Exhibit CSPA-65
Central-Delta-Tours

Summary of Results from the July 17, 2003, and September 17, 2003, Tours of the Central Delta Channels

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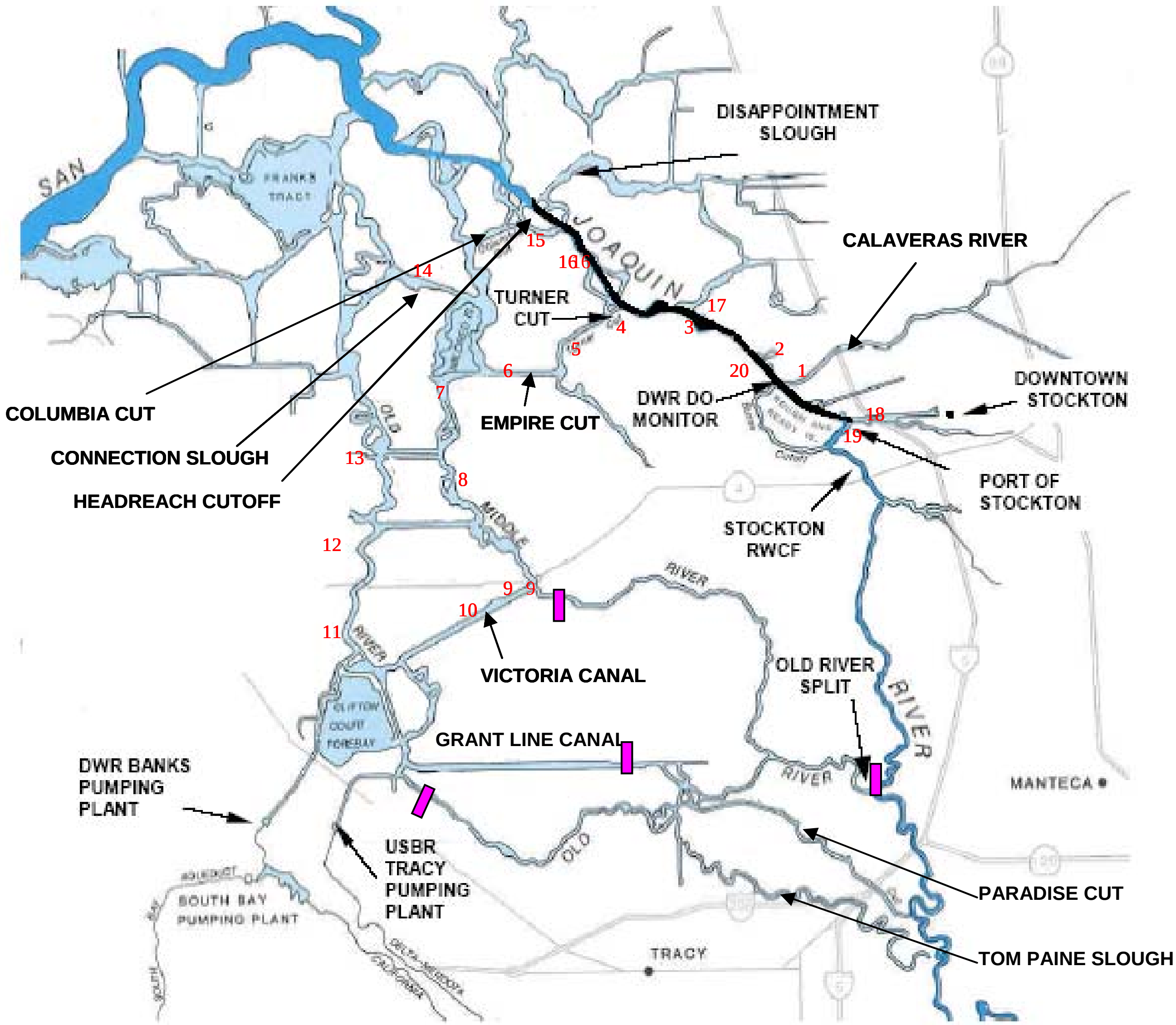
One of the key issues in managing the low dissolved oxygen (DO) problem in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) between the Port of Stockton and Disappointment Slough (critical reach) is the impact of the flow of the SJR through the DWSC on DO depletion in the critical reach of the DWSC. The California Department of Water Resources (DWR) has been conducting late summer and fall about biweekly water quality monitoring cruises ("Hayes cruises") of the San Joaquin River Deep Water Ship Channel from where it confluences with the Sacramento River in the northwestern Delta (Prisoners Point) to the Port of Stockton. Since 1985, the US Geological Survey has been monitoring SJR flow just upstream of where the SJR discharges into the DWSC (Channel Point). The Hayes cruises focus on measuring DO and temperature near the surface and near the bottom of the DWSC at selected locations along the Channel. Lee and Jones-Lee (2000), based on a review of the Hayes cruise data as well as the SJR DO TMDL studies conducted in late summer and fall 1999, as part of developing the San Joaquin River (SJR) Deep Water Ship Channel (DWSC) dissolved oxygen total maximum daily load (TMDL) "Issues" report, found that when SJR DWSC flows were a few hundred cfs, severe DO depletions below the water quality objective (WQO) occurred in the critical reach of the DWSC.

They also observed that SJR DWSC flows above about 2,000 cfs resulted in the elimination of DO depletions in the Deep Water Ship Channel below the WQO. This situation arises from the fact that the State and Federal Project export pumps cause a strong Sacramento River flow through the Central Delta to the export pumps in the South Delta. This cross SJR DWSC flow is manifested primarily at Disappointment Slough/Columbia Cut (see Figure 1). Table 1 provides sampling location distance information on the DWSC and the SJR just upstream of the DWSC. At no time has a DWR Hayes cruise ever found a DO below the water quality objective in the DWSC downstream of the Disappointment Slough/Columbia Cut location.

With elevated SJR DWSC flows greater than about 1,500 cfs, the point of minimum DO (sag) in the DWSC is, in accord with expected behavior, shifted downstream from Rough and Ready Island. While ordinarily, in riverine situations, this shift of the minimum DO would occur further downstream under high flows, because of the Sacramento River cross SJR DWSC flow

Figure 1
Map of the Delta



Adapted from Gowdy and Grober, CVRWQCB (2003) ▮ = Temporary Barrier

created by the export Project pumps, the maximum downstream extent at which DO depletion in the DWSC occurs is just below Turner Cut – i.e., between Turner Cut and Columbia Cut. As discussed by Lee and Jones-Lee (2003a), under high SJR DWSC flow conditions, the estimated travel time, based on the work of R. Brown (Jones & Stokes, 2002a), for oxygen demand loads between Channel Point and Turner Cut (see Table 1 and Figures 2 and 3) is a few days. Under elevated SJR DWSC flows there is insufficient time during the travel period for the oxygen demand loads that enter the DWSC from the SJR DWSC watershed to be exerted in the DWSC.

Lee and Jones-Lee (2000, 2003a) and Lee (2003a,b) recommend that studies be conducted to evaluate whether low-DO conditions occur in the Central Delta under high SJR

Table 1
Distances from DWSC Channel Point

DWR Station No.	City of Stockton Station	Navigation Lt. Number	Location	Distance (miles)	Tidal Excursion* (miles)
--	--	--	Mossdale	-14.4	--
--	R0A	--	Old River	-12	--
--	R0B	--	--	-8	--
--	R1	--	--	-7	--
--	--	--	French Camp Slough	-2.6	--
--	R2	--	--	-1.5	--
--	--	--	Stockton Wastewater Outfall	-0.9	2.8
14	--	--	Turning Basin	+1.1	--
--	--	--	Channel Point	0	--
13	R3	48	--	0.2	--
--	R4	45	--	1.1	1.25
12		43	--	1.4	--
--	--	--	DWR Rough & Ready Monitoring Station	1.8	--
			Calaveras River	2.0	--
11	R5	41/42	--	2.3	--
10	--	39/40	--	3.3	--
--	R6	35/36	--	4.1	--
9	--	33/34	--	5.3	--
8	--	27/28	--	6.4	--
--	R7	23/24	Turner Cut	7.1	2 miles up 3 miles down
7	--	19/20	--	8.2	--
6	R8	17/18	--	9.2	--
5	--	13/14	Columbia Cut	10.4	--
4	--	11/12	--	11.5	--
3	--	5/6	--	12.7	--
2	--	3/4	--	13.5	--
1	--	57	Prisoners Point	14.9	--

Based on NOAA Sacramento River and San Joaquin River Nautical Chart 18661 and information provided by R. Brown (Jones & Stokes, 2002a) and Casey Ralston, DWR (pers. comm., 2002)

* Information provided by R. Brown (Jones & Stokes, 2002a)

DWSC flow, when there is an elevated oxygen demand load exported into the Central Delta via Turner and Columbia Cuts. Of particular concern would be elevated oxygen demand in the side channels to these Cuts, where there is the potential for less mixing of the main channel water with the side channel water, which leads to low DO in the side channels. This information will be essential to evaluating the potential secondary impacts of increasing the flow through the DWSC by reducing the diversions of SJR water at Vernalis down Old River and/or increasing the SJR flow at Vernalis that is allowed to pass through the DWSC.

