Additional Studies on the Impact of City of Stockton Stormwater Runoff on Low DO in the SJR DWSC

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In the fall of 2002, Drs. G. Fred Lee and Anne Jones-Lee initiated an unfunded effort to evaluate the potential for city of Stockton stormwater runoff to contribute to the low-DO problem in the San Joaquin River (SJR) Deep Water Ship Channel (DWSC). This issue was supposed to have been addressed under the Scope of Work for one of the component projects of the CALFED Low-DO Directed Action project. Since it was not done and it is of potential significance to developing an assessment of the sources of oxygen demand to the DWSC, Lee and Jones-Lee compiled information on the oxygen demand (BOD) content of urban stormwater runoff. They found, based on city of Stockton monitoring data, that sufficient oxygen demand could be added to the DWSC in a one-day 0.5-inch storm to cause significant additional DO depletion in the DWSC. These results were reported to the SJR DO TMDL Steering Committee, and were incorporated into the Lee and Jones-Lee (2003) Synthesis Report on the SJR DO TMDL studies.

In early November 2002, a major fall storm occurred in the city of Stockton, in which between 0.5 and 1 inch of rain fell in the city. As reported by Lee and Jones-Lee (2003), prior to the stormwater runoff, the DO in the DWSC at the DWR Rough and Ready Island (RRI) monitoring station was between 7 and 9 mg/L. Following the storm, there was a steady decline in DO in the DWSC at the RRI station down to about 3.5 mg/L at the end of November. A check of the upstream monitoring at Mossdale showed that there was no pulse of low-DO water passing this monitoring station during that time.

The DeltaKeeper found that, associated with the November 2002 stormwater runoff event, there were fish kills in several of the city of Stockton sloughs and that the fish kills were coincident with low DO in the sloughs. Connor, et al. (1998) reported a similar fish kill for the first fall storm in 1994 in city of Stockton sloughs. This fish kill was also associated with low DO in the sloughs. Connor, et al. (1998) also reported that fish kills have been observed by residents along Smith Canal in 1994, by CVRWQCB staff in 1994 and 1995, and by the DeltaKeeper in 1995 and 1996.

The city of Stockton sloughs are connected to the Delta, and there is tidal exchange of water between the sloughs and the DWSC. Further, many of these sloughs serve as conveyance systems for routing stormwater runoff in the city of Stockton to the DWSC and the Delta. It is possible, from the data available, that the city of Stockton stormwater runoff contributed to the low DO in the DWSC during mid- to late November 2002. Lee and Jones-Lee (2003) recommended that further studies be conducted to determine if there is sufficient oxygen demand added to the DWSC in city of Stockton stormwater runoff to lead to DO water quality objective violations or increased magnitude of violations if the DO before the runoff occurred was already in violation of the water quality objective.

On August 22, 2003, a major rainfall event occurred in the Central Valley, which deposited on the order of 0.5 to 1 inch of rain in parts of the city of Stockton. A few days later, the DeltaKeeper noted a fish kill and low-DO problems in several of the city of Stockton sloughs. K. Morgan (2003) of the DeltaKeeper staff reported the following:

> **Fish Kills on Five Mile Slough and Smith Canal at Yosemite Lake**[1]
> On the morning of Monday, August 25, 2003, the DeltaKeeper received an anonymous phone call reporting a fish kill on Five Mile Slough following the Friday, August 22, storm event. The dead fish were reportedly seen in the slough at the northwest corner of Swenson Park. Following the call, DeltaKeeper's YSI 600xl Multimeter was calibrated. At Five Mile Slough at Swenson Park at the intersection of Alexandria Pl. and Lincoln Rd. there were 2-3 bluegill and dozens of juvenile catfish at the surface gulping air. At 9:36 am the water temperature was 24° C, EC was 467 µS/cm, DO was **1.7 mg/L**, and pH was 6.9.
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> Measurements on Five Mile Slough at Monte Court, just east of the previous site, showed similar conditions. There were dozens of juvenile catfish at the surface. At 9:43 am the water temperature was 23° C, EC was 397 µs/cm, DO was **1.3 mg/L,** and pH was 6.4. At Five Mile Slough at I-5 on the west side of the freeway hundreds of dead threadfin shad were on the surface of the water. I also observed 50 or more 14-16 inch carp at the surface down the centerline of the slough. At 9:55 am the water temperature was 27° C, EC was 359 µS/cm, DO was **3.2 mg/L** and pH was 7.0.
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> At Five Mile Slough at Plymouth Road thousands of dead threadfin shad were on the surface. At 10:25 am the water temperature was 26° C, EC was 368 µS/cm, DO was **2.3 mg/L** and pH was 6.9.
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> At 11:33 am at Smith Canal at Pershing Bridge, tens of thousands of minnows were at the surface gulping air and bubbles were coming up from the mud. The temperature was 28° C, EC was 705 µS/cm, DO was 5.6 mg/L and pH was 7.1. At Yosemite Lake at the beginning of Smith Canal thousands of dead threadfin shad were observed at the northeast and southeast ends of the lake. Measurements were taken at the stormwater outfall on the northeast end. At 11:40 am the water temperature was 27° C, EC was 702 µS/cm, DO was 5.2 mg/L and pH was 7.1.
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> Upon return to the DeltaKeeper facilities, I informed Blaine Drewes of the City of Stockton by telephone about the fish kills. Drewes investigated Five Mile Slough at Alexandria and Lincoln. I met with Mr. B. Drewes at Swenson Park at 1:30 pm. DO measurements confirmed the low DO levels measured earlier at Alexandria Pl. and

