August and September 2003 SJR DWSC Flow and DO

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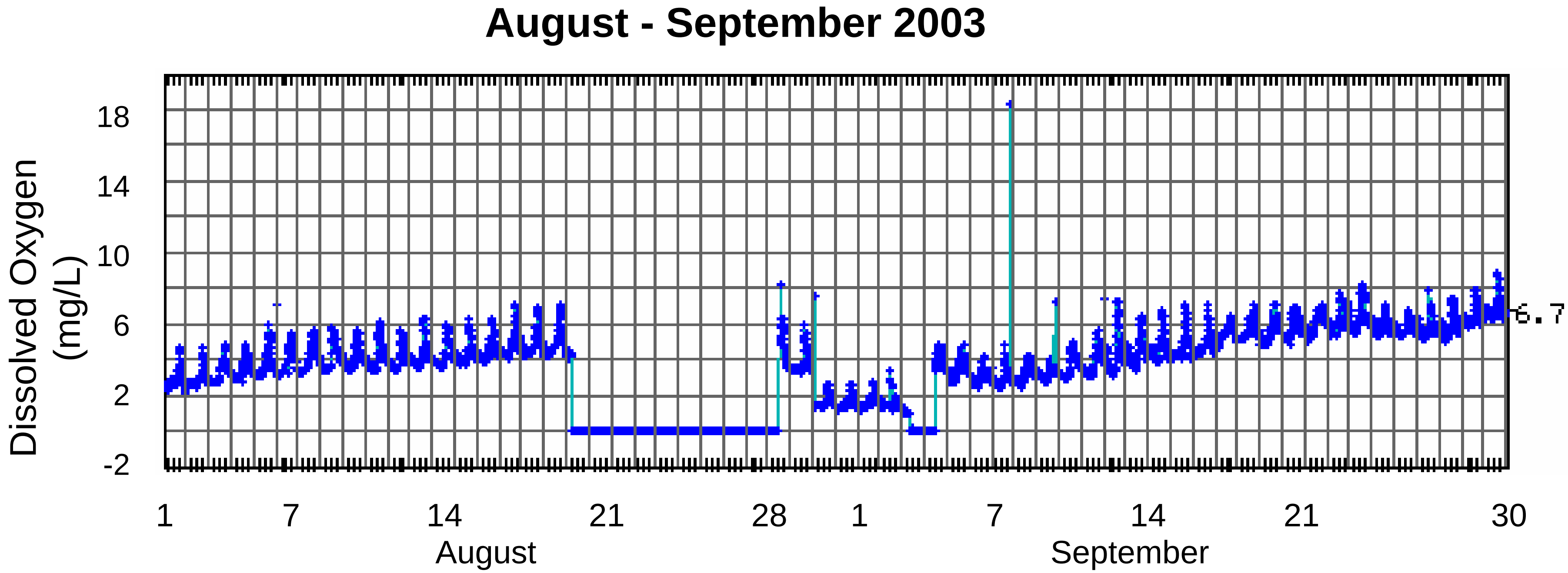
In August 2000 Lee and Jones-Lee (2000) introduced the concept that the amount of San Joaquin River (SJR) water at Vernalis that is allowed to proceed down the SJR channel to the Deep Water Ship Channel (DWSC), rather than being drawn into the South Delta through the Old River SJR split by the export pumps, greatly influences the DO depletion in the DWSC. At high SJR DWSC flows (greater than about 1,500 cfs) the hydraulic residence time (travel time) of oxygen demand added to the DWSC at Channel Point is less than about a week through the critical reach (first seven miles) of the DWSC. There are few DO depletion problems below the water quality objective (WQO) under these conditions. At these flows a large part of the total oxygen demand load added to the DWSC is mixed with Sacramento River water at Turner Cut and Columbia Cut and transported to the Central Delta on its way to the South Delta federal and state export pumps. During the time that there is low SJR Vernalis flow or when most of this flow is drawn to the South Delta export pumps, the hydraulic residence time of the critical reach (Channel Point to Turner Cut) of the DWSC is increased to several weeks to a month, and severe DO depletion in the DWSC occurs. At times (such as in February and July 2003), this can result in zero DO in the DWSC off of Rough and Ready Island.

The Lee and Jones-Lee (2003a) SJR DO TMDL "Synthesis" report presents a discussion of these issues based on the data that have been collected since 1995 on the relationship between SJR DWSC flow and DWR Rough and Ready Island (RRI) DO monitoring data through February 2003. In July 2003, Lee and Jones-Lee (2003b) presented an update of SJR DWSC flow - DO depletion through July 2003. This review showed that there were severe DO depletions in February 2003 and June-July 2003 that were associated with diversion of the SJR Vernalis water into the South Delta – i.e., there was limited SJR Vernalis water allowed to pass through the DWSC. Presented below is an update of these issues covering the period of August-September 2003.

