8.0 DISCUSSION

This study area included a wide variety of differing water and land uses, ranging from relatively undisturbed areas, to highly managed water systems. The basin drains large areas of high elevation watershed, up to 11,750 feet at Leavitt Peak near Carson Pass, where much of the flow is generated from snowmelt. As the water moves through lower elevations, runoff from multiple land uses (e.g. urban, grazing, and irrigated agriculture) contribute to the flow.

The objectives for this study were to:

1. Determine spatial and temporal trends
    a. Spatial includes moving downstream within individual sub-watersheds as well as comparisons between sub-watersheds;
    b. Temporal includes seasonal variations
2. Evaluate stakeholder identified concerns
    a. Potential impact of residential construction in a rural community (Woods Creek study)
    b. Potential impact of an agriculturally dominated subwatershed (Dry Creek) on the Tuolumne River
3. Conduct a preliminary evaluation of beneficial use protection.

In addition, this study serves as a baseline for future water quality investigations.

The following sections evaluate water quality: within each individual sub-basin as water moves downstream through various land uses over the course of a year; between hydrologic zones (i.e., upper tributary, reservoir release, lower mainstem, and valley floor); between sub-basins just prior to discharge to the San Joaquin River; at specific stakeholder requested sites (upstream and downstream of construction in Woods Creek and upstream and downstream of Dry Creek inflows to the Tuolumne River); and in context with water quality objectives, goals, and guidelines.

To provide visual summaries of the data collected, box and whisker figures of summary data and scatter plots of all data are included in these discussions. Each paired set of figures focuses on a constituent within each discussion, and sampling sites are identified by site description.

The summary data included in the box and whisker figures provides a spatial visualization of the data and includes the minimum and maximum concentrations recorded and median of all data collected. The minimum and maximum are represented by the bottom and top of the whiskers, respectively. The median is represented by a dashed line. Additionally the data was summarized by the first and third quartiles (25^{th} and 75^{th} percentiles, respectively), and is represented by the top and bottom of the box. Sites are arranged from upstream to downstream, left to right. Where necessary, they are also arranged from north to south, left to right.

The scatter plots include each data point for each site included in the discussion of the corresponding figure. The time scale starts January 4, 2003 and ends May 28, 2004. The calendar years are separated with a dashed line. When available, lines representing water quality objectives, goals, or guidelines have been included for context. Discussion of the data within the framework of these water quality objectives, goals and guidelines is included in section 8.4 Water Quality Discussion.

8.1 Spatial and Temporal Trends within Individual Sub-Basins

8.1.1 River Basin Sites

Data was more variable where spatial variability was greatest, e.g. upper watershed sites (elevation of 700 – 1750 feet), which primarily received drainage from areas dominated by native vegetation, typically forested areas mixed with chaparral and rolling grassland, and where some areas could receive runoff from rural urban communities. The lower watershed areas (from 360 feet elevation at the bottom of Lake McSwain in the Merced Watershed to 30 feet elevation at the MID Main Drain) transition from native barren and vacant areas (open lands, flood control, etc.) to areas dominated by agricultural uses. Some major cities such as Modesto and Turlock, as well as many of the smaller towns and unincorporated areas, can provide runoff, particularly during storm events, to the lower watershed areas. Both the Farmington Drainage Basin and the Valley Floor sub-basins exist in the lower watersheds and are dominated by irrigated agriculture.

Upper watershed sites were chosen to provide background or source water characteristics for the study area. Additional sites were then located progressively downstream in the main stem channels, below major inflows and land use changes. Data collection in the Tuolumne River Basin was expanded to include sites in ephemeral streams draining the upper watershed. In Figures 7 through 62, sampling sites are arranged from left to right, upstream to downstream. Where sampling sites are not linked by draining in to one another, as is the case in the Tuolumne River Tributary sites and the Valley Floor Drainage Area, sites are arranged from north to south (left to right) rather than upstream to downstream. Additionally, figures for the Farmington Drainage Area are arranged with Duck Creek at Highway 4 to the far right since all other sites from this Drainage Area eventually drain in to French Camp Slough, but the Duck Creek confluence was downstream of the French Camp site.

Concentrations and trends in the Tuolumne River Basin were generally found to be representative of the Stanislaus and Merced River Basin findings, so are discussed in detail in this section. Information specific to the Stanislaus and Merced River sites can be found in Appendix B (data) and F (graphs), and is only presented here if anomalous to Tuolumne findings.

For the parameters discussed, the first set of paired figures shows the minimum, median, maximum and 1^{st} and 3^{rd} quartiles for each site moving downstream within the main stem and within the tributaries, respectively. The second set of paired figures shows actual data points collected during the course of the study for the main stem of the Tuolumne River and its tributaries, respectively. Upper and lower watershed sites refer to those above and below Don Pedro Reservoir.

Temperature

Spatially (Figures 9 and 10), temperatures within the tributaries above Don Pedro Reservoir are comparable with median concentrations near 14-C. The upper tributary temperatures are comparable to those for the tributary below the reservoir, but somewhat lower than for the lower mainstem where measured temperatures range to 26-C though the median remains near 17-C. The exception is the consistency of temperatures released into the lower watershed from Don Pedro Reservoir (ranging from 10 to 13-C year round).

Temporally (Figures 11 and 12) both tributaries and downstream main river channel sites show seasonal variability. Winter temperatures at all sites dropped to lows between 5 to 10-C. However, all sites except La Grange were elevated in spring, summer and fall, with temperatures remaining near 25-C between June and August.

Dissolved Oxygen

Spatially (Figures 13 and 14), dissolved oxygen concentrations are very similar at all the sites, with a majority of measured concentrations reported between 8 mg/L and 13 mg/L. Slightly higher median concentrations were found in the upper tributaries than in the main stem of the Tuolumne River. The exception was the tributary in the lower watershed (Dry Creek) where the majority of dissolved oxygen concentrations were below 9.5-mg/L.

Temporally (Figures 15 and 16), a seasonal oxygen sag does appear evident for all sites in the Tuolumne River Basin except for immediately below Don Pedro Reservoir. The sag occurs as the inverse of temperature with concentrations dipping to 8 mg/L and below, between June and September. Dry Creek concentrations are consistently lower than the remaining sites with lows reaching 6 mg/L.

<u>Specific Conductance</u>

Spatially (Figures 17 and 18), specific conductance (SC) demonstrates wide variability depending on the location within the watershed. The mainstem of the Tuolumne River demonstrates consistently increasing SC moving downstream with a median near 200-umhos/cm at Shiloh. The upper tributary sites vary widely, with some sites remaining below 150-umhos/cm and others reaching 500-umhos/cm. The two sites with the highest overall concentrations are actually located within the small community of Sonora, while the remaining two upper watershed tributaries with the lower overall concentrations are ephemeral streams. The lower watershed site (Dry Creek) is also within an urban area (Modesto), but is dominated by agricultural drainage and reported concentrations more in line with the ephemeral streams.

Temporally (Figures 19 and 20), similar to temperature, consistent, year-round, SC's were reported at the site just below releases from Don Pedro Reservoir (ranging from 35 to 44 umhos/cm). The remaining main stem sites showed variations in concentration between locations, but not with the time of year except for three dips in SC to concentrations similar to concentrations in the reservoir releases. The dips correspond to spikes in releases (end of April, mid October, and mid March). The tributaries showed seasonal variability in SC except for Sullivan Creek. This section of Sullivan Creek is below Phoenix Lake and has been modified to serve as a portion of the Phoenix Ditch. Water quality at this Sullivan Creek site may reflect the quality of the lake.

Specific conductance in the Stanislaus River Basin followed similar patterns as the Tuolumne with the exception that concentrations at the lower end of the basin remained consistently near or below 100-umhos/cm (Appendix B).

Sites in the Merced watershed were also similar except for the furthest downstream site at River Road. The SC concentrations at River Road were higher than upstream sites and also seemed to vary with time of year, ranging from 37 uhmos/cm to 416 umhos/cm (Figures 21 and 22). The significant drop in SC concentrations during May corresponds to increased reservoir releases during the VAMP[1] period. Concentrations remained above 200 umhos/cm from June through September and then dropped rapidly in October 2003, after a spike in releases from Exchequer Dam, with continued lower concentrations during the winter storms from October thru March.

<u>The pH</u>

Spatially (Figures 23 and 24), unlike other parameters, reported values of pH showed similar variability just below Don Pedro Reservoir (ranging from 7.0 to 8.1 units) as other sites along the main stem of the Tuolumne River. While the majority of the reported pH values within the lower watershed were below 8.0, the majority of reported pH values in tributaries within the upper watershed were above 8.0.

Temporally (Figures 25 and 26), the pH variability does not appear related to time of year nor do the downstream, main stem concentrations track those of the reservoir releases. Over the course of a year, less pH variability was evident within a site in upper watershed tributaries, but more variability existed between sites.

<u>Turbidity</u>

Spatially (Figures 27 and 28), turbidity in the Tuolumne River remained low overall but showed a steady increase moving downstream from Don Pedro Reservoir, ranging from a mean of 1.7 NTU at La Grange to 10 NTU at Shiloh. The tributaries had overall higher medians than the main stem river,

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[1] VAMP refers to the Vernalis Adaptive Management Program, which increases flow in Stanislaus, Tuolumne, and Merced Rivers from April to May. More details on VAMP can be found in section 5.0 Precipitation and Flow: January 2003 – April 2004.

with the greatest variability reported for Curtis Creek (an ephemeral stream) and for Dry Creek on the valley floor. The highest spike reported was in Dry Creek (53.6 NTU).

Temporally (Figures 29 and 30), during the course of the year, turbidity concentrations fluctuated greatly. Tributaries to the main stem of the river showed sharp increases in turbidity during the heavy rains in February 2004. In particular, Curtis Creek, which had been dry from June through November, responded to January and February 2004 rainfall events with turbidity spikes peaking at 300 NTU. The concentrations quickly dropped down to below 2 NTU by March. The other tributaries followed a similar pattern except for Dry Creek, which receives drainage from 2123 acres of orchards and 1992 acres of pasture. Turbidity in Dry Creek increased and remained somewhat elevated during the irrigation season, ranging from 20 NTU to 40 NTU between March and September 2003 (Figures 27 and 29). The main stem river sites did not show as clear a pattern. The site just below the reservoir stayed consistently low with one spike corresponding to a spike in releases during August 2003. The remaining downstream sites inconsistently had spikes in turbidity relating to rainfall events and increased flow releases. The extreme spike in turbidity concentration during January and February 2004 for the tributaries did not appear in the river sites.

Total Organic Carbon and Total Suspended Solids

Funding constraints limited collection of TOC and TSS data to March through June 2003. For the Tuolumne River main stem sites, although overall low medians were recorded (<1.0-mg/L and <4.0-mg/L, respectively), both constituent concentrations increased progressively downstream. Spikes in TSS but not TOC occurred at the furthest downstream site in April and again in June. The spike in April corresponds to a period of heavy rainfall and elevated flow, but the spike in June occurred during a dry period. Due to the limited data available and variety of local land uses, the source is not known for this spike.

Tributaries to the Tuolumne showed a similar pattern although the elevated concentrations during April and June occurred for both TOC and TSS. Dry Creek in the lower watershed, showed the highest overall concentrations (11.0-mg/L and 24.0-mg/L, respectively). Figures for the four months of TOC and TSS data can be found in Appendix F.

Coliforms

Total coliform concentrations, Figures 31 and 32, ranged from below reporting limits (<0 MPN/100mL) to above reporting limits (>2420 MPN/100mL), with concentration at all sites above reporting limits in the late spring months. The lowest consistent, overall total coliform concentrations occurred just below Don Pedro Reservoir. Most sites, including the tributaries remained above reporting limits throughout the majority of the study period.

Spatially (Figures 33 and 34), E. coli did demonstrate some patterns. In particular, E. coli steadily increased moving downstream from La Grange (median 3 MPN) to Shiloh (median 71 MPN), although maximum concentrations stayed near 500-MPN/100mL. Concentrations in the tributaries were more variable, with concentrations in both the upper and lower watershed exceeding the maximum reporting limit (>2420-MPN/100mL).

E. coli did not appear to follow a distinct temporal pattern in the main stem sites. However, the two most downstream sites (Audie Peeples and Shiloh) had spiked increases during major rainfall events in April 2003 and February 2004, as well as during short-term flow increases in June and August 2003 (Figure 35).

In most cases, ***E. coli*** concentrations in tributaries to the main stem correlated well with rainfall and flow patterns (Figure 36). In particular, Dry Creek had ***E. coli*** spikes during major rainfall events in April 2003 and February 2004 and also during the first fall flush in October 2003. Concentrations in Dry Creek remained somewhat elevated (ranging from 133 MPN to 921 MPN) during the irrigation season (May through August). The rural ephemeral creeks (Sullivan and Curtis) also followed the spikes during the rainfall and flushing events. One anomaly was at the Mother Lode Fairgrounds site. At that site, peaks in ***E. coli*** did occur during the February 2004 rainfall events, but concentrations remained elevated for the remainder of the year (ranging from 206 MPN to 980 MPN) with individual concentrations higher than those in the lower watershed, Dry Creek site.

