12.0 DISCUSSION

The main stem river and sub-basin tiers of the SJR SWAMP effort have two main objectives: evaluate overall water quality, both temporally and spatially, and assess whether there is any indication that beneficial uses are not being protected. A third adaptive objective is to utilize the information gathered at the long-term sites for the sub-basins to help design future monitoring efforts within that sub-basin. This section discusses the results in the context of those objectives.

This five-year study covered: three dry water years, one below normal water year, and one wet year. The final year of this study was one of the wettest years on record. The overall water year effects as well as seasonal effects between storm, snowmelt, irrigation and dry seasons are depicted in a series of paired line graphs for each constituent specifically evaluated: one graph for the SJR sites and one for the Northeast Basin sites (representing temporal trends within sub-basins). If trends within one of the other sub-basins differed greatly from the Northeast Basin, a separate figure was included within the discussion.

Similarly, spatial trends were depicted using paired box and whisker figures: one figure showing summary information for SJR sites moving downstream; and the second figure showing summary information for each sub-basin, also moving downstream, as well as summary information for the San Luis Drain and New Jerusalem Drain which represent shallow groundwater within the Grassland and Delta sub-basins, respectively. Drainage basin sites were selected as being representative of the major flows to the SJR from each basin. While graphical summary information for each sub-basin was not included within this section of the report, the figures are available in Appendix R.

Wherever possible, water quality objectives, guidelines and/or targets have been noted on the figures to help put the results in context. Evaluation of the constituents and their potential impacts on the beneficial uses is evaluated in section 12.2. The data collected was utilized in combination with other available data sets during the development of the draft 2009 Clean Water Act Section 305(b) and 303(d) Integrated Report for the Central Valley Region that identifies specific beneficial use impairments for water body segments throughout the Central Valley. A summary of potential concerns for each sub-basin that may aid future monitoring design is included in the summary/conclusion of this report.

All the sites are located relatively close together in the lower reaches of the individual sub-basin prior to discharge into the SJR, therefore have similar localized land use influences, the most notable being dominance by agricultural return flows during the irrigation season. Source water does vary widely, from Sierra snow melt to imports from the Sacramento-San Joaquin Delta and may also include storm water, wetland drainage, operational spill, and ground water discharge.

12.1 Temporal and Spatial Trends

12.1.1 TEMPERATURE

Temperature was measured in degrees Celsius and ranged from 1.9 – 32.8 throughout the Basin during the 5-year study. A very consistent seasonal oscillation was seen at all the sites and tracked those within the Northeast Basin. The lowest temperatures were seen in January around 5ºC with a gradual climb to its peak in July around 25ºC (Figures 8 and 9).

The majority of the South Delta Basin sites showed the same seasonal oscillation as the Northeast Basin except New Jerusalem Drain. The New Jerusalem Tile Drain had relatively higher temperatures and shorter amplitude oscillations then the rest of the South Delta Basin sites.

Through dry and wet years the temperature showed no significant differences.

No significant spatial differences were observed either moving upstream to downstream along the main stem of the SJR, nor between sub-basins. Figures 10 and 11 show the relatively consistent ranges in temperature within the basins and SJR, respectively.

Figure 8: San Joaquin River Northeast Basin Temperature WY01-WY05

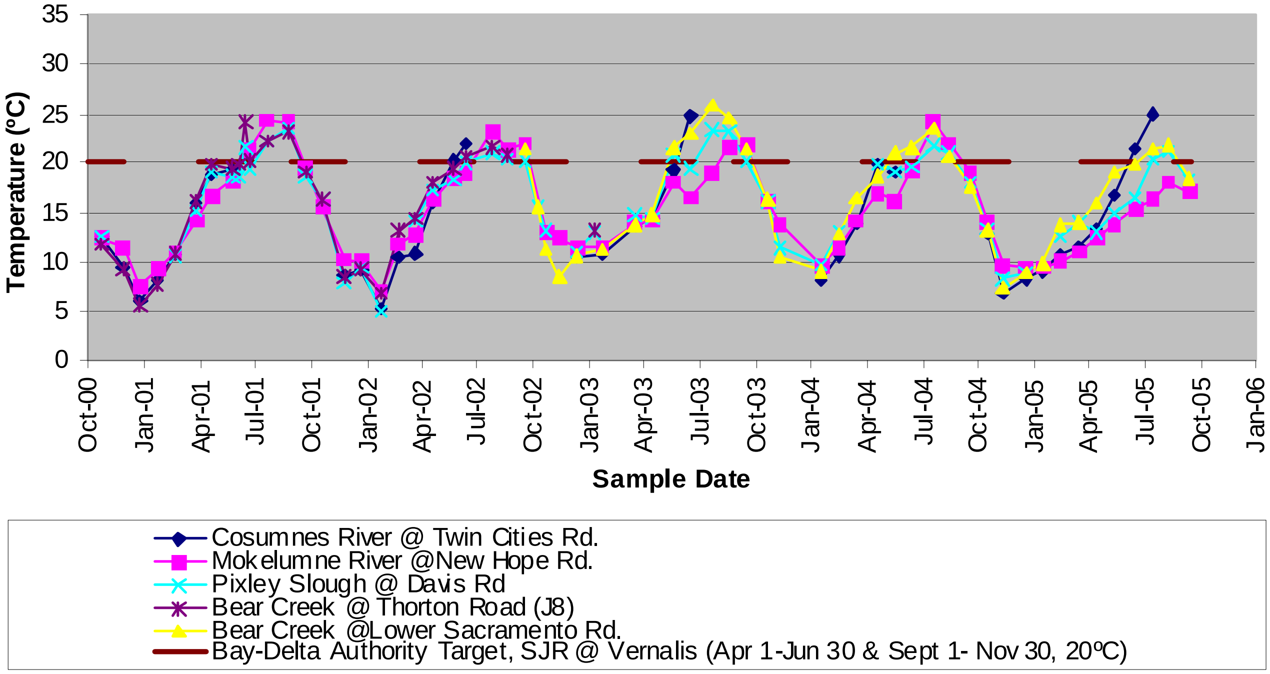


Figure 9: San Joaquin River Main Stem Temperature WY01-WY05

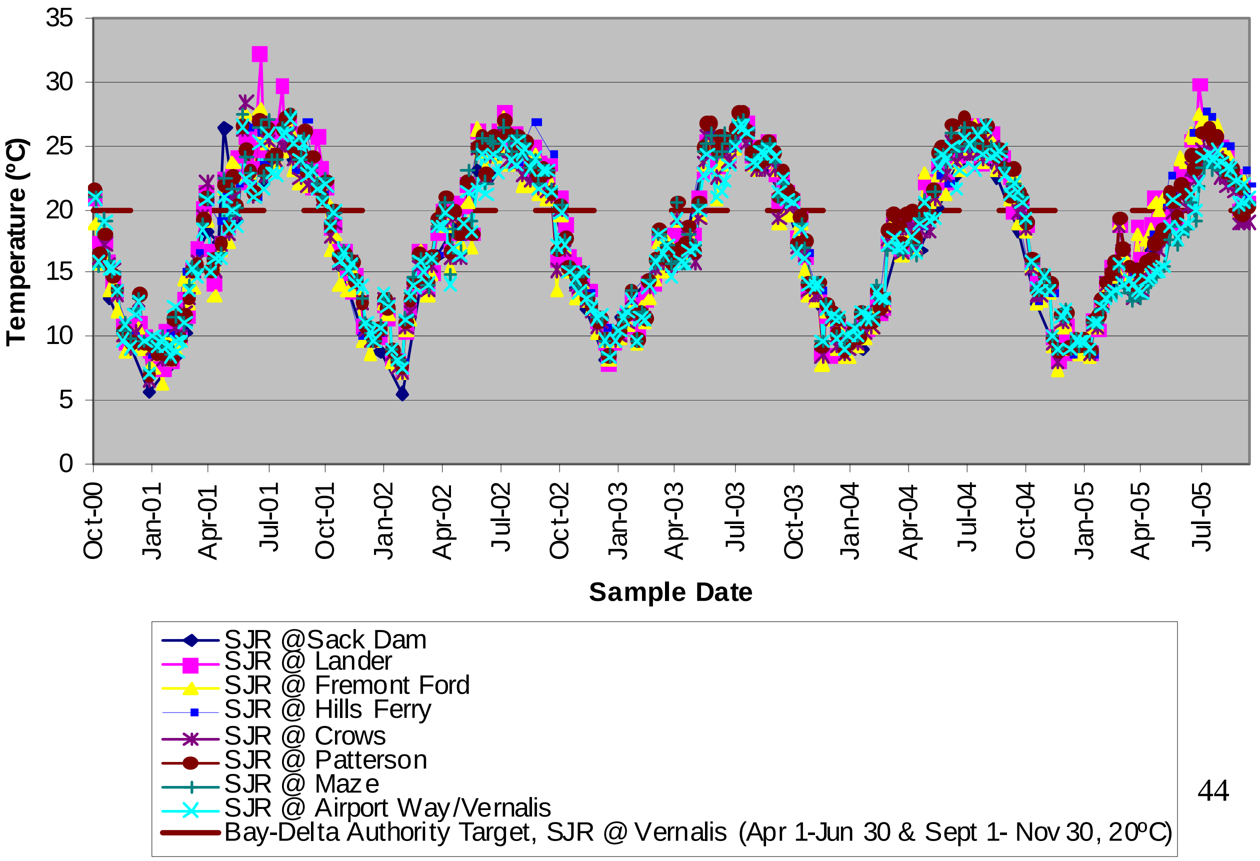


Figure 10: Basin Temperatures WY01-WY05

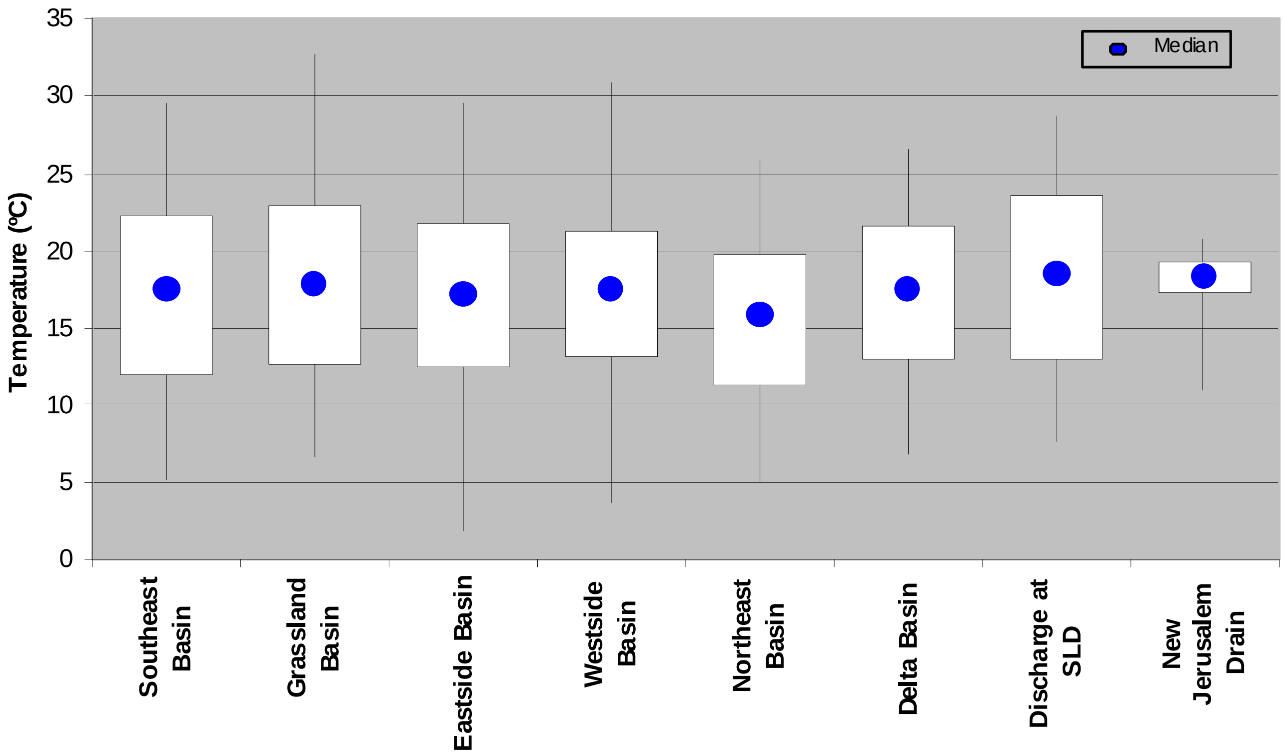
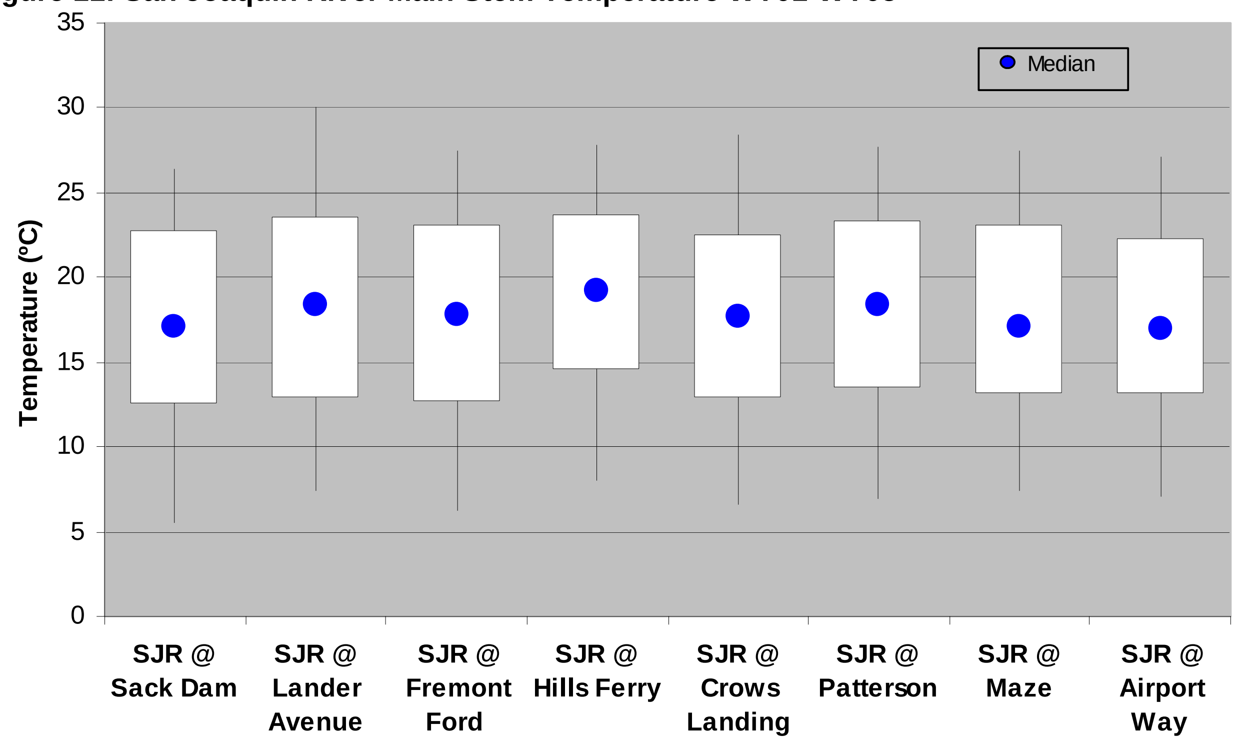


Figure 11: San Joaquin River Main Stem Temperature WY01-WY05



12.1.2 SPECIFIC CONDUCTANCE

Specific conductance (SC) values ranged from 8.0 - 5,960 µmhos/cm across the SJR Basin. Seasonal patterns in SC were not as clearly defined as for temperature. In general, SC tended to decrease during the dry season (September through November), sometimes showing a peak during the first storm runoff and then decreasing until the irrigation season began in May/June with the highest concentrations recorded during the irrigation season. Exceptions to this rule include water bodies that receive wetland releases in early spring (Grasslands sub-Basin and SJR), where additional spikes are evident (Steenson, *et al.*, 1998). This pattern is depicted in Figures 12 and 13, the NE Basin and SJR sites, respectively. In addition, overall SC values appeared to decrease during wet WY 2005, although the seasonal trend patterns remained similar. Temporal anomalies within each sub-basin are discussed below.

Northeast Basin: The Northeast basin was managed from April through October by diverting water into different channels to supply agricultural use. Each growing season, Bear Creek, which naturally would be dry for the summer months like the Cosumnes River, was dominated by agricultural supply that was diverted from the Mokelumne River. This change in water type was observed each year when the Bear Creek SC dropped to about 50 µmhos/cm, the approximate year round SC of the Mokelumne River. Pixley Slough is also dominated by agricultural supply during the growing season and seemed to follow the same trend, but it wasn't as dramatic as Bear Creek. The one notable difference between the different water year types was that Bear Creek was about 100 µmhos/cm higher during winter months of a wet year than during the dry years.

Eastside Basin: French Camp Slough and Lone Tree Creek followed the Northeast Basin's Bear Creek trend with having lower concentrations of SC in the growing season and higher concentrations during the winter. The Harding Drain also followed this same trend of higher levels during the winter months and lower levels during the agricultural season but the levels of SC are much higher than any of the other agricultural influenced sites in this basin (e.g. Turner Slough). The Eastside river sites were fairly consistent throughout the 5 years with Stanislaus River demonstrating little seasonal variability. The Tuolumne River is a little more sporadic, but always seemed to drop in April. The Merced River had the opposite trend when compared to Bear Creek in the Northeast Basin. Specific conductance levels on the Merced River went up during the growing season and down in the winter months.

Southeast Basin: Bear Creek in the Southeast Basin, like the Eastside rivers, didn't fluctuate drastically and showed sporadic levels similar to the Tuolumne River although no seasonal trends seemed to be evident in Bear Creek. Dramatic changes were identified in Deep Slough, similar to the Harding Drain, but seemed to drop drastically in the 2005 wet year when compared to the previous consecutive dry years.

South Delta Basin: The South Delta Basin's SC levels were mostly above 500 µmhos/cm unlike the Northeast basin where all the samples were below 500 µmhos/cm. The New Jerusalem Drain (discharging shallow groundwater from the basin) reported consistently high SC levels all year long fluctuating around 2500 µmhos/cm with no noticeable consistent trend.

Mountain House Creek, an ephemeral stream which historically received agricultural tail water, was dry for about half of the sampling period through 2003. In 2004, the site was removed from the sampling program due to the rapid community development with about 43,500 residents settling on the land adjacent to and surrounding the creek (Weston, 2009). The change in localized land use included rerouting storm water runoff into a collection system and resulted in continuous dry conditions for the original creek bed. During sampling conducted prior to the development (from December 2000 through February 2001), Mountain House Creek had seasonally stable SC values (typically below 1000 umhos/cm), similar to New Jerusalem Drain.

Old River is dominated by estuary flow characteristics. Old River followed the same SC characteristics of the Tuolumne River on the Eastside Basin fluctuating throughout the year with lower SC levels measured during the 2005 wet year, but overall Old River fluctuated at a higher SC level.

Tom Payne Slough fluctuated like the Harding Drain with drastic fluctuations between summer and winter months. Like the Harding Drain, Tom Payne Slough has influences other than agricultural which include NPDES discharges and tidal influences. However, similar to the rest of the Delta Basin sites, Tom Payne Slough generally reported higher SC concentrations than the Harding Drain.

Westside Basin: Like the Delta Basin, the Westside Basin had higher SC levels than the Northeast Basin. Westside sites Del Puerto Creek, Grayson Drain, Ingram Creek, Hospital Creek and Orestimba Creek are ephemeral streams dominated by irrigation return flows. Ingram Creek had the largest SC fluctuations during the irrigation season and was the only creek to have very high distinct SC values during the winter months. Orestimba Creek receives operational spill from the CCID (Central California Irrigation District) Main Canal which could result in dilution and may have contributed to the narrower range of fluctuation in SC levels when compared to the other Westside sites.

Grassland Basin: The Grassland Sites had higher values of SC than most of the other basin sites. The San Luis Drain represents shallow groundwater discharge from approximately 97,000-acres (Bureau of Reclamation, 1995) of irrigated agriculture and affects SC values observed in Mud Slough (Figure 14). All the Grassland sites had an oscillating trend that peaked in March or April, which corresponds to both wetland releases and pre-irrigation runoff (Figure 14). The Grassland Basin is highly managed and does not demonstrate a significant difference between water year types aside from slightly lower SC values during the 2005 wet year.

Spatially, the Northeast, Eastside and Southeast Basins had considerably lower levels of SC as compared to the South Delta, Westside, and Grassland Basins (Figure 15). The eastern basins draining the Sierra watershed begin with less saline water than those dependent on imports from the Delta. Although each basin had unique seasonal and temporal trends, during the 2005 wet water year there was a slight decrease in the SC values at most sites.

Inflows from the various sub-basins appear to have a dramatic overall effect on the SJR as the inflows progressively reach the river (Figures 15 and 16). As we travel downstream, Southeast Basin flows tend to be trapped at Sack Dam and diverted. The SJR at Lander Avenue is dominated by ground water accretion for much of the year and provides a background elevated SC in the river. High SC levels in Salt Slough and Mud Slough, resulting from wetland as well as surface and subsurface agricultural drainage, increase the already elevated river levels. Starting immediately downstream of the Hills Ferry site, the Eastside tributaries (Merced, Tuolumne and Stanislaus Rivers) begin to influence SC levels along the SJR and gradually lower them resulting in levels observed at Vernalis that are just slightly higher than at Sack Dam.