Figure 2

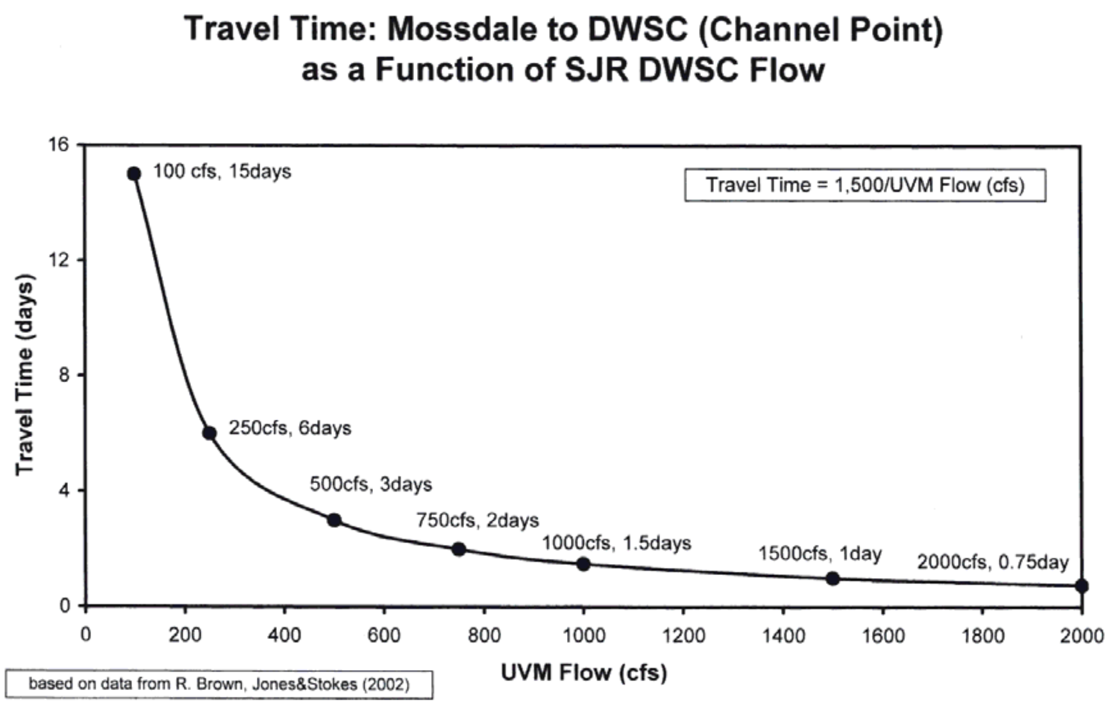
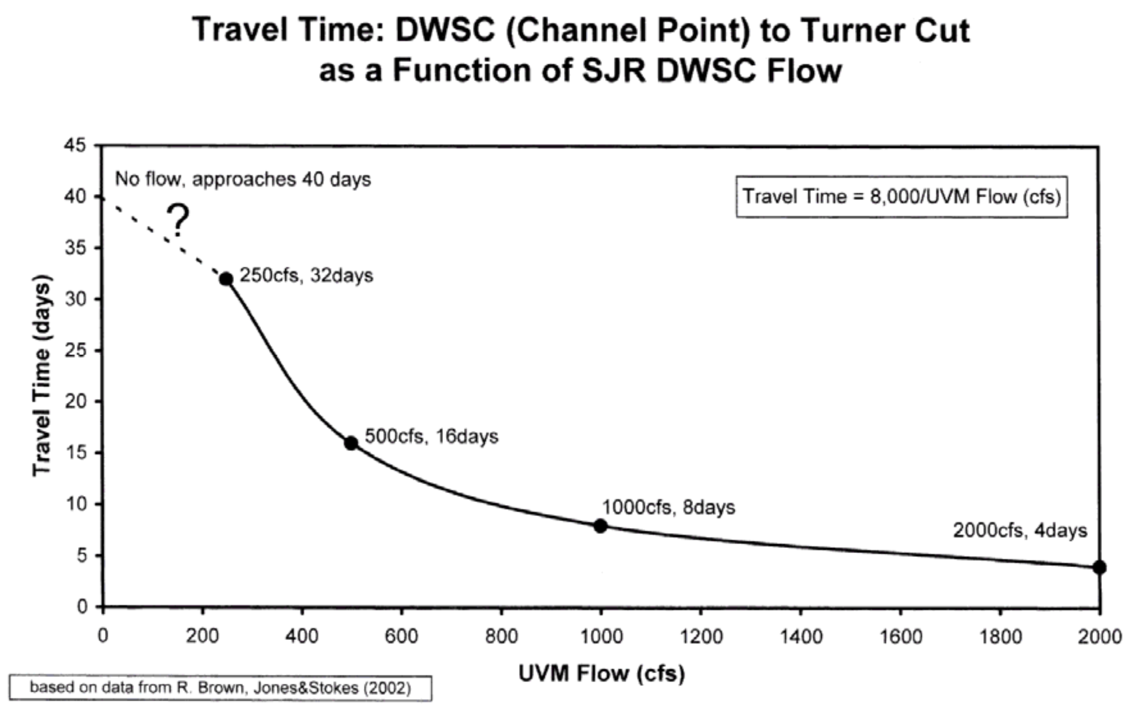


Figure 3



As discussed by Lee (2003a,b), it appears that, except under periods of drought, such as occurred in the late 1980s - early 1990s, there is adequate flow in the SJR at Vernalis to greatly reduce the magnitude and frequency of DO depletions in the Deep Water Ship Channel below the WQO, if a substantial part of the SJR at Vernalis flow is allowed to proceed through the Deep Water Ship Channel before it is exported to Central and Southern California as part of the State and Federal Projects. If this flow management approach is developed, then the magnitude of aeration and control of upstream algal nutrients that lead to increased algal growth in the Mud and Salt Slough watersheds and the SJR at Lander Avenue watershed can potentially be significantly reduced, and still meet the water quality objectives for the critical reach of the SJR DWSC.

Brown, in Jones & Stokes (2002b), conducted a study of the tidal exchange (mixing) of the Sacramento River water with SJR DWSC water near Turner Cut. He reported that the DWSC tidal exchange of Sacramento River water with DWSC water upstream of Turner Cut is small whenever DWSC flows are greater than 500 cubic feet per second (cfs). The electrical conductivity (EC) of the Sacramento River water is generally about 150 microSiemens per centimeter (µS/cm) (µmhos/cm). As this water flows across the Delta in the channels, the EC increases to about 250 µS/cm near the mouth of the Mokelumne River at the San Andreas Landing EC station. The EC of the SJR water in the DWSC is generally between about 500 µS/cm and 750 µS/cm during the irrigation season of April through August. Therefore, EC measurements allow the tidal mixing of these two sources of water to be directly observed along the DWSC in the vicinity of Turner Cut.

There is interest in examining the potential secondary impacts associated with increased SJR flow through the DWSC, as part of managing the low-DO problem in the critical reach of the DWSC. In order to gain some information on the characteristics of the Central Delta channels that could be impacted by greater SJR DWSC flow into them, Dr. G. Fred Lee, with the assistance of Kari Burr of the DeltaKeeper staff, conducted tours of the SJR DWSC and Central Delta on July 17, 2003 and September 17, 2003 in order to examine the EC and DO characteristics of the Central Delta channels relative to the DWSC. A tour of the South Delta channels was also conducted on August 5, 2003. A report of this tour is presented in a separate report (Lee, et al., 2004).

July 17, 2003, Tour of the Central Delta

The DeltaKeeper (William Jennings) made available one of the DeltaKeeper boats for the tour, and Kari Burr of the DeltaKeeper staff was responsible for making the final arrangements, including obtaining a skipper for the boat (Scott Pickering), who volunteered his time on behalf of the DeltaKeeper. In addition to Kari Burr and Dr. Lee, Mark Gowdy of the CVRWQCB, Barbara Marcotte of the California Bay-Delta Authority (CBDA) and Megan Williams, an intern at CBDA, participated in the tour. The tour left the DeltaKeeper dock on the Calaveras River at about 9:00 AM on July 17, 2003. Periodic measurements were made of the DO, temperature, electrical conductivity and Secchi depth in each of the channels covered during the tour. Temperature and specific conductivity were measured with a YSI Model 33 SCT meter. All specific conductivity measurements were corrected to 25°C using a temperature coefficient of 2 percent per degree. The conductivity meter was calibrated using a standard KCl solution. Dissolved oxygen near the water surface was measured by a YSI Model 600 XL meter with a submersible membrane electrode. The DO meter was calibrated in accordance with the equipment manufacturer’s recommendations. This calibration is periodically checked through a Winkler titration. Secchi depth was measured using a 20 cm diameter disk painted with black and white quadrants.

A map of the Central and South Delta showing the channels covered in the tour is presented in Figure 1. The data are presented in Table 2. Figure 1 shows the location of the sampling sites used in this tour. The first leg of the tour consisted of Calaveras River to Turner Cut, east on Empire Cut, south on Middle River, until reaching Victoria Canal. The tour proceeded southeast on Victoria Canal until Old River, then north on Old River to Connection Slough, then to Columbia Cut, Headreach Cutoff and the San Joaquin River Deep Water Ship Channel. The tour continued up the SJR DWSC past the starting point on the Calaveras River up to the Port beyond the "cement boat." At that point the DeltaKeeper boat turned around and proceeded down to the SJR near the US Army Corps of Engineers aerator, up to the first railroad bridge, then turned around again and returned to the Deep Water Ship Channel just off of the DWR Rough and Ready Island (RRI) monitoring station, where an additional set of measurements was made. The tour terminated at about 2:00 PM when the boat reached the DeltaKeeper dock. At this time the tide stage was near low tide. Low tide on July 17 was at 4:00 PM at Turner Cut, and at 4:30 PM at Stockton.

Table 2 shows that the first set of measurements were taken at 9:04 AM at the DeltaKeeper dock on the Calaveras River. All measurements were surface water measurements, within the upper foot. The temperature in the surface waters at 9:04 AM at the DeltaKeeper dock was 26°C, and the specific conductivity was 390 µmhos/cm. The Secchi depth was about 0.5 m. No DO measurements were made. At 9:20 AM, a set of measurements was taken in the SJR DWSC between navigation lights 42 and 41. The temperature was 25°C, EC was 410 µmhos/cm, and Secchi depth was 0.55 m. At 9:29 AM, a set of measurements was made in the main channel of the SJR DWSC just off of Windmill Cove. The surface water temperature was 25°C and the EC was 335 µmhos/cm. The surface DO was 7.6 mg/L. Saturation under these conditions was 8.3 mg/L. Secchi depth was 0.4 m. At 9:40 AM, a short distance into Turner Cut near the SJR DWSC, the temperature was 24°C. The EC had dropped to 155 µmhos/cm. The DO was 7.8 mg/L, with saturation at 8.4 mg/L. The Secchi depth was about 1 m. It was clear at that point, based on EC and Secchi depth, that a substantial amount of Sacramento River water was proceeding up the DWSC to Turner Cut, and then down Turner Cut. This was near high tide. High tide was at 8:16 AM at Turner Cut, and at 8:46 AM at Stockton.

At 9:49 AM, a set of measurements was made just off of Turner Cut Resort. The temperature was 23°C. The EC was 277 µmhos/cm. The DO was 7.2 mg/L, with saturation at 8.6 mg/L. The Secchi depth was 0.8 m. At 9:59 AM, about midway along Empire Cut, the temperature as 25°C, the EC was 248 µmhos/cm, the surface water DO was 6.0 mg/L (saturation was 8.3 mg/L), and the Secchi depth was 0.7 m. At 10:11 AM, in Old River at the Bacon Island Bridge, the temperature was 24°C, EC was 166 µmhos/cm, DO was 6.6 mg/L (saturation was 8.4 mg/L), and Secchi depth was 0.9 m. At 10:32 AM, in Lower Middle River about halfway between the Bacon Island Bridge and Victoria Canal, the temperature was 25°C, EC was 191 µmhos/cm, DO was 6.0 mg/L (saturation was 8.3 mg/L), and Secchi depth was 0.8 m. At 10:45 AM, on the eastern part of Victoria Canal, the temperature was 24°C, EC was 182 µmhos/cm, DO was 5.9 mg/L (saturation was 8.4 mg/L), and the Secchi depth was 0.9 m. At 10:56 AM, within Victoria Canal under the high voltage power transmission lines the temperature was 26°C, EC was 186 µmhos/cm, DO was 7.0 mg/L (saturation was 8.1 mg/L), and Secchi depth was 0.8 m. At 11:00 AM, in Old River near Salisbury Resort, the temperature was 24°C, EC was 215

Table 2
Central Delta Water Quality Characteristics
July 17, 2003 – High Tide at 8:00 to 9:00 AM

Time	Map Designation	Location	Temp (°C)	EC (μmhos/ cm) @ 25°C	DO (mg/L)		Secchi Depth (m)
					Surface	Saturation	
9:04 AM	1	DeltaKeeper Dock - Calaveras River	26	390	-	-	0.5
9:20	2	SJR DWSC Light 42/41	25	410	-	-	0.55
9:29	3	SJR DWSC - Windmill Cove Trailer Park	25	335	7.6	8.3	0.4
9:40	4	Turner Cut near SJR DWSC	24	155	7.8	8.4	1.0
9:49	5	Turner Cut Resort	23	277	7.2	8.6	0.8
9:59	6	Empire Cut (mid)	25	248	6.0	8.3	0.7
10:11	7	Bacon Island Bridge	24	166	6.6	8.4	0.9
10:32	8	Lower Middle River	25	191	6.0	8.3	0.8
10:45	9	Victoria Canal - East	24	182	5.9	8.4	0.9
10:56	10	Victoria Canal - Under High Voltage Transmission Line	26	186	7.0	8.1	0.8
11:00	11	Old River near Salisbury Resort	24	215	7.5	8.4	0.7
11:25	12	Cruiser Haven Bridge	26	206	6.4	8.1	0.7
11:53	13	Old River - RR Bridge	26	156	6.7	8.1	1.0
12:03 PM	14	Connection Slough Dead End	27	125	6.7	8.0	0.6
12:20	15	Headreach Cutoff - Delta Yacht Club	28	145	8.1	7.8	0.9
12:31	15	SJR DWSC Light 20	29.5	206	8.3	7.6	0.6
12:45	17	SJR DWSC - Windmill Cove Trailer Park	27.5	573	7.0	7.9	0.6
1:05	18	Port of Stockton Turning Basin	32	681	10	7.3	0.8
1:15	19	SJR near RR Bridge	30	718	6.3	7.6	0.3
1:22	20	SJR DWSC – Opposite DWR RRI Station	28.5	665	7.1	7.8	0.5

µmhos/cm, DO was 7.5 mg/L (saturation was 8.4 mg/L), and Secchi depth was 0.7 m. At 11:25 AM, near the Cruiser Haven Bridge, the temperature was 26°C, EC was 206 µmhos/cm, DO was 6.4 mg/L (saturation was 8.1 mg/L), and Secchi depth was 0.7 m. At 11:53 AM, in Old River at the railroad bridge, the temperature was 26°C, EC was 156 µmhos/cm, DO was 6.7 mg/L (saturation was 8.1 mg/L), and Secchi depth was 1 m.