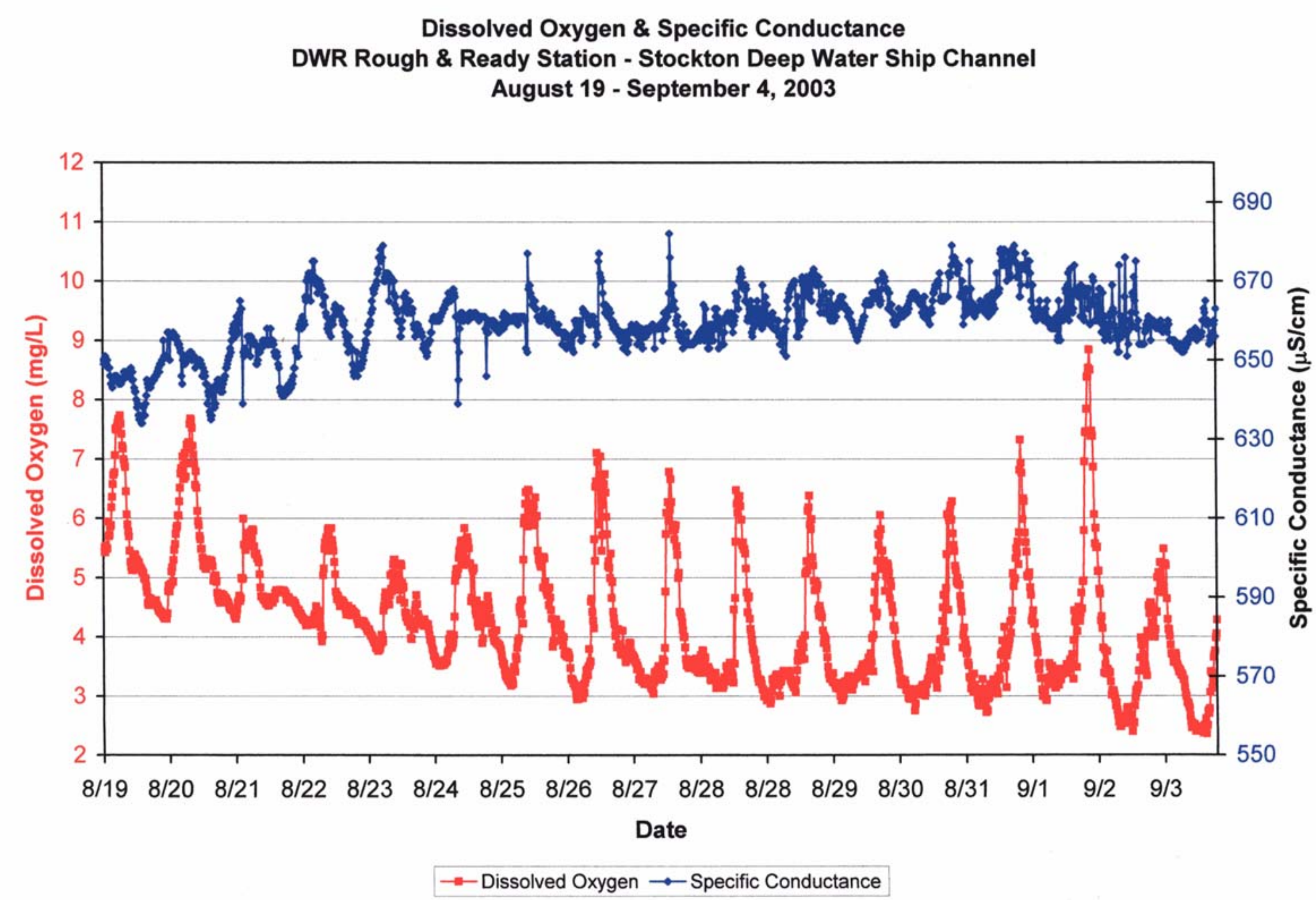
Figure 1 presents the data for DO at the RRI monitoring station for August and September 2003. Examination of the figure shows that there was a period from August 18 to 27 when the DO meter at the RRI station was not operating. This was due to the Port changing a transformer that provided electricity 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. Examination of Figures 1 and 2 shows that during August 2003 there was severe DO depletion in the DWSC, with the diel early morning DO concentrations as low as about 2 mg/L. The water quality objective for protection of fish and aquatic life at this time is 5 mg/L at any time and location in the SJR DWSC. However, in September there was a gradual increase in the low daily DO concentrations from about 2.5 mg/L up to about 6 mg/L by