Figure 12: San Joaquin River Northeast Basin Specific Conductivity WY01-WY05

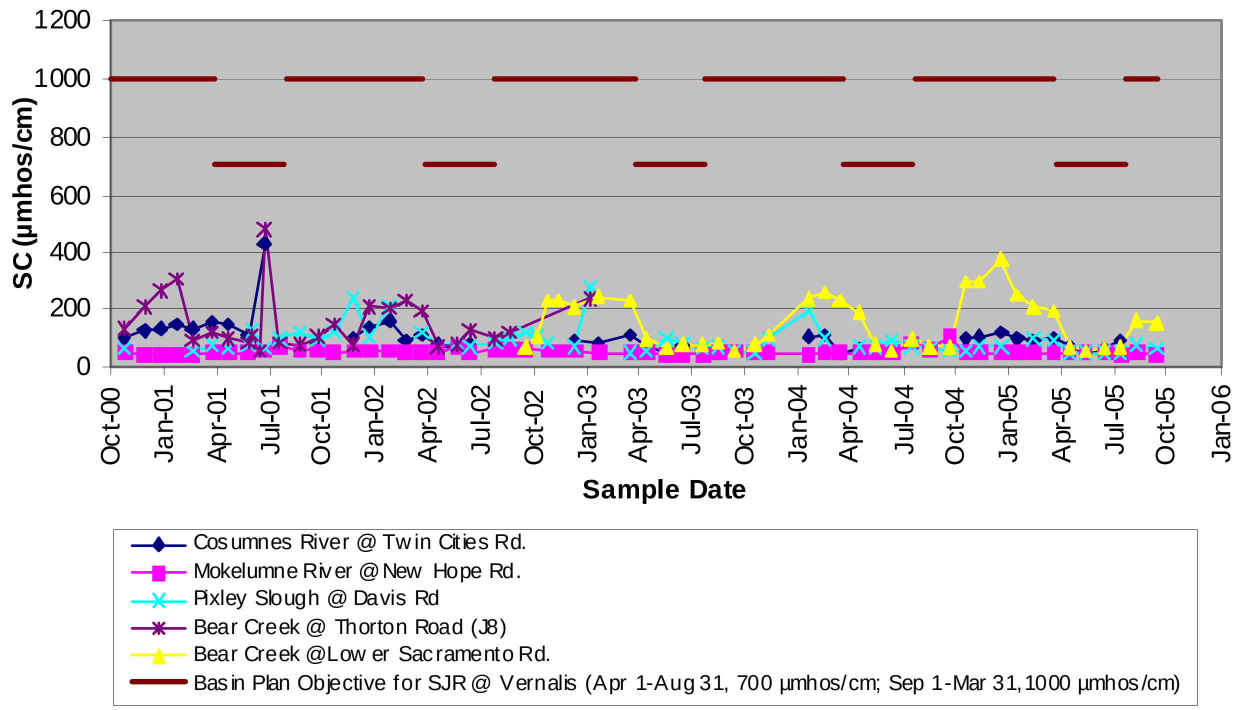


Figure 13: San Joaquin River Main Stem Specific Conductivity WY01-WY05

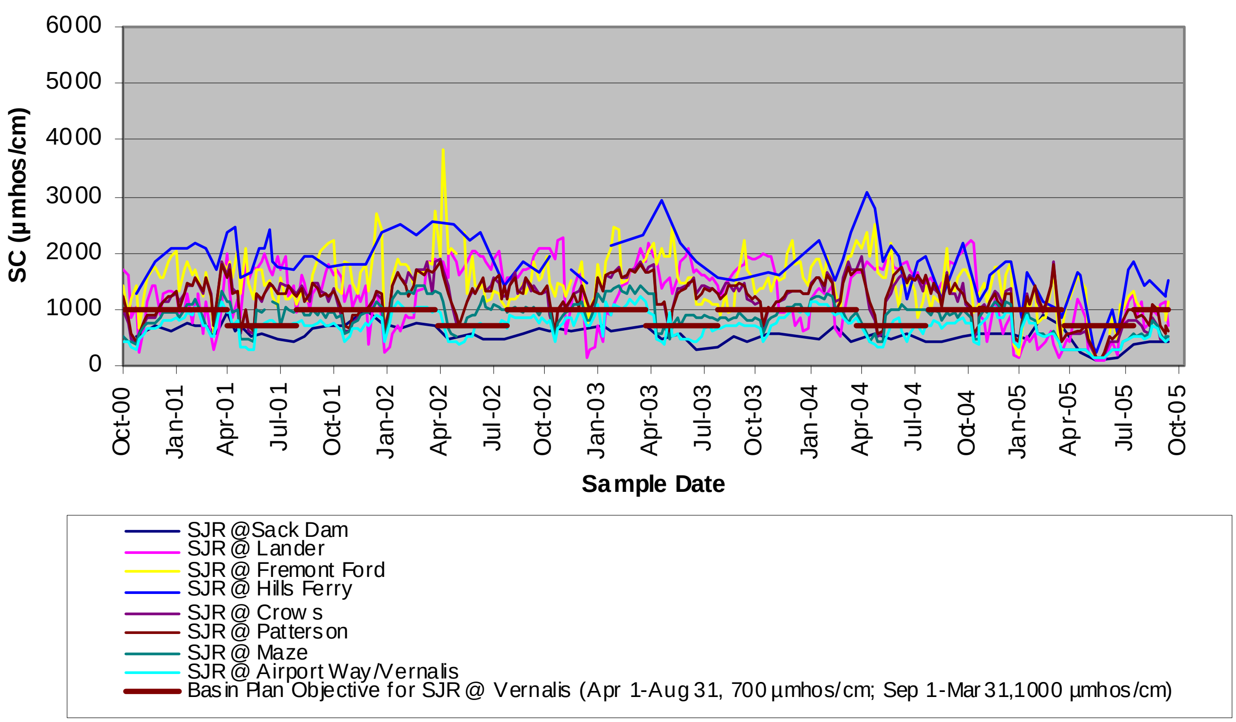


Figure 14: San Joaquin River Grassland Basin Specific Conductivity WY01-WY05

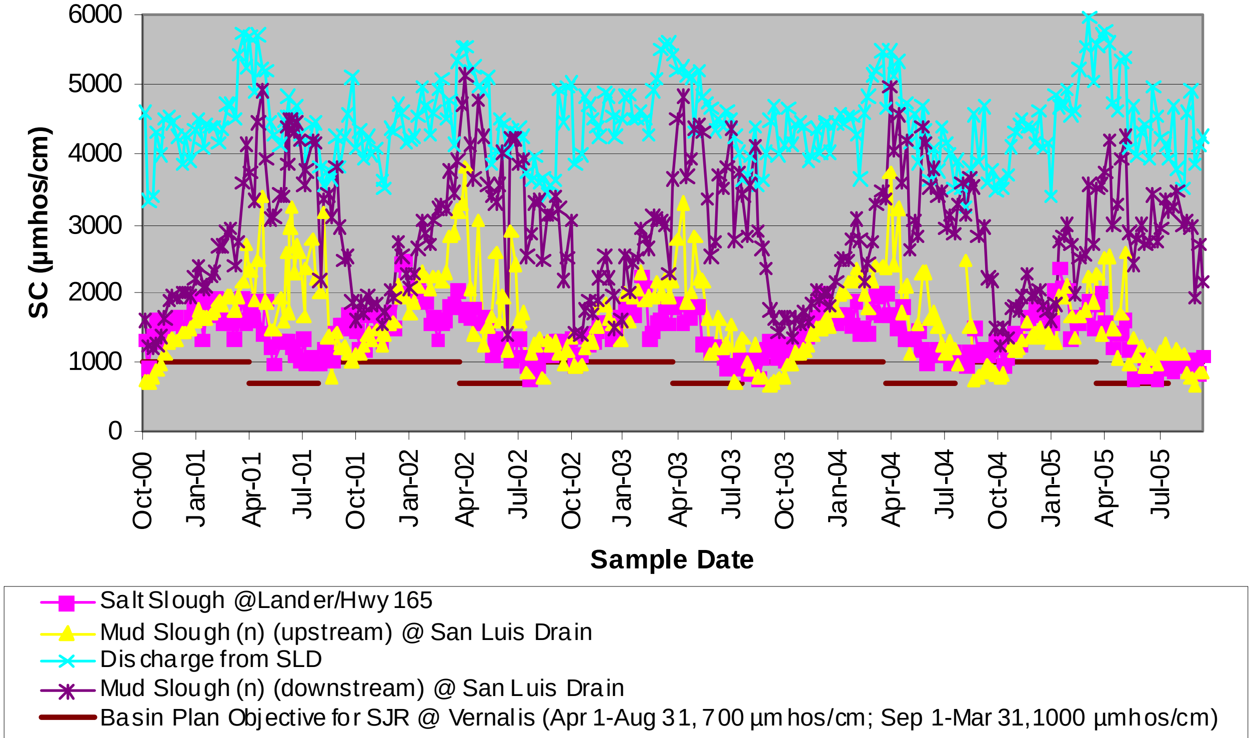


Figure 15: Basin Specific Conductivity WY01-WY05

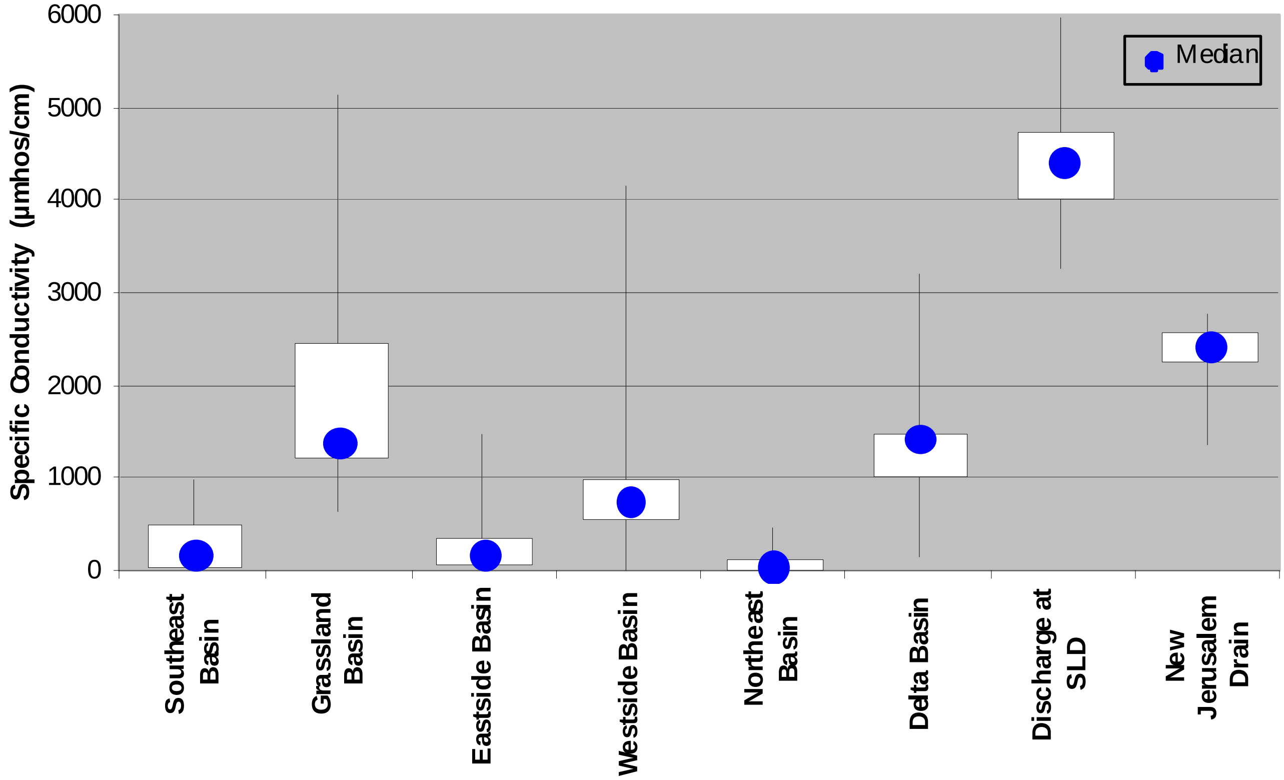
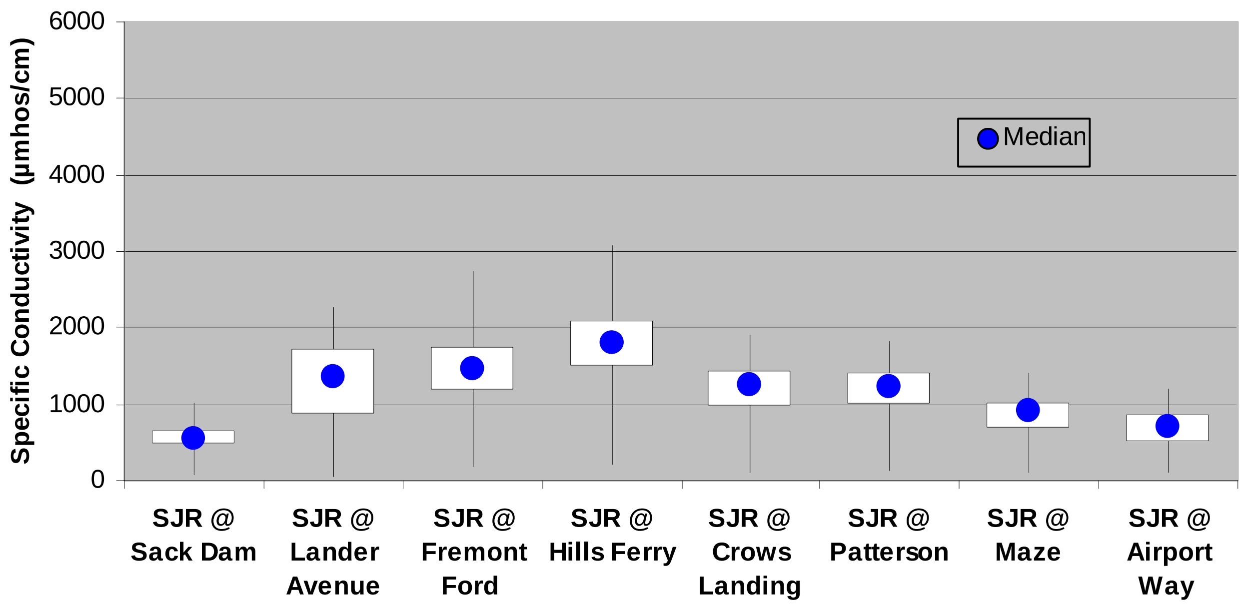


Figure 16: San Joaquin River Main Stem Specific Conductivity WY01-WY05



12.1.3 MEASURED pH

The pH values ranged from 5.4 – 10.1 across the basin. Mean values in the SJR ranged from 7.6 to 7.9 units. Few levels dropped below 6.5 pH units, though several appeared to seasonally exceed 7.5 units—during the irrigation season in the SJR and during the storm season in the Northeast Basin. Seasonal variability appeared reduced during wet WY 2005. Occasional spikes, both high and low, were seen throughout the sampling season (Figures 17 and 18).

Most of the basins appeared to follow the general trend of the Northeast Basin, with the majority of pH values falling between 7 and 8 units. The Cosumnes River had a wider range of variability compared to the Mokelumne River and the other sites. The variability seen in the Cosumnes River seemed to be most pronounced following its natural annual dry period. The Westside Basin showed similar occasional fluctuations as the Northeast Basin but reported slightly higher concentrations ranging most frequently from 7.7 to 8.4 pH units.

The Grassland Basin and the SJR sites were sampled more frequently (weekly) and demonstrated clear seasonal fluctuations with the exception of Salt Slough. The pH values found in the river and Grasslands would peak in July and drop around January, following the same trend seen in temperature results. During the 2005 wet water year, there was no peak in July which can probably be attributed to the greater flows seen during this time when compared to the previous dry years.

Spatially, the Northeast, Eastside and Southeast basins reported slightly lower pH than the Westside and Grassland Basin's (Figure 19). Those differences did not appear to impact the SJR, as there does not appear to be any distinct difference in pH moving downstream (Figure 20). All of the river sites are approximately the same range and like the basin sites show occasional fluctuations, with the smallest minimums and greatest maximums recorded at the furthest upstream (SJR at Sack Dam) and downstream (SJR at Airport) sites.

Figure 17: San Joaquin River Northeast Basin pH WY01-WY05

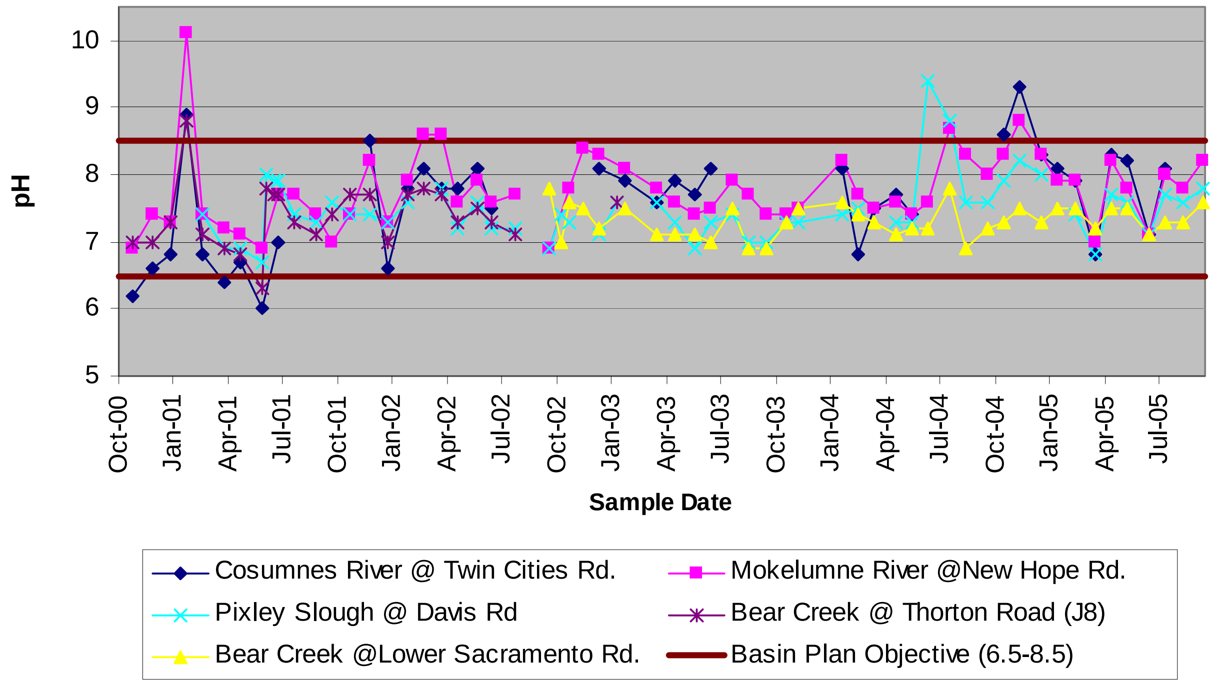


Figure 18: San Joaquin River Main Stem Specific Conductivity WY01-WY05

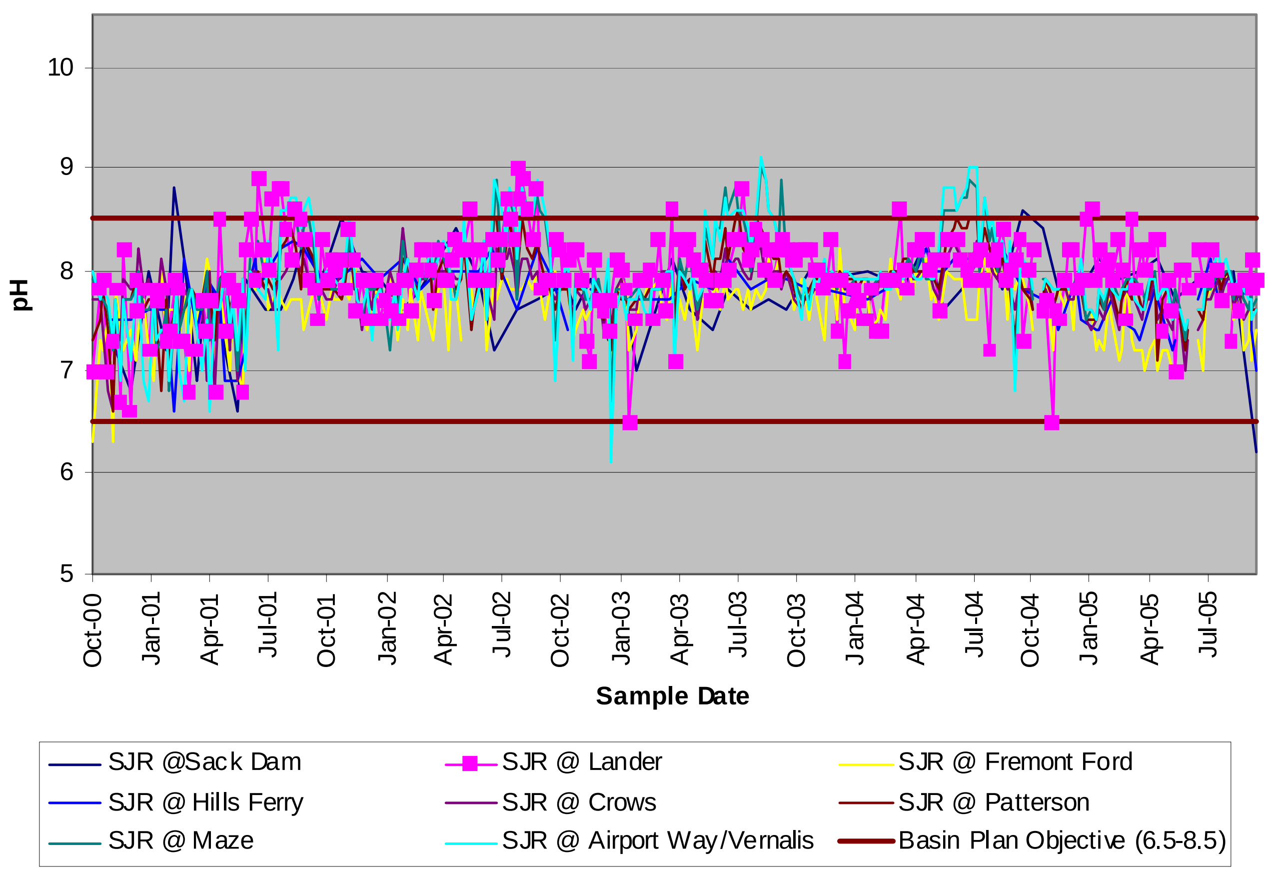


Figure 19: Basin pH WY01-WY05

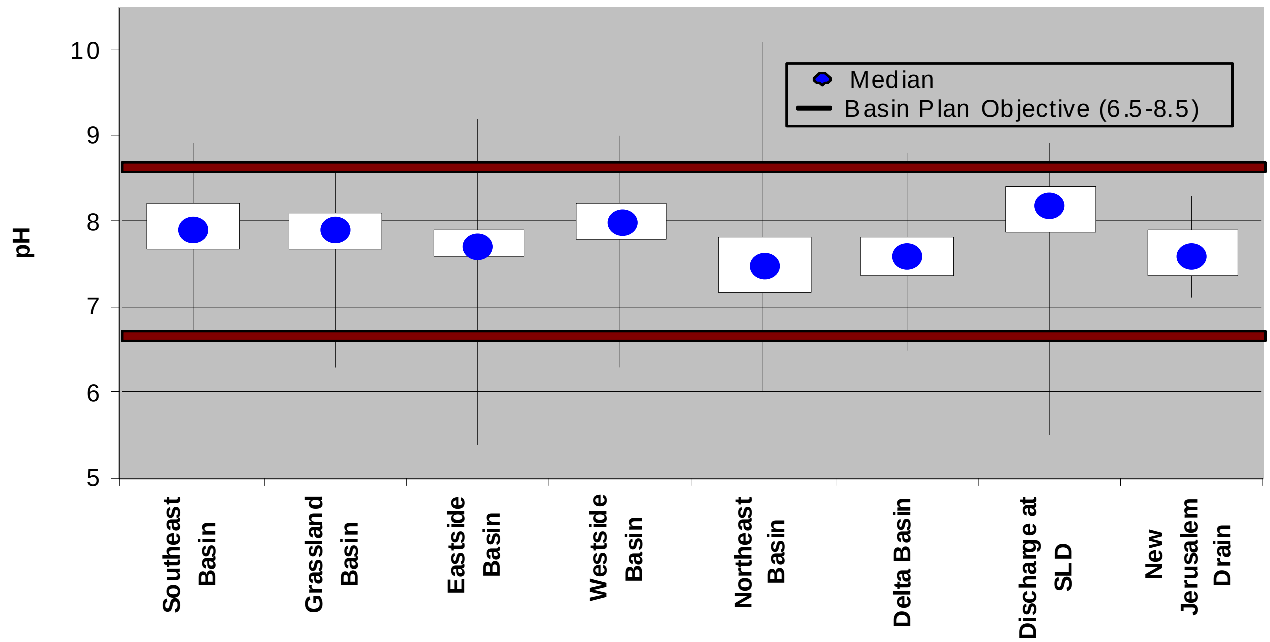
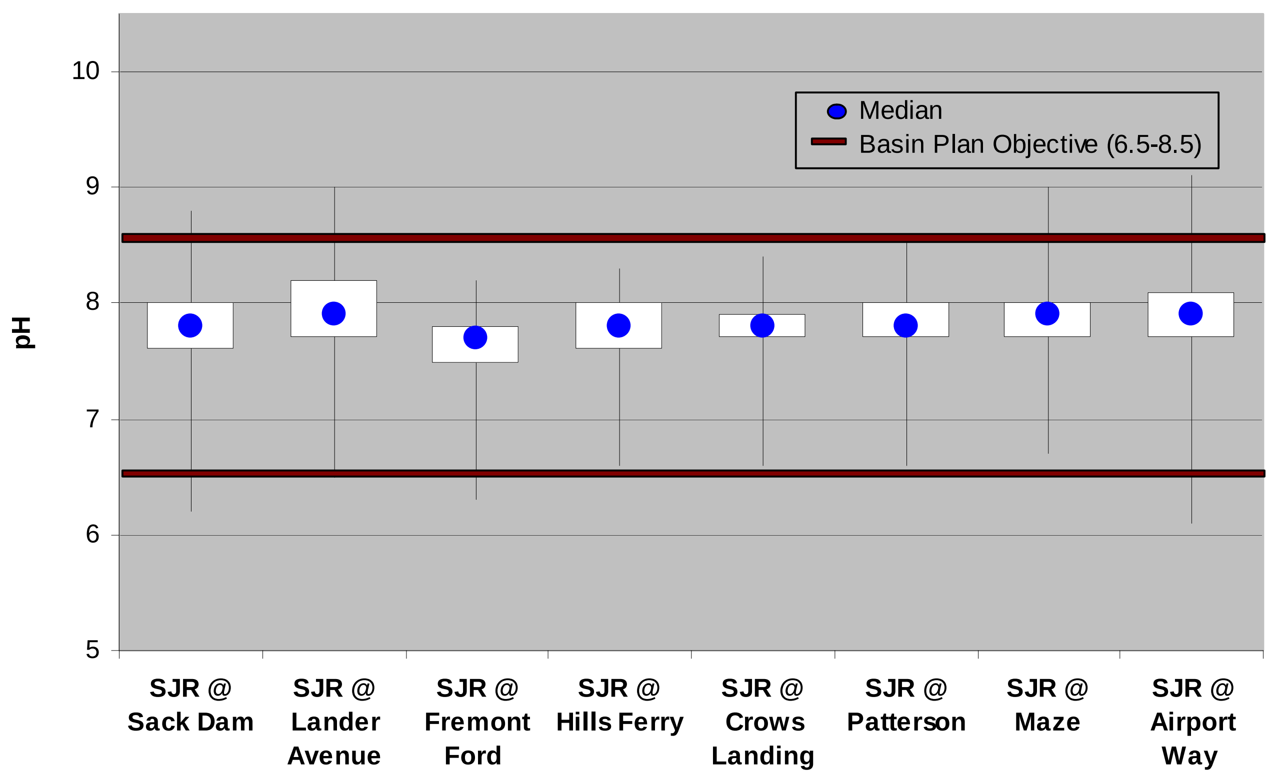


Figure 20: San Joaquin River Main Stem pH WY01-WY05



12.1.4 DISSOLVED OXYGEN

Dissolved oxygen is well known to have clear diurnal patterns which make grab sampling for trend analyses challenging, even if collecting at the same time each day. It was interesting to note that during this sampling effort, the variability in collecting weekly samples (Figure 21—the San Joaquin River sites) almost masked the seasonal pattern that was more evident with monthly sample collection (Figure 22—the Northeast Basin). In general, dissolved oxygen (DO) had a defined seasonal oscillation that is opposite of temperature. Dissolved oxygen concentrations tended to increase from October through April and decrease from May through September. The same pattern was evident during wet WY 2005, but the range in concentrations was much less. Only discharge from the San Luis and New Jerusalem Drains (both carrying shallow groundwater from their respective basins) did not appear to have significant seasonal patterns with concentrations remaining near 10 mg/L at both sites.