Figure 9 Summary Temperature: Tuolumne Main Stem, January 2003 - April 2004

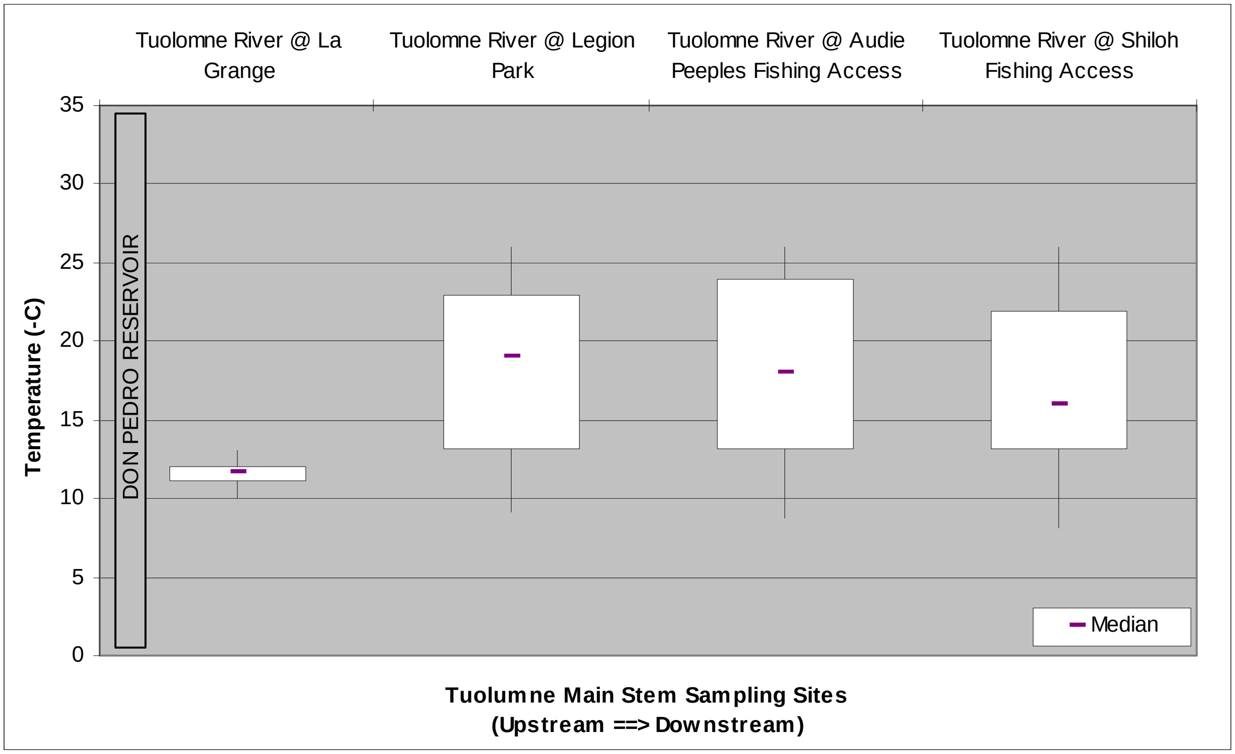


Figure 10 Summary Temperature: Tuolumne Tributaries, January 2003 - April 2004

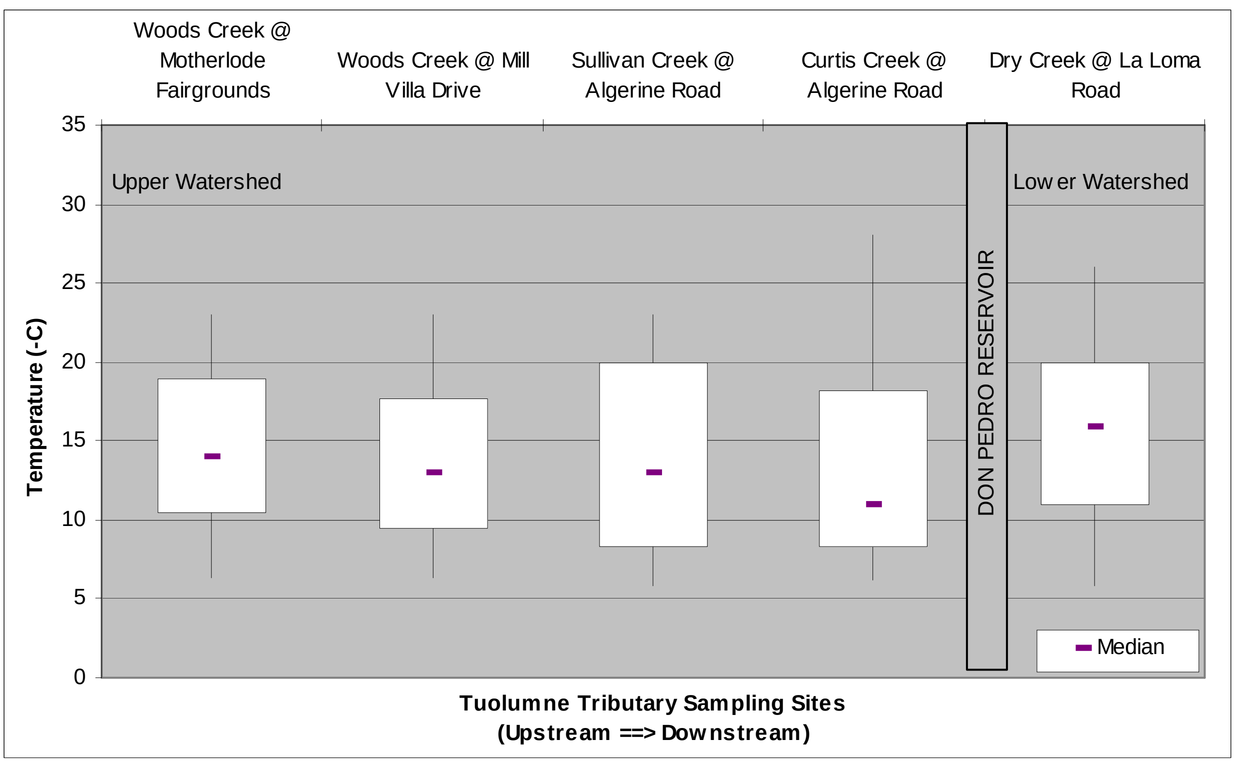


Figure 11 Biweekly Temperature: Tuolumne Main Stem, January 2003 - April 2004

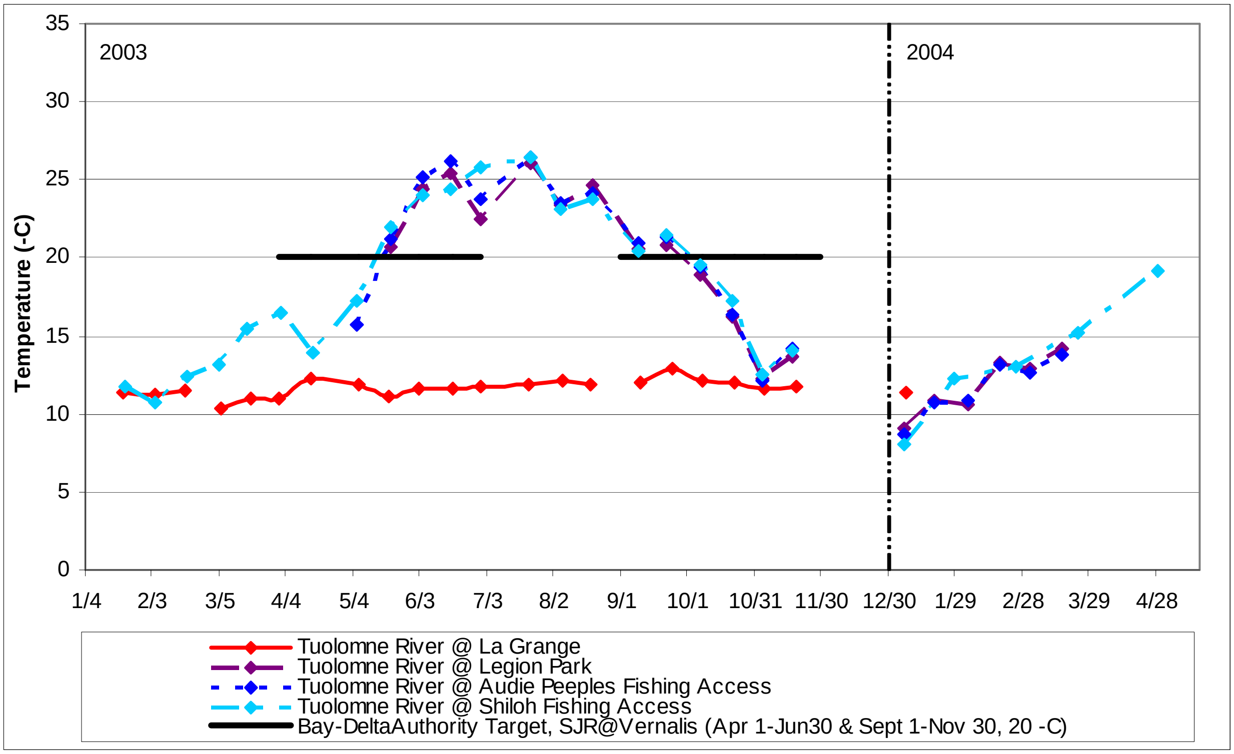


Figure 12 Biweekly Temperature: Tuolumne Tributaries, January 2003 - April 2004

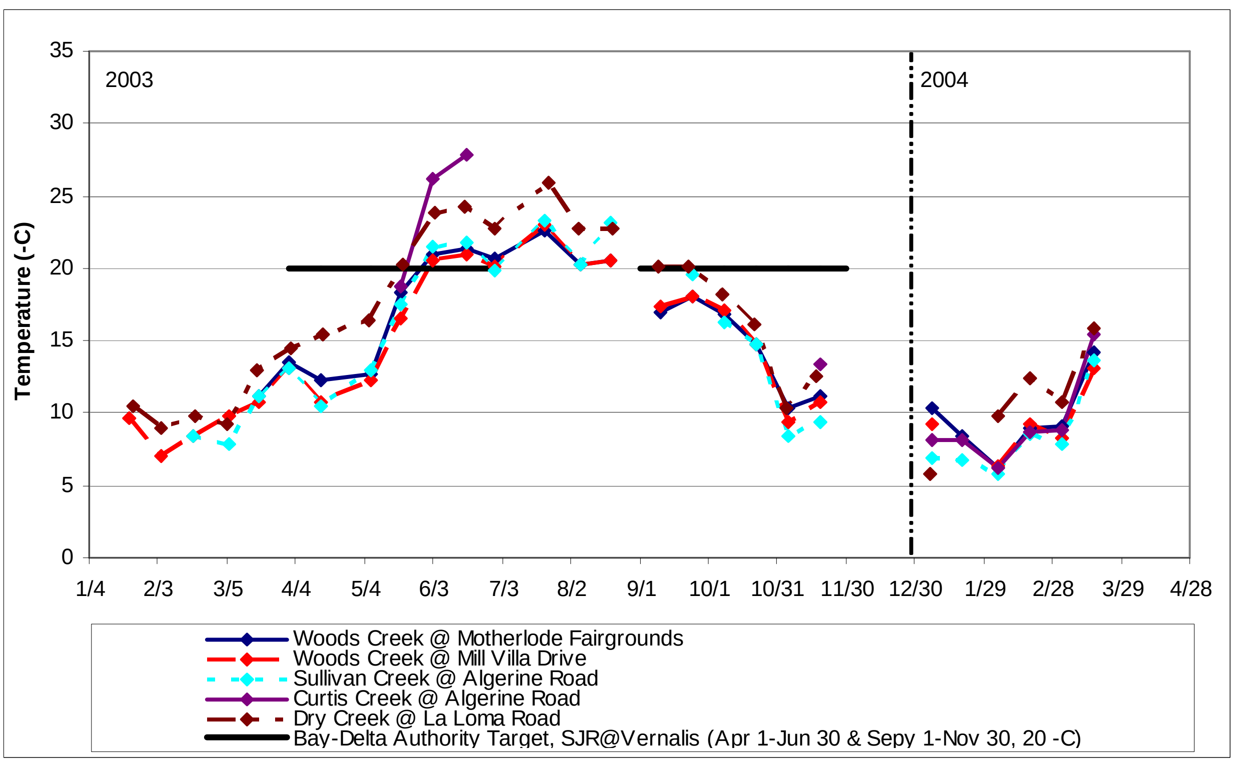


Figure 13 Summary Dissolved Oxygen: Tuolumne Main Stem, January 2003 - April 2004

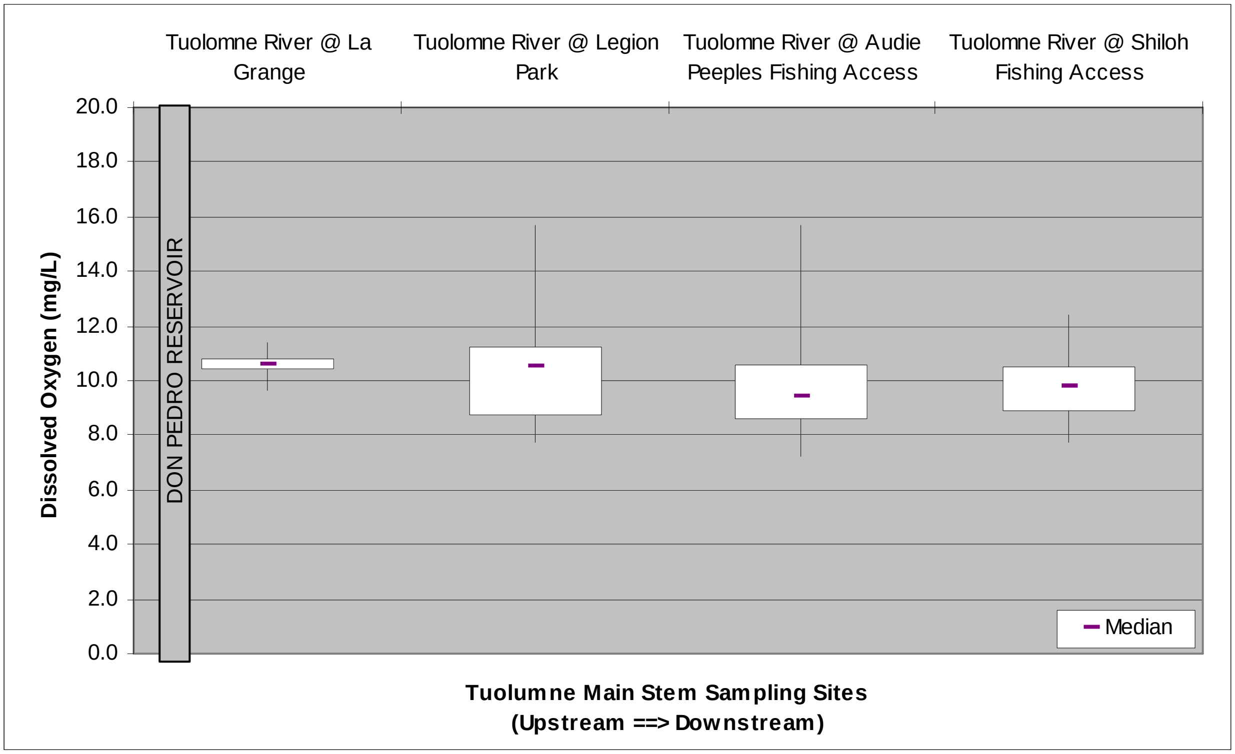


Figure 14 Summary Dissolved Oxygen: Tuolumne Tributaries, January 2003 - April 2004

Figure 15 Biweekly Dissolved Oxygen: Tuolumne Main Stem, January 2003 - April 2004

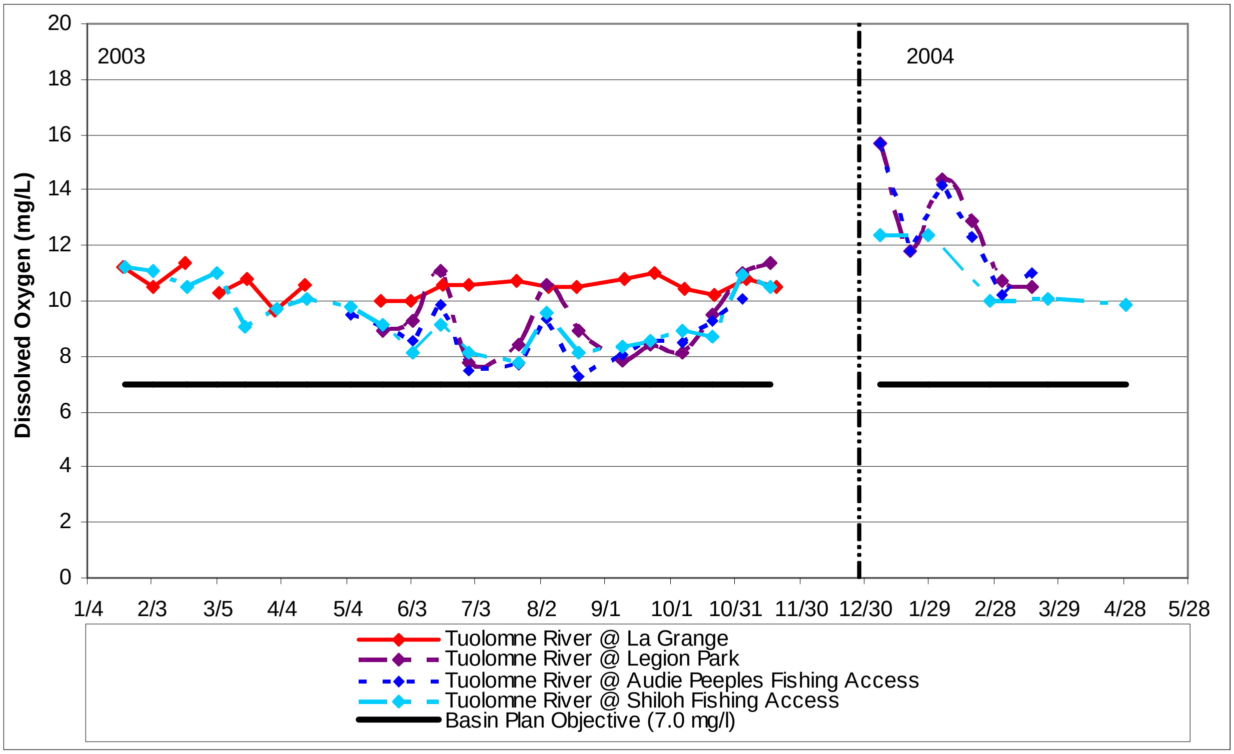


Figure 16 Biweekly Dissolved Oxygen: Tuolumne Tributaries, January 2003 - April 2004

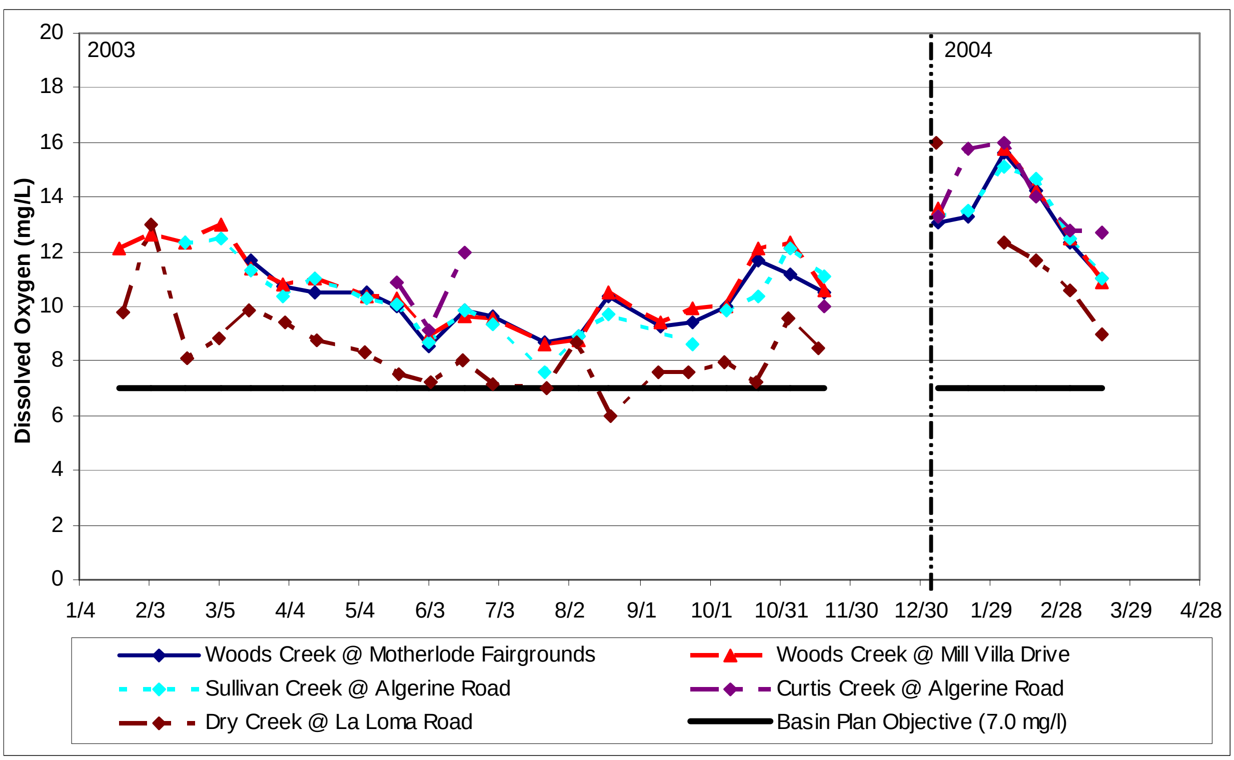


Figure 17 Summary Specific Conductance: Tuolumne Main Stem, January 2003 - April 2004

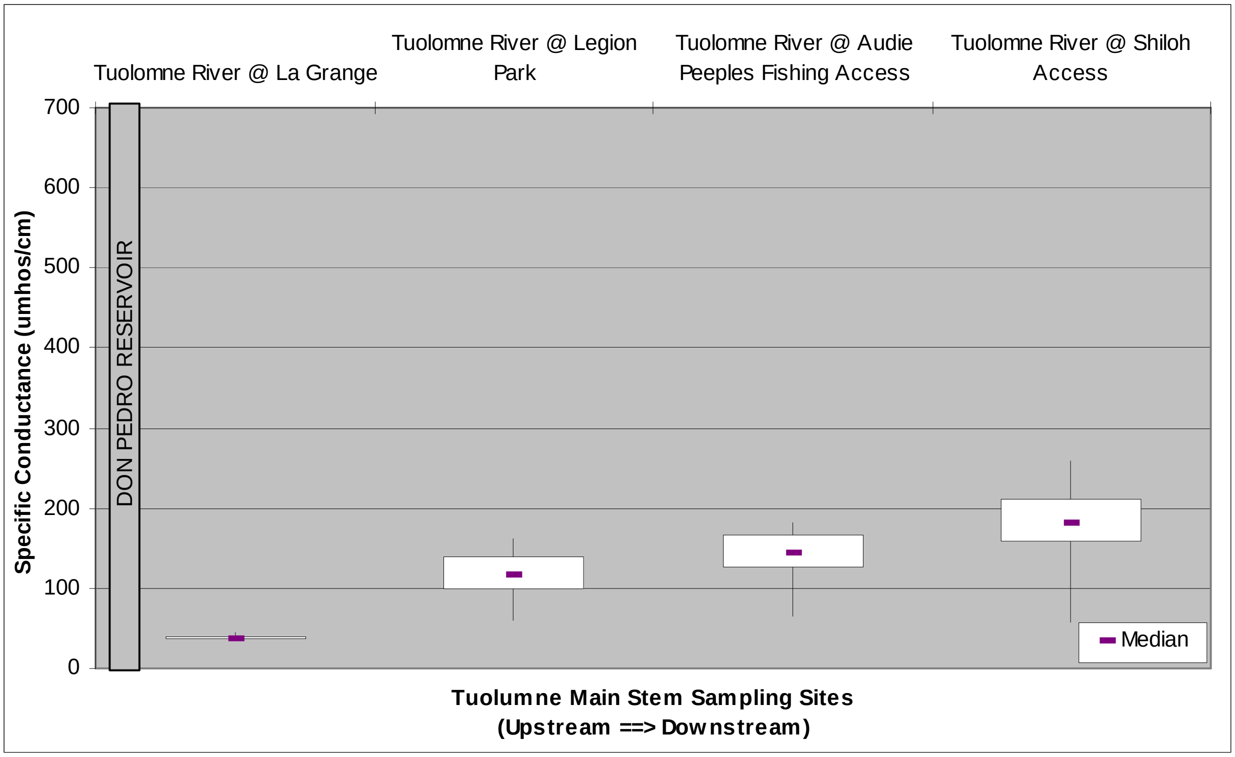


Figure 18 Summary Specific Conductance: Tuolumne Tributaries, January 2003 - April 2004

