced greater decay than it would have in the lake, where it would be progressively buried in the sediment (N recycling decreases with increasing sediment depth, see Elemental Composition section above).

Conclusions

The isotopic and elemental analysis of sediment cores from Lake Elsinore provided new insights into the depositional history and biogeochemical cycling of organic matter and nutrients in this eutrophic lake:

(i) organic matter is highly mineralized in the water column prior to permanent sedimentation;

(ii) the transition from shallow to deeper lake with the completion of LEMP resulted in increased organic matter preservation in the sediment, evidenced by an increase in OC, N, Ca, and S during this time;

(iii) a lack of correlation between iron and phosphorus, yet significant correlation between phosphorus and organic carbon and calcium in the top 10 cm suggests P cycling is controlled by calcium and organic matter rather than redox conditions and corresponding Fe geochemistry;.

(iv) fitting exponential functions to OC, TN, TP, and calcium data revealed that their decline with sediment depth is due to diagenetic processes rather than changes in water column concentrations.

(v) Lake Elsinore sediments have much higher concentrations of NH_4Cl-extractable P and lower Fe-P than other lakes in the region, with dramatically different values than Canyon Lake that are attributed to retention of particulate Fe and Al phases in Canyon Lake;

(vi) $\delta^{15}N$ values in sediment declined with completion of LEMP and the corresponding average increased mean depth of the lake;

(vii) $\delta^{15}N$ values in sediment subsequently increased due to wastewater input and denitrification.

References

Anderson, Michael A. 2010. *Bathymetric, Sedimentological and Retrospective Water Quality Analysis to Evaluate Effectiveness of the Lake Elsinore Recycled Water Pipeline Project.* Final Report Submitted to Lake Elsinore and San Jacinto Watersheds Authority.

Anderson, Michael A. 2011. Task 1: *Estimate Rate at Which Phosphorus is Rendered No Longer Bioavailable in Sediments.* Technical Memorandum submitted to Lake Elsinore and San Jacinto Watersheds Authority

American Public Health Association. 1998. *Standard Methods for the Examination of Water and Wastewater*. 20th Edition: 4-148-149.

Byrne, Roger, Matthew Kirby, Steve Lund, Liam Reidy, and Christopher Poulson. 2004. Changing Sedimentation Rates during the Last Three Centuries at Lake Elsinore, Riverside County, California. Final Report to the Santa Ana Regional Water Quality Control Board, Riverside, CA. 41pp.

California Environmental Protection Agency, Santa Ana Regional Water Quality Control Board. (1995). Water Quality Control Plan for the Santa Ana River Basin (Region 8). January 24, 1995. Updated February 2008. Accessed from California Environmental Protection Agency website http://www.swrcb.ca.gov/santaana/water_issues/programs/basin_plan/index.shtml

Carey, Cayelan C., and Emil Rydin. 2011. Lake trophic status can be determined by the depth distribution of sediment phosphorus. *Limnology & Oceanography* 56 (6): 2051-2063.

City of Lake Elsinore. 2006. Water Resources Background Report as part of the Lake Elsinore General Plan. Retrieved from lake-elsinore.org

Dean, Walter E. 2006. Characterization of Organic Matter in Lake Sediments from Minnesota and Yellowstone National Park. Report 2006-1053. Open-File Report. USGS Publications Warehouse. http://pubs.er.usgs.gov/publication/ofr20061053.

DiToro, Dominic M. 2001. *Sediment Flux Modeling*.

Dittrich, M., A. Chesnyuk, A. Gudimov, J. McCulloch, S. Quazi, J. Young, J. Winter, E. Stainsby, and G. Arhonditsis. 2013. Phosphorus Retention in a Mesotrophic Lake under Transient Loading Conditions: Insights from a Sediment Phosphorus Binding Form Study. *Water Research* 47 (3): 1433–47.

Egemose, Sara, Kasper Reitzel, Frede Ø. Andersen, and Henning S. Jensen. 2013. Resuspension-Mediated Aluminium and Phosphorus Distribution in Lake Sediments after Aluminium Treatment. *Hydrobiologia* 701 (1): 79–88.

Elsinore Valley Municipal Water District (EVMWD). http://www.evmwd.com/about/departments/public/lake.asp

Fry, Brian. 2006. *Stable Isotope Ecology*. Springer Science+Business Media, LLC.

Gälman, Veronika, Johan Rydberg, and Christian Bigler. 2009. Decadal Diagenetic Effects on δ13C and δ15 N Studied in Varved Lake Sediment. *Limnology & Oceanography* 54 (3): 917–24.

Hiriart-Baer, Véronique P., Jacqui Milne, and Christopher Marvin, 2011. Temporal trends in phosphorus and lacustrine productivity in Lake Simcoe inferred from lake sediment. *Great Lakes Research* 37: 764-771.

Hodell, David A., and Claire L. Schelske. 1998. Production, Sedimentation, and Isotopic Composition of Organic Matter in Lake Ontario. *Limnology and Oceanography* 43 (2): 200–214.

Horne, Alex J. 2009. Three Special Studies on Nitrogen Offsets in Semi-Desert Lake Elsinore in 2006-08 as part of the nutrient TMDL for reclaimed water added to stabilize lake levels. Retrieved from SAWPA: http://www.sawpa.org/wp-content/uploads/2012/09/HORNEN-OFFSETSRptDrafttoEVMWD6_001.pdf

Hudson, Tom. (City of Lake Elsinore, City Timeline) retrieved from lake-elsinore.org.

Hupfer, Michael, Dominik Zak, Reingard Roßberg, Christiane Herzog, and Rosemarie Pöthig. 2009. Evaluation of a Well-Established Sequential Phosphorus Fractionation Technique for Use in Calcite-Rich Lake Sediments: Identification and Prevention of Artifacts due to Apatite Formation. *Limnology and Oceanography: Methods* 7: 399–410.

Jan, Jiří, Jakub Borovec, Jiří Kopáček, and Josef Hejzlar. 2013. What Do Results of Common Sequential Fractionation and Single-Step Extractions Tell Us about P Binding with Fe and Al Compounds in Non-Calcareous Sediments? *Water Research* 47 (2): 547–57.

Jankowski, KathiJo, Daniel E. Schindler, and Gordon W. Holtgrieve. 2012. Assessing Nonpoint-Source Nitrogen Loading and Nitrogen Fixation in Lakes Using δ15N and Nutrient Stoichiometry. *Limnology & Oceanography* 57 (3): 1–1.

Kapanen, Galina. 2012. Pool of Mobile and Immobile Phosphorus in Sediments of the Large, Shallow Lake Peipsi over the Last 100 Years. *Environmental Monitoring and Assessment* 184 (11): 6749–63.

Kleeberg, Andreas, Christiane Herzog, and Michael Hupfer. 2013. Redox Sensitivity of Iron in Phosphorus Binding Does Not Impede Lake Restoration. *Water Research* 47 (3): 1491–1502.

Lake Elsinore/Canyon Lake TMDL Task Force. 2007. In-Lake Sediment Nutrient Reduction Plan for Lake Elsinore. Retrieved from http://www.swrcb.ca.gov/rwqcb8/water_issues/programs/tmdl/docs/elsinore/implemetation/Lake_Elsinore_Sediment_Nutrient_Reduction_Plan_10-22-07.pdf

Lake Elsinore/Canyon Lake TMDL Task Force. 2010. Lake Elsinore & Canyon Lake Nutrient TMDL Annual Water Quality Report. Final Report prepared for Santa Ana Regional Water Quality Control Board.

Lehmann, Moritz F, Stefano M Bernasconi, Alberto Barbieri, and Judith A McKenzie. 2002. Preservation of Organic Matter and Alteration of Its Carbon and Nitrogen Isotope Composition during Simulated and in Situ Early Sedimentary Diagenesis. *Geochimica et Cosmochimica Acta* 66 (20): 3573–84.

Lu, Yuehan, Philip A. Meyers, Thomas H. Johengen, Brian J. Eadie, John A. Robbins, and Haejin Han. 2010. δ^{15}N Values in Lake Erie Sediments as Indicators of Nitrogen Biogeochemical Dynamics during Cultural Eutrophication. *Chemical Geology* 273 (1/2): 1–7.

Machiwa, John F. 2010. Stable Carbon and Nitrogen Isotopic Signatures of Organic Matter Sources in near-Shore Areas of Lake Victoria, East Africa. *Journal of Great Lakes Research* 36 (1): 1–8.

Martinez, D. and M.A. Anderson. 2013. Methane production and ebullition in a shallow, artificially aerated, eutrophic temperate lake (Lake Elsinore, CA). *Sci. Total Environ.* 454-455:457-465.

Moosmann, Lorenz, René Gächter, Beat Müller, and Alfred Wüest. 2006. Is Phosphorus Retention in Autochthonous Lake Sediments Controlled by Oxygen or Phosphorus? *Limnology and Oceanography* 51 (1_part_2): 763–71.

Pilgrim, Keith M., Brian J. Huser, and Patrick L. Brezonik. 2007. A Method for Comparative Evaluation of Whole-Lake and Inflow Alum Treatment. *Water Research* 41 (6): 1215–24.

Riverside County Flood Control & Water Conservation District. 2013. Comprehensive Nutrient Reduction Plan for Lake Elsinore and Canyon Lake. CDM Smith Consulting.

Rydin, E. 2000. Potentially Mobile Phosphorus in Lake Erken Sediment. *Water Research* 34 (7): 2037–42.

Søndergaard, Martin, Jens Peder Jensen, and Erik Jeppesen. 2003. Role of Sediment and Internal Loading of Phosphorus in Shallow Lakes. *Hydrobiologia* 506-509 (1-3): 135–45.

