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Memorandum

To: *Mr. Richard Haller, SAWPA*

From: *Greg Wetterau*

Date: *August 9, 2010*

Subject: *Santa Ana Regional Interceptor March Water Quality Sampling*

Background

The Santa Ana Watershed Project Authority (SAWPA) owns and operates the Santa Ana Regional Interceptor (SARI) line within San Bernardino and Riverside Counties, accepting brine and other wastewater discharges within the Santa Ana Watershed. This interceptor was initially constructed to provide disposal of highly saline discharges from groundwater desalination facilities, power plants, and industrial users, in order to protect the inland water quality in the upper Santa Ana River Watershed. Due to the initially low flows of these higher salinity wastewaters, the SARI line has temporarily accommodated lower salinity domestic and industrial wastewaters to provide revenue and maintain system flows closer to design capacities.

The SARI pipeline conveys the wastewater to the Orange County Sanitation District (OCSD) system, where the water is treated and ultimately discharged through an ocean outfall. OCSD charges SAWPA for treatment and disposal, based on the flow, biochemical oxygen demand (BOD), and total suspended solids (TSS) of the wastewater measured at the Orange County Meter (S01). SAWPA then charges agencies discharging to the SARI line based on the same parameters, with predetermined rates established to cover the charges from OCSD, pipeline maintenance, and other related costs to SAWPA.

Large differences between measured levels of TSS entering the SARI line and those measured at the Orange County line (S01) have been observed over the last several years, with the TSS often measuring twice as high at the S01 meter, compared to the TSS entering the system. These differences created both a problem with solids deposition in the pipeline and a revenue imbalance, where the expenses for TSS fees from OCSD could not be offset by revenue received from the SARI dischargers. SAWPA initiated the SARI Water Quality Study to better identify the sources of this solids imbalance, and the SARI Sediment and Solids Control Study to identify means of controlling solids generation. The results and recommendations of these studies were reported in memoranda submitted to SAWPA on April 27, 2007 and March 23, 2009. The results indicated that both inorganic suspended solids and organic suspended solids were generated from dissolved solids (TDS) in the pipeline. The majority of the

inorganic solids production was the results of precipitation of calcium, which was found to have severely scaled the pipelines in various portions of the system. Organic solids formation was measured as volatile suspended solids (VSS) and was responsible for the majority of the solids that remained in suspension at S01. VSS formation is less understood than the inorganic precipitation, but is believe to be caused by a combination of biological growth (BOD reduction) and organic coagulation. This memorandum documents system-wide sampling events conducted to further characterize the VSS generation. The sampling will be followed by bench testing to identify potential methods for control of inorganic and organic solids generation in the SARI line.

Sampling Protocol

System wide sampling of the upper SARI line was conducted over two different sampling days, with the southern reaches (Reach IVB and Reach V) sampled between March 16 and 17, 2010 and the northern reaches (Reach IVA, IVD, and IVE) sampled between March 30 and 31, 2010. Twenty-four hour composite samples were taken at 15 minute increments starting at 11:00 am. The SARI line was divided into two separate portions, sampled on different days, due to the large number of dischargers and monitoring points and the limited number of composite samplers available. The locations of samples taken on each sampling day are identified in Table 1.

In addition to monitoring all dischargers with flow on the sampling days, composite samples were taken from nine locations within the SARI pipelines before and after each major flow convergence or desalter discharge. Complete sampling data from the March 17 and 31 testing are included as Attachment A of this memorandum. The measured parameters included:

- Flow
- pH (grab sample)
- Temperature (grab sample)
- DO (grab sample)
- Alkalinity
- Hardness
- Calcium
- Magnesium
- Sodium
- Chloride
- Silica
- Sulfate
- TKN
- Organic N
- Nitrate-N
- Ammonia-N
- Total Organic Carbon (TOC) (3/17 only)
- Dissolved Organic Carbon (DOC)
- Small Diameter DOC (<0.1 micron) (3/31 only)
- Biochemical Oxygen Demand (BOD)
- Chemical Oxygen Demand (COD)
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Volatile Suspended Solids (VSS)

On March 31, DOC was measured using both the standard 0.45 micron filter and a tighter 0.1 micron filter to differentiate between small diameter DOC (<0.1 micron) and large diameter

DOC (>0.1 micron). It is thought that large diameter DOC will be more susceptible to coagulation induced by blending with high salinity brines. Monitoring of both DOC size ranges allows for the observation of any changes in the DOC specific to the large or small diameter solids.