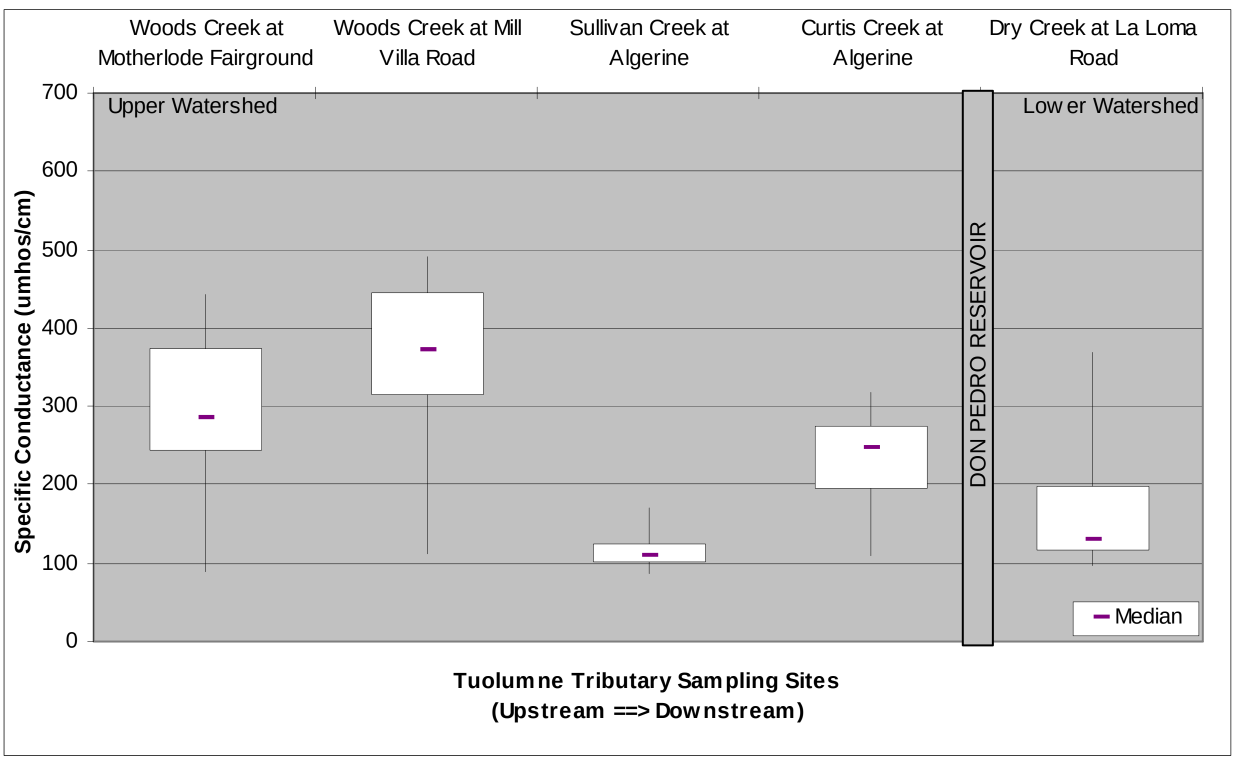


Figure 19 Biweekly Specific Conductance: Tuolumne Main Stem, January 2003 - April 2004

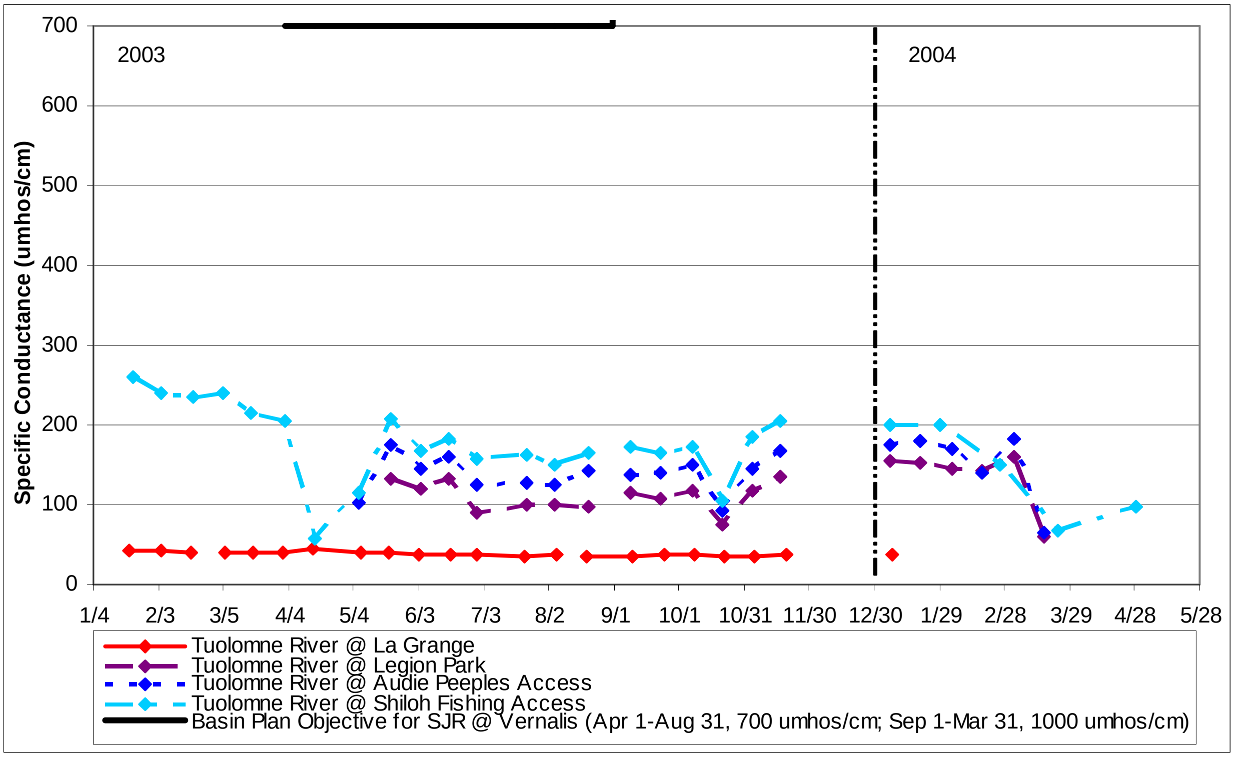


Figure 20 Biweekly Specific Conductance: Tuolumne Tributaries, January 2003 - April 2004

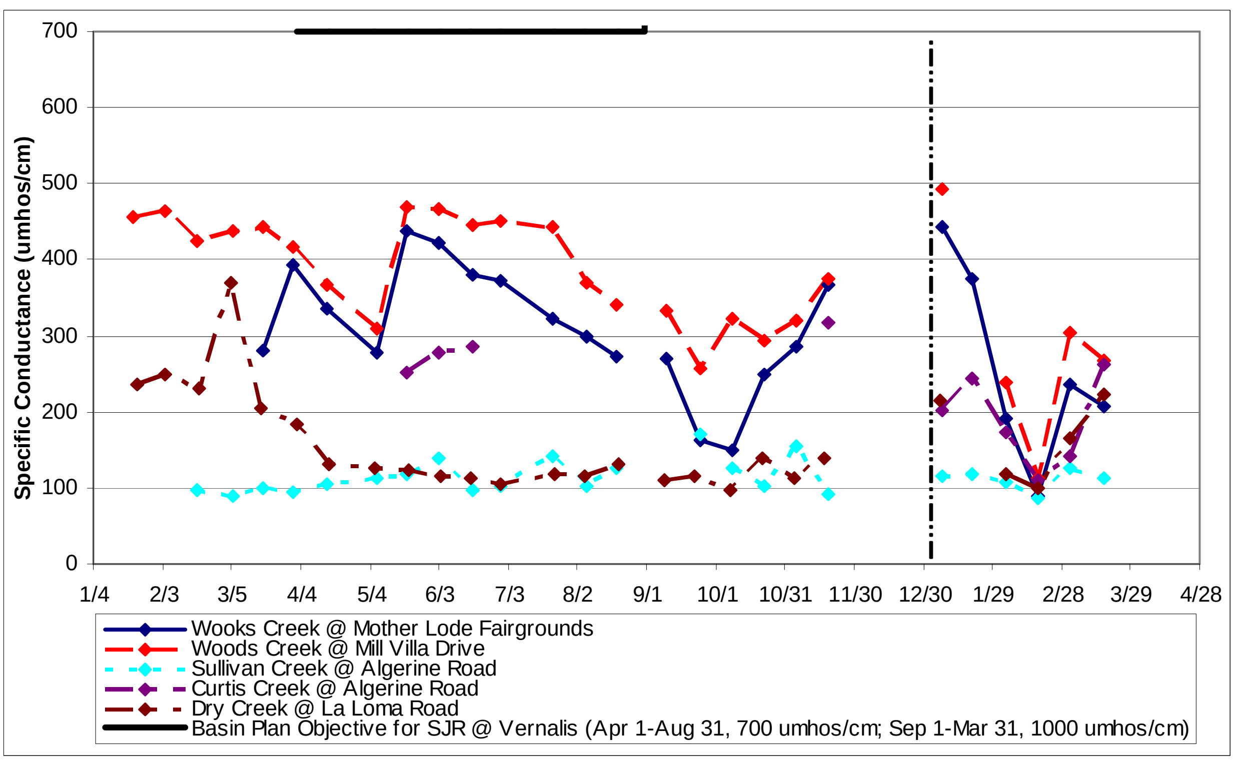


Figure 21 Summary Specific Conductance: Merced Main Stem, January 2003 - April 2004

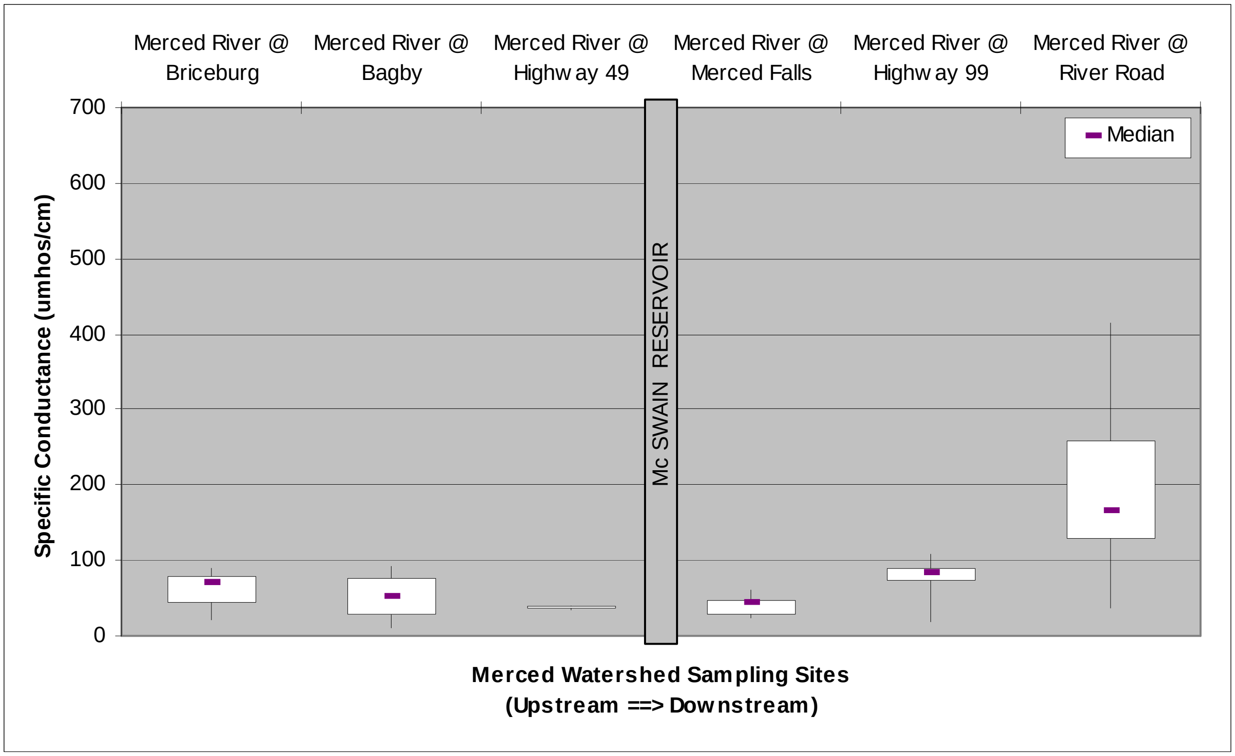


Figure 22 Biweekly Specific Conductance: Merced Main Stem, January 2003 - April 2004