Teranes, Jane L., and Stefano M. Bernasconi. 2000. The Record of Nitrate Utilization and Productivity Limitation Provided by δ^{15}N Values in Lake Organic Matter-A Study of Sediment Trap and Core Sediments from Baldeggersee, Switzerland. *Limnology and Oceanography* 45 (4): 801–13.

Torres, Isabela C., Patrick W. Inglett, Mark Brenner, William F. Kenney, and K. Ramesh Reddy. 2012. Stable Isotope (δ13C and δ15N) Values of Sediment Organic Matter in Subtropical Lakes of Different Trophic Status. *Journal of Paleolimnology* 47 (4): 693–706.

U.S. Geological Survey. USGS Current Conditions for the Nation. Site #11070500, San Jacinto R NR Elsinore. http://waterdata.usgs.gov/nwis/uv?

Victoria, Reynaldo Luiz, Luiz Antonio Martinelli, Paulo C. O. Trivelin, Eiichi Matsui, Bruce R. Forsberg, Jeffrey E. Richey, and Allan H. Devol. 1992. The Use of Stable Isotopes in Studies of Nutrient Cycling: Carbon Isotope Composition of Amazon Varzea Sediments. *Biotropica* 24 (2): 240–49.

Vreca, Polona, and Gregor Muri. 2006. Changes in Accumulation of Organic Matter and Stable Carbon and Nitrogen Isotopes in Sediments of Two Slovenian Mountain Lakes (Lake Ledvica and Lake Planina), Induced by Eutrophication Changes. *Limnology & Oceanography* 51 (1): 781–90.

Wakefield, Elisha Marie. 2001. *Internal Loading of Nutrients in Three Southern California Lakes*.

Wetzel, Robert. 2001. *Limnology: Lake and River Ecosystems*. Third Edition. Elsevier Academic Press.

Widerlund, Anders, Sara Chlot, and Björn Öhlander. 2014. Sedimentary Records of δ13C, δ15N and Organic Matter Accumulation in Lakes Receiving Nutrient-Rich Mine Waters. *Science of the Total Environment* 485-486 (July): 205–15.

Technical Memorandum

Task 2.2: Fishery Hydroacoustic Survey and Ecology of Lake Elsinore: Spring 2015

Objective

The objective of this task was to quantify the fishery in Lake Elsinore for comparison with earlier survey results. A limited sampling of the phytoplankton and zooplankton communities was also conducted.

Approach

Zooplankton were sampled on March 7, 2015 near the deep-water site (site 6 or E2) and near the San Jacinto River channel/ski school site via vertical tows with an 80 µm Wisconsin net. Samples were preserved with 70% ethanol in the field, returned to the laboratory and inspected under Nikon compound and dissecting microscopes. Approximately 250 individuals were inspected and counted from each site. Water samples were also collected at about 0.3 m depth into 125 mL polypropylene bottles at the 2 sites, returned to the laboratory and the phytoplankton community was inspected under a Nikon compound microscope. Total dissolved solid (TDS) concentrations of the water samples were calculated from measured electrical conductance values.

A hydroacoustic survey was conducted on April 2, 20125 to quantify the fishery in the lake for comparison with earlier survey results. The survey was conducted using a BioSonics DT-X echosounder with a 201-kHz split beam transducer. Data were acquired at 5 pps. The transducer was calibrated using a tungsten-carbide calibration sphere in the field prior to collection of acoustic data and at the end of the day's survey. Echograms were analyzed using BioSonics VisualAnalyzer.

Results

Lake level and TDS

Four years of drought had substantially lowered the level of Lake Elsinore; surface elevation was approximately 1236.6 ft above MSL at the time of these measurements in spring 2015. The TDS concentrations reached 2700 mg/L which were the highest since regular monitoring began in 2000. This value exceeded the previous high of about 2300 mg/L in late 2003.

Phytoplankton

Transparency of the lake was very poor throughout the spring and summer of 2015, with Secchi depth values <10 – 15 cm throughout this period. The poor clarity resulted from excessive amounts of phytoplankton in the water column, with the phytoplankton community strongly dominated (>95%) by the filamentous blue-green algae *Pseudanabaena* (formerly *Oscillatoria*). This phytoplankton dominated the community during the very poor transparencies and very high chlorophyll a concentrations observed in 2002-2004, but was also the dominant phytoplankton during the summer of 2010 as well, when Secchi depths averaged 30 - 40 cm (*P. limnetica* comprised 75-90% of biomass in June-August 2010) (Anderson et al., 2011). This species appears to have a unique adaptation to shallow, relatively well-mixed high TDS conditions at Lake Elsinore. The species is also a poor food resource for filter-feeding *Daphnia* and other large-bodied cladocera, since the filaments are too large to enter the mouth and further interfere with filtration of smaller phytoplankton.

Zooplankton

A total of 489 individuals were inspected and counted from the two sites sampled on March 7, 2015. Adult copepods dominated the zooplankton community, comprising 83.8% of the total individuals counted (Table 1; Fig. 1a,b). Juvenile copepods (nauplii) were the second most abundant group of zooplankton at 14.7% of the community (Table 1; Fig 1a). Rotifers were absent at site 6, although 4 individuals were identified in the sample collected near the San Jacinto River inlet site (Table 1). A single *Daphnia* was present in the samples (Fig. 1c), corresponding to a relative abundance of 0.2% within the zooplankton community. Also depicted in Fig. 1 as small filaments are *Pseudanabaena.*

Table 1. Zooplankton community in Lake Elsinore: March 7, 2015.

Site	Copepods	Nauplii	Rotifers	*Daphnia*	Total
SJR Inlet	180	55	4	1	242
Site 6 (E2)	230	17	0	0	247

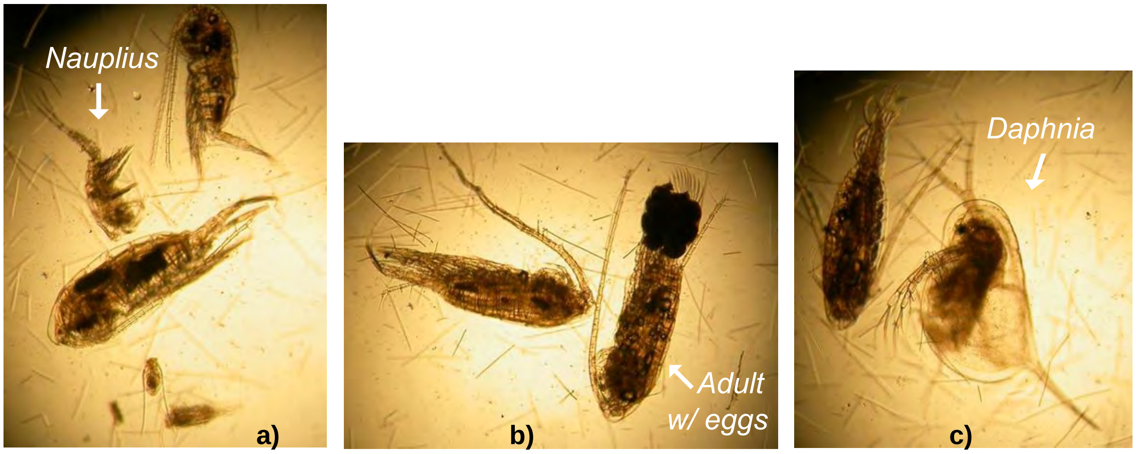


Fig. 1. Images of zooplankton in Lake Elsinore: a) adult copepods and nauplius; b) adult copepods, including reproductive adult; c) the single Daphnia present in samples. Filaments are Pseudanabaena.

This low proportion of *Daphnia* within the zooplankton community is consistent with findings from 2003-4 and 2009-10 when cladocerans comprised <0.6% of the community (Anderson et al., 2011). High TDS and/or high threadfin shad populations are thought to be responsible (Veiga-Nascimento, 2005).

Fishery

The hydroacoustic survey was conducted along the 7 transverse transects as in previous surveys (Fig. 2). The short longitudinal transect in the southern end of the lake was not surveyed due to the very shallow depth over most of the transect.

Fig. 2. Hydroacoustic survey transects.

Aggregating the transect data, population estimates were determined for 16 acoustic size classes from -30 to -70 dB (2.5 dB/bin) (Fig. 3). Love's equation (Love, 1970) was used to estimate fish length (Fig. 3, upper x-axis) from the acoustic target strength (Fig. 3, lower x-axis) as done in previous surveys (eq 1):

$$TS = 19.1 \log L - 0.9 \log F - 62.0 \tag{1}$$

where TS is the target strength (dB) and F is the echosounder acoustic frequency (kHz). As noted in Anderson et al. (2011), these length estimates are thought to be biased low based upon paired hydroacoustic and gill net measurements, but are retained here for comparison with other reported values and survey results. One sees that numerical abundance of fish in Lake Elsinore are dominated by small fish <3.5 cm in length (Fig. 3). These small fish comprise 95.6% of the total number of fish targets identified in the survey and are estimated to be present at an areal density of approximately 54,100 fish/acre. This approximate size class (1-3.5 cm) is consistent with threadfin shad, which are thought to dominate the fishery. In contrast, the population density for fish >20 cm in length is estimated to be 12.3 fish/acre.

