CANYON LAKE HYPOLIMNETIC OXYGENATION SYSTEM
PRELIMINARY DESIGN PHASE I REPORT

Prepared for:

Lake Elsinore & San Jacinto
Watersheds Authority

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Job #: 9653E | April 2011
(February 2011) - Revised

PACE
Advanced Water Engineering

Addendum #1

PACE
Advanced Water Engineering

REPORT ADDENDUM #1

Date: April 18, 2011

To: Rick Whetsel, Senior Watershed Planner
Santa Ana Watershed Project Authority (SAWPA)
Direct: (951) 354-4222
Email: rwhetsel@sawpa.org

From: Andy Komor, MS, PE

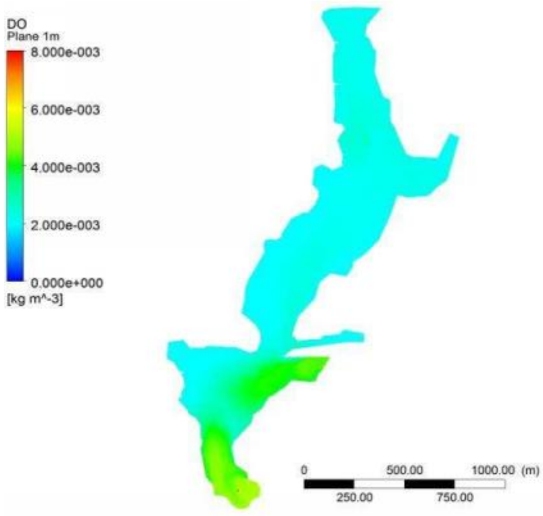
Re: Report Addendum #1 # 9653E

After completion of the preliminary design report dated February 2011, this report addendum was created to provide supplemental information and to re-examine a variant of the preferred alternative for the project. Based on 40 comments received from the project stakeholders, with the comments and responses included at the end of this addendum, it was understood that a smaller treatment system, constructed in phases, was desired to reduce life cycle costs and allow for slow long-term improvement in lake water quality. The originally recommended treatment alternative was #10, and this variant is referred to as alternative #10b. Because alternative #10 and #10b are dual-zone systems, they can be easily phased to include only one of the treatment skids to provide treatment to only a portion of the lake in the first phase. Phase one includes supplying the treatment skid for zones 2 and 3 only, and phase two includes waiting to include the zone 1 treatment skid.

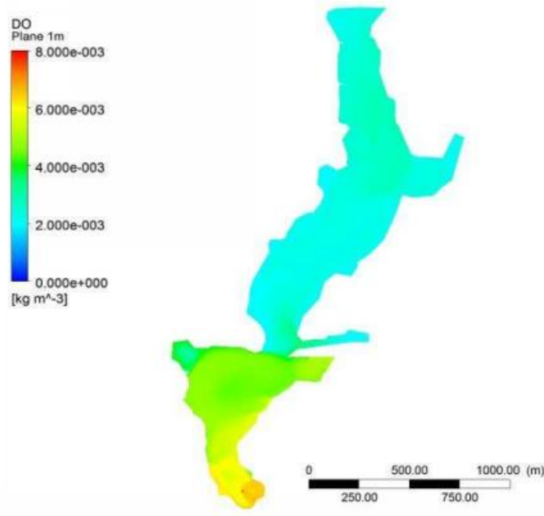
Alternative #10b includes 1,700 lbs of total oxygen supply at 3,200 gpm water flow to zones 2 and 3 using a 1.2 times safety factor for the oxygen depletion rates; whereas, alternative #10 included 3,000 lbs/day of total oxygen supply at 4,100 gpm water flow to zones 2 and 3 with a 1.5 times safety factor for the oxygen depletion rates. The lake was computer modeled using the alternative #10b design criteria, and the model results is shown in Exhibit 1 in the Report Addendum. The preliminary system layout is shown in Exhibit 2 in the Report Addendum. As discussed in response comment 37, the level of design certainty for success of the original alternative #10 was essentially 100% based on a higher safety factor and higher margin of safety. Alternative #10b includes about a 50-80% certainty of achieving 5 mg/L dissolved oxygen along the hypolimnion. Using the first phase of Alternative #10b would include about a 30-40% certainty in the first year, but higher in subsequent years as the sediment layer becomes more oxidized.

Capital, operation and maintenance, life cycle, and annualized bond re-payments at 5% interest are shown in Tables A1 and A2 for the entire Alternative #10b and the first phase of Alternative #10b.

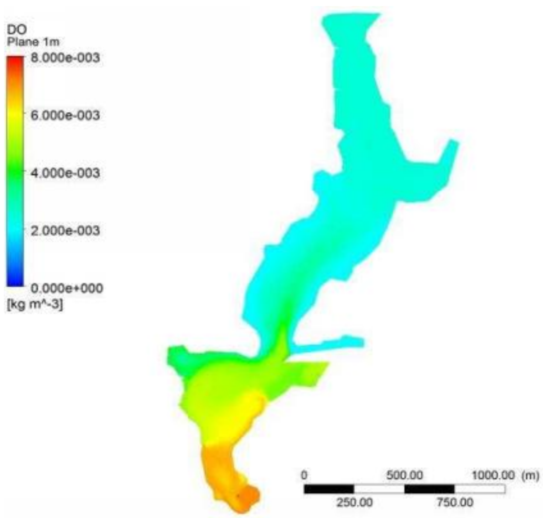
Exhibit 1: 1,700 lbs O_2/day delivered by 4,800 gpm (1.2X Safety Factor)



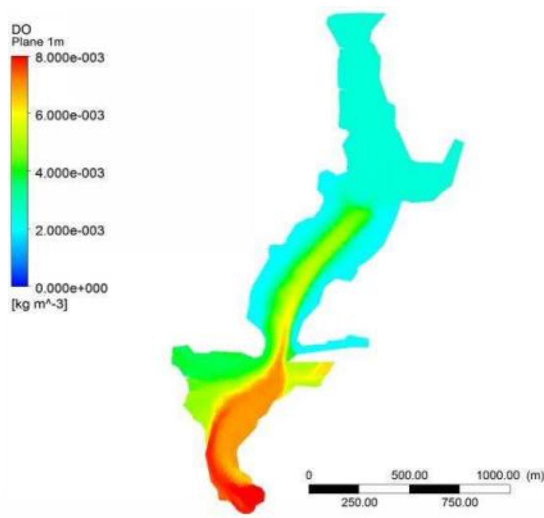
20 Days of Operation



50 Days of Operation

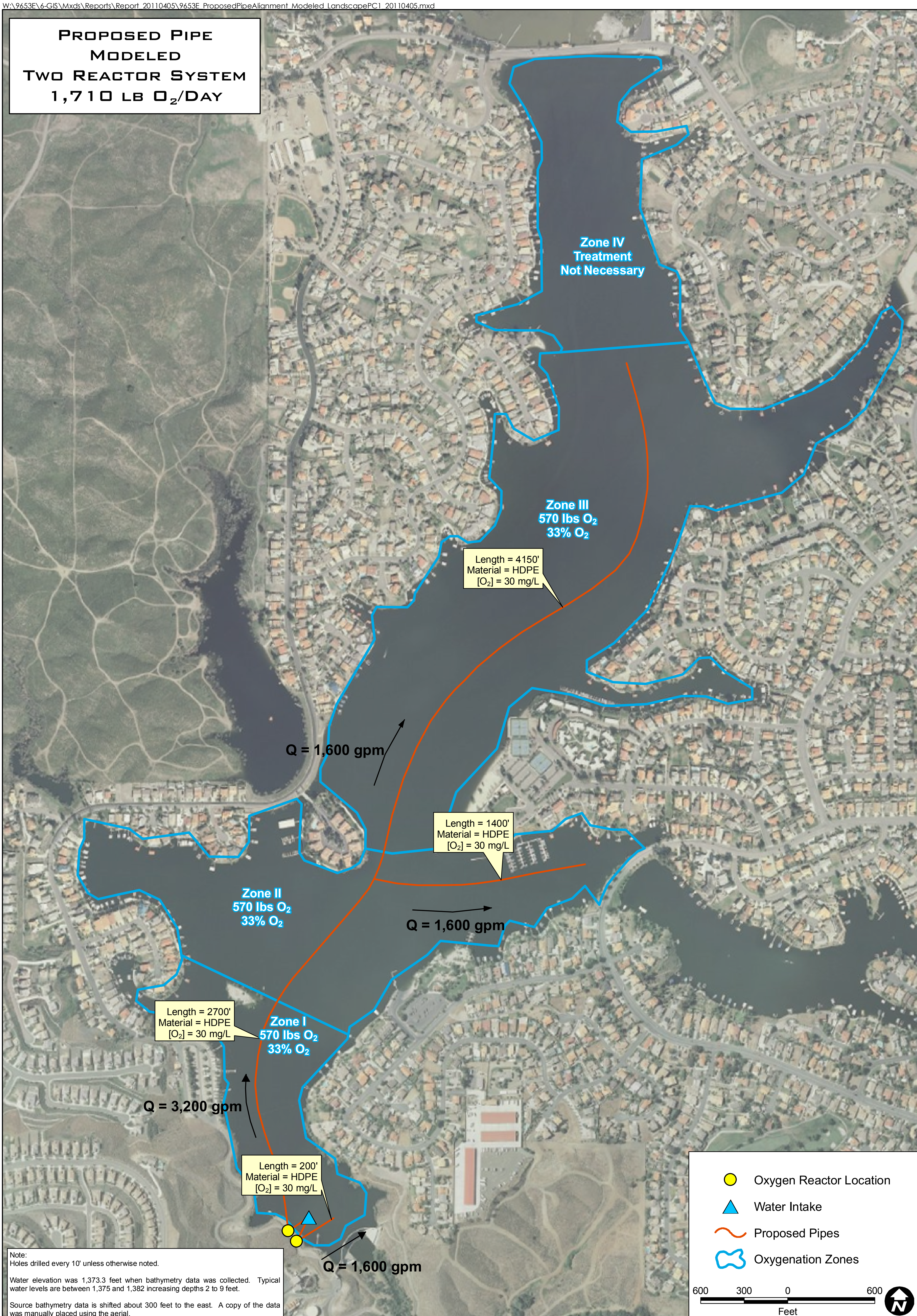


70 Days of Operation



100 Days of Operation

Proposed Pipe Modeled Two Reactor System 1,710 lb O_2/Day



Note:
Holes drilled every 10' unless otherwise noted.

Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.

Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

FIGURE

PACE
Advanced Water Engineering

SCALE	1" = 657.490516774236'
DESIGNED	PC
DRAWING	PC
CHECKED	JP
DATE	04/05/11
JOB NO.	9653-E

JOB
CANYON LAKE AERATION PROJECT
Riverside CA

TITLE
PROPOSED PIPE LAYOUT MODELED

Shoreline Installation 2 SDOX Units
All Phases

Capital Cost - Shoreline Installation, 2 Units (1,200 lbs/day Zone 2/3 + 600 lb/day Zone 1, LOX	quantity	units	cost/unit	total cost
Site Civil and Building				
Intake Suction Cans Rehab			-	$50,000
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
LOX Facility Civil Improvements	-		-	$25,000
SUBTOTAL				**$150,000**
Underwater Civil				
Dredging Equipment	15	cy	$250	$3,750
Underwater Concrete Cassions Materials and Equipment	15	cy	$750	$11,250
SUBTOTAL				**$15,000**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$80	$216,000
Concrete Ballast for 18" Pipe Installed	18	cy	$1,200	$21,600
14" HDPE Piping	4,150	LF	$65	$269,750
Concrete Ballast for 14" Pipe Installed	16	cy	$1,200	$19,200
10" HDPE Piping	1,400	LF	$40	$56,000
Concrete Ballast for 10" and 6" Pipe Installed	4	cy	$1,500	$6,000
6" HDPE Pipe for Zone I	200	LF	$25	$5,000
16" Onshore Piping	350	LF	$90	$31,500
SUBTOTAL				**$625,050**
Equipment				
Onshore 1200 lb Oxygenation System Skid	1		$150,000	$150,000
Onshore 600 lb Oxygenation System Skid	1		$110,000	$110,000
Submersible Pumps (3,200 gpm and 800 @ 25')	2		$35,000	$70,000
Misc Valves / Instrumentation				$30,000
Mechanical Piping / Hosing / Supports / Misc.				$40,000
SUBTOTAL				**$400,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$40,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$195,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	200	man days	$440	$88,000
Divers	15	crew days	$5,000	$75,000
Per Diem	200	man days	$75	$15,000
SUBTOTAL				**$178,000**
SUM SUBTOTAL				**$1,563,050**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$46,892
FINAL SUBTOTAL				**$1,729,942**
Contingency 10%				$172,994
Contractor Overhead 15%				$259,491
TOTAL				**$2,162,427**

O&M Cost - Shoreline Installation, 2 Units (1,800 lbs/day, LOX)				
Electrical	33	kW-hr	$0.12	$25,661
Maintenance	200	hr	$50	$10,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	7	refills/year	$4,059	$28,412
Equipment Replacement				$15,000
Yearly O&M Cost				**$100,073**
20 Yr Life Cycle Cost (5% Discount Rate)				**$3,409,557**
20 Yr Annual Payment (5% Interest Rate)				**$273,592**

Shoreline Installation 2 SDOX Units
Phase I

Capital Cost - Shoreline Installation, 1 of 2 Units (1,200 lbs/day Zone 2/3, LOX)	quantity	units	cost/unit	total cost
Site Civil and Building				
Intake Suction Cans Rehab			-	$30,000
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
LOX Facility Civil Improvements	-		-	$25,000
SUBTOTAL				**$130,000**
Underwater Civil				
Dredging Equipment	15	cy	$250	$3,750
Underwater Concrete Cassions Materials and Equipment	15	cy	$750	$11,250
SUBTOTAL				**$15,000**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$80	$216,000
Concrete Ballast for 18" Pipe Installed	18	cy	$1,200	$21,600
14" HDPE Piping	4,150	LF	$65	$269,750
Concrete Ballast for 14" Pipe Installed	16	cy	$1,200	$19,200
10" HDPE Piping	1,400	LF	$40	$56,000
Concrete Ballast for 10" Pipe Installed	3	cy	$1,500	$4,500
16" Onshore Piping	350	LF	$90	$31,500
SUBTOTAL				**$618,550**
Equipment				
Onshore 1200 lb Oxygenation System Skid	1		$150,000	$150,000
Submersible Pump (3,200 gpm @ 25')	1		$50,000	$50,000
Misc Valves / Instrumentation				$25,000
Mechanical Piping / Hosing / Supports / Misc.				$30,000
SUBTOTAL				**$255,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$30,000
Control Panel and Programming				$25,000
Conduit / Wiring / Disconnects				$30,000
Lighting				$5,000
SUBTOTAL				**$165,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	150	man days	$440	$66,000
Divers	12	crew days	$5,000	$60,000
Per Diem	150	man days	$75	$11,250
SUBTOTAL				**$137,250**
SUM SUBTOTAL				**$1,320,800**
Design, Engineering, Startup				$100,000
Bonding and Insurance 3%				$39,624
FINAL SUBTOTAL				**$1,460,424**
Contingency 10%				$146,042
Contractor Overhead 15%				$219,064
TOTAL				**$1,825,530**

O&M Cost - Shoreline Installation, 2 Units (1,800 lbs/day, LOX)				
Electrical	22	kW-hr	$0.12	$17,107
Maintenance	130	hr	$50	$6,500
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	5	refills/year	$4,059	$20,294
Equipment Replacement				$10,000
Yearly O&M Cost				**$74,902**
20 Yr Life Cycle Cost (5% Discount Rate)				**$2,758,969**
20 Yr Annual Payment (5% Interest Rate)				**$221,387**

Technical Memorandum

Date: March 30, 2011

To: Rick Whetsel, SAWPA Senior Watershed Planner

From: Andy Komor, MS, PE

Re: **Preliminary Response to HOS Comments** # 9653E

PACE RESPONSE TO COMMENTS

(From James Grimm, 3/9/11)

Design:

1. Sampling showed that the December rates of oxygen depletion are six times lower than the September rates. Why does the system size remain approximately the same as it was before the December sampling data was available?

The revised system size is approximately the same as the previously estimated system size, despite a six times reduction in oxygen depletion, for two reasons:

1) **the volume to be treated approximately doubles by using a lake level four feet below the top of the dam instead of 10 feet below the top of the dam**

2) **only a portion of the oxygen depletion rate was used in the previously estimated system size for several reasons outlined in the December, 2010 powerpoint presentation, but the entire rate was used in the revised system size**

2. The preliminary design needs to include a “Instrumentation and Piping Drawing” (P&ID) that shows all valves, instruments, pumps, interconnecting piping, special equipment, etc.

An instrumentation and piping diagram was not included in this preliminary design scope. We expect it to be created as a first step in the next design phase.

3. The preliminary design also needs to identify all equipment (valves, instruments, pumps, special equipment, etc) by manufacture and part number. It should also show how the pipes would be secured to the bottom of the lake.

Identification of all equipment and securing pipes to the bottom of the lake was not included in this preliminary design scope. We expect it to be designed in the next design phase.

4. Page E-4, 2nd Para and page 7-54, 4th Para:
Does the term “modified side-stream” mean that the output of the BlueinGreen system is mixed with non-oxygenated lake water by a mixing valve system as shown in fig 21 on page 5-27 to produce a lower oxygen concentration ? If so, how are these valves controlled: automatically or by the operator ? If automatically, what does that control system look like, if by operator, how does he know where to position the valves ?

To clarify, the modified side-stream includes mixing of the two water sources described. The mixing is achieved using a carefully designed orifice nozzle which controls the discharge of high oxygen water from the oxygenation equipment into the large pipe containing lower oxygen water. The nozzle shall be sized by the manufacturer, and verified by the engineer, to achieve proper back pressure for optimal oxygenation equipment operation. The nozzle is not adjustable.

5. "Pump speed can be perfectly regulated to optimize oxygen dissolution in the water". Will the pump speed be automatically controlled or controlled by the operator. If automatically, what does that control system look like ? If controlled by the operator how does the operator know when the system has optimum oxygen dissolution in the water ? "This is achieved by maintaining a constant water level in the tank ……..." Is this done by automatic control or by the operator ? If automatically, what does that control system look like ? If by operator, how does the operator know if there is a constant water level in the tank ? Is there a tank water level sight glass or other device ?

The pump will contain a variable frequency drive (VFD) which allows automatic change in speed to achieve a desired flow. The flow will be directly dependent on the feedback from a level instrument located in the oxygenation tank.

6. Page 3-14, para 1, last sentence:
I don't the typical water surface level is maintained at 1375. The lake level max is 1382 controlled by the dam height. The lake level min is 1372 controlled by a lease agreement between Canyon Lake POA and EVMWD. EVMWD keeps historic lake level elevations. This data could be use to determine the nominal lake level over the years for the months of April through November to determine what lake level should be used to determine the volume of the hypolimnion to be used in sizing the system.

For clarity, a full lake makes the oxygenation system larger. Since the lake is often full at the end of the spring, and evaporation will only decrease the lake by four feet throughout the summer, it seems reasonable to use the dam height minus four feet as a good design criteria.

7. Page 3-19, 1st Para: "……… lake level was 5 ft below dam spillway". 5 ft below the dam spillway is 1377 but the text and table use 1378 and 1358. This is only a difference of one foot but it makes a significant difference in the volume of the hypolimnion and thus system sizing. What lake level and hypolimnion volume were used for sizing?

Table 3 presents information based on 10 feet below the dam or a water surface of 1372 feet, and Table 4 presents information based on four feet below the dam or a water surface of 1378. The text preceding both tables in inaccurate.

8. Page 4-20, last Para, and last sentence: says layers are 6 meters below the top of the hypolimnion. Should that be below top of the lake ?

The sentence shall be corrected to say 6 meters above the bottom of the lake.

9. Page 4-21 to 4-24:
All 4 options shown achieve more than 5 mg/l in some areas with option 10 having the greatest area with more than 5 mg/l and a significant area of over 8 mg/l. This appears to be a distribution problem. Can the distribution be improved resulting in a smaller size system ?

The distribution of oxygen appears reasonably good to PACE, for example the distribution of high oxygen is achieved to all three zones in 100 days. To improve the distribution, additional mixing flow is required, but additional mixing flow will greatly increase the capital cost considering the piping accounts for 40+% of the capital cost.

10. Page 5-29, last Para: "……..and alarm problems in the system operation". Does the BlueInGreen system have an alarm system and if so what does it look like ? The last line says"……. and is further described in section 6". I do not see that in section 6, where is it ?

Sentence should be revised to say:

The BlueInGreen system has advantages over the speece cone in that the oxygen saturation into the water column is tightly controlled with a variable speed pump to optimize efficiency. When oxygen is not properly dissolved or other problems occur in system operation, the BlueInGreen system automatically reacts to adjust its operation or has a system shutdown and alarms operations staff; whereas, the Speece Cone system does not provide these real time adjustments or safety shutdown functions.

The BlueInGreen system is further described in Section 7, not Section 6.

10. Page 7-55, fig 29: What is the cylindrical object between the 2 BIGSDOX units ?

The cylindrical object is no longer necessary. It shall be omitted.

11. Page 7-56, fig 30: upper view,
a. what does "from treatment location" mean ?
b. What are the yellow circles in the upper and lower views trying to show ?
c. What are the 2 "Dissolved Oxygen" gages trying to show ?

> **a. In the case of Canyon Lake, the treatment location is the low-oxygen bottom lake waters that require treatment.**
>
> **b. The yellow circles indicate areas where oxygen is dissolving into the water (top schematic) or diffusing into the water column (bottom schematic).**
>
> **c. The dissolved oxygen gauges are showing the theoretical standard BlueInGreen design oxygen concentrations in the treatment reactor and in a reservoir.**

12. We need to try to keep the size of the system down and thus the cost down, but we do not want to undersize it. Toward that end, we should consider the following:

a. Does the entire vertical height of the hypolimnion need to be the greater than 5 mg/l or is it just the lower level near the water/sediment interface that is critical ?

b. A safety factor of 1.5 seems high. What is the rational for that number ?

c. Was wind mixing taken into consideration for sizing the system ?

> **a. In our experience the hypolimnion oxygen concentration is similar vertically, so the bottom of the hypolimnion and the top of the hypoliminion have similar concentrations, and it is difficult to trap high oxygen near the sediments as a means of reducing the**

overall system size. We will rerun the model examining the oxygen concentration nearer the sediments.

b. **This safety factor is based on our experience with other reservoir system treatment designs for inefficient diffusion and dispersion, and includes standard inefficiencies used by ECO2 Speece Cone for oxygen bubbles that come out of solution (about 10% of applied oxygen). We can consider a lower safety factor, with the understanding that a level of design safety will not be provided.**

c. **Wind mixing historically mixes the top 20 feet of Canyon Lake and does not change the hypolimnion layer volume.**

Editorial:

13. Page E-1, 1st para, next to last sentence: “Central Body”. I am not sure if there is an official name, but it is commonly referred to as the “Main Body” or “Main Lake”.

14. Page E-2, Fig ES2: a reference to where these zones are may be helpful (i.e. “see page 2-12 for zone location”).

15. Page E-4, define WTP, LOX & EVMWD. Provide a reference as to where locations A, B & C are (i.e. see fig 25, page 5-33).

16. Page E-4, 1st para, 5th sentence: “he LOX” should be “the LOX”.

17. Page 3-15, 1st line: CL was divided into 3 zones for purpose of design but fig 12 shows 4 zones.

18. Page 5-26, last Para, next to last sentence: “……….. while diluting the water that will be pumped to zones I and II……..”. Should be zones II and III.

19. Page 5-27, fig 21: it is difficulty to see the 3 different colors on the schematic.

20. Page 5-33, Para 5.3: “……. As seen in fig 252.” Should be fig 25.

21. The tabs for appendix A and B are reversed.

All editorial corrections noted.

(from Tim Moore, 3/14/11)

22. It appears that the HOS is designed to assure compliance with the DO objective by oxygenating the water directly. Such an approach is both straight forward and conservative. However, it also requires a much larger and more costly system than previously anticipated.
In retrospect, much of the added cost may be due to the fact that the system is designed to achieve the DO objective less than 100 days after it begins operation. There may be another way to spec the system. Dr. Anderson's previous research shows there is a significant "feedback loop" governing the nutrient cycle in Canyon Lake. Sequestering nutrients in the sediment, via oxygenation, is expected to produce a cumulative compound benefit. Thus, in addition to assuming that the HOS can meet the DO objective directly, it is also appropriate to consider the indirect benefits associated with reducing phosphorus releases from the sediment and thereby interrupting the nutrient cycle.

Because every winter the bottom sediments are oxygenated for several months, the current winter oxygen depletion rates are in our opinion somewhat similar to the anticipated summer oxygen depletion rates of future years with the oxygenation system running. They both represent an aerobic depletion rate. We understand Dr. Anderson has shown slight improvement year to year with continued oxygen supply to create an almost 100% aerobic condition in the sediments, but an aerobic depletion rate is an aerobic depletion rate and it won't change drastically in our opinion. We agree that creating oxygen in 100 days starting from zero oxygen is really irrelevant, and we intend on re-running the models starting with saturated spring oxygen conditions and maintaining oxygen throughout the summer.

23. If a smaller HOS were built and begin operation by 2014, we would have at least two full years to meet the interim DO targets and nearly seven years to meet the final targets. Dr. Anderson should be able to calculate the incremental and cumulative indirect benefits associated with building such a HOS in Canyon Lake.

Since the proposed Option 10 dual zone system contains two independent treatment systems, it seems reasonable to install the zone 2/3 system first prior to installing the zone 1 system to monitor its effectiveness over a two-year period prior to expanding. The zone 2/3 system contains the critical mixing energy to distribute the oxygen properly.

24. The omission of indirect, long term, cumulative benefits and the addition of a substantial safety factor likely account for the large difference between Dr. Anderson's initial cost estimate (<$1 million) and Pace's more recent estimate (>$4 million). We need a more sophisticated modeling analysis of the type that Dr. Anderson did for Lake Elsinore in his report of March, 2006.

Doubling the treatment volume from Dr. Anderson's initial cost estimate to account for higher lake levels would increase the original cost estimates. Assuming it doubled, Dr. Anderson's estimate could be nearly $2M. In Table 32 the capital cost estimate for Option 10 for LOX was $2.56M, not >$4M. Thus, the two cost estimates are similar. Considering the doubling of cost of oil-based plastic pipe in eight years from when Dr. Anderson's estimate was provided, these estimates are even more comparable.

(from Dr. Anderson 3/18/11)

The report summarizes results from measurements conducted at the lake and in the laboratory, with hydrodynamic modeling of dissolved oxygen (DO) distribution to develop and evaluate several hypolimnetic oxygenation design alternatives. The approach adopted is sound and the report is well-written. The sediment oxygen demand and water oxygen demand rates measured by PACE in December 2010 are encouragingly similar to those that we found in 2007 (Anderson et al., 2007). The higher lake level and thicker hypolimnion than used in our previous work appears to be a principal reason for total DO demands that are higher than those reported in our study. PACE properly also included a safety factor in their design recommendations. Hydrodynamic modeling was a very useful tool for optimizing delivery of DO across the main basin of the lake. Modeling results suggest that option 10 provides efficient distribution of DO, with sufficient capacity to meet most any likely lake water quality condition. PACE also makes a strong case for use of liquid oxygen and the BlueInGreen system over the Speece Cone.