Spatially, the Grassland and Westside Basins had consistently higher DO levels than the Northeast Basin and non-river Eastside Basin sites, with the non-river sites of French Camp Slough and Lone Tree Creek reporting the lowest recorded DO concentration (0.4 mg/L) in May 2002 and October 2004, respectively. The highest values were observed in the San Luis Drain which had a mean of 12.5 mg/L.

The river itself did not demonstrate much spatial variability with the majority of the reported values tracking near 10 mg/L DO. The greatest overall site variability was noted at Lander Avenue, with high and low spikes that did not tend to track the remaining sites. The two lowest overall DO concentrations of 0.6-mg/L and 1.3-mg/L were recorded at Sack Dam and at Airport Way, the most upstream and most downstream sites, respectively

Figure 21: San Joaquin River Main Stem Dissolved Oxygen WY01-WY05

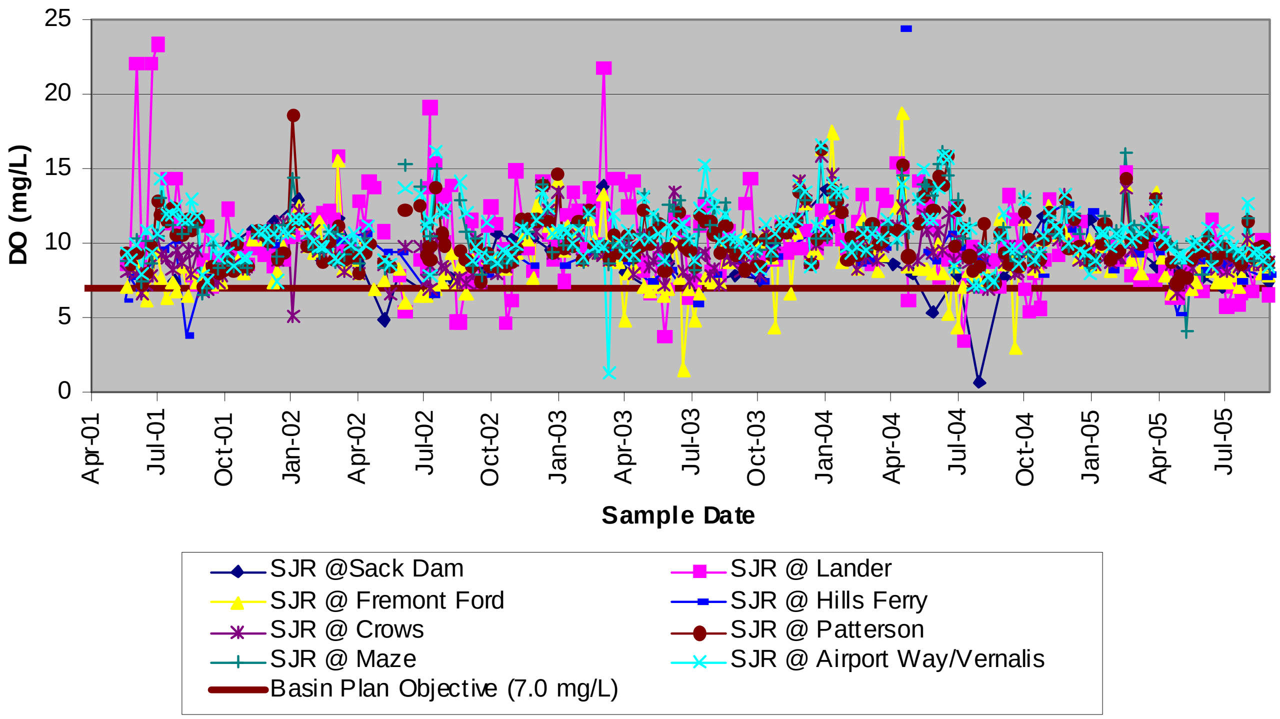
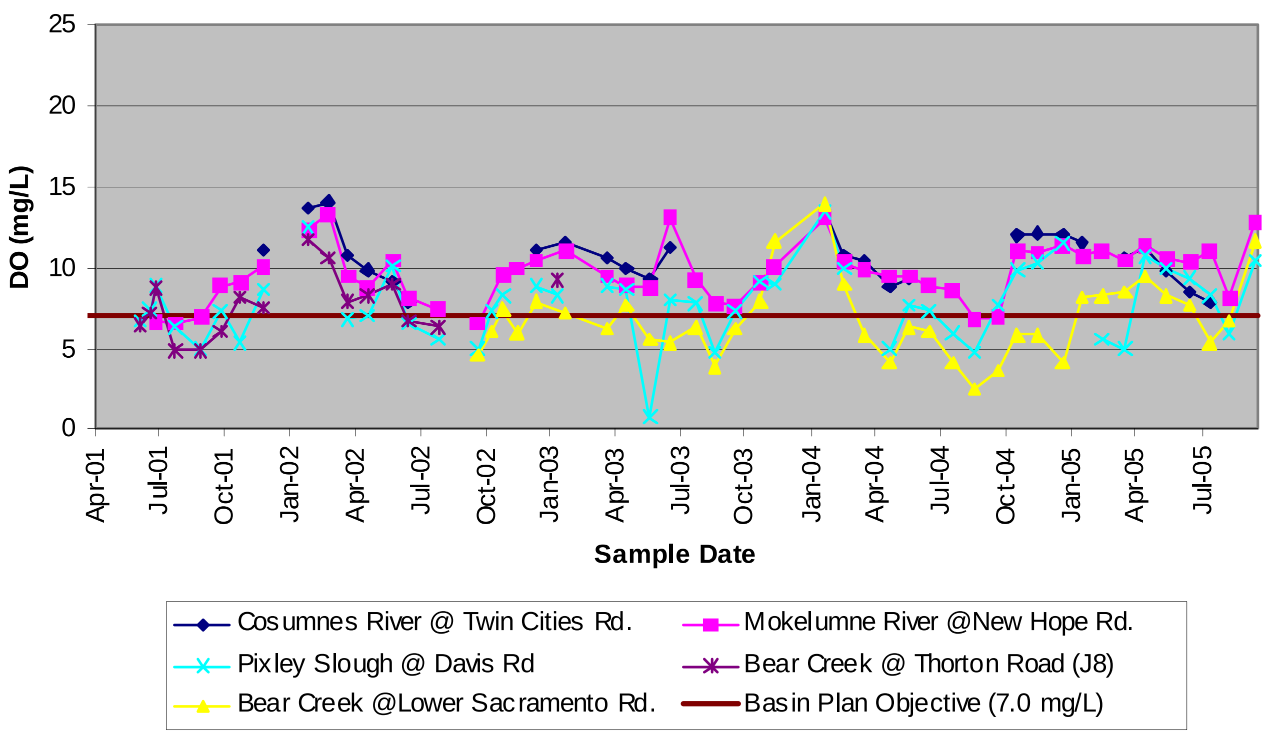


Figure 22: San Joaquin River Northeast Basin Dissolved Oxygen WY01-WY05



12.1.5 TURBIDITY

Turbidity findings are based on samples taken from July 2002 through June 2004, which encompasses portions of three water years: WY2001 (dry); WY2002 (dry); and WY2003 (below normal). The limited data set does not appear to demonstrate specific seasonal trends reporting spikes and dips throughout the year with individual sites both in the Northeast Basin and along the SJR. However, most sites did demonstrate a spike in turbidity that corresponded to a winter storm in December 2002 (Figures 23 and 24). Most of the sites appeared to show the greatest fluctuation in concentrations during the WY2003 irrigation season (April through August 2003), with a number of high values recorded. Mud Slough (north) and Salt Slough within the Grassland Sub-Basin also demonstrated increases during wetland flood-up (September) and wetland releases (April). Both these water bodies receive drainage from wetland habitat. These spikes were echoed in data for the San Joaquin River at Hills Ferry and at Fremont Ford—sites downstream of the Grasslands' inflows but upstream of the first Eastside river inflow (the Merced River).

Spatially, the Westside and Grassland Basins reported higher overall turbidity than basins draining the Sierra or the Delta. The exception was the Southeast Basin which had overall turbidity concentrations similar to the Grassland Basin. Both basins receive wetland drainage.

The Westside basin consists of ephemeral streams dominated by agricultural discharges and reported greater and more frequent fluctuations in turbidity then the rest of the Basins (Figure 25). Storm water inflows and run-off were the most evident in Salado Creek during the 2002 storm event resulting in a turbidity value of 1990 NTU.

The differences in the Basins are clearly shown by how they affect the SJR (Figure 26). Figure 27 provides an example of the impact that sub-basin inflow can have on the SJR during a pre-irrigation and wetland drainage period (23 – 27 March 2003). The dashed pink line representing a 5% increase over "background" Lander Avenue concentrations, helps visualize Westside inflows to the river increasing turbidity until the main Eastside rivers provide fresh water and bring the turbidity back down to slightly above SJR at Lander levels. Figure 28 is an example during the winter storm event (18 – 19 December 2002). The Westside influences again raise the turbidity above "background" Lander Avenue concentrations until after Hills Ferry when the Eastside Rivers enter the system. Figure 28 shows that during a winter storm event, turbidity in the SJR at Lander is greater than the turbidity downstream at Vernalis—opposite the finding during early spring.

Figure 23: San Joaquin River Northeast Basin Turbidity WY02-WY04

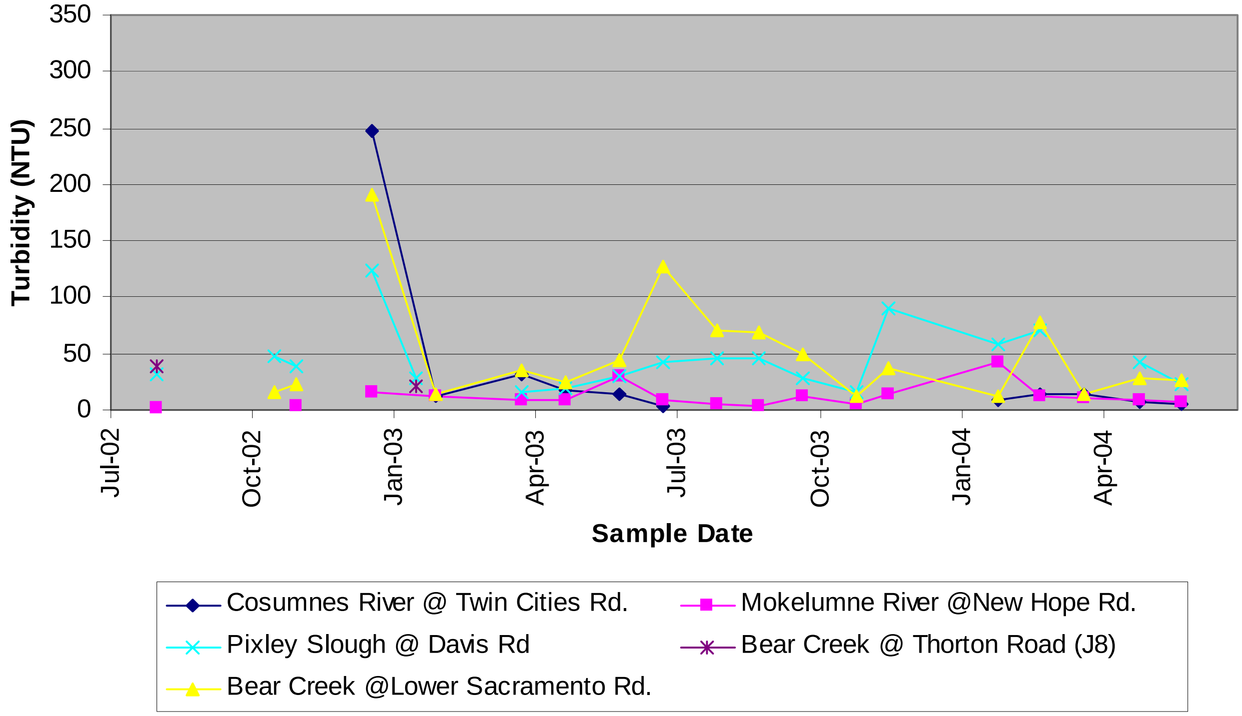


Figure 24: San Joaquin River Main Stem Turbidity WY01-WY05

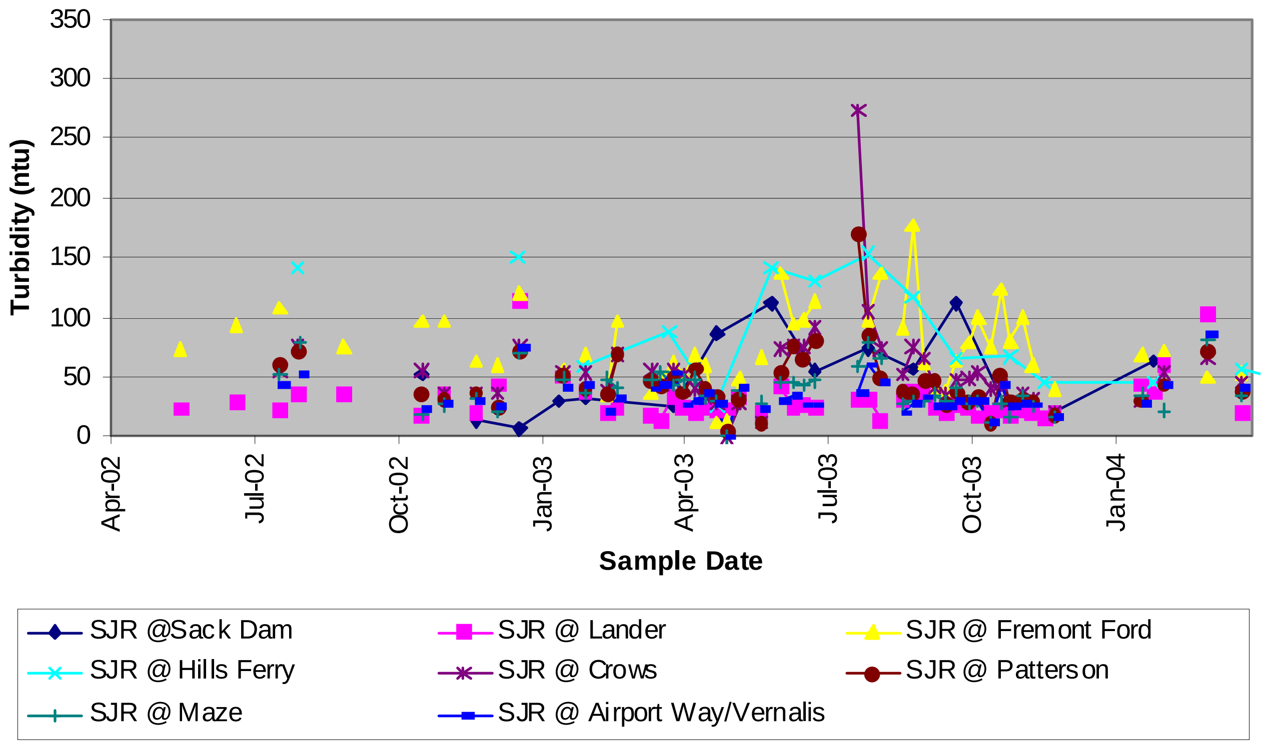


Figure 25: Basin Turbidity WY02-WY04

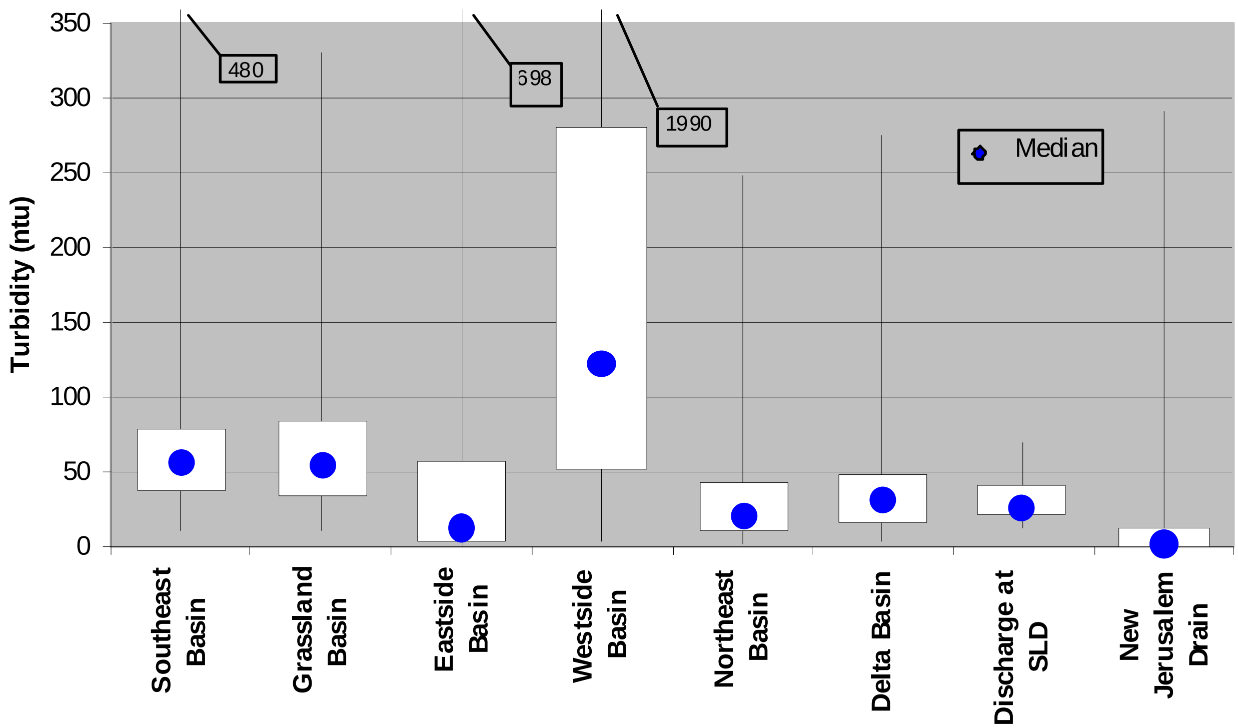


Figure 26: San Joaquin River Main Stem Turbidity WY02-WY04

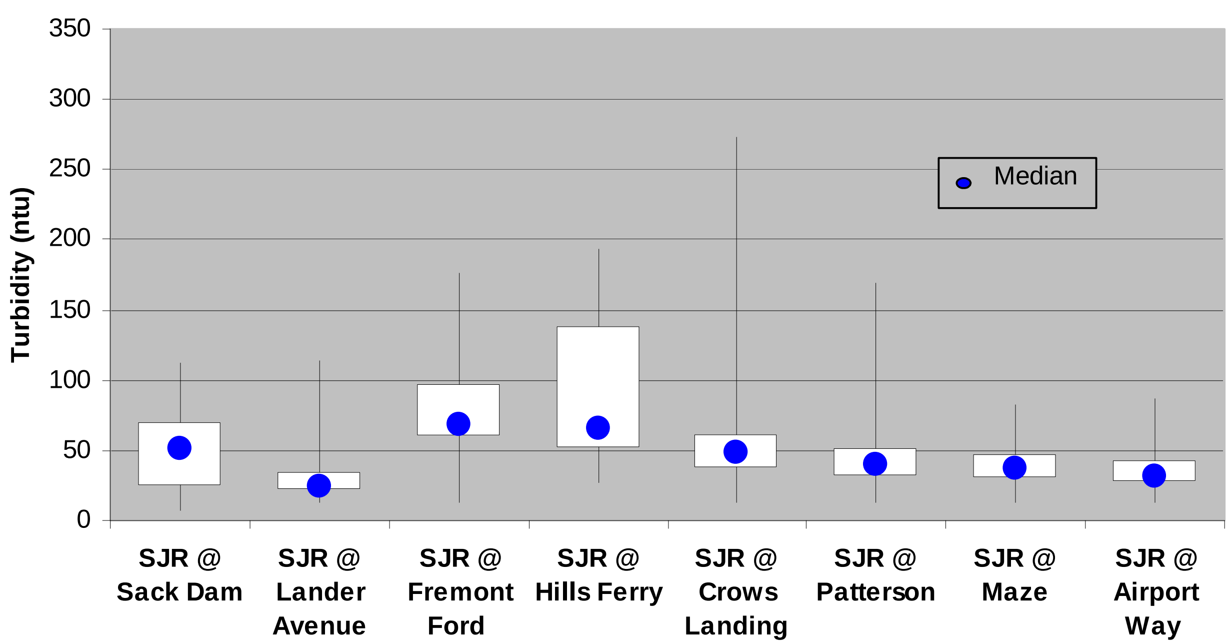


Figure 27: Turbidity Influences on the San Joaquin River from Lander to Airport Way/ Vernalis 3-25-03 and 3-27-03. Blue data points represent turbidity concentrations on the river. Pink lines are the Basin Plan objective with the river sites as background. Orange arrows represent west side influences, green arrows represent eastside influences and blue arrows represent major tributary input.