[1] Morgan, K., "Fish Kills on Five Mile Slough and Smith Canal at Yosemite Lake," email to Mr. Brett Stevens, California Central Valley Regional Water Quality Control Board, Sacramento, CA, August 27 (2003).

Lincoln Rd., and a small dead carp was observed. A walk along Five Mile Slough near the golf course revealed thousands of dead threadfin shad.

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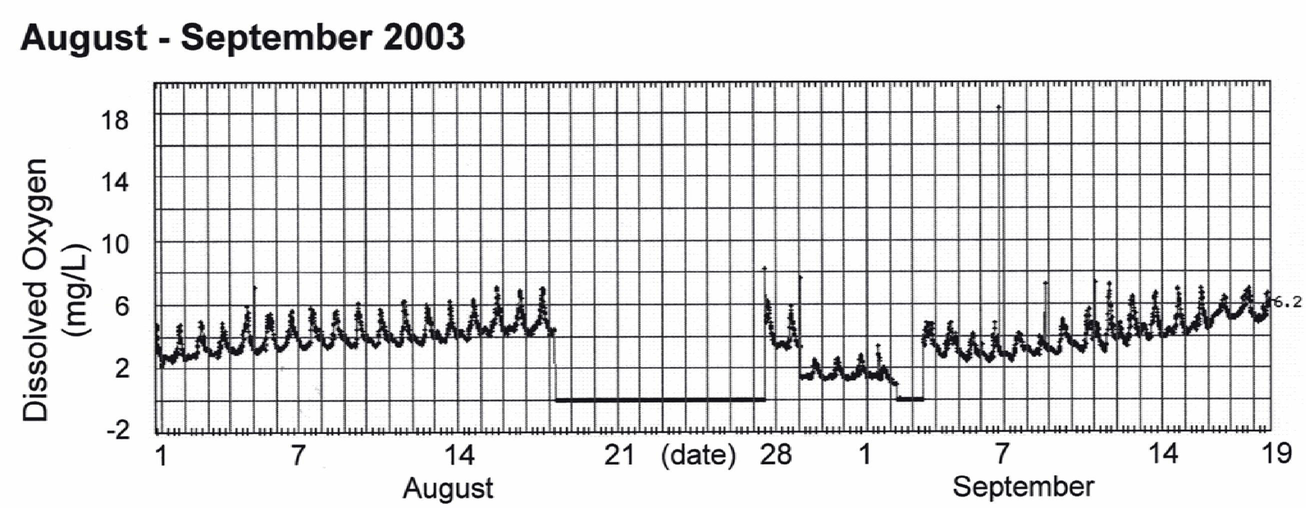
Low dissolved oxygen levels related to stormwater runoff from the August 22 storm event appear to be the cause of these fish kills. This fish kill in these waterbodies was similar to that observed after the stormwater runoff event in the city of Stockton in early November 2002.