(from LESJWA Staff 3/21/11)

Executive Summary

25. Page E-1, Fig ES1, right hand legend for water depth missing.

26. Page E-4, 1st para, 5th sentence: “he LOX” should be “the LOX”.

Section 1

27. Pages 1-5, Fig 4, right hand legend for water depth missing.

28. Pages 1-6, Fig 5, right hand legend for water depth missing.

29. Pages 1-7, Fig 6, right hand legend for water depth missing.

Section 3

30. Pages 3-13, Fig 11, top legend for DO concentration missing.

Section 5

31. Page 5-33, 1st para, 2nd sentence, replace Figure 252 with Figure 25.

All editorial corrections noted.

(from Ron Young, 3/29/11)

32. There was concern about the design trying to create a 'high' DO throughout the hypolimniom and not just the sediment layer where the recycling of nutrients takes place under anaerobic conditions as the anaerobic bacteria are in the sediment and not in the water column. This may cause the O2 demand to be way too large for the actual needs of the deep sediment area.

In our experience the hypolimnion oxygen concentration is similar vertically, so the bottom of the hypolimnion and the top of the hypoliminion have similar concentrations, and it is difficult to trap high oxygen near the sediments as a means of reducing the overall system size. We will rerun the model examining the oxygen concentration nearer the sediments.

33. Another area of concern is the escalating cost from the first Anderson estimate of $0.5 to 1 MM, then Pace initial estimate at $2MM, and now at $3MM. With the loss of WLA and possible participants above Mystic Lake a more lean design may be needed. If generation is reduced then capital will also reduce making costs more possible for agency participation.

Doubling the treatment volume from Dr. Anderson’s initial cost estimate to account for higher lake levels would increase the original cost estimates. Assuming it doubled, Dr. Anderson’s estimate could be nearly $2M. In Table 32 the capital cost estimate for Option 10 for LOX was $2.56M, not >$4M. Thus, the two cost estimates are similar. Considering the doubling of cost of oil-based plastic pipe in eight years from when Dr. Anderson’s estimate was provided, these estimates are even more comparable.

The 1.5X safety factor used in the design was based on our experience with other reservoir system treatment designs. We can consider a lower safety factor, with the understanding that a

level of design safety will not be provided. We also recommend consideration of proceeding with installation of only one of the two Option 10 dual-zone oxygenation systems as described in comment 23.

34. With all the interest in cost, the life cycle costs should be more detailed with a breakdown of assumptions so costs can be allocated based on WLA of agencies above Canyon Lake.

Life-cycle cost is not detailed Section 6 because it is calculated simply as the capital cost plus the 20-year present worth O&M cost at 8% discount rate. The O&M cost is based on nine months of operation per year.

35. The TAC with input from Anderson and Komor should take a look at the hybrid of Phosloc and HOS. Maybe HOS is only a fraction of the size and cost.

The oxygen depletion rate will be dependent on the quantity of organic material in the water column and sediments, consisting of many things including natural debris and dead algae. Assuming phosphorus was decreased, dead algae could decrease, which would decrease the organic material, and would decrease the oxygen depletion rate. It is difficult to quantify this potential benefit at this time. It seems reasonable in an effort to take advantage of these benefits to install the HOS system in a phased approach as described in comment 23 to allow time for a smaller system to operate and monitor the lake oxygen improvement.

36. PACE should do a payback calc on O2 generation vs. LOX based on the number of days per year that the systems operate, which might be about 1/2 of the year.

Using Option 10 O&M cost estimates with an oxygen generator in Table 30 and with LOX in Table 33, the difference in annual O&M is approximately $21,000 per year, with LOX being more expensive. The difference in capital cost, comparing Table 29 with Table 32, shows a difference in capital cost of approximately $370,000, with LOX being less expensive. Thus, assuming no discount rate, the payback would be approximately 18 years.

37. PACE should add a discussion on how the system will meet the TMDL requirements. I'd like to see some probabilities if possible on reducing the nutrient recycling so the pollutant credits can be calculated and costed out for trading.

The TMDL Targets are shown in Table 1 of the report (NOTE: the DO limits were stated incorrectly in the report but have been revised herein):

Table 1: Basin Plan Resolution No. R8-2004-0037 TMDL Targets for Canyon Lake

Indicator	TMDL Targets
Total Phosphorus Concentration	≤ 0.1 mg/L in 2020
Total Nitrogen Concentration	≤ 0.75 mg/L in 2020
NH3-Nitrogen Concentration	CMC and CCC limits per formula
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Chlorophyll a Concentration	≤ 40 ug/L in 2015

Epilimnion DO Concentration	≥ 5 mg/L in 2015*
Hypolimnion DO Concentration	≥ 5 mg/L in 2020*

The scope of work we have provided is to meet the DO concentration hypolimnion objective of the TMDL. We believe the probability of meeting this DO concentration objective is essentially 100% if Option 10 was installed. By installing the first phase of Option 10, we believe the probability decreases to 50-80%. The benefit to the other three parameters was not part of our scope, but it is reasonable that the phosphorus and ammonia will decrease with oxidized sediments. Decreased dissolution of phosphorus and ammonia will decrease algae, which decreases chlorophyll. The exact quantity of decrease is difficult to predict, but based on experience could be on the order of 25-50% reduction after five years of operation.

38. Can we get some expectations on the hybrid systems discussed by Tim to see how much different they may be from pure HOS?

We are not sure of which hybrid systems are described, whether it is hybrid Phosloc/HOS or phased HOS or something else. Response 35 describes information related to the hybrid Phosloc approach and response 23 describes information related to the phased HOS approach.

39. Should there be some recognition of the value for siting the facilities on EVMWD property so we are seem as adding value to the solution to reduce requests for paying to get intangible benefits due to HOS. The water treatment plant operation schedule won't be the same as the HOS operation but there will be some overlap. The WTP only operates about 5 months / yr. and can start and stop during spring and fall turnover when there is mixing to bring iron and manganese water to the surface.

Assumed that this question was directed at staff.

40. Does HOS operation guarantee no FE or MN during turnover events?

In an oxidized condition iron and manganese will not dissolve into the water column in the hypolimnion during a stratified summer condition. Thus, instead of seeing elevated iron and manganese rise to the surface after a turnover, the epilimnion background iron and manganese concentrations shall also be present at the bottom of the reservoir before, during, and after turnover.

Lake Elsinore & San Jacinto Watersheds Authority

Canyon Lake Hypolimnetic Oxygenation System

April 2011
(February 2011) – Revised

Prepared For:

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PACE JN 9653E

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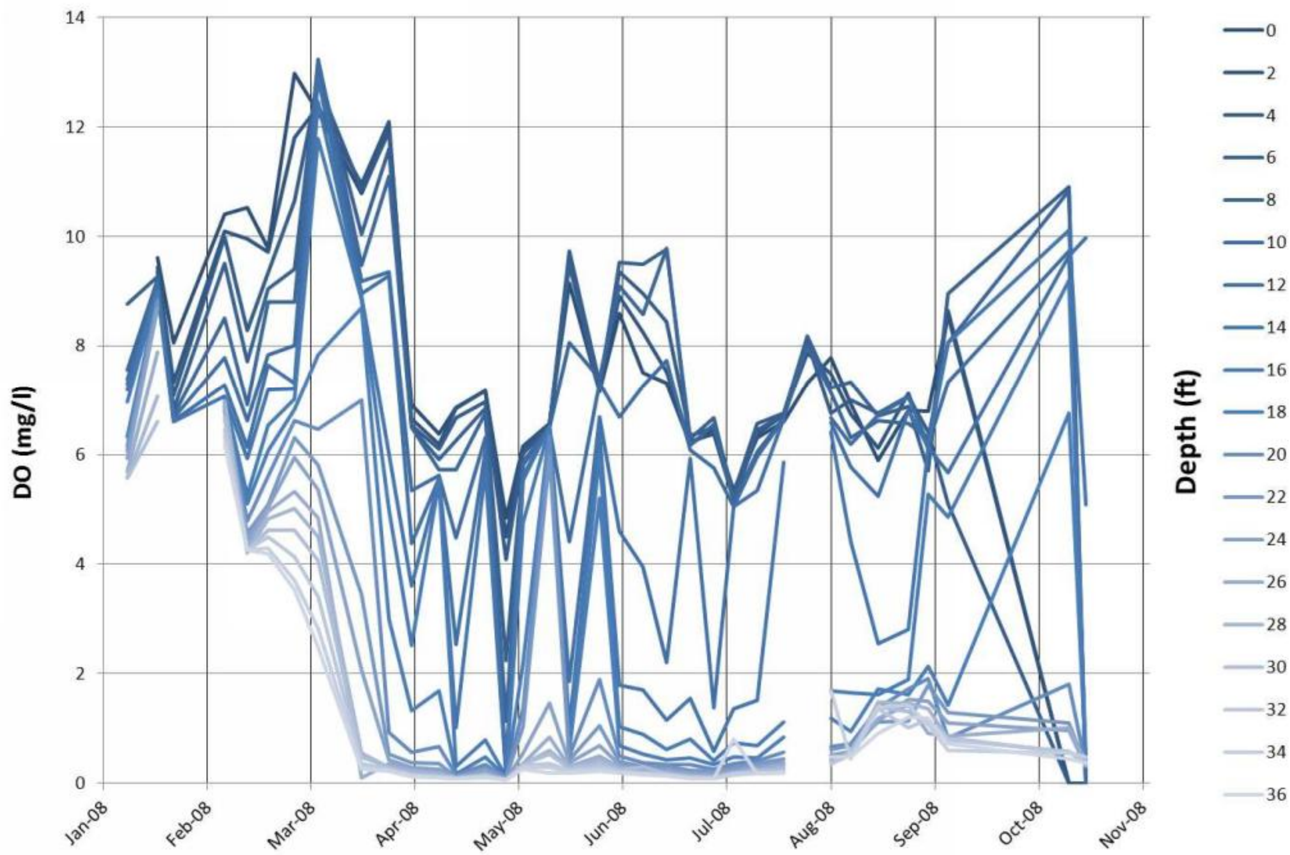
Executive Summary

Executive Summary

Canyon Lake is listed on the Clean Water Act Section 303(d) list as impaired for excessive nutrients and high bacteria. The Regional Water Quality Control Board identified numeric water quality targets for total phosphorus, total nitrogen, ammonia, chlorophyll a, and dissolved oxygen. The primary in-lake treatment strategy recommended by the project stakeholders was a deep water, or hypolimnetic, oxygenation system. This report describes the preliminary design of this oxygenation system for the Main Lake of Canyon Lake. Figure ES1 shows Canyon Lake's low oxygen concentrations at water depths below 20 feet throughout the summer.

Figure ES1: 2008 Canyon Lake Oxygen versus Time at Various Depths

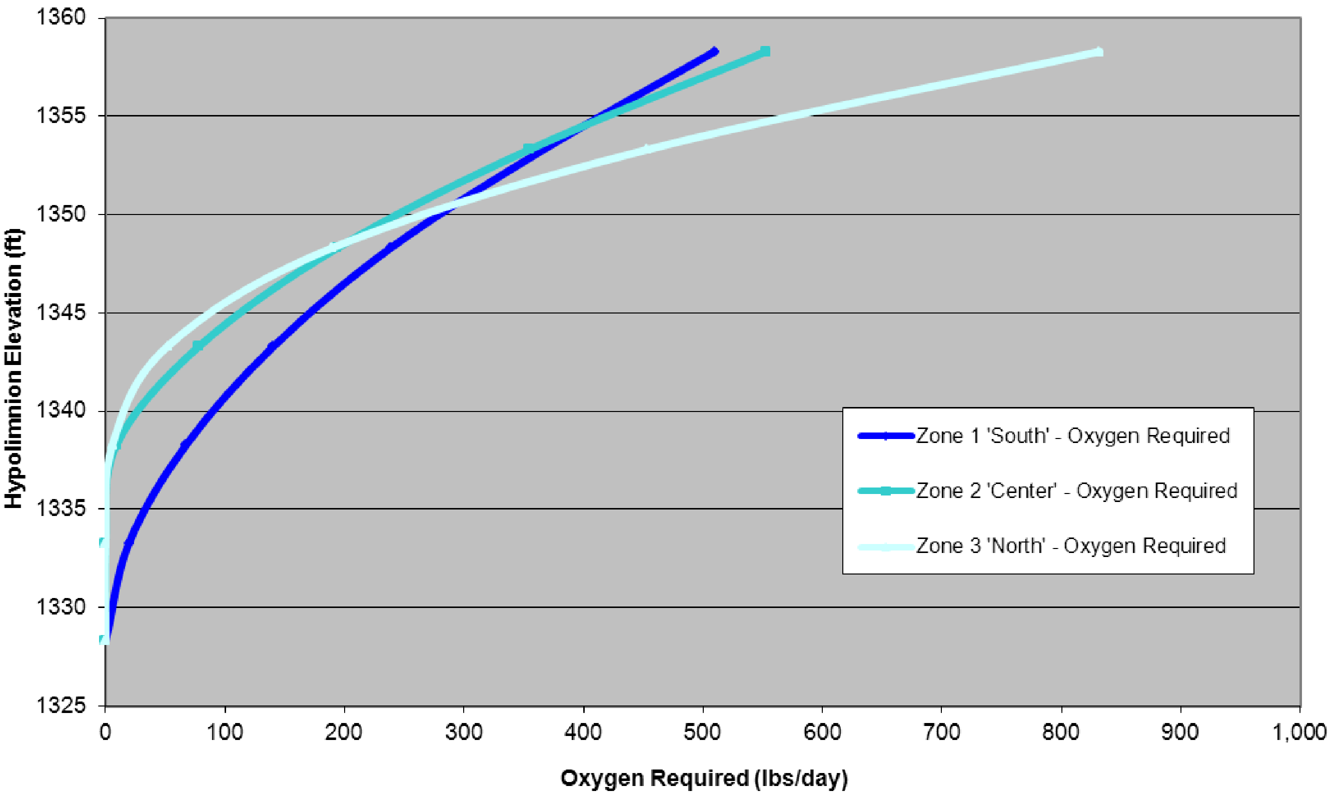


The following new data was collected as part of the preliminary design report evaluation:

1. Depth measurements to augment and clarify the existing bathymetry
2. Bottom of lake organic muck layer depth and characteristics near the dam
3. Location of deep and flat location suitable for submerged equipment (buoy installed)
4. Temperature, pH, and oxygen profiles during three periods of 2010
5. September collection of samples and experimentation of oxygen depletion rates from six sites including soil, bottom water, and top water at three different temperatures
6. December collection of samples and experimentation of oxygen depletion rates from three sites including soil and bottom water at a temperature of 15°C

Oxygen requirements for the Canyon Lake hypolimnetic oxygenation system were calculated using results from the oxygen depletion tests in conjunction with bathymetric data of the lake showing volume versus depth. Oxygen depletion rates of water (mg/L/day) and soil (g/m^2/day) were multiplied by the total volume of water and area of soil to be treated.

Figure ES2: Combined Soil and Water Hypolimnion Oxygen Depletion versus Hypolimnion Level



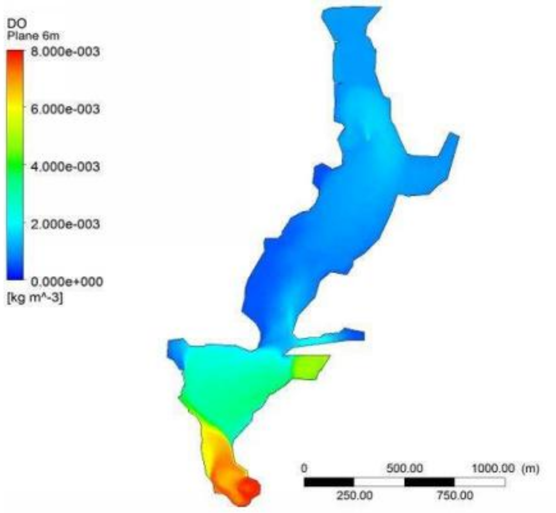
A modeling analysis was performed to evaluate the effectiveness of supplying the suggested oxygen quantities to Canyon Lake at various flows and oxygen concentrations. Ten different options were created and modeled. A 3D Computational Fluid Dynamic (CFD) model was developed for the main reservoir using bathymetric data provided. The experimental oxygen demands were used to determine the rate of oxygen depletion throughout the lake. The level of the lake was 1378 feet above sea level in order to evaluate a condition with a higher oxygen demand as compared to a lower lake elevation. Each system was run for a 100 day time duration at a 10 day time step interval.

Of the ten options listed, four options in particular were chosen to present in this report because they display well the effectiveness of increased water flow and oxygen output:

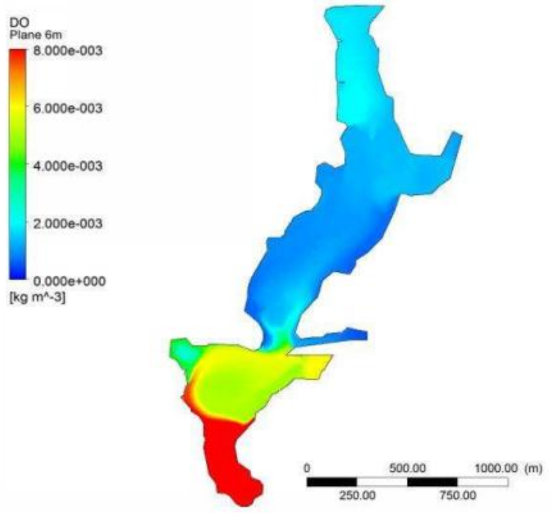
- Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
- Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
- Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
- Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L

Figures ES3a, ES3b, ES3c, and ES3d show model results from option 10. The images are of Canyon Lake at a depth of 6 meters (20 feet) below the top of the hypolimnion layer.

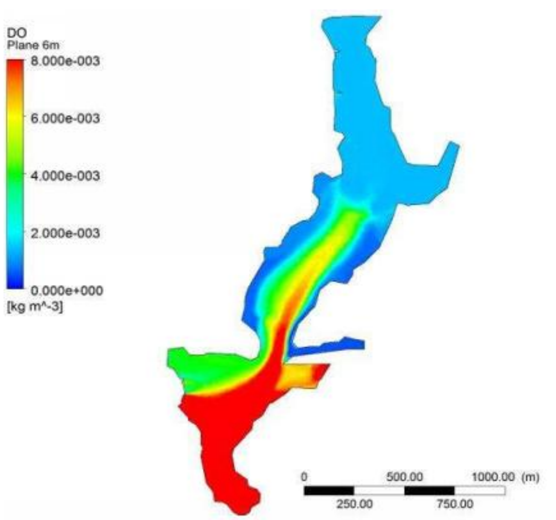
Figure ES3: - Option 10: 3,000 lbs O2/day delivered by 5,000 gpm



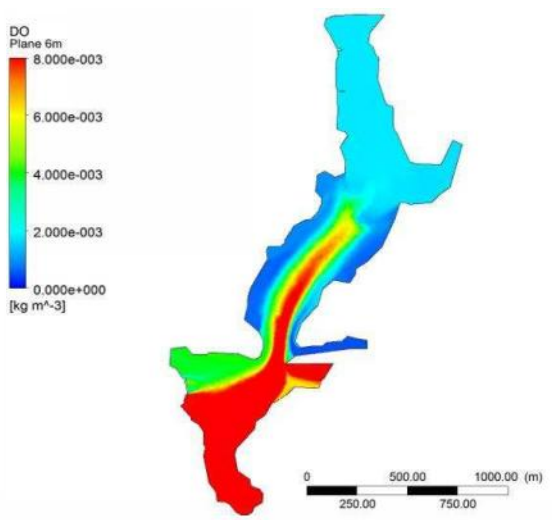
20 Days of Operation



50 Days of Operation



70 Days of Operation



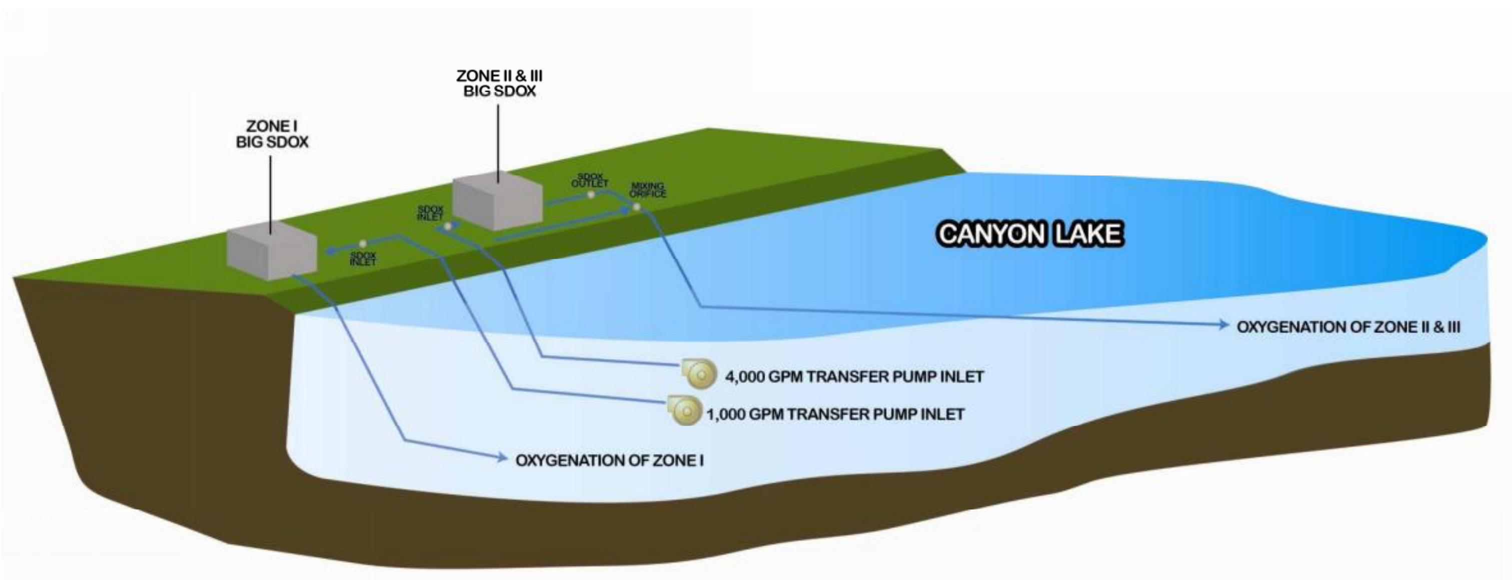
100 Days of Operation

After review of the information presented, after meetings with operations staff from EVMWD (Elsinore Valley Municipal Water District), and after careful evaluation of model results and cost estimates, PACE recommends proceeding with option 10 (3,000 lb/day at 5,000 gpm system) using two on-shore oxygenation systems: one high oxygen concentration system for zone 1, and one low oxygen concentration, high flowrate system for zones 2 and 3. When considering onsite oxygen generation or LOX (Liquid Oxygen) for oxygen production, the LOX system seems to be more advantageous because: 1) electrical upgrades will be costly and LOX does not require new electrical, 2) LOX is very quiet and requires very little maintenance, 3) LOX is better at delivering peak oxygen when necessary, 4) there is ample space and good access for LOX in Location A. Equipment locations can be found in Figure 25 on page 5-33.

PACE recommends the following: use a standard high pressure/high oxygen concentration BlueInGreen system for zone 1 and a modified side-stream low pressure/low oxygen concentration BlueInGreen system for zones 2 and 3. BlueInGreen's SDOX system is lower capital cost, smaller size, and unlike the Speece Cone, the BlueInGreen system is easier to operate because the pump speed can be perfectly regulated to optimize oxygen dissolution in the water. This is achieved by maintaining a constant water level in the tank, and water is sprayed through the headspace.

The systems could be located at the Canyon Lake WTP (Water Treatment Plant) as follows: Location B can be outfitted with new submersible pumps using the existing intake structure, Location A parking lot can be used for a new dual tank LOX facility, and Location C can be used to install two new BlueInGreen SDOX skids. The anticipated costs for this proposed system are as follows: capital cost $2.6M, annual operation and maintenance cost $0.14M, and 30 year life cycle cost $4.0M.

Figure ES4: Conceptual Schematic of Canyon Lake Dual On-Shore Oxygenation System



Main Report

Main Report

1 Background to Canyon Lake Oxygen Deficiency

Canyon Lake is listed on the Clean Water Act Section 303(d) list as impaired for excessive nutrients and high bacteria. The Regional Water Quality Control Board, Santa Ana Region, adopted a resolution in 2004 to amend the Basin Plan to incorporate total maximum daily loads (TMDLs) for Canyon Lake to control nutrients, specifically identifying numeric water quality targets for total phosphorus, total nitrogen, ammonia, chlorophyll a, and dissolved oxygen. This TMDL was subsequently approved by the State Water Resources Control Board and by the U.S. Environmental Protection Agency.

As part of the TMDL, an In-lake Sediment Nutrient Treatment Plan was prepared and strategies were initiated to prevent the release of excess nutrients from lake sediments. The plan was completed and submitted to the Regional Board in July 2007. This study was followed-up with additional analysis, the "Predicted Effects of External Load Reductions and In-Lake Treatment on Water Quality in Canyon Lake – a Supplemental Simulation Study" was completed in December 2008. This report prepared by Dr. Michael Anderson demonstrates that in-lake oxygenation treatment will enhance oxygen and phosphorus, but both in-lake oxygenation treatment and a large reduction in external nutrient sources from the watershed are required to approach meeting agency goals.

Table 1: Basin Plan Resolution No. R8-2004-0037 TMDL Targets for Canyon Lake

Indicator	TMDL Targets
Total Phosphorus Concentration	≤ 0.1 mg/L in 2020
Total Nitrogen Concentration	≤ 0.75 mg/L in 2020
NH3-Nitrogen Concentration	CMC and CCC limits per formula
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Chlorophyll a Concentration	≤ 40 ug/L in 2015
Epilimnion DO* Concentration	≥ 5 ug/L in 2015
Hypolimnion DO* Concentration	≥ 40 ug/L in 2015

* - dissolved oxygen abbreviated by DO

The primary in-lake treatment strategy recommended by the project stakeholders was a deep water, or hypolimnetic, oxygenation system. This report describes the preliminary design of this oxygenation system for the Central Body of Canyon Lake.

Canyon Lake was formed in 1928 when the Canyon Lake / Railroad Canyon Dam was constructed. The lake has three main sections – the relatively shallow East Bay (depths generally less than 10 ft), the deeper Central Body of the lake (depths in excess of 40 ft), and the area north of the causeway that connects with the San Jacinto River. Elsinore Valley Municipal Water District (EVMWD) has used the reservoir as a potable water source since 1957 when the Canyon Lake water treatment plant began operation. Allowable recreational activities on Canyon Lake are defined in the lease agreement between EVMWD and the Canyon Lake POA and include swimming, boating, fishing and water sports.