Table 1 – Water Quality Sampling Locations

Southern Reaches (March 17)		**Northern Reaches (March 31)**	
Location	**Reach**	**Location**	**Reach**
EMWD Master Meter (Perris, Mennifee, Wastehaulers)	V	Mountainview Power Plant	IVE
Inland Empire Energy Center (IEEC)	V	SBVMWD Truck Dump	IVE
SARI Monitoring Point 1 (**M1**)	V	Agua Mansa Power Plant	IVE
Arlington Desalter	IVB	SARI Monitoring Point 5 (**M5**)	IVE
SARI Monitoring Point 2 (**M2**)	IVB	Stringfellow	IVD
SARI Monitoring Point 3 (**M3**)	IVB	SARI Monitoring Point 6 (**M6**)	IVD
Temescal Desalter	IVB	JCSD Etiwanda (including Chino 2E)	IVD
Chino Rehabilitation Center (CRC)	IVB	JCSD Wineville (including Chino 2W)	IVD
Corona Energy Partners (CEP)	IVB	JCSD Hamner	IVD
Dairy Famers of America (DFA)	IVB	JCSD Celebration	IVD
Dart Containers	IVB	SARI Monitoring Point 7 (**M7**)	IVD
SARI Monitoring Point 4 (**M4**)	IVB	California Institute for Women (CIW)	IVD
SARI Monitoring Point 8 (**M8**)	IVA	Chino 1 Desalter	IVD
OCWD S01 (**M9**)	IV	IEUA S05	IVA
		Bonview	IVA
		SARI Monitoring Point 8 (**M8**)	IVA
		SARI Monitoring Point 4 (**M4**)	IVB
		Green River Golf Course	IV
		OCSD S01 (**M9**)	IV

Mass Balance Results

Mass balance analysis was carried out for monitored compounds (listed previously) within the upper SARI line to determine whether reductions within the pipeline could be observed, giving evidence of precipitation of sparingly soluble salts, biological uptake of organic or inorganic nutrients, or coagulation of organic material. For this study, the projected pounds per day loading of quantitative parameters from each measured discharger was calculated based on the flow and measured concentration on March 17th and 31st for the south and north sections of the SARI line, respectively. These projected loads were then compared with calculated loads for the same parameters, based on the measured concentrations within the SARI line and the sum of all influent flows upstream of each sampling point.

To clarify the terminology for this discussion, the following definitions will be used:

- "Projected loads" refers to pounds per day of a parameter (ions, solids, compounds) projected to be present at a SARI line sampling point based on the upstream influent loads.
- "Measured loads" refers to the pounds per day of the above parameter calculated based on the measured concentration at the sampling point and the sum of the upstream influent flows.

South Section Results Evaluation

A map showing the sampling locations and summary of results of the South Section measured on March 17, 2010 is presented in **Figure 1.** The following paragraphs discuss the water quality observations for each monitoring point:

M1: This monitoring point includes flows from the Perris and Mennifee desalters as well as brine discharged from International Rectifier at a truck unloading station, all of which are measured by the EMWD Master Meter. The sample point also includes flow from the Inland Empire Energy Center. The sampling results showed 6 percent (or 1,003 lb/day) loss of calcium and 50 percent (or 64 lb/day) loss of TOC, indicating settling from both inorganic precipitation and organic coagulation. The TSS and VSS also decreased by 18 percent and 38 percent, respectively. The water quality results do not indicate biological activity, as BOD was not lost in this portion of the pipeline.

A significant discrepancy was seen in the TDS, where the measured value was 130 percent higher than the projected value. Because all the major cations and anions were measured for these samples, the TDS can also be estimated based on the sum of individual ions. Estimating the TDS at M1 as the sum of the measured ions suggests that the actual TDS at M1 may be closer to 7,600 mg/L, rather than the 15,000 mg/L measured. This calculated TDS is within 1 percent of the projected TDS from the sum of ions entering upstream of M1, suggesting that the measured TDS concentration may not be accurate at this monitoring point.

M2: This monitoring point includes only flows from the Arlington desalter measured before the convergence with Reach V. Heavy build-up of scale on this reach was reported in early 2010, suggesting that solids are being lost between the desalter and the convergence with Reach V, however, because the Arlington desalter water quality was monitored at the convergences, the projected and measured values are identical for this monitoring point.