At 12:03 PM, in the Connection Slough dead-end, the temperature was 27°C, EC was 125 µmhos/cm, DO was 6.7 mg/L (saturation was 8.0 mg/L), and Secchi depth was 0.6 m. At 12:20 PM, at the Headreach Cutoff between Columbia Cut and the SJR DWSC near the Delta Yacht Club, the temperature was 28°C, the EC was 145 µmhos/cm, DO was 8.1 mg/L (saturation was 7.8 mg/L), and Secchi depth was 0.9 m. Measurements made by the Sacramento Regional County Sanitation District on the Sacramento River just upstream of the Freeport Bridge showed that the Sacramento River had an EC of 110 µmhos/cm, which is close to that found at near Headreach Cutoff on the same day.

At 12:31 PM, in the SJR DWSC near navigation light 20 just upstream of Disappointment Slough/Columbia Cut, the temperature was 29.5°C, EC was 206 µmhos/cm, DO was 8.3 mg/L (saturation was 7.6 mg/L), and Secchi depth was 0.6. At 12:45 in the SJR DWSC just off of Windmill Cove where the readings had been taken earlier in the morning, the temperature was 27.5°C, EC was 573 µmhos/cm, DO was 7.0 mg/L (saturation was 7.9 mg/L), and Secchi depth was 0.6 m. At 1:05 PM, a set of measurements was made at the Port of Stockton Turning Basin. The temperature was 32°C, EC was 681 µmhos/cm, DO was 10 mg/L (saturation was 7.3 mg/L), and Secchi depth was 0.8 m. At 1:15 PM, in the SJR near the railroad bridge, the temperature was 30°C, EC was 718 µmhos/cm, DO was 6.3 mg/L (saturation was 7.6 mg/L), and Secchi depth was 0.3 m. At 1:22 PM, in the SJR opposite the DWR RRI monitoring station, the temperature was 28.5°C, EC was 665 µmhos/cm, DO was 7.1 mg/L (saturation was 7.8 mg/L), and Secchi depth was 0.5 m.

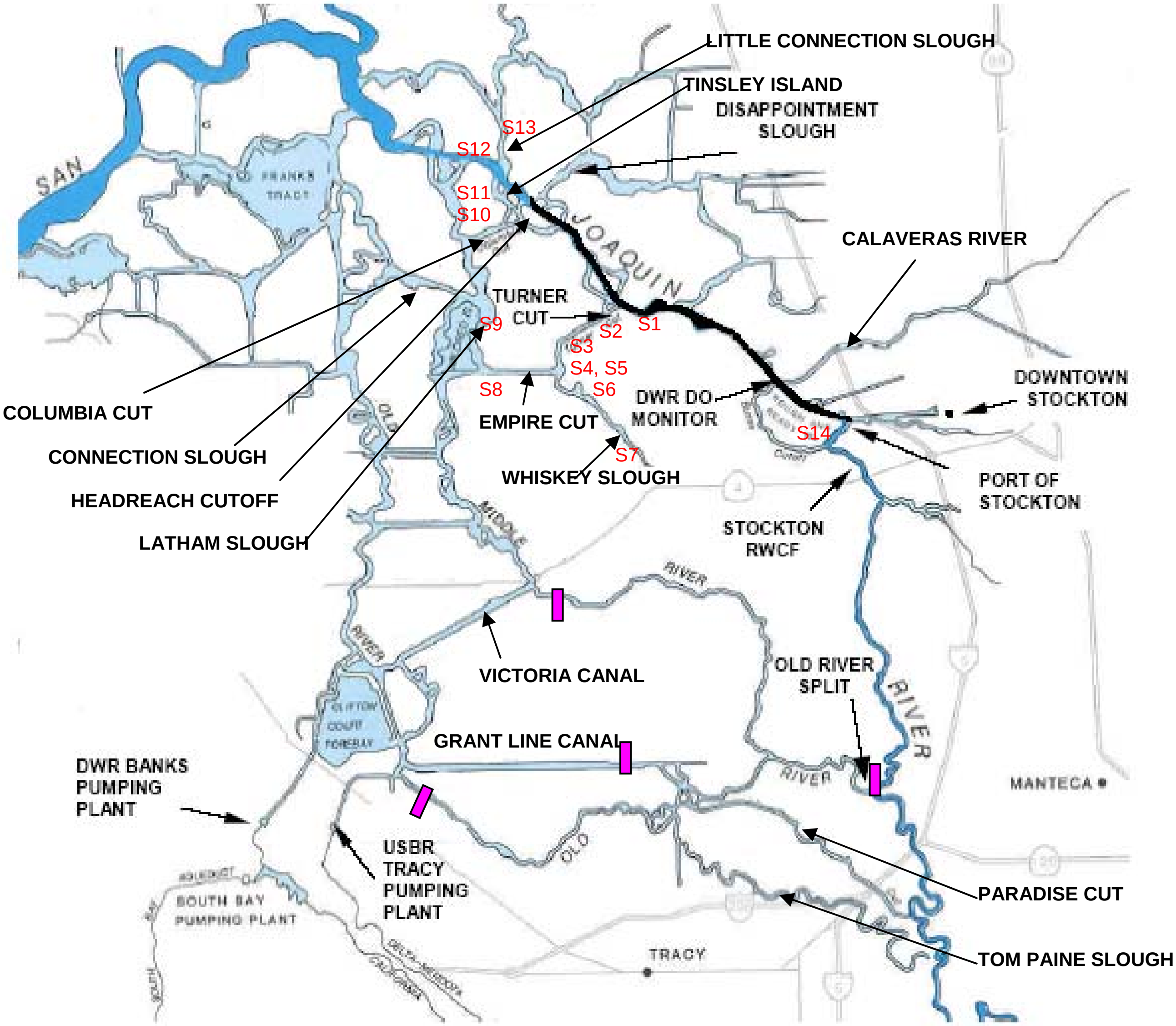
September 17, 2003, Tour of the Central Delta

G. Fred Lee, with the assistance of Kari Burr of the DeltaKeeper staff, organized and conducted a second tour of the Central Delta channels on September 17, 2003. This tour was specifically designed to measure, as close as possible under the conditions that exist, the maximum downstream migration of the SJR DWSC water into Turner Cut and Columbia Cut. Also, this tour was designed to examine the daily low of the DO concentration in the Turner Cut area. Low tide in the Turner Cut area occurred at about 5:30 AM on September 17, 2003.

Since it was dark at the beginning of the tour when measurements were made at S1 and S2, Secchi depth was determined using a flashlight. The weather conditions on September 17 were bright sun, and by mid-morning there was a 20- to 30-mph wind from the north. The air temperature was 55° F at 6:00 AM and 70° F at 12:00 noon.

Figure 4 shows a map of the Delta, with the approximate monitoring locations for the September 17 tour designated as S1 through S14. Table 3 presents the data and a description of each of the monitoring locations.

Figure 4
Delta Map, Showing Sampling Locations for 9/17/03 Tour



Adapted from Gowdy and Grober (2003) = Temporary Barrier

The first monitoring location (S1) was on the SJR DWSC at Windmill Cove. The measurements at S1 on September 17 were made at 6:00 AM. The temperature was 23°C, the EC was 688 µmhos/cm, the surface DO was 5.3 mg/L (with a saturation of 8.6 mg/L) and the Secchi depth was 0.5 m. The channel depth at this point was 11.2 m. Burr, as part of the DeltaKeeper sampling run for pathogen indicator organisms that took place on September 15, 2003 (two days earlier), arrived at S1 at 11:27 AM, which was near high tide. High tide occurred at about noon at this location on September 15. The temperature at that time was 24°C, the EC was 630 µmhos/cm, the surface DO was 6.1 mg/L (with a saturation of 8.4 mg/L). No Secchi depth measurements were made at that time.

Table 3
Central Delta Water Quality Characteristics
September 17, 2003 – Turner Cut High Tide at Noon, Low Tide at 5:40 AM

Date and Time	Map Symbol	Location	Temp (°C)	EC (µmhos/cm) @ 25°C	DO (mg/L)		Secchi Depth (m)	Channel Depth (m)
					Surface	Sat.		
9/17/03 6:00 AM	S1	SJR DWSC at Windmill Cove Trailer Park	23	688	5.3	8.6	0.5	11.2
9/15/03 11:27 AM	S1	SJR DWSC at Windmill Cove Trailer Park	24	630	6.1	8.4	-	11.2
9/17/03 6:16 AM	S2	Turner Cut, 0.5 mile from SJR DWSC	23	374	7.4	8.6	0.7	4.5
9/15/03 10:15 AM	S3	Turner Cut Resort	23	316	7.9	8.6	-	4.5
9/15/03 10:23 AM	S4	Turner Cut, Tiki Lagun Resort	23	287	7.6	8.6	-	-
9/17/03 6:31 AM	S5	Turner Cut Bridge	23	429	7.3	8.6	0.7	8
9/17/03 6:45 AM	S6	Whiskey Slough, 0.5 mile from Turner Cut	22	540	7.2	8.7	0.4	2.4
9/17/03 7:00 AM	S7	Whiskey Slough Harbor	23.5	447	7.2	8.5	0.7	3
9/17/03 7:30 AM	S8	Empire Cut, near Middle River	23	407	7.4	8.6	0.8	7.3
9/17/03 7:39 AM	S9	Latham Slough (Middle River)	22	270	7.7	8.7	1.2	5.4
9/17/03 7:51 AM	S10	Columbia Cut, near towers	22	235	8.3	8.7	1.4	2.8
9/17/03 8:07 AM	S11	Channel west of Tinsley Island, at Stockton Waterski Club	22	215	8.1	8.7	1.4	3.5
9:17/03 8:16 AM	S12	DWSC, near Light 3 (just downstream of Columbia Cut, east of the DWSC)	22	229	8.5	8.7	1.0	2.4
9/17/03 8:31 AM	S13	Little Connection Slough at Herman and Helen’s Resort	21	193	8.5	8.9	0.9	6.4
9:17/03 9:18 AM	S2	Turner Cut, 0.5 mile from SJR DWSC	22	316	7.9	8.7	0.9	4.5
9:17/03 9:42 AM	S1	SJR DWSC at Windmill Cove Trailer Park	23.5	655	5.6	8.5	0.6	11.2
9/17/03 10:04 AM	S14	SJR near RR Bridge	23	674	6.5	8.6	0.5	4.8

Location S2 was 0.5 mile down Turner Cut from the SJR DWSC. It was monitored on September 17 at 6:16 AM. The temperature was 23°C, the EC was 374 µmhos/cm, the surface DO was 7.4 mg/L (with a saturation of 8.6 mg/L) and the Secchi depth was 0.7 m. The channel depth at location S2 was 4.5 m. Comparing the measurements taken September 17 at the SJR DWSC at Windmill Cove with those taken 0.5 mile down Turner Cut shows that there was an appreciable amount of Sacramento River water mixing with SJR DWSC water at Turner Cut, with the result that the EC was decreased from 688 µmhos/cm to 374 µmhos/cm and the DO was increased from 5.3 mg/L to 7.4 mg/L. Also, there was about a 20 cm increase in water clarity at location S2.