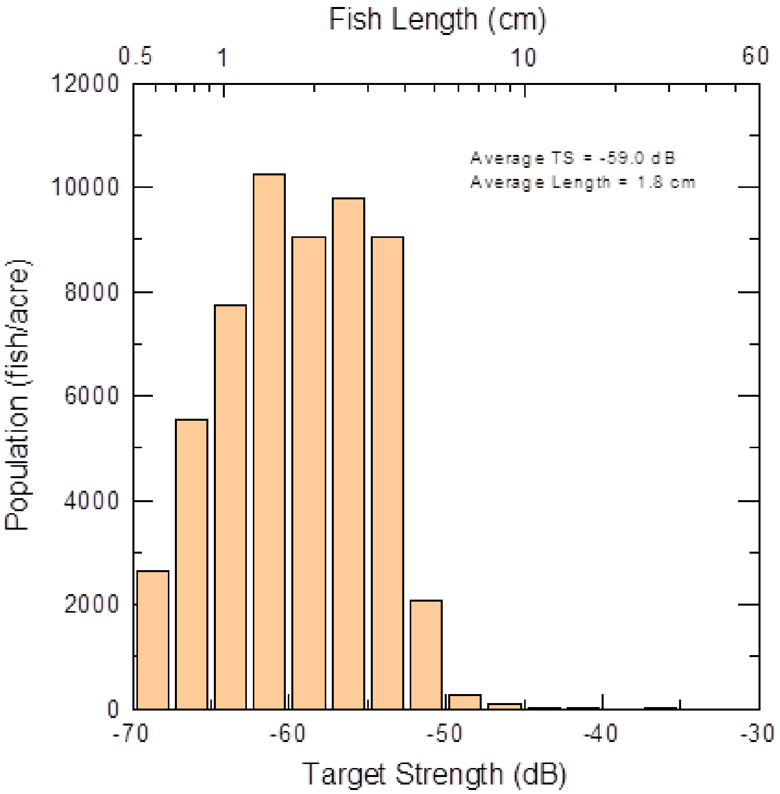


Fig. 3. Population estimates (fish/acre) vs. target strength (dB) (lower x-axis) and approximate fish length based upon Love's equation (upper x-axis).

The results from this survey can be compared with other hydroacoustic surveys conducted at the lake (Table 2). The April 24, 2008 survey yielded a population estimate of 18,090 fish/acre with a mean size of 4.7 cm. Fish >20 cm, which would principally represent piscivores and carp, number 1,050 fish/acre and comprise 5.8% of the entire fish population. The survey conducted following the fish kill in the summer of 2009 found dramatically reduced total population (2,2867 fish/acre) with slightly lower mean size that found in April 2008 (Table 2). Density of fish >20 cm was only 6/acre and constituted only 0.2% of the total population. Populations had rebounded quickly by December 1, 2010, reaching 27,720 fish/acre with a mean size of 4.3 cm; abundance of fish >20 cm in length increased slower, but did reach 273 fish/acre and 1.0% of the total population.

Table 2. Fish survey results comparing current survey (April 2, 2015) with surveys conducted in 2008 and 2010.

Date	Population (fish/acre)	Mean Size[a] (cm)	Size Range[a] (cm)	Fish >20 cm[a] (fish/acre)
April 24, 2008	18,090	4.7	0.5 - 100	1,050 (5.8%)
March 15, 2010[b]	2,867	4.0	0.5 – 29	6 (0.2%)
December 1, 2010	27,720	4.3	0.5 – 61	273 (1.0%)
April 2, 2015	56,600	1.8	0.5 - 30	12 (0.02%)

[a] *Based on Loves' equation.*

[b] *March 15, 2010 survey was conducted after fish kill in summer of 2009.*

The present survey, conducted on April 2, 2015, found the largest population of fish in the lake (56,600 fish/acre), although the fish were much smaller in size than in other surveys (mean length of 1.8 cm) (Table 2). Moreover, very few fish larger fish (>20 cm) were present at the time of this survey. As previously noted, the TDS at the time of this survey was the highest at any time since regular monitoring began at the lake, and values were markedly higher than observed in 2008 and 2010. Threadfin shad are tolerant of salinities as high as 15,000 mg/L; in contrast, black crappie have a maximum salinity tolerance of about 2,000 mg/L. Black crappie were the dominant piscivore present in Lake Elsinore in 2006-2007 based upon beach seine observations during carp removal efforts at the lake, but are thought to be effectively absent in 2015. Largemouth bass can tolerate higher salinities than black crappie, although literature suggests reproduction and recruitment can be impaired at TDS values greater that about 2,000-2,500 mg/L.

Based upon these findings, the lake in spring 2015 was in very poor ecological condition, with a very large amount of *Pseudanabaena*, limited capacity for zooplankton grazing of phytoplankton, and susceptible to a large fish kill. A modest fish kill was observed beginning August 4, 2015.

Conclusions

The results of these ecological measurements made at Lake Elsinore in spring 2015 indicate:

(i) very poor water quality, with TDS at levels not seen at the lake since regular monitoring began in 2000, and Secchi depth values <10-15 cm;

(ii) a zooplankton community dominated by copepods and nauplii, with negligible numbers of rotifers and a single Daphnia identified in samples;

(iii) an ecologically unsustainable fishery, with a very large number of small threadfin shad and low relative number of larger fish;

(iv) the subsequent fish kill in the summer of 2015 may have helped rebalance the fishery and food web in the lake, although reduction in the TDS concentration and inundation of shoreline vegetation providing new habitat is thought to provide greater ecological value.

References

Anderson, M.A. 2008. *Hydroacoustic Fisheries Survey for Lake Elsinore: Spring, 2008.* Draft Final Report to the City of Lake Elsinore. 15 pp.

Anderson, M.A., J. Tobin and M. Tobin. 2011. *Biological Monitoring for Lake Elsinore.* Final Report to the Lake Elsinore-San Jacinto Watershed Authority. 57 pp.

Love, R.H. 1970. Dorsal-aspect target strength of an individual fish. *J. Acoust. Soc. Am.* 49:816-823.

Technical Memorandum

Task 2.3: Bathymetric Survey and Sediment Hydroacoustic Study of Canyon Lake

Objectives

The overall objective of this task was to better understand the basin characteristics of Canyon Lake. Specific objectives were to:

- Develop up-to-date bathymetric map
- Derive up-to-date storage curve for the reservoir
- Estimate volume of sediment deposited and its distribution
- Characterize distribution of sediment properties across the basin

Approach

A hydroacoustic survey was conducted at Canyon Lake over 2-days on December 16-17, 2014. The survey was conducted using a BioSonics DTX echosounder with multiplexed 38- and 430-kHz single beam transducers with integrated pitch-roll sensors and a 201-kHz split beam transducer (Table 1). Transducers were operated at 5 pps on each frequency, with 0.4 ms pulse duration. Transducers were mounted 0.5 m below the water surface with position recorded using a JRC 202W real-time differential GPS. Data were acquired using BioSonics VisualAcquisition v.6.0 software on a Dell ATG laptop. Calibrations were conducted each day using tungsten carbide spheres of known target strength. Data files were processed using BioSonics VBT software.

Table 1. Transducer configurations used in this study.

Property	DTX-38	DTX-200	DTX-420
Frequency (kHz)	38	201	430
Beam angle (°)	10.0	6.6	7.0
Source level (dB µPa^{-1})	217.0	221.3	220.0
Receive sensitivity (dbC µPa^{-1})	-41.1	-57.6	-62.9
Pulse length (ms)	0.4	0.4	0.4
Pings per second (pps)	5	5	5

Water column and sediments were also sampled. Water temperature and conductivity profiles were measured daily with an YSI CastAway CTD. Bottom sediments were sampled with an Ekman dredge at 5 sites across the lake, homogenized and subsampled into 500-mL widemouth glass jars with Teflon lined screw top lids, and returned to the lab for basic characterization. Phosphorus in bottom sediments of lakes exists in numerous forms, including a mobile form (mobile-P) that includes soluble/exchangeable forms as well as that associated with iron (Fe)(III) phases that can be released upon reduction of Fe(III) under low dissolved oxygen (DO) conditions (Reitzel et al., 2005; Pilgrim et al., 2007). Mobile-P in surficial sediments has been shown to be strongly correlated with internal recycling rates (Pilgrim et al., 2007), with the mobile-P pool reduced by amounts consistent with that released to the water column (Reitzel et al., 2005).

Sediment grab samples were subsampled for dry-weight determination and extracted for mobile-P following Pilgrim et al. (2007). Water content was determined on subsamples that were heated overnight at 105 °C. Total C and N were measured by dry-combustion methods using a Thermo Flash EA NC soil analyzer (Nelson and Sommers, 1982). Inorganic C and $CaCO_3$ were determined manometrically following Loeppert and Suarez (1996), with organic C taken as the difference between total C and inorganic C. Duplicate analyses were conducted at a rate of at least one every 10 samples within an analytical batch.

Results

Bathymetry

Depth varied widely across the lake, with predictably greatest values located near the dam in the main basin of the lake, exceeding 17 m at full pool (Fig. 1). The north and east basins possessed lower depths, with less than about 11 m in the east basin near the causeway, and less than about 7 m throughout the north basin (Fig. 1).

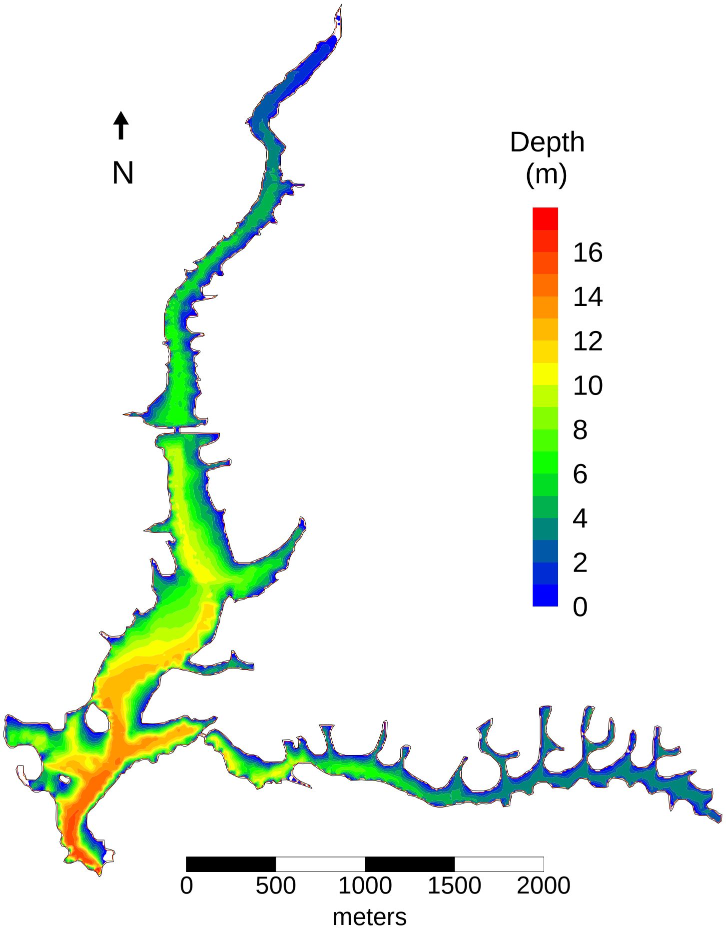


Fig. 1. Bathymetry of Canyon Lake.