M3: This monitoring point includes all of the flows measured at M1 and M2 with no additional dischargers on the sampling date. A small flow contribution from UBF Foods contributes approximately 60,000 gallons during a typical month, however, no flow was measured from this discharge point on the sampling day. Results at the M3 monitoring point

showed that 6 percent of the calcium (994 mg/L) and 44 percent of the TOC (65 mg/L) were lost upstream of this monitoring point. Since these losses are similar to the losses seen upstream of M1, the calcium and TOC numbers do not suggest that additional settling occurred between M1 and M3 on the sampling day. However, a significant loss in TSS and VSS was seen, representing 70 percent of the TSS and 60 percent of the VSS, presenting conflicting results on whether or not settling occurred within these segments of the SARI line. As with M1, there was no evidence of biological growth in this segment, with the quantity of BOD essentially unchanged from the upstream monitoring point.

M4: This monitoring point includes all the flows measured at M3 with the addition of the Temescal desalter, California Rehabilitation Center (CRC), and smaller flows from Dart Container, Dairy Farmers of America (DFA), and Corona Energy Partners (CEP). This monitoring point shows considerable loss of DOC and formation of VSS within the SARI line. While only 30 percent of the TSS entering the system upstream of M4 is VSS, more than 70 percent is VSS measured at M4, indicating both the loss of inorganic TSS (potentially from settling and scaling) and the formation of organic suspended solids from DOC. As with the upstream monitoring points, there is no evidence of biological growth or a loss in BOD.

Total hardness loss upstream of M4 was about 9 percent (10,000 lb/day), with calcium loss 6 percent (1,832 lbs). It should be noted that the sample results also showed a 5 percent increase in sodium, a 9 percent increase in chloride, and a 5 percent increase in TDS. Because sodium and chloride are generally inert, not reacting with inorganic precipitates, biological organisms, or organic floc, their quantities should remain relatively consistent with projected concentrations, regardless of the interactions of solids within the pipeline. The 5 to 9 percent variability in these two parameters suggests that the level of accuracy in the water quality results for this sampling day may be within 5 to 9 percent. As such, evidence for the loss of calcium and total hardness may not be conclusively significant, however, the 36 percent loss of DOC and 154 percent increase in VSS suggests that conversion of dissolved organic particles to suspended solids was significant in the southern SARI reaches on March 17.

North Reach Results Evaluation

A map showing the sampling locations and summary of results of the North Section measured on March 31, 2010 is presented in **Figure 2.** The following paragraphs discuss the water quality observations for each monitoring point:

M5: This monitoring point included flow from the Mountainview power plant, the Agua Mansa (El Colton) power plant, and the San Bernardino Municipal Water District (SBMWD) truck dump. The EnerTech discharge, which normally contributes flow upstream of M5, was not operational during the month of March. Results from this sampling point indicate a 41 percent reduction in calcium (338 lb) and 35 percent reduction in magnesium (48 lb), however, similar losses were seen for sodium (33 percent) and chloride (43 percent),

suggesting that the discrepancy may be due to variations in the flow not adequately accounted for by the composite samplers. Approximately 64 percent of the chloride and 60 percent of the calcium entering the SARI line upstream of M5 came from the SBMWD truck dump on the sampling day. Because truck dump flows are highly intermittent and highly concentrated, the downstream composite sampler may be unable to obtain truly representative samples this close to the discharge point. With a travel time greater than 24 hours between the SBMWD truck dump and OCSD S01, these variations in flow and water quality would be expected to balance out over time.

While the losses in calcium and magnesium may not be measureably significant, the 100 percent loss of BOD, 95 percent loss of TKN, and 84 percent loss of dissolved oxygen are a strong indication of biological growth. A 1,300 percent increase in VSS was also measured (131 lbs), along with a 1,600 percent increase in TSS (365 lbs), further supporting the impact of biological growth upstream of M5.

M6: This monitoring point included flow only from M5 and from the Stringfellow discharge. Small quantities (less than 4 percent) of calcium and magnesium loss were observed, but similar to the M5 monitoring point, these variations were smaller than the variations in sodium and chloride concentrations, suggesting that the losses may not be statistically significant. DOC loading to this part of the SARI line is relatively low, however, approximately 33 percent of the DOC appeared to be lost, with equal proportions lost for small diameter DOC (less than 0.1 micron) and large diameter DOC (greater than 0.1 micron). Similar to the M5 monitoring point, all of the BOD entering the SARI line upstream of M6 (131 lbs) was lost with 92 percent of the TKN (9.6 lbs) lost, along with 71 percent of the dissolved oxygen. An increase in VSS was observed at M6, representing a 307 percent (30 lbs) increase above the VSS entering the SARI line, with the TSS increase measured 277 percent (64 lbs) above the TSS entering the SARI line. While the TSS and VSS measured at M6 were higher than the quantities entering the SARI line upstream, these measured quantities were only a quarter of the measured quantities at M5, , suggesting that significant settling may have occurred between the two monitoring points. It should also be noted that approximately half of the TSS increase is associated with non-organic TSS, suggesting that inorganic precipitation may still be occurring, even if the loss of calcium was insignificant on the sampling day.