On September 15, at 10:15 AM, Burr made measurements at location S3, which is the Turner Cut Resort. She found that the temperature was 23°C, the EC was 316 µmhos/cm, the surface DO was 7.9 mg/L (with a saturation of 8.6 mg/L). It is evident that about September 15 and 17, there was an appreciable amount of lower conductivity Sacramento River water mixing with the SJR DWSC water at Turner Cut.

Burr also made measurements at S4 on September 15 at 10:23 AM. These measurements were made at the Tiki Lagun Resort area, which is just downstream of the Turner Cut Resort. At this location the specific conductance had decreased from 316 µmhos/cm at Turner Cut Resort, to 287 µmhos/cm at S4. The surface DO at the Tiki Lagun area was 7.6, with a saturation of 8.6.

On September 17, at 6:31 AM, measurements were taken at location S5, which is just upstream of the Turner Cut bridge, which is another mile or so downstream of the Tiki Lagun Resort. The specific conductance increased to 429 µmhos/cm from 374 µmhos/cm near the mouth of Turner Cut. The surface DO decreased slightly from 7.4 mg/L to 7.3 mg/L (with a saturation of 8.6 mg/L), and Secchi depth remained the same (0.7 m).

Two locations were monitored on Whiskey Slough, which is a shallow (2 to 3 m deep) dead-end side channel of Turner Cut. Location S6, which is 0.5 mile into Whiskey Slough from Turner Cut, was monitored on September 17 at 6:45 AM. The EC was 540 µmhos/cm, and the surface DO was 7.2 mg/L (with a saturation of 8.7 mg/L). The Secchi depth was 0.4 m, indicating that it was somewhat more turbid than Turner Cut.

At 7:00 AM, location S7 was monitored at Whiskey Slough Harbor, which is near the end of the slough. The temperature was slightly warmer, at 23.5°C. The EC was down to 447 µmhos/cm, and the surface DO was 7.2 mg/L, with a saturation of 8.5 mg/L. It was also somewhat clearer, with a Secchi depth of 0.7 m. On September 17 there was no agricultural irrigation occurring, with the result that there were no irrigation returns that were discharging. The DO situation in Whiskey Slough may be different when there is higher SJR DWSC flow and when irrigation return water is being discharged to the slough. .

Location S8 was on Empire Cut near where it joins with Middle River. This location was monitored at 7:30 AM. The temperature was 23°C, the EC was 407 µmhos/cm, the surface DO was 7.4 mg/L (with a saturation of 8.6 mg/L), and the Secchi depth was 0.8 m. It would be expected that Empire Cut near Middle River would contain elevated amounts of Sacramento River water, which would be brought down Middle River toward the South Delta export pumps.

Location S9 was monitored at 7:39 AM. This location is on Latham Slough, which is on the east side of Mildred Island (a flooded island). It is part of the Middle River flow system. The temperature at S9 was 22°C, the EC was 270 µmhos/cm, the surface DO was 7.7 mg/L (with a saturation of 8.7 mg/L), and the Secchi depth was 1.2 m. It is of interest that again on this cruise, as on the July 17 cruise, the DO in Middle River, which is dominated by Sacramento River water, is about 1 mg/L less than saturation.

Location S10 was monitored on September 17 at 7:51 AM. This location is on Columbia Cut near the towers, which are about halfway down Columbia Cut from Middle River. The temperature was 22°C, the EC was 235 µmhos/cm, the surface DO was 8.3 mg/L (with a saturation of 8.7 mg/L), and the Secchi depth was 1.4 m. The Columbia Cut water showed higher concentrations of Sacramento River water (lower EC, higher DO and greater Secchi depth).

Location S11 was monitored at 8:07 AM. This is a channel west of Tinsley Island, as part of the Columbia Cut/Disappointment Slough network. Measurements were taken near the Stockton Waterski Club. The temperature was 22°C, the EC was 215 µmhos/cm, the surface DO was 8.1 mg/L (with a saturation of 8.7 mg/L), and the Secchi depth was 1.4 m. Columbia Cut and the channel west of Tinsley Island at the Stockton Waterski Club were dominated by high-quality Sacramento River water at the time of monitoring. No SJR DWSC water would be expected to be present at these locations.

Location S12, which was monitored on September 17 at 8:16 AM, was just off of the DWSC near Light 3 on the east side of the DWSC. The temperature was 22°C, the EC was 229 µmhos/cm, the surface DO was 8.5 mg/L (with a saturation of 8.7 mg/L), and the Secchi depth was 1.0 m. Again, the water at this location had the same characteristics of low EC and elevated DO compared to waters upstream of this point, which are influenced by the SJR DWSC. The wind at the time of sampling at this location was 20 to 30 mph from the north, and was stirring up a shallow bay to the north and east of the sampling location.

Location S13 was monitored at 8:31 AM. S13 is located on Little Connection Slough at Herman and Helen's Resort. The temperature was 21°C, the EC was 193 µmhos/cm (the lowest found on the tour), the surface DO was 8.5 mg/L (with a saturation of 8.9 mg/L), and the Secchi depth was 0.9 m. Measurements made by the Sacramento Regional County Sanitation District on the Sacramento River just upstream of the Freeport Bridge showed that the Sacramento River had an EC of 190 µmhos/cm, which is close to that found at S13 on the same day.

The next location to be monitored was a re-sampling of Turner Cut 0.5 mile from the DWSC (location S2). Measurements were taken at 9:18 AM. The temperature was 22°C, the EC was 316 µmhos/cm, the surface DO was 7.9 mg/L (with a saturation of 8.7 mg/L), and the Secchi depth was 0.9 m. Comparing this measurement to location S2 sampled at 6:16 AM shows that the EC has decreased from 374 µmhos/cm to 316 µmhos/cm at 9:18 AM. This is to be expected, since the earlier measurements were taken near low tide. With the tide increasing significantly by 9:18 AM, one would expect a larger amount of Sacramento River water to be mixed with the SJR DWSC water that enters Turner Cut. Similarly, there was about 0.5 mg/L increase in DO at this location from 6:16 AM to 9:18 AM.

Location S1 was sampled again at 9:42 AM. This location is the SJR DWSC at Windmill Cove Trailer Park. The EC was 655 µmhos/cm, compared to 688 µmhos/cm at 6:00 AM. The surface DO was 5.6 mg/L, compared to 5.3 mg/L at 6:00 AM. The Secchi depth at 9:42 AM was 0.6 m. It is clear that Sacramento River water was not mixing with the SJR DWSC water upstream of Turner Cut.

The last monitoring location was S14, in the SJR near the railroad bridge. This location was monitored at 10:04 AM. The temperature was 23°C, the EC was 674 µmhos/cm, the surface DO was 5.6 mg/L (with a saturation of 8.5 mg/L), and the Secchi depth was 0.5 m.

The estimated SJR DWSC flow was about 500 cfs on September 15 and September 17. Therefore, the conditions of the September 17 tour were not worst-case conditions with respect to the potential impact of SJR DWSC flow on low DO in Turner Cut. The true worst-case conditions for oxygen demand load impacts in Turner Cut would involve higher SJR DWSC flows and higher temperatures. The worst-case conditions would be early in the summer when there is at least 1,500 – and preferably 2,000 – cfs of SJR water passing through the DWSC and into Turner Cut. This would place the greatest oxygen demand load into Turner Cut. Also, the temperatures at the time of measurement on September 17 were 22 to 23°C; worst-case conditions would occur if the temperatures were in excess of 25 to 28°C, which occurs in the DWSC at times during the summer.

Lee and Jones-Lee (2003b) has summarized the impact of the cross SJR DWSC flow of the Sacramento River on its way to the export pumps, where he pointed out that the DWR Hayes cruises of summer 2003 included EC measurements. The EC data showed that there is a sharp change in EC downstream of Turner Cut. It is clear that, except under very high SJR flows associated with flood flow conditions in the winter-spring, there is little to no SJR DWSC water in the DWSC downstream of Columbia Cut. Lee discusses the importance of this situation in enabling fall run Chinook salmon to find their home waters upstream of the DWSC. During the summer and fall there is no upstream chemical signal at the mouth of the Delta to guide the Chinook salmon to their home stream. This may help explain why genetic studies of SJR Chinook salmon taken from the eastside tributary rivers do not show the typical genetic signature of their home stream water. This is another of the impacts of the state and federal Delta export projects on the resources of the Delta.

Delta Inflows and Exports

The water quality characteristics of the Central and Southern Delta are highly impacted by the federal and state export projects. Table 4 presents a summary of the information pertinent to flows into and exported from the Delta, as well as the conditions that existed in the SJR DWSC near the DWR RRI monitoring station at the time of the July 17 tour. Table 5 presents the flow of the SJR through the DWSC during July near the date of the tour. The tour started out at close to high tide and the tide remained close to high tide in each of the channels when they were visited, until late morning. By then the tide was down about a foot from high tide, as the tour reached Victoria Canal.