Very shallow conditions were present near the inflows of the San Jacinto River and Salt Creek, reflecting natural topography and the deposition of material eroded from the watershed. Bathymetric measurements also revealed the original channel for the San Jacinto River which was located on the western side of the lake through the north basin and into the main basin (Fig. 1). The channel was not clearly defined near the mid-portion of the main basin due presumably to deposition of material there, likely derived from construction activities during development of the community. The channel is again evident in the southern part of the lake, representing its deepest region (Fig. 1).

The bathymetric data were used to develop an up-to-date storage curve and elevation-area curve for the lake (Fig. 2). Included is storage curve provided by EVMWD (Fig. 2a, dashed line). The interpolation assumed the shoreline throughout the north basin and most of the main basin to grade to 0 m at full pool, while the shoreline of east basin was defined by sea walls with an assumed depth of 0.6 m. The basin elevation ranged from a minimum value of 1323.36 ft (above MSL), immediately adjacent to the dam face, to the spillway elevation of 1381.76 ft. The full pool volume of Canyon Lake was calculated to be 8758 acre-feet, a value that is 3110 acre-feet less than EVMWD's prior storage curve apparently developed in 1993. The downward displacement of lake volume at a given surface elevation represents loss of storage; measurements thus indicate that the lake has lost significant storage over time.

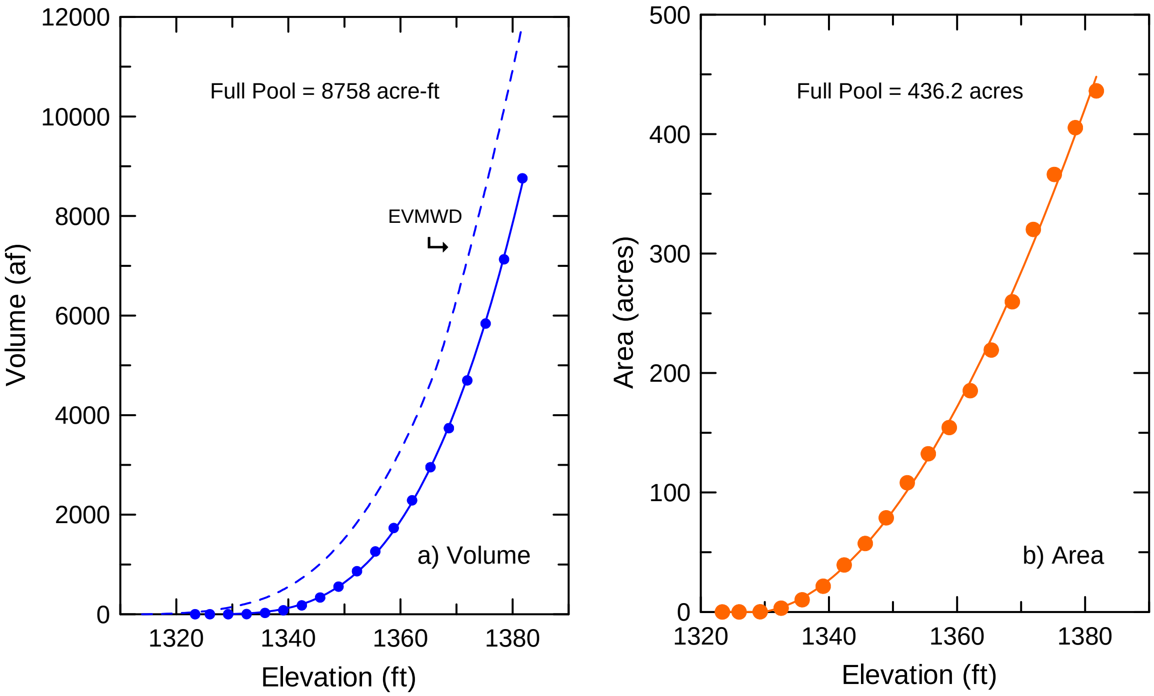


Fig. 2. Canyon Lake hypsography: a) volume vs. elevation (dashed line is EVMWD data from 1993), and b) surface area vs. elevation.

The lake volume was well-fit (r^2=0.9998) by the 3rd-order polynomial of the form:

$$Vol\ (af) = -129913027.7 + 293417.3*Elev - 220.9033*Elev^2 + 0.0554373*Elev^3 \qquad (1)$$

The surface area at full pool was calculated to be 436.2 acres (Fig. 2b). Lake surface area was reasonably described (r^2=0.9980) with the 3rd-order polynomial:

$$Area\ (acres) = 1271585.1 - 2645.223*Elev + 1.82046*Elev^2 - 0.00041385*Elev^3 \qquad (2)$$

In addition, the elevation-area-volume relations for the individual basins were also developed. The main basin contributes the largest area and volume to the lake, at 252.8 acres and 6439.8 acre-feet, representing 58.0% of the total area and 73.5 % of the total volume, respectively (Table 1). The east and north basins collectively comprise over 40% of the lake area, but contribute only about 25% of the total lake volume (at full pool) (Table 2).

Table 2. Individual basin and total lake metrics.

	Area (acres)	Volume (acre-ft)	Mean Depth (ft)	Maximum Depth (ft)
Main Basin	252.8 (58.0%)	6439.8 (73.5%)	25.5	58.4
East Basin	102.5 (23.5%)	1406.8 (16.1%)	13.78	38.7
North Basin	80.9 (18.5%)	911.2 (10.4%)	11.3	26.2
Total	436.2 (100%)	8757.9 (100%)	20.1	58.4

Storage curves for individual basins were also extracted from bathymetric data (Fig. 3).

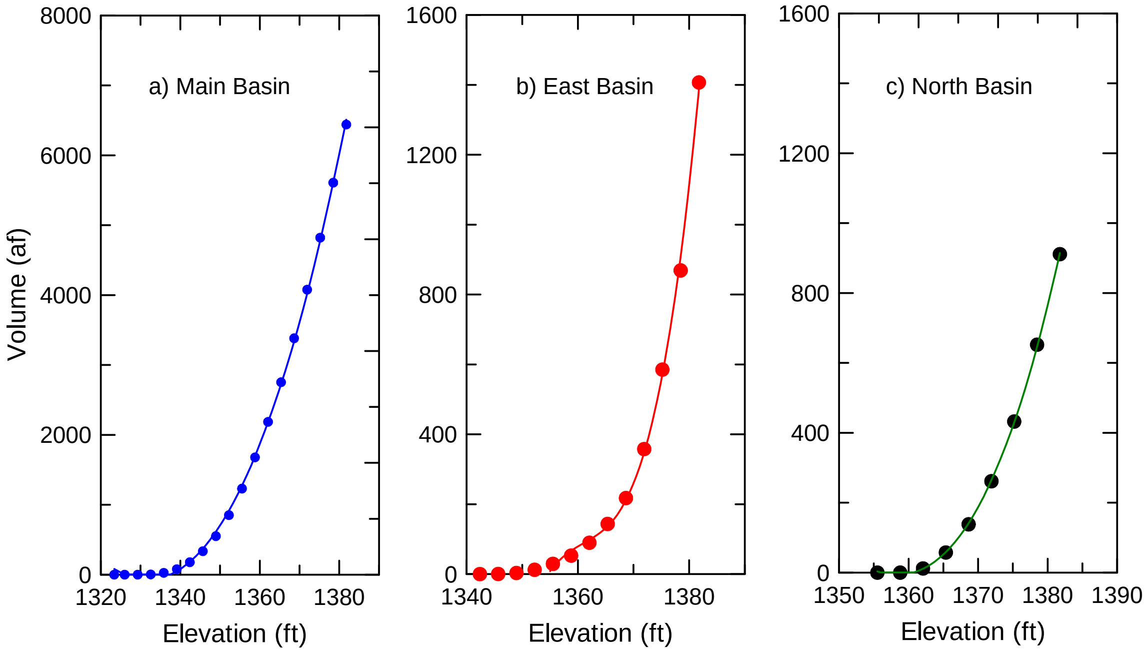


Fig. 3. Volume-elevation relationships for a) main basin, b) east basin and c) north basin.

The volumes of the individual basins were also reasonably-described ($r^2>0.998$) by 3rd-order polynomials:

$$Vol_{main} = -18099718.1 + 43668.02*Elev - 34.9638*Elev^2 + 0.0092954*Elev^3 \qquad (3)$$

$$Vol_{east} = -312755907.3 + 689395.0*Elev - 506.541*Elev^2 + 0.1240641*Elev^3 \qquad (4)$$

$$Vol_{north} = -50991062.6 + 114231.5*Elev - 85.2843*E*Elev^2 + 0.0212201*Elev^3 \qquad (5)$$

Sediment Thickness

Thickness of the sediment was derived from echograms based upon the penetration and attenuation of the 38-kHz sound wave within the sediments. Very hard sediments limit penetration of the sound wave, while fine-textured organic-rich sediments with high water contents allow penetration of the sound wave to considerable depths within the sediments before reverberation from harder weathered bedrock or soil. Thickness of the sediment ranged from 0 – 8 m, and varied across the basin in a complex way, with some evidence of infilling of the original San Jacinto River and Salt Creek channels, deposition of material derived from grading and construction within the local watershed and from erosion from upper watersheds (Fig. 4).