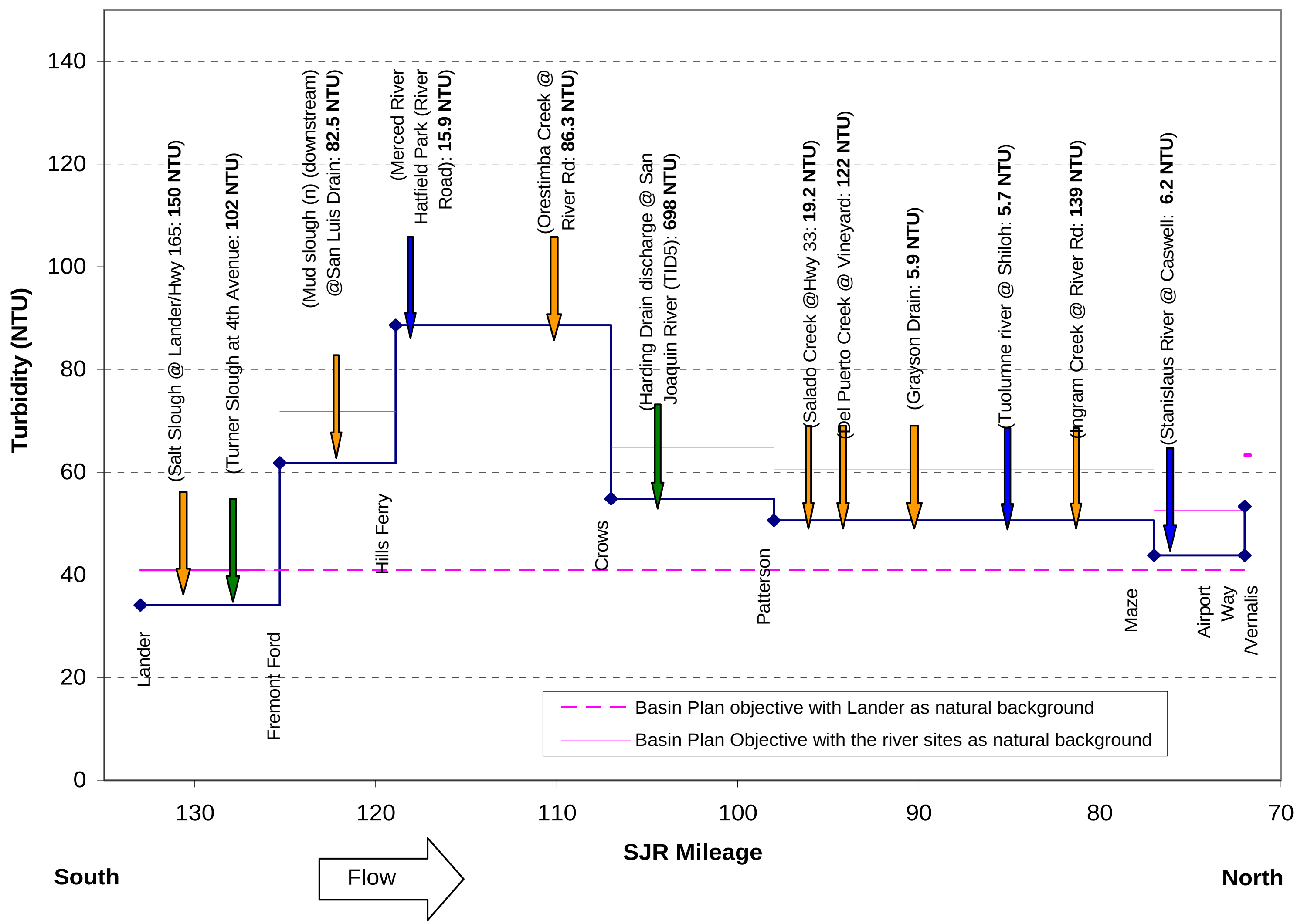
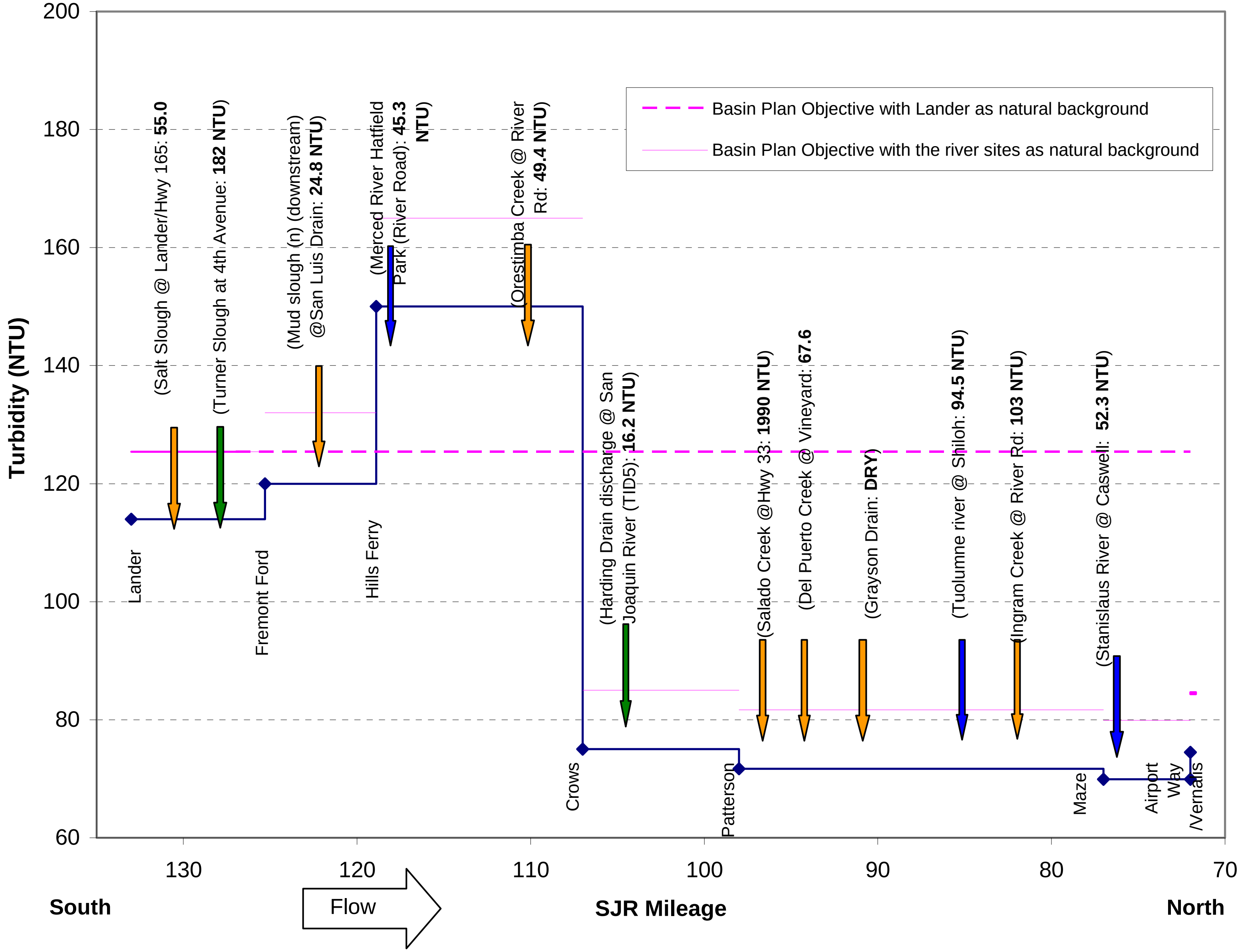


Figure 28: Turbidity Influences on the San Joaquin River from Lander to Airport Way/ Vernalis 12-18-02 and 12-19-02. Blue data points represent turbidity concentrations on the river. Pink lines are the Basin Plan objective with the river sites as background. Orange arrows represent west side influences, green arrows represent eastside influences and blue arrows represent major tributary input.



12.1.6 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS) samples were generally collected weekly at the SJR main stem sites (except during WY04 where no TSS samples were collected due to funding shortfalls) and monthly during WY01 at all the drainage basin sites. TSS was also collected monthly during the irrigation season (June thru August) in WY05 at the Westside Basin sites. Elevated levels in both the SJR and Basins between January and April 2001 correspond to a series of significant (greater than 1-inch) rainfall events. The TSS begins to climb again at the beginning of the irrigation season (June) and remain elevated, but concentrations remained lower than the spikes seen during storm events. For the SJR sites, there was no obvious difference in concentrations during wet WY 2005, except for an increased frequency of spikes during winter rainfall events (Figure 29).

Figure 30 displays the TSS data available during the irrigation season (March thru September) during both WY01 and WY05 for the Westside Basin sites. The incomplete data sets indicate increasing concentrations, particularly in Ingram and Hospital Creeks and Grayson Drain which show a number of spikes above 3,000 mg/L TSS. The variability in findings indicates the need for more continuous data sets during the irrigation season.

Spatially, similar to turbidity, the Westside and Grassland Basins had higher concentrations of TSS when compared to the other Basins (Figure 31). Most of the larger waterways seemed to track consistently with the river sites downstream of their inflows. In particular, the highest overall levels of TSS in the SJR were recorded at Fremont Ford and Hills Ferry (Figure 32)—downstream of Grassland Basin and some Westside Basin inflows, but upstream of the Merced River and other Eastside Basin influences. Overall concentrations in the SJR remained below 100-mg/L TSS with a median near 50-mg/L, as did all the sub-basins except the Westside. Although median Westside Basin TSS concentrations remained near 75-mg/L, 50% of the concentrations ranged between 40 mg/L and 345 mg/L.

Some unique findings within selected sub-basins are noted below.

Northeast Basin: Although similar in land use and size, the Cosumnes River TSS concentrations appeared to more directly track storm events when compared to the Mokelumne River (Figure 33). The one major difference between the basins is that flow from the Mokelumne River is regulated by Camanche Reservoir. Reservoirs on other major rivers in the SJR Basin likely have similar buffering effects.

Eastside Basin: Similar to turbidity, Turner Slough and Harding Drain had larger and more fluctuating TSS values than that of the rivers sites.

Grassland Basin: The Discharge from SLD was monitored for TSS weekly through the Grassland Bypass Program. Flow in the drain is specifically regulated to minimize potential for bed sediment suspension and storm event influences. The TSS concentrations in the drain remained relatively constant just below 50-mg/L and did not reflect patterns noted in other Grassland waterbodies.

Figure 29: San Joaquin River Main Stem Total Suspended Solids WY01-WY05

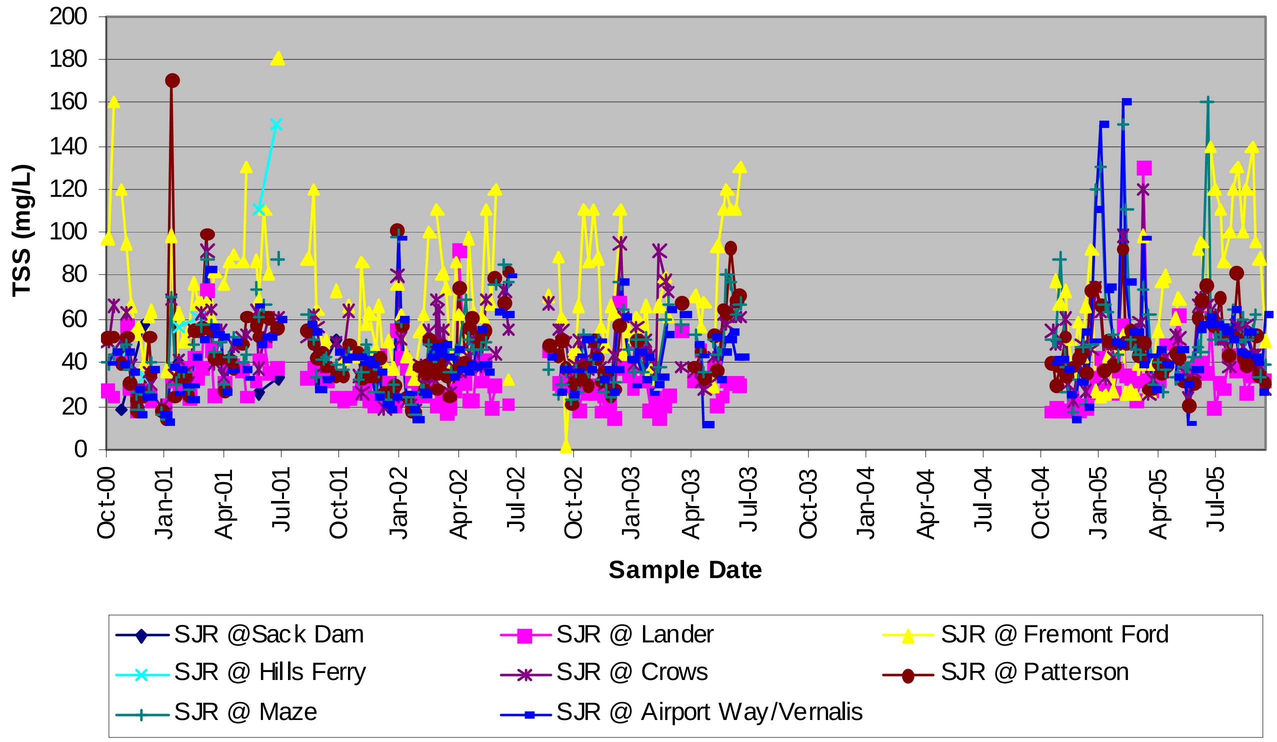


Figure 30: San Joaquin River Westside Basin Total Suspended Solids Irrigation Season WY01 and WY05

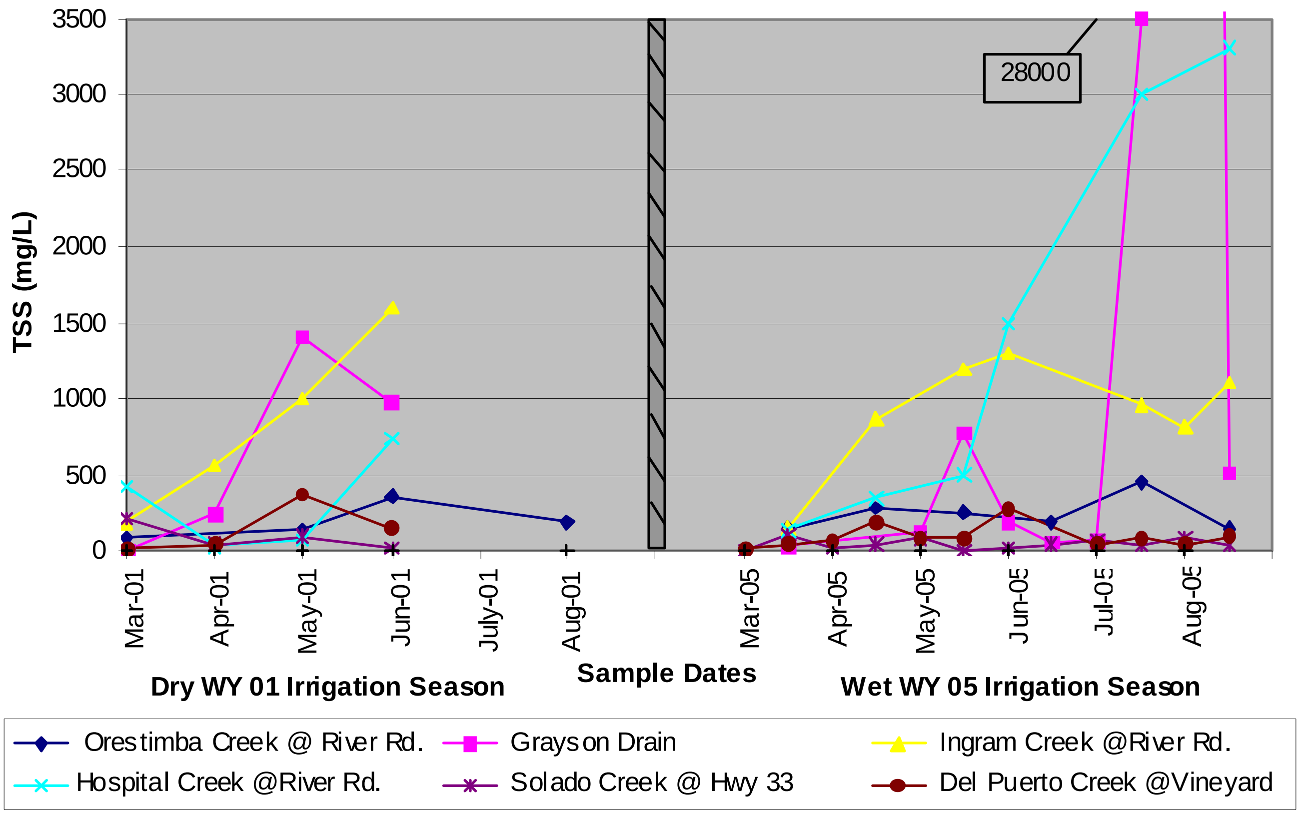


Figure 31: Basin Total Suspended Solids WY01-WY05

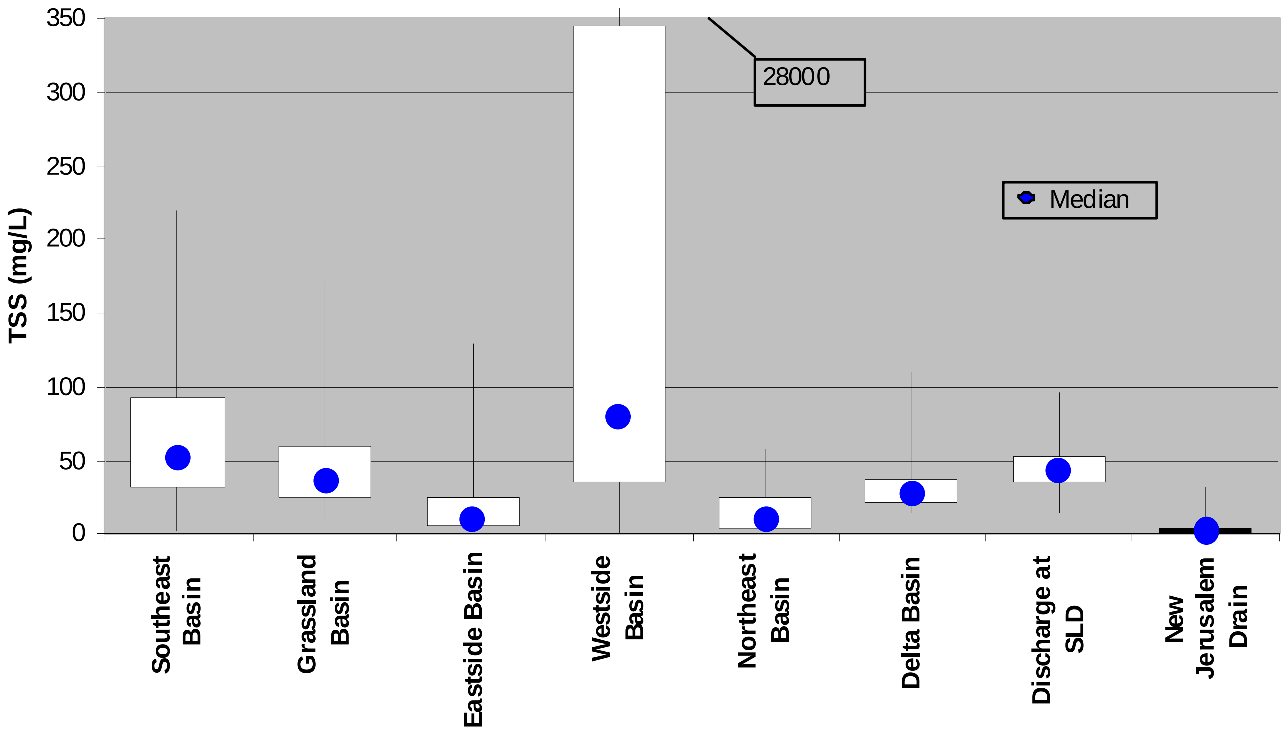


Figure 32: San Joaquin River Main Stem Total Suspended Solids WY01-WY05

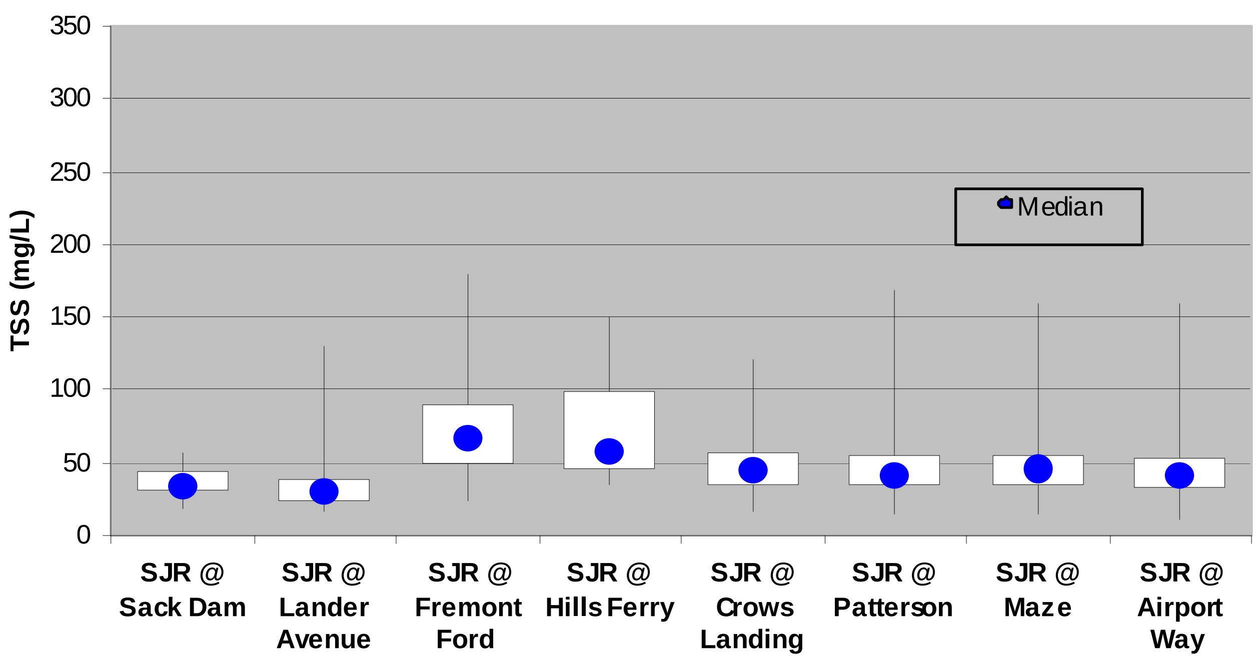
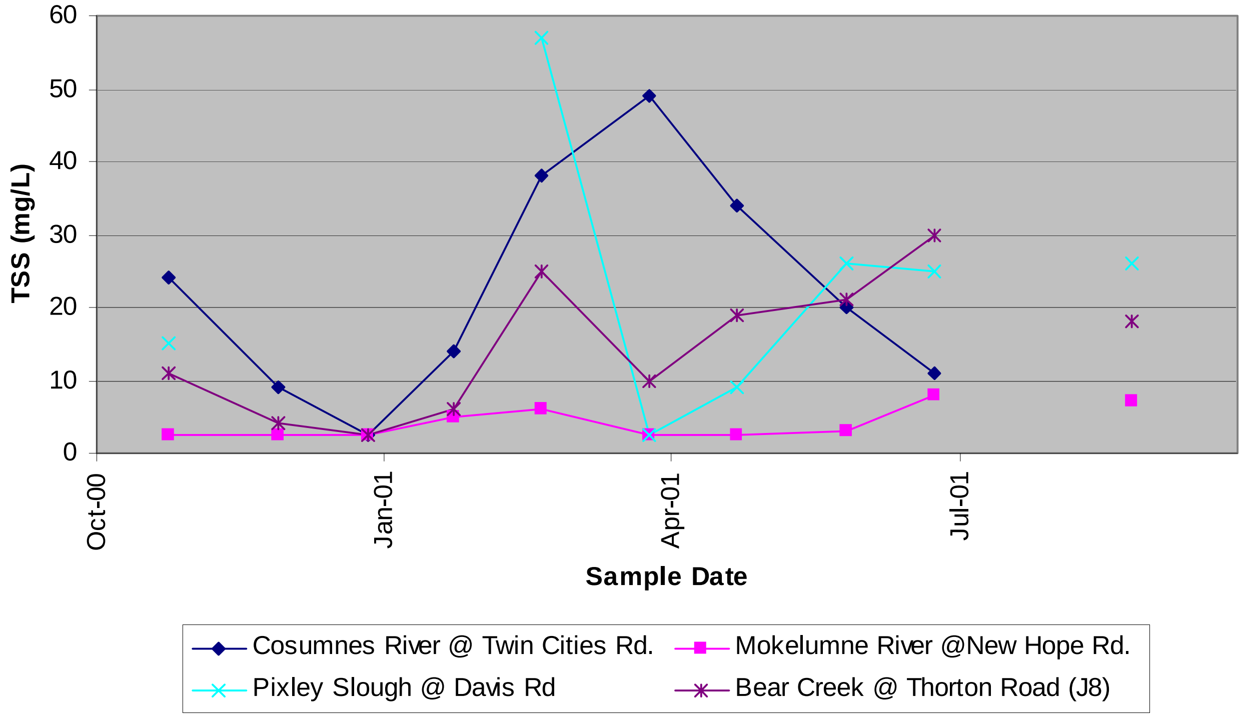


Figure 33: San Joaquin River Northeast Basin Total Suspended Solids WY01



12.1.7 TOTAL ORGANIC CARBON

Total organic carbon (TOC) samples were to be collected weekly at the SJR main stem sites and monthly at the drainage basin sites. Unfortunately, major gaps exist in the data due to both limited funding and sample quality control. Key gaps exist for the river sites during the winter storm periods (January thru March) of 2002, 2003 and 2004. Data for sites collected in the basin demonstrate the same gaps with the addition of no data between May 2003 and October 2004. The distinct data gaps make trend analyses difficult.

In general, the major river sites appear less susceptible to random spikes in concentration and demonstrate elevated levels during winter storm events and the irrigation season. Using the Eastside Basin as an example (Figure 34) the river sites (Merced and Tuolumne Rivers) do not fluctuate as drastically as Turner Slough and Lone Tree Creek. Some of the spikes in TOC concentrations correspond to storm events, such as the spike seen in Lone Tree Creek in the winter of WY2005. Other spikes (Turner Slough in Dec 2000 and French Camp Slough in May 2002) don’t correspond to a large or first-flush storm event. The Cosumnes River was an exception to the other major river sites in that it did show a dramatic spike in June of 2001, which corresponds to a small rain event just before this ephemeral stretch of the river dried (Figure 35). At no other time did TOC concentrations rise as drastically at this site before the seasonal dry periods.

Sites moving downstream along the SJR that receive wetland discharge (Lander Avenue, Fremont Ford and Hills Ferry) also show elevated concentrations during wetland releases in early spring. During wet WY05, TOC concentrations in the SJR tended to decrease after the final storms in April and did not show the same magnitude of increase during the irrigation season as was evident during previous dry years (Figure 36).

Overall, total organic carbon values ranged from <1.0 mg/L at many of the sites to a maximum of 67 mg/L at Lone Tree Creek. Between the basins, the Grassland basin has a higher median TOC than all the other basins (Figure 37). The Northeast and Eastside river sites have the lowest concentration of TOC. The non-river sites for the rest of the basins have higher concentrations, fluctuations and high spikes of TOC. These spikes could be influenced by storm events, agricultural and wetland management practices. Some unique characteristics for selected basins are discussed below:

South Delta Basin: The South Delta Basin on average had lower concentrations of TOC than the Eastside Basin non-river sites. The New Jerusalem Drain had the lowest concentration of TOC throughout the sampling period. There was one large TOC spike found in the New Jerusalem Drain, Tom Payne Slough, and Old River between the end of August and October of 2001. No rainfall was measured during August 2001, with the first rains starting in September 2001. The early spike measured in TOC could have been attributed to agricultural influence with the later part being a combination of agricultural influence and storm flows.