M7: This monitoring point included flow from M6, JCSD Etiwanda (including Chino 2 East), JCSD Wineville (including Chino 2 West), JCSD Hamner, and JCSD Celebration. While all of these JCSD discharges include domestic wastewater, approximately 40 percent of the flow comes from Chino 2 desalination concentrate or ion exchange waste. The remaining 60 percent is a mix of domestic and industrial wastewater. JCSD Etiwanda discharged 7,000 lbs of TSS and 6,000 lbs of VSS into the SARI line upstream of M7 during the sampling day, which is roughly four times higher than the typical suspended solids discharge from this location. A large quantity of these suspended solids (2,656 lbs of TSS and 2,972 lbs of VSS)

had been lost by the time the flow reached the M7 monitoring point. In addition, over 90 percent of the DOC loading (corresponding to 4,000 lbs) was also lost to the system, with the smaller size DOC loss slightly higher than the larger DOC (93 percent vs. 91 percent). BOD loss remained significant, with 83 percent (16,700 lbs) of the BOD, 45 percent of the TKN, and 40 percent of the dissolved oxygen lost upstream of M7. These results are a strong indication of both biological growth and settling of solids within this stretch of the SARI line.

M8: This monitoring point included flow from M7, the California Institute for Women (CIW), Chino 1 Desalter, IEUA S05, IEUA truck dump station, and Bonview. Apart from the Chino 1 Desalter, the remaining flows are a mix of industrial and domestic wastewater. Results from this sampling point indicated that the loss of TSS and VSS continued, with the total pounds of suspended solids decreasing by 40 percent from M7 to M8 in spite of the 4,000 pounds of TSS and 3,000 pounds of VSS added to the system between these monitoring points. DOC loss remained close to 90 percent with little difference for the small and large diameter DOC. Loss of BOD and TKN continued, indicating that biological growth was still a significant factor in this portion of the SARI.

M9: This monitoring point included flow from M8, Green River Golf Course, and from Reach IVB, measured on the sampling day at monitoring point M4. M9 is identical to the OCSD S01 monitoring point, where flow, TSS, and BOD fees are determined for SAWPA. Results from this monitoring point confirm that both TSS and VSS were lost in the system on the monitoring day, representing 7,384 lbs (44%) of TSS and 6,870 lbs (54%) of VSS. Sodium, chloride, and TDS measurements at M9 were within 5 percent of their projected values, indicating that the variability seen at upstream monitoring points (M5 and M6) was no longer observable as the flows balanced in the extended pipeline. Loss of DOC was extensive, with 77 percent of the small diameter DOC lost (3,308 lbs) and 80 percent of the larger diameter DOC lost (1,178 lbs). While a small loss in calcium (2 percent) was observed, this was less than the variability in the sodium and chloride measurements, and may not be significant. It should be noted, however, that this 2 percent, whether significant or not, represented 1,600 pounds of calcium, which is greater than the inorganic component of the TSS lost on the sampling day.