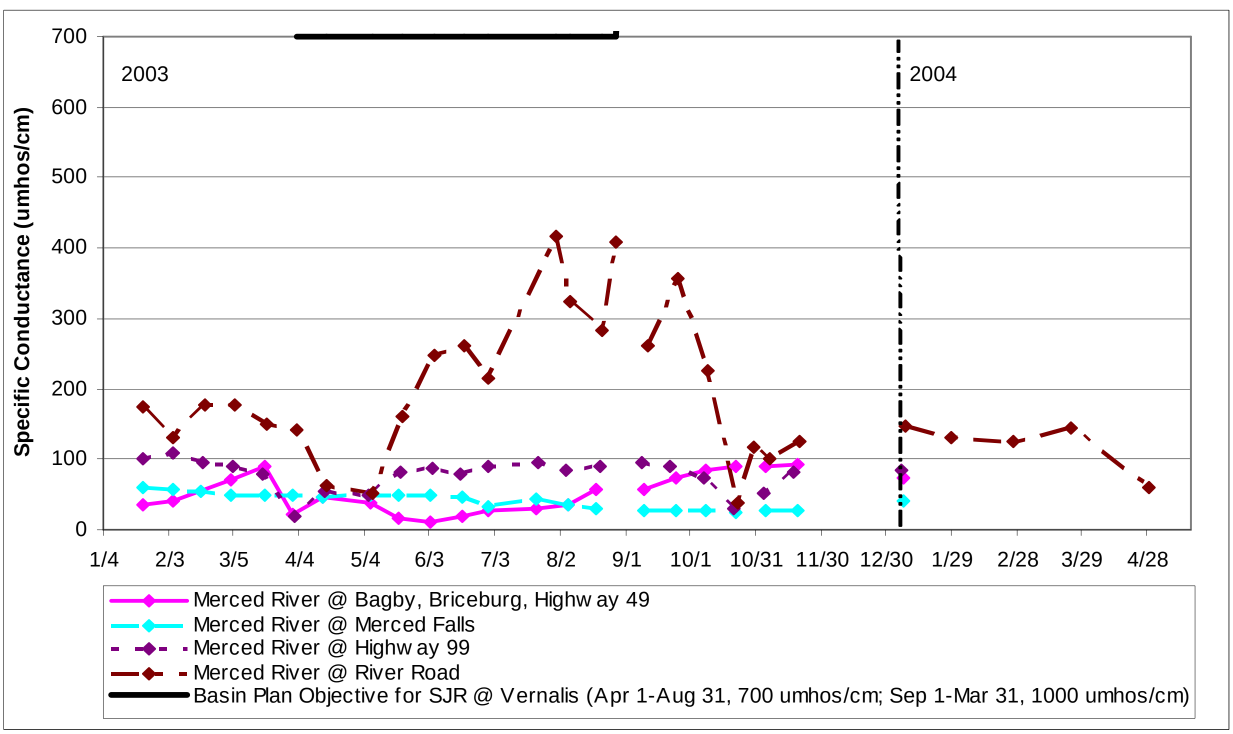


Figure 23 Summary pH: Tuolumne Main Stem, January 2003 - April 2004

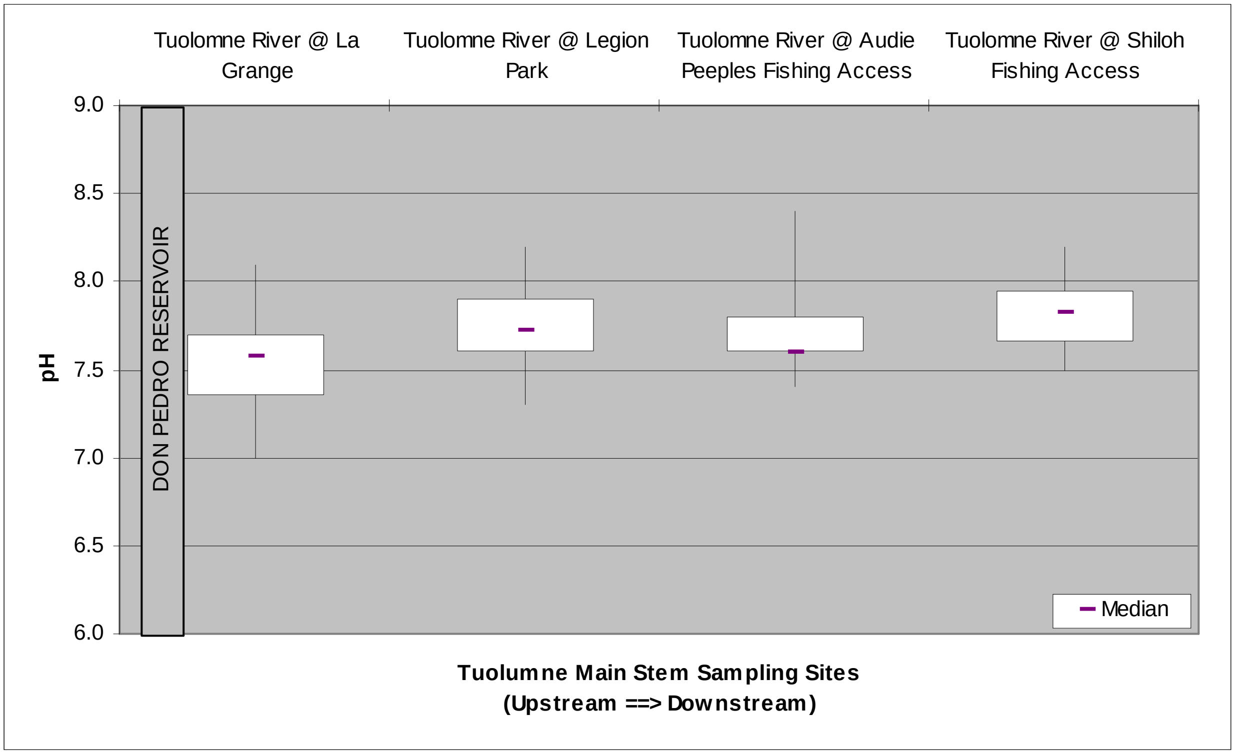


Figure 24 Summary pH: Tuolumne Tributaries, January 2003 - April 2004

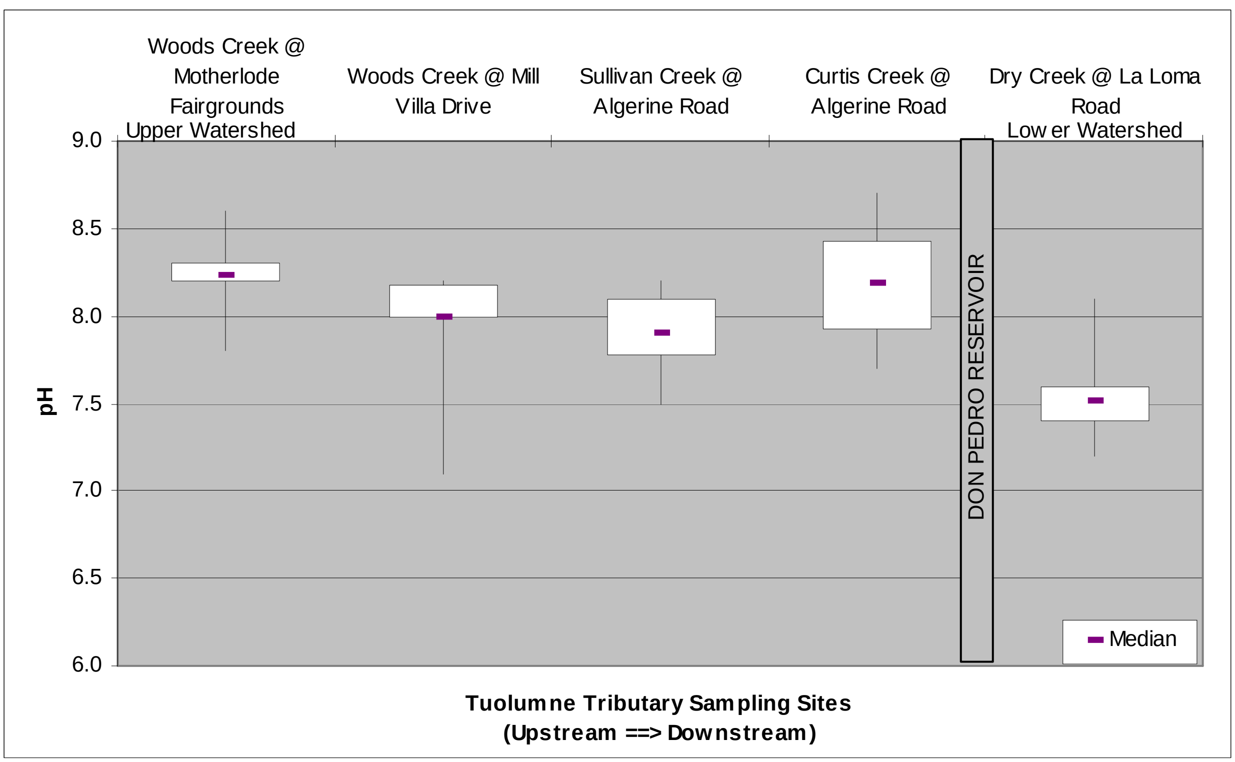


Figure 25 Biweekly pH: Tuolumne Main Stem, January 2003 - April 2004

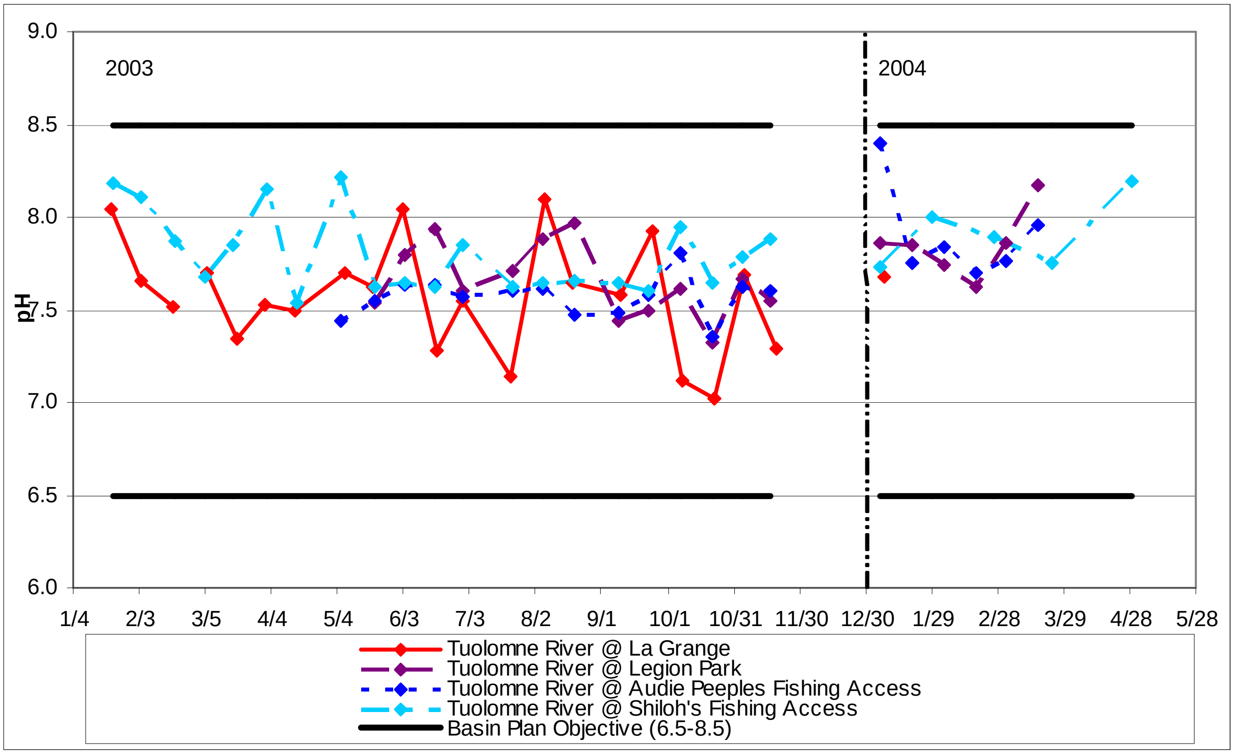


Figure 26 Biweekly pH: Tuolumne Tributaries, January 2003 - April 2004

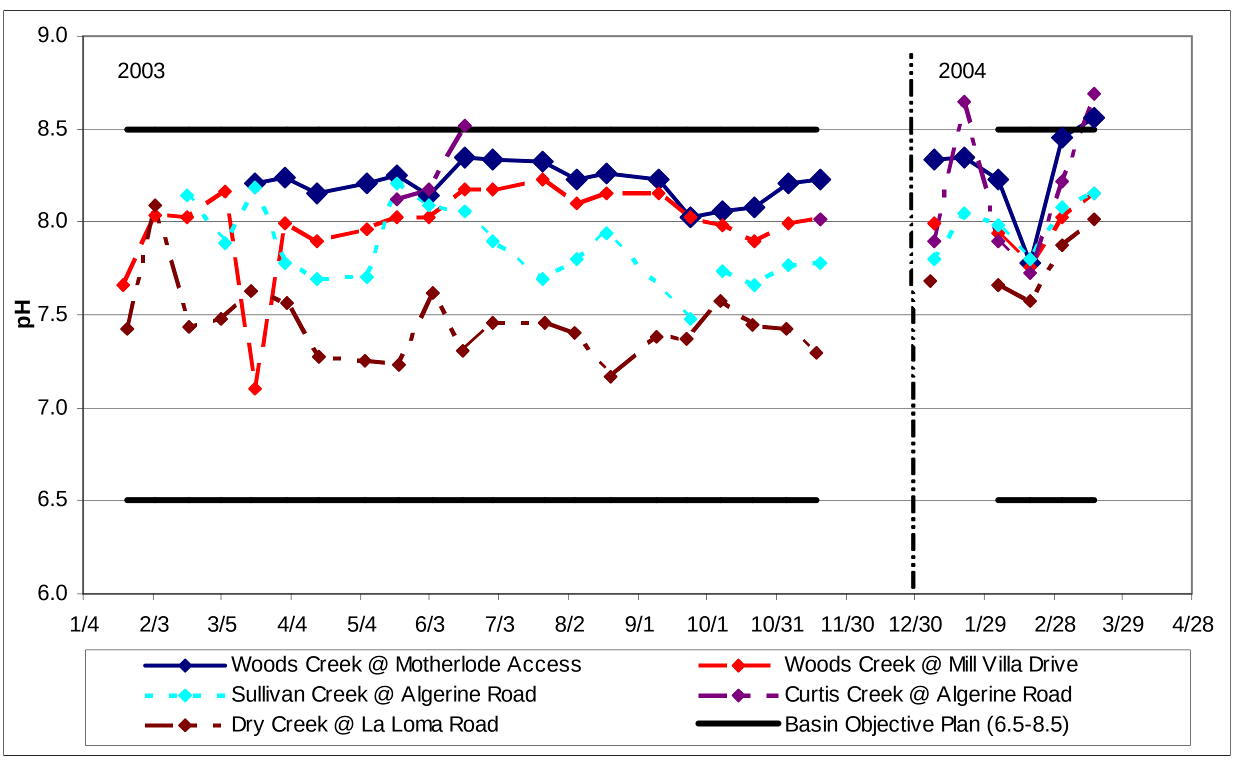


Figure 27 Summary Turbidity: Tuolumne Main Stem, January 2003 - April 2004