Westside Basin: Westside Basin TOC concentrations fluctuated like the Eastside Basin non-river sites, but without as large of spikes. In addition to spikes in June of 2001, the same distinct spike noted in the South Delta in October of 2001 also occurred in Westside water bodies—. The October 2001 spike corresponded to the first rains after a very dry summer.

Grassland Basin: The Grassland Basin’s fluctuations looked very similar to the Westside Basin’s, with major spikes in the fall of 2001. Levels of TOC were typically higher early in the fall, when local flows also increase due to spill from the seasonal flooding of surrounding wetland habitat. Levels typically dropped after the initial week of wetland flood-up and prior to the first storm event. Concentrations of TOC during wet WY of 2005 for the Grassland basin were noticeably more stable than those measured during the dry WY of 2001.

Moving down the main stem of the SJR (Figure 38), Sack Dam had a median background concentration of 3-mg/L TOC. The median TOC concentrations then peaks to 8-mg/L at the next downstream site (SJR at Lander) and progressively decreases until reaching the boundary of the Delta (Airport Way) with a median TOC back near 3-mg/L. The Lander Avenue site had the highest concentrations and most dramatic fluctuations of TOC along the SJR. Inflows from the sub-basins seem to contribute to the drop in concentration of TOC moving toward the Delta.

Figure 34: San Joaquin River Eastside Basin Total Organic Carbon WY01-WY05

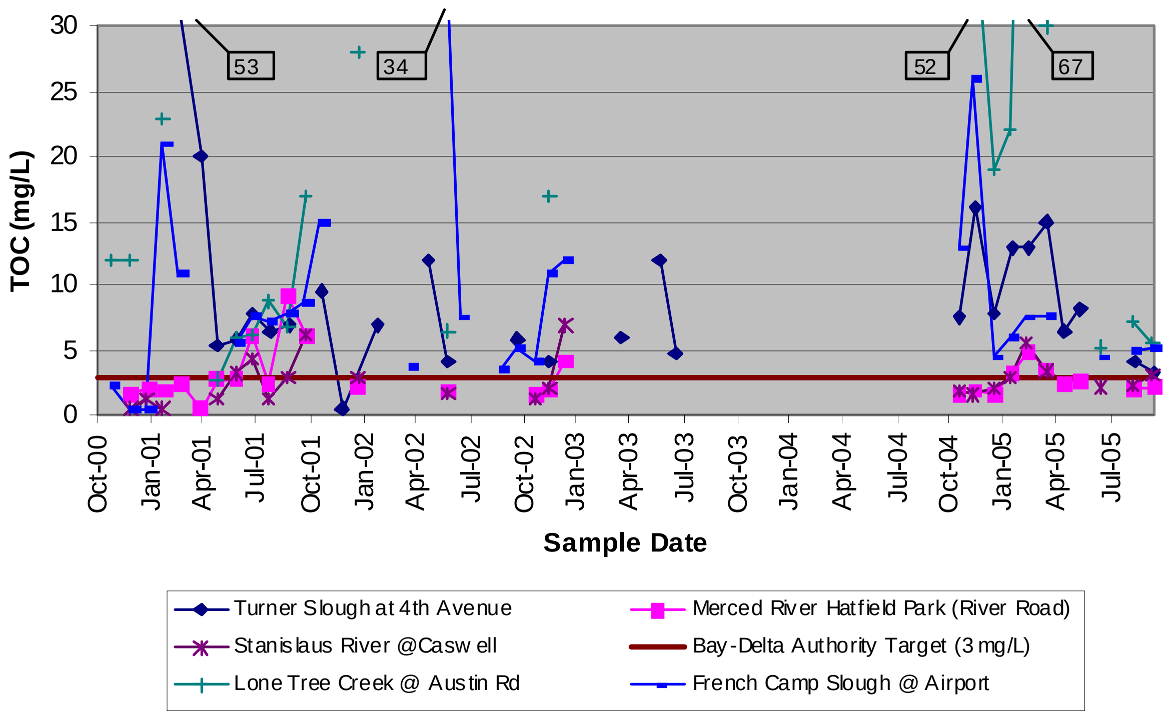


Figure 35: San Joaquin River Northeast Basin Total Organic Carbon WY01 – WY05

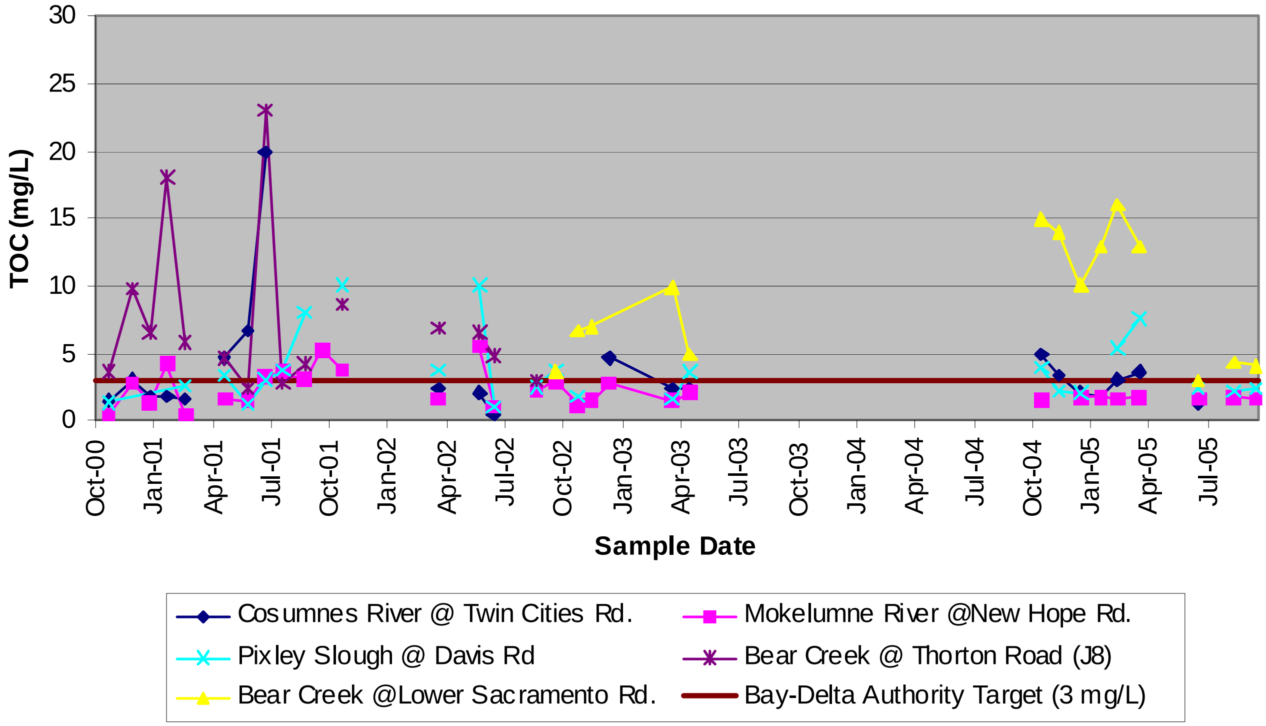


Figure 36: San Joaquin River Main Stem Total Organic Carbon WY01 – WY05

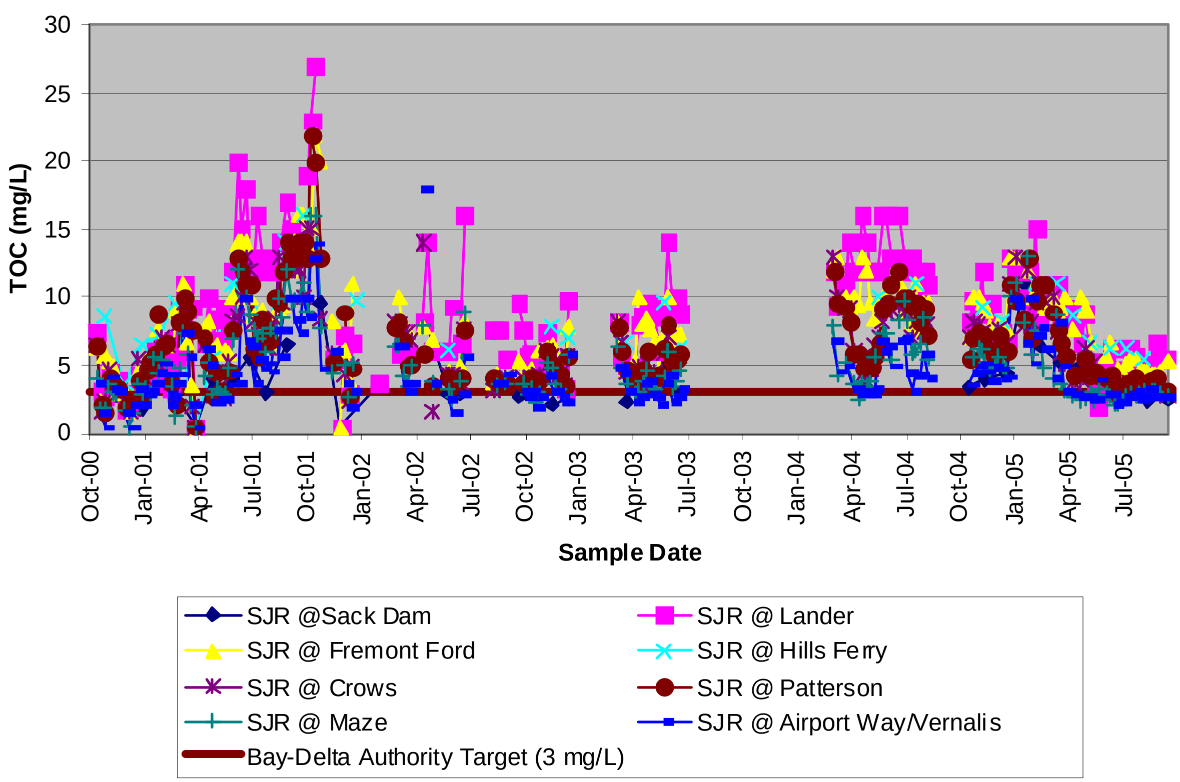


Figure 37: Basin Total Organic Carbon WY01-WY05

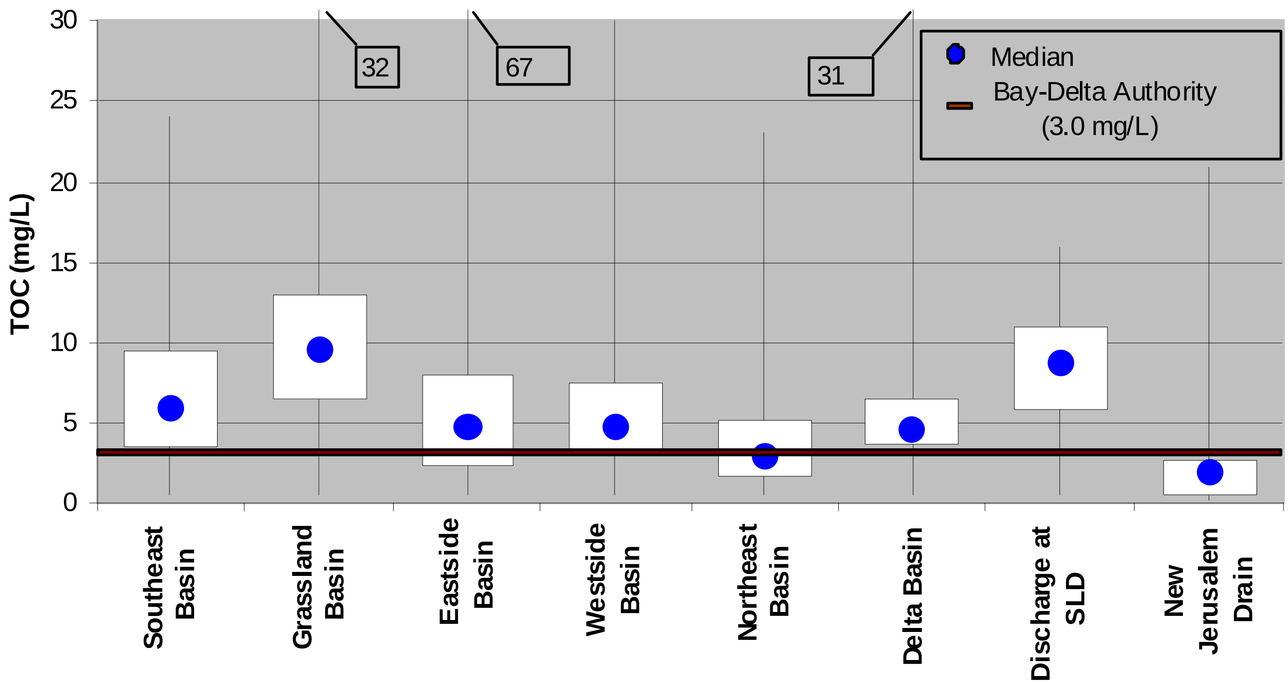
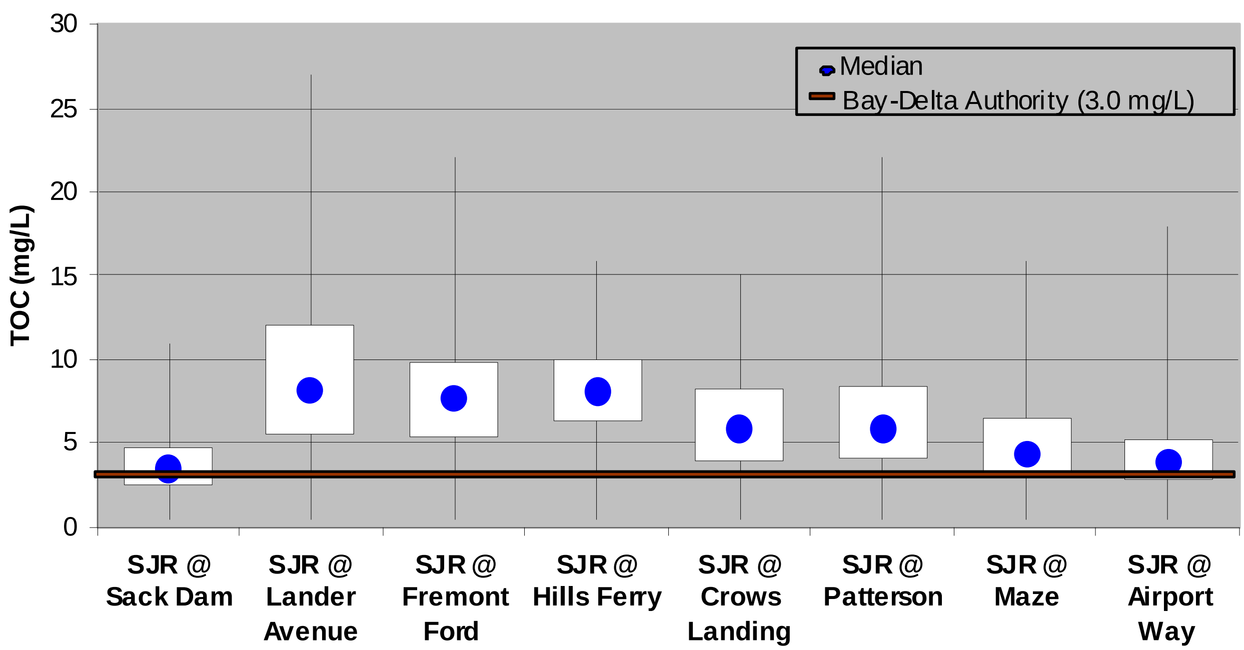


Figure 38: San Joaquin River Main Stem Total Organic Carbon WY01-WY05



12.1.8 BACTERIA

Total coliform and *Escherichia coli (E. coli)* sampling began in July 2002 and continued through WY05. The analytical method used for bacteria analyses during this study (IDEXX) has a maximum detection limit of 2419.6 MPN/100ml and a minimum detection limit of 1 MPN/100ml, numbers which were used as the upper and lower boundaries for median concentration calculations and graphs. Results ranged from 52 MPN to >2419.6 MPN for total coliform and1.0 MPN to >2419.6 MPN for *E.coli*.

Total coliform concentrations tended to exceed the maximum detection limits at most sites except during storm events—when the concentrations decreased rapidly. Figure 39 demonstrates the trend for the Northeast Basin.

In contrast, the majority of *E. coli* concentrations (a subset of total coliform) were reported within the detectable ranges and showed sporadic spikes in concentration, some related to storm events and others related to dry periods. Figures 40 and 41 demonstrate the variability seen in the results for the Northeast Basin and SJR sites, respectively. A number of the *E. coli* spikes during the winter season occurred when the sample was collected during the first flush of a major storm series—at a time when the total coliform was still above reporting limits, with subsequent samples showing much lower concentrations. Of particular note is that during WY02, sampling frequency at the Northeast Basin sites increased to twice a month as that watershed cycled into the rotational basin sampling schedule. The increased sampling related to an increase in the number of spikes reported at those sites. In addition, a greater number of elevated *E. coli* concentrations were detected in the SJR between January and June during wet WY05 when compared to previous water years.

Spatially, total coliform appeared uniformly high throughout the SJR Basin and was normally above detection limits with lower concentrations mostly seen during high flow events. For *E. coli*, the Grassland and South Delta Basin had lower concentrations compared to the rest of the basins (Figure 42). The Westside Basin had a considerable increased number of *E. coli* spikes when compared to the rest of the basins as well as higher overall spikes during low flow time periods. Both the Westside and Southeast Basins reported 50% of samples collected falling between 200 MPN/100ml and 1200 MPN/100ml—much higher than the remaining basins.

The river itself had the highest median *E. coli* concentration (124 MPN/100ml) at the Hills Ferry site, just prior to inflow from the Eastside rivers. The Hills Ferry site also had the highest overall concentrations in the SJR, but the majority of samples remained well below 235 MPN/100ml (the US EPA guideline for full contact recreation) (Figure 43).

Some unique characteristics noted for selected sub-basins follow.

Northeast Basin: The Northeast Basin's total coliform stayed mostly at the maximum detection limit until higher flow events during which the levels dropped (Figure 39). Lower concentrations during high flow events were more pronounced for the river sites than Bear Creek and Pixley Slough. *E. coli* was mostly found to be around the lower level of detection and would spike upwards during lower flow events (Figure 40). The river sites did not seem to spike as frequently as Bear Creek and Pixley Slough. *E. coli* in Bear Creek and Pixley Slough also spiked periodically during higher flow events.

South Delta Basin: South Delta Basin bacteria concentrations had a similar trend to the Northeast Basin, but overall *E. coli* had much lower concentrations. *E. coli* for the New Jerusalem Drain never went above 27 MPN/100ml, which is likely related to the fact that it is a collection system for shallow ground water (subsurface tile drainage). The two samples collect in Mountain House Creek prior to drainage diversion after urban conversion, were both very high with the lowest sample at 1046.0 MPN/100ml.

Westside Basin: The Westside Basin showed the same trend as the Northeast Basin river sites. *E. coli* found in the Westside Basin showed the greatest number of spikes throughout the whole year. Orestimba Creek had the lowest number of samples above the detection limit for *E. coli*, but the second highest geometric mean.

Grassland Basin: The Grassland Basin had lower *E. coli* levels, similar to the Delta Basin, with only two samples found above the detection limit. The discharge from SLD had the lowest levels of *E. coli* in the basin. The SLD also consists of subsurface tile drainage, similar to the New Jerusalem Drain, but for a larger area.