Table 4
Characteristics of the Delta and Its Inflows/Exports on July 17, 2003

<table>
<tr><td colspan="4">SJR Vernalis Flow</td><td colspan="3">1,325 cfs</td></tr>
<tr><td colspan="4">SJR DWSC Flow</td><td colspan="3">413 cfs</td></tr>
<tr><td colspan="4">Sacramento River at Freeport Flow</td><td colspan="3">23,724 cfs</td></tr>
<tr><td colspan="4">Total Delta Inflow</td><td colspan="3">25,049 cfs</td></tr>
<tr><td colspan="4">Export – Clifton Court (Banks)</td><td colspan="3">6,525 cfs</td></tr>
<tr><td colspan="4">Export – Tracy</td><td colspan="3">4,349 cfs</td></tr>
<tr><td colspan="4">Export – Contra Costa</td><td colspan="3">232 cfs</td></tr>
<tr><td colspan="4">Export – Barker Slough</td><td colspan="3">112 cfs</td></tr>
<tr><td colspan="4">Total Export</td><td colspan="3">11,218 cfs</td></tr>
<tr><td colspan="3">DO (mg/L)</td><td>EC (µmhos/cm)</td><td colspan="3">Tide (ft)</td></tr>
<tr><td>Low</td><td>High</td><td></td><td></td><td>Low</td><td>High</td><td></td></tr>
<tr><td>3.8
at 11:00 AM</td><td>7.9
at 6:00 PM</td><td>5.0
at 1:00 PM</td><td>575
at noon</td><td>1.9
at 3:00 AM</td><td>4.5
at 10:00 AM</td><td>0.2
at 5:00 PM</td></tr>
</table>

From DWR website, http://wwwoco.water.ca.gov/weekly/WKWTRRPT

Table 5
Flow of the SJR through the DWSC during July 2003

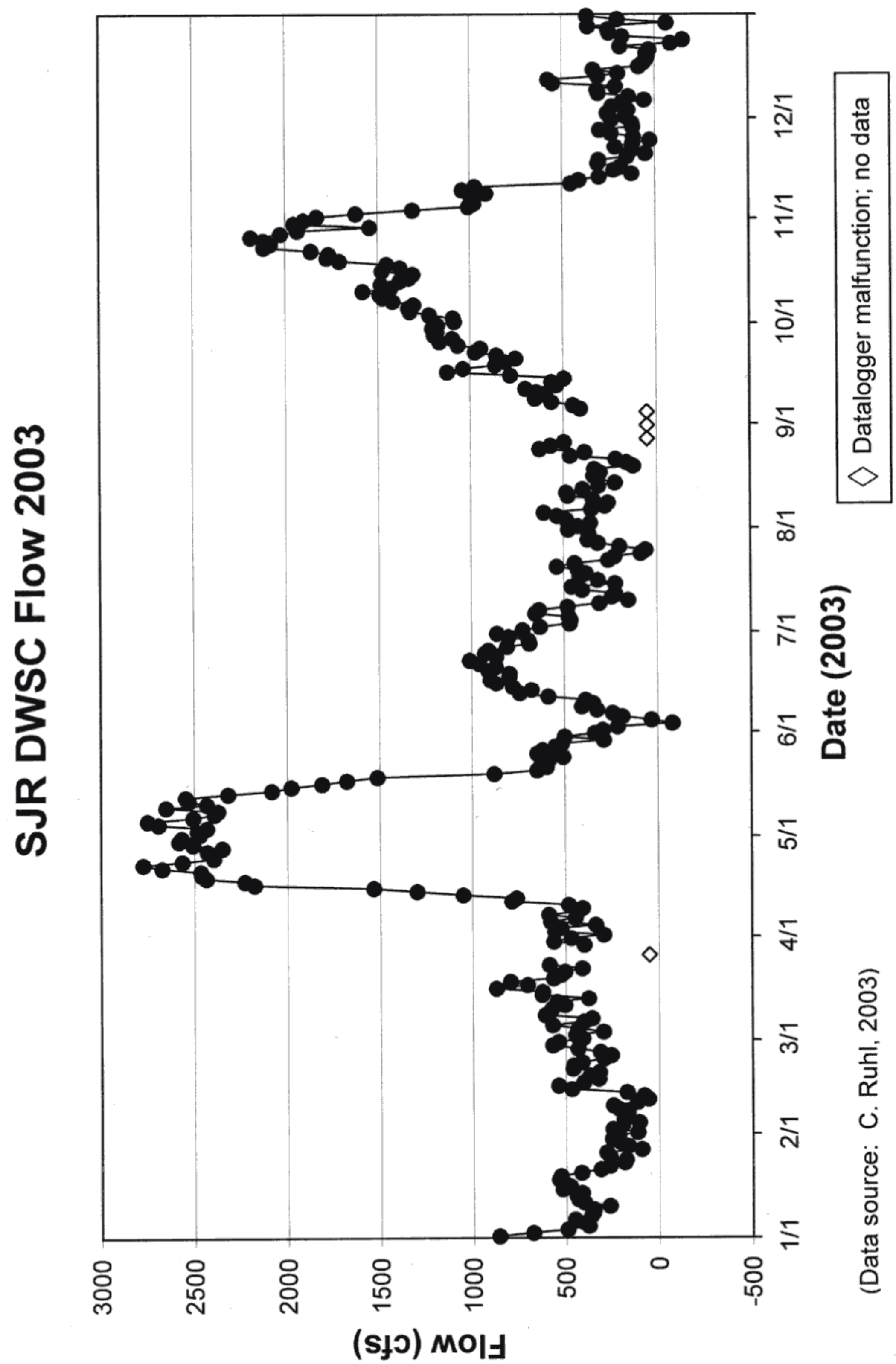
Date	Flow (cfs)
7/5/03	478
7/6/03	690
7/7/03	603
7/8/03	495
7/9/03	301
7/10/03	150
7/11/03	245
7/12/03	224
7/13/03	401
7/14/03	456
7/15/03	221
7/16/03	314
7/17/03	413
7/18/03	382
7/19/03	414
7/20/03	545

From C. Ruhl, USGS, pers. comm. (2003).

As shown in Table 4, on July 17 the SJR flow at Vernalis was 1,325 cfs. The SJR DWSC flow (see Table 5) was 413 cfs. During early July 2003 the SJR DWSC flows ranged from a low of about 150 cfs on July 10, to almost 700 cfs on July 6, and were variable from day to day. The Sacramento River flow at Freeport was 23,724 cfs, to give a total Sacramento –San Joaquin River Delta inflow of 25,049 cfs. In addition, there are several eastside rivers, such as the Mokelumne and Calaveras, which contribute flow directly to the Delta. According to DWR Operations records, the total eastside river flow in late July 2003 was 600 to 700 cfs.

Figure 5 presents the SJR DWSC flows for 2003. The flows during mid-July 2003 were in the range of the summer 2003 flows.

Figure 5



As shown above in Table 4, on July 17 the State Project export at Clifton Court (Banks Pumping Station) was 6,525 cfs. The Federal Project export from the South Delta at Tracy Pumping Station was 4,349 cfs, the Contra Costa Water District's export was 232 cfs, and the export from Barker Slough was 112 cfs, for a total export of 11,218 cfs. The Federal and State Projects, therefore, represented 97 percent of the total Delta export pumping on July 17, 2003. Further, all of the SJR Vernalis water and about 42 percent of the Sacramento River water was either consumed by irrigated Delta agriculture or exported by the State and Federal Projects on that day. According to Hari Rajbhandari (pers. comm., 2004), DWR input-export modeling of Delta agriculture does not readily allow computation of irrigated agricultural water consumption along a specific channel on a specific day.

The measurements at the DWR RRI station showed a low DO on July 17, 2003, of 3.8 mg/L at 11:00 AM, and a high DO of 7.9 mg/L at 6:00 PM. At about 1:00 PM (about the time of the tour sampling), the DO reading at the RRI station was about 5 mg/L. The measurements made as part of the tour off of that station at about the same time in mid-Channel, but in the surface water (upper 1 ft), showed a DO of 7.1 mg/L. As discussed by Lee and Jones-Lee (2003a), the DWR RRI monitoring station does not show the maximum peak DO concentrations that occur in late afternoon, because it is sampling about the upper one-third of the water column, and therefore, since photosynthesis is primarily in the upper three feet, with most of it occurring in the first one foot or so, the measurements on the tour would be expected to be higher than those reported by the DWR RRI station at the same time. The EC recorded by the DWR RRI station was 575 µmhos/cm at about noon. This compares to the measurements made at 1:22 PM of about 536 µmhos/cm.

The most surprising finding of this tour was that Old River and Middle River in the Central Delta are showing DO concentrations in the morning, up until about noon, that are 1 to 2 mg/L below saturation. While these DO concentrations are not in violation of water quality objectives, they show that the Sacramento River water that mixes with the SJR DWSC water is not at DO saturation. This could be a significant issue if additional oxygen demand load from the SJR DWSC is mixed into this water. Under these conditions, especially in side channels or on some of the flooded islands, there may be DO water quality objective violations of the 5 mg/L objective during early morning hours, due to the mixing of the SJR DWSC water with the Sacramento River water. Based on existing information it is concluded that there is need to do further studies on whether DO depletion below the WQO occurs during elevated SJR DWSC flows that transport large amounts of oxygen demand into the Central Delta via Turner Cut and Columbia Cut.

On July 17, 2003, the total Delta export pumping was 11,218 cfs (see Table 4). At that time the SJR Vernalis flow into Old River was approximately 912 cfs. This value does not include the small amount of agricultural diversions that occur between Vernalis and the UVM gaging point near the DWSC. The export at Tracy on this day was 4,349 cfs, which means that approximately 3,437 cfs of the Tracy export water was derived from the Sacramento River.

The Delta import and export information for September 17, 2003, is presented in Table 6. As shown in Table 6, the SJR flow at Vernalis was about 1,500 cfs. The SJR DWSC flow was 500 cfs. During early September 2003 the SJR DWSC flows ranged from a low of about 500 cfs to about 1,200 cfs and were variable from day to day. The Sacramento River flow at Freeport was estimated to be about 16,000 cfs, to give a total DWR-reported Sacramento –San Joaquin River Delta inflow of 17,767 cfs.

Table 6
Characteristics of the Delta and Its Inflows/Exports on September 17, 2003

SJR Vernalis Flow	~1,500 cfs
SJR DWSC Flow	500 cfs
Sacramento River at Freeport Flow	~16,000 cfs
Total Delta Inflow	**17,767 cfs**
Export – Clifton Court (Banks)	7,013 cfs
Export – Tracy	3,481 cfs
Export – Contra Costa	149 cfs
Export – Barker Slough	68 cfs
Total Export	**10,711 cfs**

On September 17 the State Project export at Clifton Court (Banks Pumping Station) was 7,013 cfs. The Federal Project export from the South Delta at Tracy Pumping Station was 3,481 cfs, the Contra Costa Water District's export was 149 cfs, and the export from Barker Slough was 68 cfs, for a total export of 10,711 cfs. The Federal and State Projects, therefore, represented 98 percent of the total Delta export pumping on September 17, 2003. Further, all of the SJR Vernalis flow and 58 percent of the Sacramento River flow were either consumed by Delta irrigated agriculture or exported by the State and Federal Projects.

On September 17, 2003, the SJR Vernalis flow into Old River was approximately 1,000 cfs. This value is estimated based on the USGS gaging of the SJR Vernalis flows and the USGS UVM gaging of the SJR just upstream of where it enters the DWSC. It does not include the small amount of agricultural diversions that occur between Vernalis and the UVM gaging point near the DWSC. The export at Tracy on this day was 3,481 cfs, which means that approximately 2,500 cfs of the Tracy export water was derived from the Sacramento River. This value does not account for any South Delta irrigation diversions that were occurring on September 17, 2003.

As shown in Figure 6, the measurements at the DWR RRI station showed a low DO on September 17, 2003, of about 4 mg/L in early morning and a high DO of about 7 mg/L in late afternoon. Therefore, near the time of the September 17 tour, there was a several mg/L diel change in DO with a low of 4 mg/L occurring in early morning and a high for the day of about 7 mg/L occurring in late afternoon.

