Upper San Leandro Hypolimnetic Oxygenation System

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Introduction:

- Upper San Leandro (USL) is a drinking water reservoir near Oakland, CA.
- Approximately 75% of the water is local runoff.
- Historically, nutrients in the reservoir have contributed to blue green algae blooms that generated high levels of geosmin at the surface sometimes over 700 ng/L.
- Taste and odor complaints occurred in the summer and fall due to geosmin levels higher than the treatment plant capability.
- The hypolimnetic oxygenation system was installed in 2001 to reduce internal nutrient loading.

Water Treatment Plant

- The USL water treatment plant uses an ozone feed system capable of treating geosmin levels up to 100 ng/L at plant capacity.
- In 1995 and 1996 geosmin levels exceeded 500 ng/L at the plant.
- In 1997 a hydrogen peroxide feed was added to treat geosmin levels up to a total of 350 ng/L.
- Before the oxygenation system, the District limited USL production to 30 MGD during the summer to allow sufficient treatment contact time in case of a geosmin event.

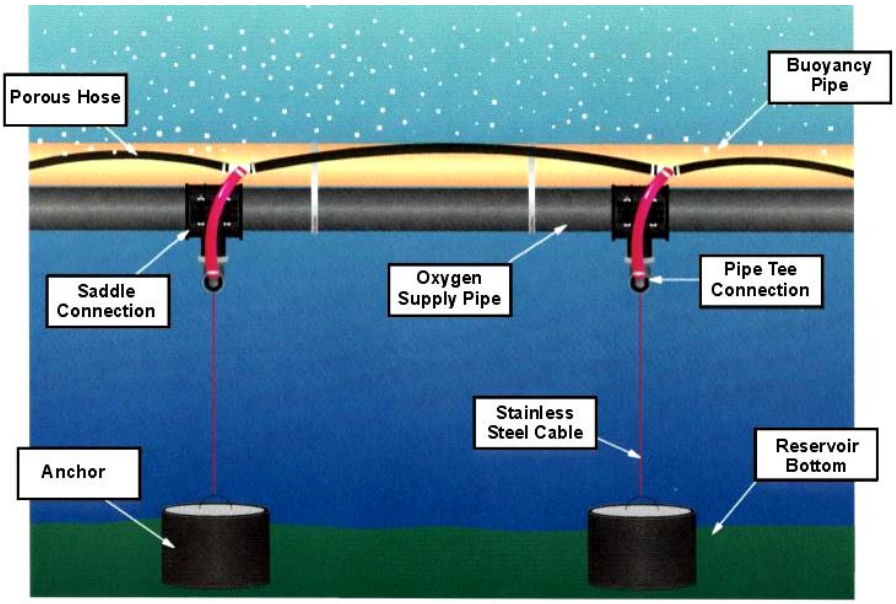
Oxygen Supply

- The line diffusers are supplied with pure gaseous oxygen.
- Liquid oxygen is trucked to a 6,000 gallon storage tank onsite.
- Vaporization of the liquid oxygen provides the pressure to move the gas through the diffusers.
- The oxygen delivery capacity is 150 scfm (9 tons per day).
- Oxygen flow is controlled by a remotely operated control valve and flow meter at the tank.

USL Oxygen Supply Facility

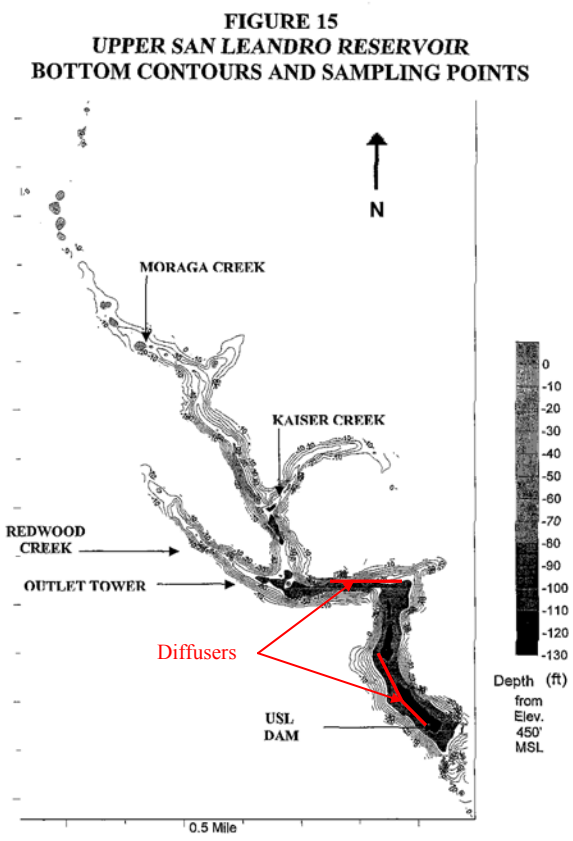
Line Diffuser:

The Upper San Leandro hypolimnetic oxygenation system includes a single line diffuser supplied by the liquid oxygen storage and supply facility. The diffuser piping extends 8,500 feet along the centerline of the reservoir with two sections of porous hose diffuser – one near the dam and one around a bend in the reservoir near the water supply intake tower. The diffuser design is similar to that developed for the Tennessee Valley Authority for hydropower applications (Mobley, 2000) and was supplied by Mobley Engineering, Inc. The elevation and oxygen delivery flow rate of the diffuser was designed to place oxygen in specific layers and areas of the reservoir as specified by East Bay Municipal Utility District. A flow control valve was installed between the two diffusers to provide some adjustment of flow distribution. The Upper San Leandro hypolimnetic oxygenation system was fully operational in 2002.



Line Diffuser Schematic

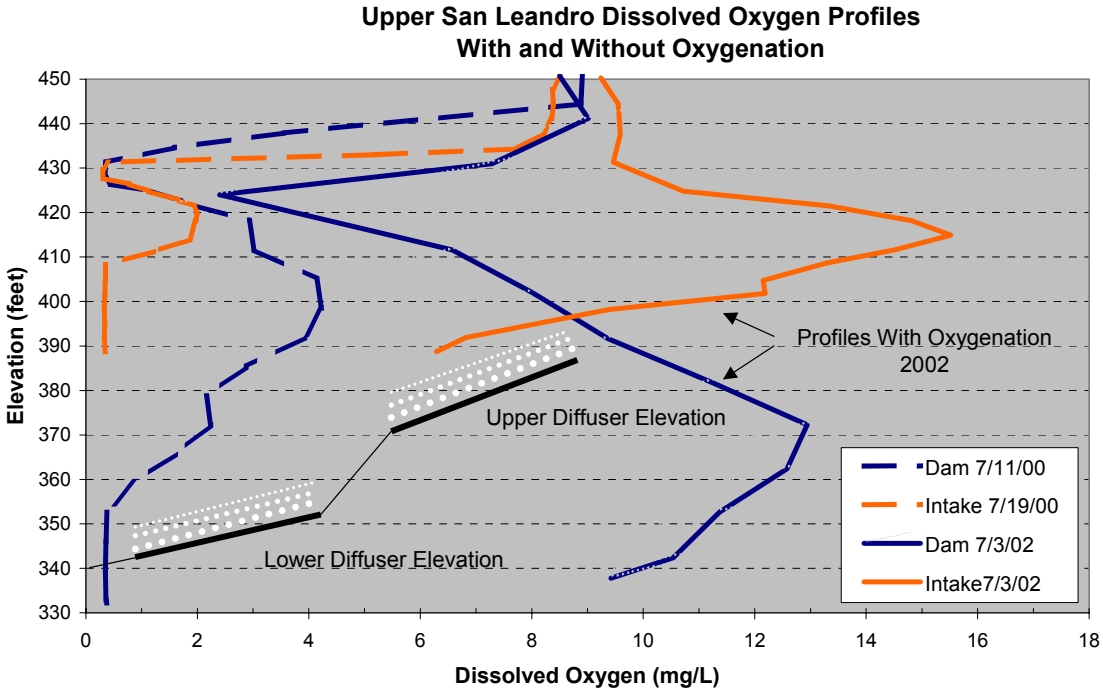
USL Diffuser Prepared for Deployment



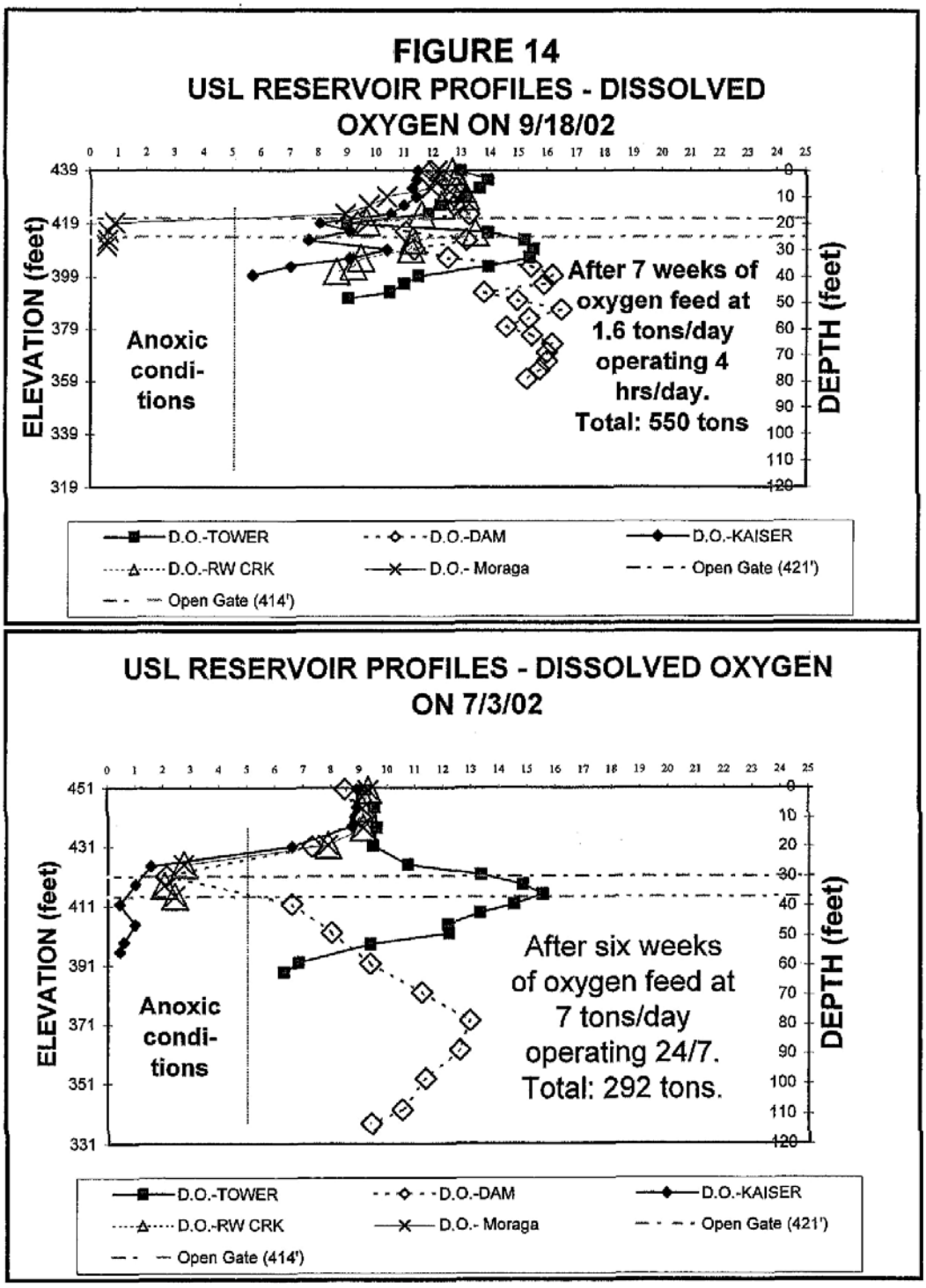
Results in the Reservoir:

- Increased DO levels
- Lower manganese levels
- Slightly higher pH
- Slightly increased temperature
- NH_4-N reduced by 95% *
- NO_3-N increased by 85% *
- TN-N increased by 5% *
- Phosphate decreased by 35% *
- Geosmin levels decreased

* As compared to 2 previous years (Horne et. al, 2003)



USL Reservoir Profiles With and Without Oxygenation



USL Reservoir Profiles Showing Increasing Extent of Oxygenation Effectiveness With Time and Operational Changes (Jung, 2002)

Results at the Water Treatment Plant:

- Ozone dose decreased by 45%
  - ⋆ $11 per million gallons cost savings
- Hydrogen peroxide advance oxidation treatment was eliminated
  - ⋆ $12 per million gallons cost savings
- Chlorine use decreased by 18%
  - ⋆ $3 per million gallons cost savings
- Trihalomethane (THM) levels in the treated water were reduced by 50%
- TOC remained the same (as expected for the short term)
- Chemical cost savings are more than twice the cost of oxygen used ($340/day)

Conclusion:

The operation of the hypolimnetic oxygenation system in Upper San Leandro Reservoir has provided East Bay Municipal Utility District with the following benefits:

- ✓ Reduced chemical treatment requirements
- ✓ Increased treatment capacity
- ✓ Reduced THM formation
- ✓ Significant overall cost savings

Operation of USL Reservoir's hypolimnetic oxygenation system in 2002 resulted in water quality impacts at USL Reservoir and changes in operating practices in USL Water Treatment Plant (WTP). These impacts included: increased dissolved oxygen levels, lower manganese levels, and slightly higher pH and temperatures in the reservoir. For USL's WTP two miles away, ozone doses decreased an average of 45 percent, peroxide feed was eliminated and chlorine doses decreased by 18 percent from the previous year. Distribution system THMs accordingly, decreased from 39 to 19 ug/l. A partial day operation procedure was developed by East Bay Municipal Utility District to provide the additional mixing required to spread the oxygen input as desired over this dendritic reservoir.

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