Figure 39: San Joaquin River Northeast Basin Total Coliform WY02-WY05

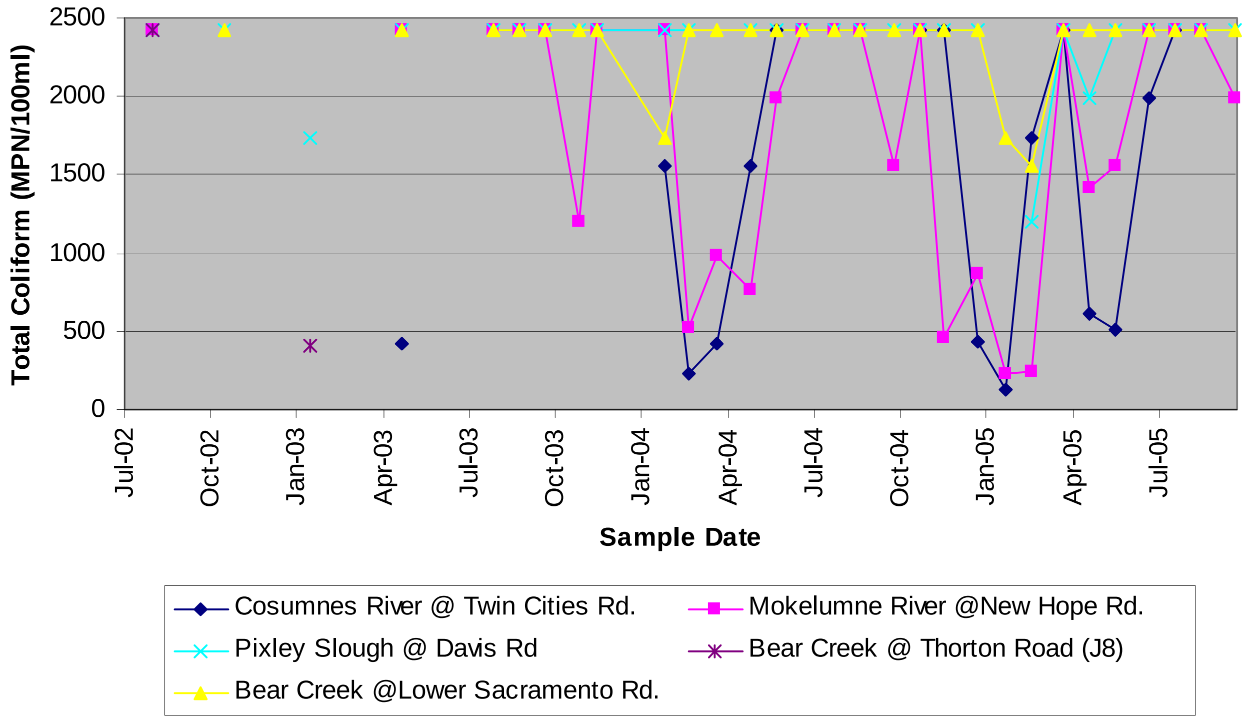


Figure 40: San Joaquin River Northeast Basin *E. coli* WY02-WY05

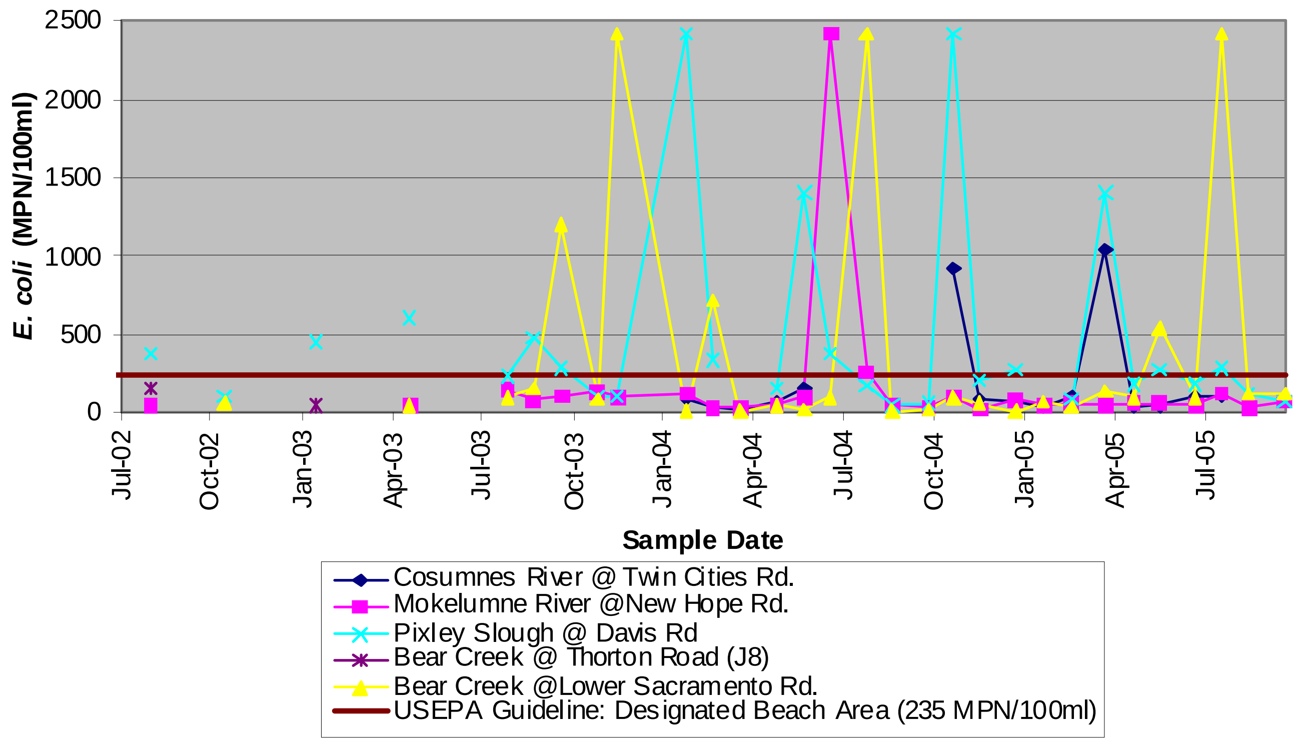


Figure 41: San Joaquin River Main Stem *E. coli* WY01 – WY05

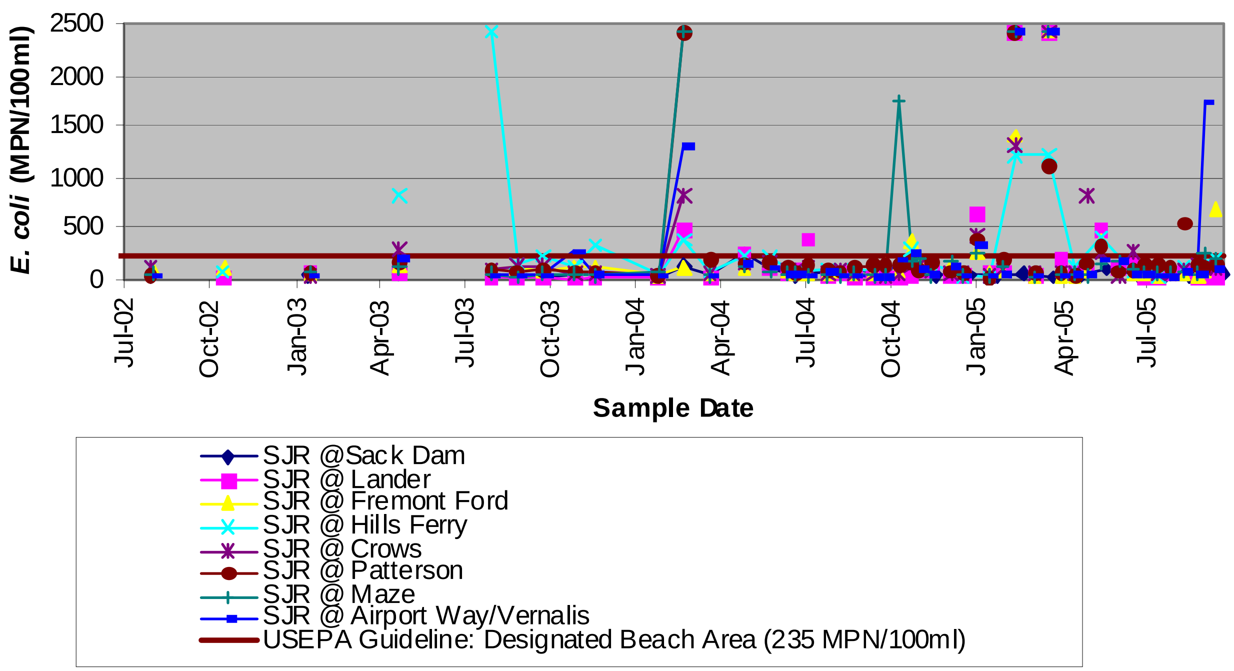


Figure 42: Basin *E. coli* WY02-WY05

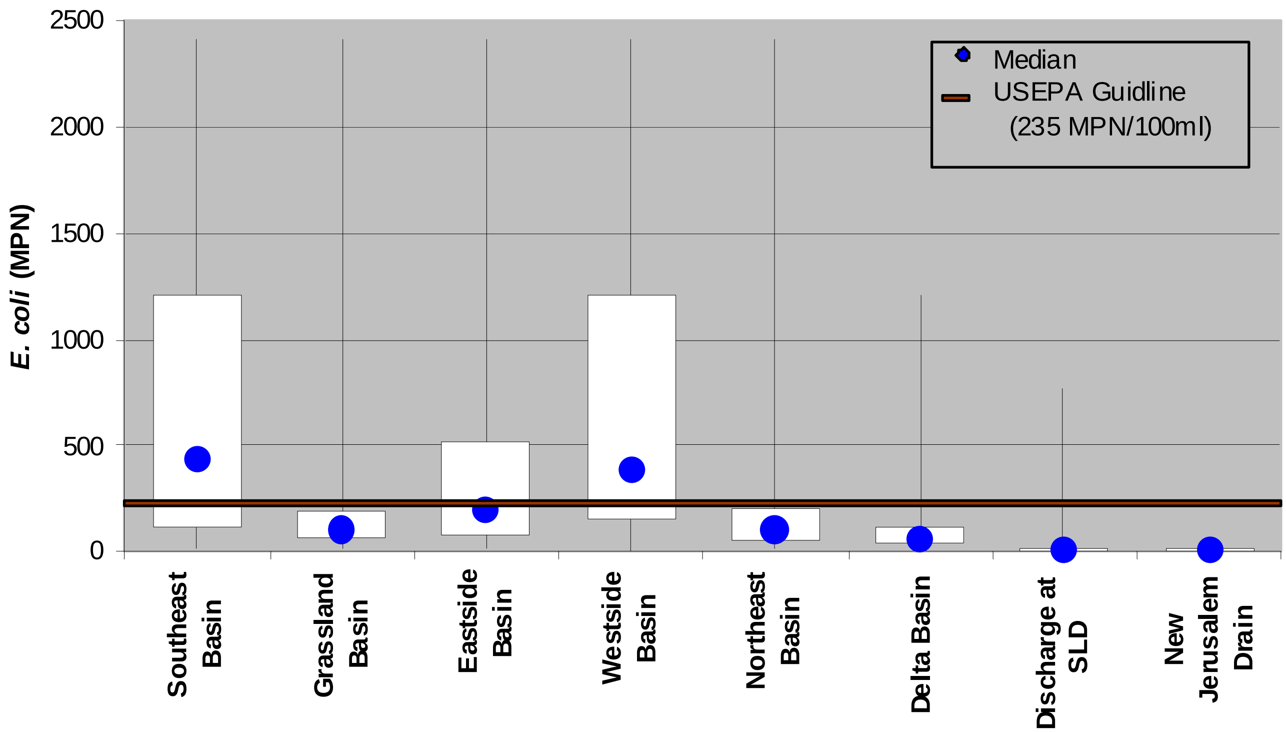
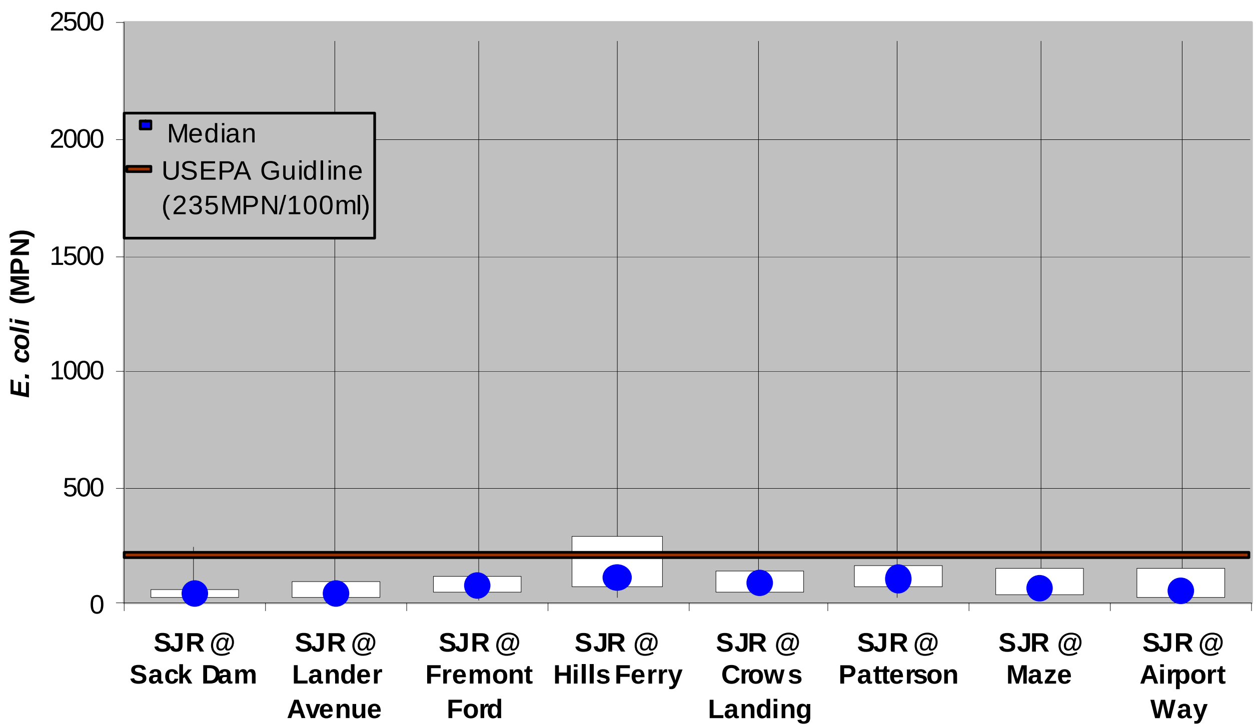


Figure 43: San Joaquin River Main Stem *E. coli* WY02-WY05



12.1.9 NUTRIENTS

Nutrient samples were collected throughout the basin on a monthly basis through WY02 (excluding nitrate-N and ammonia-N). At the end of fiscal year 02/03, an initial review of the data collected and a review of collaboration efforts with the Total Maximum Daily Load (TMDL) programs (specifically the TMDL for dissolved oxygen) were completed. With a redirection of the DO TMDL program to conduct continuous measurements at select sites and add additional monitoring for chlorophyll a, nutrient collection at most of the drainage basin sites was discontinued to avoid duplication of effort. The exceptions were Mud Slough upstream of SLD, Discharge at SLD and Mud Slough (downstream) @ SLD which are monitored in conjunction with the Grassland Bypass Program, and continued collection at the SJR main stem sites of SJR @ Fremont Ford and SJR @ Crows Landing until December 2004. Much of the data for WY02 and the first half of WY03 was removed from the data set due to failed QA/QC.

Most of the nutrients at sites within the SJR Basin had relatively low levels, with the exception of nitrate; however, the limited data set makes trend analyses difficult. Figure 44 depicts available SJR nitrate information for this program. From the information collected in WY01, nitrate increases during both the storm season (January thru March) and then again during the irrigation season. The available data mirrors portions of those trends in 2002 and 2003.

Nitrate concentrations reported for the Northeast Basin were all below 6-mg/L, with little discernible trends during the single water year of data (WY01)(Figure 45). The Westside Basin reported higher overall concentrations and a distinct spike in Orestimba Creek during the storm season and spikes in Del Puerto during April (typically a pre-irrigation period) as well as June thru September (Figure 46).

Spatially, nitrate is high at several sites throughout the basin especially the Discharge at SLD and New Jerusalem Drain—both of which carry subsurface agricultural drainage (shallow groundwater) and had the majority of concentrations reported above 45-mg/L. The Harding Drain within the Eastside Basin was also somewhat elevated with values ranging from 9.9 mg/L to 44 mg/L. Overall, the Westside Basin had the highest median nitrate concentration (12-mg/L) when compared to the rest of the SJR Basin (Figure 47). Information from the specific sub-basins is listed below.

Northeast Basin: The Northeast Basin had very low levels of nutrients and most of the collected sample results were non-detect. The Mokelumne River had only 5 samples that were just slightly above detection levels. The Cosumnes River had slightly higher levels of nitrate, phosphorus and potassium than the Mokelumne River. Pixley Slough nutrient levels, unlike Bear Creek, have lower levels of nutrients than the Cosumnes River. Bear Creek had the highest concentrations of nutrients for the Northeast Basin. Higher concentrations of nutrients mostly occurred during the winter months.

Eastside Basin: The Eastside Basin river sites had low concentrations similar to the Northeast Basin river sites. French Camp Slough and Lone Tree Creek had higher fluctuating levels than Bear Creek in the Northeast Basin. Harding Drain had higher fluctuating levels for all nutrient samples collected in the basin. Turner Slough had high levels during January 2001 through April 2001 for TKN, phosphorus, orthophosphate-P and potassium. For the rest of the sampling period the concentrations at Turner Slough were comparable to the river sites within the basin.

Southeast Basin: The Southeast Basin had fluctuating levels of nutrients similar to Bear Creek in the Northeast Basin.

South Delta Basin: All sites within the South Delta Basin reported low levels of nutrients except for nitrate levels in the New Jerusalem Drain. The nitrate levels in the New Jerusalem Drain were six times higher than the other South Delta Basin sites as well as the river sites of the Northeast Basin.

Westside Basin: Overall the Westside Basin reported higher nitrate levels than the other Basins (Figure 47). Salado and Orestimba Creeks showed higher concentrations during the winter months and Del Puerto Creek typically showed a spike during the irrigation season.

Grassland Basin: The discharge from SLD had the highest concentration of nitrate, but had lower concentrations of the other nutrients compared to the rest of the Grassland sites. Nitrate concentrations in the SLD were highly elevated in the winter and decreased somewhat but remained elevated above 45-mg/L through the irrigation season. Mud Slough (north) downstream of the SLD discharge tracked the drain's concentrations and had much higher concentrations of nitrates than Mud Slough upstream.

The Main Stem SJR showed increasing nitrate concentrations between Lander and Patterson—the stretch of river receiving inflows from the Grassland (including SLD) and Westside Basins and the Merced River (Figure 48). Nitrates decrease from SJR at Patterson to Airport Way with inflows from the Tuolumne and Stanislaus Rivers. Most other nutrient concentrations decreased in the main stem of the river moving down the system or stayed the same resulting in very low concentrations. The New Jerusalem Drain enters the SJR downstream of Airport Way.