Figure 1



August - September 2003
Dissolved Oxygen
(mg/L)
18
14
10
6
2
-2
6.7
1
7
14
21
28
1
7
14
21
30
August
September

Figure 2

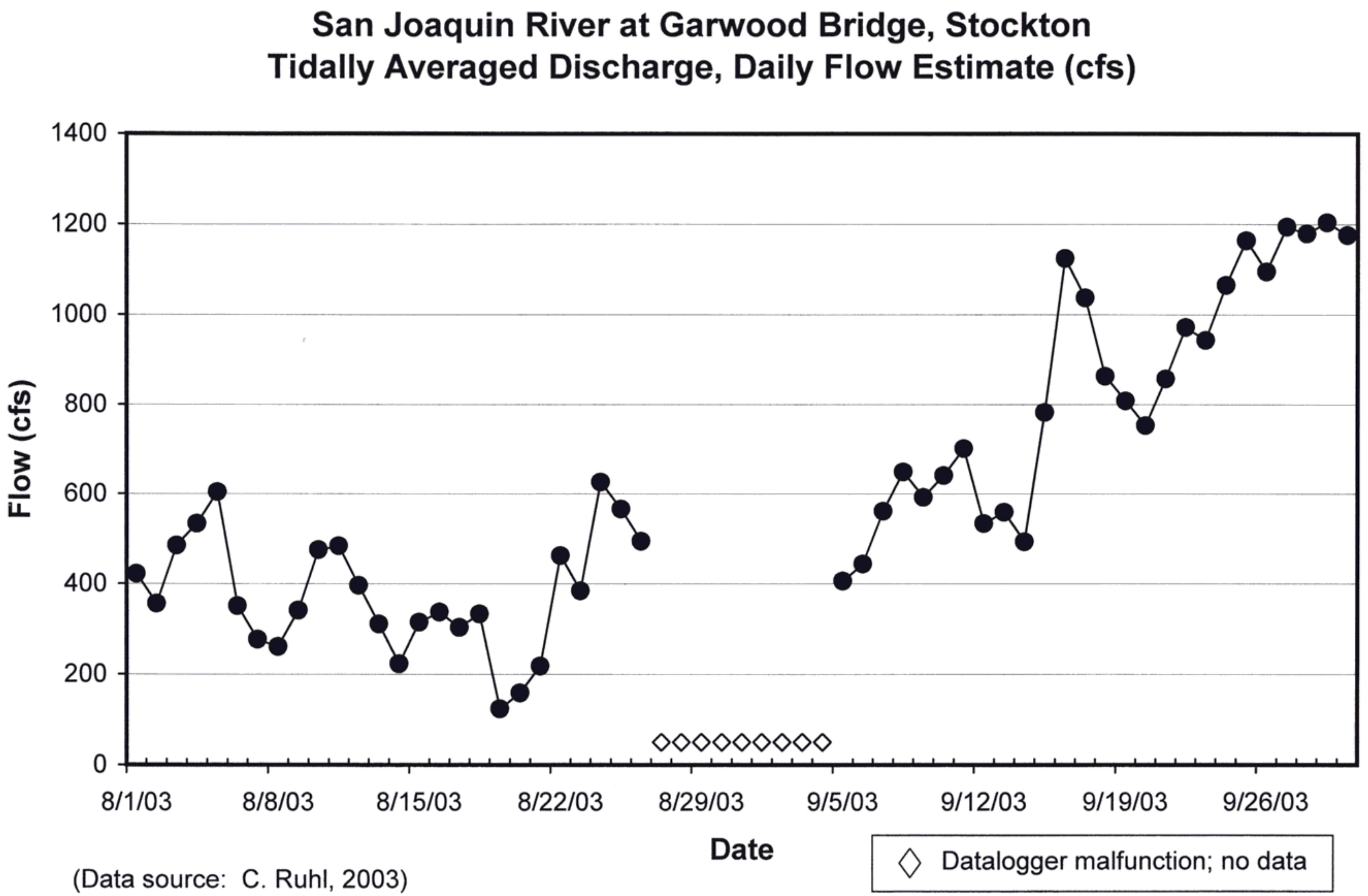

Dissolved Oxygen & Specific Conductance
DWR Rough & Ready Station - Stockton Deep Water Ship Channel
August 19 - September 4, 2003
Dissolved Oxygen (mg/L)
12
11
10
9
8
7
6
5
4
3
2
Specific Conductance (µS/cm)
690
670
650
630
610
590
570
550
8/19
8/20
8/21
8/22
8/23
8/24
8/25
8/26
8/27
8/28
8/28
8/29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

the end of the month. On September 1 the water quality objective for DO in the critical reach of the DWSC between Channel Point and Turner Cut is 6 mg/L at any time during the day or night within this part of the DWSC. This value was established to protect the fall run home stream migration of Chinook salmon through the DWSC. The daily diel changes in DO are related to the photosynthetic/respiratory activity of algae during the day and the bacterial and algal respiratory consumption of oxygen during the night.