Figure 6
DWR RRI DO Monitoring During Mid-September 2003

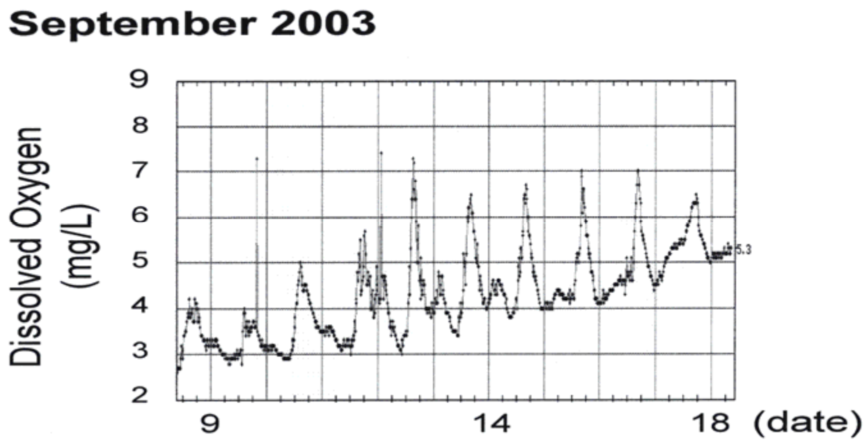


Figure 7 presents the DWR RRI DO monitoring results during the summer and fall 2003. At the time of the September 17 tour, the diel DO was typical of the September 2003 daily change in DO. The September 2003 RRI DO data showed daily WQO violations that were within the range of violations that occurred at other times during the summer and fall.

The EC recorded on September 17, 2003, by the DWR RRI station was 670 µmhos/cm during that day. This value compares to the tour measurements of DWSC and SJR at the railroad bridge just upstream of the DWSC of 674 µmhos/cm.

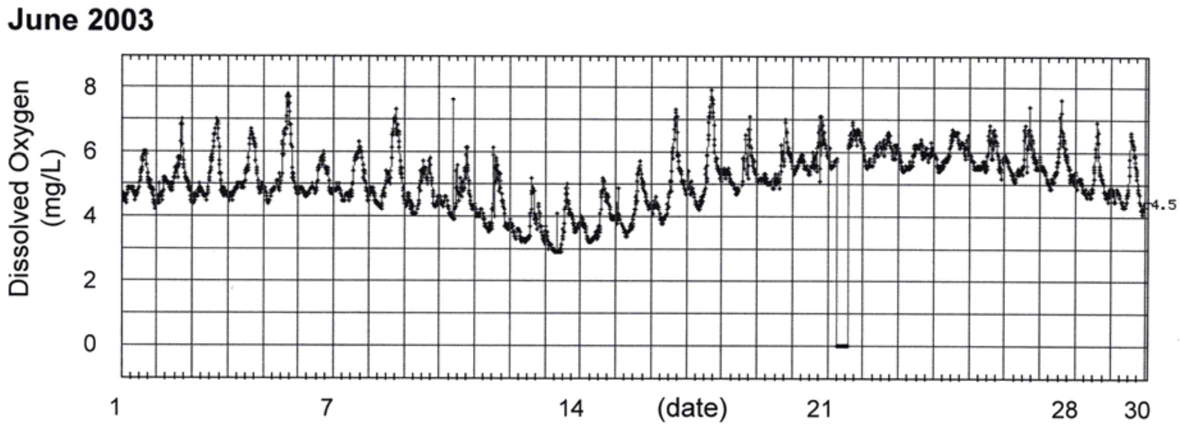
Overall, the July 17, 2003, and September 17, 2003, tours were conducted on typical flow conditions for the summer 2003 in the Delta. As discussed above, neither the July nor September tours were conducted on worst-case conditions for maximum expected export of oxygen demand into Turner Cut from the DWSC.

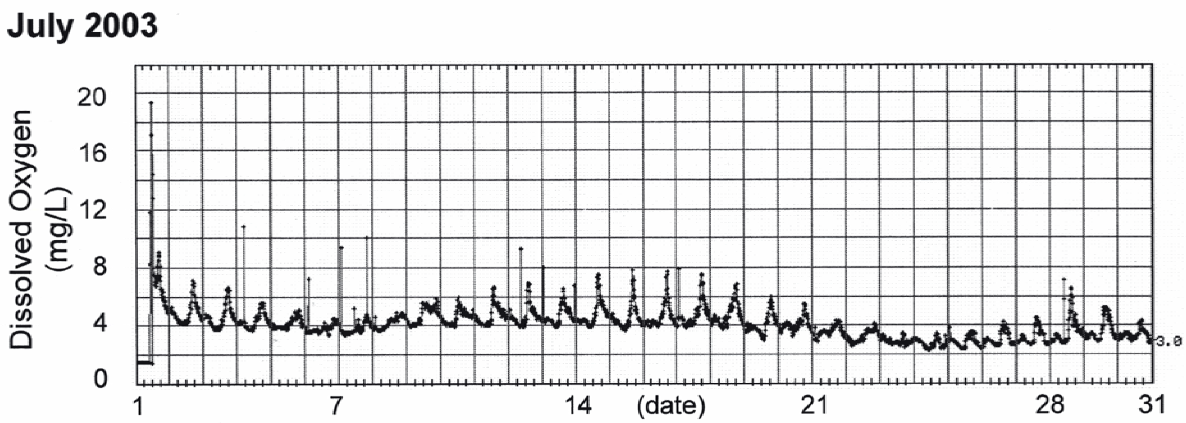
Factors Impacting Central Delta Water Quality

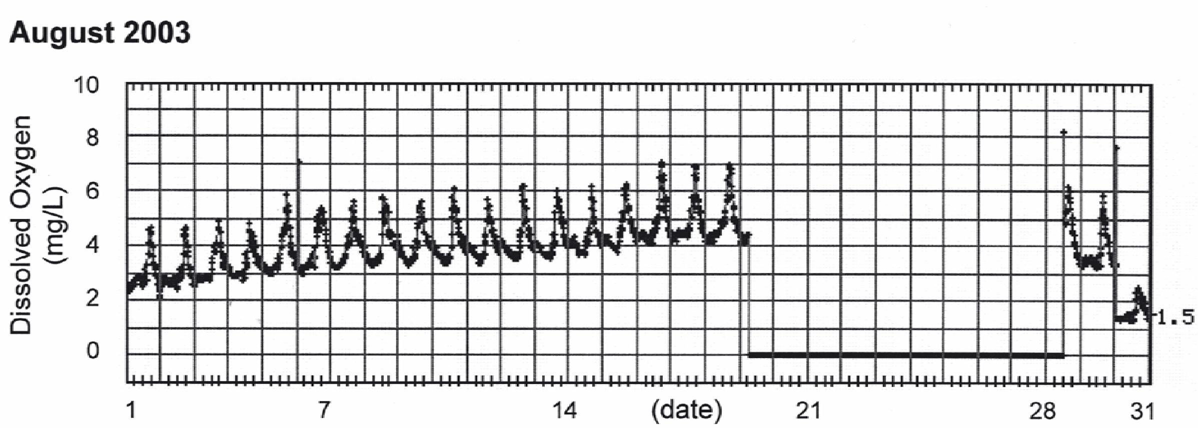
There are several factors that influence the water quality characteristics of the Central Delta and South Delta. The most important issue influencing Central Delta water quality is the flow of Sacramento River water to the South Delta export pumps. For many potential pollutants in Central and South Delta waters, the inflow of Sacramento River water into the Central Delta and, to some extent, the South Delta dilutes the constituents present in San Joaquin River waters added to the Delta, wastewater and stormwater discharges to the Delta including those from the cities of Stockton and Tracy, and Delta irrigation return waters that have the potential to impair beneficial uses of Central and South Delta waters. However, the Sacramento River water also contains several constituents that are potential pollutants in the Delta. A review of several of these issues is presented below.

Delta Cross Channel A factor that could influence the amount of Sacramento River water that dilutes the San Joaquin River Deep Water Ship Channel water in the vicinity of Turner Cut and Columbia Cut is the operations of the Delta Cross Channel (DCC). The Delta Cross Channel, less than a mile long, was constructed to connect the Sacramento River (near Locke and Walnut Grove) with Snodgrass Slough and the Mokelumne River System, to allow a greater amount of

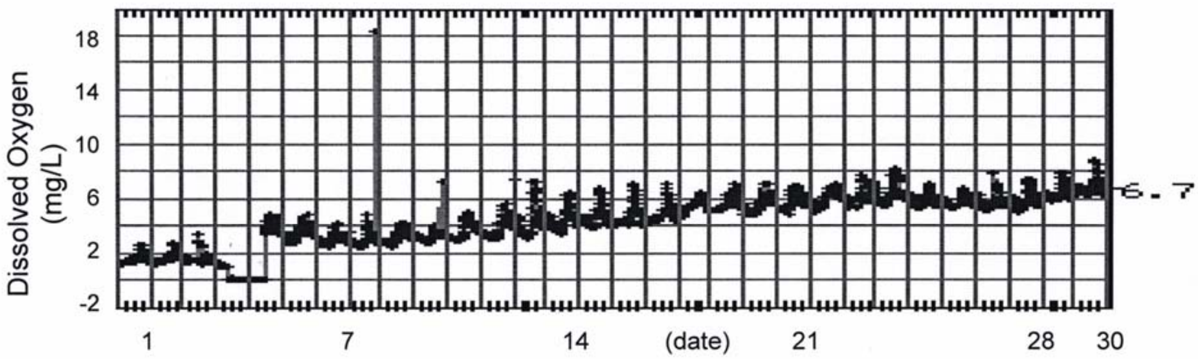
Figure 7
SJR DWSC RRI DO June-November 2003



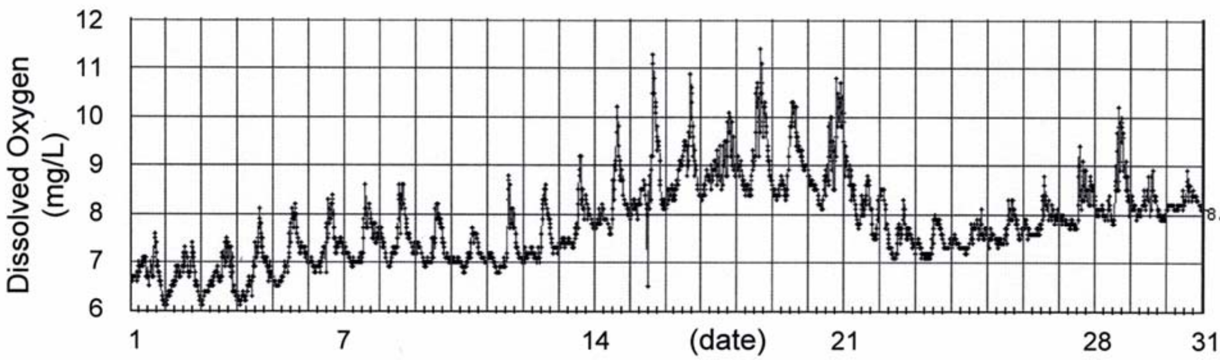




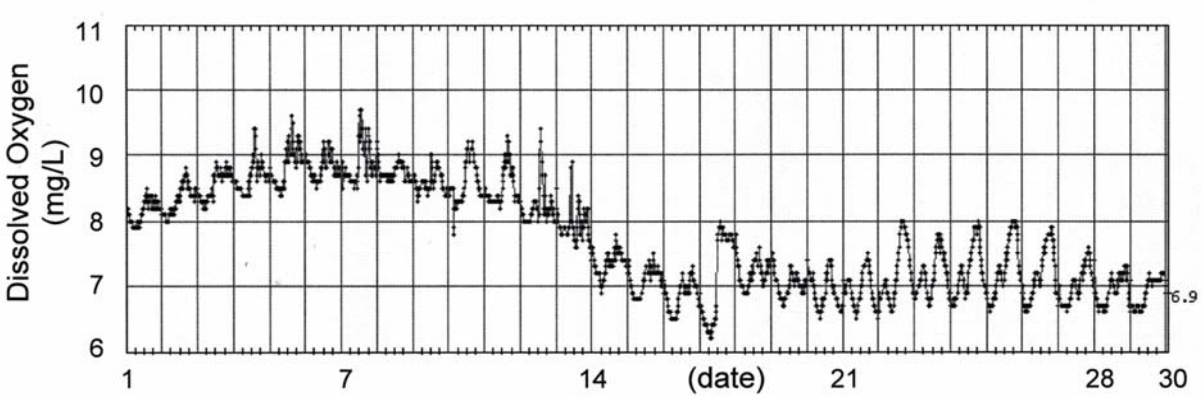
September 2003



October 2003



November 2003



Sacramento River water to enter the eastern Delta than would normally occur. The DCC has hydraulically controlled gates that control the flow through the Cross Channel. When the gates are open, there is flow of the Sacramento River water through the DCC. The gates, however, are closed for the purpose of protecting Sacramento River fish from being drawn into the Central Delta via the Cross Channel. Presented below is US Bureau of Reclamation (USBR) information on the operations of the DCC:

According to DWR, the DCC is operated as follows:

"The Delta Cross Channel Gates are operated in accordance with State Water Resources Control Board Decision 1641 as follows:

1. *From November 1 through January 31. Gates will be closed for a total of up to 45 days for fisheries protection as requested by the US Fish & Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Department of Fish & Game (DFG). Gates may be closed on very short notice and may be closed on weekends.*
2. *From February 1 through May 20. Gates will be closed.*
3. *From May 21 through June 15. Gates will be closed for a total of 14 days for fisheries protection as requested by the USFWS, NMFS, and DFG. Gates may be closed on very short notice. Whenever possible, gates will be open on the weekends (Saturday and Sunday) and the weekday holiday on Memorial Day weekend, but this cannot be guaranteed.*
4. *From June 16 through October 31. Gates will generally be open, but this cannot be guaranteed. Hydrodynamic and fishery experiments have been conducted in late summer and early fall in 2000 and 2001 and are expected to continue thru 2003. These often require intermittent closures.*
5. *High flows on the Sacramento River, unforeseen fishery protection actions or water quality compliance in the Delta may necessitate a short term closure.*

USBR standing operation procedures call for gate closure when flow on the Sacramento River reaches the 20,000 to 25,000 cfs range.

Gate opening and closing times are approximate, since an operator must travel to the site to perform the change. The opening and closing of the gates generally takes 30 minutes to one hour."

(from http://www.usbr.gov/mp/cvo/vungvari/xcgtxt.html)

In accordance with normal operations, during the time of the July 17 and September 17 tours, the gates on the DCC were open, allowing maximum Sacramento River water to enter the eastern Delta. There are times, however, when the DCC gates are closed. This could influence the amount of Sacramento River water that is available for dilution of the San Joaquin River Deep Water Ship Channel water at Columbia Cut and Turner Cut. According to C. Creel of DWR (pers. comm., 2003), *"Normal operation in the summer could be to either close or open the DCC gates."* During the time that the DCC gates are closed, there could be greater concentrations of oxygen demand present in Turner Cut and Columbia Cut, and therefore a somewhat greater potential for low DO to occur along these Cuts, especially in side channels.

Impact of Delta Export Pumping Rates

Another time when there would be less dilution of the San Joaquin River Deep Water Ship Channel water at Turner Cut and Columbia Cut by Sacramento River water is when the rate of pumping by the two export Projects is reduced. Since the dilution of the SJR DWSC water by Sacramento River water at Columbia Cut and Turner Cut is export-pumping-driven, particular attention needs to be given to situations of elevated SJR DWSC flow with elevated oxygen demand content, low tide, DCC gates closed, and reduced pumping at the export pumps. This combination could be the key to creating low-DO conditions in the Central Delta.

M. Nolasco and W. Dibben of DWR Operations and Maintenance Division have provided the Delta export flows for the period 1979 through June 2003. This information was examined to see the magnitude of the changes in export flow from the South Delta. The State and Federal Project pumps make up essentially all of the export of water from the Delta. (On July 17, 2003, the two Projects represented 97 percent of the total Delta export pumping, and on September 17, 2003, the two Projects represented 98 percent of the total Delta export pumping.) There are also small amounts (typically, a few hundred cfs) of water exported for other purposes, such as for the Contra Costa Water District. It is the Federal and State export pumps that are primarily responsible for bringing Sacramento River water into the Central Delta. Table 7 presents a summary of high and low daily and monthly Delta export flows from 1990 through June 2003.

Table 7
Delta Export Flows 1990 through June 2003

Year	Daily Flow (cfs)			
	High		Low	
	cfs	Date	cfs	Date
2003 (thru 6/30)	12,200	3/1	1,014	5/13
2002	12,251	1/1	1,156	5/19
2001	11,825	12/31	1,053	5/30
2000	13,338	2/18	1,605	5/6
1999	11,807	8/22	832	1/4
1998	11,686	8/16	858	2/27
1997	11,600	7/23	33	1/26
1996	11,599	1/20	1,394	3/7
1995	12,853	1/14	72	3/11
1994	11,099	9/6	0	7/7
1993	14,661	1/20	1,488	4/27
1992	10,557	2/18	0	11/4
1991	10,527	3/6	950	8/16
1990	10,853	4/4	1,109	12/2

According to Nolasco (pers. comm., 2003), there are a variety of factors (such as pump and conveyance structure maintenance, excessive fish capture, etc.) that influence the magnitude of the daily Delta export flows through the State and Federal Projects. Table 7 shows that during the period of 1990 through June 2003, the high daily flows were typically in the range of 10,000 to 14,000 cfs. Normally, the highest export flows occurred during the winter, although at times it can be during the summer. The low daily export flows ranged from no flow to about 1,500 cfs. Examination of the daily flow data (not shown) shows that there is no pattern of when extreme low flows occur, with respect to season or other factors. This conclusion is supported by Nolasco (pers. comm., 2003). It is during these low export flows that there would be less Sacramento River water transported to the State and Federal Project pumps. At times, the extreme low flows occur for only a day, and are elevated on the days on either side of this low-flow day. It could take several days of low export flow to significantly impact DO depletion in the Turner and Columbia Cut channels and associated side channels through altering the amount of Sacramento River dilution water that mixes with the SJR DWSC water.

Examination of the complete database (data not shown), shows that there can be rapid changes in the daily export pumping by the Projects. For example, in June 2003, the total daily export pumping ranged from about 10,000 to 11,000 cfs for the first 24 days of the month. Beginning on the 25th, for the next five days, the export pumping by the Projects was about 8,000 to 9,000 cfs. Therefore, there was about a 2,000 cfs difference for these five days, which would affect the amount of Sacramento River water that was diluting SJR DWSC water in Turner Cut and Columbia Cut.

During 1998 and 2000, which were high SJR DWSC flow years with few DO WQO violations, when there were also substantial algal loads contributed to the SJR DWSC during the summer and fall from upstream sources and therefore substantial oxygen demand transported into Turner Cut and Columbia Cut, the export pumping by the Projects was typically on the order of 10,000 to 11,000 cfs. There were, however, several days during the summer and fall when the export pumping was decreased to 8,000 to 9,000 cfs. It is evident that there can be rapid changes in the amount of Sacramento River water that is available for mixing/dilution of the SJR DWSC water, associated with the variability of the export pumping of South Delta water by the Projects.

The amount of export pumping from the South Delta by the State and Federal Projects, in addition to influencing the amount of Sacramento River water that is available to dilute the SJR DWSC water at Turner Cut and Columbia Cut, also influences the amount of SJR water at Vernalis that enters Old River and, therefore, the amount of SJR Vernalis water that flows through the DWSC.

South Delta Improvements Program

The South Delta Improvements Program (SDIP) will affect the flow of Sacramento River water through the Central Delta and South Delta. The Department of Water Resources Bay-Delta Office Delta Planning Branch has provided the following information on the South Delta Improvements Program:

> *"The Department of Water Resources and US Bureau of Reclamation are responsible for implementing CALFED's South Delta Improvements Program. Actions contemplated as*

part of the SDIP include providing for more reliable long-term export capability by the state and federal water projects, protection of local diversions, and reducing impacts on San Joaquin River salmon. Specifically, the CALFED actions in the South Delta Improvements Program include consideration of placement of a fish barrier at the head of Old River, up to three hydraulic barriers in south Delta channels, dredging and extension of some agricultural diversions, and increasing diversion capability of Clifton Court Forebay to 8,500 cubic feet per second.

The 2000 CALFED Record of Decision includes the following elements:

- *Increase SWP pumping from the current limit from March 15 to December 15 to 8,500 cfs; and modify existing pumping criteria from December 15 to March 15 to allow greater use of SWP export capacity.*
- *Increase SWP pumping to the maximum capability of 10,300 cfs.*
- *Design and construct new fish screens at the Clifton Court Forebay and Tracy pumping plant facilities to allow the export facilities to pump at full capacity more regularly.*
- *Dredge and install operable barriers to ensure water of adequate quantity and quality to agricultural diverters within the South Delta. (The fish barrier proposed for the Head of Old River is contained in this element.)*

Uncertainties associated with Fish Screen design and funding and lack of results from fish screen testing facilities at the Tracy pumping plant necessitated that DWR delay the implementation of construction of the new fish screen facilities. Without the new fish screen facilities, no new intake into Clifton Court Forebay was proposed. DWR has therefore delayed implementation of increasing SWP diversions to 10,300 cfs."
(from http://sdelta.water.ca.gov/)

According to C. Creel, DWR (pers. comm., 2003),

> *"The existing capacity at Banks Pumping Plant is about 10,300 cfs. However, the SWP cannot achieve exports that high under the current regulatory framework. Per an agreement with USACE, the Clifton Court Forebay inflow is operated to achieve a three-day average inflow of about 6,680 cfs. From mid-December through mid-March, the inflow can be increased to about 6,680 cfs plus an additional amount that is equal to one-third of the Vernalis flow when it is 1,000 cfs or higher."*

In April 2004 Creel provided the following additional information,

> *"1. There is a USACE permit that allows DWR to pump at 7,180 cfs during the July through September period. This allows for an additional 500 cfs pumping for purposes of benefiting the fisheries (lower exports during the spring means the EWA must make water available in the summer and fall to the projects). This permit was initially issued in 2000 and re-issued last year. The permit is scheduled to sunset after next year because the additional pumping for the EWA would be covered by a new permit for the South Delta Improvements Program.*

2. The 'Corps permits' … regarding the 6,680 is actually an understanding between the Department and USACE. The existing pumping plant and its operations are covered by a nationwide permit for work that was completed prior to 1969. The USACE agreed that as long as the Department operated in a manner consistent with historical operations, no new permit would be necessary. This understanding is memorialized in a USACE Public Notice dated October 13, 1981. In short, the Public Notice stipulates that we plan to operate to a daily maximum of 13,870 acre-feet and 3-day average maximum diversion of 13,250 acre-feet (this amounts to 6,680 cfs). The exception to these limits are:

a. Noted in item 1 above.

b. We can exceed the 6,680 cfs maximum between mid-December and mid-March by an amount equal to one-third of Vernalis when the SJ is at or above 1,000 cfs.