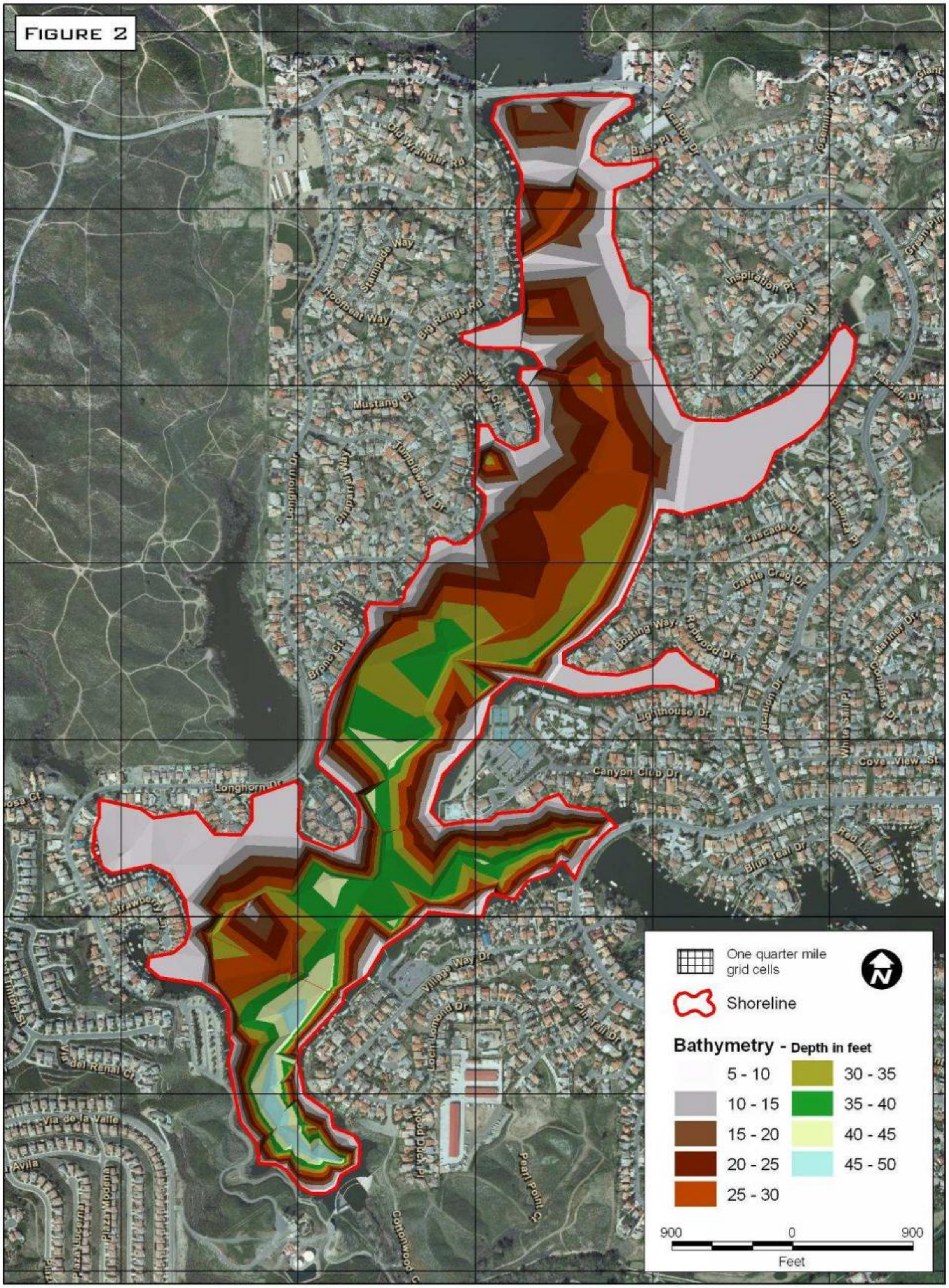
The Central Body of Canyon Lake is a monomictic, eutrophic lake that typically stratifies from about late-February/early-March through late-November/early-December each year. Maximum depth of the main body of the lake is about 50 feet, with a mean depth of approximately 20 feet. In the Central Body of the lake the water column is divided into three depth zones, with the deep-water layer starting at about the 20 to 25 foot depths by mid-summer, with oxygen depletions at or near zero at 16 to 18 feet. The deep water becomes anaerobic and devoid of dissolved oxygen by early summer each year. This low oxygen condition causes the release of dissolved iron, manganese, ammonia, hydrogen sulfide, phosphorus and other substances that degrade potable water quality. Phosphorus release from sediments under anaerobic conditions may increase eutrophication through internal phosphorus loading.

Figure 1 shows a vicinity map including the three main sections of Canyon Lake, and Figure 2 shows a bathymetry map of the Central Body.

Figure 1: Vicinity Map of Canyon Lake

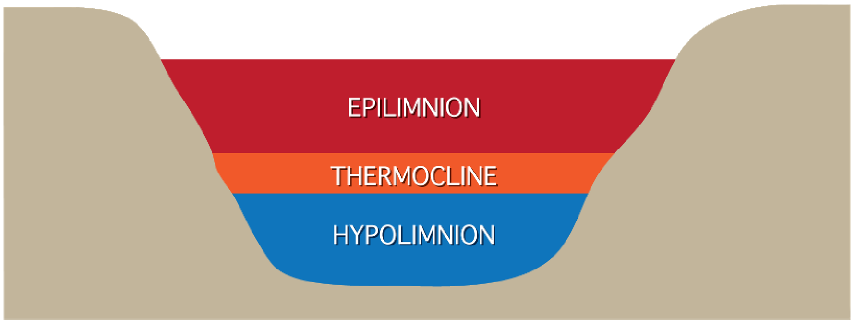
PACE

Figure 2: Bathymetry Map of Central Body of Canyon Lake



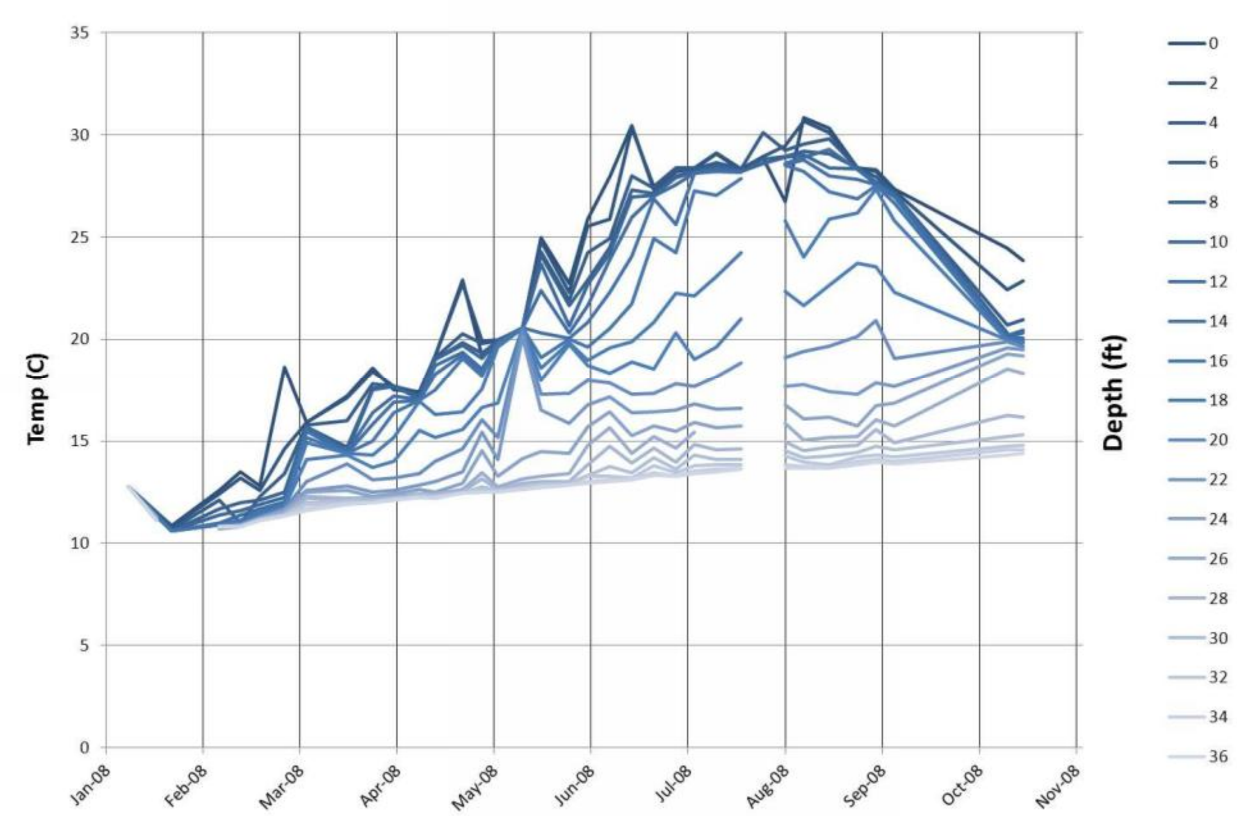
For purposes of discussion, the top layer of lake water is referred to as the epilimnion, which is typically the warm, low-density water present at the top of a lake. The bottom layer of lake water is the hypoliminion, which consists of cool, high-density water. The layer in-between the epilimnion and hypolimnion is the thermocline, which is the layer of water with transitioning temperature

Figure 3: Lake Layer Terminology



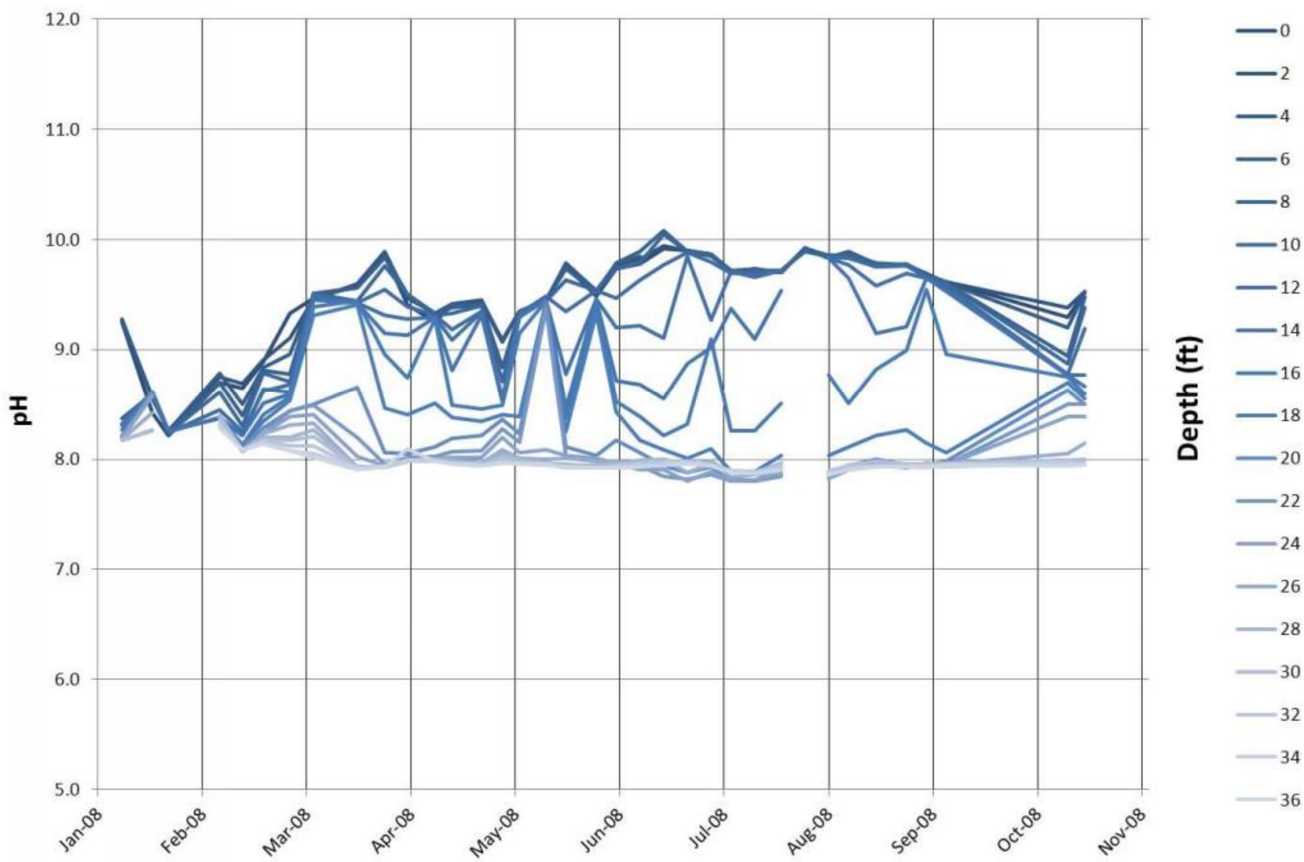
EVMWD has been collecting weekly temperature, pH, and dissolved oxygen measurements from Canyon Lake near the Canyon Lake Water Treatment Plant for the past seven years. 2008 had one of the best data records available, and the data is shown in Figures 4, 5, and 6. As shown in Figure 4, the hypolimnion was thermally separated from the upper layers of water by a density difference, and atmospheric oxygen was not able to penetrate to the lower depths (see Figure 6).

Figure 4: 2008 Canyon Lake Temperature versus Time at Various Depths



The lack of photosynthetic activity and the presence of bacterial respiration in the hypolimnion are indicated by lower pH as shown in Figure 5. The epilimnion had higher pH due to high algae and other photosynthetic organisms including cyanobacteria.

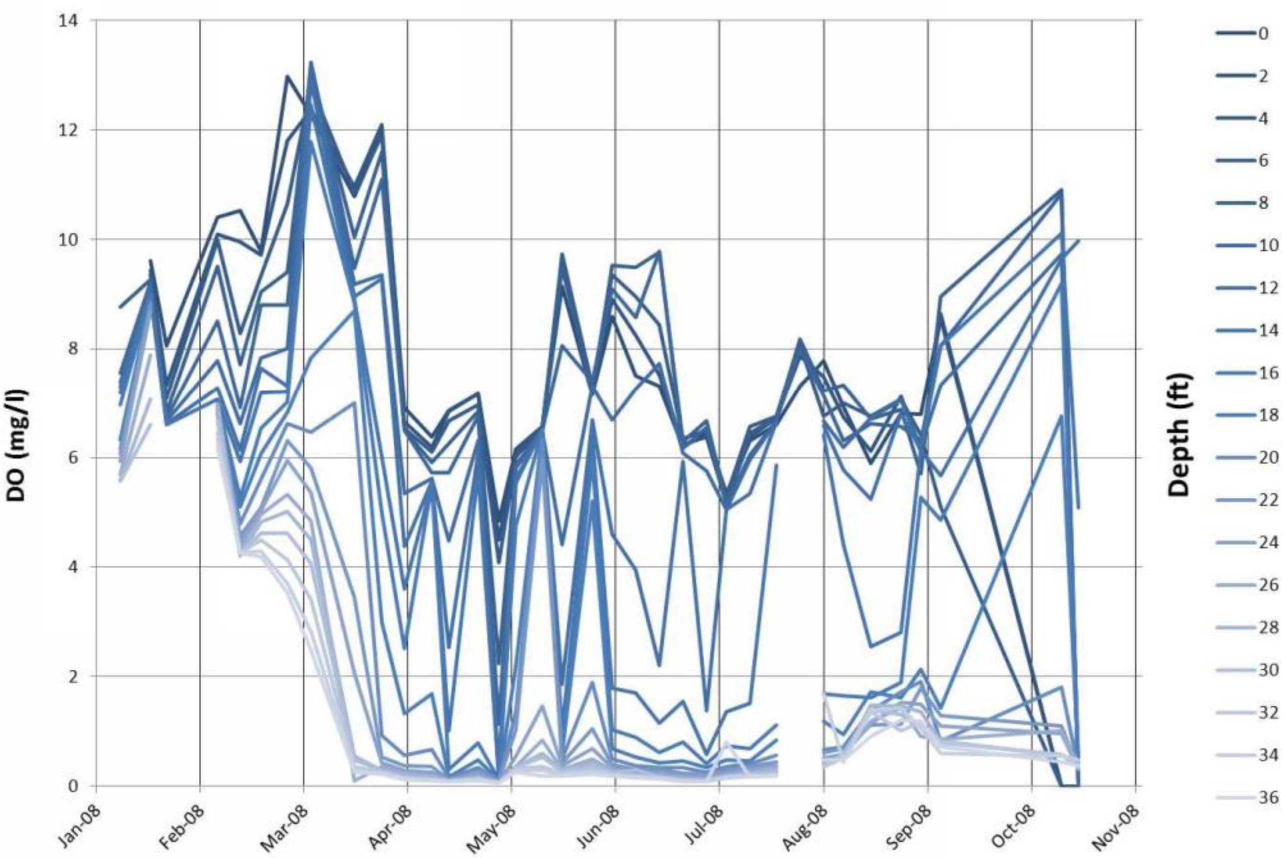
Figure 5: 2008 Canyon Lake pH versus Time at Various Depths



As shown in Figure 6, starting in early April through November, Canyon Lake has zero oxygen in the hypolimnion. This is typical of deep reservoirs such as Canyon Lake without mechanical mixing or oxygen injection systems. The disadvantage of having low oxygen in bottom waters is that it causes reduced constituents such as iron, manganese, phosphorus, ammonia, and sulfide to dissolve into the water column. The dissolution of these constituents then causes immediate bacterial respiration of oxygen, but also high quantities of algal growth, and the decaying algae is ultimately consumed by bacteria and respired. The high rates of respiration cause additional oxygen depletion and additional nutrient dissolution.

The reversal of this process is similar in that in theory it is exponentially beneficial: increases bottom water oxygen will reduce nutrient dissolution, which decreases algal growth, which decreases bacterial respiration. The other benefit of hypolimnetic oxygen injection without mixing is that the cool temperatures shown in Figure 6 reduce metabolic activity which reduces oxygen consumption.

Figure 6: 2008 Canyon Lake Oxygen versus Time at Various Depths



2 New Data Collection Performed

The following new data was collected as part of the preliminary design report evaluation:

1. Depth measurements to augment and clarify the existing bathymetry
2. Bottom of lake organic muck layer depth and characteristics near the dam
3. Location of deep and flat location suitable for submerged equipment (buoy installed)
4. Temperature, pH, and oxygen profiles during three periods of 2010
5. September collection of samples and experimentation of oxygen depletion rates from six sites including soil, bottom water, and top water at three different temperatures
6. December collection of samples and experimentation of oxygen depletion rates from three sites including soil and bottom water at a temperature of 15°C

2.1 Depth Measurements

Bathymetric data provided to PACE showed a large mound in the topography of the lake on the border of Zone I and Zone II. It was unclear whether this mound was actually present or caused by interpolating between the points surrounding the area of concern. PACE performed a site visit in November 2010 to clarify the results. Depth measurements were taken where the mound was supposedly located and it was determined that the mound did not exist. The removal of this mound from the bottom of the lake increased the volume of the hypolimnion.

2.2 Muck Layer Depth

In October 2010 a diver investigation was performed on the Canyon Lake bottom near the southern dam. The diver was to measure the muck layer depth during the investigation using a six foot retractable rod. It was found that the diver could not reach solid lake bottom through the muck layer using the six foot rod. The muck was then measured from the surface using 10' galvanized pipe segments. It was found that the area near the dam had a consistent muck depth of 8 – 10 feet.

Muck measurements were taken for Zone II and Zone III during the November 2010 site visit. Muck depth in the main body of Zone II and the southern area of Zone III remained similar to that found near the dam: between 8 – 10 feet thick. The northern half of Zone III had a thinner muck thickness of 4 – 5 feet.

2.3 Submerged Equipment Location

During the October 2010 diver investigation a suitable location for a submerged oxygenation skid and intake pumps was to be determined. A suitable location was defined as a flat expanse of lake bottom, clear of obstructions, with a thin muck layer, preferably near the treatment plant shore.

It was discovered using sonar attached to the boat and trolling the dam area that the area is relatively flat. The diver performed two dives to ensure the area was clear of obstructions. Obstructions were found near the intake structure to the treatment plant, but north of the intake there were no obstructions. A buoy was placed at a location deemed suitable for the submerged equipment. The location of this buoy can be seen in the following figure.

Figure 7: Buoy Location for Submerged Equipment

2.4 Temperature and Oxygen Profiles

Temperature, oxygen, conductivity, pH, and ORP measurements were collected from six sampling sites at Canyon Lake in September 2010, two sites in October 2010, and two sites in December 2010. Measurements were taken using a YSI 650 MDS with a Model 600 Sonde.

2.5 September Oxygen Depletion Test – Summer Period

On September 9, 2010 PACE conducted a site visit to Canyon Lake to collect samples for testing. Six sites were selected throughout the lake to provide a comprehensive representation of the system. These sites are shown in Figure 8. Water samples were collected from the top (surface) and bottom (2' from the bottom) using a Wildco® Horizontal Alpha™ water sampler with a capacity of 3.2 L. Core soil samples were collected from all six sites using a Wildco® 196-F65 Tall Ekman Bottom Grab (6" x 6" x 9"). To contain core samples, 2.5" x 12"clear plastic tubes were used. Two soil samples, two bottom water samples, and two top water samples were collected from each site except for site 40 which only had one top water sample due to available space for testing. Water and sediment samples were transported in coolers to the PACE Environmental Water Laboratories (Fountain Valley, CA) where oxygen depletion tests were performed. The samples collected on September 9, 2010 were tested for oxygen depletion rates from September 10 – September 22, 2010. The samples were placed in a water bath that could maintain constant temperature for the tests. The three temperatures used for this test were 15°C, 22°C, and 27°C. The setup for these tests are shown in Figure 8.

Figure 8: Six Sampling Site Locations for September 9, 2010 Oxygen Testing

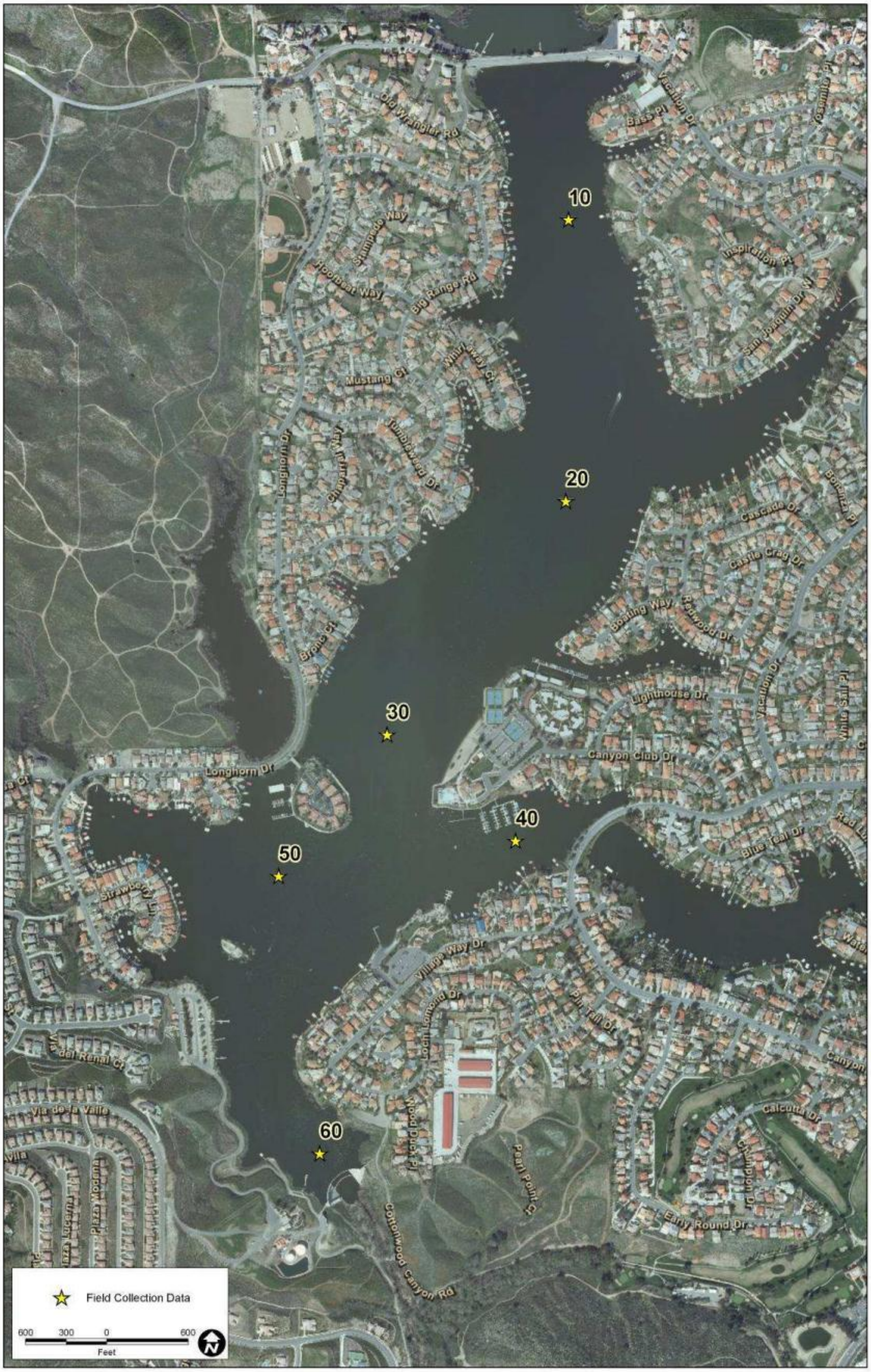


Figure 9: Water and Sediment Oxygen Depletion Testing Setup

Every sample was aerated, and re-aerated, prior to each depletion test so that the dissolved oxygen would be at measurable concentrations. Dissolved oxygen concentrations were measured with a Hach LBOD101 Luminescent Dissolved Oxygen Probe. Dissolved oxygen would be measured every hour for the first three hours, and then every 8-16 hours afterward until depletion rates were determined to be zero. After every measuring interval each tube was purged of excess air space using nitrogen and then sealed to prevent introducing new oxygen to the test.

2.6 December Oxygen Depletion Test – Winter Period

A second round of sampling was performed on December 17, 2010 in order to determine oxygen depletion rates after destratification had occurred. Three points were chosen for this round of sampling, one location per oxygenation zone as decided by PACE during previous design steps. The sampling locations for this round can be seen in Figure 10. Three bottom water samples and three core soil samples were taken from each site using the same equipment as had been used during the September 9th visit. Samples were transported to the PACE Environmental Water Laboratories where oxygen depletion tests were once again performed at varying temperatures for the following week.

The samples collected on December 17, 2010 were tested for oxygen depletion rates from December 19 – December 21, 2010. The samples were placed in a water bath that could maintain constant temperature for the tests. Since it had been determined that the hypolimnion water temperature is consistently around 15°C, the test was only run at this one temperature. Every sample was aerated, and re-aerated, prior to the test so that the dissolved oxygen would be at measurable concentrations. Dissolved oxygen concentrations were measured with a Hach LBOD101 Luminescent Dissolved Oxygen Probe. Dissolved oxygen would be measured every hour for the first two hours, and then every 8-16 hours afterward until depletion rates were determined to be zero. After every measuring interval each tube was purged of excess air space using nitrogen and then sealed to prevent introducing new oxygen to the test.