Figure 3 presents the USGS data (provided by C. Ruhl) for the flow of the SJR through the DWSC for August and September 2003. During August, the flows were variable, ranging from a low of about 120 cfs to a high of about 600 cfs. There was a period at the end of August and early September when the USGS flow meter was not working properly. Beginning in early September, the flows increased from about 400 cfs to about 700 cfs, then back down to 500 cfs. On September 17, they shot up to approximately 1,130 cfs, dropped down again by September 20, then went back up to about 1,200 cfs. The fall Head of Old River closure took place beginning in early September, and was completed about September 19. This closure, however, is quite different in character from the spring closure, in that a substantial part of the SJR Vernalis flow in the fall passes through and over the barrier in order to enable Chinook salmon that are in the South Delta to migrate to home stream waters.

Examination of Figures 1, 2 and 3 shows that, whenever the SJR DWSC flows are on the order of 1,000 cfs or more, the DO in the DWSC off of Rough and Ready Island is at or near the water quality objective. However, even with flows of 1,200 cfs, there can still be early morning violations of the DO water quality objective in the surface waters of the DWSC near the Rough and Ready Island monitoring station. It has been found from past studies that flows on the order of 1,500 cfs or more are needed to avoid DO water quality objective violations in the DWSC. It should also be understood, as discussed by Lee and Jones-Lee (2003a) that at times, the near-bottom waters of the DWSC have DO values one to two mg/L below the surface water values, such as those reported by the DWR RRI monitoring station. Under the current regulatory requirements, the DO at any time (such as early morning) and location (such as near the bottom of the Channel) is the basis for determining whether there is a violation of the water quality objective that must be eliminated under the current TMDL effort. It is also clear from the August 2003 data that when the SJR DWSC flows are a few hundred cfs there is severe DO depletion below the water quality objective. This has been repeatedly found since 1995, when the USGS installed the UVM flow meter on the SJR just upstream of where it enters the DWSC.