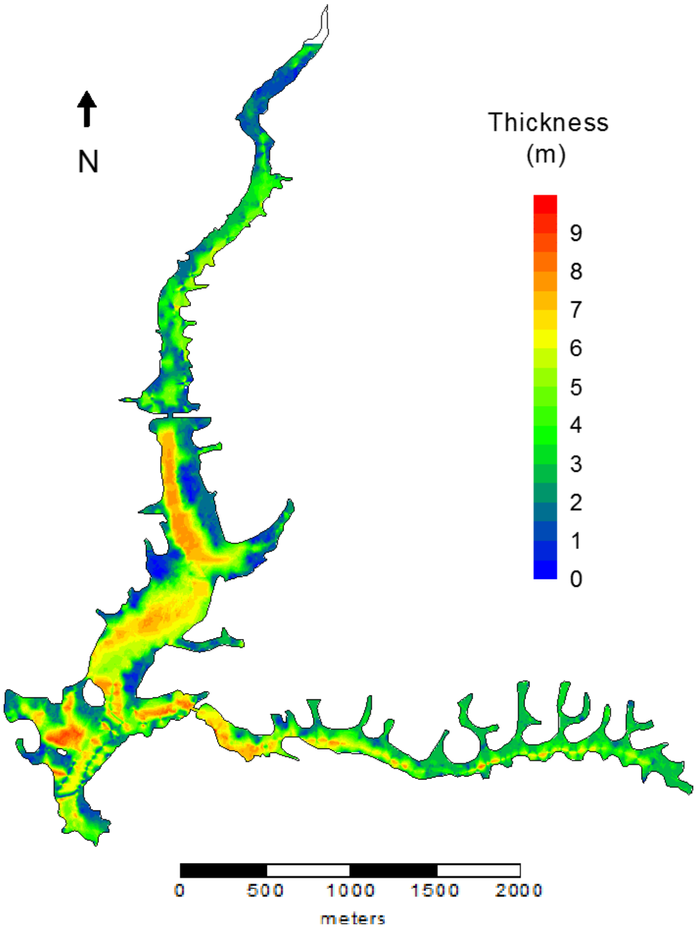


Fig. 4. Sediment thickness in Canyon Lake.

Based upon these measurements, it is estimated that sedimentation over the past 88 yrs since the dam was constructed has reduced the capacity of the reservoir by >5000 acre-feet and potentially as much as 8000 acre-feet or more.

Sediment Organic C Content

The attributes of the bottom echo have been found to be correlated with surficial sediment physical and chemical properties (Anderson and Pacheco, 2011). For example the fractal (box) dimension of the bottom echo at 430-kHz was very strongly correlated with the organic C content of surficial bottom sediments. The regression equation developed in that study was used to estimate the organic C content of sediments in Canyon Lake (Fig. 5).

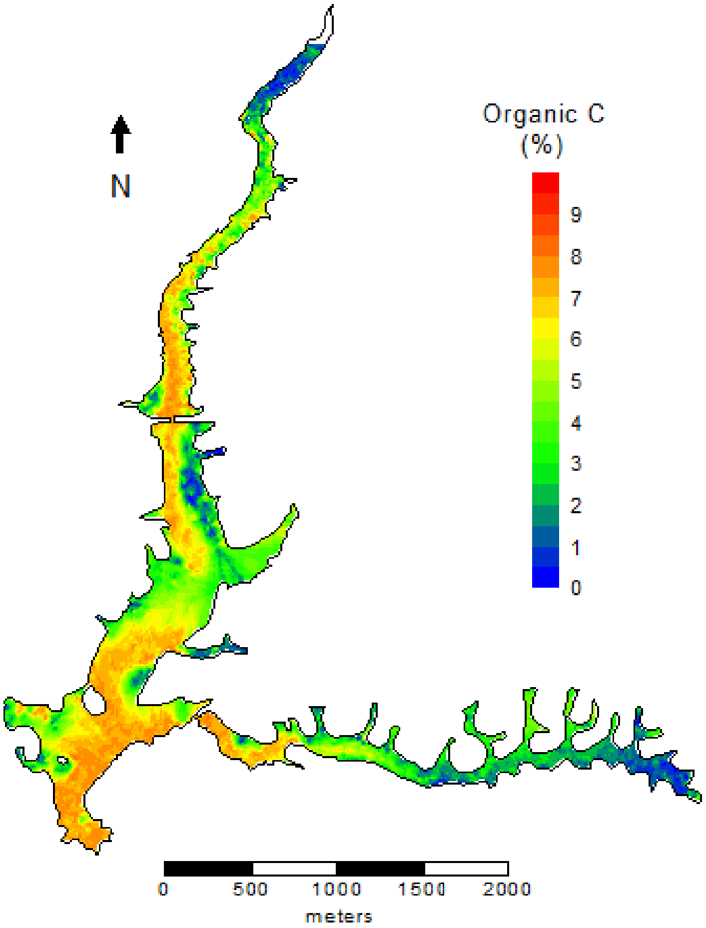


Fig. 5. Sediment organic C content in Canyon Lake.

Organic C contents of surficial sediments were very low near the influent of San Jacinto River and Salt Creek (<1%) as a result of deposition of coarse-textured material eroded from the watershed, and due to scouring and further transport of finer-textured material during inflow events. Organic C contents increased at greater distances into east and north basins, with strong focusing of organic matter in the deeper waters of the main basin, especially near the dam (Fig. 5).

Sediment Mobile-P Content

The mobile-P content of sediments has been found to be strongly correlated with P flux from sediments under low DO conditions and is now commonly used to guide alum treatments of lakes. Mobile-P was quanitifed on sediment grab samples from 5 sites on the lake when hydroacoustic measurements were also conducted. A nonlinear relationship was found between the fractal dimension of the bottom echo envelope and mobile-P content (Fig. 6).

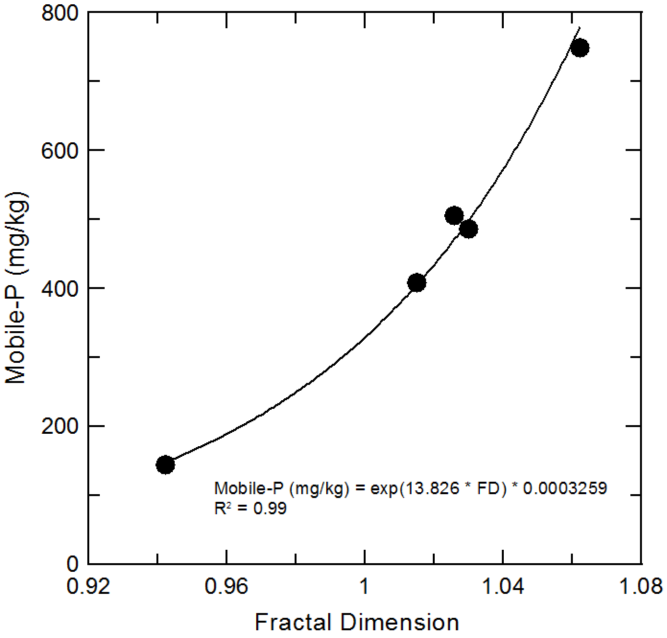


Fig. 6. Mobile-P content in surficial sediment vs. fractal dimension of bottom echo at 430-kHz.

This allowed us to remotely sense mobile-P content of sediments and to develop a map of its distribution across the lake (Fig. 7). Mobile-P content of surficial sediments was enriched in original river channel in the north basin; mobile-P was also elevated in deeper sediments near closer to dam (Fig. 7). Understanding of the distribution of mobile-P helps guide alum treatment for sediment P inactivation. Thus, alum treatments designed to inactivate mobile-P in the main basin sediments of Canyon Lake would be most effective when targeting the large inventories at the southern end of the lake. The limited exchange between basins during most of the year (excluding large runoff and flushing events) requires that each basin be treated essentially as an independent lake.

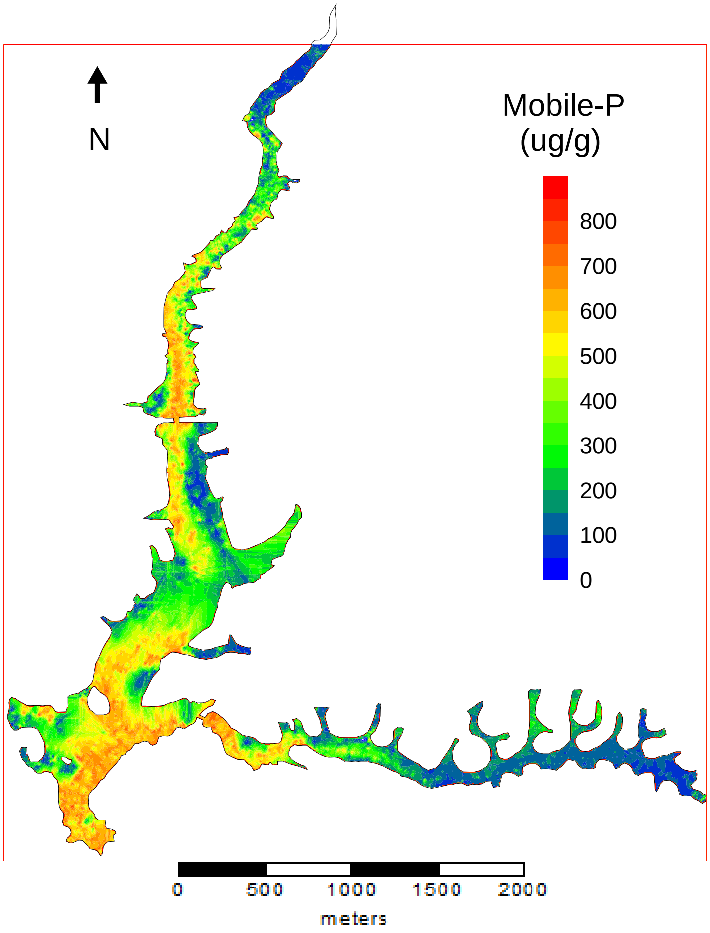


Fig. 7. Sediment mobile-P content in Canyon Lake.