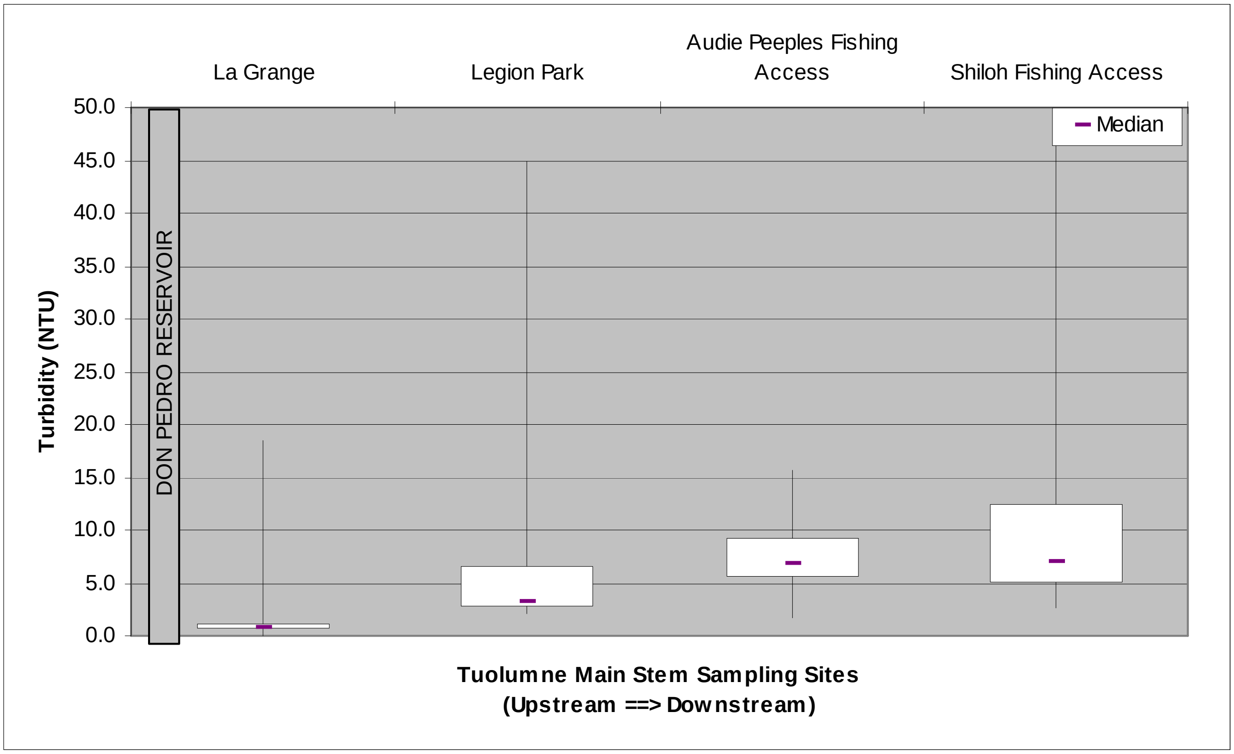


Figure 28 Summary Turbidity: Tuolumne Tributaries, January 2003 - April 2004

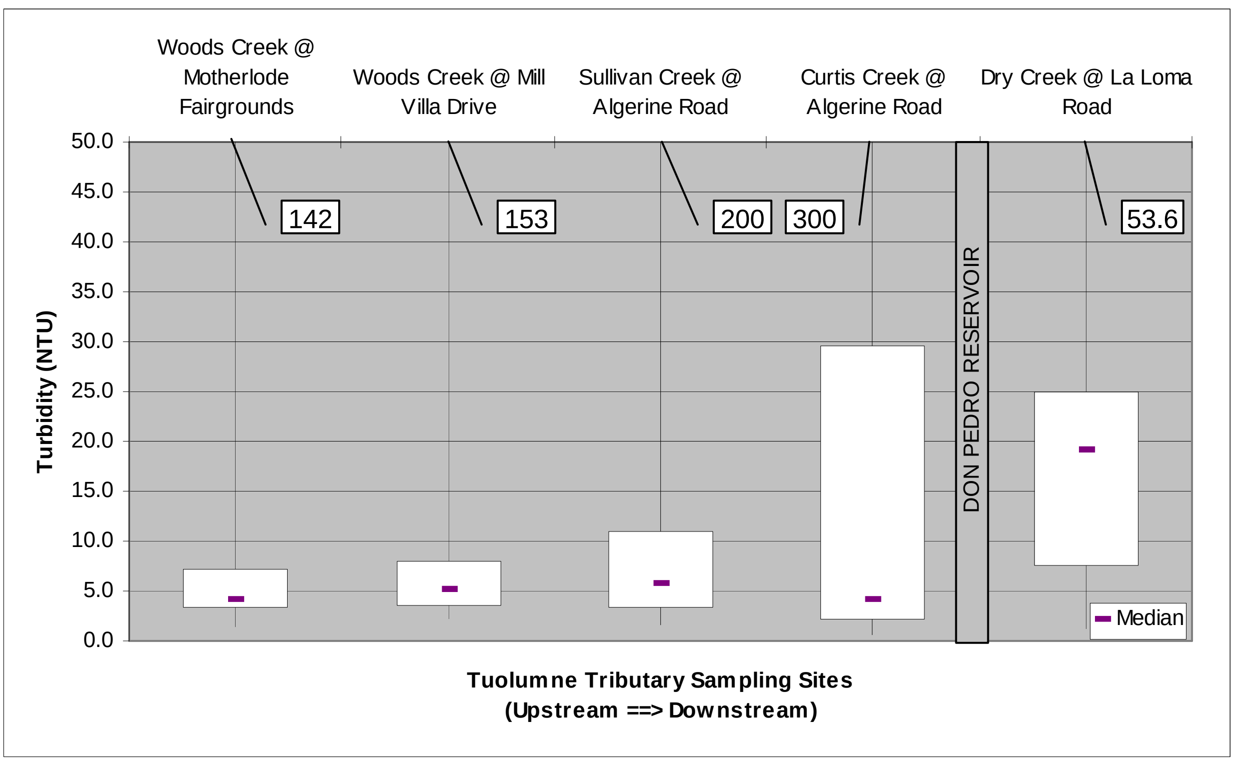


Figure 29 Biweekly Turbidity: Tuolumne Main Stem, January 2003 - April 2004

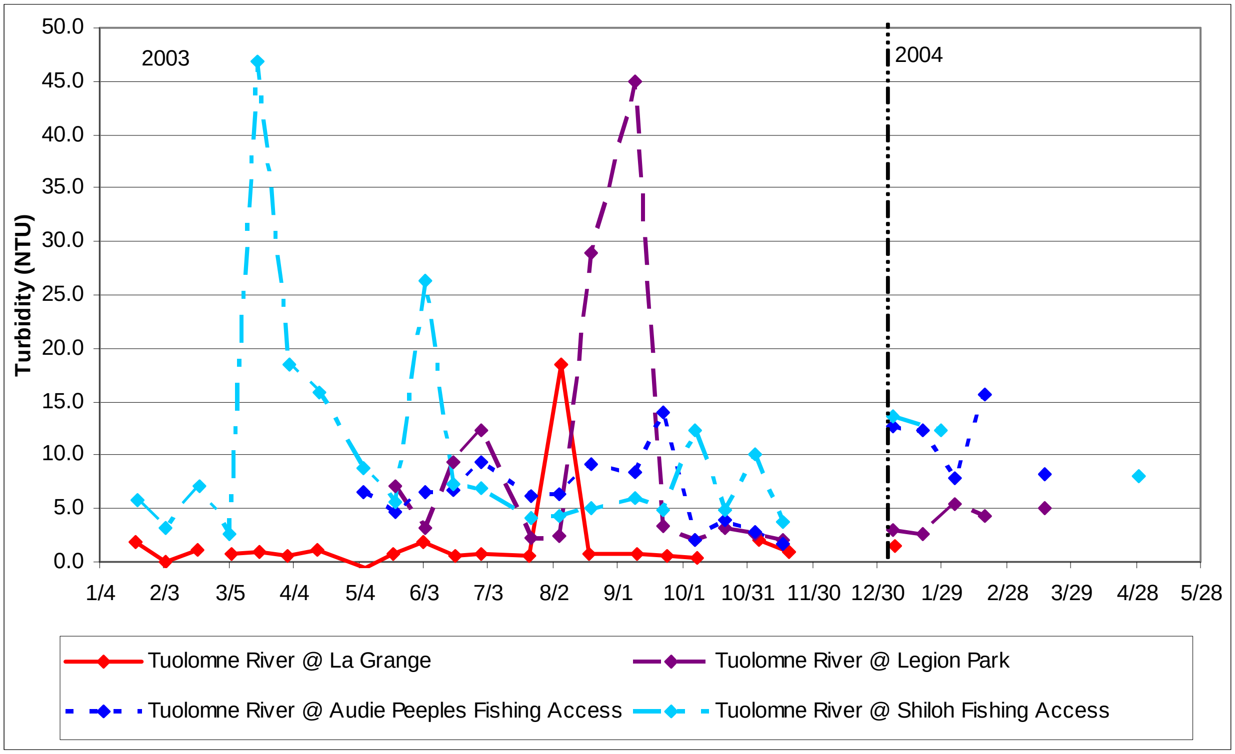


Figure 30 Biweekly Turbidity: Tuolumne Tributaries, January 2003 - April 2004

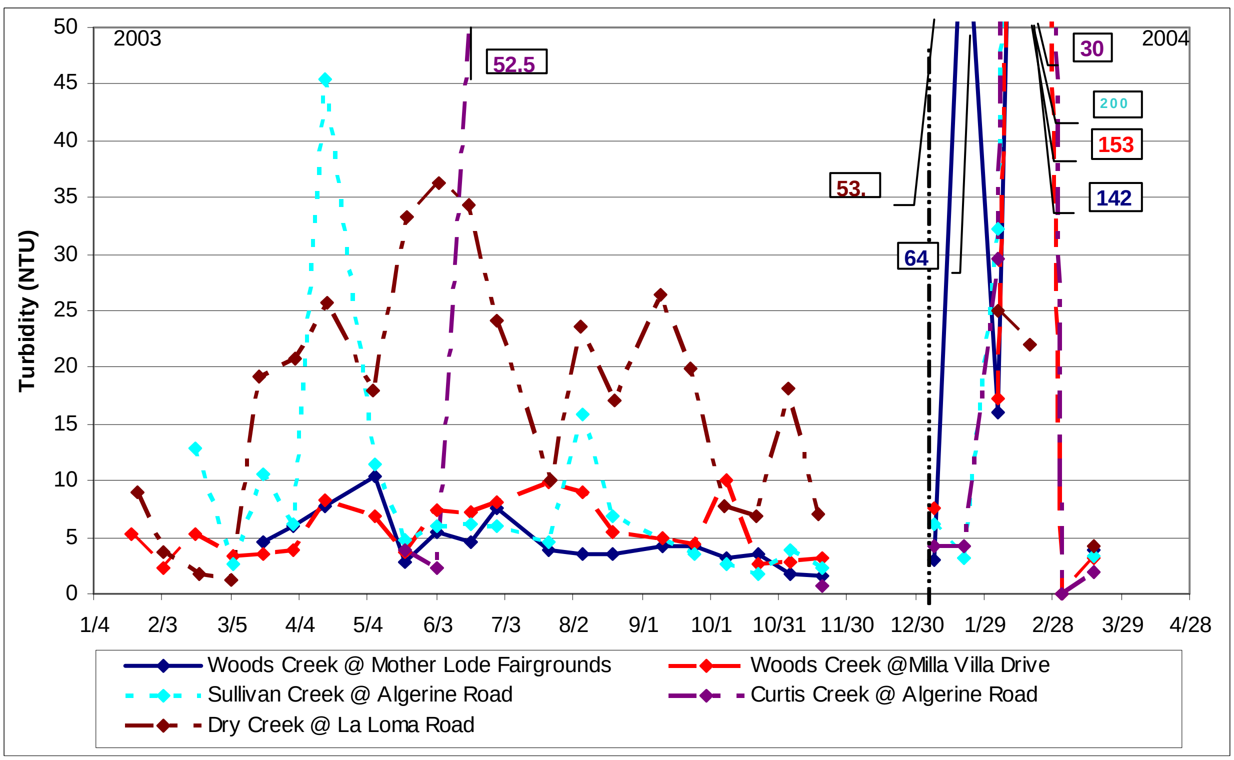


Figure 31 Summary Total Coliform: Tuolumne Main Stem, January 2003 - April 2004

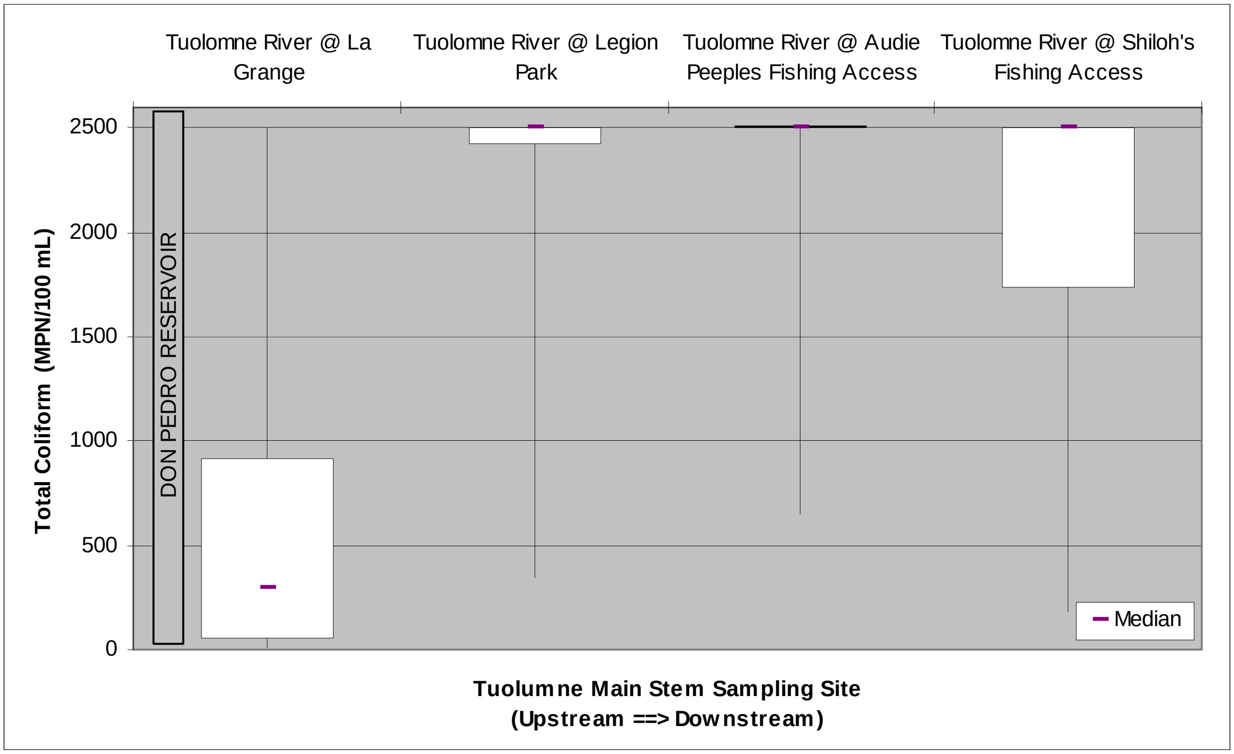


Figure 32 Summary Total Coliform: Tuolumne Tributaries, January 2003 - April 2004

