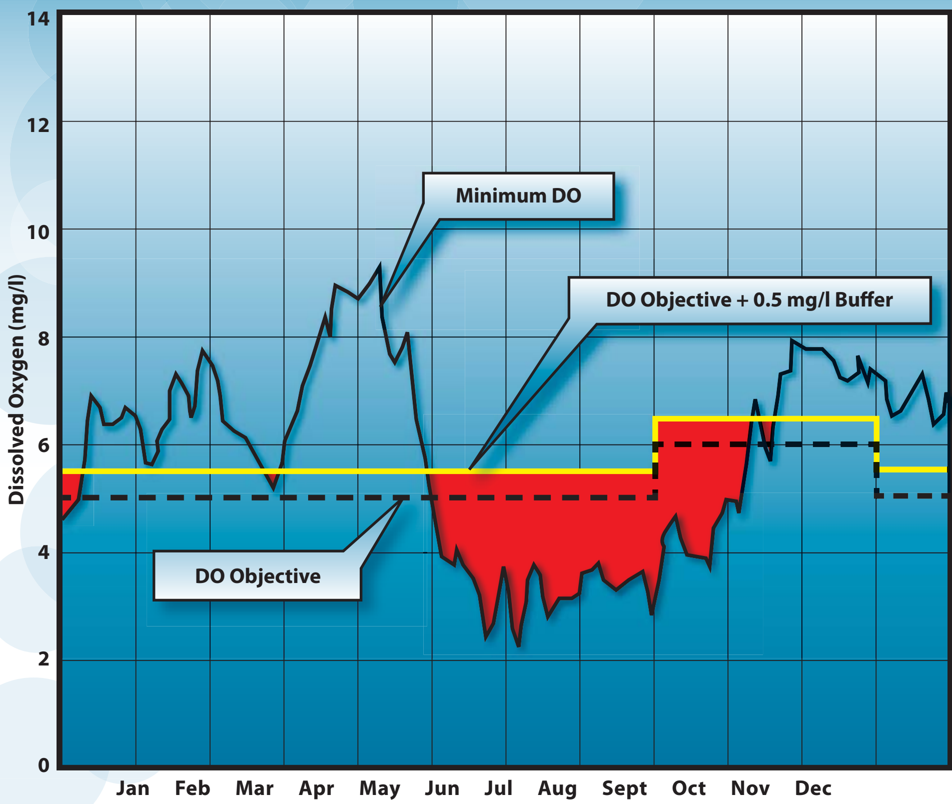
Aeration Demonstration Project in the Stockton Deep Water Ship Channel

CALIFORNIA
BAY–DELTA AUTHORITY

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

The Stockton Deep Water Ship Channel (DWSC) is a maintained (i.e., dredged) portion of the San Joaquin River that begins at the mouth of the river near Antioch and terminates in Stockton, California. It is used as a shipping channel allowing large vessels access to the interior of the Central Valley from the open sea. The shipping channel ends at the Port of Stockton East Complex turning basin where vessels can reverse their orientation before departing. The DWSC is dredged annually to a depth of at least 35 feet measured at the lowest low diurnal tidal cycle (mean lower low water).

The concentration of dissolved oxygen (DO) in the DWSC is a function of three primary factors: change in flow conditions in the San Joaquin River, the depth and width of the DWSC, and upstream contributions of algae and other oxygen-depleting substances. High flows in the River, greater than 2,000 cubic feet per second (cfs), can prevent decreases in DO concentrations by diluting and transporting oxygen-depleting substances more quickly through the DWSC. At lower flows, the volume of the DWSC significantly increases the time it takes water to flow through the DWSC. This allows algae and other oxygen-depleting substances to settle to the bottom of the channel. Sunlight only penetrates the top few feet of the water column in the DWSC, limiting algal growth to the few feet near the surface. As algae and other oxygen-depleting substances settle to the bottom of the channel under low flow conditions, they decay. The growing algae at the surface does provide DO to the DWSC through photosynthesis, but the net effect of decaying algae is a reduction in DO levels as the algae respire and bacteria decompose the dead algae.



Dissolved Oxygen Deficit in the Deep Water Ship Channel • 2001

In 2001, the oxygen deficit was calculated to be 10,000 lbs per day

The DO Deficit

Water quality objectives are established by the Regional Water Quality Control Boards (RWQCBs) to protect the beneficial uses of water bodies in California. The DO water quality objective (the minimum DO concentration) for the San Joaquin River, from Turner Cut to Stockton, is 6 milligrams per liter (mg/l) from September 1 to November 30 and 5 mg/l throughout the rest of the year. However, water quality monitoring data have indicated that the DWSC frequently has DO levels that are lower than the water quality objectives.