Conclusions

The hydroacoustic study provided valuable new insights in the characteristics of Canyon Lake:

- The hydroacoustic survey provides up to date bathymetry and elevation-area-volume relations for Canyon Lake
- Measurements also provided new detailed understanding of the distribution, properties and thickness of sediment within the lake
- Sedimentation is projected to have reduced storage capacity by >5000 acre-feet and potentially as much as 8000 acre-feet or more since dam construction in 1927

- Sediments enriched in mobile-P and organic matter were deposited in deeper regions of lake, and represent regions of greater nutrient flux and oxygen demand

References

Anderson, M.A. and P. Pacheco. 2011. Characterization of bottom sediments in lakes using hydroacoustic methods and comparison with laboratory measurements. *Water Res.* 45: 4399-4408.

Loeppert, R.H. and D.L. Suarez. 1996. Carbonate and gypsum. In: Sparks, DL, editor. *Methods of Soil Analysis. Part 3.* 3rd ed. Agronomy Monographs 9. ASA and SSSA. Madison, WI. pp. 437-474.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. In: A.L. Page, R.H. Miller, and D.R. Keeney, editors *Methods of Soil Analysis, Part 2*. 2nd ed. Agronomy Monographs 9. ASA and SSSA., Madison, WI. pp. 539-580.

Pilgrim, K.M., B.J. Huser and P.L. Brezonik. 2007. A method for comparative evaluation of whole-lake and inflow alum treatment. *Water Res.* 41:1215-1224.

Reitzel, K., J. Hansen, J., F. Ø. Andersen, K.S. Hansen, and H.S. Jensen. 2005. Lake restoration by dosing aluminum relative to mobile posphorus in the sediment. *Environ. Sci. Technol.* 39: 4134–4140.

Page Intentionally Blank

Technical Memorandum

Task 2.4: Mobile-P and Internal Phosphorus Recycling Rates in Canyon Lake

Objective

The objective of this task was to improve understanding of phosphorus biogeochemistry in Canyon Lake sediments and the factors affecting P recycling through measurements of mobile-P contents and internal recycling rates of sediments.

Approach

Measurements of mobile-P, Al-P and internal P recycling rates in Canyon Lake were conducted to assess progress made by alum additions in sequestering bioavailable/mobile-P. Mobile-P and Al-P contents of sediments were determined on grab samples and cores collected from the 5 sites previously sampled for water quality and nutrient flux measurements (Fig. 1) following Pilgrim et al. (2007). In additional P flux measurements were made on triplicated intact sediment cores following Anderson (2001).

Fig. 1. Sampling sites on Canyon Lake.

An Ekman dredge was used to collect a grab sample, which was then subsampled by carefully inserting a 30.5 cm by 6.3 cm diameter Lucite tube approximately 10 cm into the sediment. The bottom of the core was sealed using a rubber stopper. The core was then carefully topped off with bottom water sampled using a van Dorn sampler, stoppered with zero headspace and transported back to the lab.

Cores were then incubated in the dark at the temperature and DO levels measured at the time of sampling. Approximately 10 mL of water were removed daily, filtered and analyzed for soluble PO_4-P using a Seal discrete analyzer following standard methods (APHA, 1989). Dissolved oxygen concentrations were measured using a YSI Model 55 DO meter, with the water briefly sparged with N_2 or lab air as needed to maintain DO and to very gently mix the water column within the core. The measured change in concentration was used in conjunction with water volume and sediment-water interfacial area to calculate nutrient flux rates and compared with previously measured values.

Results

P Internal Recycling Rates

The flux of PO_4-P from bottom sediments sampled in August 2014 was lower at 4 out of 5 sites compared with average values measured in 2001, 2002 and 2006 (Fig. 2).

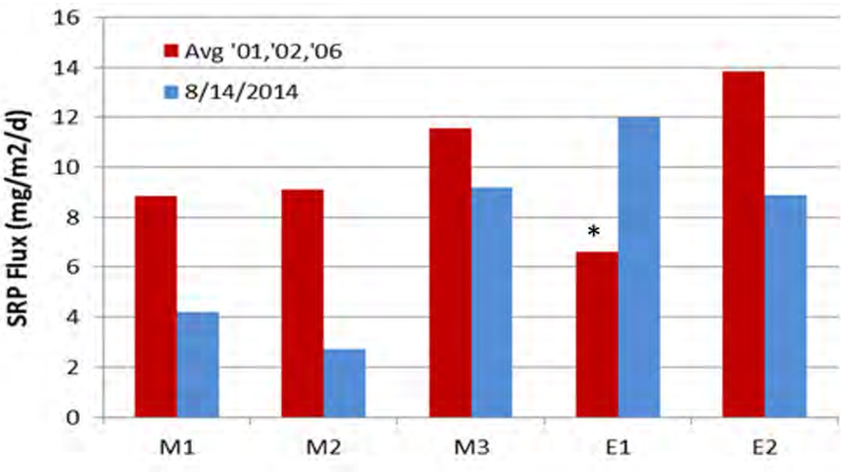


*Fig. 2. PO_4-P flux rates measured at the 5 sampling station comparing the average values from 2001, 2002 and 2006 with rates measured on August 14, 2014. *Data available only for 2006 at site E1.*

Average values do obscure strong inter-annual variability, however. In particular, the very large runoff events in 2005 increased subsequent PO_4-P flux rates at sites M1 and E2 (Fig. 3). If we ignore the 2006 data and its impact on average values, alum treatments in F'13 and W'14 appear to have had more modest and variable impacts on PO_4-P flux (Fig. 3). Inter-annual variability in rate of sediment release of PO_4-P makes it difficult to draw conclusions about effects of alum applications on P recycling from sediments as of the time of these measurements. It is thought that speciation of P within the sediments may provide a more sensitive measure of alum effects; moreover, mobile-P measurements are increasingly used to design alum treatment projects and determine appropriate alum application rates (Pilgrim et al., 2007).

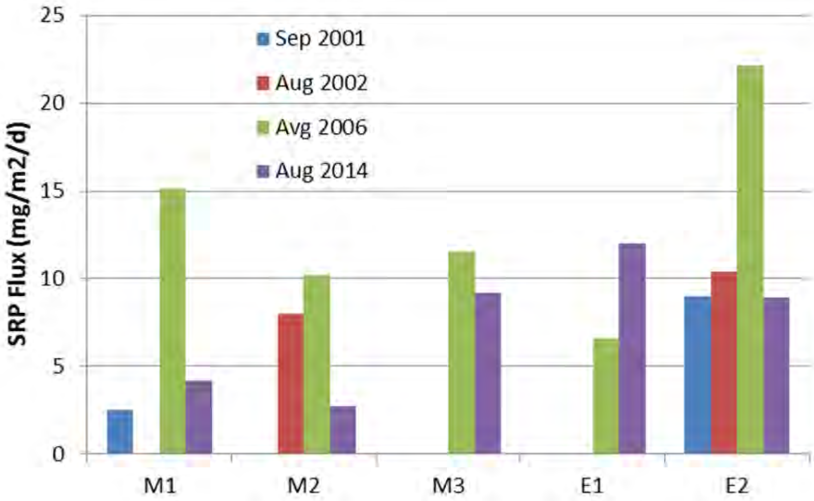


Fig. 3. Summer PO_4-P flux rates from intact cores collected from Canyon Lake.

Mobile-P and Al-P Contents

Mobile-P contents in sediments of Canyon Lake were markedly higher than concentrations recently measured in Lake Elsinore and Big Bear Lake (Fig. 4). The concentration at site M1 was 749 µg/g, a value nearly 4x larger than the highest concentration measured at Lake Elsinore and 2.8x higher than the highest concentration in Big Bear Lake (Fig. 4). Concentrations of mobile-P at sites M2, M3 and E1 were 409 – 506 µg/g, while site E2 in East Bay was 145 µg/g.

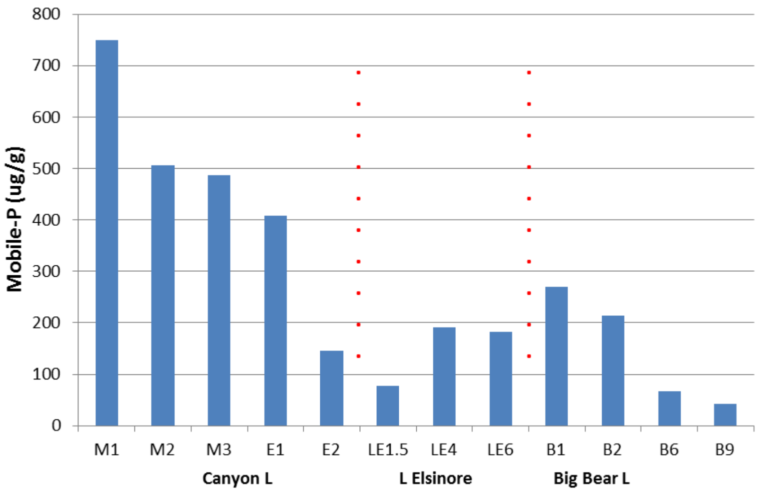


Fig. 4. Mobile-P content (µg/g) of sediment samples collected from Canyon Lake, Lake Elsinore and Big Bear Lake.