Figure 10: Three Sampling Site Locations for December 17, 2010 Oxygen Testing

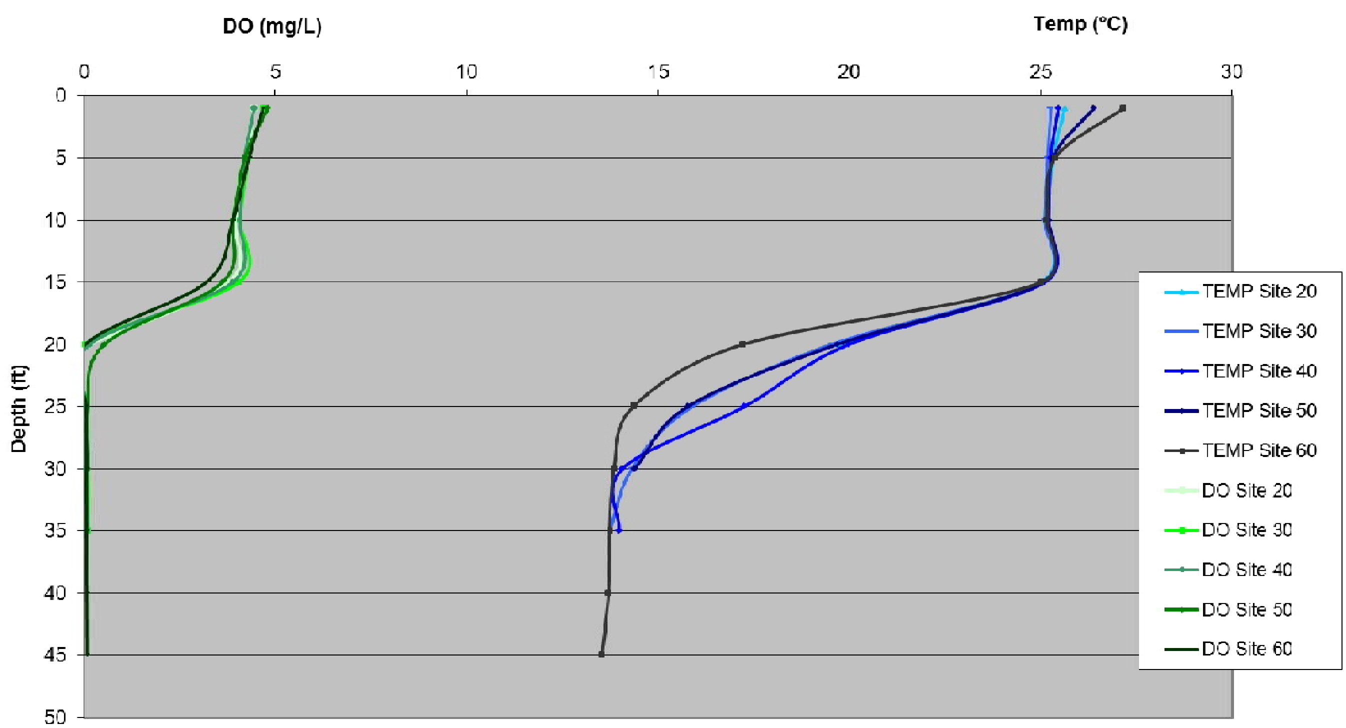
3 Calculated Oxygen Requirements

Oxygen requirements for the Canyon Lake hypolimnetic oxygenation system were calculated using results from the oxygen depletion tests in conjunction with bathymetric data of the lake showing volume versus depth. Oxygen depletion rates of water (mg/L/day) and soil (g/m^2/day) were multiplied by the total volume of water and area of soil to be treated.

3.1 Size of Hypolimnion

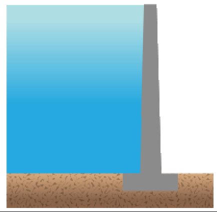
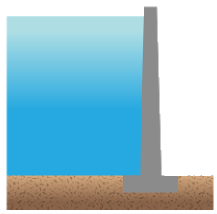
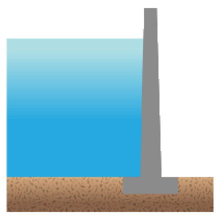
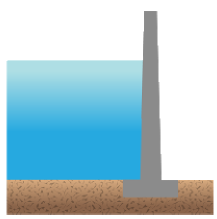
Historical temperature and dissolved oxygen data as shown in Section 1 shows the hypolimnion layer begins at approximately 20 feet deep. The 2010 profiling data supports this conclusion. As shown in Figure 11, stratification can be seen during the September site visit. The epilimnion was warmed throughout the spring and summer while the hypolimnion remained cold, preventing the two layers from mixing, and causing oxygen concentrations to reduce to essentially zero milligrams per liter.

Figure 11: 9/9/2010 Canyon Lake Dissolved Oxygen (Green) & Temp (Blue) at Varying Depth



The volume of water to be treated was therefore calculated as all hypolimnetic water located 20 feet or deeper in the lake. The volume and area to be treated are shown in Table 2. Canyon Lake has a maximum water surface elevation of 1,382 feet above sea level, where spill over occurs downstream of the dam on the south end of the lake. The storage volume of the lake at this water elevation is approximately 6,000 acre-feet, or nearly 2 billion gallons of water. Typical water surface elevation is maintained at 1,375 feet.

Table 2: Canyon Lake Area and Volume and Area and Volume of Hypolimnion

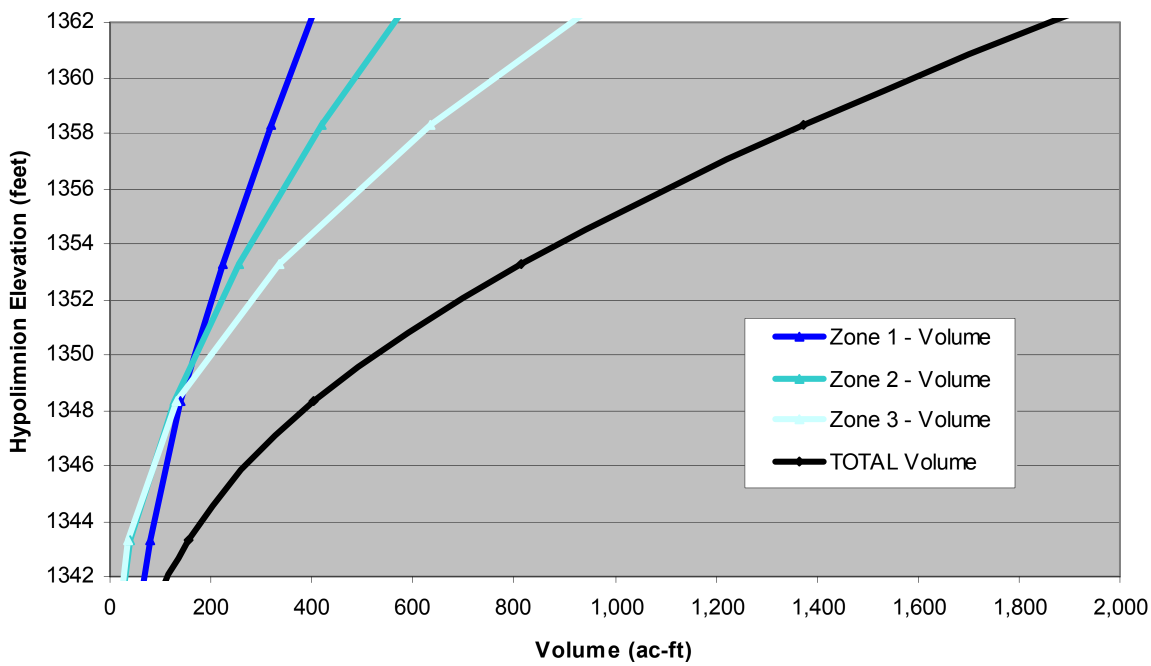
Lake Elevation *(ft)*		Total Lake Area *(ac)*	Total Lake Vol *(ac-ft)*	Hypolimnion Area *(ac)*	Hypolimnion Vol *(ac-ft)*
1382		~230	5,924	152	1,874
1378		~230	5,055	130	1,340
1375		~230	4,368	110	962
1372		~220	3,707	99	768

* - NOTE: Bathymetric data obtained from LESJWA on 8/10/10 from City of Canyon Lake (undated) was used for the first round of calculations, but due to extrapolation showed a large underwater mound in the south end of Zone II. PACE conducted a survey of the mound on November 17, 2010, and discovered the mound was not present. The new survey data points were implemented into the calculation and the hypolimnion volume was increased by 51,000,000 gallons, and the data in Table 2 reflects this adjustment.

Canyon Lake was divided into three oxygenation zones (Zones I – III) and one zone that does not require treatment (Zone IV) for the purposes of design:

Figure 12: Three Zones Used for Oxygenation Design

Figure 13: Elevation of the Hypolimnion (20 Ft below Water Surface) versus Hypolimnion Volume



As shown in Figure 13, the three zones have similar volumes of hypolimnetic water that requires oxygenation, however, zones 2 and 3 expand in volume at a faster rate with increasing depth as compared to zone 1.

3.2 Oxygen Depletion Rates in Hypolimnion

Results from the water and sediment oxygen depletion testing in September (summer condition) and December (winter condition) were widely varying, with water oxygen demands in the summer being approximately seven times higher than winter rates. September (summer) results showed extremely high oxygen depletion in both the water and sediments, even after multiple re-aeration steps, likely due to the long duration of anaerobic conditions and buildup of reduced constituents such as sulfide, manganese, iron, and ammonia. It was accepted that the high rates of summer condition oxygen depletion was mostly irrelevant to the oxygenation system design, because the proposed oxygenation system would never allow accumulation of reduced constituents which create excessive oxygen demands. Thus, the December results were thought to be more representative of the oxygen demand requirements from an aerobic system such as Canyon Lake with an oxygenation injection system.

Thus, for the purposes of this report, only the December winter period results are presented. Soil and water oxygen depletion rates are shown in Figures 14 and 15. Oxygen depletion due to soil bacteria respiration was linear, with site 25 in zone 2 and site 35 in zone 1 having similar rates of oxygen reduction, but site 15 in zone 3 had nearly half the rate of depletion as compared to zones 2 and 3. In general, zone 3 is located in a shallower portion of the lake, and is believed to be subject to lower duration anaerobic conditions. Also, during muck depth measurement, zone 3 had a shallower muck depth, which represents a lower quantity of high-respiration organic bacteria.

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Figure 14: Canyon Lake Soil Oxygen Depletion Test Results from Winter Period (December 17, 2010)

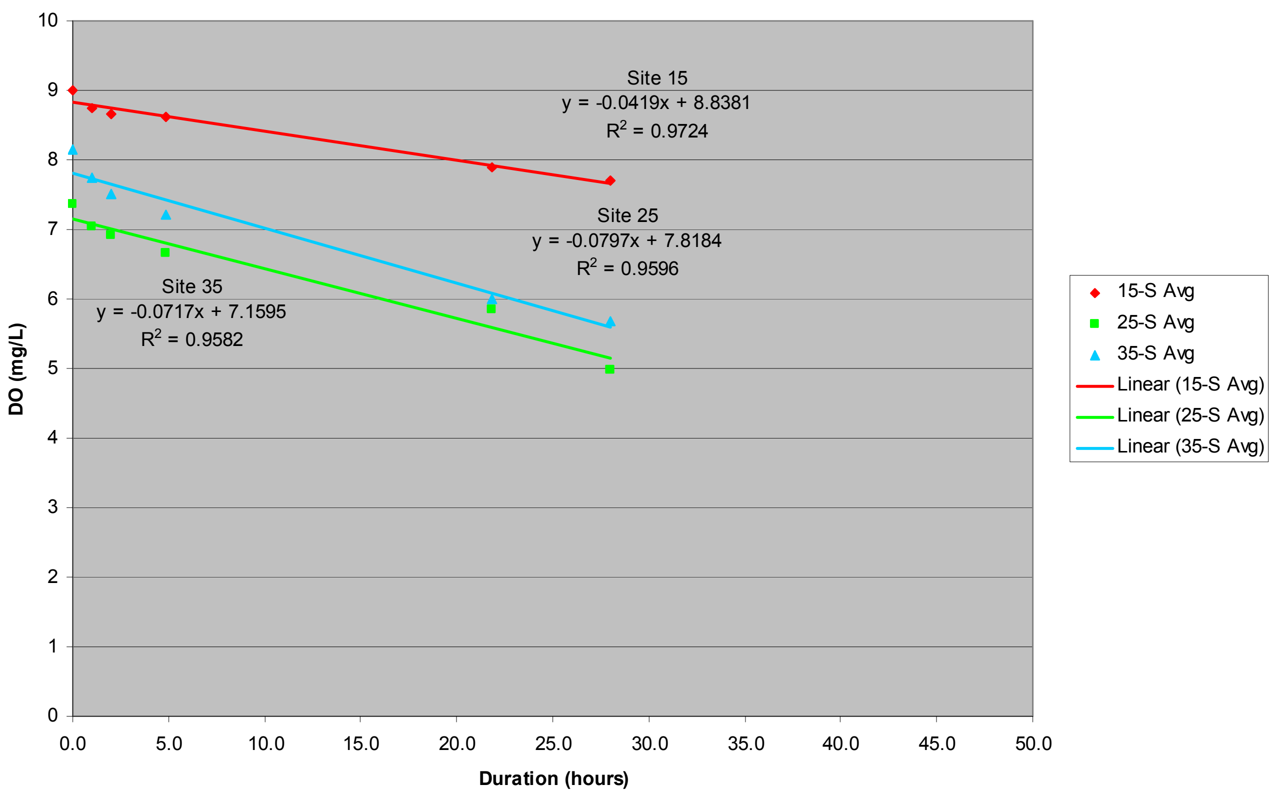
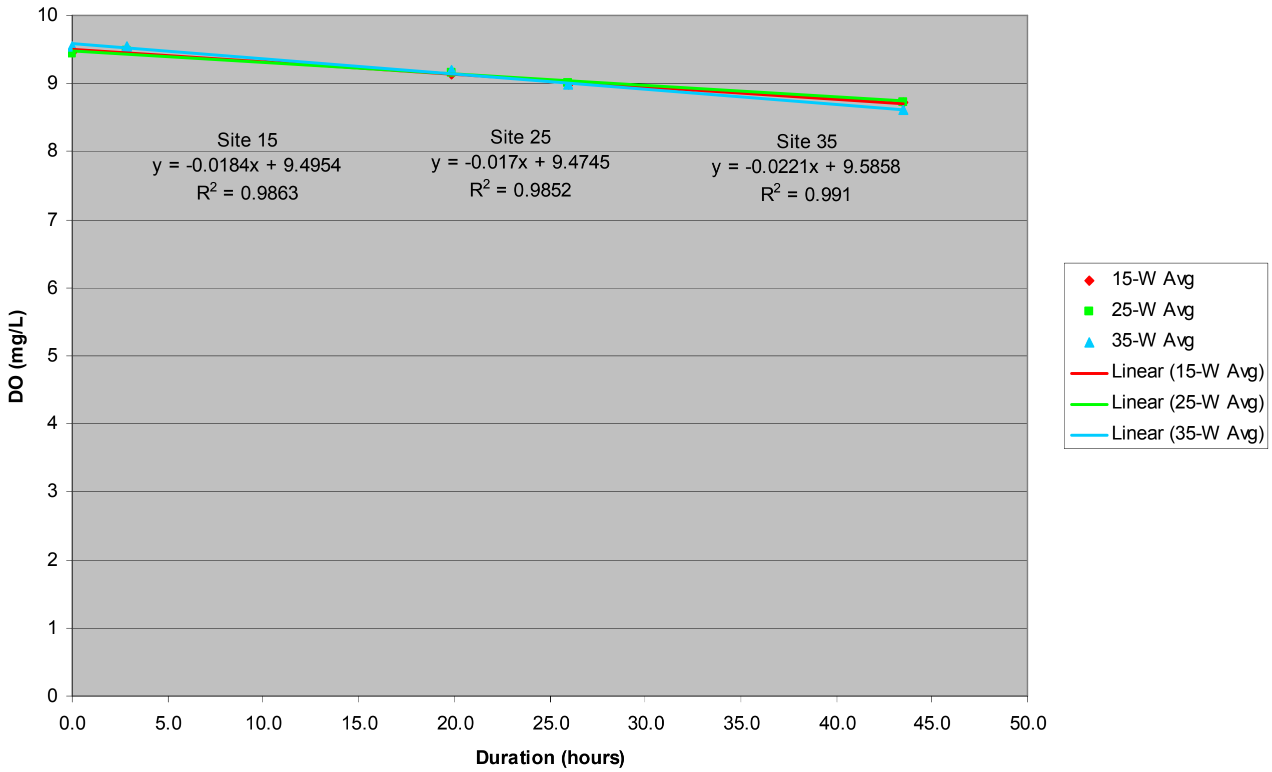


Figure 15: Canyon Lake Water Oxygen Depletion Test Results from Winter Period (December 17, 2010)



3.3 Combined Oxygen Demand Calculations for Hypolimnion

The December 2010 water oxygen demands from lake zones 1-3 were multiplied by the hypolimnetic volume and the soil oxygen demands from lake zones 1-3 were multiplied by the hypolimnetic soil area to determine the total oxygen demand of Canyon Lake. The first set of calculations was performed assuming the hypolimnion began 20 feet below the water surface during the original bathymetric survey, or the hypolimnion starting below 1,352 feet above sea level, as shown in Table 3.

Table 3: Canyon Lake Combined Soil and Water Oxygen Demand at 1,372 Lake Elevation

	Zone I		Zone II		Zone III	
Soil Conditions	0.281	$g/m^2/d$	0.267	$g/m^2/d$	0.115	$g/m^2/d$
Soil Area	801,000	ft^2	1,284,000	ft^2	2,239,000	ft^2
Soil Demand	46	lbs/d	70	lbs/d	53	lbs/d
Water Conditions	0.531	mg/L/d	0.409	mg/L/d	0.441	mg/L/d
Water Volume	72,386,000	gallons	83,394,000	gallons	108,916,000	gallons
Water Demand	320	lbs/d	284	lbs/d	400	lbs/d
Soil and Water Demand	366	lbs/d	354	lbs/d	453	lbs/d
				Total Demand	**1,172**	**lbs/d**
				Safety Factor	1.5	
				Design Demand	**1,758**	**lbs/d**

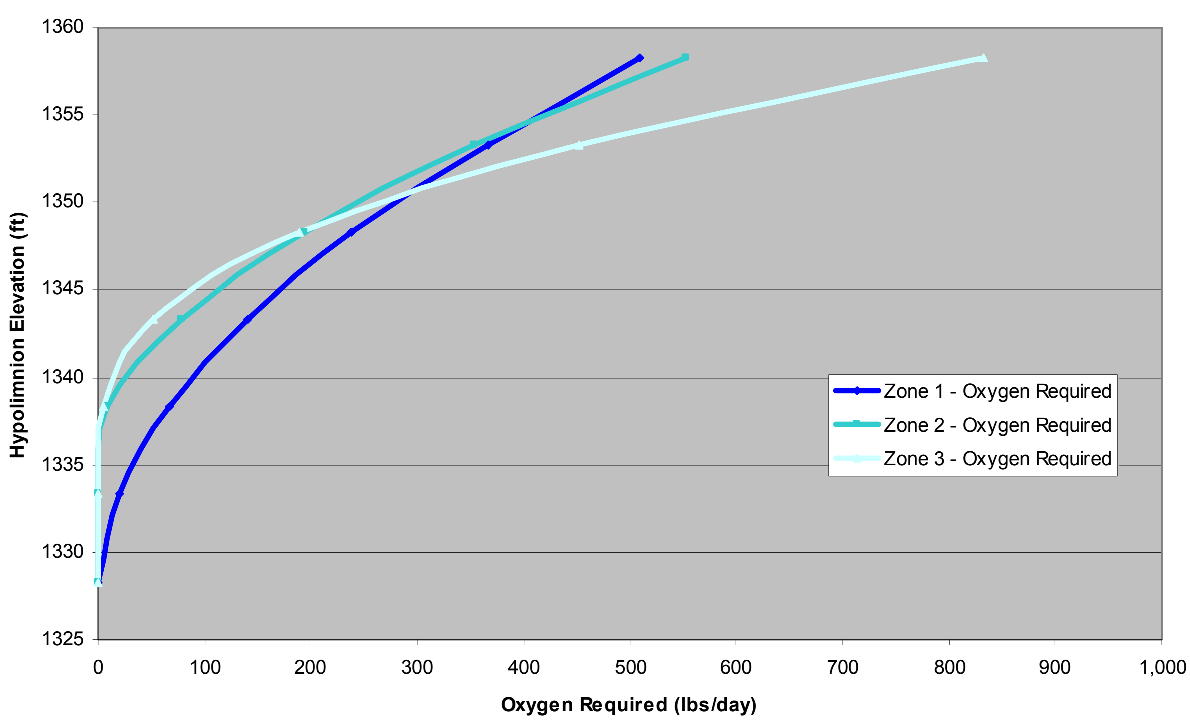
The oxygen demand for Canyon Lake was also calculated assuming the lake elevation was four feet below the dam spillway. In this condition the hypolimnion elevation would include water and soil below an elevation of 1,358 feet as shown in Table 4. The increase of hypolimnion thickness by six feet will increase the oxygen demand by over 60% due to the large increase in area and available volume over the six feet.

Table 4: Canyon Lake Combined Soil and Water Oxygen Demand at 1,378 ft Lake Elevation

	Zone I		Zone II		Zone III	
Soil Conditions	0.281	$g/m^2/d$	0.267	$g/m^2/d$	0.115	$g/m^2/d$
Soil Area	881,000	ft^2	1,581,000	ft^2	3,018,000	ft^2
Soil Demand	51	lbs/d	86	lbs/d	71	lbs/d
Water Conditions	0.531	mg/L/d	0.409	mg/L/d	0.441	mg/L/d
Water Volume	103,835,000	gallons	136,967,000	gallons	207,221,000	gallons
Water Demand	459	lbs/d	466	lbs/d	761	lbs/d
Soil and Water Demand	510	lbs/d	552	lbs/d	832	lbs/d
				Total Demand	**1,894**	**lbs/d**
				Safety Factor	1.5	
				Design Demand	**2,841**	**lbs/d**

Figure 16 shows total combined oxygen demand versus hypolimnion elevation, which demonstrates the large increase in oxygen demand with increases in lake level.

Figure 16: Combined Soil and Water Hypolimnion Oxygen Depletion Versus Hypolimnion Level



4 Model Results & Alternative Discussion

A modeling analysis was performed to evaluate the effectiveness of supplying the suggested oxygen quantities to Canyon Lake at various flows and oxygen concentrations. Ten different options were created and modeled as shown in Table 5. Appendix A shows a plan-view layout of these ten options.

Table 5: 10 Oxygen Delivery Options Considered and Modeled

Option	Total O2 Delivered	Total Water Flow	Zone 2/3 Flow	Submerged?
	(lb/day)	*(gpm)*	*(gpm)*	
1	**2,000**	**3,700**	**2,150**	**Yes**
2	4,000	7,400	4,300	No
3	**2,000**	**6,000**	**4,550**	**Yes**
4	4,000	12,000	6,000	No
5	3,700	1,400	950	No
6	2,000	gas	gas	NA
7	2,000	2,100 + gas	2,100	No
8	**3,000**	**9,000**	**6,100**	**No**
9	3,000	6,000 + gas	6,000	No
10	**3,000**	**5,000**	**4,100**	**No**

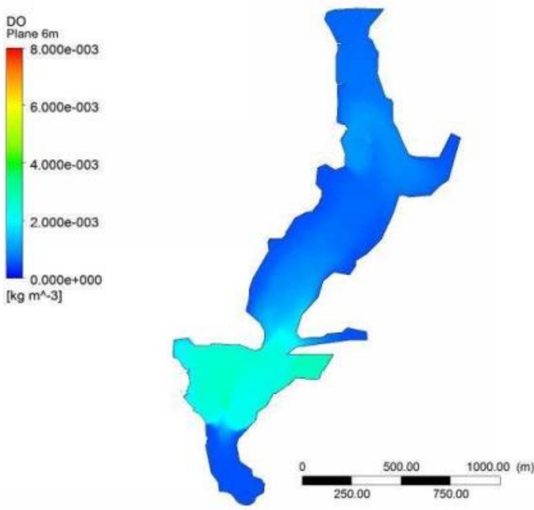
A 3D Computational Fluid Dynamic (CFD) model was developed for the main reservoir using bathymetric data provided. The experimental oxygen demands were used to determine the rate of oxygen depletion throughout the lake. The level of the lake was 1378 feet above sea level in order to evaluate a condition with a higher oxygen demand as compared to a lower lake elevation. Each system was run for a 100 day time duration at a 10 day time step interval.

Of the ten options listed in Table 4, four options in particular were chosen to present in this report because they display well the effectiveness of increased water flow and oxygen output:

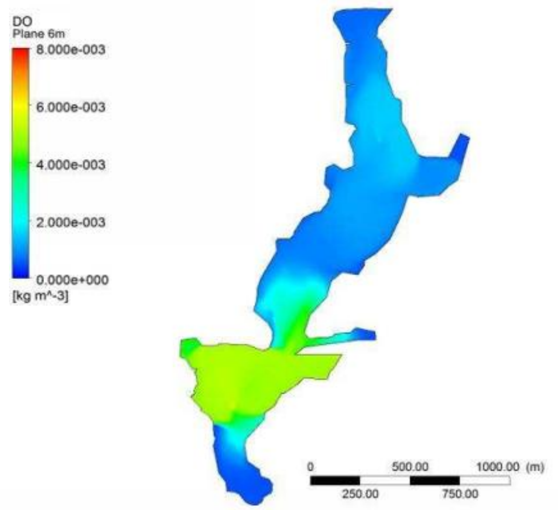
- Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
- Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
- Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
- Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L

Figures 17 show model results from option 1, figure 18 shows model results from option 3, figure 19 shows model results from option 8, and figure 20 shows model results from option 10. The images are of Canyon Lake at a depth of 6 meters (20 feet) above the lake bottom.