A DO deficit, defined here as the quantity of oxygen that must be added to the DWSC to meet the water quality objectives, was calculated using DO and flow data from 2001. Based on the daily minimum DO concentrations at the DWR Rough & Ready Island station and the daily net flow measured at the Stockton UVM flow station, about 1 million lbs of oxygen would have been needed in the summer of 2001. This includes a 0.5-mg/l DO buffer added to the water quality objective. An aeration or oxygenation device that delivered about 10,000 lbs per day, operating for 100 days, may have satisfied the measured DO deficit during the summer of 2001. It should be noted that water year 2001 was a slightly below-normal year and that during a dry or critical year with lower river flows the oxygen deficit could be much larger.

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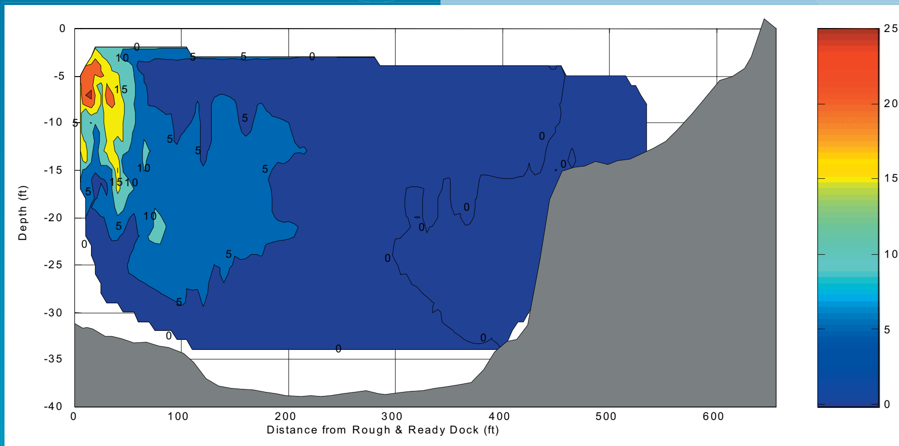
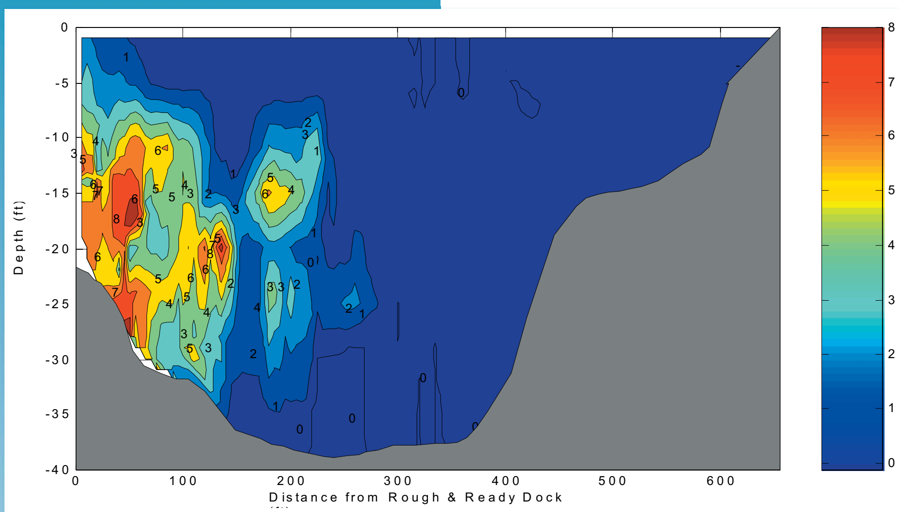
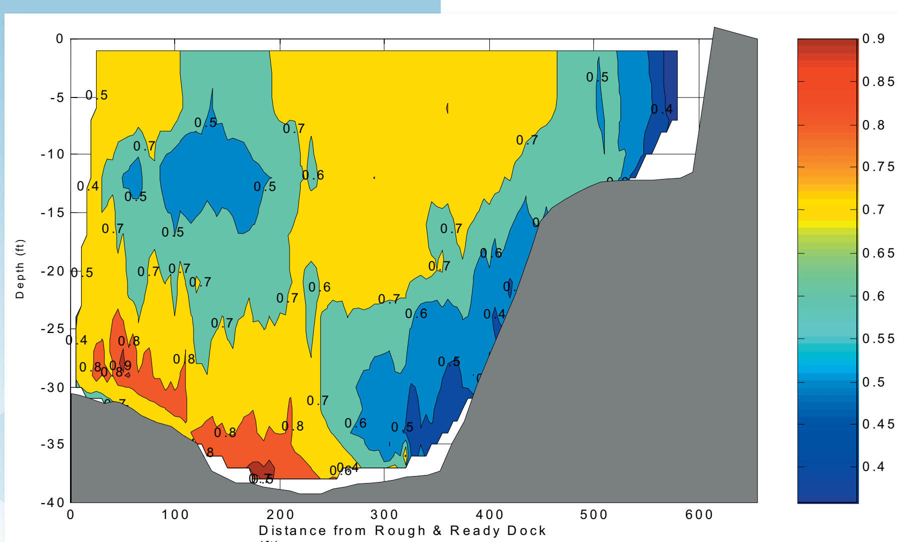