In order to examine whether there was a possible connection between low DO in the SJR DWSC as measured at the RRI monitoring station and the August 22, 2003, rainfall event, the DWR RRI DO monitoring data were examined. Figure 1 presents the data for DO at the RRI monitoring station from the period August 1 through September 19. Examination of the figure shows that there was a period from August 18 to 27 when the DO meter at the RRI station was not operating. This was due to the Port changing a transformer that provided electricity to the station. DWR installed a portable battery-operated DO and EC meter at the RRI station. According to M. Dempsey of DWR, the data that were collected while the regular RRI DO monitoring equipment was not functioning were produced using a YSI 6600 floating monitor that was suspended within the water column at 1 m below the surface. These data are presented in Figure 2.

Figure 1



Examination of Figures 1 and 2 shows that, prior to the August 22 storm, as shown in Figure 1, the DO in the DWSC at the RRI station was gradually increasing from a low of about 2 mg/L on August 1 to a low on August 18 of about 4 mg/L. During this period there was a diel change in DO of about 2 mg/L each day, indicating that there were substantial algal populations in the DWSC at this time. Examination of the data in Figure 2 shows that the August 20 and 21 minimum DO concentrations were about 4.4 mg/L. There was a maximum peak DO on August 21 of about 6 mg/L; however, beginning on August 22, the minimum DO each day decreased, so that by August 26, the minimum DO was 3 mg/L. There was a substantial diel DO change each day through September 3. The data then picks up again in Figure 1, when the regular DWR RRI DO meter started to operate reliably, and by September 19 the minimum DO was about 5 mg/L.
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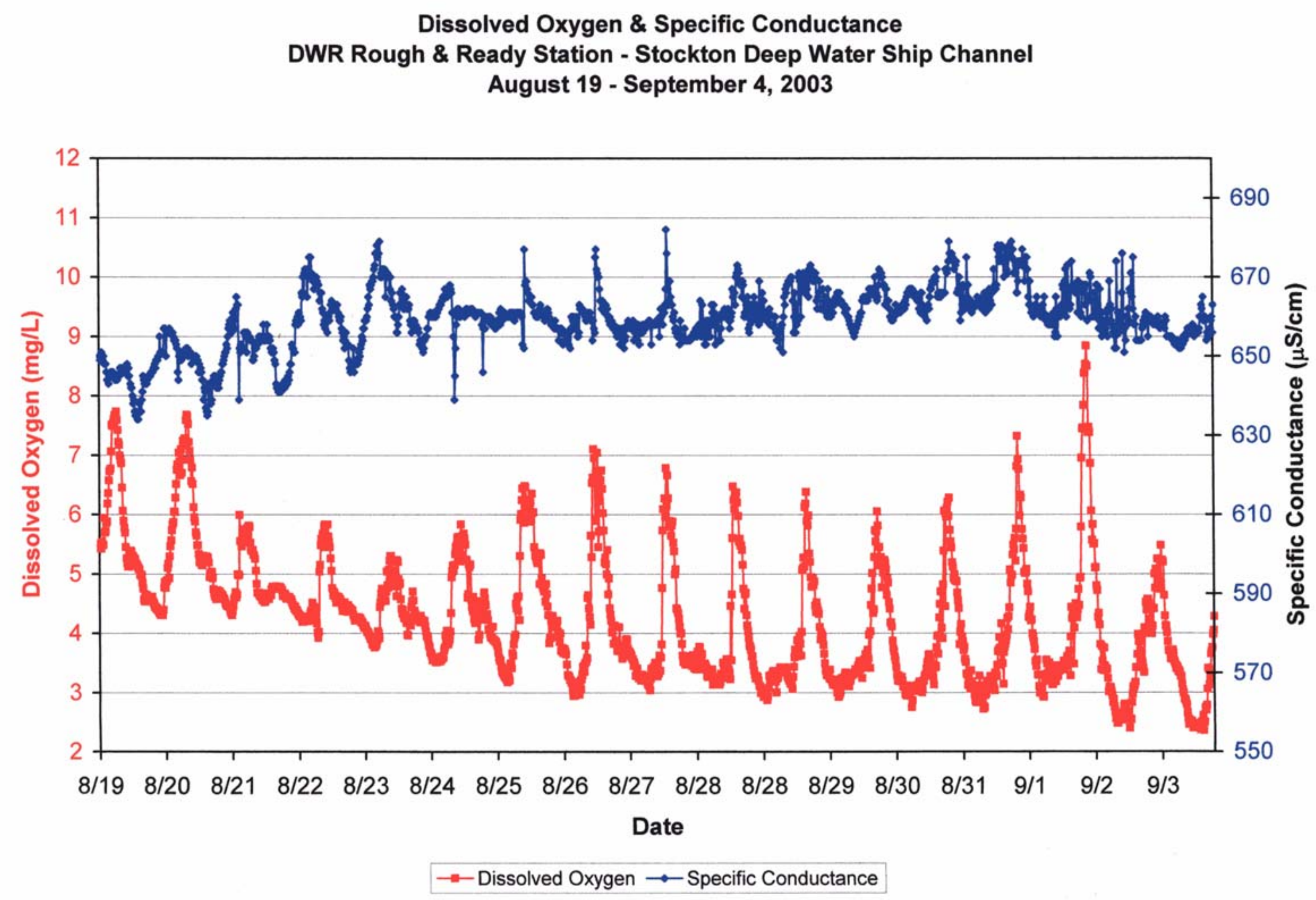
Figure 2