Mobile-P is generally better expressed on an areal basis since it better correlates with flux rates and allows for calculation of alum dose. Assuming a reactive depth of 10 cm, the range of mobile-P contents is reduced among the 3 lakes, but Canyon Lake is still consistently the highest at an average concentration of 6.68 g mobile-P/m^2 (Fig. 5).

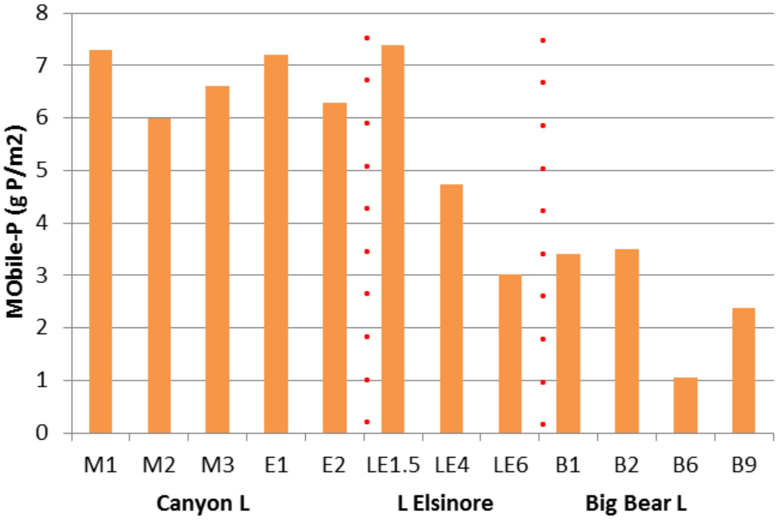


Fig. 5. Mobile-P content, expressed on areal basis (g P/m^2), of sediment samples collected from Canyon Lake, Lake Elsinore and Big Bear Lake.

Assuming a 20:1 Al:P ratio for the alum floc (Berkowitz et al, 2006), the mobile-P pool in the sediments of Canyon Lake may require up to 140 g Al/m^2, an average value much higher than that for Lake Elsinore or Big Bear Lake, although comparably high application rates would be needed for some regions on Lake Elsinore (Fig. 6).

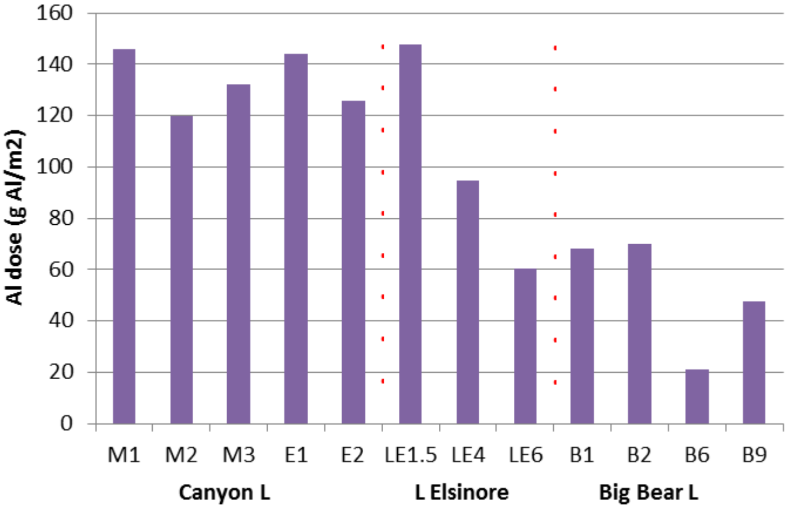


Fig. 6. Alum dose, expressed as g Al/m^2, based upon mobile-P values assuming 20:1 Al:P ratio.

The hydroacoustic survey conducted on Canyon Lake in December 2014 (Task 2.3) quantified the acoustic properties of bottom sediments as well as bathymetry. The fractal dimension of the bottom echo envelope was strongly correlated with mobile-P content of bottom sediments (Fig. 7), allowing development of a map showing mobile-P distribution across the lake (Fig. 8, previously presented in the Task 2.3 tech memo).

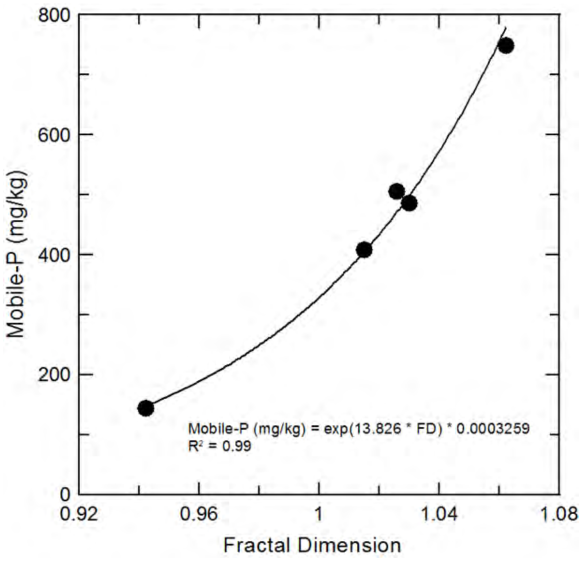


Fig. 7. Mobile-P content of Canyon Lake sediment vs fractal dimension of bottom echo envelope.

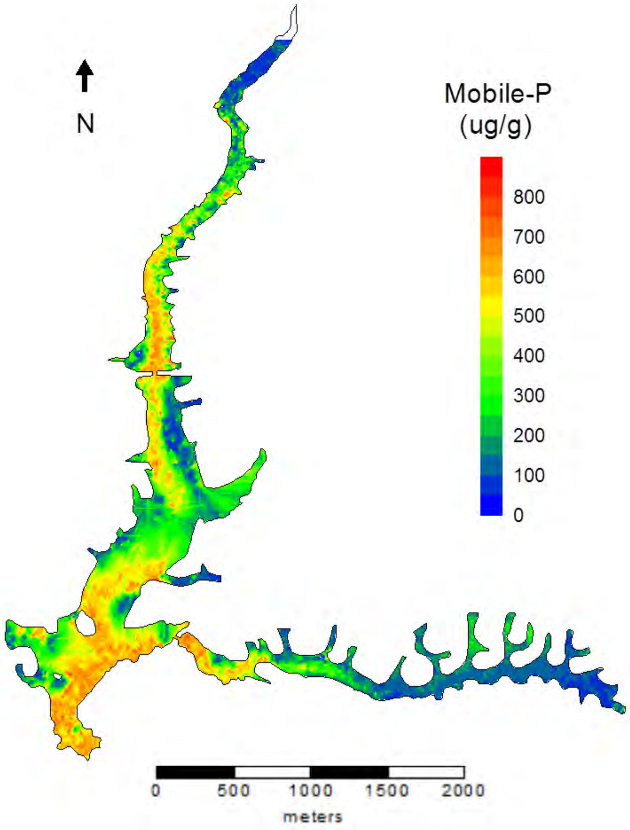


Fig. 8. Distribution of mobile-P in bottom sediments of Canyon Lake.

The results presented above were based upon grab samples collected using an Ekman dredge that samples to approximately 10-15 cm depth in soft cohesive sediments and less in coarser textured uncohesive material. Intact sediment cores were also collected from each of the 5 sampling sites on Canyon Lake and sectioned into 1 cm increments that were subsequently extracted for mobile-P and Al-P (Fig. 9).

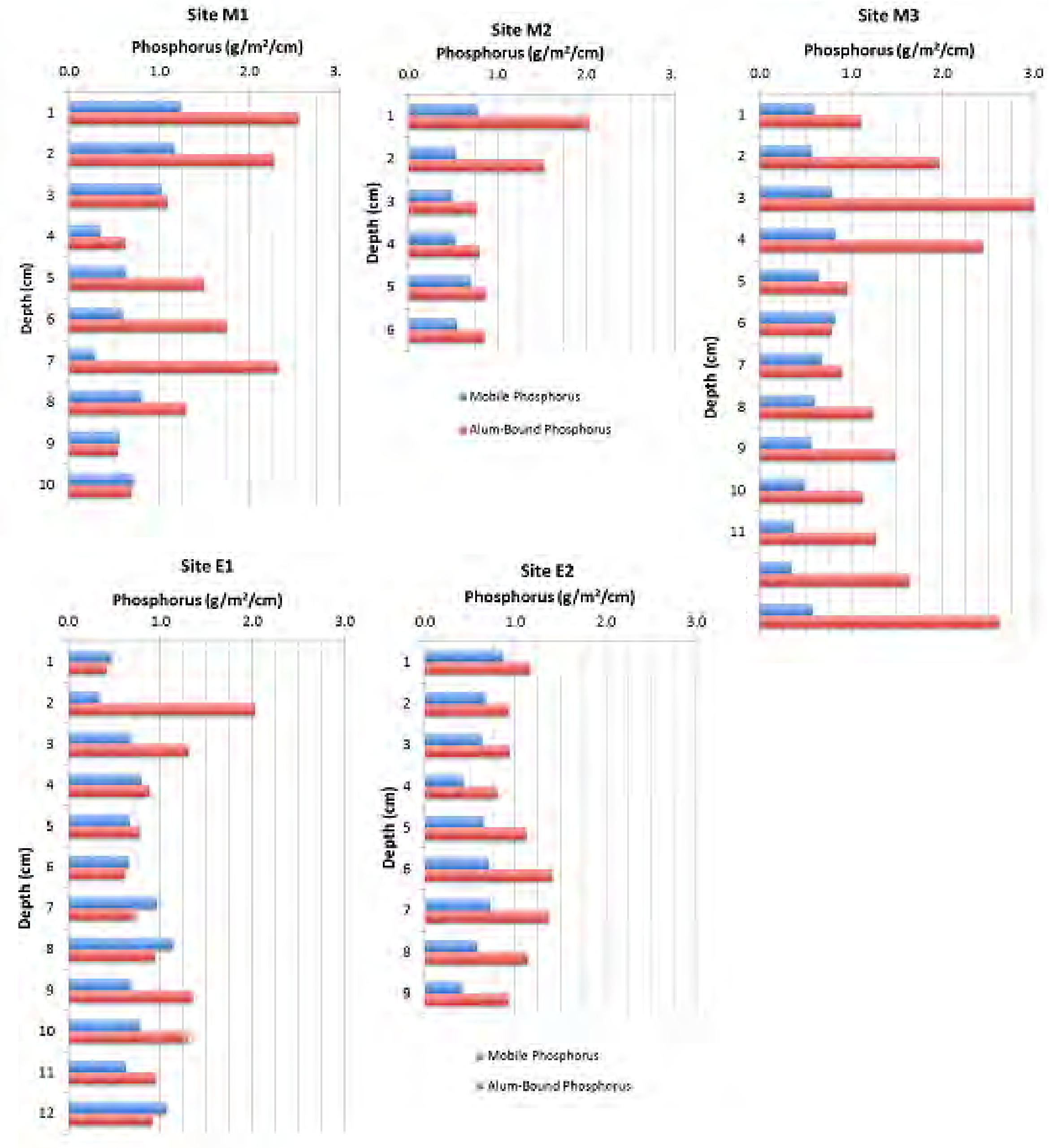


Fig. 9. Vertical distribution of mobile-P and Al-P in sediments of Canyon Lake.