Vertical and Lateral Distribution of Dye at 1-hour after Injection (upstream 1,000 feet)



Vertical and Lateral Distribution of Dye after 6 hours (downstream 500 feet)

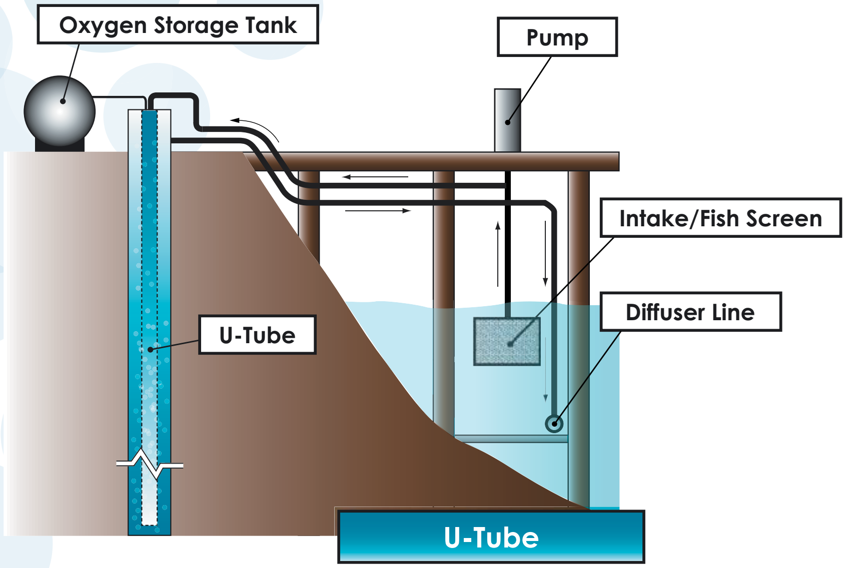


Vertical and Lateral Distribution of Dye after 24 hours (downstream 1,000 feet)

Natural Mixing Characteristics

On November 26, 2002, a study was performed to evaluate how rapidly dye would spread from an oxygenation device at the Rough & Ready Island dock across the DWSC to the opposite shore. Researchers reasoned that lateral spreading and mixing of the dye would indicate how well an aeration or oxygen injection system would spread water with an increased DO concentration across and throughout the DWSC. Approximately 500 feet wide, the DWSC has a mean depth of 30 feet, resulting in a cross-section area of about 15,000 square feet. Water moves upstream about 1 mile during a three-foot tidal variance twice each day.

On the day of the study, the measured lateral mixing from tidal flow dispersion was nearly complete by the end of the day. While lateral mixing was minimal during the first 6 hours after dye injection when tidal flow was low, tidal mixing was sufficient to yield nearly uniform lateral dye concentrations after 24 hours. This study demonstrated that tidal flows strongly influence lateral dispersion in the DWSC near Rough & Ready Island. It also showed that lateral mixing is sufficient to allow the aeration or oxygenation system to be installed under the Rough & Ready Island dock and still maintain improved DO concentrations throughout the DWSC.



Demonstration Project

Delivering 10,000 lbs per day of dissolved oxygen to the DWSC can be accomplished using a number of artificial aeration techniques. These techniques range from mechanical mixing to submerged bubble column systems. Jones & Stokes evaluated several of these technologies in 2003 and 2004. Through this work, it was determined that a U-Tube aeration system could provide the needed quantity of oxygen most efficiently.

The U-Tube works by injecting oxygen into water that is being pumped through a deep well. By subjecting the oxygen bubbles to increased pressure, more oxygen can be dissolve into the water. This oxygen rich water is then delivered to the DWSC through a submerged diffuser that relies on natural mixing characteristics to ensure thorough mixing.

Use of a U-Tube aeration system situated at Rough & Ready Island will allow testing of this aeration technology in a natural tidal system that regularly experiences low dissolved oxygen levels. The basic hypothesis to be tested is whether or not providing 10,000 lbs per day of oxygen to the DWSC will have an appreciable effect on the dissolved oxygen levels. A demonstration project, which will be performed over a two-year period, will also allow assessment of various operational parameters for the U-Tube technology. Along with ascertaining the effectiveness of the U-Tube for aerating the channel, this demonstration will allow for the examination of other, possibly unintended consequences of large-scale aeration prior to using this technology on a more permanent basis.

Project Timeline

August 2004
Aeration Technology Engineering Feasibility Study

August-October 2004
DWSC Aeration Technology Tests

August 2004-March 2005
Design Aeration Technology

Fall 2005
Construct Pilot Aeration Device

Summer 2006-Summer 2007
Pilot Testing and Adaptive Management