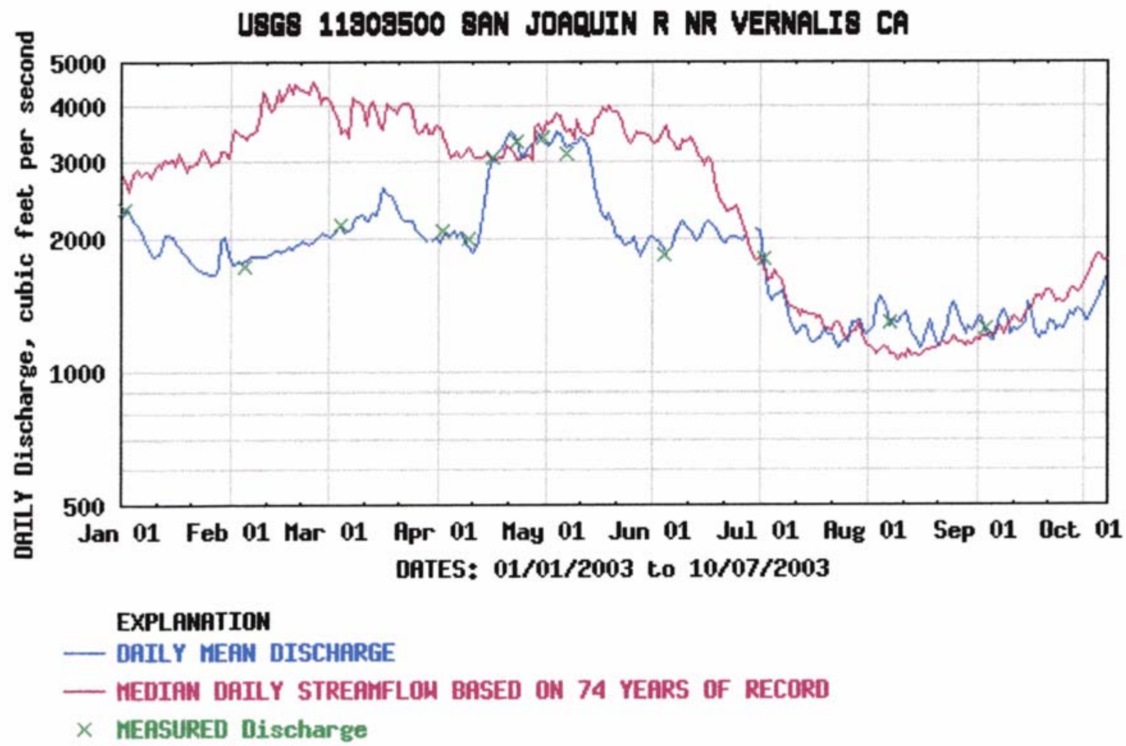
Figure 3



San Joaquin River at Garwood Bridge, Stockton
Tidally Averaged Discharge, Daily Flow Estimate (cfs)
Flow (cfs)
1400
1200
1000
800
600
400
200
0
8/1/03
8/8/03
8/15/03
8/22/03
8/29/03
9/5/03
9/12/03
9/19/03
9/26/03
Date
Datalogger malfunction; no data
(Data source: C. Ruhl, 2003)

As shown in Figure 4, during August and September the SJR at Vernalis flows were from about 1,300 to about 1,700 cfs. Therefore, at the time of closure of the Head of Old River barrier about September 20, the SJR Vernalis flow was about 1,400 cfs. The SJR flow through the DWSC was between 750 and almost 1,000 cfs at the same time. Therefore, even with the Head of Old River barrier "closed," there was still appreciable SJR Vernalis flow into the South Delta via Old River.

Figure 4



The August/September DO and flow data provide additional support for the conclusion that, under low SJR flows through the DWSC (i.e., when there is 1,000 or more cfs of SJR flow at Vernalis and most of this flow is diverted down Old River into the South Delta by the export pumps), the critical reach of the DWSC between Channel Point and Turner Cut experiences low DO. However, whenever the flows of the SJR through the DWSC are over about 1,200 cfs, the surface DO measured at the DWR RRI station is generally near or above the water quality objective. It is important to understand that the magnitude of the flow needed to significantly reduce the DO WQO violations depends on the magnitude and the characteristics of the upstream oxygen demand loads.

Recently the CVRWQCB (George Lockwood) has made available the updated data for the city of Stockton wastewater loads of BOD and ammonia to the SJR. While, as previously reported (Lee and Jones-Lee, 2003b), early in the summer, the City was having trouble controlling high ammonia concentrations, the July and August 2003 data show that it has been able to achieve a monthly average ammonia concentration in its wastewater effluent of about 3.5 mg/L N.

As discussed in the Synthesis Report (Lee and Jones-Lee, 2003a), when the city of Stockton wastewater concentrations of ammonia are 20 to 25 mg/L N and the SJR flows through the DWSC are a few hundred cfs, the dominant source of oxygen demand for the DWSC is the City's ammonia, which at times can represent on the order of 90 percent of the total oxygen demand load. However, under elevated SJR DWSC flows of 1,000 or more cfs and City ammonia concentrations on the order of 3 mg/L N, the city of Stockton's wastewater contribution of total oxygen demand load is 20 to 30 percent. Those conditions normally apply through the summer and early fall. Later in the fall, when algal growth in the SJR upstream of the DWSC is reduced due to reduced sunlight and colder temperatures, the upstream algal load of oxygen demand is considerably less. Usually at that time the city of Stockton ammonia load is increased.

The CVRWQCB has issued an updated NPDES wastewater discharge permit to the city of Stockton, which limits the ammonia concentrations in the effluent to a monthly average of 2 mg/L N. This is the current permit limit for ammonia discharges that the City must achieve. In order to achieve this concentration of ammonia in the City's wastewater effluent, the City will have to nitrify the effluent before discharge to the SJR just upstream of the DWSC. Achieving this concentration of ammonia in the effluent will greatly reduce the City's contribution of oxygen demand to the DWSC.

Overall, summer 2003 data provide additional evidence that whenever the SJR at Vernalis water is largely drawn down Old River to the export pumps and the SJR DWSC has only a few hundred cfs of net SJR flow through it, there is severe DO depletion in the DWSC. As discussed earlier, this relates to the fact that under those low flows the hydraulic residence time for any algae and ammonia – i.e., the primary oxygen demand constituents – that enter the DWSC is weeks, instead of a few days. Recently, as part of developing the South Delta Improvement Project that evolved from the NAPA meeting, several of those responsible for managing flow in the SJR that enters the DWSC have indicated that additional SJR DWSC flow will be provided to help solve the low-DO problem in the DWSC. The details of this situation have not been developed.

References

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