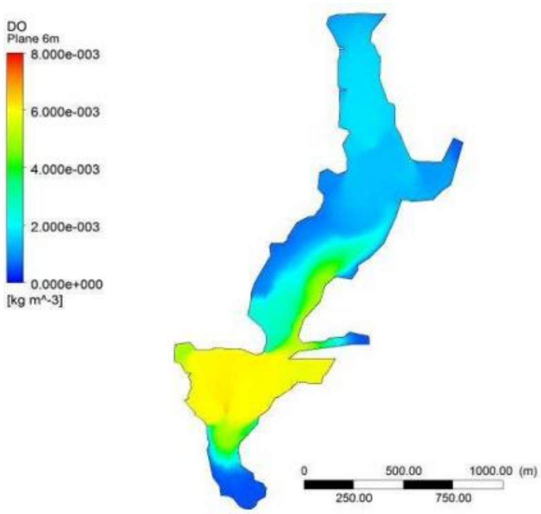
Figure 17: - Option 1: 2,000 lbs O_2/day delivered by 3,650 gpm



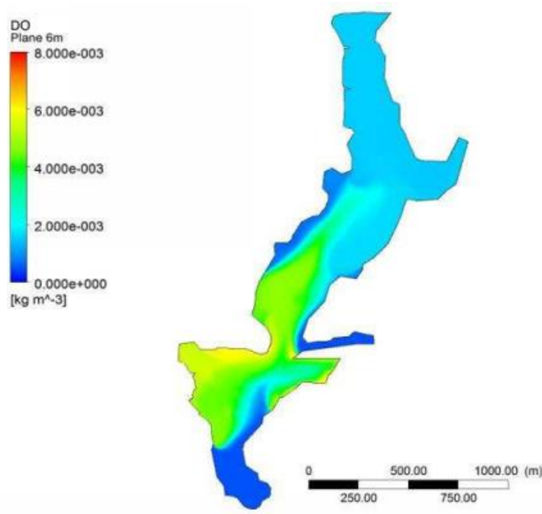
20 Days of Operation



50 Days of Operation

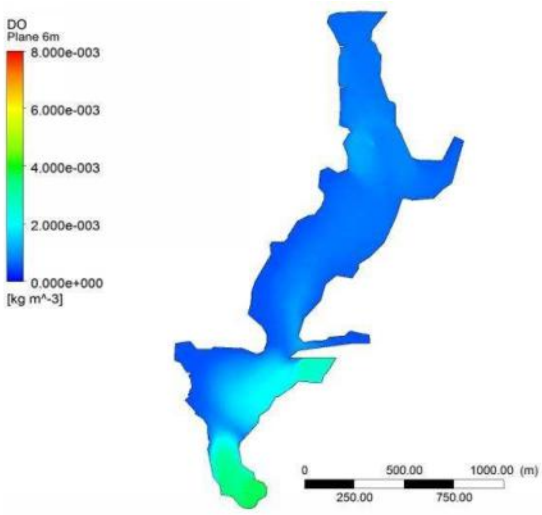


70 Days of Operation

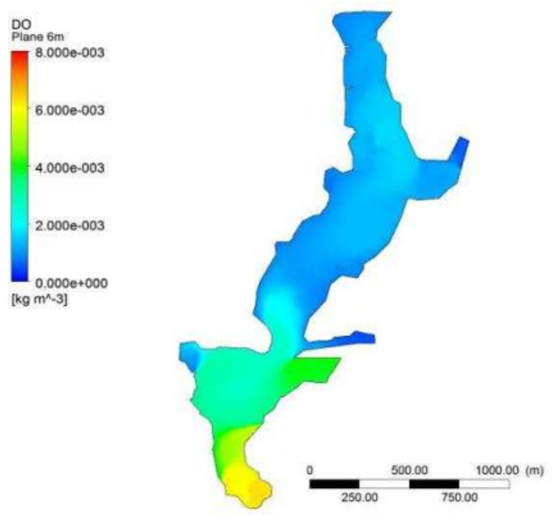


100 Days of Operation

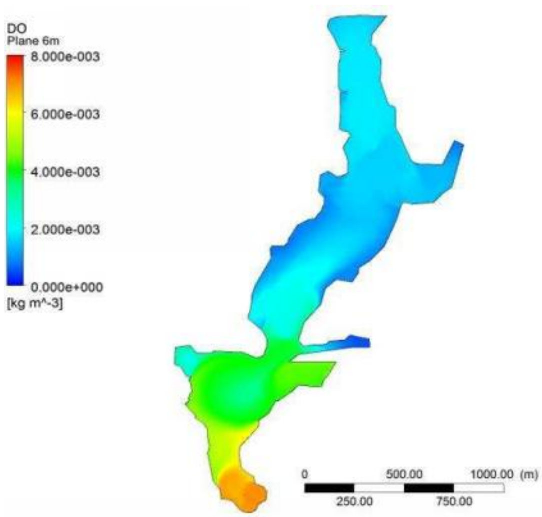
Figure 18: - Option 3: 2,000 lbs O_2/day delivered by 6,000 gpm



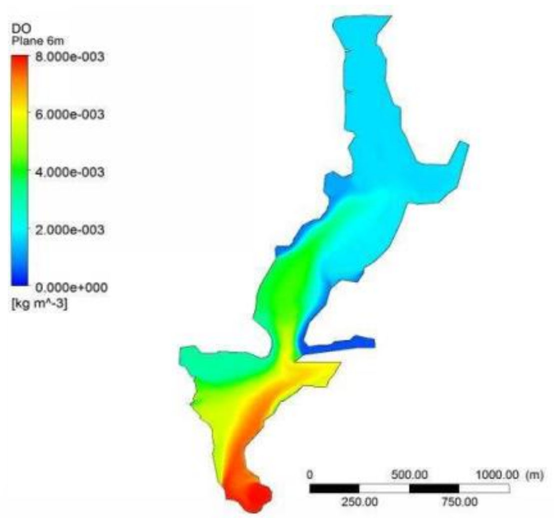
20 Days of Operation



50 Days of Operation

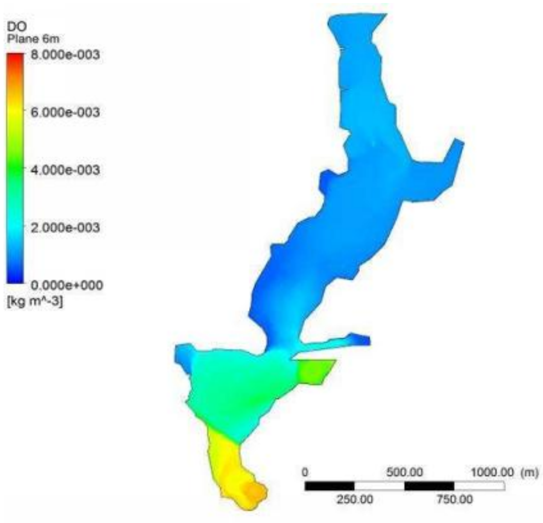


70 Days of Operation

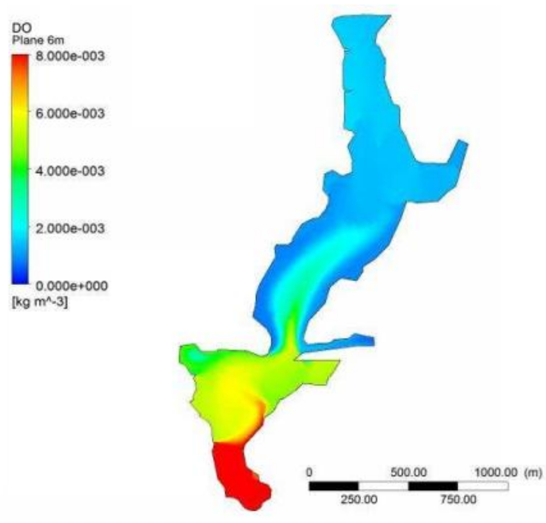


100 Days of Operation

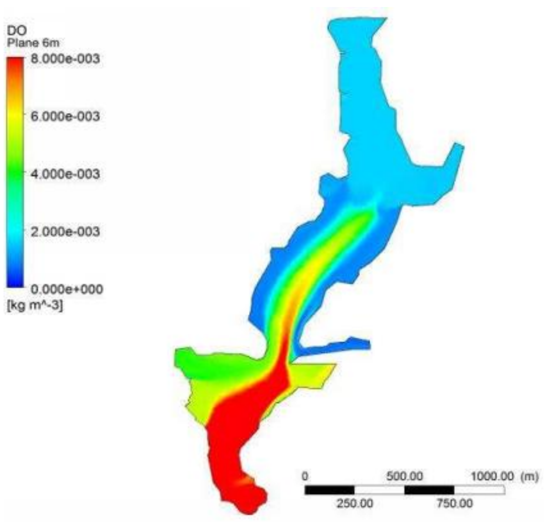
Figure 19: - Option 8: 3,000 lbs O_2/day delivered by 9,000 gpm



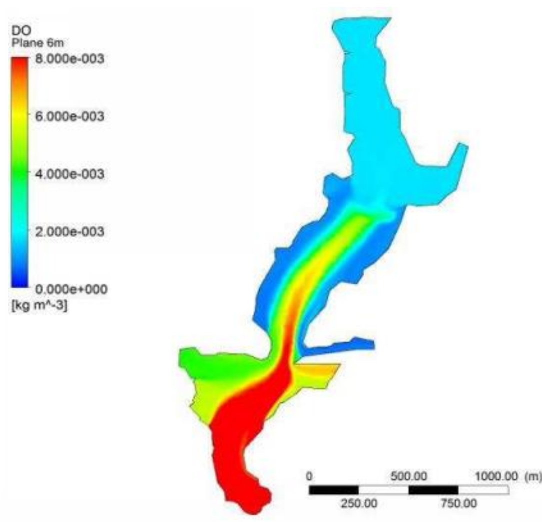
20 Days of Operation



50 Days of Operation

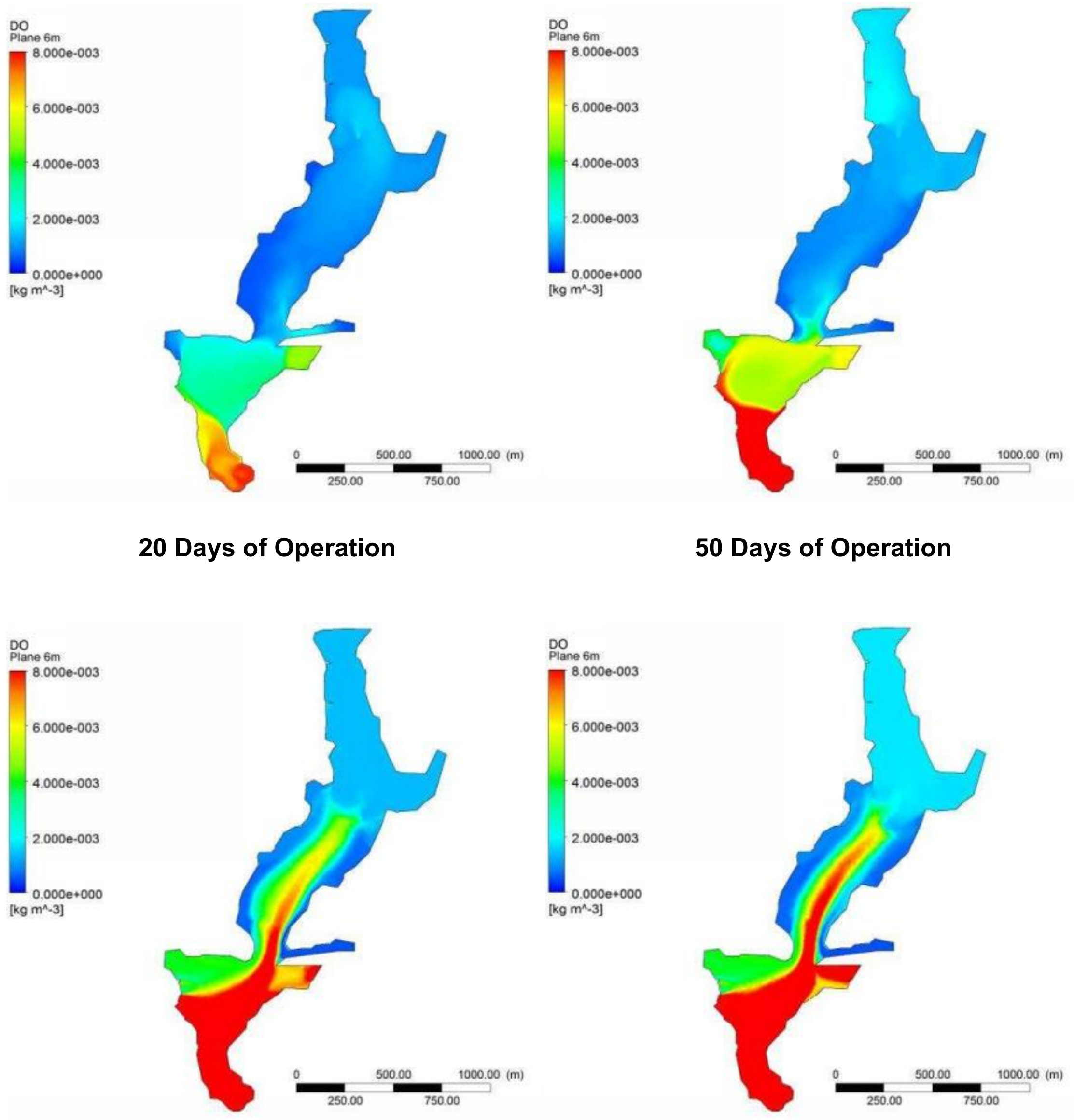


70 Days of Operation



100 Days of Operation

Figure 20: - Option 10: 3,000 lbs O_2/day delivered by 5,000 gpm



20 Days of Operation **50 Days of Operation**

70 Days of Operation **100 Days of Operation**

As shown in Figures 17, 18, 19 and 20, in 100 days of operation the oxygen concentration in the hypolimnion is greatly improved in all scenarios compared to existing observed oxygen concentrations. The first major observation from the model results is that a certain quantity of water flow rate is important to distribute the oxygen both horizontally and vertically, which is demonstrated in the better oxygen content and distribution in Figure 18 (option 3) versus Figure 17 (option 1). Figure 18 (option 3) had 60% higher water flow (6,000 gpm compared to 3,700 gpm) to the whole lake and nearly double the water flow to zones 2 and 3 as compared to option 1. Secondly, the modeled 2,000 lb/day oxygen supply in Figure 18 (option 3) results in only a small portion of hypolimnion having an oxygen concentration above 5 mg/L, but the modeled 3,000 lb/day oxygen supply in Figure 19 (option 8) achieves a very high percentage of the hypoliminion having an oxygen concentration above 5 mg/L in 100 days of operation. Thus, the 1.5 times safety factor, which is included in the 3,000 lb/day design discussed in Section 3, appears to be very important to meeting the project objectives for oxygen content. Finally, it appears that using a higher concentration with a lower flow into zone 1 (option 10) produces comparable results to option 8, even though these two options supply the same mass of oxygen to the system, although it takes about 30 extra days to get the desired mixing to zones 2 and 3.

5 Oxygenation Systems Considered

5.1 Three Methods of Oxygenation Delivery

5.1.1 ECO$_2$ Speece Cone

The ECO$_2$ speece cone system operates by pumping water through a conical shaped oxygen transfer reactor. Inside the cone pure oxygen is introduced to the water stream and creates super-oxygenated water that is then pumped throughout the lake. The system will operate at a pressure of approximately 30 psi when submerged at the bottom of the lake or approximately 15 psi if installed on the shore. The saturation point of oxygen in water is directly related to the pressure of the water. Since the pressure of the submerged speece cone is double that of the shoreline speece cone, the dissolved oxygen concentration in the water can also be doubled. The submerged and shoreline DO concentrations can be seen in Table 6.

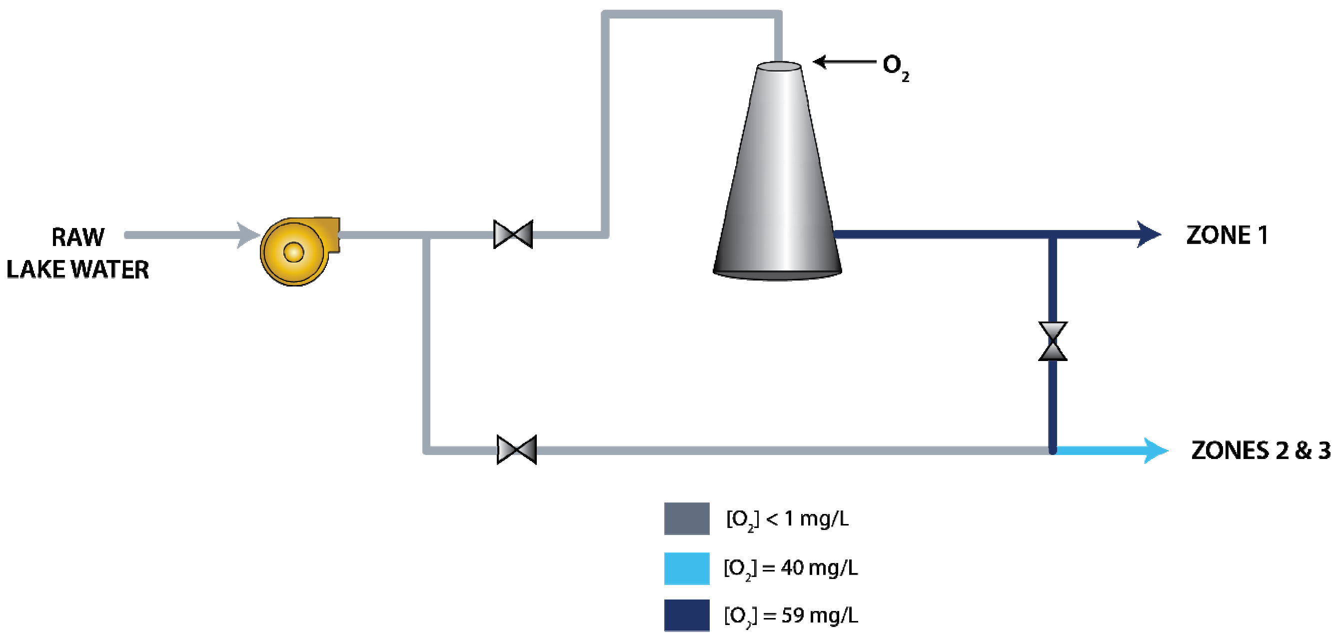
Table 6: ECO2 Speece Cone Design O2 Concentrations

	Submerged Cone	Shoreline Cone
Pressure (atm)	>2	~1
Theoretical O_2 Sat (mg/L)	100	50
Absorption Efficiency (%)	~70	~70
Design Discharge [O_2] (mg/L)	60	30

5.1.1.1 Submerged Speece Cone

The higher concentration of oxygen achieved by the submerged cone allows for a lower flow rate than that required by the shoreline option. In this case a flow rate of nearly 3,700 gpm is required to pass through the speece cone to deliver 2,000 lbs of O_2/day required by the lake's hypolimnion in option 1. The natural slope of the lake causes the depths of water to become shallower in the north. Where the cone discharge pipe terminates in the north, the water depth is no longer sufficient to create enough pressure to keep the 60 mg/L of oxygen dissolved in the water. In this case a side stream system would be used to deliver the high concentration of oxygenated water to the deep area by the dam while diluting the water that will be pumped to Zones II and III to prevent the oxygen from coming out of solution. The diluted concentration to the northern zones would be 40 mg/L. This increases the required flow rate to the north. A schematic for this dilution process can be seen in Figure 21.

Figure 21: Submerged Speece Cone Conceptual Flow Schematic



A summary of the submerged cone option can be seen in Table 6.

Table 7: Submerged Speece Cone Design Parameters (Option 1 of 10 System Design)

Flow Rate	3,650	gpm		
Head Required	32.5	ft		
Speece Cone Size	6	ft		
Piping	10	in dia	2,600	ft
	12	in dia	4,150	ft
	18	in dia	2,700	ft
Pump Power	45	hp	55	A

5.1.1.2 Shoreline Speece Cone

The limited saturation point of oxygen in water for the shoreline speece cone installation requires a higher flow rate for this option compared to the submerged option. Using the concentration of 30 mg/L, 6,000 gpm needs to pass through the speece cone to achieve the 2,000 lbs of O_2/day required by the lake's hypolimnion as shown in option 3. The lake is deep enough in the north to keep the 30 mg/L of oxygen dissolved in the water. The flow rate is still substantially larger than the submerged option, requiring larger piping and pumping requirements. A summary of the shoreline cone option can be seen in Table 8.

Table 8: Shoreline Speece Cone Design Parameters (Option 3 of 10 System Design)

Flow Rate	6,000	gpm		
Head Required	32.5	ft		
Speece Cone Size	10	ft		
Piping	12	in dia	1,400	ft
	16	in dia	4,150	ft
	20	in dia	1,500	ft
	24	in dia	1,200	ft
Pump Power	75	hp	89	A

The higher flow rate required by the shoreline option compared to the submerged option causes an increase in required pipe sizes, speece cone size, pump size, and power. This causes the capital cost for equipment to be greater. However, divers are not needed to install the shoreline speece cone or maintain it. Divers will only be needed to install and maintain the pipeline. This reduces the manpower cost of compared to the submerged option which requires divers to install and maintain the speece cone and pipelines. There is also an added advantage to the increase flow rate as shown in Section 4. By increasing the flow rate from 3,650 gpm to 6,000 gpm, the hydraulic retention time is decreased from 85 days to 52 days at lake elevation 1378 feet, which means it will take less time for the super oxygenated water to travel throughout the lake.

In order to accommodate an increased oxygen supply up to 3,000 lb/day in option 8, a shoreline designed system would pump 9,000 gpm of water with a DO concentration of 30 mg/L. The hydraulic retention time of this system would be further reduced to 35 days. A summary of the shoreline cone option to deliver 3,000 lbs/day can be seen in Table 9.

Table 9: Shoreline Speece Cone Design Parameters (Option 8 of 10 System Design)

Flow Rate	9,000	gpm		
Head Required	34.5	ft		
Speece Cone Size	12	ft		
Piping	16	in dia	1,400	ft
	20	in dia	4,150	ft
	24	in dia	1,500	ft
	30	in dia	1,200	ft
Pump Power	102	hp	89	A

5.1.2 *BlueInGreen's Supersaturated Dissolved Oxygen (SDOX)*

BlueInGreen's SDOX system works in a similar manner as ECO_2's speece cone. Water is pumped into a pressurized tank instead of a cone where oxygen is transferred into the water under pressure. However, the SDOX system generally has a much higher back-pressure to allow for a higher saturation point of oxygen in the water. Under BlueInGreen's standard system design, the equipment operates at a pressure of nearly 90 psi, allowing a concentration of 230 mg/L of dissolved oxygen and reducing the pumping flow rate of the system. This design concentration requires a flow rate of only 700 gpm to deliver nearly 2,000 lbs of O_2/day, or 1,400 gpm to deliver nearly 4,000 lbs of O_2/day (option 5). The hydraulic retention time for the 2,000 lb/day system design would be 400 days.

The high oxygen concentrations of this design require the super saturated water to remain pressurized in the pipelines or else the oxygen would come out of solution. If the oxygen does come out of solution, gas will accumulate at the high points of the pipeline, causing restriction of flow and improper operation. Gas relief holes drilled into the discharge piping, common for the speece cone design, are not generally used for the SDOX system since the pipeline must remain highly pressurized. The end of the pipelines will be capped to create a back pressure in the pipe and all of the saturated water will be delivered to the hypolimnion through small holes drilled at given intervals. Once the saturated water is mixed with the lake water, the concentration of oxygen is dispersed into the lake to prevent oxygen from coming out of solution. An image of a BlueInGreen SDOX pressurized vessel can be seen in Figure 22.

Figure 22: BlueInGreen SDOX Installation at Lake Thunderbird, OK

Various modifications to the standard BlueInGreen system design can be considered to work more effectively in Canyon Lake. The BlueInGreen system has advantages over the speece cone in that the oxygen saturation into the water column is tightly controlled with a variable speed pump to optimize efficiency. When oxygen is not properly dissolved or other problems occur in system operation, the BlueInGreen system automatically reacts to adjust its operation or has a system shutdown and alarms operations staff; whereas, the Speece Cone system does not provide these real time adjustments or safety shutdown functions.

5.1.3 Gas Diffuser System (Soaker Hose)

Instead of dissolving oxygen in a water column and delivering the oxygenated water to the lake, pure gaseous oxygen could alternatively be delivered. The challenge with gas diffusers is two-fold: 1) the gas has a tendency to mix the lake which removes the advantages of stratification and 2) the diffusers become a maintenance problem due to biofouling, pressure differences along the lines, and damage from fish hooks and other submerged objects. Plastic and ceramic membranes are capable of gas diffusion but typically require high flux rates that could cause unwanted mixing. A coarse bubble diffuser, such as a soaker hose system, is another type of diffuser feasible for Canyon Lake. Soaker hoses are typically used in gardening as a way to allow water to seep out the entire length of the hose. When the hose is pressurized, it expands, opening pores that allow the contents of the hose to exit. A network of these hoses could theoretically be placed on the bottom of the lake and connected to an oxygen supply. Pressurized oxygen in the hose will expand the hose and transfer the oxygen to the hypolimnion layer. An image of a soaker hose that is oxygenating a water bath can be seen in Figure 23.

Figure 23: Soaker Hose Oxygenating a Water Bath in PACE Laboratory

The benefit to using a gas diffuser a relative inexpense of the system when compared to the other two oxygenation systems described. Equipment for this option would include an oxygen supply and a piping system that can deliver the oxygen to the network of hoses. There are several disadvantages associated with using a soaker hose to oxygenate the hypolimnion: 1) 50% or more of the delivered oxygen may be lost to atmosphere, 2) water circulation is not created since there is no pumping and redistribution of oxygenated water throughout the lake, 3) durability of the diffusers may be low.

5.2 Two Methods of Oxygen Generation

Two systems are available to supply oxygen for the proposed equipment. These two options each have benefits and drawbacks which are described below. The two systems are: 1) onsite oxygen generation via mechanical gas separation process and 2) offsite generation and bi-monthly delivery of liquid oxygen (LOX) and onsite storage in steel tanks.

5.2.1 Oxygen Generator

Onsite oxygen generators create pure oxygen by mechanically separating the oxygen from air which is approximately 20% oxygen and 80% nitrogen. The generator will pull air into the system through a sieve that will separate the oxygen from the nitrogen. The generator operates on a cycle of pulling air in to separate the oxygen and nitrogen, the expelling the nitrogen from the system and pushing oxygen into the oxygen transfer vessel.

Figure 24: Oxygen Generator Installation at Oso Reservoir in Mission Viejo, CA

Oxygen generators can create substantial noise for surrounding properties. Past installations have required sound attenuation to be installed on buildings housing oxygen generators to prevent the sound nuisance to local residents. Oxygen generators have a set oxygen supply that can be attained. The system can be turned down to deliver less oxygen than the design limit, but there is a maximum oxygen supply that can be achieved unlike LOX, which has higher peak output capacity. PCI, a leading vacuum swing oxygen generator manufacturer, makes oxygen generators up to only 1,750 lbs/day in one unit, so potentially multiple units would be required. Oxygen generators also require electrical power, although relatively the same power as the pumping equipment,

Oxygen generators will incur a substantial capital cost for the project: 2 units at $115,000 each. This does not include extra costs caused by doubling the required power upgrade to the Canyon Lake Water Treatment Plant service entrance. There will also be extra costs in upgrading wiring and conduits to the proposed generator location and installation of electrical panels.

The electrical cost to supply oxygen at a rate of 3,000 lbs/day using oxygen generators is approximately $105/day assuming power can be supplied at a rate of $0.12 / kW-hr.

5.2.2 Liquid Oxygen

Liquid oxygen (LOX) as the supply for the oxygenation system is the alternative to oxygen generators. Liquid oxygen is a cryogenic fluid that is maintained at a temperature of approximately -300°F. The low temperature causes the oxygen to remain in liquid form which is stored in an onsite vacuum insulated tank. LOX becomes a gas by passing through an ambient vaporizer that heats up the liquid, causing it to boil. The pressure created by this boiling process is sufficient to push the oxygen into the oxygenation system so that no compressors are needed.