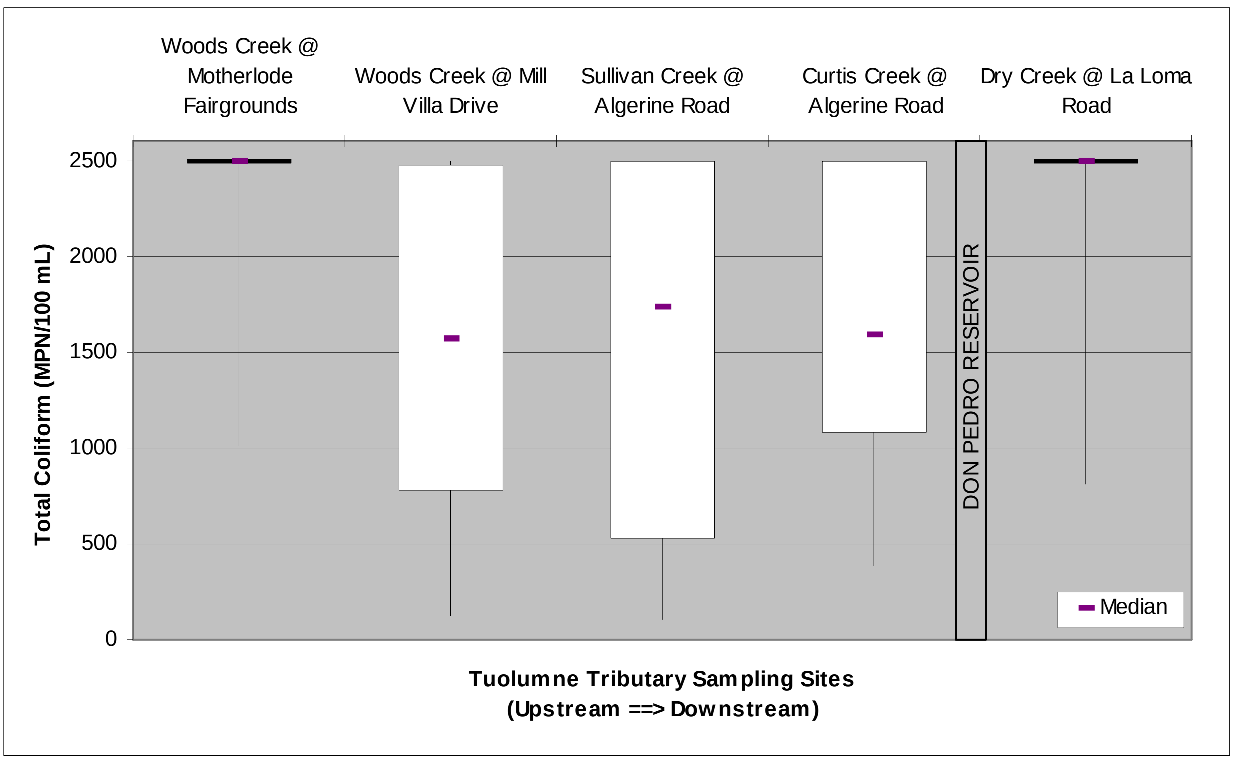


Figure 33 Summary ***E. coli***: Tuolumne Main Stem, January 2003 - April 2004

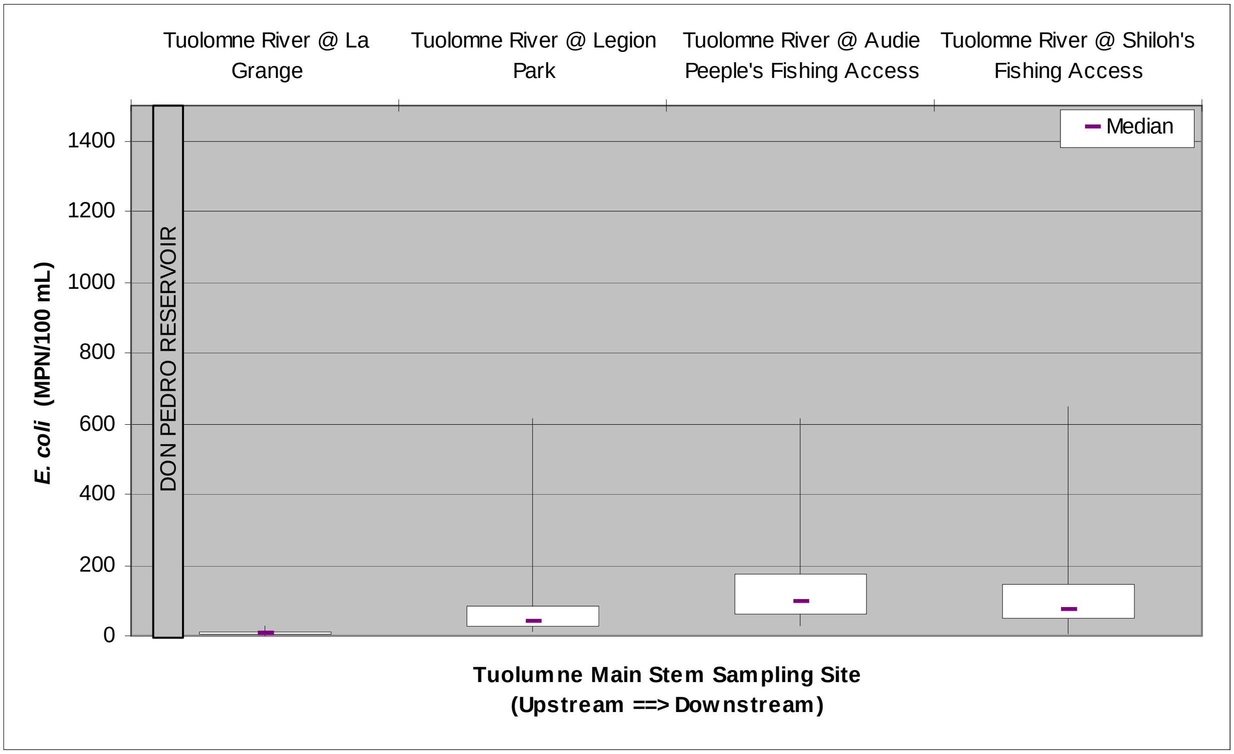


Figure 34 Summary ***E. coli***: Tuolumne Tributaries, January 2003 - April 2004

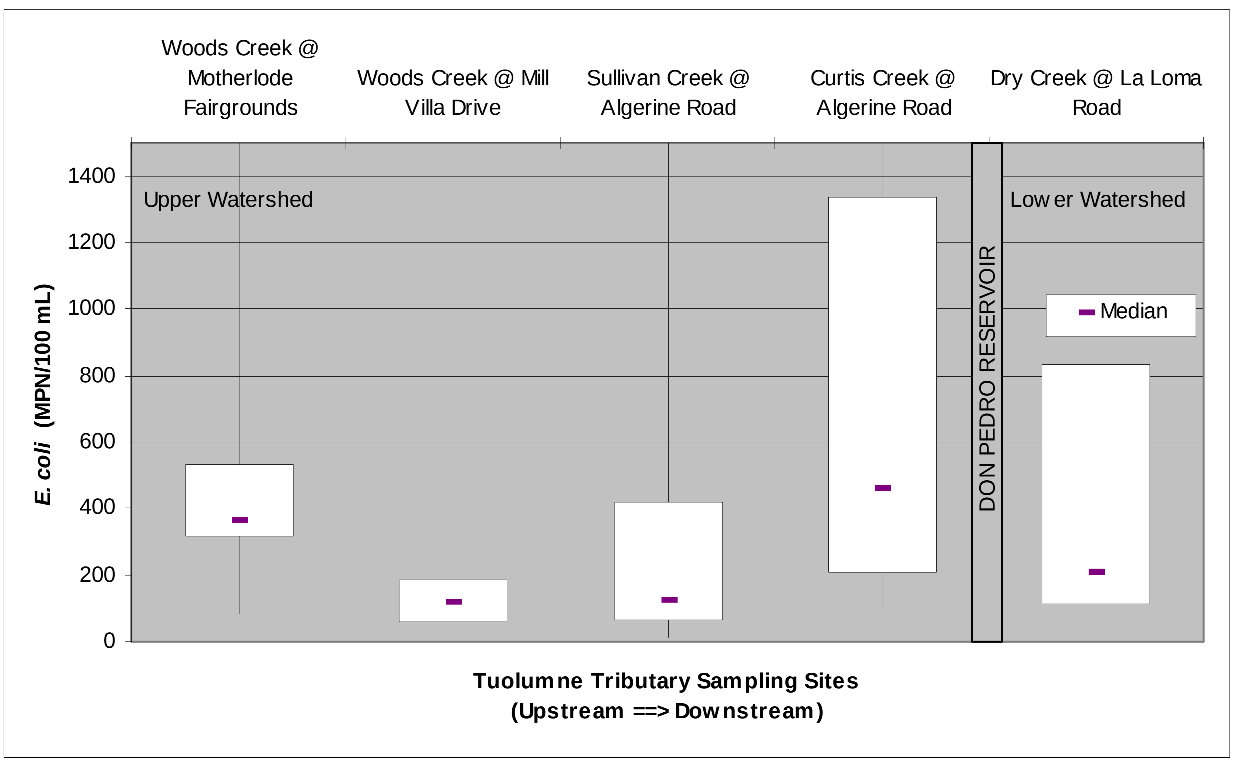


Figure 35 Biweekly ***E. coli***: Tuolumne Main Stem, January 2003 - April 2004

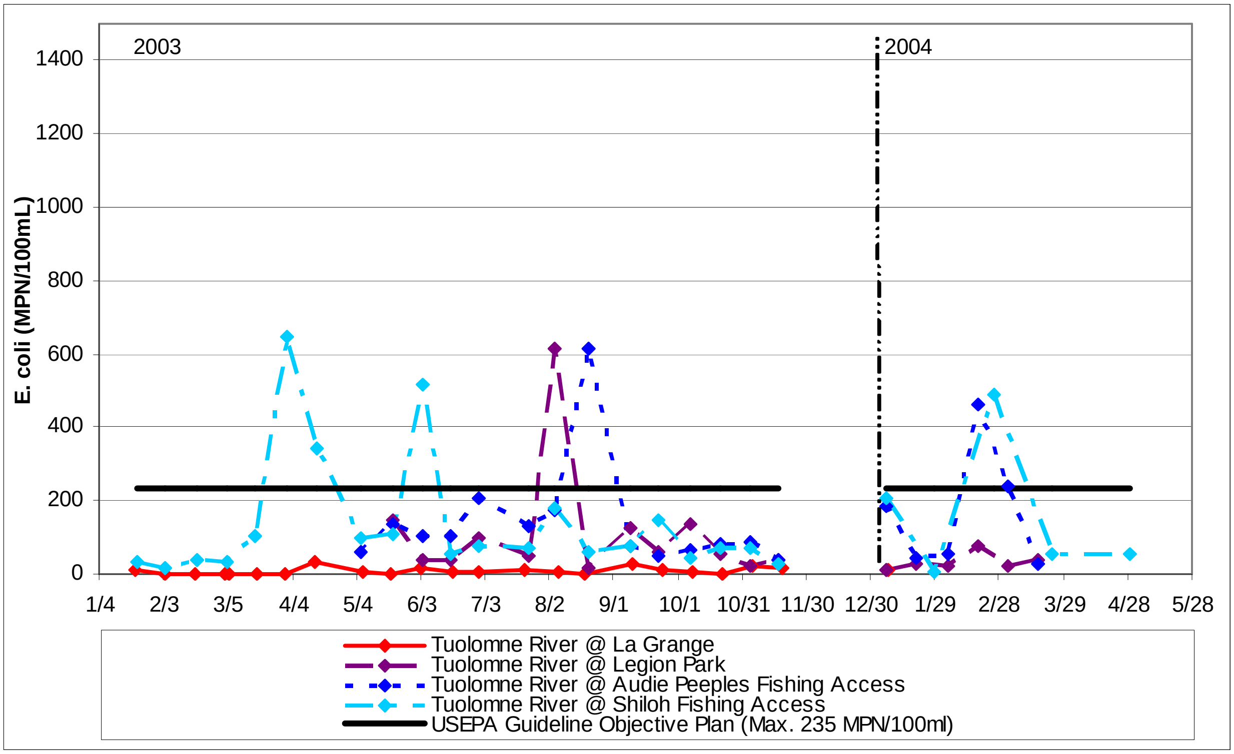
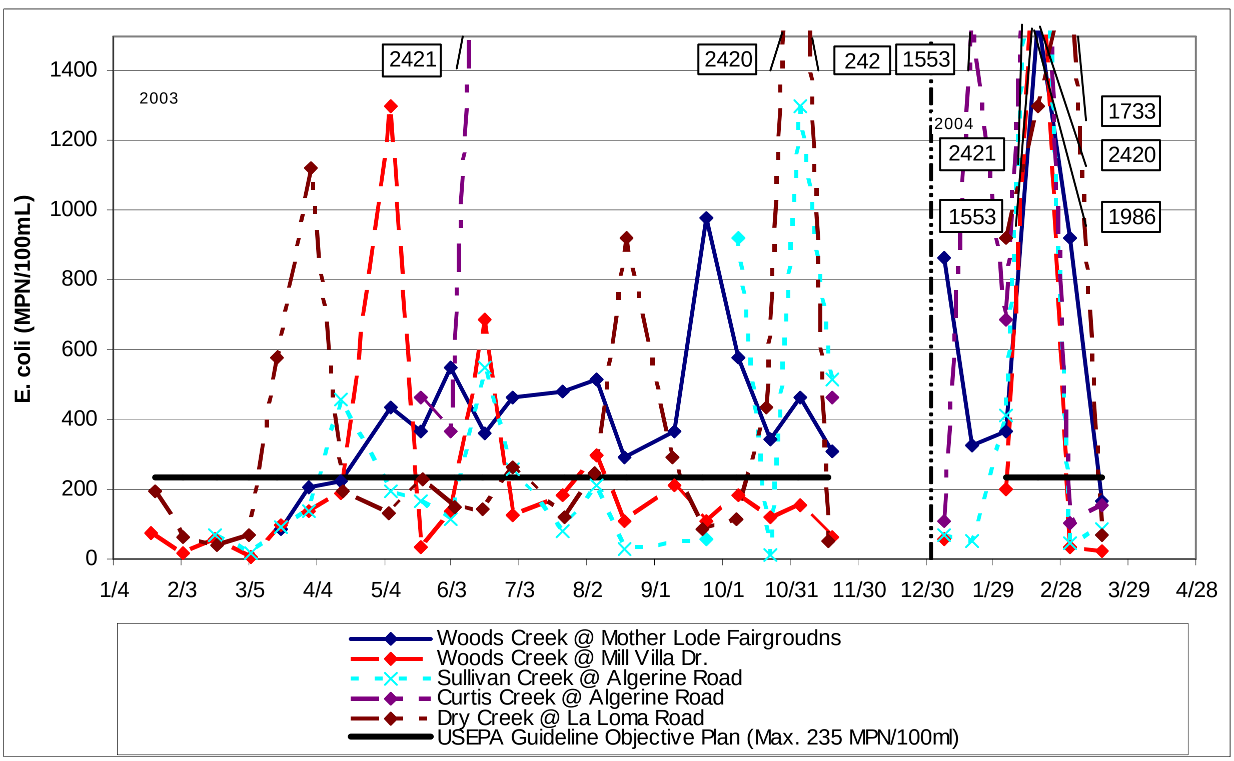


Figure 36 Biweekly ***E. coli***: Tuolumne Tributaries, January 2003 - April 2004



8.1.2 Lower Sub-basins (Farmington and Valley Floor Drainage Areas)

Both the Farmington and Valley Floor areas fall below the 70 ft elevation and have land use dominated by open space grazing, flood control basins and irrigated agriculture. Aside from flood flows in the winter and spring, the majority of flow is from controlled releases and re-circulated agricultural tailwater.

For the parameters discussed, figures at the end of this section are paired to show relationships in the Farmington and Valley Floor Drainage areas, respectively. The first set of paired figures shows the minimum, median, maximum, and 1st and 3rd quartiles for each site. The site furthest to the left in each figure (Littlejohn's Creek at Sonora Road in the Farmington figures, and Tuolumne River at La Grange in the Valley Floor area) was used for this study as the source or background water since these sites are the furthest upstream sites in each area that was sampled. Aside from Littlejohns Creek at Sonora Road and the Tuolumne River at La Grange, all remaining sites are in agriculturally dominated water bodies. Sites in the Farmington Drainage area are listed from upstream to downstream, except for Duck Creek, which is north of the rest of the sites. In the Valley Floor figures, the sites are broken into categories of source, drains, and then laterals. The divisions are indicated with a black dashed line. Within the drain and lateral categories, sites are listed from left to right, north to south. The second set of paired figures shows actual data points collected during the course of the study.

Data was limited for Duck Creek at Highway 4 and Littlejohn's Creek at Austin road due to the extended dry conditions. Water typically flowed in these two channels during the irrigation season, from June through August, and then after individual rainfall events (see Appendix B for individual point details).

Temperature

Figure sets 37/39 and 38/40 depict temperatures within the Farmington and Valley Floor subareas, respectively. Median temperatures did not vary greatly between locations, with most median temperatures ranging between 16 and 21-C. The exceptions were Duck Creek at HWY 4 in the Farmington Drainage Basin and Tuolumne River at La Grange. The majority of temperatures measured in Duck Creek were collected during the summer and remained above 20-C with a median of 24-C. In contrast, the Tuolumne River at LaGrange, source water to the Valley Floor Drainage Area, flowed year round and remained consistently near 12-degrees C.

Temperatures did fluctuate consistently by season (Figures 38 and 39). Temperatures remained elevated (above 20-C) at all sites between May and September, with the highest summer temperatures recorded in the upstream site, Littlejohns Creek at Sonora (ranging from 25-C to 30-C).

Dissolved Oxygen

Dissolved oxygen in the Farmington Basin was consistent overall between sites with all sites showing a seasonal inverse to the temperature pattern (Figures 41 and 43). DO concentrations remained at a low range (6 mg/L to 8 mg/l) between May and September but rebounded to above 10 mg/L during the remainder of the year.

The Valley Floor area showed greater diversity in DO concentrations between sites and a much less pronounced DO sag pattern during the summer (Figures 42 and 44). Although the MID Main Drain did show a dramatic drop in DO during the irrigation season, with half of the reported concentrations below 4 mg/L, the majority of sites reported fairly consistently between 8 mg/L and 12 mg/L. The only other site to dip to or below 2 mg/L DO was TID Lateral 2 at Grayson Road in February and April.

Specific Conductance

Similar to DO measurements, SC concentrations at Farmington area sites showed consistency both between sites and over seasons (Figures 45 and 47). The majority of SC concentrations remained near 200 umhos/cm except during winter storm runoff when SC's exceeded 400 umhos/cm.

In contrast, great variability in SC concentrations existed both between sites and during the course of the year in the Valley Floor sites (Figures 46 and 48). The fluctuations are likely due to the alternating water sources within each channel—freshwater operational spills, tailwater runoff, groundwater, and/or urban/industrial drainage. A general trend toward high SC's (greater than 1000 umhos/cm) occurred in both TID Harding Drain and TID Laterals 6/7.

pH

The pH findings reflected the SC results with more consistency in Farmington area sites and wide variability in Valley Floor sites (Figures 49 through 52). Only two sites varied less than 1 pH unit over the course of the study (upstream Farmington Basin and Duck Creek). The remaining sites varied up to 2.5 pH units over the course of the year. In the Farmington Drainage Area, fluctuations in pH were greatest in the winter and early spring, but then stabilized during the dry summer months. In the Valley Floor Drainage Area, the seasonal trend at the MID Main Drain and Lateral 6/8 at Dunn Road was to increase during the winter months and then decrease during the summer months. The pH at the remaining sites, Lower Lateral 2, Lateral ¾ at Paradise Road, Harding Drain, and Lateral 7 at Central, fluctuated throughout they year, with no noticeable pattern.

Turbidity

Turbidity appeared primarily site dependent with spikes in concentration correlating to rainfall events and irrigation (Figures 53 through 56).

The upper Farmington area site remained consistently below 5 NTU except during two rainfall events in February 2004 when concentrations reached 18 NTU and 44 NTU respectively.

In general, turbidity in the Valley Floor Drainage area stayed between 30 and 70 NTU at the majority of sites, with occasional spikes reaching 200 NTU in the spring and fall months at Laterals 6/8 at Dunn Road, Harding Drain, and Lower lateral 2 at Grayson. Turbidity at the MID Main Drain at Shoemake was consistently higher than the other sites, especially April through the end of August, when readings fluctuated between 9.2 and 135 NTU.

Total Organic Carbon (TOC) and Total Suspended Solids (TSS)

Due to limited funding, TOC and TSS were only collected between March and June 2003. During that time period, spikes in concentration were clearly related to rainfall events. (Summary figures of the data are available in Appendix F.) Overall concentrations between sites did not necessarily follow a pattern except that upper watershed sites had consistently low TOC and TSS (below 6 mg/L and <5.0 mg/L, respectively) and the Main Drain was consistently high (medians of 16 mg/L and 27 mg/L, respectively). The remaining sites in the Farmington area showed higher TOC in agriculturally dominated areas (Littlejohns at Austin) than in combined urban/agriculturally influenced areas (Lone Tree and French Camp). The reverse held true for TSS concentrations. Potential causes for the elevated TOC near Austin included runoff from surrounding pasture, while the immediate areas surrounding Lone Tree and French Camp were undergoing residential urban development including some major construction projects.

Coliforms

Median total coliform concentrations, Figures 57 and 58, were high overall, but were lowest at the source sites (Littlejohn's Creek at Sonora Road in the Farmington Area and Tuolumne River at La

Grange in the Valley Floor Drainage Area. Median concentrations at all the remaining sites were either above the reporting limit (>2420 MPN/100ml) or near the reporting limit (1860 MPN/100 ml at Lateral ¾ at Paradise Road and 2420 at Lower Lateral 2 at Grayson Road.

E. coli data showed variability between sites and concentration did not seem correlated to season except for the Farmington upper watershed site, Littlejohn's Creek at Sonora Road (Figures 59 through 62). That site's higher concentrations were consistently linked to rainfall events with the highest concentrations (>2420 MPN/100 mL) occurring just after the first flush rainfall event after summer (November 2003), and after two major storm events in February 2004. Concentrations at this site also peaked in June, which corresponded to a peak at the downstream site, Littlejohn's Creek at Austin Road. Peak E. coli concentrations at the other sites did not follow a specific pattern and may be dependent on the source of water flowing in the channel during the time of sampling (spill, tailwater, groundwater, urban, etc.). The supply laterals (Lower Lateral 2 at Grayson and Lateral 7 at Central Ave.) tended to have the lowest overall concentrations, while those surrounded by pasture (Littlejohns and Lone Tree) tended to be elevated. The highest consistent levels (median >2420 MPN/100 mL) was at the Main Drain at Shoemake Road—a site that receives agricultural drainage and is along side a 200-acre dairy operation.

Figure 37 Summary Temperature: Farmington Drainage Area, January 2003 - April 2004

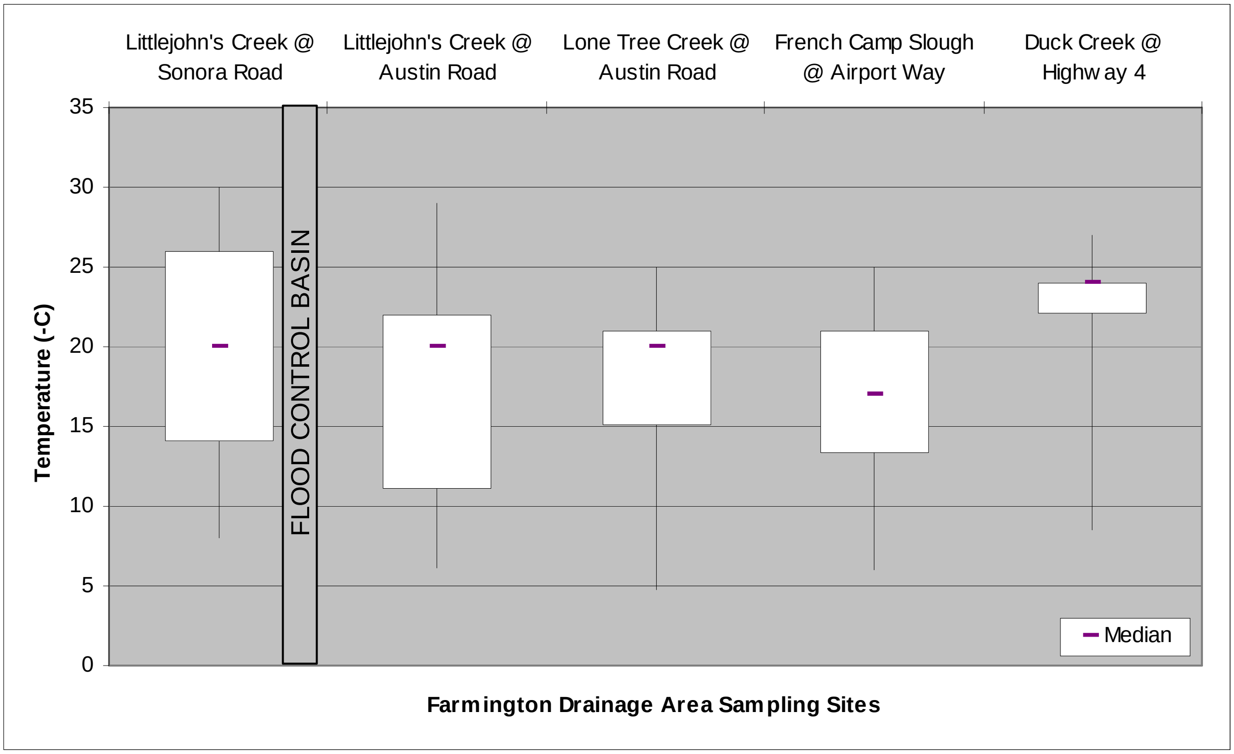


Figure 38 Summary Temperature: Valley Floor Drainage Area, January 2003 - April 2004

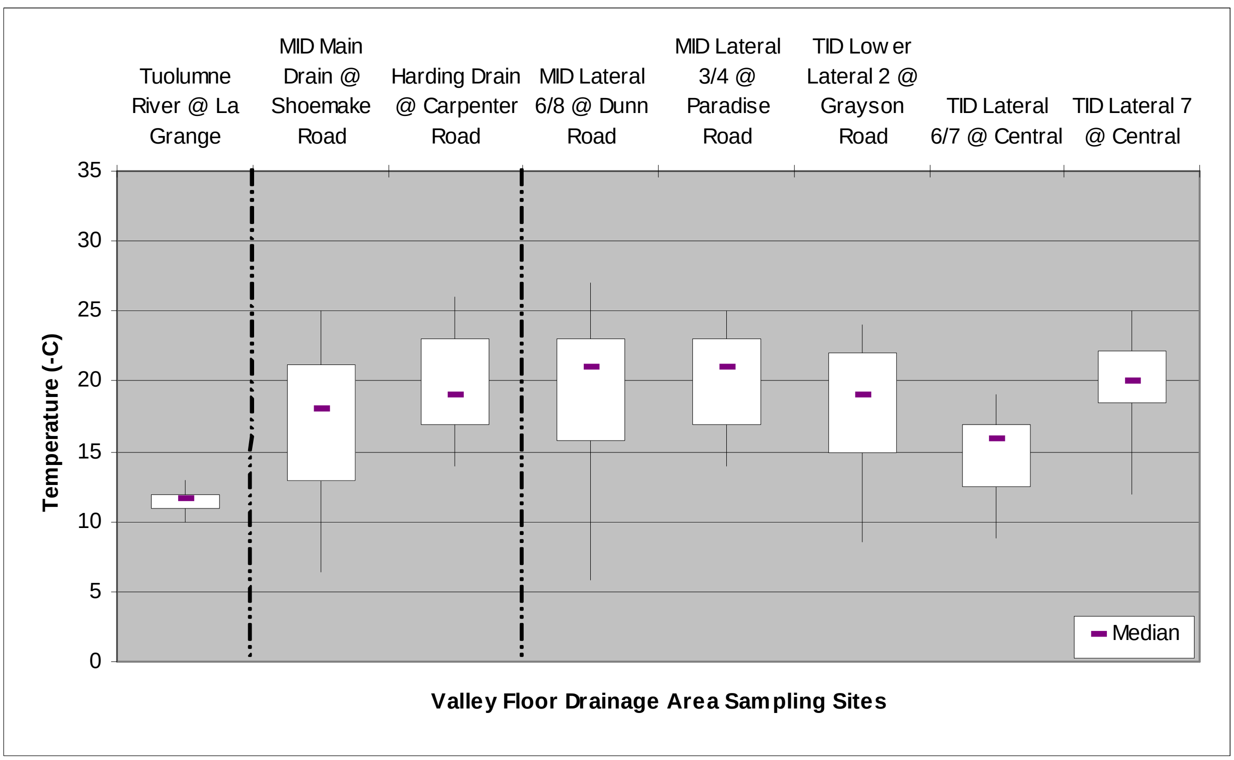


Figure 39 Biweekly Temperature: Farmington Drainage Area, January 2003 - April 2004