Phosphorus extracted with NaOH and assigned to the aluminum-bound pool (that would include P bound to both natural Al phases as well as added alum) (Fig. 9, red bars) typically exceeded concentrations of mobile-P, often by a relatively wide margin (Fig. 9 blue bars), although clear vertical trends across the sites are not apparent. Ideally, a reduction in mobile-P and a corresponding increase in Al-P would result from an alum treatment and signify the conversion of labile forms of P to unreactive forms. The 7 cm depth at site M1 might be conjectured to conform to this, but would require added alum floc to have settled to this depth within the sediments in a relatively narrow band. Watershed inputs of inorganic particles with large runoff events, intervals of drought, and other processes would also be expected to alter properties with depth.

Despite this complexity, it is interesting to compare P fractionation results from sediment samples collected in December 2006 (Whiteford et al., 2007), following the tremendous runoff and siltation to Canyon Lake from winter 2005 storms, with results in this study (Fig. 10). The results for 2014 and 2006 are presented side-by-side as stacked bar charts for the NH_4Cl-P, Fe-P and Al-P fractions, with sites separated from each other by dashed lines. Soluble and readily exchangeable P (NH_4Cl-P) comprised a small fraction of P in the sediments in both 2006 and 2014 (Fig. 10, dark red bar), while Fe-P comprised a much larger fraction (Fig. 10, pale blue bar). The sum of these 2 phases is taken as mobile-P; what is clear is the Fe-P and mobile-P contents were much higher at all sites in 2006 when compared with 2014 (Fig. 10). Encouragingly, Al-P contents were often quite a bit higher in 2014 than 2006, potentially indicating the alum treatments had some success in lowering mobile-P and increasing the fraction bound to Al.

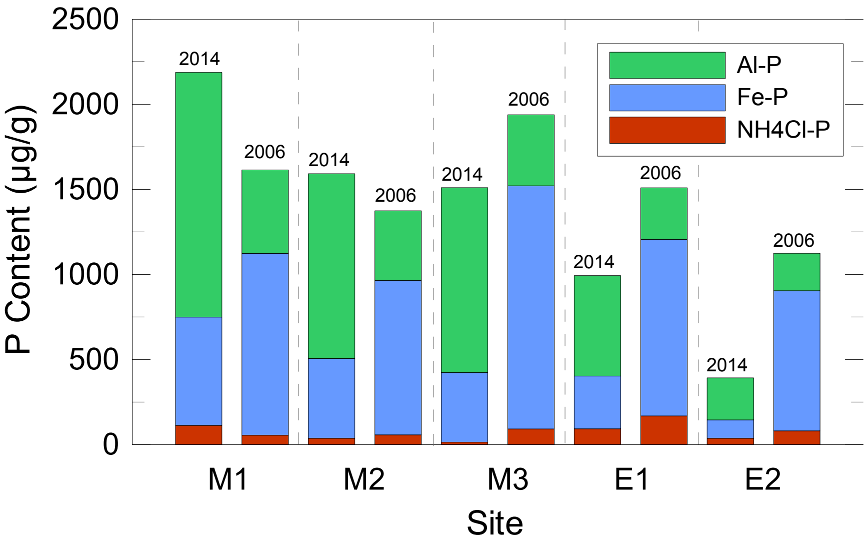


Fig. 10. Phosphorus fractionation in sediments of Canyon Lake comparing results from samples collected in this study with those from 2006 (Whiteford et al., 2007).

There are interesting lake management implications from the P fractionation results for Canyon Lake and Lake Elsinore. The differences between these 2 lakes can be attributed in part to the San Jacinto River that delivers a substantial amount of inorganic particulate material, eroded from the watershed, which is retained within Canyon Lake. As a result, Canyon Lake has much higher mobile-P contents, chiefly as Fe-P, than Lake Elsinore (Task 2.1 Tech Memo). With high reducible Fe-bound P phases in Canyon Lake, Canyon Lake would likely be more responsive to aeration/ oxygenation than Lake Elsinore. The limited amount of Fe delivered to Lake Elsinore, and the previously established formation of $FeS_2(s)$ phases within the sediments (Anderson, 2001) is thought to constrain effectiveness of aeration at sequestering sediment PO_4-P there.

Conclusions

The results of these measurements indicate:

(i) Canyon Lake has much higher mobile-P contents than Lake Elsinore and Big Bear Lake;

(ii) the mobile-P pool in Canyon Lake is chiefly comprised of PO_4-P associated with reducible Fe phases (Fe-P), making it more amenable to aeration/oxygenation for sequestering PO4-P within the sediments than Lake Elsinore with very little Fe-P.

(iii) mobile-P concentrations are generally much higher in deeper regions of the lake as a result of sediment focusing processes;

(ii) P fractionation results indicate a reduction in mobile-P and increase in Al-P contents since 2006 in Canyon Lake that may result from differences in hydrologic conditions, alum applications, or other factors.

References

Anderson, M.A. 2001. *Internal Loading and Nutrient Cycling in Lake Elsinore.* Final Report to the Santa Ana Regional Water Quality Control Board. 52 pp.

Berkowitz, J., M.A. Anderson and C. Amrhein. 2006. Influence of aging on phosphorus sorption to alum floc in lake water. *Water Res.* 40:911-916.

Boudreau, S. and M.A. Anderson, 2016. *Task 2.1: Stable Isotope, Elemental and Mobile-P Measurements in Lake Elsinore Sediments.* Technical Memorandum the Lake Elsinore & Canyon Lake TMDL Task Force. 24 pp.

Pilgrim, K.M., B.J. Huser and P.L. Brezonik. 2007. A method for comparative evaluation of whole-lake and inflow alum treatment. *Water Res.* 41:1215-1224.

Whiteford, J., C. Paez and M. Anderson. 2007. *Sediment Nutrient Flux and Oxygen Demand Study for Canyon Lake with Nutrient Monitoring and Assessment of In-Lake Alternatives: January-March 2007.* Draft Report to LESJWA. 15 pp.

Page Intentionally Blank

LESJWA BOARD MEMORANDUM NO. 791

DATE: April 21, 2016

SUBJECT: TMDL Task Force Status Report

TO: LESJWA Board of Directors

FROM: Mark R. Norton, P.E., Authority Administrator

RECOMMENDATION

Staff recommends that the Board of Directors receive and file this status report on the Lake Elsinore and Canyon Lake TMDL Task Force.

BACKGROUND

The Lake Elsinore and Canyon Lake TMDL Task Force has met on January 13, February 23, and March 22, 2016, since the last status report was prepared. During this time, CDM Smith initiated the effort to revise and update the Lake Elsinore and Canyon Lake nutrient TMDLs. The main focus of this effort includes the preparation of an updated TMDL Technical Report. On March 7, 2016, CDM Smith released initial draft chapters of the report for review by the TMDL Technical Subcommittee, including the Introduction (Chp 1) and Problem Statement (Chp 2). The TMDL Technical Report is on schedule to be completed in December 2017.

Also in March, Dr. Michael Anderson of UC Riverside completed modeling analysis of Lake Elsinore and Canyon Lake. This effort included extensive hydrological and water quality modeling of each lake designed to answer important questions to support the effort to update and revise the Lake Elsinore and Canyon Lake nutrient TMDLs. The results of these analyses are addressed in technical memorandums, which have been reviewed by the Task Force and are expected to be finalized by Dr. Anderson in April.

The Task Force continues to work with the Lake Elsinore operators to work on a new operation and maintenance agreement for the Lake Elsinore aeration system. This new agreement will incorporate credits for funding support by the Riverside County MS4 permittees and others to meet their responsibility to control internal nutrient loads. In February, a revised cost sharing allocation was presented to stakeholders. It is anticipated that a final cost sharing agreement will be brought forward to stakeholders for approval at the May 5th TMDL Task Force meeting.

For Canyon Lake, due to the initial success of the alum pilot project completed in September 2015, stakeholders recommended the use of remaining grant funds (available through 2018) to conduct additional alum applications. At this time, the Task Force and consultants are evaluating the opportunity to conduct an alum application in May 2016. To support this effort, as well as show progress made by the Task Force in addressing the TMDLs, the Task Force and consultants are preparing an interim compliance report for Canyon Lake and Lake Elsinore with a draft of the report due in April 2016.

RESOURCES IMPACT

All staff administration time applied to the TMDL Task Force comes from the TMDL budget and is funded only by the TMDL Task Force parties.

MN:dm