Figure 44: San Joaquin River Main Stem Nitrate WY01 – WY04

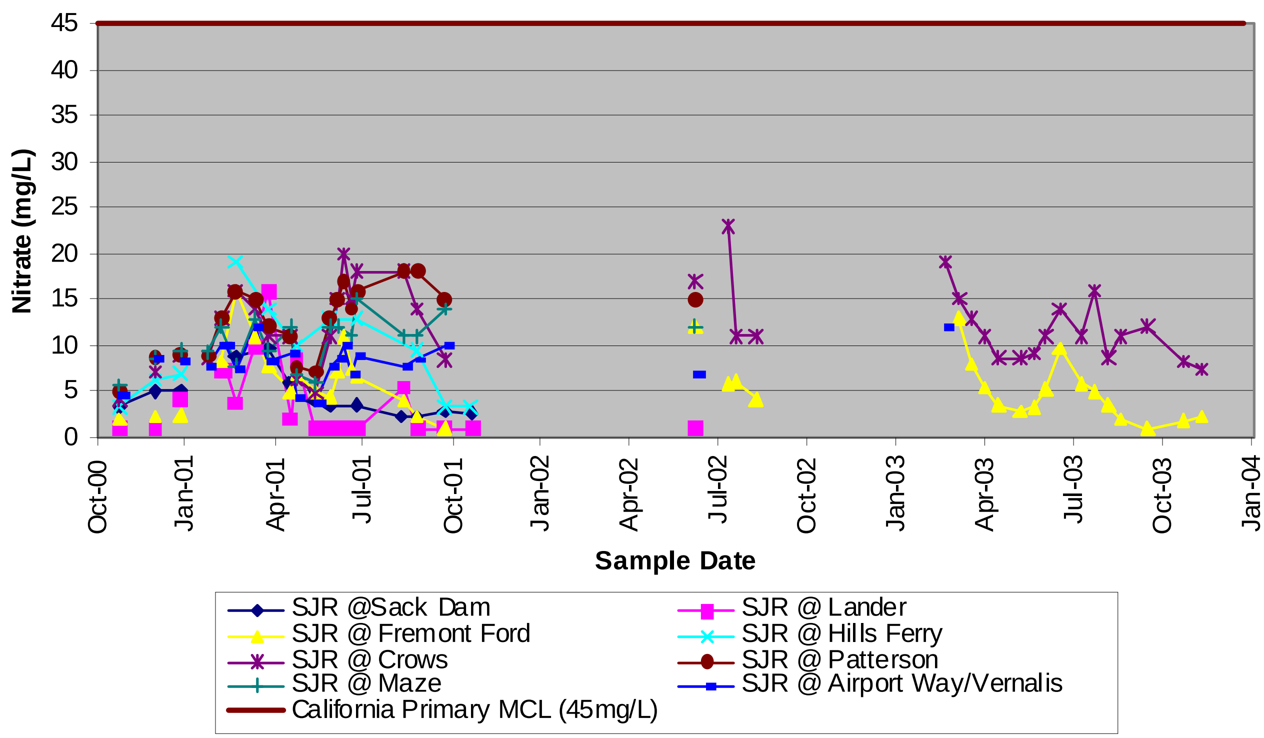


Figure 45: San Joaquin River Northeast Basin Nitrate WY01

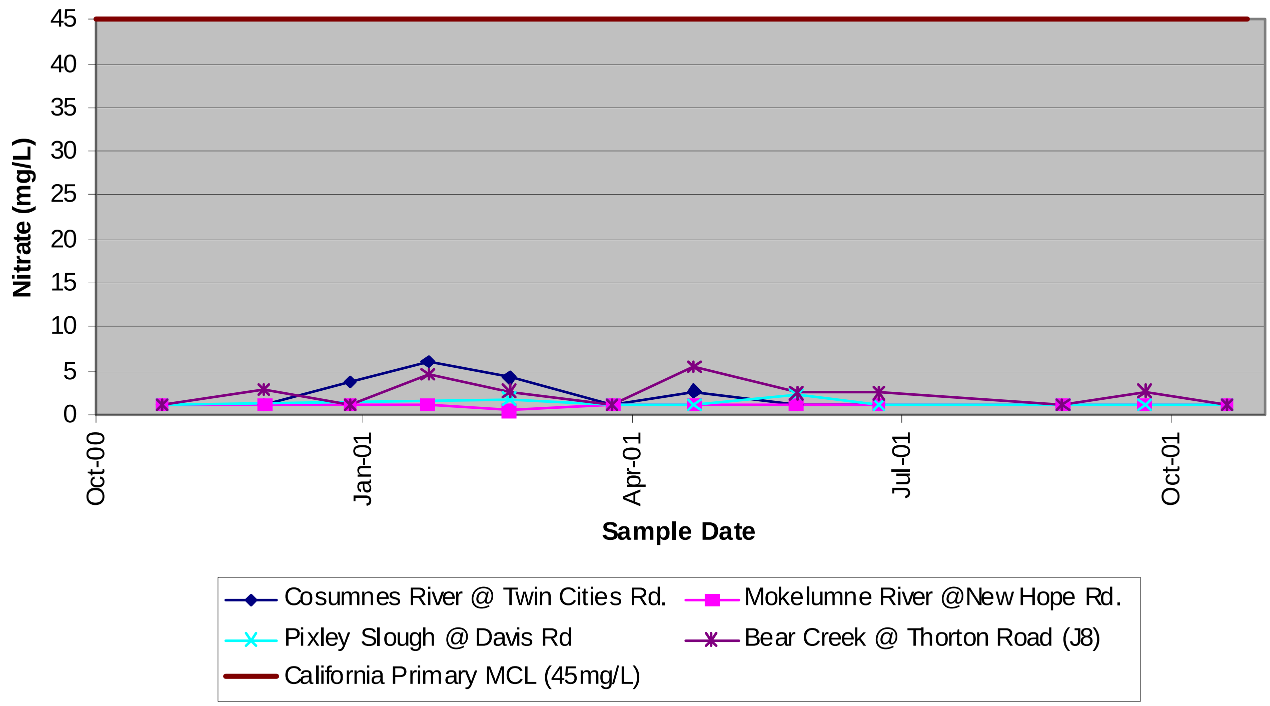


Figure 46: San Joaquin River Westside Basin Nitrate WY01

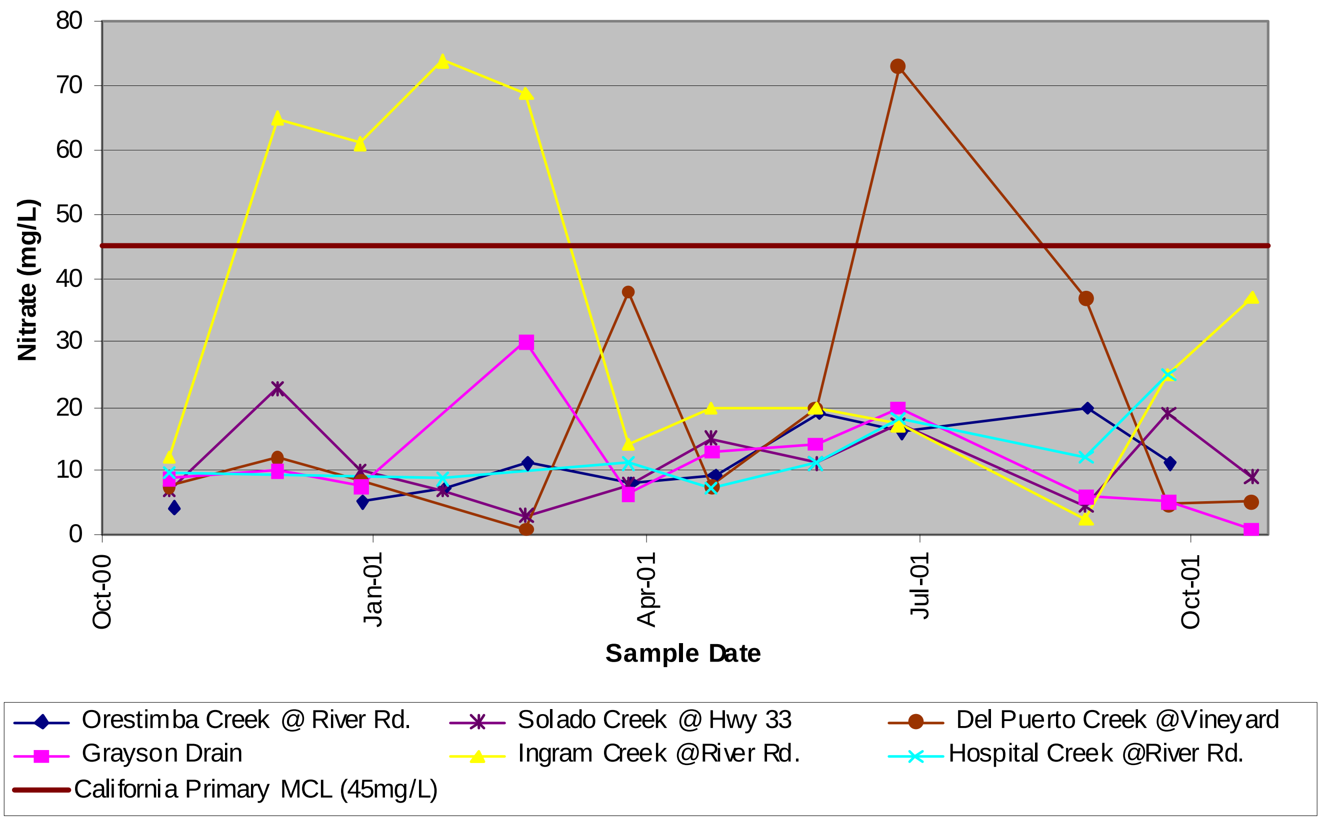


Figure 47: Basin Nitrate WY01-WY02

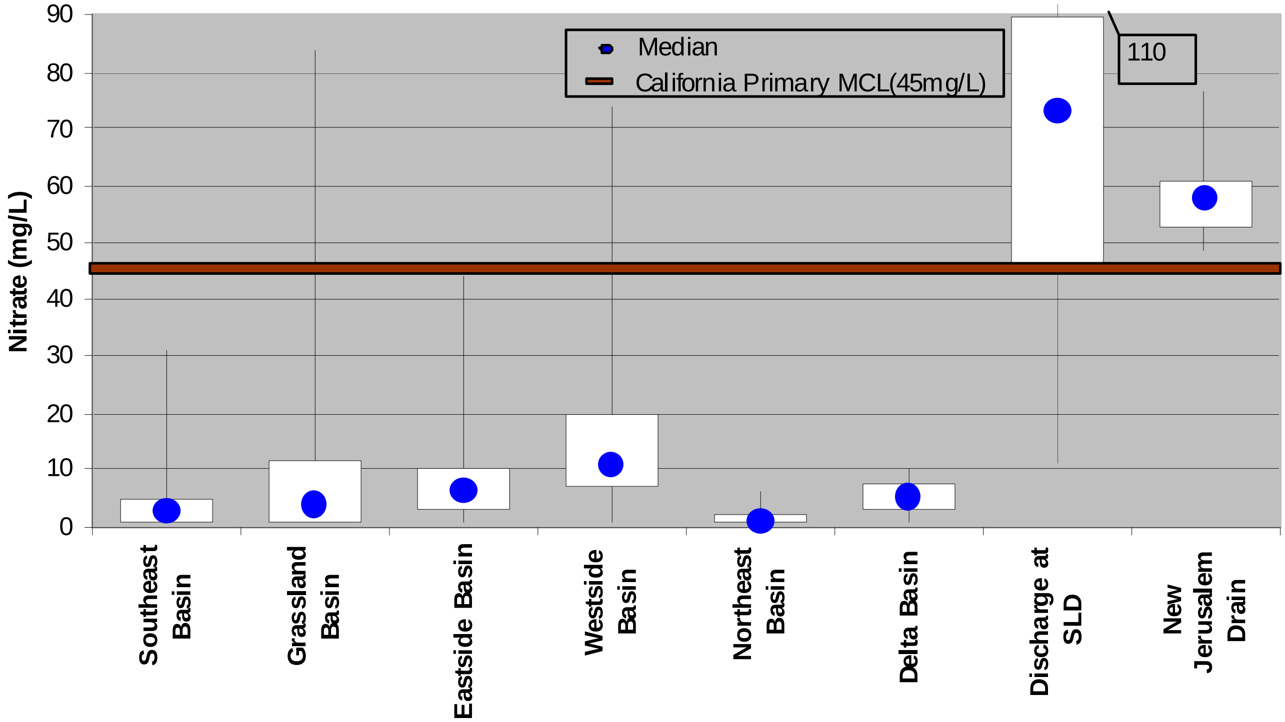
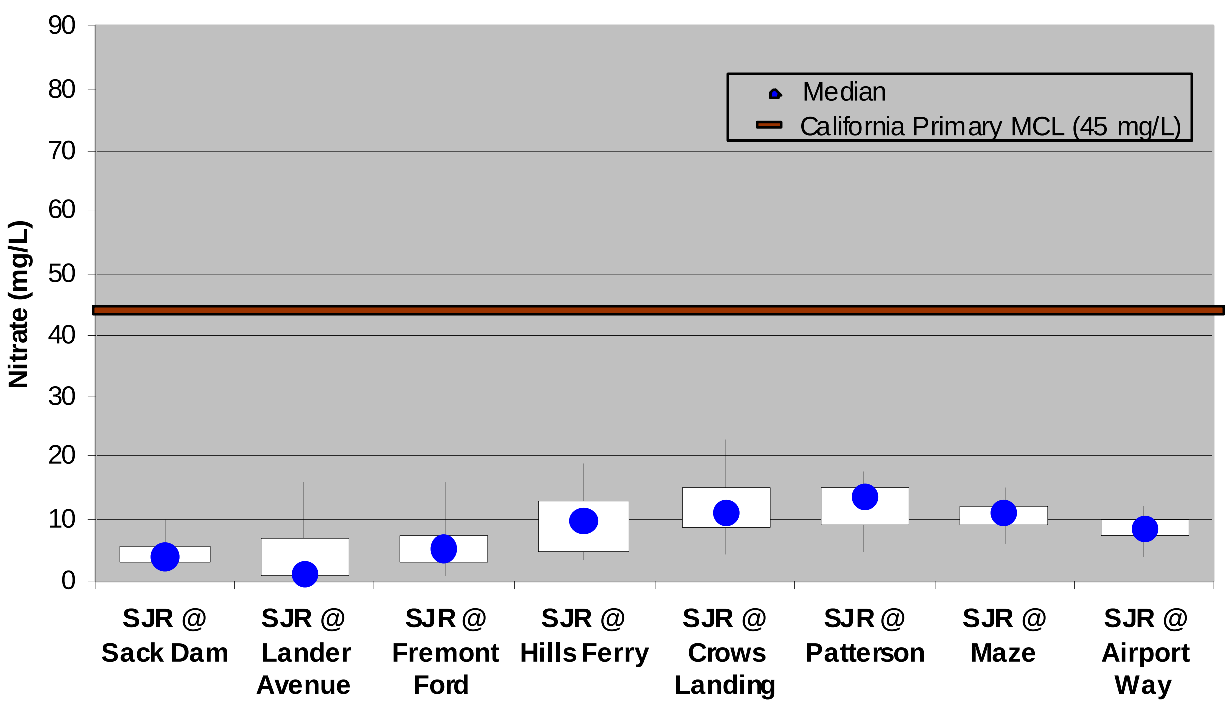


Figure 48: San Joaquin River Main Stem Nitrate WY02-WY04



12.1.10 BIOCHEMICAL OXYGEN DEMAND

As with the nutrient samples, Biochemical Oxygen Demand (BOD) samples were collected throughout the basin on a monthly basis through WY02. At the end of fiscal year 02/03, an initial review of the data collected was completed, as well as a review of collaboration efforts with the DO Total Maximum Daily Load (TMDL) effort. A change in the monitoring strategy for the DO TMDL eliminated the need for continued BOD analyses by this effort.

Biochemical Oxygen Demand (BOD) is a procedure that measures how fast biological organisms use oxygen in a body of water. Bodies of water with higher concentrations of organic matter have aerobic bacteria that decompose organic matter using the available oxygen within the water body. High nitrates and phosphates also contribute to higher BOD because they contribute to increased plant and algae growth which increase plant loss contributing to higher organic waste. Increased temperatures also contribute to higher algae growth. For this discussion we will be looking only at BOD_5 (biochemical oxygen demand 5-day test).

Higher fluctuations in BOD_5 occurred at most sites during the winter months and corresponded to spikes in flow and TOC. Concentrations of BOD_5 also increased and remained elevated during summer months, peaking during September, which again tracked TOC concentrations.

Spatially, all of the Eastside river sites had low concentrations of BOD_5 which reflect their low concentrations of TSS and TOC, when compared to the rest of the SJR Basin sites. The rest of the basin sites, except New Jerusalem Drain, had higher levels of TOC and TSS, and BOD_5. Figure 49 shows the Northeast basin as a whole had the lowest BOD_5 compared to the rest of the Basins. Some distinct findings within each sub-basin are noted below.

Northeast Basin: The Northeast Basin Mokelumne River had BOD_5 concentrations at or below 1 mg/L. The Cosumnes River had levels similar to the Mokelumne River most of the time except during June 2001, which was just before the river dried and the BOD_5 level increased to about 4 mg/L. This increase corresponds to the light rain event that occurred just before the river went dry and a similar spike in the TOC concentration. Potential inflow of nutrients and organic matter during the rain event, coupled with the already decreased flows and increased temperatures encourages algae growth, and may have contributed to higher BOD_5 levels. Pixley Slough and Bear Creek had higher fluctuations of BOD during the winter months of January and February.

Eastside Basin: The Eastside Basin river sites had BOD_5 levels mostly under 1 mg/L. There was one very large spike within all the river sites in December 2002, which corresponds to a storm event. The rest of the Eastside Basin sites fluctuate between 2 mg/L to 8 mg/L. The Harding Drain had the highest quartiles compared to the other Eastside Basin sites that had agricultural influences.

Southeast and Westside Basins: The BOD_5 concentrations in both basins fluctuated like the non-river sites of the Eastside Basin with multiple spikes in the summer and winter.

South Delta Basin: The BOD_5 concentrations at most of the South Delta Basin sites fluctuated like the non-river sites of the Eastside Basin except for the New Jerusalem Drain. Although the New Jerusalem Drain had high nitrate concentrations, it also had very low TSS and TOC concentrations, and BOD_5 levels hovering just above the detection limit of 0.1 mg/L.

Grassland Basin: The Grassland Basin fluctuated like the non-river sites of the Eastside Basin as well but fluctuated at slightly lower levels.

The Main Stem SJR sites whisker plot (Figure 50) looks very similar to the TOC whisker plot (Figure 38). BOD_5 has a very similar trend to TOC with Sack Dam having concentrations below 1 mg/L. The

SJR at Lander had the highest fluctuations of BOD_5 when compared to all the other sampling locations along the SJR. The BOD_5 concentrations tend to decrease from SJR at Lander to the SJR at Airport Way where BOD_5 is mostly under 2 mg/L.

Figure 49: Basin BOD-5 Day WY02-WY03

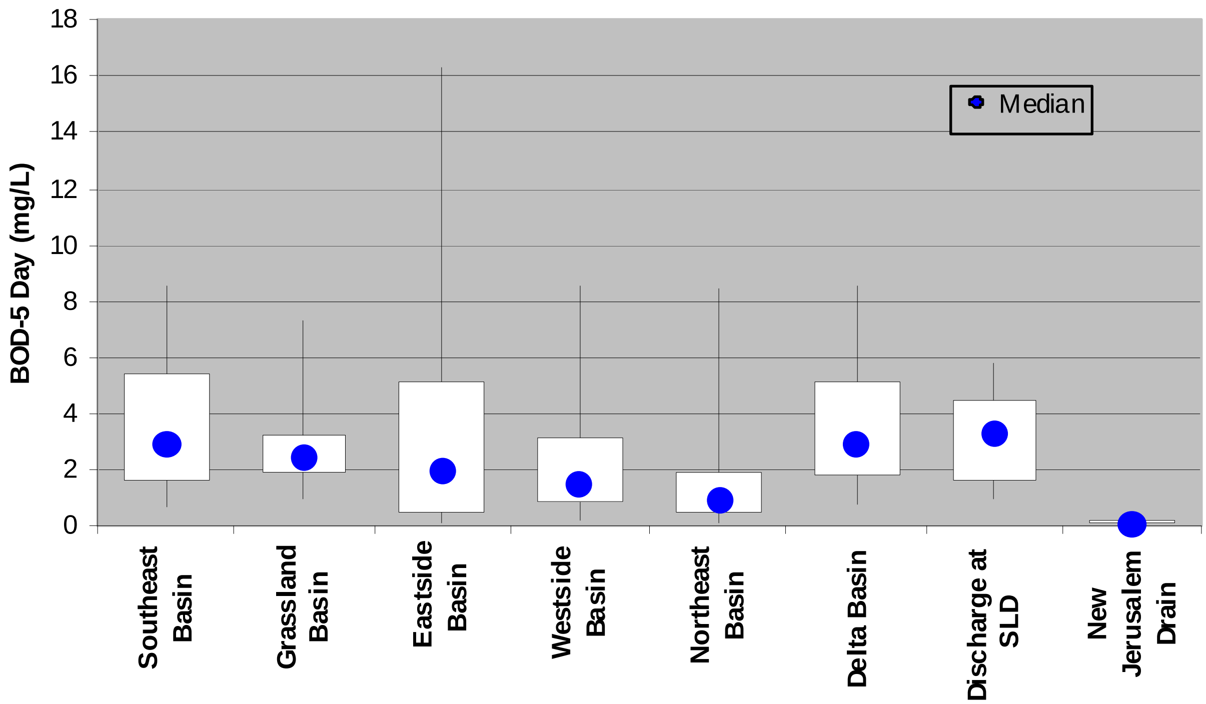
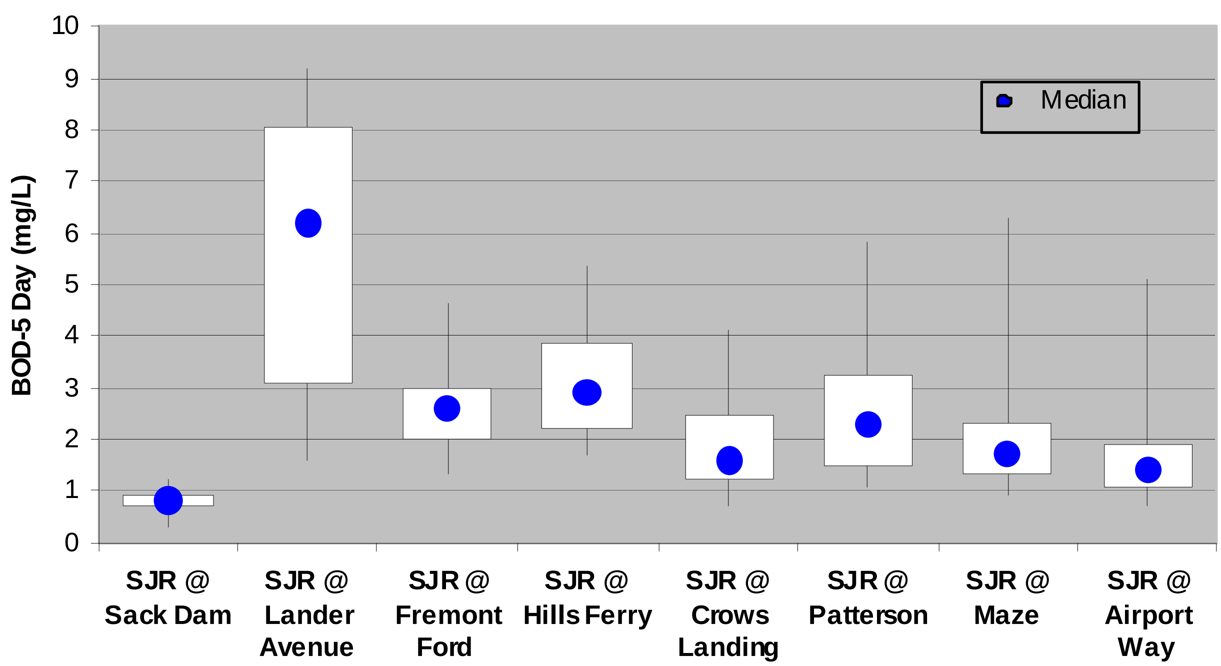


Figure 50: San Joaquin River Main Stem BOD-5 Day WY02-WY03



12.1.11 MINERAL ANALYSIS

Mineral samples were collected throughout the basin on a monthly basis during WY01 and sporadically during WY02 and WY03. At the end of fiscal year 02/03, an initial review of the data collected was done, as well as a review of collaboration efforts with other in-house programs, which resulted in a re-prioritization of monitoring efforts and the elimination of minerals from monitoring efforts.

Within the limited dataset, some general patterns are discernible. In general, the highest mineral concentrations occur along the western side of the SJR Basin, with elevated sodium concentrations and sulfate the dominant anion draining from the Grassland and Westside Basins and chloride the dominant anion from the Delta Basin. The eastern side of the SJR Basin reported much lower overall mineral concentrations with chloride the dominant anion. Carbonate was typically not detected or detected at very low levels, usually within the Westside Basin.

Along the western side of the valley, the SLD influences overall mineral discharges from the Grassland Basin, with elevated concentrations year-round. Concentrations of chloride and sulfate from the drain tend to dominate concentrations in Mud Slough (north) as winter dilution flow decreases. In contrast, during the dry season, sodium levels are elevated in Mud Slough (north) both upstream and downstream of the SLD discharge. The upstream concentrations are likely due to shallow groundwater discharge into the channel. For the remainder of the western side of the valley, mineral concentrations tended to increase during the winter then decrease but become somewhat elevated during the irrigation season. Sulfate and chloride concentrations all remained below the secondary drinking water MCL (250 mg/L), but sodium tended to remain above the irrigation supply guideline of 69-mg/L. The New Jerusalem Drain was the exception for sodium on the western side of the valley with concentrations remaining near 300 mg/L year-round.

Along the eastern side of the valley (the Southeast, Eastside, and Northeast Basins), sodium, chloride and sulfate concentrations all remained well below guidelines. Sodium did tend to show low level spiking throughout the year.

Some sites did show unique characteristics. Within the Westside Basin, Ingram Creek displayed pronounced seasonal fluctuation, similar to Tom Payne Slough of the Delta Basin, with marked increases in all minerals during storm events. Mud Slough (north) upstream of the SLD, was lower than the SLD in all mineral concentrations except total alkalinity and bicarbonate.

While seasonal fluctuations of mineral concentrations are not distinctly seen within the SJR, the Main Stem sites do reflect the inflows from the various sub-basins. Mud Slough (north)'s influence on Hills Ferry is distinctly seen with all the mineral concentrations at this site consistently higher compared to the rest of the river. Sack Dam has the lowest concentrations within the river, but with the influences from the Southeast Basin, Grassland Basin and Turner Slough, mineral concentrations peak at Hills Ferry. Once the Eastside Basin rivers enter the SJR, mineral concentrations substantially decrease moving downstream to Airport Way, even with elevated concentrations coming in from the Westside Basin.

12.1.12 TRACE ELEMENTS

Trace element samples were collected throughout the basin on a monthly basis through WY02. Hardness was analyzed simultaneously for each trace element sample in order to allow evaluation against aquatic life criteria. At the end of fiscal year 02/03, an initial review of the data collected and a review of collaboration efforts with other in-house programs were completed. Re-prioritization of monitoring efforts resulted in a removal of trace element collection. Note that during the collection period reporting limits changed for some constituents.

Many of the results for this study were below the analytical reporting level. Some trace elements did appear to show some trends, depending on the location within the SJR valley. In general, the Northeast and Eastside Basin river sites have lower concentrations than the other basins within the SJR valley. One issue to note with this finding is that the hardness levels in the northeast basin are also lower when compared to the other sub-basins. Hardness concentration is particularly important for aquatic life because hardness tends to buffer toxic impacts, allowing tolerance of higher concentrations of many trace elements. Some distinct findings within each sub-basin are listed below.

Northeast Basin: Most of the trace elements sampled in the Northeast Basin had results below the reporting limit. Copper and zinc were the only two metals that were consistently above minimum reporting levels for all the sites within the Northeast Basin. Chromium had multiple samples above detection for most sites except the Mokelumne River which only had two samples for total chromium above detection levels.

Eastside Basin: The Eastside Basin river sites were similar to the Mokelumne River with non-detect values for all metal constituents, except copper and zinc. The Eastside Basin river sites had more non-detect values for zinc than the Mokelumne River. The non-river sites were comparable to the river sites data, except for having higher concentrations of copper, zinc and total chromium. Nickel was also reported at concentrations above minimum reporting levels for the non-river sites during the winter higher flow periods.

Southeast Basin: The Southeast Basin sites were similar to the non-river sites of the Eastside Basin. One exception was Deep Slough which had high levels of arsenic and total nickel reported year-round.

South Delta Basin: The New Jerusalem Drain had non-detect values for most of the trace elements except for chromium where high concentrations were detected. Tom Payne Slough trace element concentrations were similar to that of the Deep Slough, having higher levels of arsenic, but with minimal total nickel. Old River and Mountain House Creek both had very low levels of arsenic. Mountain House Creek, similar to Deep Slough, had total nickel concentrations found throughout the sampling period.

Westside Basin: The Westside Basin unlike the Northeast Basin had more detected concentrations of total lead and had higher concentrations and major spikes of copper, zinc, and chromium. Hospital Creek had the largest spikes of copper, zinc, nickel and chromium. These very large spikes seemed to occur mostly during the irrigation season. Del Puerto Creek was the only Westside basin site that did not have any samples above the minimum detection level for lead.

Grassland Basin: Salt Slough had very similar concentrations of trace elements compared to Deep Slough with just slightly lower levels of arsenic. Mud Slough Upstream was similar to Salt Slough having detectable arsenic but at slightly lower concentrations. The dominant trace element concentrations at the Discharge from SLD site were chromium and copper.

The majority of the concentrations of trace elements that were seen in the Main Stem SJR were the dominant trace elements identified in the sub-basins including; arsenic, chromium, copper, nickel and zinc. With most of these constituents, trace element concentrations went up from Sack Dam to Hills Ferry due to the Grassland influences and from Hills Ferry downstream to Airport Way concentrations decreased due to the Eastside river influences. This trend is similar to the trend seen with minerals.

12.1.13 TOXICITY

Funding constraints limited the overall number of full (three species) water column toxicity tests. The three species tested were fathead minnow (*Pimephelas promelas*, sensitive to elevated nutrients, especially ammonia), *Ceriodaphnia dubia* (sensitive to organic chemicals such as orthophosphorus-pesticides), and algae (such as *Selanastrum capricornutum*, sensitive to trace elements). During Water Years 01, 02 and partially in 03 acute toxicity tests were run on fathead minnow and *Ceriodaphnia dubia*, and while it was encouraging to see limited if any acute effects, there was concern that dilution flows might be masking some effect. Analyzing samples for chronic toxicity was more costly, but considered a more conservative option.

With limited funding during WY 04, toxicity samples for chronic fathead minnow and chronic *Ceriodaphnia dubia* were collected in the Main Stem during the irrigation season only. During WY 05, toxicity samples for acute and chronic fathead minnows, acute and chronic *Ceriodaphnia dubia*, and acute algae were collected once a month at the various sites shown in Table 1. Funding was not available to run toxicity identification evaluations (TIE) on samples identified as a toxic event and therefore results can only be evaluated against data collected during each sampling event.

The sporadic sampling did not discern specific trends. Results in Table 6 are discussed by sub-basin below.

Northeast Basin: Northeast Basin had recorded toxicity in the Cosumnes River and Bear Creek for the acute fathead minnow test (Table 6). One hundred percent of the four samples collected at Cosumnes River for the acute algae test had a reduction of cell growth. The Mokelumne River only displayed toxicity for the chronic fathead minnow test. The rest of the samples during the sampling period displayed no toxic event.

Eastside Basin: Within the Eastside Basin acute fathead minnow toxic events were only reported for French Camp Slough. Lone Tree Creek had one toxic event for acute *Ceriodaphnia dubia*. Acute algae and chronic fathead minnow test were only conducted at the river sites, except for four acute algae samples collected at Harding drain, and each site had toxic events (for algae reduction and increase in cell growth were found). Over 50 percent of the samples collected at Tuolumne River reported toxic events for the chronic fathead minnow test.

Southeast Basin: Bear Creek at Bert Crane Road had three toxic events for the acute fathead minnow test. The remainder of the samples displayed no toxic events.

South Delta Basin: The New Jerusalem Drain had one toxic event for the acute fathead minnow test and the acute *Ceriodaphnia dubia* test. Both of the two samples collected for the acute algae toxicity had a growth statistical difference which could be due to the very high nitrate concentrations within the New Jerusalem Drain. Tom Payne Slough had one toxic event (reduction of cell growth) out of one sample collected for the acute algae test. Mountain House Creek had one toxic event (increase in cell growth) out of two samples collected for the acute algae test.

Westside Basin: Toxic events were seen at Orestimba Creek, Grayson Drain and Hospital Creek for the acute *Ceriodaphnia dubia* test. No other toxic events were observed. Note that only acute fathead minnow and *Ceriodaphnia dubia* samples were collected and analyzed within the Westside Basin.

Grassland Basin: Salt Slough had a total of three acute algae samples collected with two having a reduction in growth and one being an increase in algae growth. None of the seventeen samples collected at Salt Slough for acute fathead minnow or acute *Ceriodaphnia dubi*a had toxic events.

Spatially, not one basin stands out from the rest. As a whole, a majority of the acute algae samples within the SJR Basin had a toxic reduction or growth in algae. Only twelve samples out of 59 collected throughout the basin did not have a statistical difference from the control whether being a reduction or increase in algae growth.

The Main Stem SJR sites reflected the same finding of the Basin sites with only eight out of the 31 samples of acute algae not having a statistical reduction or increase in growth when compared to the controls. At least one toxic event was found in each of the Main Stem sites sampled for the chronic fathead minnow and chronic *Ceriodaphnia dubia* tests.

12.2 Evaluation of Beneficial Uses

To evaluate potential impact, indicators were chosen for four broad beneficial uses as shown in Table 3:

1. Drinking water (Specific Conductivity, Total Organic Carbon, Trace Metals, Nutrients);
2. Aquatic life (pH, Temperature, Dissolved Oxygen, Turbidity, Trace Metals, Minerals and Water Column Toxicity);
3. Irrigation water supply (Specific Conductivity, Minerals); and
4. Recreation (bacteria).

Exceedances/ elevated levels tables were created with the data collected using the applicable water quality goals and objectives as described in section 9.2. Appendix P provides the exceedance/ elevated levels tables which compare the total number of samples collected with the total number showing elevated levels for temperature, pH, SC, TOC, DO, turbidity (within the legal boundaries of the Delta), bacteria, nitrate, nitrate-N, ammonia-N, chloride, sulfate, TDS, sodium, total and dissolved arsenic, total and dissolved cadmium, total chromium, total and dissolved copper, total and dissolved lead, total and dissolved nickel, total and dissolved zinc and total mercury. Most of the criteria used to set trace element limits take into account the hardness of the water at the time of sample collection since increasing hardness will tend to buffer the effect of particular trace elements. The hardness calculations were taken into account in both the summary tables presented in Appendix P and the discussion here. Constituents in Appendix P are evaluated against multiple objectives and goals, when applicable, for comparison of beneficial use impacts. Turbidity outside the Delta is discussed separately below.

The Basin Plan Objective for turbidity within the San Joaquin River Basin was designed for point source discharges. When evaluating turbidity basin wide, with weeks between turbidity results and miles between sites, the following evaluations should be looked at objectively and viewed as an overall comparison of the basin. With this in mind, see Table 7 for the selected upstream sites that were chosen to describe “natural background” for this Basin Plan Objective. Note for Cosumnes River at Twin Cities Road, Bear Creek at Lower Sacramento Road, French Camp Slough at Airport, and Lone Tree Creek at Austin Rd that the sites were compared to the Delta objective because they discharge directly into the Delta. Also, upstream sites are really not applicable to compare with the Main Stem river sites and were not evaluated using the above approach. Turbidity effects along the Main Stem are discussed in section 12.1 of the discussion section. Monthly geometric means were used because of collection time differences. See Table 7 for the number of times the monthly geometric mean of a site is greater than the monthly geometric mean of the selected upstream site using the calculations of the Basin plan objective.