There is no capital cost for a liquid oxygen system as they are leased from suppliers for a monthly fee between $1,500 and $2,000. The supplier also maintains the system so operators will not be required to perform any maintenance on the tanks or vaporizers.

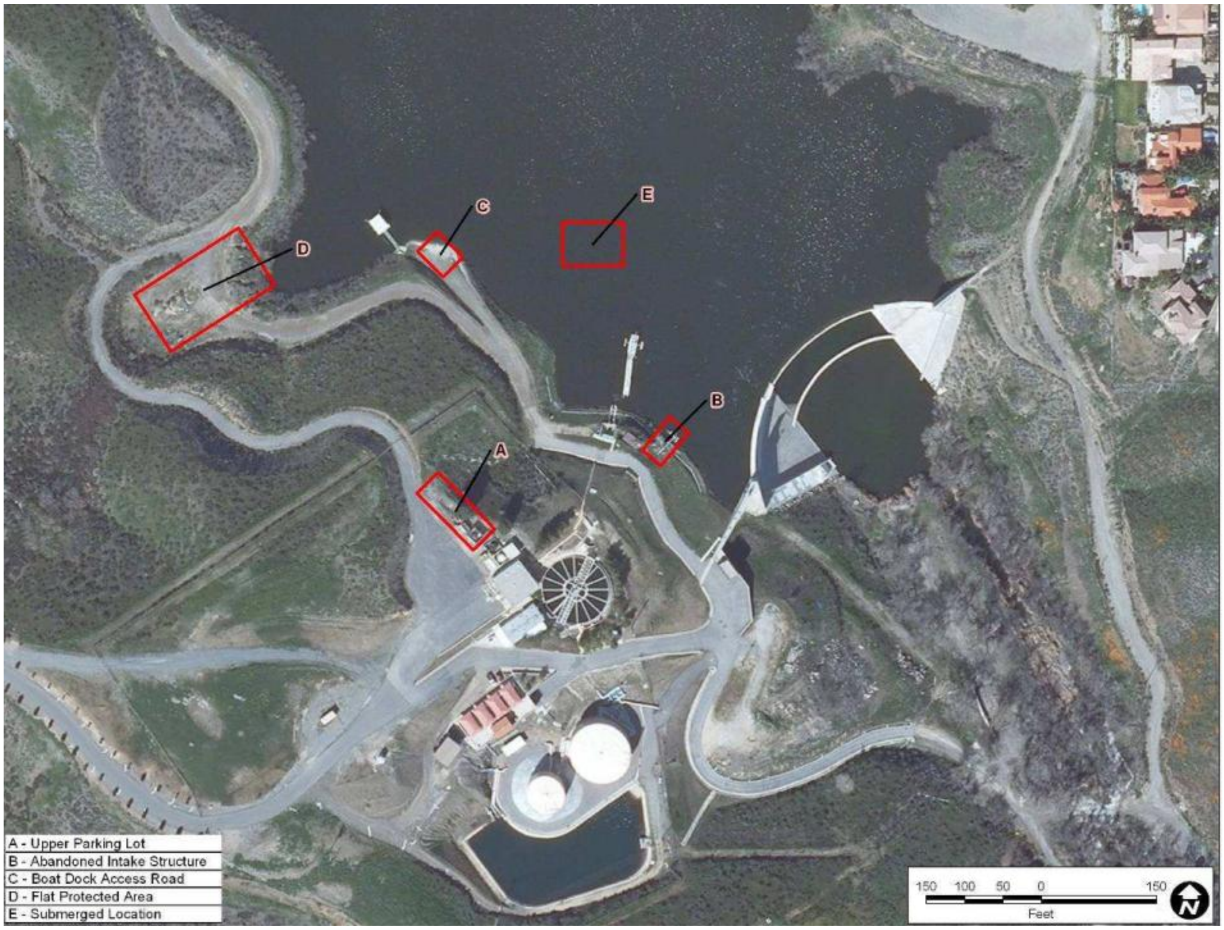
Liquid oxygen must be shipped in periodically to refill the tanks. 18 wheel trucks are the method of shipment of liquid oxygen and must pass through the local neighborhood streets to access the Canyon Lake Water Treatment Plant. Delivery of LOX is expected occur every 3 – 4 weeks, depending on the oxygen consumption of the system. 18 wheel trucks currently travel to the treatment plant on a bi-monthly basis to deliver a variety of consumable chemicals.

Liquid oxygen costs $0.42 / 100 cubic feet delivered. Each delivery has 40 tons of oxygen, which equates to a cost of $4,060/delivery. If the rate of oxygen consumption is 3,000 lbs/day, a delivery must be made every 27 days. This deliver cost, along with a monthly lease of $1,750, means the daily operating cost for a 3,000 lbs/day system would be $210, or double the daily operating cost of the oxygen generator option.

5.3 Equipment Location

Five areas have been considered for equipment installation for the oxygenation system equipment including oxygen generation and storage. The five areas can be seen in Figure 25.

Figure 25: Canyon Lake Proposed Equipment Locations



Not every location identified can house all of the required equipment. Table 10 shows which equipment can be located at each location.

Table 10: Proposed Equipment Locations Based on Figure 22

Location	Intake Pumps	Speece Cone	LOX Tank	O_2 Generator
A			X	X
B	X			
C	X	X		
D	X	X	X	
E	X	X		

Note: “X” used to signify equipment can be installed at location.

5.3.1 Location A: Upper Parking Lot

The upper parking lot of the treatment plant has been identified as suitable location for the oxygen generators or the liquid oxygen tanks. The oxygen generators can be installed in the old chemical storage building. The building is constructed using concrete masonry units (CMU). It consists of two rooms, one is 19 ft x 18 ft, the other is 12 ft x 19 ft. This is large enough to house both oxygen generators required to meet the oxygen demand of the system. Required improvements to the building include new electrical wiring, sound attenuation, HVAC system. A picture of the old chemical storage building can be seen in Figure 26.

Figure 26: Proposed Oxygen Generator Building (Location A)

The parking lot area near this building would also be a good location to install liquid oxygen tanks. The area has space for installation and setbacks required for a liquid oxygen system. The large parking lot and proximity to the treatment plant entrance also provide easy access for the refilling trucks.

5.3.2 *Location B: Abandoned Intake Structure*

North of the dam on the western shore are four 36" diameter pipes that were once used as the intake structure for the Canyon Lake Water Treatment Plant. These pipes are currently abandoned and could be used as the water intake site for the oxygenation system. The pipes would be fitted with a rail system allowing submersible pumps to be lowered to the bottom of the lake. Since the pipes go all the way to the bottom of the dam area, the water would be ideal for the oxygenation system.

Figure 27: Abandoned Intake Structure and Pipes (Location B)

5.3.3 *Location C: Boat Dock Access Road*

EVMWD has a boat dock north of the Canyon Lake Water Treatment Plant that is accessed by a road running along the shoreline from the dam. The area near the boat dock has open space near the access road that could be leveled to allow for installation of an onshore oxygenation system. The intake pumps could be localized with onshore oxygenation equipment at this location with the construction of an intake structure. The oxygenation equipment could also be provided with water from Location B if it is desirable to use the abandoned intake structure.

5.3.4 *Location D: Flat Protected Area*

A large, flat area is located near the shore of the lake on the northwest side of the Canyon Lake Water Treatment Plant. The area sits at the bottom of the hill and is protected on three sides by the hill; the fourth side being open to the lake. This location would be ideal for locating all the required equipment at one site. It is large enough to install a speece cone, liquid oxygen system, and allow room for LOX refill trucks room to turn around. The road to the site is likely suitable to allow trucks access for refilling the LOX tank. The proximity to the water makes an intake structure at this site feasible. However, the intakes would need to be longer than the other two viable locations to reach the deep, cold water necessary for the oxygenation system. Location D can be seen in Figure 28.

Figure 28: Flat Protected Area Northwest of Canyon Lake WTP (Location D)

5.3.5 Location E: Submerged Location

A submerged speece cone and intake pumps could be installed on the lake bottom instead of on the shore. This option allows the speece cone to take advantage of the pressure of the lake water to increase the DO saturation point and reduce pumping requirements. PACE conducted a diver survey on October 21, 2010 to find a suitable area for an underwater installation. Location E was found to be a flat, obstruction free area that was in the deeper area of the lake making it an attractive site for the underwater equipment.

6 Capital, O&M, and Life Cycle Costs

Options 1, 3, 8, and 10, which were modeled in Section 5, have estimated costs as shown in the following tables.

Option 1 - 2,000 lbs O_2/day, 3,650 gpm of water at [O_2] of 60 and 40 mg/L
Tables 10a, 10b, and 10c – Option 1 with Oxygen Generation
Tables 11a, 11b, and 11c – Option 1 with LOX

Option 3 - 2,000 lbs O_2/day, 6,000 gpm of water at [O_2] of 30 mg/L
Tables 12a, 12b, and 12c – Option 3 with Oxygen Generation
Tables 13a, 13b, and 13c – Option 3 with LOX

Option 8 - 3,000 lbs O_2/day, 9,000 gpm of water at [O_2] of 30 mg/L
Tables 14a, 14b, and 14c – Option 8 with Oxygen Generation
Tables 15a, 15b, and 15c – Option 8 with LOX

Option 10 - 3,000 lbs O_2/day, 5,000 gpm of water at [O_2] of 150 and 40 mg/L
Tables 16a, 16b, and 16c – Option 10 with Oxygen Generation
Tables 17a, 17b, and 17c – Option 10 with LOX

Table 11: Capital Cost of Option 1 with Oxygen Generator

Capital Cost - Submerged Installation (2,000 lbs/day, O_2 Generator)	quantity	units	cost/unit	total cost
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$0
SUBTOTAL				**$20,000**
Underwater Civil				
Dredging	170	cy	$125	$21,250
Concrete Pads	170	cy	$250	$42,500
SUBTOTAL				**$63,750**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$64	$172,800
Concrete Ballast for 18" Pipe	49.6	cy	$1,000	$49,600
12" HDPE Piping	4,150	LF	$45	$186,750
Concrete Ballast for 12" Pipe	38.2	cy	$1,000	$38,200
10" HDPE Piping	1,400	LF	$33	$46,200
Concrete Ballast for 10" Pipe	9.2	cy	$1,000	$9,200
10" HDPE Piping	1,200	LF	$33	$39,600
Concrete Ballast for 10" Pipe	7.9	cy	$1,000	$7,900
SUBTOTAL				**$550,250**
Equipment				
6' Speece Cone	1		$190,735	$190,735
DOCS 500 Oxygen Generator	1		$115,000	$115,000
Pump (3,000 gpm @ 33')	2		$45,000	$90,000
Submersible Cable for pumps	100	LF	$250	$25,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$50,000
SUBTOTAL				**$500,735**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$15,000
Motor Control Center				$50,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$200,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	280	man days	$440	$123,200
Divers	80	man days	$2,000	$160,000
Per Diem	360	man days	$75	$27,000
SUBTOTAL				**$310,200**
SUM SUBTOTAL				**$1,644,935**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$49,348
FINAL SUBTOTAL				**$1,814,283**
Contingency 10%				$181,428
Overhead and Profit 15%				$272,142
TOTAL				**$2,267,854**

Table 12: Operations and Maintenance Cost of Option 1 with Oxygen Generator

O&M Cost - Submerged Installation (2,000 lbs/day, O_2 Generator)				
Electrical	60	kW-hr	$0.12	$46,656
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$25,037
Yearly O&M Cost				**$86,693**

Table 13: 20-Year Life Cycle Cost of Option 1 with Oxygen Generator

20 Yr Life Cycle Cost	**$3,348,237**

Table 14: Capital Cost of Option 1 with LOX

Capital Cost - Submerged Installation (2,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$60,000
SUBTOTAL				**$65,000**
Underwater Civil				
Dredging	170	cy	$125	$21,250
Concrete Pads	170	cy	$250	$42,500
SUBTOTAL				**$63,750**
Mechanical Piping and Valving				
18" HDPE Piping	2,700	LF	$64	$172,800
Concrete Ballast for 18" Pipe	49.6	cy	$1,000	$49,600
12" HDPE Piping	4,150	LF	$45	$186,750
Concrete Ballast for 12" Pipe	38.2	cy	$1,000	$38,200
10" HDPE Piping	1,400	LF	$33	$46,200
Concrete Ballast for 10" Pipe	9.2	cy	$1,000	$9,200
10" HDPE Piping	1,200	LF	$33	$39,600
Concrete Ballast for 10" Pipe	7.9	cy	$1,000	$7,900
SUBTOTAL				**$550,250**
Equipment				
6' Speece Cone	1		$190,735	$190,735
Pump (3,000 gpm @ 33')	2		$45,000	$90,000
Submersible Cable for pumps	100	LF	$250	$25,000
Valves / Instrumentation				$25,000
Mechanical Piping / Supports / Misc.				$50,000
SUBTOTAL				**$380,735**
Electrical Systems				
New Service Entrance				$45,000
Power Distribution Section				$15,000
Motor Control Center				$35,000
Control Panel and Programming				$25,000
Conduit / Wiring / Disconnects				$30,000
Lighting				$5,000
SUBTOTAL				**$155,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	220	man days	$440	$96,800
Divers	80	man days	$2,000	$160,000
Per Diem	300	man days	$75	$22,500
SUBTOTAL				**$279,300**
SUM SUBTOTAL				**$1,494,035**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$44,821
FINAL SUBTOTAL				**$1,658,856**
Contingency 10%				$165,886
Overhead and Profit 15%				$248,828
TOTAL				**$2,073,570**

Table 15: Operations and Maintenance Cost of Option 1 with LOX

O&M Cost - Submerged Installation (2,000 lbs/day, LOX)				
Electrical	35	kW-hr	$0.12	$27,216
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	6	refills/year	$5,307	$31,841
Equipment Replacement				$19,037
Yearly O&M Cost				**$114,094**

Table 16: 20-Year Life Cycle Cost of Option 1 with LOX

20 Yr Life Cycle Cost	**$3,495,432**

Table 17: Capital Cost of Option 3 with Oxygen Generator

Capital Cost - Shoreline Installation (2,000 lbs/day, O_2 Generator)				
	quantity	*units*	*cost/unit*	*total cost*
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	1,200	LF	$114	$136,800
Concrete Ballast for 24" Pipe	39.2	cy	$1,000	$39,200
20" HDPE Piping	1,500	LF	$90	$135,000
Concrete Ballast for 20" Pipe	34.0	cy	$1,000	$34,000
16" HDPE Piping	4,150	LF	$60	$249,000
Concrete Ballast for 16" Pipe	60.2	cy	$1,000	$60,200
12" HDPE Piping	1,400	LF	$45	$63,000
Concrete Ballast for 12" Pipe	12.9	cy	$1,000	$12,900
24" Suction Pipe	200	LF	$114	$22,800
SUBTOTAL				**$752,900**
Equipment				
SDOX System	1		$165,000	$165,000
DOCS 500 Oxygen Generator	1		$115,000	$115,000
Pump (6,000 gpm @ 33')	2		$55,000	$110,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$445,000**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$15,000
Motor Control Center				$50,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$45,000
Lighting				$5,000
SUBTOTAL				**$205,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	295	man days	$440	$129,800
Divers	70	man days	$2,000	$140,000
Per Diem	365	man days	$75	$27,375
SUBTOTAL				**$297,175**
SUM SUBTOTAL				**$1,740,325**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$52,210
FINAL SUBTOTAL				**$1,912,535**
Contingency 10%				$191,253
Overhead and Profit 15%				$286,880
TOTAL				**$2,390,668**

Table 18: Operations and Maintenance Cost of Option 3 with Oxygen Generator

O&M Cost - Shoreline Installation (2,000 lbs/day, O_2 Generator)				
Electrical	80	kW-hr	$0.12	$62,208
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$22,250
Yearly O&M Cost				**$99,458**

Table 19: 20-Year Life Cycle Cost of Option 3 with Oxygen Generator

20 Yr Life Cycle Cost	**$3,367,162**

Table 20: Capital Cost of Option 3 with LOX

Capital Cost - Shoreline Installation (2,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	1,200	LF	$114	$136,800
Concrete Ballast for 24" Pipe	39.2	cy	$1,000	$39,200
20" HDPE Piping	1,500	LF	$90	$135,000
Concrete Ballast for 20" Pipe	34.0	cy	$1,000	$34,000
16" HDPE Piping	4,150	LF	$60	$249,000
Concrete Ballast for 16" Pipe	60.2	cy	$1,000	$60,200
12" HDPE Piping	1,400	LF	$45	$63,000
Concrete Ballast for 12" Pipe	12.9	cy	$1,000	$12,900
24" Suction Pipe	200	LF	$114	$22,800
SUBTOTAL				**$752,900**
Equipment				
SDOX System	1		$165,000	$165,000
Pump (6,000 gpm @ 33')	2		$55,000	$110,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$330,000**
Electrical Systems				
New Service Entrance				$45,000
Power Distribution Section				$15,000
Motor Control Center				$35,000
Control Panel and Programming				$30,000
Conduit / Wiring / Disconnects				$35,000
Lighting				$5,000
SUBTOTAL				**$165,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	235	man days	$440	$103,400
Divers	70	man days	$2,000	$140,000
Per Diem	305	man days	$75	$22,875
SUBTOTAL				**$266,275**
SUM SUBTOTAL				**$1,599,425**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$47,983
FINAL SUBTOTAL				**$1,767,408**
Contingency 10%				$176,741
Overhead and Profit 15%				$265,111
TOTAL				**$2,209,260**

Table 21: Operations and Maintenance Cost of Option 3 with LOX

O&M Cost - Shoreline Installation (2,000 lbs/day, LOX)				
Electrical	55	kW-hr	$0.12	$42,768
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	6	refills/year	$5,307	$31,841
Equipment Replacement				$16,500
Yearly O&M Cost				**$127,109**

Table 22: 20-Year Life Cycle Cost of Option 3 with LOX

20 Yr Life Cycle Cost	**$3,457,236**

Table 23: Capital Cost of Option 8 with Oxygen Generator

Capital Cost - ShorelineInstallation (3,000 lbs/day, O_2 Generator)	quantity	units	cost/unit	total cost
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
30" HDPE Piping	1,200	LF	$175	$210,000
Concrete Ballast for 30" Pipe	61.2	cy	$1,000	$61,200
24" HDPE Piping	1,500	LF	$114	$171,000
Concrete Ballast for 24" Pipe	49.0	cy	$1,000	$49,000
20" HDPE Piping	4,150	LF	$90	$373,500
Concrete Ballast for 20" Pipe	94.0	cy	$1,000	$94,000
16" HDPE Piping	1,400	LF	$60	$84,000
Concrete Ballast for 16" Pipe	20.3	cy	$1,000	$20,300
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$1,098,000**
Equipment				
SDOX Unit	1		$345,000	$345,000
DOCS 500 Oxygen Generator	2		$115,000	$230,000
Pump (9,000 gpm @ 33')	2		$90,000	$180,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$810,000**
Electrical Systems				
New Service Entrance				$70,000
Power Distribution Section				$25,000
Motor Control Center				$60,000
Control Panel and Programming				$50,000
Conduit / Wiring / Disconnects				$55,000
Lighting				$5,000
SUBTOTAL				**$265,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	305	man days	$440	$134,200
Divers	75	man days	$2,000	$150,000
Per Diem	380	man days	$75	$28,500
SUBTOTAL				**$312,700**
SUM SUBTOTAL				**$2,525,950**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$75,779
FINAL SUBTOTAL				**$2,721,729**
Contingency 10%				$272,173
Overhead and Profit 15%				$408,259
TOTAL				**$3,402,161**

Table 24: Operations and Maintenance Cost of Option 8 with Oxygen Generator

O&M Cost - Shoreline Installation (3,000 lbs/day, O_2 Generator)				
Electrical	120	kW-hr	$0.12	$93,312
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$40,500
Yearly O&M Cost				**$148,812**

Table 25: 20-Year Life Cycle Cost of Option 8 with Oxygen Generator

20 Yr Life Cycle Cost	**$4,825,046**

Table 26: Capital Cost of Option 8 with LOX

Capital Cost - Shoreline Installation (3,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
30" HDPE Piping	1,200	LF	$175	$210,000
Concrete Ballast for 30" Pipe	61.2	cy	$1,000	$61,200
24" HDPE Piping	1,500	LF	$114	$171,000
Concrete Ballast for 24" Pipe	49.0	cy	$1,000	$49,000
20" HDPE Piping	4,150	LF	$90	$373,500
Concrete Ballast for 20" Pipe	94.0	cy	$1,000	$94,000
16" HDPE Piping	1,400	LF	$60	$84,000
Concrete Ballast for 16" Pipe	20.3	cy	$1,000	$20,300
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$1,098,000**
Equipment				
SDOX Unit	1		$345,000	$345,000
Pump (9,000 gpm @ 33')	2		$90,000	$180,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$580,000**
Electrical Systems				
New Service Entrance				$60,000
Power Distribution Section				$20,000
Motor Control Center				$50,000
Control Panel and Programming				$40,000
Conduit / Wiring / Disconnects				$35,000
Lighting				$5,000
SUBTOTAL				**$210,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	245	man days	$440	$107,800
Divers	75	man days	$2,000	$150,000
Per Diem	320	man days	$75	$24,000
SUBTOTAL				**$281,800**
SUM SUBTOTAL				**$2,255,050**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$67,652
FINAL SUBTOTAL				**$2,442,702**
Contingency 10%				$244,270
Overhead and Profit 15%				$366,405
TOTAL				**$3,053,377**

Table 27: Operations and Maintenance Cost of Option 8 with LOX

O&M Cost - Shoreline Installation (3,000 lbs/day, LOX)				
Electrical	75	kW-hr	$0.12	$58,320
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	11	refills/year	$4,059	$44,648
Equipment Replacement				$29,000
Yearly O&M Cost				**$167,968**

Table 28: 20-Year Life Cycle Cost of Option 8 with LOX

20 Yr Life Cycle Cost	**$4,702,508**

Table 29: Capital Cost of Option 10 with Oxygen Generator

Capital Cost - Shoreline Installation, 2 Units (3,000 lbs/day, O_2 Generator)	quantity	units	cost/unit	total cost
Onshore Civil				
Trenching	-		-	$5,000
Building Improvements	-		-	$15,000
Equipment Pad / Aesthetic Treatments	-		-	$15,000
SUBTOTAL				**$35,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	2,700	LF	$114	$307,800
Concrete Ballast for 24" Pipe	88.1	cy	$1,000	$88,100
18" HDPE Piping	4,150	LF	$70	$290,500
Concrete Ballast for 18" Pipe	76.2	cy	$1,000	$76,200
14" HDPE Piping	1,400	LF	$50	$70,000
Concrete Ballast for 14" Pipe	15.6	cy	$1,000	$15,600
8" HDPE Pipe for Zone I	200	LF	$25	$5,000
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$888,200**
Equipment				
SDOX Unit for Zone I	1		$129,950	$129,950
SDOX Unit for Zone II and III	1		$165,000	$165,000
DOCS 500 Oxygen Generator	2		$115,000	$230,000
Pump (5,000 gpm @ 33')	2		$50,000	$100,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$679,950**
Electrical Systems				
New Service Entrance				$65,000
Power Distribution Section				$20,000
Motor Control Center				$55,000
Control Panel and Programming				$40,000
Conduit / Wiring / Disconnects				$50,000
Lighting				$5,000
SUBTOTAL				**$235,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	305	man days	$440	$134,200
Divers	75	man days	$2,000	$150,000
Per Diem	380	man days	$75	$28,500
SUBTOTAL				**$312,700**
SUM SUBTOTAL				**$2,156,100**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$64,683
FINAL SUBTOTAL				**$2,340,783**
Contingency 10%				$234,078
Overhead and Profit 15%				$351,117
TOTAL				**$2,925,979**

Table 30: Operations and Maintenance Cost of Option 10 with Oxygen Generator

O&M Cost - Shoreline Installation, 2 Unts (3,000 lbs/day, O_2 Generator)				
Electrical	95	kW-hr	$0.12	$73,872
Maintenance	300	hr	$50	$15,000
Equipment Replacement				$33,998
Yearly O&M Cost				**$122,870**

Table 31: 20-Year Life Cycle Cost of Option 10 with Oxygen Generator

20 Yr Life Cycle Cost	**$4,132,330**

Table 32: Capital Cost of Option 10 with LOX

Capital Cost - Shoreline Installation, 2 Units (3,000 lbs/day, LOX)				
	quantity	*units*	*cost/unit*	*total cost*
Site Civil and Building				
Trenching	-		-	$5,000
Building Improvements	-		-	$0
Equipment Pad / Aesthetic Treatments / Security Fencing	-		-	$75,000
SUBTOTAL				**$80,000**
Underwater Civil				
Dredging	14	cy	$125	$1,750
Concrete Pads	14	cy	$250	$3,500
SUBTOTAL				**$5,250**
Mechanical Piping and Valving				
24" HDPE Piping	2,700	LF	$114	$307,800
Concrete Ballast for 24" Pipe	88.1	cy	$1,000	$88,100
18" HDPE Piping	4,150	LF	$70	$290,500
Concrete Ballast for 18" Pipe	76.2	cy	$1,000	$76,200
14" HDPE Piping	1,400	LF	$50	$70,000
Concrete Ballast for 14" Pipe	15.6	cy	$1,000	$15,600
8" HDPE Pipe for Zone I	200	LF	$25	$5,000
30" Suction Pipe	200	LF	$175	$35,000
SUBTOTAL				**$888,200**
Equipment				
SDOX Unit for Zone I	1		$129,950	$129,950
SDOX Unit for Zone II and III	1		$129,950	$129,950
Pump (5,000 gpm @ 33')	2		$50,000	$100,000
Valves / Instrumentation				$30,000
Mechanical Piping / Supports / Misc.				$25,000
SUBTOTAL				**$414,900**
Electrical Systems				
New Service Entrance				$55,000
Power Distribution Section				$20,000
Motor Control Center				$45,000
Control Panel and Programming				$35,000
Conduit / Wiring / Disconnects				$40,000
Lighting				$5,000
SUBTOTAL				**$200,000**
Labor				
Labor to Install Civil, Mechanical, Electrical	245	man days	$440	$107,800
Divers	75	man days	$2,000	$150,000
Per Diem	320	man days	$75	$24,000
SUBTOTAL				**$281,800**
SUM SUBTOTAL				**$1,870,150**
Design, Engineering, Startup				$120,000
Bonding and Insurance 3%				$56,105
FINAL SUBTOTAL				**$2,046,255**
Contingency 10%				$204,625
Overhead and Profit 15%				$306,938
TOTAL				**$2,557,818**

Table 33: Operations and Maintenance Cost of Option 10 with LOX

O&M Cost - Shoreline Installation, 2 Units (3,000 lbs/day, LOX)				
Electrical	55	kW-hr	$0.12	$42,768
Maintenance	300	hr	$50	$15,000
Liquid Oxygen Lease	12	month	$1,750	$21,000
Liquid Oxygen Delivery	11	refills/year	$4,059	$44,648
Equipment Replacement				$20,745
Yearly O&M Cost				**$144,161**

Table 34: 20-Year Life Cycle Cost of Option 10 with LOX

20 Yr Life Cycle Cost	**$3,973,209**

7 Recommendations and Next Steps

After review of the information presented, after meetings with operations staff from EVMWD, and after careful evaluation of model results and cost estimates, PACE recommends proceeding with option 10 using two on-shore oxygenation systems: one high oxygen concentration system for zone 1, and one low oxygen concentration, high flowrate system for zones 2 and 3. It is recommended to use a liquid transfer oxygenation system such as a Speece Cone or BlueInGreen system instead of a gaseous oxygen system such as the soaker hose concept because of the perceived reliability problems of gas diffusers, the loss of nearly 50% of the oxygen delivered, and the lack of mixing.