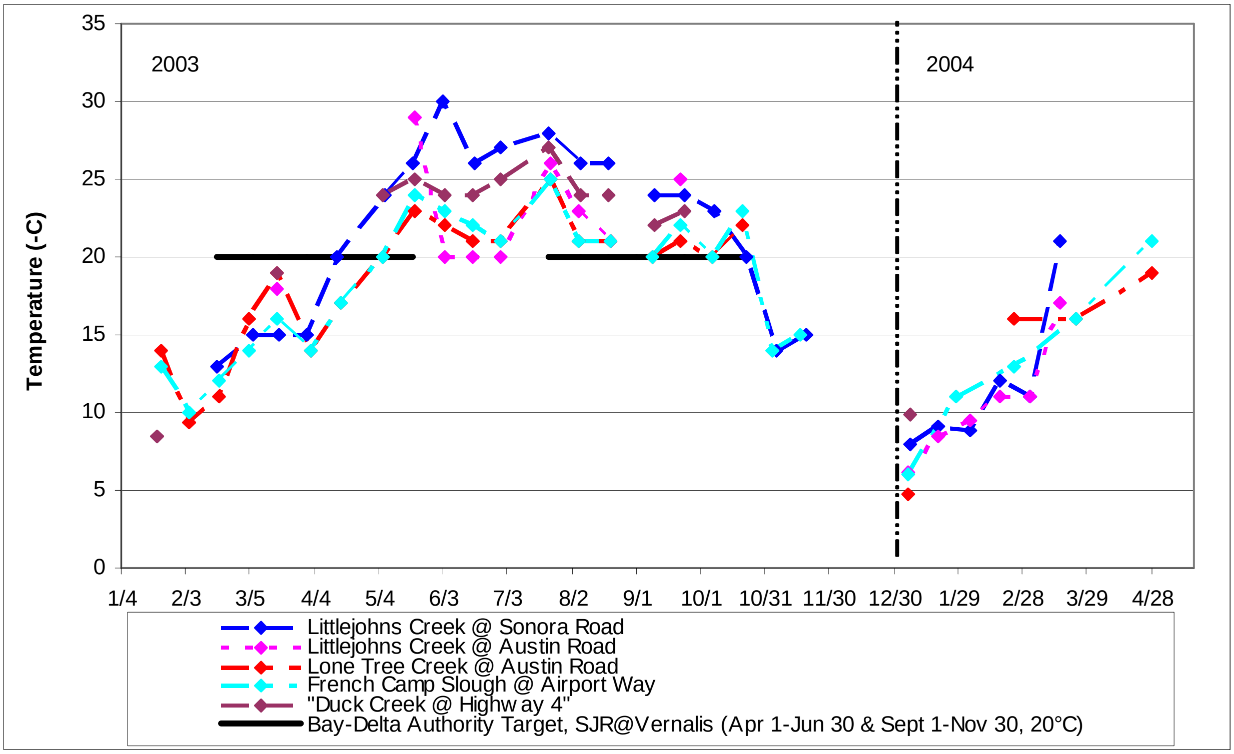


Figure 40 Biweekly Temperature: Valley Floor Drainage Area, January 2003 - April 2004

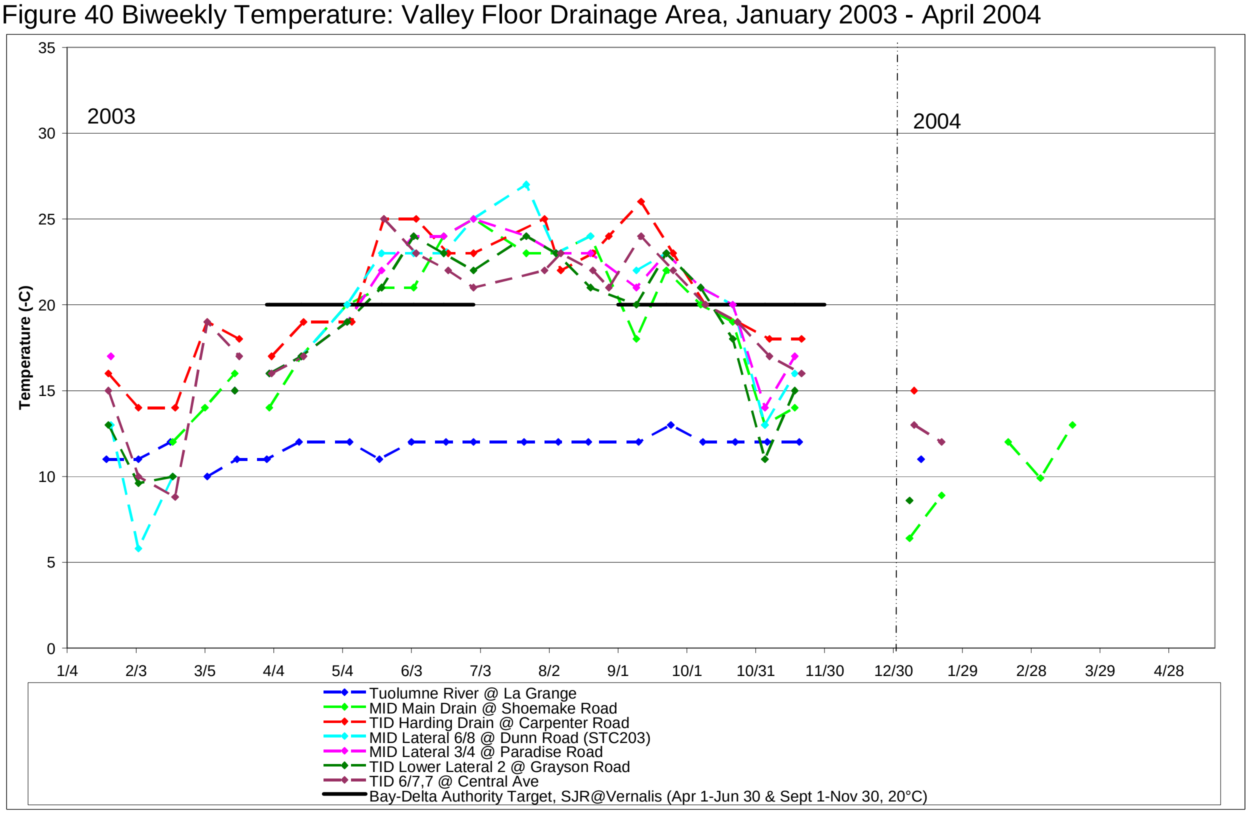


Figure 41 Summary Dissolved Oxygen: Farmington Drainage Area, January 2003 - April 2004

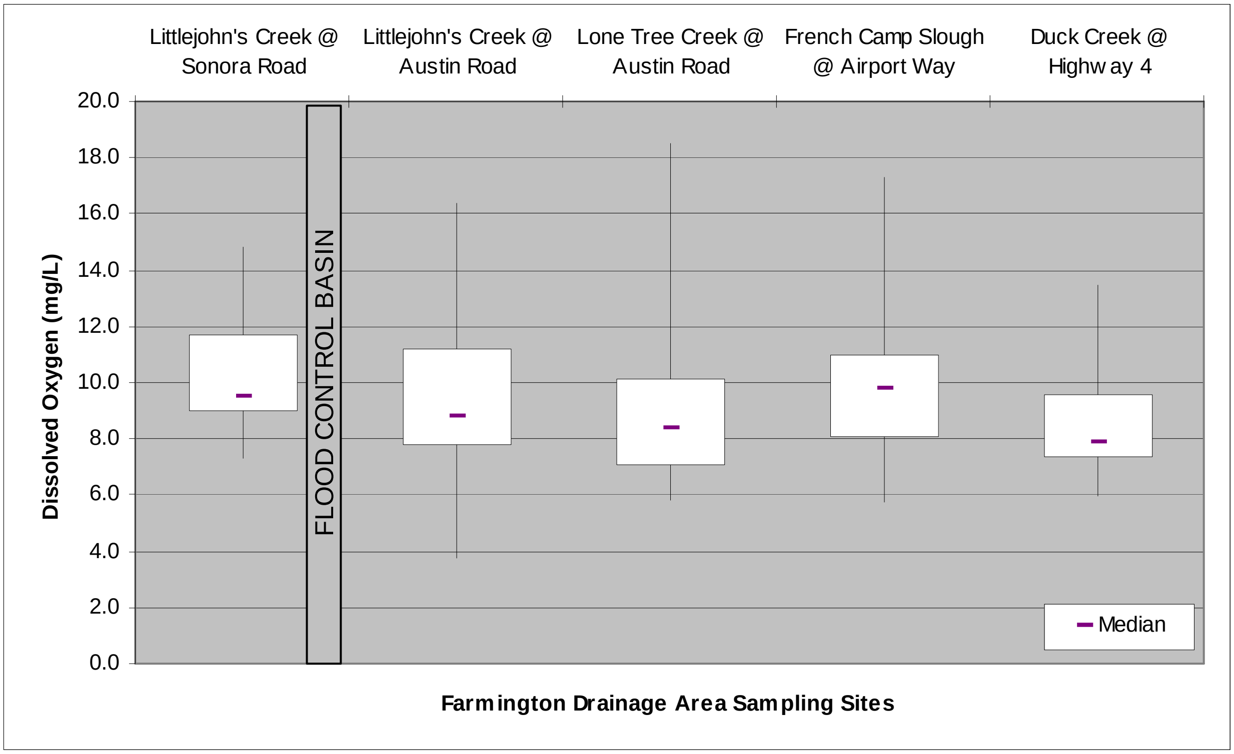


Figure 42 Summary Dissolved Oxygen: Valley Floor Drainage Area, January 2003 – April 2004

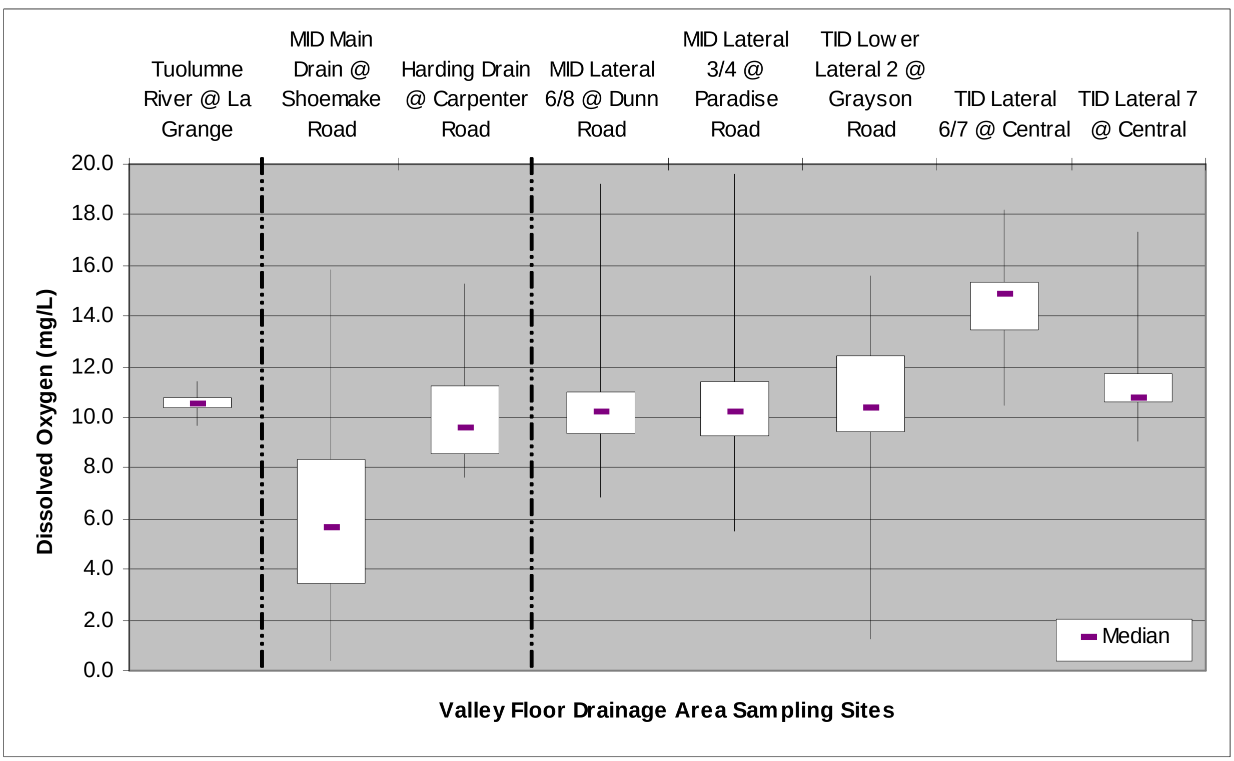


Figure 43 Biweekly Dissolved Oxygen: Farmington Drainage Area, January 2003 - April 2004

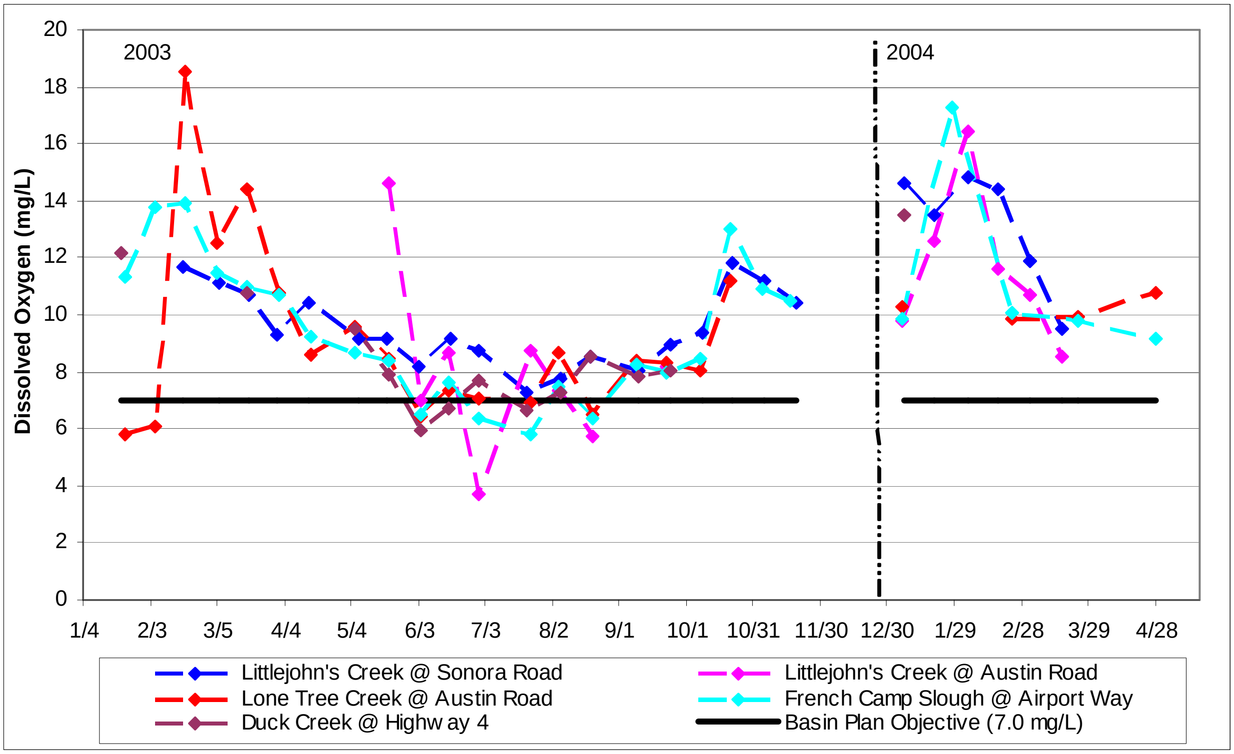


Figure 44 Biweekly Dissolved Oxygen: Valley Floor Drainage Area, January 2003 – April 2004

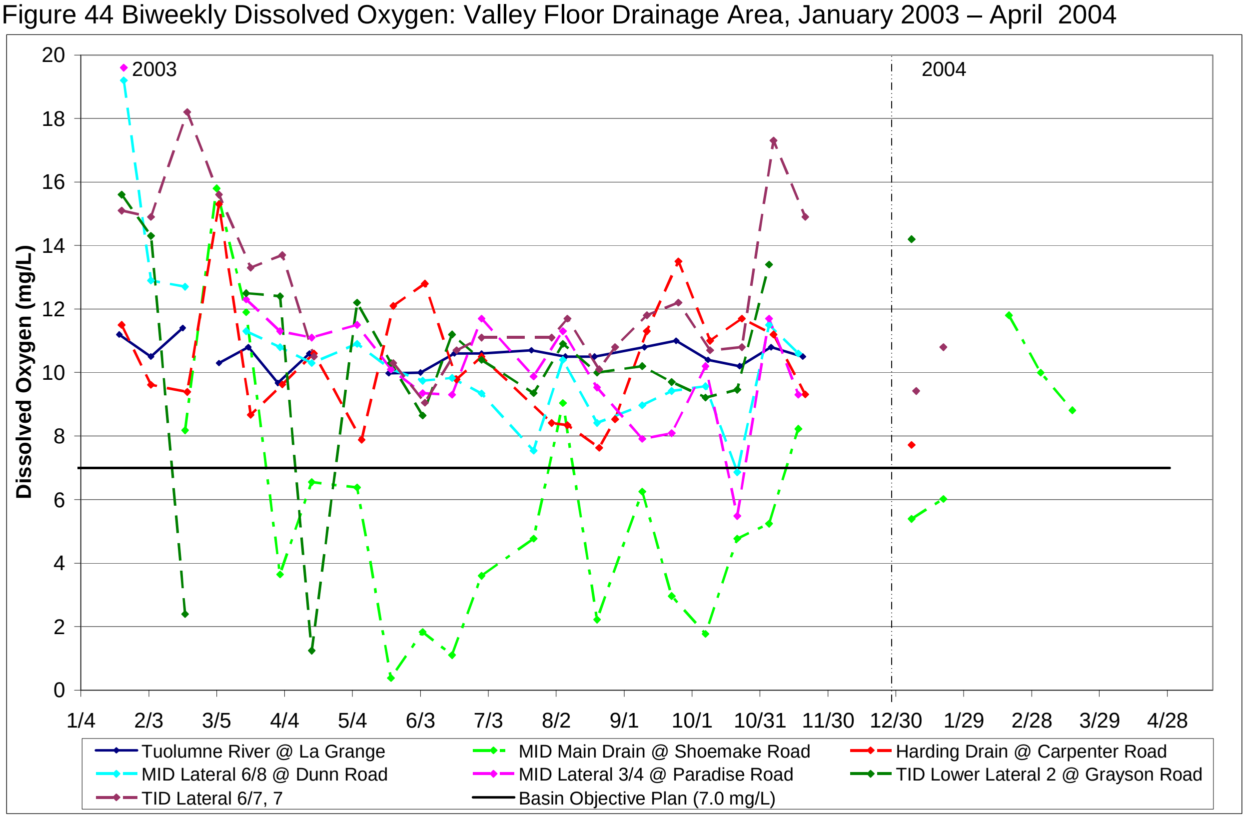


Figure 45 Summary Specific Conductance: Farmington Drainage Area, January 2003 - April 2004