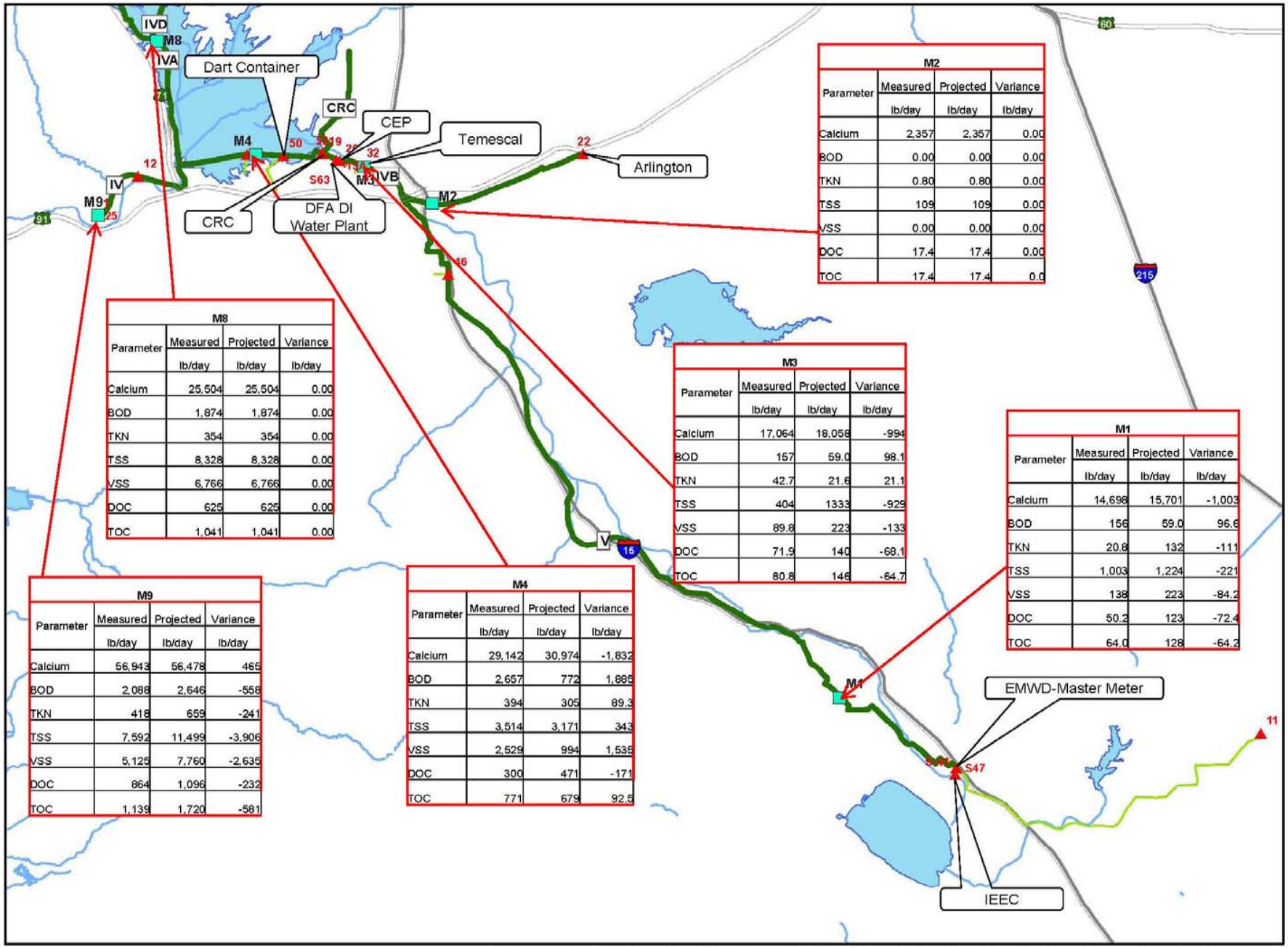

Figure 1 – Water Quality Results for March 17 Testing in Southern SARI Reaches

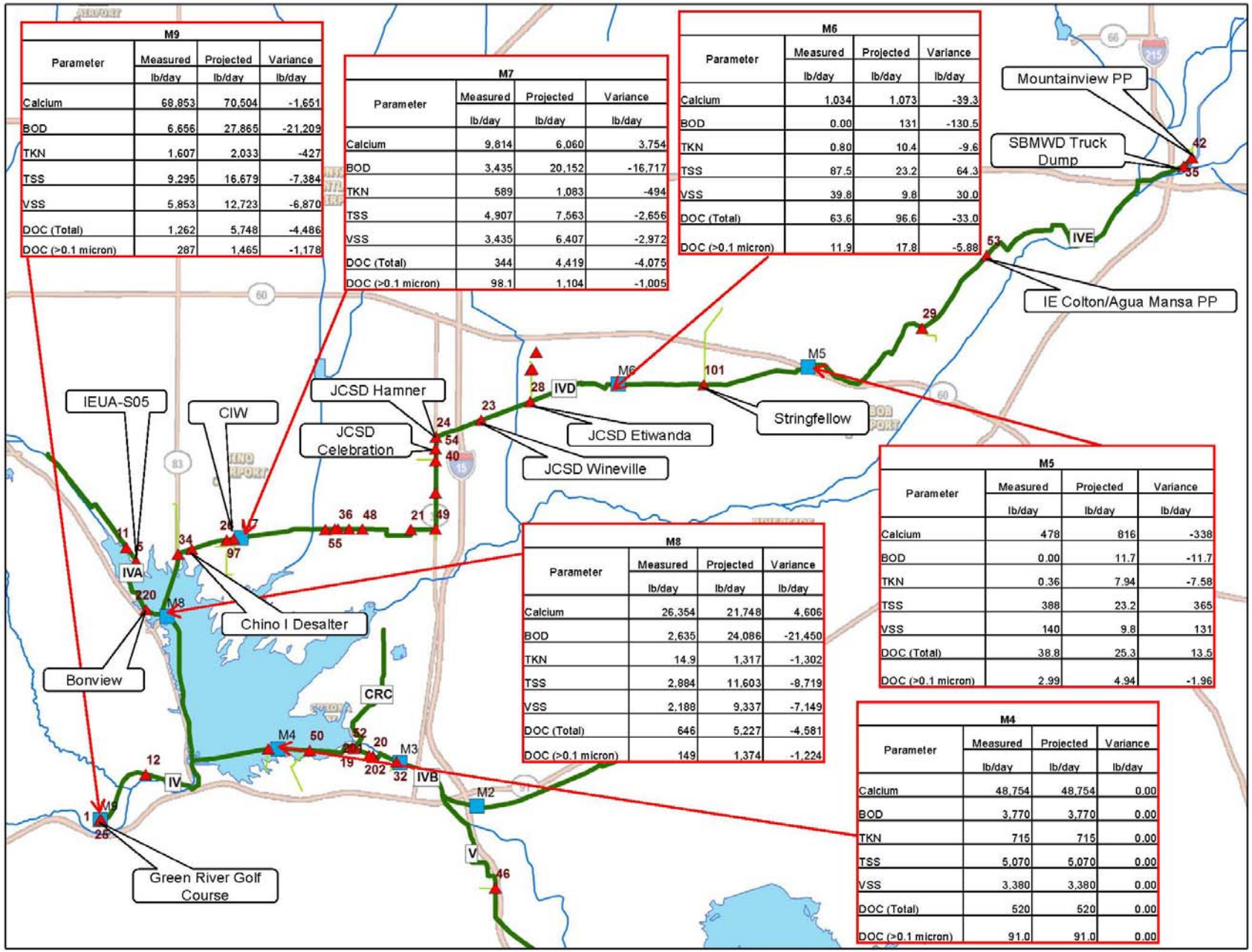

Figure 2 – Water Quality Results for March 31 Testing in Northern SARI Reaches

Conclusions

Synchronized sampling events were conducted on the southern reaches of the upper SARI line on March 17, 2010 and the northern reaches on March 31. Results from the southern reaches suggest that loss of calcium due to precipitation and scaling continued, however, more significant was a 36 percent reduction in the dissolved organic carbon (DOC) within the system and a related 154 percent increase in organic suspended solids (VSS). No evidence of biological growth was observed in the southern reaches, suggesting that the conversion of DOC to VSS was driven by coagulation of organic material. No differentiation was made between the larger DOC (greater than 0.1 micron) and the smaller DOC (less than 0.1 micron) for the southern reaches.

Results from the northern reach suggest that biological growth played a major role in the conversion of DOC to VSS, however, more than half of this VSS was lost within the pipeline on the sampling day due to settling. An unusually high discharge of TSS from JCSD Etiwanda had lost half of the VSS by the time flow reached the first downstream monitoring point (M7). The loss of TSS and VSS then continued downstream of this monitoring point with additional domestic and industrial discharger flows entering the SARI line and 80 percent of the TSS and VSS unaccounted for at a monitoring point downstream of the Reach IVA and IVD convergence (M8). 90 percent of the DOC was also lost within the system, primarily within the portion of the SARI between Reach IVA and JCSD Etiwanda, where the majority of the domestic wastewater flows are discharges. In all, over 7,000 pounds of TSS and 4,000 pounds of DOC were lost within the northern reaches of the SARI line on March 31. These solids will either remain in the system until cleaned, or will work their way downstream to the S01 monitoring point, contributing to the TSS imbalance on another day.

Biological growth appears to have been a significant contributor to the loss of DOC in the northern reaches, however, significant DOC loss was seen in the southern reaches without any indication of biological growth.