The reason for using an on-shore system instead of a submerged system is three fold: 1) the bottom of the lake contains a very high quantity of organic muck which will increase a submerged system installation cost and delay permitting, 2) the submerged system is more difficult to maintain because divers are required, and 3) long-term leveling of equipment is more challenging which can cause gas accumulation and potential damage to equipment.

When considering onsite oxygen generation or LOX for oxygen production, both systems or a combination of systems may be considered. At first glance the LOX system seems to be more advantageous because: 1) electrical upgrades will be costly and LOX does not require new electrical, 2) LOX is very quiet and requires very little maintenance, 3) LOX is better at delivering peak oxygen when necessary, 4) there is ample space and good access for LOX in Location A. The LOX system has more daily operation cost for oxygen supply by nearly 2:1, but does not have maintenance cost, and the estimated life-cycle cost for LOX is lower for a 3,000 lb/day system. The biggest drawback to the LOX system will be the need for large liquid-oxygen-carrying trucks coming to the site multiple times per month.

When considering whether to use an onshore Speece Cone or the BlueInGreen system for the proposed option 10 design, although both systems appear to work effectively, PACE recommends the following: use a standard high pressure/high oxygen concentration BlueInGreen system for zone 1 and a modified side-stream low pressure/low oxygen concentration BlueInGreen system for zones 2 and 3. BlueInGreen's SDOX system is lower capital cost, smaller size, and unlike the Speece Cone, the BlueInGreen system is easier to operate because the pump speed can be perfectly regulated to optimize oxygen dissolution in the water. This is achieved by maintaining a constant water level in the tank, and water is sprayed through the headspace. The Speece Cone does not have a spray, but rather water is pumped through a pipe with a gaseous cloud, which cannot be easily regulated. Thus, the Speece Cone controls require a higher safety factor for inefficiencies to avoid over gassing the cone (and floating it if submerged).

The systems could be located at the Canyon Lake WTP as follows: Location B can be outfitted with new submersible pumps using the existing intake structure, Location A parking lot can be used for a new dual tank LOX facility, and Location C can be used to install two new BlueInGreen SDOX skids. The next step to installation would include a site survey for the locations described and preparation of plans and specifications for bid by qualified contractors.

A schematic of the proposed setup is shown in Figure 29. Graphics of the BlueInGreen SDOX units are shown in Figure 30.

Figure 29: Conceptual Schematic of Proposed Dual BlueInGreen (BIG) On Shore System

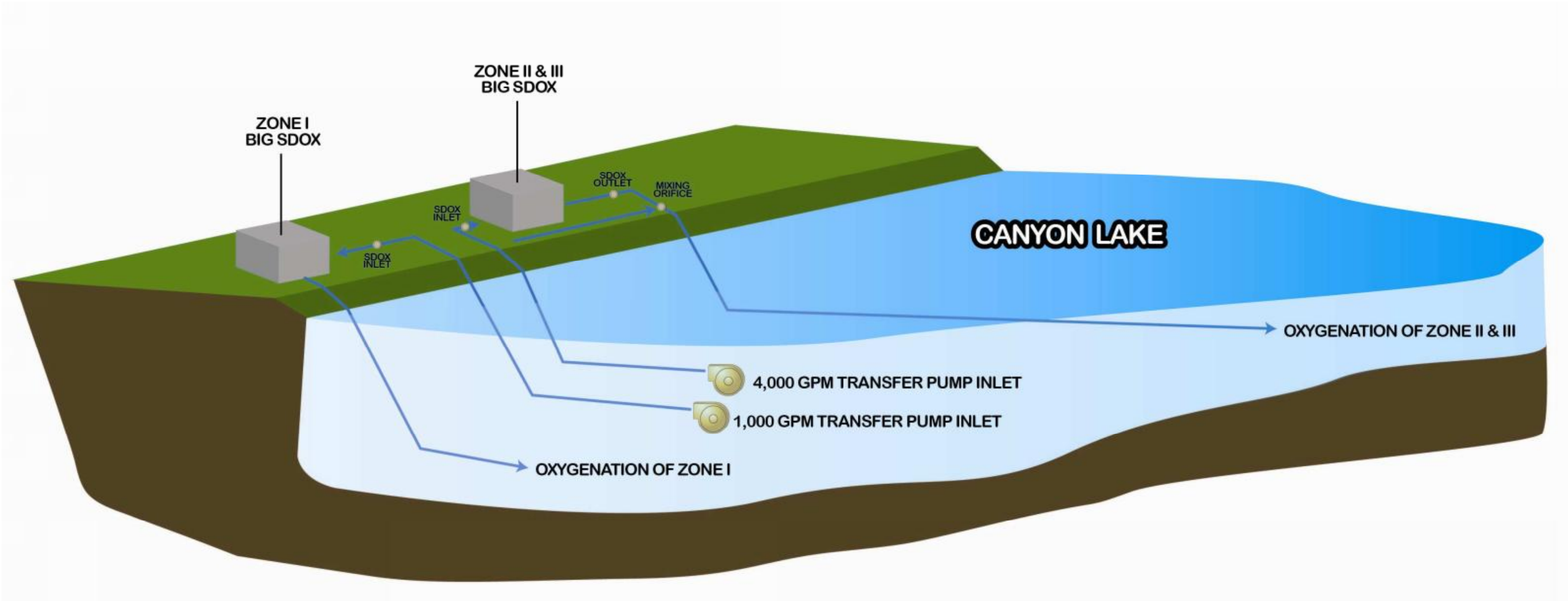
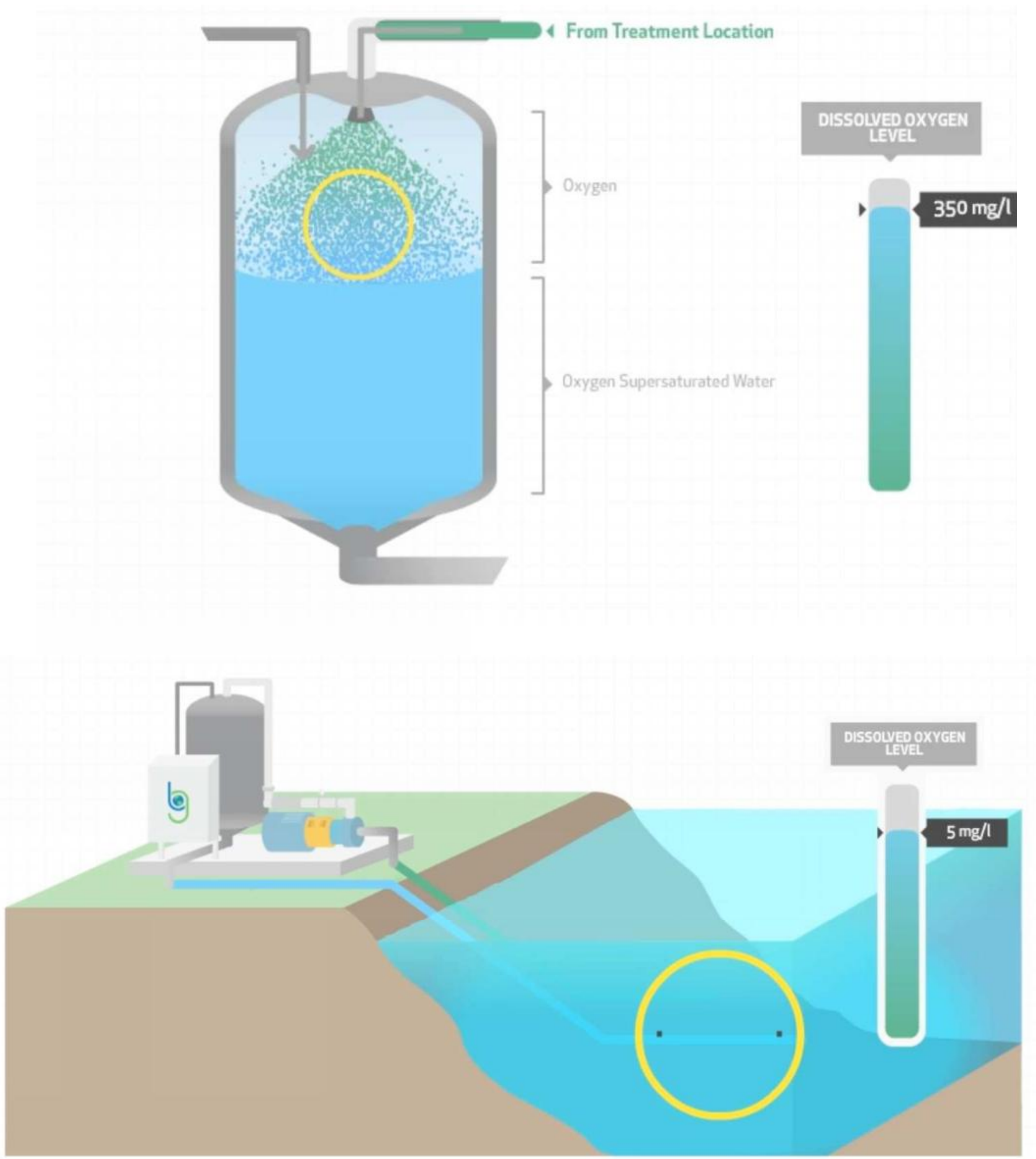


Figure 30: **Schematic of Standard BlueInGreen (BIG) On Shore System**



8 Permitting and Scheduling

Table 35: Anticipated Biological and Regulatory Permitting Project Schedule

Task	Dates
Notice to Proceed from with complete project description, project plans, CAD files, and other required project data.	10/04/11
Biological survey field work completed (within a week of receipt of Notice to Proceed)	10/11/11
Draft Biological Report completed (One week following completion of field work)	10/25/11
Contact USACE, CDFG, and RWQCB to discuss project and possible site visit. (Within five days working days of Notice to Proceed)	10/08/11
Complete field work for Jurisdictional Delineation Report if required by USACE (within one week from receipt of the Notice to Proceed).	10/11/11
Meet to discuss appropriate CEQA documentation (within 10 days of receipt of the Notice to Proceed). If Agency agrees to authorize the project under a Categorical Exemption (CE), the CE will be prepared. If a Mitigated Negative Declaration is determined to be appropriate, an Initial Study/Mitigated Negative Declaration (IS/MND) will be prepared.	10/14/11
Prepare draft application package that includes: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation (previously prepared), NOD, CDFG fee receipts, revises JD report, and Approved Jurisdictional Determination Form for Review (three days)	11/01/11
Prepare final Permit Application Package including: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation, NOD, CDFG fee receipts, revises JD report if one is required, prepares an Approved Jurisdictional Determination Form, and proposed mitigation strategy if required by the agencies. Obtains application signatures and filing fees for CDFG 1602 and RWQCB 401 applications and submits application package to USACE, RWQCB and CDFG. (One week)	11/15/11
Contact agencies to discuss applications to determine if additional information for a complete application. (Three weeks from date of application submittal to agencies)	11/22/11
Date agencies must determine if applications are complete. (30 days from date of application submittal)	12/ 01/11
Permit processing. Anticipated permit approvals (3 months)	1/04/12

Appendix B provides a sample permitting proposal from Bonterra for a submerged speece cone oxygenation system option with onsite oxygen generators.

Appendix A

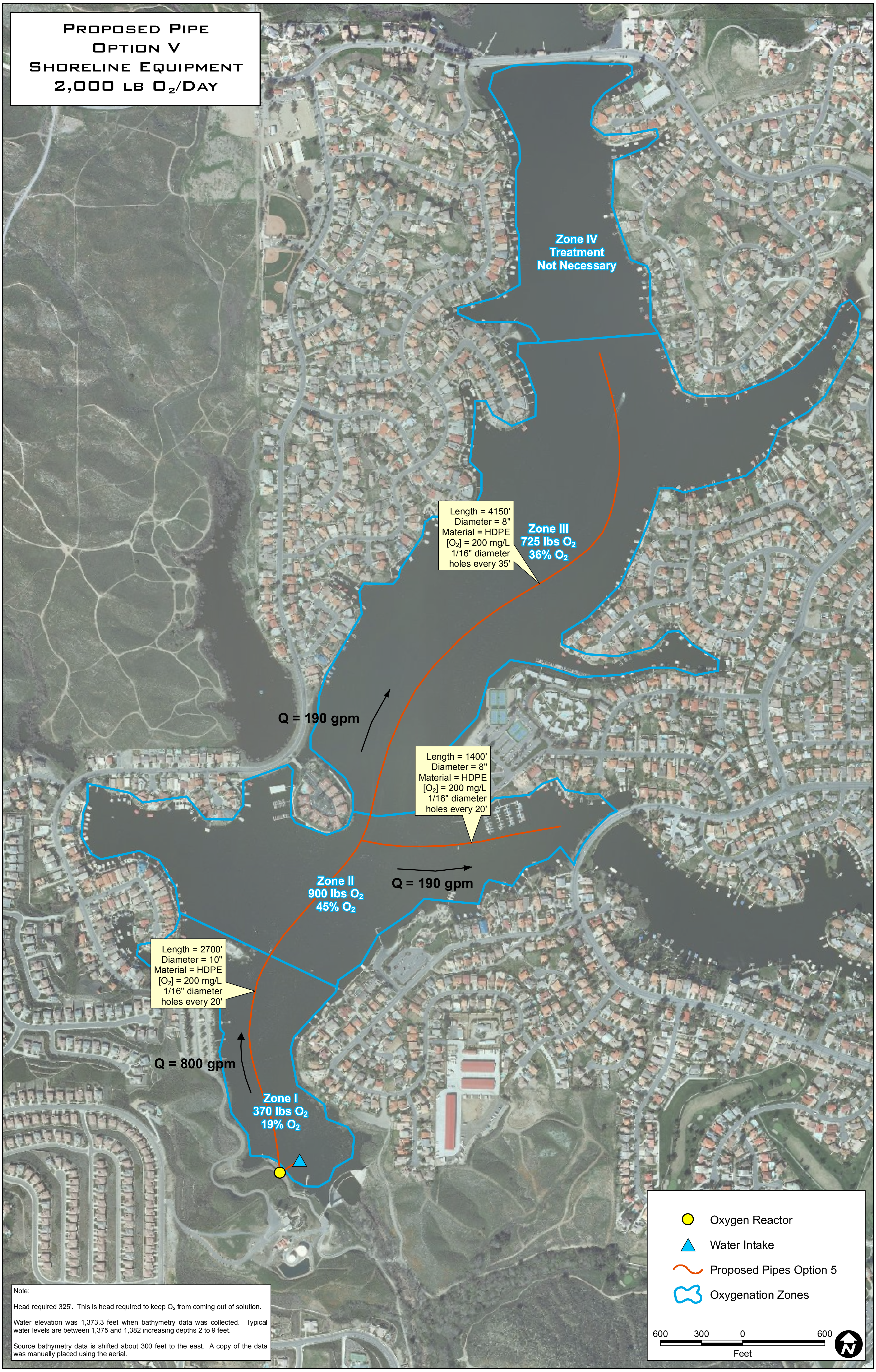
Appendix A

PROPOSED PIPE
OPTION I
SUBMERGED EQUIPMENT
2,000 LB O_2/DAY
Zone IV
Treatment
Not Necessary
Zone III
460 lbs O_2
22% O_2
Length = 4150'
Diameter = 12"
Material = HDPE
$[O_2]$ = 40 mg/L
Q = 970 gpm
Length = 1400'
Diameter = 10"
Material = HDPE
$[O_2]$ = 40 mg/L
Zone II
500 lbs O_2
24% O_2
Q = 915 gpm
Length = 2700'
Diameter = 18"
Material = HDPE
$[O_2]$ = 40 mg/L
Q = 1,500 gpm
Q = 2,150 gpm
Length = 1200'
Diameter = 10"
Material = HDPE
$[O_2]$ = 59 mg/L
Zone I
1,115 lbs O_2
54% O_2
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 32.5'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.
Oxygen Reactor
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet

PROPOSED PIPE
OPTION II
SUBMERGED EQUIPMENT
4,000 LB O2/DAY
Zone IV
Treatment
Not Necessary
Zone III
955 lbs O2
23% O2
Length = 4150'
Diameter = 18"
Material = HDPE
[O2] = 40 mg/L
Q = 1,850 gpm
Length = 1400'
Diameter = 14"
Material = HDPE
[O2] = 40 mg/L
Zone II
950 lbs O2
23% O2
Q = 1,490 gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O2] = 40 mg/L
Q = 3,000 gpm
Q = 4,300 gpm
Length = 1200'
Diameter = 16"
Material = HDPE
[O2] = 59 mg/L
Zone I
2,240 lbs O2
54% O2
Oxygen Reactor
& Water Intake
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 29'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

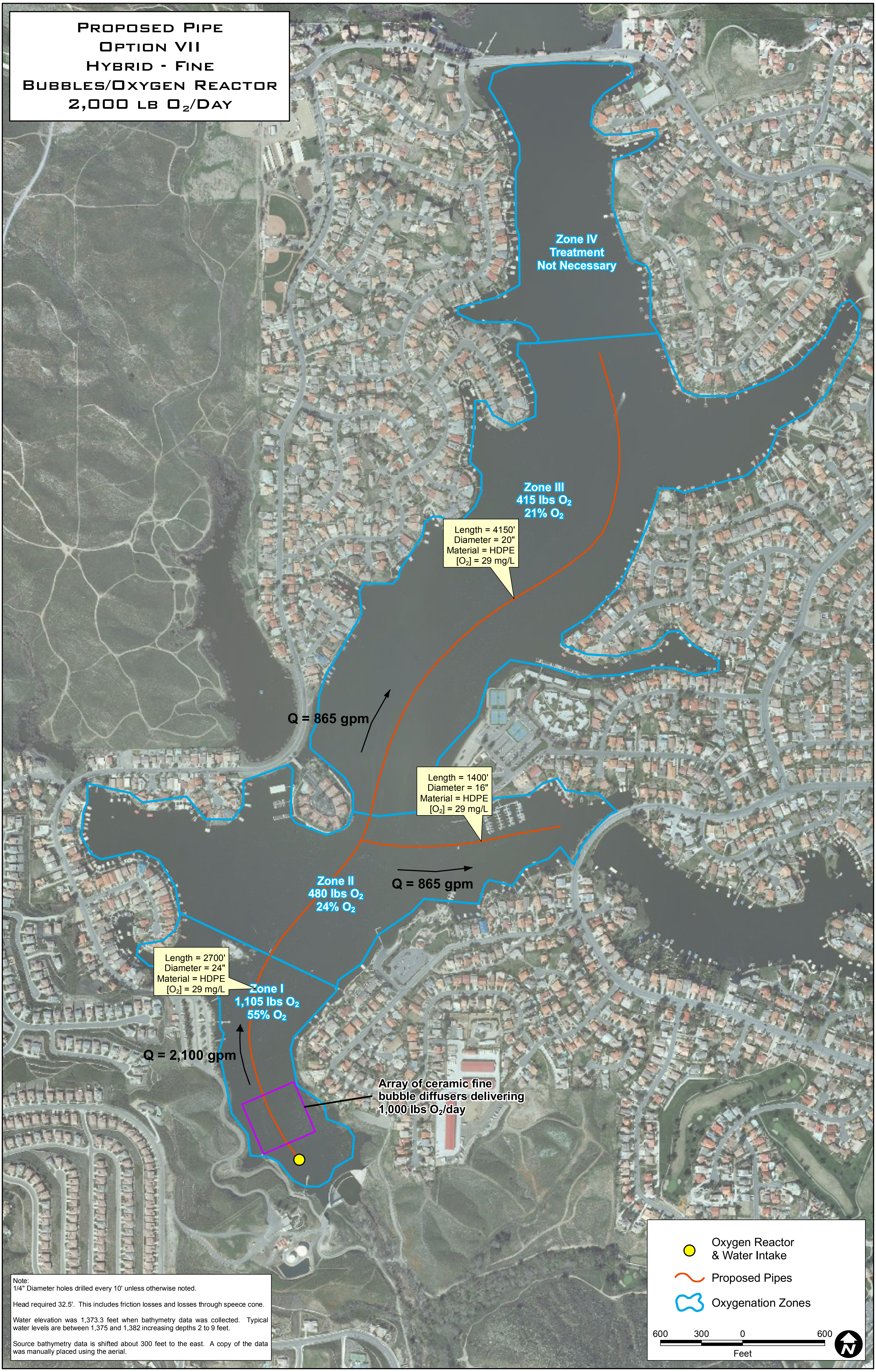
PROPOSED PIPE
OPTION III
SHORELINE EQUIPMENT
2,000 LB O2/DAY
Zone IV
Treatment
Not Necessary
Length = 4150'
Diameter = 16"
Material = HDPE
[O2] = 29 mg/L
Zone III
540 lbs O2
25% O2
Q = 1,780 gpm
Length = 1400'
Diameter = 12"
Material = HDPE
[O2] = 29 mg/L
Length = 1500'
Diameter = 20"
Material = HDPE
[O2] = 29 mg/L
Q = 1,530 gpm
Zone II
650 lbs O2
31% O2
Zone I
920 lbs O2
44% O2
Q = 1,450 gpm
Length = 1200'
Diameter = 24"
Material = HDPE
[O2] = 29 mg/L
Q = 6,000 gpm
Oxygen reactor
Water Intake
Transition to 20" HDPE
with 2 - 4" outlets.
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 32.5'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option IV
Shoreline Equipment
4,000 lb O2/Day
Zone IV
Treatment
Not Necessary
Zone III
990 lbs O2
23% O2
Length = 4150'
Diameter = 24"
Material = HDPE
[O2] = 29 mg/L
Q = 2,800 gpm
Length = 1400'
Diameter = 18"
Material = HDPE
[O2] = 29 mg/L
Zone II
1,170 lbs O2
28% O2
Length = 1500'
Diameter = 30"
Material = HDPE
[O2] = 29 mg/L
Q = 2,800 gpm
Zone I
2,070 lbs O2
49% O2
Q = 5,435 gpm
Q = 12,000 gpm
Length = 1200'
Diameter = 30"
Material = HDPE
[O2] = 29 mg/L
Oxygen Reactor
Water Intake
2 - 8" outlets.
Proposed Pipes Option 4
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 28'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.



PROPOSED PIPE
OPTION V
SHORELINE EQUIPMENT
2,000 LB O_2/DAY
Zone IV
Treatment
Not Necessary
Length = 4150'
Diameter = 8"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 35'
Zone III
725 lbs O_2
36% O_2
Q = 190 gpm
Length = 1400'
Diameter = 8"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 20'
Zone II
900 lbs O_2
45% O_2
Q = 190 gpm
Length = 2700'
Diameter = 10"
Material = HDPE
[O_2] = 200 mg/L
1/16" diameter
holes every 20'
Q = 800 gpm
Zone I
370 lbs O_2
19% O_2
Oxygen Reactor
Water Intake
Proposed Pipes Option 5
Oxygenation Zones
600 300 0 600
Feet
Note:
Head required 325'. This is head required to keep O_2 from coming out of solution.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option VII
Hybrid - Fine Bubbles/Oxygen Reactor
2,000 lb O_2/Day



Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.

Head required 32.5'. This includes friction losses and losses through speece cone.

Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.

Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe Option VIII Shoreline Equipment 3,000 lb O_2/Day

Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.

Head required 36'. This includes friction losses and losses through speece cone. Does not include head required to pump up to the shore.

Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.

Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

Proposed Pipe
Option IX
Hybrid - Fine
Bubbles/Oxygen Reactor
3,000 lb O_2/Day
Zone IV
Treatment
Not Necessary
Zone III
1,000 lbs O_2
33% O_2
Length = 4150'
Diameter = 20"
Material = HDPE
[O_2] = 29 mg/L
Q = 2,990 gpm
Length = 1400'
Diameter = 16"
Material = HDPE
[O_2] = 29 mg/L
Zone II
965 lbs O_2
32% O_2
Q = 2,700gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O_2] = 29 mg/L
Zone I
1,050 lbs O_2
35% O_2
Q = 6,000 gpm
Array of ceramic fine bubble diffusers delivering 1,000 lbs O_2/day
Oxygen Reactor Location
Water Intake
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Head required 38'. This includes friction losses and losses through speece cone.
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.


Proposed Pipe
Option X
Two Reactor System
3,000 lb O2/Day
Zone IV
Treatment
Not Necessary
Zone III
1,000 lbs O2
34% O2
Length = 4150'
Diameter = 18"
Material = HDPE
[O2] = 40 mg/L
Q = 2,100 gpm
Length = 1400'
Diameter = 14"
Material = HDPE
[O2] = 40 mg/L
Zone II
900 lbs O2
30% O2
Q = 1,750gpm
Length = 2700'
Diameter = 24"
Material = HDPE
[O2] = 40 mg/L
Q = 4,100 gpm
Zone I
1,050 lbs O2
36% O2
Q = TBD
Oxygen Reactor Location
Water Intake
Proposed Pipes
Oxygenation Zones
600 300 0 600
Feet
Note:
1/4" Diameter holes drilled every 10' unless otherwise noted.
Numbers for Zone I include 1,000 lb O2 injected by second system
Water elevation was 1,373.3 feet when bathymetry data was collected. Typical water levels are between 1,375 and 1,382 increasing depths 2 to 9 feet.
Source bathymetry data is shifted about 300 feet to the east. A copy of the data was manually placed using the aerial.

PACE
Advanced Water Engineering

Appendix B

Appendix B

ATTACHMENT A

SCOPE OF WORK AND FEES
CANYON LAKE AERATOR PROJECT
BIOLOGICAL RESOURCES, ENVIRONMENTAL, AND REGULATORY PERMITTING SERVICES

September 21, 2010

PROJECT UNDERSTANDING

The proposed Canyon Lake Aerator project includes the following project components:

- The project will occur at the very southern tip of the lake. An oxygen generator will be installed at the existing water treatment plant on a slab about 13' x 13'. Since the oxygen generator is noisy and ramps up and down continuously, it will be installed indoors. The residents of the private Canyon Lake Community are very sensitive to noise.

- The piping from the oxygen generator and the electrical lines will be run overland in an existing chemical feed conduit box that extends partially into the lake. There may be some trenching across the road to access the conduit box where it goes underground. In the lake, the lines will lie on the lake bottom in a conduit and no trenching will be required.

- A concrete pad, approximately 10' x 30', will be constructed at the bottom of the lake for the speece cone foundation. Some dredging of muck will be required and will likely be around 30 CY more or less. We will be doing some coring in the area to determine the actual depth. The pad will likely be poured in place as an underwater installation with marine grade concrete. Depth is approximately 45 feet.