3. The diversion permit from the SWRCB allows for up to 10,350 cfs pumping at Banks for the SWP. …Either project may pump for the other (this is referred to as Joint Point of Diversion or JPOD) if specific criteria are met. The criteria … in general … are designed to protect water levels, fisheries, and water quality.

* * *

The theoretical maximum combined (CVP and SWP) export rate is almost 15,000 cfs; however, I don't believe the projects have ever maintained that level of pumping for more than a very brief period of time (in fact I'm not sure that we have ever been at maximum pumping at the same time). In order to get to that level of pumping, we would need to see over 11,000 cfs flow at Vernalis (and generally by the time the SJ system is that high we have no place to store water in the CVP or SWP systems). It is not uncommon to see combined exports around 10-11,000 cfs even in the summer and fall periods.

… The allowable pumping at Banks can exceed 8,500 cfs if conditions are right. Therefore, I would expect to see examples of brief periods when SWP pumping is over 8,500 cfs (but it is always between mid-December and mid-March). If you look at monthly average pumping, however, I don't think you'll see anything above 7,500 cfs. This is because many factors can affect our ability to divert water into Clifton Court Forebay including tide conditions, water quality in the Western Delta, as wells as weeds coming into the forebay."

As discussed above, at times the current Delta export pumping, which is primarily accomplished through the State and Federal Projects, has had a maximum actual pumping rate of about 13,000 to 14,000 cfs. The State Project currently has a maximum allowed pumping rate of 8,500 cfs, which will be increased to 10,300 cfs as part of the SDIP. This represents a potential increase of about 1,800 cfs. Since essentially all of the San Joaquin River water at Vernalis, except during flood flow conditions, is now being exported by the two Projects, either through Old River diversions or Turner Cut and Columbia Cut flows, this additional export flow will be derived from the Sacramento River and Delta eastside tributary rivers. Therefore, an increase in Sacramento River water passing through the Central Delta will occur with the completion of the SDIP during the times when the State Project pumps are operating at their maximum capacity.

This will tend to further dilute any adverse impacts of SJR DWSC water on Central Delta water quality. It is also possible that there could be reduced pumping by the State Project during times when there are restrictions on export pumping at the State Project pumps, which would reduce the amount of mixing/dilution water available for the SJR DWSC waters that are transported through Turner Cut and Columbia Cut.

Mixing/Dilution of SJR DWSC Water with Sacramento River Water in Turner Cut

Brown, in Jones & Stokes (2002b), has provided information on the characteristics of the tidal and net downstream flows of the DWSC near Turner Cut and within Turner Cut. He reports that the three-foot tide stage change at Turner Cut produces an average tidal flow of the DWSC near Turner Cut of about 7,800 cfs. The average tidal excursion in the DWSC at Turner Cut is about two miles. He further reports that, based on DWR measurements made in the mid-1990s, the tidal flows in Turner Cut averaged about 3,600 cfs during May 1997. The expected tidal excursion in Turner Cut is about 2.9 miles.

From the information available in Table 3 and the flow conditions that existed on September 17, 2003, it is estimated that the 500 cfs of SJR DWSC water that was drawn into Turner Cut by the export pumps would have mixed with about 1,300 cfs of Sacramento River water at the DWSC head of Turner Cut to give the resultant EC found in Turner Cut. It is apparent, based on the reduction of EC that occurred within Turner Cut, that there was appreciable Sacramento River water entering Turner Cut on the days of both of the tours.

An estimate of the dilution/mixing that occurs between SJR DWSC water and Sacramento River water can be made from the following assumed conditions:

- Recent year typical flows in the SJR at Vernalis during the summer and fall are on the order of 2,000 cfs.
- If it is assumed that that 500 cfs of this flow is allowed to enter the South Delta at the Head of Old River split, then approximately 1,500 cfs of SJR Vernalis water would pass through the DWSC into Turner Cut.
- If the total export pumping by the State and Federal Projects is assumed to be 10,000 cfs, then 8,000 cfs of Sacramento River water has to be drawn to the export pumps to meet the 10,000 cfs export – i.e., all of the SJR Vernalis water is exported by the State and Federal Projects. The amount of Sacramento River water that is drawn to the export pumps will be slightly larger than this amount based on Delta irrigated agriculture water consumption in the South and Central Delta.

If the flow of the SJR DWSC were increased to the current DO TMDL target flow of 1,500 cfs, there still would be some Sacramento River water entering Turner Cut to dilute the EC and other constituents. The net result of the increased SJR DWSC flow into Turner Cut would be to cause those who use Turner Cut waters for irrigation, cooling, etc., to experience elevated concentrations of potential pollutants in Turner Cut water. Of particular concern would be the effect of EC on irrigated agriculture. It is apparent that increasing the SJR flow through the DWSC to help solve the low-DO problem would not increase the EC in Turner Cut to values that would cause excessive EC for irrigated agriculture along Turner Cut – i.e., 700 µmhos/cm. As

Lee and Jones-Lee (2003a) have pointed out, in some years (such as 1998 and 2000), this situation already occurs in Turner Cut.

Nader (pers. comm., 2003) has indicated that, based on DWR modeling of Delta flows in summer 1997 and 1999, about 55 to 60 percent of the Sacramento River flow to the export pumps goes through the Central Delta in Middle River, and 40 to 45 percent goes through the Central Delta in Old River. If the SJR Vernalis flow is about 2,000 cfs and 500 of this is drawn into the South Delta at the Head of Old River, leaving 1,500 cfs to pass through the DWSC into Turner Cut, and the total export pumping is assumed to be about 10,000 cfs, then approximately 8,000 cfs of Sacramento River water is brought through the Central Delta to the export pumps. Assuming a 50-50 split in the flow of Sacramento River water through the Central Delta between Sacramento River water in Middle River and Old River, the Turner Cut water associated constituents would be further diluted when this water mixes with the Middle River water at the Middle River Turner Cut juncture.

Part of the potential pollutants originally derived from the DWSC that pass through Turner Cut into Middle River would be removed from Middle River by irrigated agriculture along Middle River and would pass into the South Delta where Middle River enters the South Delta at Victoria Canal. Further, more Sacramento River water would enter the South Delta to feed the Federal export pump, since less of the SJR Vernalis water would enter the South Delta at the Head of Old River. Some of the DWSC water that enters Turner Cut/Middle River would be transported to Old River through Central Delta channels that connect Middle River and Ole River and tidal induced mixing. The flows of Middle River into the South Delta will likely change significantly upon commencement of the operations of the permanent barriers and dredging on Middle River in the South Delta. According to the CALFED ROD, the permanent barriers in the South Delta are scheduled to be completed in 2007. Recently DWR staff has indicated that this project is on schedule.

It is evident that there will be need to do studies to determine if any of the constituents in the SJR Vernalis waters that now during the summer and fall pass primarily into the South Delta at the Head of Old River would cause any significant water quality problems to water users in the Central and western South Delta, as well as to those who export South Delta water for domestic water supply purposes. These studies should be coordinated with the current DWR water supply water quality monitoring program. The constituents of particular concern are EC, TOC and nutrients.

Impact of Altered Turner Cut/Central Delta Flows on Fisheries

One of the issues that needs to be addressed as part of evaluating the impact of increasing the SJR DWSC flows to reduce the frequency and magnitude of the low-DO problem in the DWSC is its impact on the fisheries of the Delta. Lee and Jones-Lee (2003a) have recommended that an effort be made to gain the assistance of the Delta fisheries experts to ascertain fisheries issues of concern in increasing the SJR DWSC flow to reduce the magnitude and frequency of the low-DO problem in the DWSC. These discussions could lead to the development of special purpose studies that would provide the information needed to address fisheries issues associated with increasing the SJR DWSC flows to help solve the DWSC low-DO problem.

Conclusions and Recommendations

Based on the results of the July 17, 2003, and September 17, 2003, tours of the Central Delta and an analysis of existing information, it is concluded that the export down Turner Cut and Columbia Cut of large amounts of oxygen demand present in SJR DWSC water could lead to DO concentrations in parts of the Central Delta that would violate water quality objectives. The September 17, 2003, tour, which was specifically targeted to the worst case-most likely situation for low DO in Turner Cut and its associated side channels during mid-September 2003, did not show DO problems in Turner Cut or other Central Delta channels. However, the mid-September tour was not conducted under worst-case conditions.

It is recommended that, as part of the Phase I TMDL studies of the low-DO problem in the SJR DWSC, focused monitoring for low-DO conditions be conducted in Turner Cut, Columbia Cut, and the side channels (Whiskey Slough) and flooded islands connected to these Cuts. As discussed herein, there are a number of factors that influence the potential for the SJR DWSC oxygen demand loads that are exported into Turner Cut and Columbia Cut to lead to DO WQO violations in the Central Delta. The studies that are conducted should be specifically designed to examine worst-case conditions of minimum Sacramento River water flow into Columbia Cut and Turner Cut during times of maximum export of oxygen demand from the SJR DWSC into these waterbodies.

Elements of Recommended Study Program. The overall objective of the Central Delta Low DO study program is to determine if increasing the flow of the SJR through the DWSC to shorten the hydraulic residence time that oxygen demand loads spend in the critical reach of the DWSC can be done without having an adverse impact on Central or South Delta water quality and the waters that are exported from the Delta by the State and Federal Projects and the Contra Costa Water District. If it is found that there is a potential for adverse impacts to Delta water quality, then a further objective would be to determine how the increased SJR flow through the DWSC could be accomplished and control these adverse impacts.

An element of the study program should include a review of the changes in the water quality characteristics that could be attributed to the higher SJR DWSC flows through Turner Cut, in the South Delta, Central Delta and the waters exported from the Delta by the State and Federal projects during 1998 and 2000 when there were higher summer/fall flows of the SJR through the DWSC.

The proposed study program should involve appointing a panel of experts who would oversee the studies. Those who are responsible for conducting the studies would work with the panel in developing the overall approach for the study program. The panel should consist of representatives of organizations (such as DWR, USGS) who are familiar with Delta channel flow issues, water utilities, fish and wildlife representatives, environmental groups, the California Bay-Delta Authority, the CVRWQCB, agricultural interests in the Delta and the SJR DWSC watershed, and others as appropriate.

The overall approach would be one in which those responsible for conducting the studies would present a draft study plan to the panel that would cover the next quarter, for their review and comment. Based on these comments, a final study plan would be developed and implemented. As the data become available, likely at quarterly intervals, a summary of the results would be presented to the panel.

If, during the course of the study, unusual or unexpected results are obtained, this would be immediately brought to the attention of the panel, with recommendations on how to further investigate the situation. An example of this type might be a fish kill or extremely low dissolved oxygen in one of the side channels such as Whiskey Slough, which is a dead-end channel off of Turner Cut.

Special-purpose monitoring runs would be conducted, which would specifically target conditions that could lead to water quality problems in Turner Cut, Columbia Cut, Empire Cut or Headreach Cut. Some of the conditions of concern would be elevated flow of the SJR through the DWSC in the period of mid-May through mid-December, which would carry significant loads of oxygen demand in the form of planktonic algae and city of Stockton wastewater ammonia through the critical reach of the DWSC. Another factor to consider is the influence of the State and Federal Project pumping rates, as well as whether the Delta Cross Channel gates are open or closed. Also of concern is the influence of the presence or absence of the temporary barriers on Middle River, Grant Line Canal and Old River in the South Delta on flows through the South Delta as they impact flows through the SJR DWSC and Turner Cut.

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