Dissolved Oxygen & Specific Conductance
DWR Rough & Ready Station - Stockton Deep Water Ship Channel
August 19 - September 4, 2003
Dissolved Oxygen (mg/L)
12
11
10
9
8
7
6
5
4
3
2
Specific Conductance (µS/cm)
690
670
650
630
610
590
570
550
8/19 8/20 8/21 8/22 8/23 8/24 8/25 8/26 8/27 8/28 8/28 8/29 8/30 8/31 9/1 9/2 9/3
Date
Dissolved Oxygen
Specific Conductance

There is a coincidence, therefore, in the decreased DO at the RRI station beginning shortly after the August 22 runoff event, which persisted for about 15 days.

Figure 2 presents the EC prior to, during and following the stormwater runoff event. It ranged from a low of about 650 µS/cm to a high of almost 1,100 µS/cm. Normally, it is expected that urban stormwater runoff will have a relatively low EC of 50 to 150 µS/cm. Examination of Figure 2 does not show any change in the EC in the DWSC during the stormwater runoff event. This is likely due to the fact that, while city of Stockton urban stormwater runoff has significant BOD load, its total contribution of flow to the DWSC is small, and therefore it is not expected to influence the EC of the DWSC. Figure 2 shows that there were changes in EC during the day that were likely related to tidal influences, which bring water masses from different sources, such as the Port, SJR upstream of the DWSC and SJR DWSC water past the RRI station.

The flow of the SJR through the DWSC at the time of the August 22 storm ranged from about 100 cfs a few days before the storm to about 450 cfs during the runoff event. A few days after the runoff event the SJR DWSC flow was up to 600 cfs.

Implications for Phase I TMDL Studies

During the Phase I TMDL efforts, special-purpose studies should be conducted, which will specifically focus on defining the potential role of city of Stockton urban stormwater runoff as a source of oxygen demand for the DWSC that contributes to causing or increasing the magnitude of DO depletions below the water quality objective. These studies should include measurement of the oxygen demand load from the city of Stockton to the DWSC through selective BOD measurements during the course of several storms, especially in the fall and early winter at selected locations, with a well-defined urban watershed. These studies should be defined to develop BOD export coefficients from dominant types of land use within the city of Stockton.

In addition to monitoring total and soluble BOD, ammonia, TOC and EC, it will be important to obtain an estimate of the total flow from the well-defined area, for various sizes of storms and seasons. Another factor to consider is to attempt to match monitored stormwater runoff events with various SJR DWSC flows. It is likely that the greatest impacts will occur when the SJR DWSC flows are low – i.e., less than 500 cfs. Ideally, this monitoring effort should be coordinated with the city of Stockton's NPDES permit monitoring, thereby reducing its cost. Because of the variability of the systems being monitored, it will be necessary to carry out this monitoring for at least three years. At the same time, monitoring of the upstream SJR loads to the DWSC should be conducted, such as at Mossdale, or if a newer station is established between Mossdale and Channel Point, at that location, as well as the City's domestic wastewater oxygen demand load, with particular reference to ammonia, organic nitrogen and carbonaceous BOD.

Since the characteristics of urban stormwater runoff BOD are likely to be different from domestic wastewater or algal derived BOD, it would be important to conduct a number of representative BOD exertion versus time studies, in order to establish the BOD rate constant.

While conducting studies of this type, it would be appropriate to also consider other local inputs of BOD that could be influenced by stormwater runoff, such as from dairies, agricultural activities, industrial runoff, etc., in the French Camp Slough watershed.

References

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