- Divers will be utilized to bolt the speece cone to the slab and attach the piping and electrical to the submersible pumps. Once installed, the speece cone will not be seen or heard above the water. The fish will be able to hear the underwater pumps though.

As we discussed, the project is very small and will not likely result in significant impacts to the biological resources within or near the lake or the residents living in close proximately to the lake. The following tasks assume minimal impacts but address both alternative environmental and regulatory permitting strategies.

TASK 1 ENVIRONMENTAL DOCUMENTATION

Task 1.1 Project Initiation

BonTerra Consulting will attend a kickoff meeting with Elsinore Valley Municipal Water District (EVMWD) staff, Pacific Advanced Civil Engineering, Inc. (PACE) and other team members to discuss the proposed scope of work and to coordinate and identify data gaps and potential issues of concern and to obtain relevant supporting technical documents, planning documents, and other existing pertinent information. The appropriate level of environmental documentation (Categorical Exemption [CE] vs. Initial Study/Mitigated Negative Declaration [ISI/MND]) will be discussed. This coordination effort is intended to ensure that EVMWD and PACE concur with the scope of work, studies to be completed, and appropriate environmental documentation for the project. The project schedule will also be discussed at this meeting. Attendance at one project meeting is assumed for this task.

Task 1.1 Deliverable: 1. Attendance at one project meeting

Task 2.2 Preparation of Environmental Documentation

Once the appropriate level of environmental documentation has been determined, BonTerra Consulting will prepare the environmental document. At the request of the PACE/EVMWD, this section of the scope of work has been organized to address preparation of a CE as Option A and an IS/MND as Option B.

Option A: Categorical Exemption (CE)

Preparation of CEQA Categorical Exemption/NEPA Categorical Exclusion

In compliance with Section 15062 of the CEQA Guidelines and Code of Federal Regulations, Title 40, Chapter 1, Part 6, Section 6.107, BonTerra Consulting will prepare a Notice of Exemption for the project. The Notice of Exemption will follow the format provided as Appendix E to the CEQA Guidelines. This notice will include a description of the project, the location of the project including a vicinity map, a finding that the project is exempt from CEQA and NEPA, and a statement substantiating this finding. A brief statement will also be included identifying how the notice conforms to the required elements set forth in CEQA and NEPA.

This scope of work assumes that EVMWD/PACE will provide BonTerra with necessary information to prepare the project description, including any available structural elevations. BonTerra Consulting will conduct a site evaluation to substantiate the findings of no environmental impacts. The site evaluation will include a description of the site's existing conditions related to land use, biological resources, aesthetics, recreational resources, and any other relevant information.

Filing of the CE/CE

Following approval of the CE/CE, the Notice of Exemption shall be filed with the Governor's Office of Planning and Research State Clearinghouse and the EPA. BonTerra will coordinate the necessary filings on behalf of EVMWD.

Option A (CE) Deliverables: 1. Three copies of Notice of Exemption

Option B: Initial Study/Mitigated Negative Declaration (IS/MND)

Preparation of CEQA Initial Study

In compliance with Section 15063 of the State CEQA Guidelines, the IS will contain a Project Description, including its location; a discussion of the environmental setting; and identification of the Project's potential environmental effects. This Scope of Work assumes that PACE will provide BonTerra Consulting with the necessary information to prepare the Project Description for the IS including the specific location of the project, limits of grading, quantities of earthwork, and interface of the proposed facilities with other District facilities. The discussion of the environmental setting will be based on a review of existing literature and a site visit. The discussion of the environmental effects will follow the environmental checklist form included in Appendix G of the State CEQA Guidelines unless another format is requested by EVMWD. An explanation for all checklist answers will be included to provide an understanding of how the IS conclusions were reached. Mitigation measures will be clearly identified to facilitate the development of the mitigation monitoring program. Following is a description of the work effort for assessing potential environmental effects relative to each topical issue.

- Aesthetics – The proposed project would occur largely underground; however, an oxygen generator and housing unit would be installed aboveground. BonTerra Consulting will assess potential visual changes resulting from these aboveground appurtenances. Mitigation will be recommended, as necessary.

- Agriculture and Forestry Resources – Although no impacts to agriculture and forestry resources are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to agriculture and forestry resources.

- Air Quality – Based on preliminary reviews, construction and operational emissions would be well below the South Coast Air Quality Management District's (SCAQMD) emission thresholds. BonTerra Consulting will qualitatively discuss air quality impacts from the Project's short-term construction and long-term operations, and recommend mitigation measures that may be appropriate.

- Biological Resources – BonTerra Consulting will prepare a biological constraints report that will incorporate an underwater survey, as indicated in Task 2.7, Biological Survey, below. The IS/MND will summarize the findings of the biological survey, including the existing conditions, potential impacts, and mitigation measures, The potential direct, indirect, and cumulative impacts on biological resources, as a result of construction of the project, will be identified.

- Cultural Resources – BonTerra Consulting will prepare a CEQA-compliant, Phase I Cultural Resources technical letter report which will include literature reviews, complete a field survey, and applicable Native American consultation. The IS/MND will summarize the findings of the study and provide recommendations for management of any cultural resources documents within the project site.

- Geology and Soils– BonTerra Consulting will summarize geotechnical information to be provided by EVMWD and information previously prepared for the site vicinity. This scope of work assumes that the existing documentation will provide sufficient information to address the questions in the CEQA checklist. Mitigation measures will be identified, as necessary.

- Greenhouse Gas Emissions - Preliminary reviews indicate that proposed project's greenhouse gas emissions would be considerably less than any screening level for small Projects. BonTerra Consulting will qualitatively address greenhouse gas (GHG) emissions from the proposed Project.

- Hazards and Hazardous Materials - BonTerra Consulting will prepare a qualitative discussion of potential hazards associated with construction and operation of the project.

- Hydrology and Water Quality - BonTerra Consulting will summarize technical information to be provided by the EVMWD/PACE. This scope of work assumes that the information available will be sufficient to address the questions identified in the CEQA checklist.

- Land Use and Planning – BonTerra Consulting will conduct a site visit to document existing land uses surrounding the project site and will review existing planning documents relevant to the project area. A discussion of the compatibility of the project with surrounding land uses and consistency with applicable planning documents will be provided. Mitigation measures will be provided, as necessary.

- Mineral Resources - Although no impacts to mineral resources are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to mineral resources.

- Noise – BonTerra Consulting will qualitatively discuss potential short-term construction-related noise and operations noise impacts. Mitigation measures will be identified, as necessary.

- Population and Housing – Although no impacts to population and housing are anticipated with the proposed project, BonTerra Consulting will prepare a qualitative discussion related to population and housing.

- Public Services and Utilities – The proposed project would not affect public services or utilities. Appropriate documentation will be provided to confirm this assumption. Mitigation will be provided, as necessary.

- Recreation – BonTerra Consulting will assess potential direct and indirect impacts to existing and proposed recreational facilities from the project. Mitigation will be provided, as necessary.

- Transportation/Traffic – BonTerra Consulting will describe the construction-related, operations, and maintenance trips from the proposed project to address the questions in the CEQA checklist.

Preparation of IS/MND for Distribution

Following EVMWD/PACE review of the IS, BonTerra Consulting will revise the IS, if necessary, to address comments and suggested revisions provided by EVMWD/PACE that are within the scope of work. Should comments require additional technical studies or the description of the project be substantially modified, an amendment would be required. Concurrent with preparation of the revised IS, BonTerra Consulting will prepare the necessary documentation for the MND, including a proposed finding that the project will not have a significant effect on the environment, with implementation of mitigation measures. This will be submitted to the EVMWD/PACE for review with the revised IS.

Following receipt of comments from EVMWD/PACE on the IS/MND, the document will be finalized and submitted to the EVMWD for signature. A draft distribution list will be developed and submitted to the EVMWD for review and approval. BonTerra Consulting will reproduce and distribute the IS/MND to a public distribution list of up to 20 individuals and agencies. A notice that the lead agency proposes to adopt an MND needs to be provided to the public, prior to adoption of the MND. This notice should be published in a local newspaper or, at a minimum, posted at the project site. It is assumed that BonTerra Consulting would prepare the notice, but that the SMWD will submit the notice to the newspaper and/ or post it at the project site.

The IS/MND will be submitted to the State Clearinghouse and will be distributed for a 30-day public review period.

Response to Comments

Once the 30-day MND review period has ended, BonTerra Consulting will review the comments received and develop an approach to responding to these comments. Responses to comments are not required, but they are recommended to assist the lead agency in the decision making process. Topical responses, with a brief summary of the response and reference back to the larger response, will be used if multiple comments are received on the same issue. This will allow a more complete response without undue repetition. The draft responses to comments will be submitted to the EVMWD/PACE for review. In compliance with Section 15074 of the CEQA Guidelines, the decision-making body of the lead agency must consider the proposed MND together with any comments received during the public review process.

Notice of Determination

Following adoption of the MND by EVMWD, BonTerra Consulting will prepare the Notice of Determination (NOD) to be filed with the County Clerk and State Clearinghouse. BonTerra Consulting will coordinate the necessary NOD filings on behalf of EVMWD. Assuming the MND finds that the project would have an impact on biological resources, the project would require the payment of fees to the CDFG with the NOD. BonTerra Consulting will file on behalf of the EVMWD; however, the EVMWD would submit the check for the required fees.

Mitigation Monitoring

To comply with Public Resources Code 21081.6, BonTerra Consulting will prepare a mitigation monitoring program (MMP) for adoption with the MND. The MMP is required to ensure compliance with adopted mitigation requirements during project implementation. The program will be prepared in matrix format and will provide the timing and responsibility for each mitigation measure. A draft copy will be submitted for review by EVMWD/PACE. Revisions will be made accordingly.

Option B (IS/MND) Deliverables:

1. Attendance at one meeting
2. Three copies each of the screencheck IS
3. Three copies of the IS/draft MND
4. 30 copies of the IS/MND (20 for distribution, 10 for EVMWD staff and board use)
5. Three copies of draft responses to comments
6. Ten copies of final responses to comments
7. Notice of Determination
8. Five copies of the draft MMP
9. Ten copies of the final MMP

Project Management and Meetings

BonTerra Consulting will coordinate with PACE/EVMWD, as necessary, throughout the CEQA documentation process to ensure compliance with the scope and schedule. In addition to the two meetings previously identified, this scope of work assumes the need for two additional coordination meetings with EVMWD/PACE personnel. Additionally, BonTerra Consulting's principal-in-charge and/or project manager will attend one public hearing, if requested by the EVMWD.

Project Management and Meetings Deliverables:

1. Attendance at up to two team meetings. These meetings will be attended by BonTerra Consulting's project manager
2. Attendance at one public hearing. This meeting will be attended by BonTerra Consulting's principal-in-charge and/or project manager

TASK 2 REGULATORY PERMITTING SCOPE OF WORK

Task 2.1 Jurisdictional Delineation Report (Optional)

A Nationwide Permit No. 18 (Minor Discharges) requires a jurisdictional delineation if more than 10 cubic yards of discharge is proposed below the plain of the defined Ordinary High Water Mark (OHWM) or below the surface of the lake. BonTerra Consulting will contact the U.S. Army Corps of Engineers (USACE) to determine if a jurisdictional delineation is necessary. If one is, BonTerra Consulting will perform a jurisdictional delineation to map jurisdictional "waters of the U.S.," including wetlands (if present), and/or "waters of the State" for the construction of the Canyon Lake Project. The proposed project is defined as the ultimate limits of project disturbance including grading and any other construction-related activity that involve temporary and/or permanent ground/vegetation disturbances that can be characterized as dredge or fill within "waters of the U.S.," including wetlands, and/or "waters of the State". The delineation will result in the identification of the jurisdictional boundaries based on the ordinary high water mark(s) (OHWM) on the project site and indicate the presence of any adjacent wetlands not within the jurisdictional OHWM. The actual presence or absence of wetlands on site will be verified through the presence of wetlands hydrologic conditions, hydrophytic vegetation, and hydric soils pursuant to the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Arid West Region* (USACE 2008) and the 1987 Corps Manual. Any special status species observed will be reported to the CNDDB. Waters of the State will be identified based on the presence of bed, bank, stream and riparian vegetation.

The PACE/EVMWD will provide BonTerra Consulting with existing topographic contour data at 2-foot intervals in a CAD or GIS file. This data will be used in conjunction with digital color aerial photography for recording the U.S. Army Corps of Engineers (USACE) and CDFG jurisdictional limits. The PACE/EVMWD will also provide digital files of the proposed project to be used for impact assessment, specifically the limits of permanent structural and temporary construction disturbance limits including haul routes and equipment and materials staging areas. The PACE/EVMWD will also provide BonTerra Consulting with the hydrology report as well as a list of Best Management Practices (BMPs) that would be used to avoid and/or minimize impacts to water quality during construction.

The Jurisdictional Delineation Report (JD Report) would be used to: (1) assess jurisdictional impacts to state and federal jurisdictional waters; (2) prepare an individual or nationwide permit (NWP) if project impacts fit within the established threshold for a NWP authorization; (3) provide the jurisdictional information necessary for the supporting documentation; and (3) support the request for subsequent USACE, CDFG, and RWQCB permits.

This scope includes one revision to the draft JD Report based on comments received by the PACE/EVMWD.

Task 2.2 A Preliminary Jurisdictional Determination Form (Optional)

If a jurisdictional delineation is required by the USACE, BonTerra Consulting will prepare and process a "Preliminary Jurisdictional Determination Form" through the USACE. The process for obtaining a "Preliminary Jurisdictional Delineation" for the project involves the following actions: 1) Submittal of the JD Report and a completed "Preliminary Jurisdictional Delineation Form" to the USACE. The Preliminary Jurisdictional Determination does not require review by USACE Headquarters or the Environmental Protection Agency and is generally processed within 30 days of receipt by the USACE.

Task 2.3 USACE Clean Water Act Section 404 Permit Water Quality Certification

The project is very small and would likely be authorized under Nationwide Permits 18 (Minor Discharges). BonTerra Consulting will prepare and submit a permit application to the USACE, following review and approval of the application by the PACE/EVMWD, to satisfy the requirements of Section 404(b) (1) of the Clean Water Act. The project engineer will provide a PDF of the entire project will all project components. The permit application package will include the Regional Water Quality Control Board (RWQCB) Clean Water Act Section 401 Water Quality Certification and California Fish and Game Code Section 1602 Streambed Alteration Agreement notification which will be completed under Tasks No. 4 and 5. This task includes one revision in response to comments by the PACE/EVMWD.

Please note that if the USACE determines that the project must be authorized under a Letter of Permission, a budget augment would be required to prepare the application and obtain the necessary notification information.

Task 2.4 RWQCB Clean Water Act Section 401 Water Quality Certification

A Section 401 Water Quality Certification application will be prepared and submitted to the Santa Ana RWQCB (SARWQCB) following review and approval of the application by the PACE/EVMWD. This task will include a consistency review of the Basin Plan that includes: 1.) Beneficial Uses - uses of water for drinking, agriculture, navigation, recreation, and fish and wildlife habitat; 2.) Objectives - numeric and narrative limits on water characteristics or bans on substances, which affect water quality; and 3.) Anti-Degradation Policy - which requires that existing high-quality waters be protected and maintained. This certification is necessary prior to the USACE concurring with discharges of fill material under the USACE permit process. This task includes one revision following PACE/EVMWD review. The PACE/EVMWD will also provide written descriptions and graphics (if available) of the proposed construction and post-construction Best Management Practices (BMPs). This task does not include the permit filing fees.

Task 2.5 CDFG Fish And Game Code Section 1602 Agreement Streambed Alteration Application/Notification

A California Department of Fish and Game (CDFG) Section 1602 Lake or Streambed Notification application for a Streambed Alteration Agreement will be prepared and submitted to the CDFG following review and approval of the application by the PACE/EVMWD. The submittal package will include: (1) Form FG 2023; (2) vicinity map; (3) project description; (4) jurisdictional delineation map; and (5) site photos. The application filing fees are based on total construction costs and will be provided by PACE/EVMWD prior to the submittal of the application. A check from PACE/EVMWD in the amount specified by the CDFG fee schedule shall be provided by the PACE/EVMWD to BonTerra Consulting prior to the submittal of the application. The check shall be payable to the California Department of Fish and Game. This task does not include the development of a Habitat Mitigation and Monitoring Plan (HMMP)/mitigation plan. If an HMMP is required by CDFG, the concept HMMP/mitigation plan must be completed prior to the submittal of this application and would be need to be completed under a separate task.

Task 2.6 Permit Processing and Management

Following submittal of the application packages to the affected regulatory agencies, BonTerra Consulting will contact designated agency staff to confirm receipt of the application submittal packages. BonTerra Consulting, in coordination with PACE/EVMWD, will contact the appropriate USACE, CDFG, and RWQCB staff to: (1) provide an overview of the proposed project; (2) the extent of existing jurisdictional and biological resources as defined by the JD Report; (3) identify anticipated project impacts to these resources; (4) identify proposed mitigation (if required) to address the type and value of riparian habitat impacted by the project and mitigation ratios established by USACE-accepted habitat assessment methodologies; and (5) verification of the type of regulatory permit/authorization required and schedule for permit issuance. This would typically occur as part of a pre-application meeting However, if agency staff cannot attend a pre-application meeting due to current and future state budget constraints and/or state-mandated furlough days, BonTerra Consulting will schedule meetings at these agency at their respective office(s) to provide project information identified above and obtain comments from the assigned state and/or federal staff person(s), and recommendations concerning the appropriate regulatory permit authorization(s).

BonTerra Consulting will process the USACE Section 404 permit, CDFG Section 1602 Streambed Alteration Agreement notification, and SARWQCB Section 401 WQC permit including preparation of correspondence, and participation in telephone calls between agency staff assigned to process the permits. These services also include up to two meetings with assigned regulatory agency staff during the permit application review process. BonTerra Consulting will provide regulatory permit status reports to the PACE/EVMWD each month until the permits are issued. It is difficult to anticipate all of the processing requirements associated with this task. As a result, if the proposed coordination budget exceeds the amount identified in this task, BonTerra Consulting will request a contract budget augment to complete the regulatory process.

Task 2.7 Biological Survey

A survey will be conducted in the vicinity of the proposed approximately 10’ x 30’ concrete base and speece cone. The biological investigators will conduct dive field survey to check for invasive mussels and other aquatic life. Two divers, and a support skipper. The survey will be conducted over field day with vessel. A biological constraints letter report will be prepared and will include existing conditions, an impact analysis, and mitigation plan (if required). This task also includes project management and up to two meetings at 3 hours each.

ATTACHMENT B

TABLE 1
BIOLOIGCAL AND REGULATORY PERMITTING
PROJECT SCHEDULE

Task	Dates
Notice to Proceed from PACE with complete project description, project plans, CAD files, and other required project data.	10/04/10
Biological survey field work completed (within a week of receipt of Notice to Proceed)	10/11/10
Draft Biological Report completed (One week following completion of field work)	10/25/10
BonTerra contacts USACE, CDFG, and RWQCB to discuss project and possible site visit. (Within five days working days of Notice to Proceed)	10/08/10
BonTerra completes field work for Jurisdictional Delineation Report if required by USACE (within one week from receipt of the Notice to Proceed).	10/11/10
BonTerra meeting with PACE and Water District to discuss appropriate CEQA documentation (within 10 days of receipt of the Notice to Proceed). If the District agrees to authorize the project under a Categorical Exemption (CE), the CE will be prepared. If a Mitigated Negative Declaration is determined to be appropriate, an Initial Study/Mitigated Negative Declaration (IS/MND) will be prepared. **Refer to Table 2 below for environmental documentation schedule**	10/14/10
BonTerra prepares draft the application package that includes: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation (previously prepared), NOD, CDFG fee receipts, revises JD report, and Approved Jurisdictional Determination Form for PACE and District Review (three days)	11/01/10
BonTerra prepares the final Permit Application Package including: USACE 404 Permit, CDFG 1602 SAA, and RWQCB 401 Water Quality Certification Notifications/Applications, CEQA documentation, NOD, CDFG fee receipts, revises JD report if one is required, prepares an Approved Jurisdictional Determination Form, and proposed mitigation strategy if required by the agencies. BonTerra obtains application signatures and filing fees for CDFG 1602 and RWQCB 401 applications and submits application package to USACE, RWQCB and CDFG. (One week)	11/15/10
BonTerra contacts agencies to discuss applications to determine if additional information for a complete application. (Three weeks from date of application submittal to agencies)	11/22/10
Date agencies must determine if applications are complete. (30 days from date of application submittal)	12/ 01/10
Permit processing. Anticipated permit approvals (3 months)	1/04/11

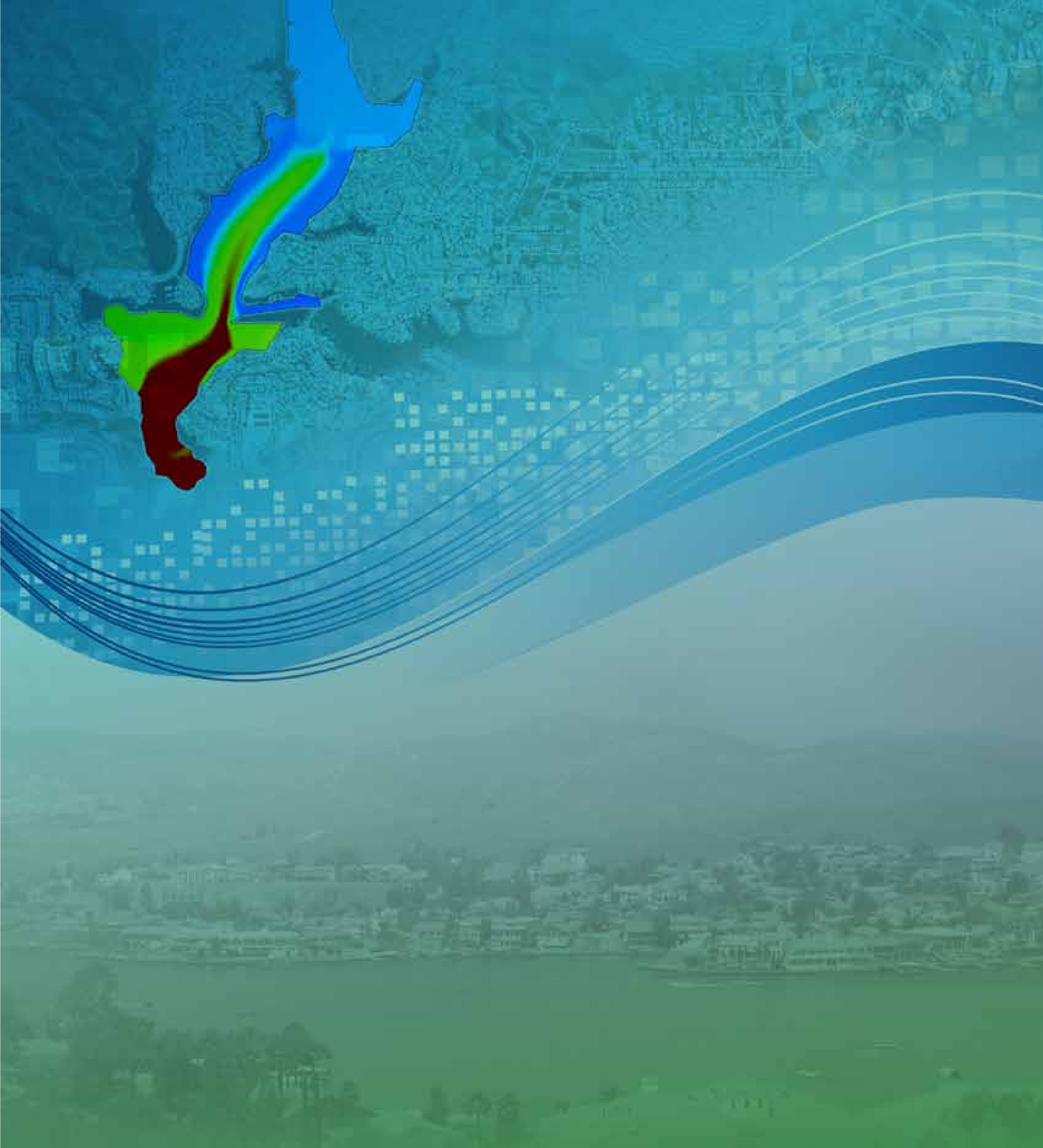
TABLE 2
ENVIRONMENTAL DOCUMENTATION SCHEUDLE (OPTIONS A AND B)
PROJECT SCHEDULE

Task	Dates
OPTION A – CATEGORICAL EXEMPTION	
BonTerra prepares screencheck CE/CE	10/15/10-10/29/10
PACE/EVMWD reviews screencheck CE/CE	11/1/10-11/5/10
BonTerra prepares final CE/CE	11/8/10-11/19/10
EVMWD Board of Directors Meeting	TBD
OPTION B – INITIAL STUDY/MITIGATED NEGATIVE DECLARATION	
BonTerra prepares screencheck draft IS/MND	10/15/10-11/19/10
PACE/EVMWD reviews screencheck draft IS/MND	11/22/10-11/29/10
BonTerra prepares Approval Draft IS/MND	11/30/10-12/7/10
PACE/EVMWD reviews Approval Draft IS/MND	12/8/10-12/10/10
BonTerra prepares Draft IS/MND	12/13/10-12/17/10
Public Review Period	12/20/10-1/18/11
BonTerra submits draft Responses to Comments	1/24/11
1. PACE/EVMWD reviews Responses to Comments	1/25/11-1/28/11
2 BonTerra submits final Responses to Comments	2/3/11
3. BonTerra prepares Mitigation Monitoring Program	2/3/11
Public Hearings	TBD
BonTerra files Notice of Determination (within five days of project approval)	TBD

FEE ESTIMATE

September 21, 2010

TASK			FEE
BonTerra Consulting Professional Fees			
Task 1	Environmental Documentation		
	Task 1.1	Project Initiation	
	Task 1.2	Preparation of Environmental Documentation	
		(Option A – Categorical Exemption)	$6,010.00
		(Option B – Initial Study/Mitigated Negative Declaration)	$23,785.00
Task 2	Regulatory Permitting		
	Task 2.1	Jurisdictional Delineation Report (Optional)	$5,601.00
	Task 2.2	A Preliminary Jurisdictional Determination (Optional)	$1,305.00
	Task 2.3	USACE Section 404 Permit Water Quality Certification	$4,121.00
	Task 2.4	RWQCB Section 401 Water Quality Certification	$5,421.00
	Task 2.5	CDFG Fish and Game Code Section 1602 Agreement	$4,988.00
	Task 2.6	Permit Processing and Management	$11,608.00
	Task 2.7	Biological Survey	$8,160.00
		Labor Fees (Option A)	**$40,308.00**
		Labor Fees (Option B)	**$57,083.00**
		Optional Tasks	**$6,906.00**
Other Direct Costs			
Reproduction			$ .00
Deliveries			100.00
Mileage			355.00
Other			200.00
		Other Direct Costs	**$ .00**
		TOTAL FEE ESTIMATE (OPTION A)	***$41,536.00***
		TOTAL FEE ESTIMATE (OPTION B)	***$58,538.00***



PACE

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