The following discussion highlights information from Appendix P and Table 7 to assess beneficial use status in the SJR Basin.

Table 7: Selected Upstream Site Locations and Number of Turbidity Samples Greater than Selected Upstream site

Location	Site	Selected Upstream location	Selected Upstream Site	Turbidity's Monthly GeoMean Count*	Number of samples greater than Selected Upstream site using the Basin Plan Turbidity Objective
Main Stem					
SJR @Sack Dam	541MAD007	NA	NA	NA	NA
SJR @ Lander	541MER522	NA	NA	NA	NA
SJR @ Fremont Ford	541MER538	NA	NA	NA	NA
SJR @ Hills Ferry	541STC512	NA	NA	NA	NA
SJR @ Crows	535STC504	NA	NA	NA	NA
SJR @ Patterson	541STC507	NA	NA	NA	NA
SJR @ Maze	541STC510	NA	NA	NA	NA
SJR @ Airport Way/Vernalis	541SJC501	NA	NA	NA	NA
			Total Main Stem Count	0	0
Southeast Basin					
Deep Slough Green House Rd	535MER577	SJR @Sack Dam	541MAD007	17	8
Santa Rita Slough at Highway 152	541MER015	SJR @Sack Dam	541MAD007	NA	NA
Bear Creek Bert Crane Rd	535MER007	SJR @Sack Dam	541MAD007	13	10
			Total Southeast Basin Count	30	18
Grassland Basin					
Salt Slough @Lander/Hwy 165	541MER531	SJR @ Lander	541MER522	23	21
Mud Slough (n) (upstream) @ San Luis Drain	541MER536	SJR @ Fremont Ford	541MER538	21	3
Discharge from SLD	541MER535	Mud Slough (n) (upstream) @ San Luis Drain	541MER536	21	5
Mud Slough (n) (downstream) @ San Luis Drain	541MER542	SJR @ Fremont Ford	541MER538	22	2
			Total Grassland Basin Count	87	31
Eastside Basin					
Turner Slough at 4th Avenue	535MER576	SJR @ Lander	541MER522	17	17
Merced River Hatfield Park (River Road)	541MER546	SJR @ Hills Ferry	541STC512	10	0
Harding Drain discharge @ San Joaquin River (TID5	535STC501	SJR @ Crows	535STC504	13	1
Tuolumne River @ Shiloh	535STC513	SJR @ Patterson	541STC507	16	1
Stanislaus River @Caswell	535STC514	SJR @ Maze	541STC510	9	1
			Total Eastside Basin Count	65	20
West Side Basin					
Orestimba Creek @ River Rd.	541STC019	SJR @ Hills Ferry	541STC512	17	14
Solado Creek @ Hwy 33	541STC515	SJR @ Patterson	541STC507	11	8
Del Puerto Creek @Vineyard	541STC516	SJR @ Patterson	541STC507	16	11
Grayson Drain	541STC030	SJR @ Patterson	541STC507	13	11
Ingram Creek @River Rd.	541STC040	SJR @ Patterson	541STC507	14	7
Hospital Creek @River Rd.	541STC042	SJR @ Patterson	541STC507	13	9
			Total West Side Basin Count	84	60
Northeast Basin					
Cosumnes River @ Twin Cities Rd.	531SAC001	Discharges into Delta waters	150NTU	11	0
Mokelumne River @New Hope Rd.	544SAC002	Delta Waters		NA	NA
Pixley Slough @ Davis Rd	531SJC507	Bear Creek @Lower Sacramento Rd.	531SJC515	16	6
Bear Creek @ Thorton Road (J8)	544SJC508	Delta Waters		NA	NA
Bear Creek @Lower Sacramento Rd.	531SJC515	Discharges into Delta waters	150NTU	17	0
French Camp Slough @ Airport	531SJC504	Discharges into Delta waters	150NTU	8	0
Lone Tree Creek @ Austin Rd	531SJC503	Discharges into Delta waters	150NTU	6	0
			Total Northeast Basin Count	58	6
Delta Basin					
New Jerusalem Drain	544SJC001	Delta Waters		NA	NA
Tom Payne Slough @Paradise Rd.	544SJC505	Delta Waters		NA	NA
Old River @Tracy Blvd	544SJC506	Delta Waters		NA	NA
Mountain House Creek	544SJC509	Delta Waters		NA	NA
			Total Delta Basin Count	0	0

*Number of times the monthly geomean was able to be calculated

Drinking Water (Specific Conductivity, Total Organic Carbon, Trace Metals, *E. coli*, Nutrients)

Indicators used to evaluate a potential impact to drinking water (sources of municipal and domestic supply) included salt measured as specific conductivity (umhos/cm), total organic carbon (TOC), selected trace elements (total arsenic, cadmium, copper, mercury, nickel, lead and zinc), nitrate and *E. coli*. For all of the indicators except *E. coli*, there are specific numeric objectives or goals for drinking water that results can be evaluated against (Appendix Q1 and Q2). There are no specific numeric criteria for *E. coli* related to consumption but the presence of *E. coli* would indicate that the water would need to be treated prior to consumption.

For specific conductivity, the California Secondary MCL of 2200 umhos/cm for short term exposure was utilized. Elevated levels are found in the South Delta Basin non-river sites and in Salado Creek within the Westside Basin. The Main Stem sites that displayed elevated levels above this goal were SJR at Lander, SJR at Fremont Ford and SJR at Hills Ferry. These Main Stem sites are located upstream of the first eastside inflow (Merced River) and are therefore dominated by groundwater accretion and inflows from the Southeast and Grassland Sub-basins. Once the Eastside rivers flow into the SJR, the specific conductivity within the SJR declines until Vernalis.

The TOC goal of 3.0 mg/L is based on the Bay Delta Authority's guideline for water quality in the Sacramento-San Joaquin Delta (Cal Fed Bay-Delta Program, 2000). This indicator was chosen to help identify potential sources of TOC to the Delta since all water bodies monitored flow into the San Joaquin River and ultimately into the Delta. Overall TOC concentrations were reported above 3.0-mg/L throughout the SJR Basin (Figure 51). The Northeast Basin had the lowest concentrations of TOC compared to the rest of the SJR Basins, but still exceeded 3.0-mg/L about half of the time. Storm events and agricultural runoff during the irrigation season correlated well with many of the spikes in concentration, but the goal was surpassed in the majority of the sites at other times of the year as well and at sites that were not identified as receiving agricultural return flows.

Roughly 10-percent of the 526-nitrate samples collected exceeded the nitrate California Primary MCL (45 mg/L). All of the 10 samples collected at New Jerusalem Drain (representing shallow ground water in the Westside Basin) were above this objective. The Grasslands Basin also had elevated levels of nitrate at all sites except Mud Slough upstream of SLD. Two sites (Discharge at SLD and Mud Slough (downstream) @ SLD—both within the Grassland Basin) had samples that exceeded the nitrate-N California Primary MCL (10 mg/L).

For total arsenic two goals were evaluated for drinking water: 1) the Basin Plan Objective for the California Primary MCL of 50 µg/L and 2) the USEPA Primary MCL of 10 µg/L. No samples exceeded the Basin Plan objective during the 5 year sampling period. Thirteen samples exceeded the USEPA primary MCL. The three sites that had elevated levels above this goal were SJR at Lander, Deep Slough and the Grayson Drain.

The total cadmium Basin Plan Objective for the California Primary MCL of 5 µg/L, total copper Basin Plan Objective for the California Primary MCL of 1000 µg/L, and the total zinc Basin Plan Objective for the California Primary MCL of 5000 µg/L were never exceeded during the 5 year study.

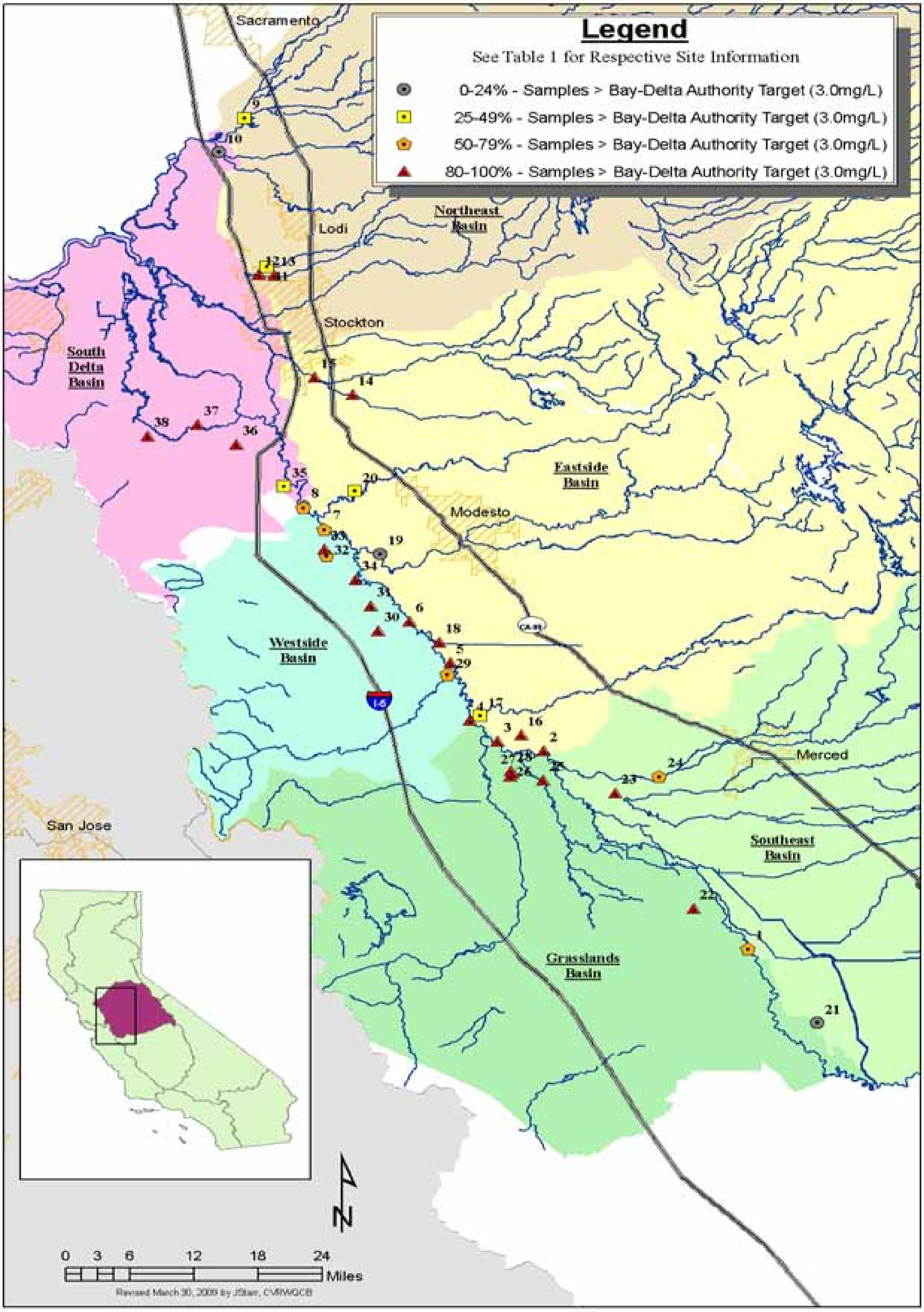
The total chromium Basin Plan Objective for the California Primary MCL of 50 µg/L, total lead Basin Plan Objective for the California Primary MCL of 15 µg/L, and the total nickel Basin Plan Objective for

California Primary MCL of 100 µg/L were all exceeded by three sites in the Westside Basin. Hospital Creek, Ingram Creek and Grayson Drain exceeded these goals during the irrigation season.

The total mercury Basin Plan Objective for the California Primary MCL of 2 µg/L was never exceeded during the 5 year sampling period. Total mercury was found elevated above the California Toxics Rule (USEPA) for sources of drinking water, 0.05 µg/L, once in Hospital Creek (0.2 µg/L).

Table 8 is a quick summary to show whether the river or any of the basins have potential beneficial use impacts based on the indicators evaluated.

Figure 51: Percentage of Total Organic Carbon samples greater than the Bay-Delta Authority Target (3.0 mg/L)



Aquatic Life (pH, Temperature, Dissolved Oxygen, Turbidity, Trace Metals, Minerals and Water Column Toxicity)

The Basin Plan objective for pH for freshwater with COLD or WARM beneficial uses is a range between 6.5 to 8.5 units. Each of the Basins exceeded this objective multiple times, but no site exceeded this objective more than 18 percent of the time. The Main Stem and the Grasslands exceeded this objective during the summer irrigation season. The other basins exceeded this objective randomly with drastic fluctuations.

The Bay-Delta Authority target for a temperature of 20ºC from April 1 – June 30 and from September 1 – November 30 applies to the San Joaquin River at Vernalis. Samples collected at Vernalis had temperatures recorded above this target 41% of the time during the 5-year study. Every site within the SJR Basin reported temperatures above this target at least once during the sampling period with the highest percentages seen within the Southeast and Grassland Basins.

The dissolved oxygen Basin Plan objective of 7.0-mg/L (described in Appendix Q1 as outside the Delta for cold/spawning beneficial use) was used for all non-Delta sites. Results were found below the above objective at least once for every site except for the Cosumnes and Stanislaus Rivers. The basin with the highest percentage of results below the objective was the Northeast Basin in the non-river sites and the lowest percentages were found in the Westside Basin. Sites within the legal boundaries of the Delta were evaluated against the Basin Plan objective of 5.0 mg/L for dissolved oxygen. All Delta sites were below this objective at least once except New Jerusalem Drain. Tom Payne Slough had the highest percentage of results below this objective with 19 out of 47 samples.

Sites within the legal boundaries of the Delta were evaluated against the Basin Plan objective of 150 NTU for turbidity. This objective was only exceeded once at Mountain House Creek during a non-storm event. New Jerusalem Drain and Mountain House Creek both exceeded the objective during the December 2002 storm event, however this objective doesn't apply for storm events. For non-Delta sites the Basin Plan objective was designed for specific discharges. As described in the turbidity results section of this report, Table 7 attempts to use the Basin Plan objective to have an overall assessment of the SJR Basin turbidity concentrations. The Westside Basin had greater turbidity 71 percent of the time compared to the selected upstream sites. Higher turbidity levels were typically associated with major storm events and irrigation seasons.

The USEPA California Toxics Rule for total and dissolved cadmium, total and dissolved nickel, dissolved arsenic, dissolved lead, and dissolved zinc was never surpassed during the sampling period. No samples were elevated above the USEPA National Ambient Water Quality Criteria for 1 hour average of 1.4 µg/L for total mercury during the sampling period.

The USEPA California Toxics Rule for total and dissolved copper was exceeded in multiple samples, primarily in the non-river sites of the Northeast and Eastside Basin, particularly in French Camp Slough, Lone Tree Creek, and Pixley Slough. In addition the Westside and Southeast Basin had a few elevated samples for total copper as well. The USEPA California Toxics Rule for total lead was exceeded once in the Mokelumne River. Pixley Slough reported one sample above the USEPA California Toxics Rule for total zinc. Even though the concentrations of the metals were lower in the Northeast and Eastside Basins when compared to the Westside Basin, the hardness levels were also comparatively low which resulted in lower concentration thresholds that could impact aquatic life.

No sample was reported above the chloride USEPA National Ambient Water Quality Criteria for 1-hour average of 860 mg/L during the study.

Various levels of water column toxicity were reported on multiple occasions (Table 6). A higher percentage of chronic toxicity was reported as compared to acute toxicity. Acute algae toxicity samples were collected less frequently than other toxicity samples, but had the highest percentage (50 percent) of toxic findings (samples having a reduction or increase in growth at all sites except for Fremont Ford).

In summary there were multiple concerns throughout the basin for aquatic life. Drastic fluctuations of pH occur at multiple locations, but for the majority of the time most sites are within range of the Basin Plan objective. Elevated temperatures during the spring and fall may impact fish migration. Low DO levels were seen in multiple sites, most consistently in non-river sites, but no overt impact (e.g. fish kills) was ever noted. Trace element results exceeding hardness adjusted criteria were mostly reported in the Northeast and Eastside basins—as were the lowest hardness concentrations. Total copper was the primary trace element of concern having higher percentages of elevated levels in French Camp Slough, Lone Tree Creek, and Pixley Slough. Turbidity concentrations can become highly elevated during storm events and the irrigation season but become difficult to interpret with the fluctuation of background concentrations.

Irrigation Water Supply (Specific Conductivity, Minerals)

For specific conductivity the Basin Plan has an objective of 700 umhos/cm April through August and 1000 umhos/cm September through March for SJR at Airport Way (also known as Vernalis). This objective only applies to a maximum thirty day running average. Although approximately 21 percent of individual samples collected at Vernalis had concentrations above the noted objective during the sampling period, exceedances can not be determined using the limited grab samples.

Multiple samples at concentrations above the Water Quality Goal for Agriculture of 700 umhos/cm (Marshack, 2003) were found in all basins except the Northeast Basin. The Eastside Basin had the lowest percentage of elevated samples (39 out of 409—9.5%) and the Grasslands (1047 out of 1049--~100%), Westside (330 out of 516—64%) and the South Delta Basin (163 out of 188—87%) had the highest percentages of elevated samples. Multiple samples collected along the SJR also had concentrations reported above the Water Quality Goal for Agriculture. The elevated concentrations were consistently clustered between Lander Avenue (primarily ground water accretions) and Maze Blvd., a stretch of river receiving inflows from the Grassland, Eastside and Westside Basins.

Chloride and sodium concentrations that were above water quality goals of 106 mg/L and 69-mg/L, respectively, tracked elevated levels of specific conductance.

Concentrations above the total dissolved solids Water Quality for Agriculture goal of 450 mg/L occurred mostly in the Grasslands and Westside Basin. The Northeast Basin was never above this goal and most of the elevated concentrations reported in the Eastside Basin were found in the Harding Drain.

In summary, salt concentrations throughout the SJR Basin appear to be elevated above optimal concentrations for irrigation water supply, except within the Northeast and Eastside Basins. Salt is a well documented issue within the Grasslands and Westside Basins, with the natural background of the area being highly saline and high salinity water being pumped from the Delta to meet agricultural needs. Huge continuous efforts to control salt have been implemented in the past and continue to this day.

See the future actives section 14.0 of this report for more information on the current efforts being made to address salt in the SJR valley.

Recreation (Bacteria)

All the sites monitored during this study are either specifically designated or tributary to a water body designated for full contact recreation (e.g. swimming), except for the San Luis Drain and New Jerusalem Drain. As a conservative approach, the USEPA Guideline for full contact of 235 MPN/100ml *E. coli* was used to evaluate the entire SJR basin. Many of sites may not support full recreational contact due to physical attribute (e.g. ankle deep water), however, the use of a single guideline provided consistency for the review.

The highest percentages of *E. coli* concentrations exceeding 235 MPN/100ml were found in the Westside Basin and the non-river sites of the Eastside Basin (Figure 52). *E. coli* spikes were seen during high and low flow events meaning *E. coli* spikes are randomly present during both winter storm events when it would be unlikely to find people swimming and during the warmer summer season when most recreational contact would occur.

Figure 52: Percentage of *E. coli* samples greater than the USEPA Guideline: Designated Beach Area (235 MPN/100ml)

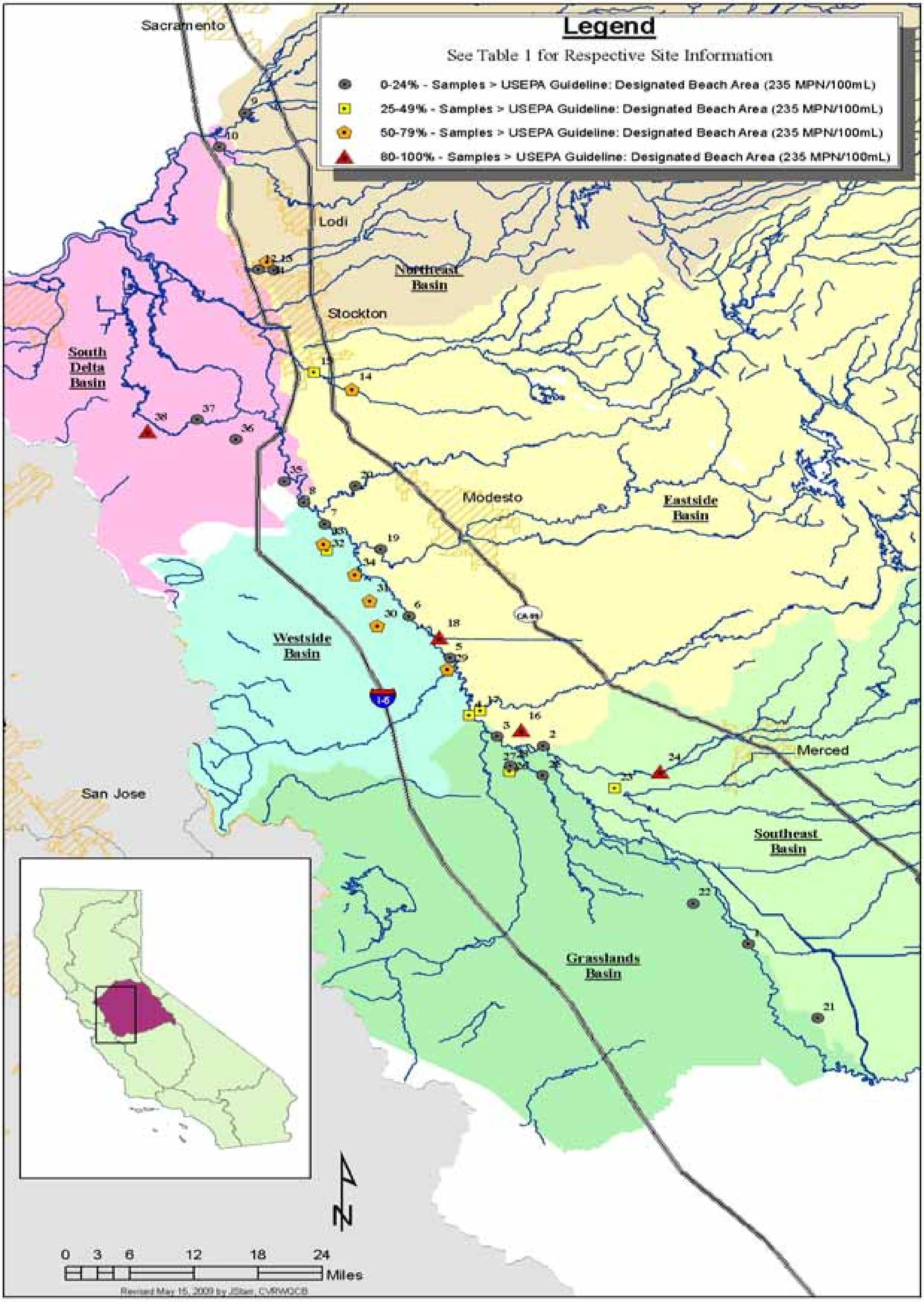


Table 8: Summary of Potential Beneficial Use Concerns: San Joaquin River and Sub-Basin Sites (2000 to 2005)

Beneficial Use/Indicator	San Joaquin River							Sub-Basins					
	Sack Dam	Lander Ave	Fremont Ford	Crows Landing	Patterson	Maze	Airport	SE	Grassland	East	West	NE	S. Delta
Drinking Water													
Specific Conductivity		X	X	X					NA		X		X
Total Organic Carbon	X	X	X	X	X	X	X	X	X	X	X	X	X
Trace Elements		T. Arsenic						T. Arsenic			4		
E. coli	X	X	X	X	X	X	X	X	X	X	X	X	X
Nutrients[3]									Nitrate		Nitrate		Nitrate
Aquatic Life													
pH	X	X	X		X	X	X	X	X	X	X	X	X
Temperature	X	X	X	X	X	X	X	X	X	X	X	X	X
Dissolved Oxygen	X	X	X	X	X	X	X	X	X	X	X	X	X
Turbidity	NA	NA	NA	NA	NA	NA	NA	X	X	X	X	X	X
Trace Elements								T. Copper			T. Copper	5	
Minerals													
Water Column Toxicity	7	X	1	X	X	2	X	X	X	X	X	X	X
Irrigation Water Supply													
Specific Conductivity	X	X	X	X	X	X	X	X	X	X	X		X
Minerals	X	X	X	X	X	X	X	X	X	X	X		X
Recreation (Swimming)													
E. coli	X	X	X	X	X	X	X	X	X	X	X	X	X

X =One or more result above a goal or objective

NA = There is no goal or objective applicable to the location

[1]Only had three samples taken with no toxic event found

[2] Only had one sample taken with no toxic event found

[3] Found for Nitrate only

[4] total arsenic, total chromium, total lead, total nickel and total mercury results were found above drinking water goals

[5] total and dissolved copper, total lead, and total zinc were found above aquatic life goals

[6] total and dissolved copper were found above aquatic life goals

[7] no samples were taken