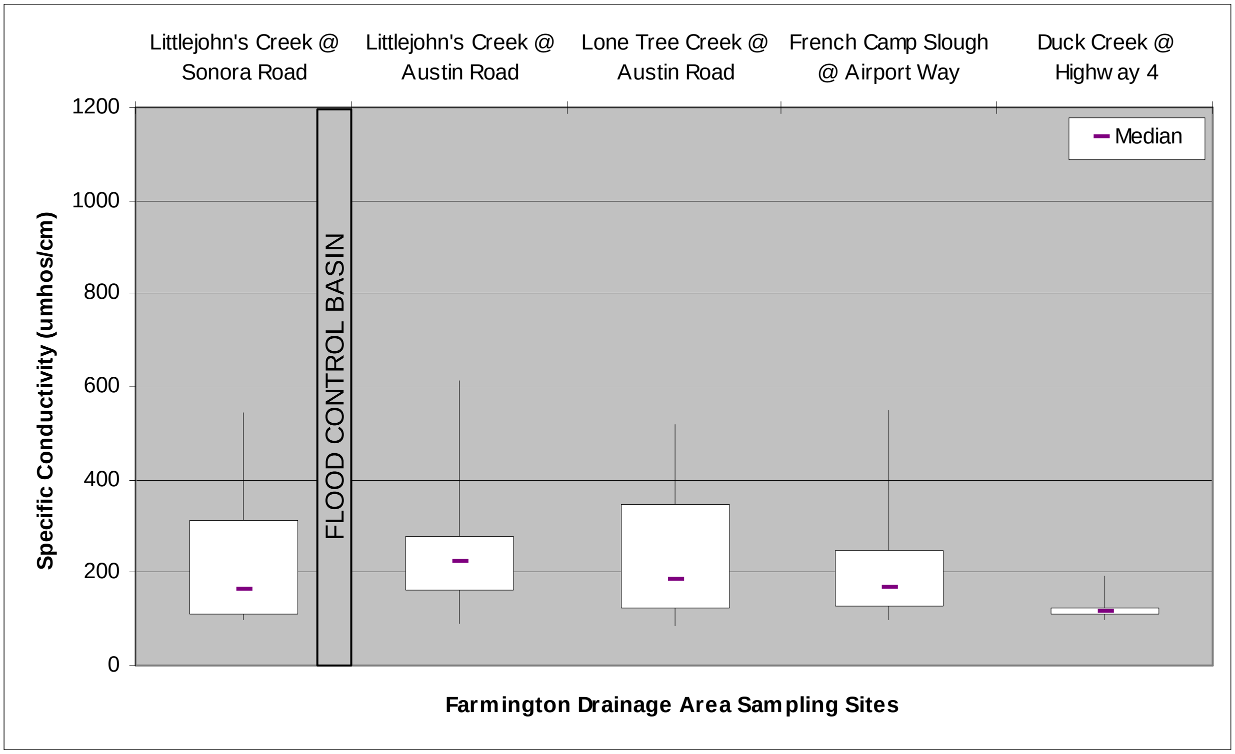


Figure 46 Summary Specific Conductance: Valley Floor Drainage Area, January 2003 - April 2004

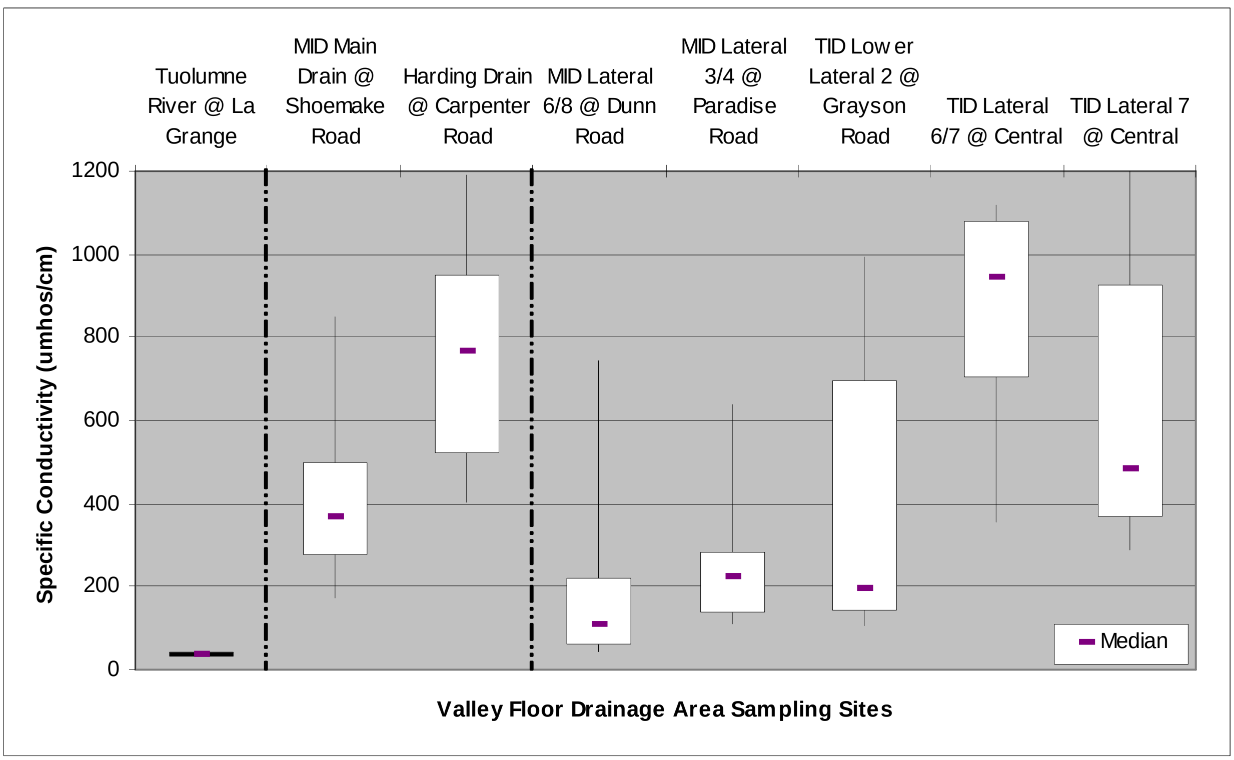


Figure 47 Biweekly Specific Conductance: Farmington Drainage Area, January 2003 - April 2004

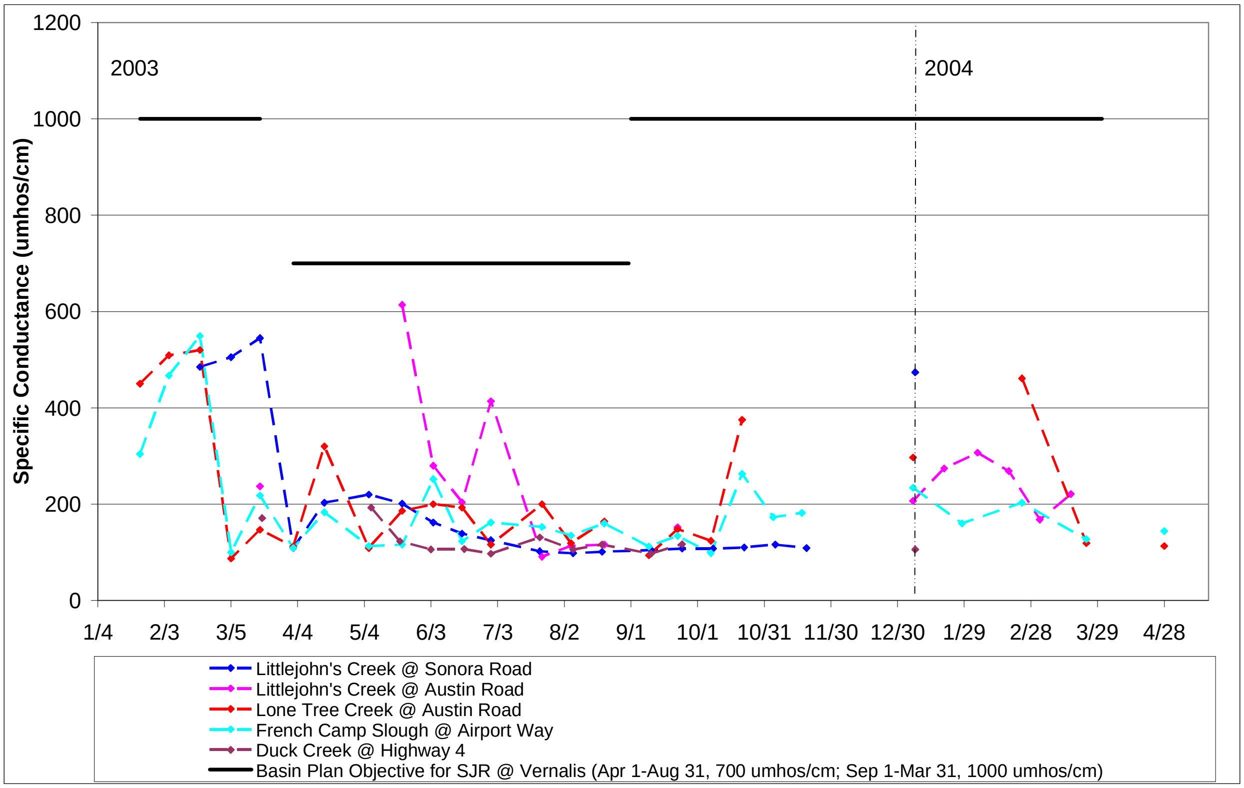


Figure 48 Biweekly Specific Conductance: Valley Floor Drainage Area, January 2003 -April 2004

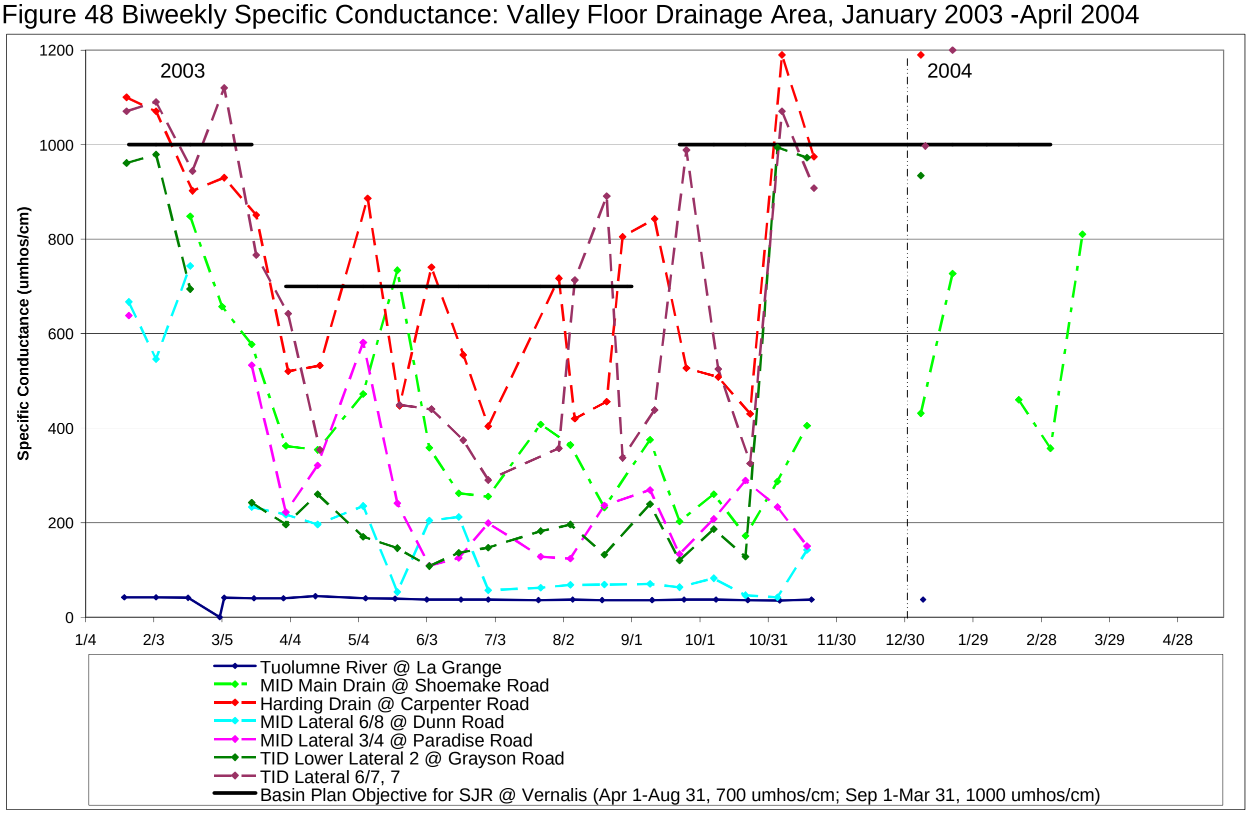


Figure 49 Summary pH: Farmington Drainage Area, January 2003 - April 2004

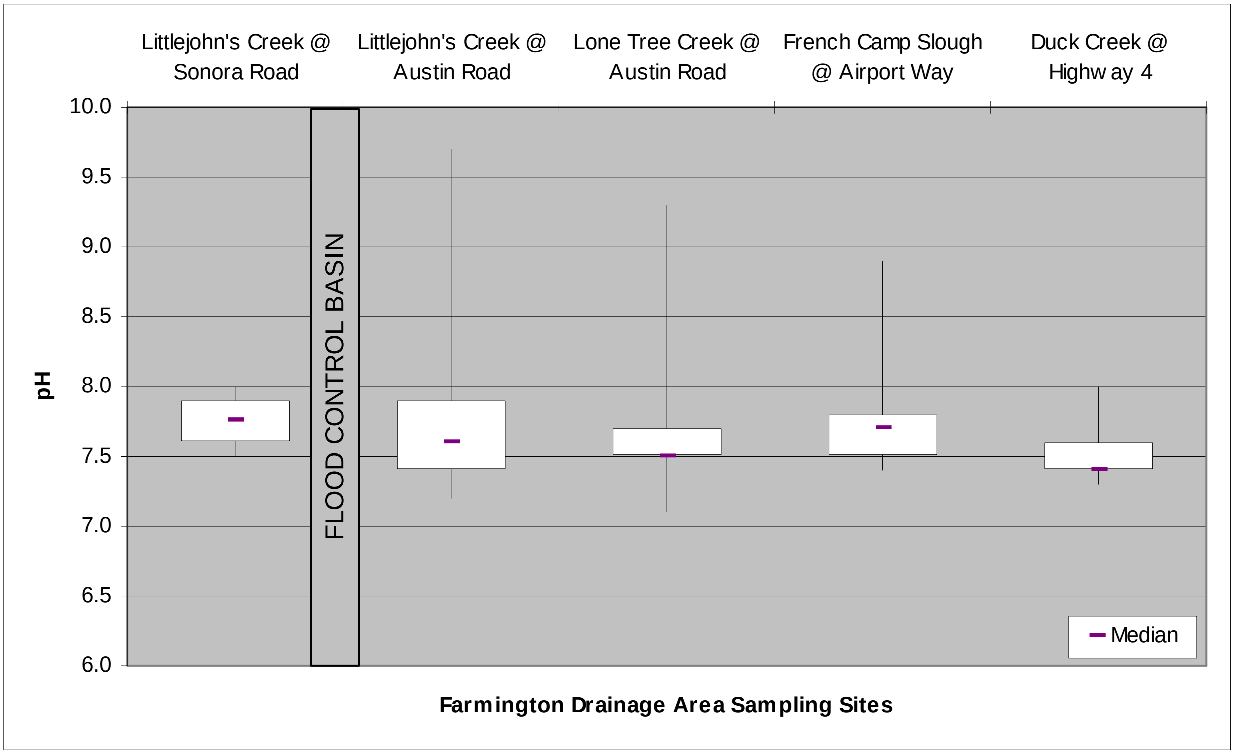


Figure 50 Summary pH: Valley Floor Drainage Area, January 2003 - April 2004

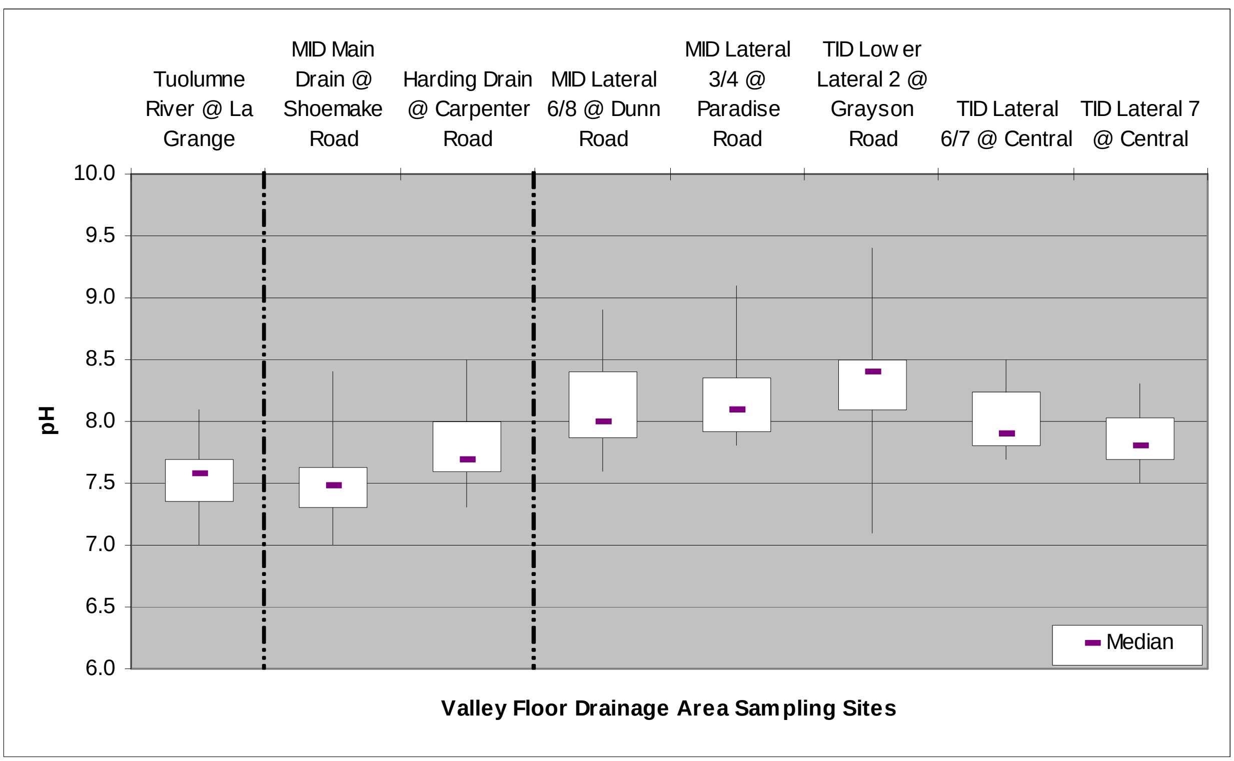


Figure 51 Biweekly pH: Farmington Drainage Area, January 2003 - April 2004

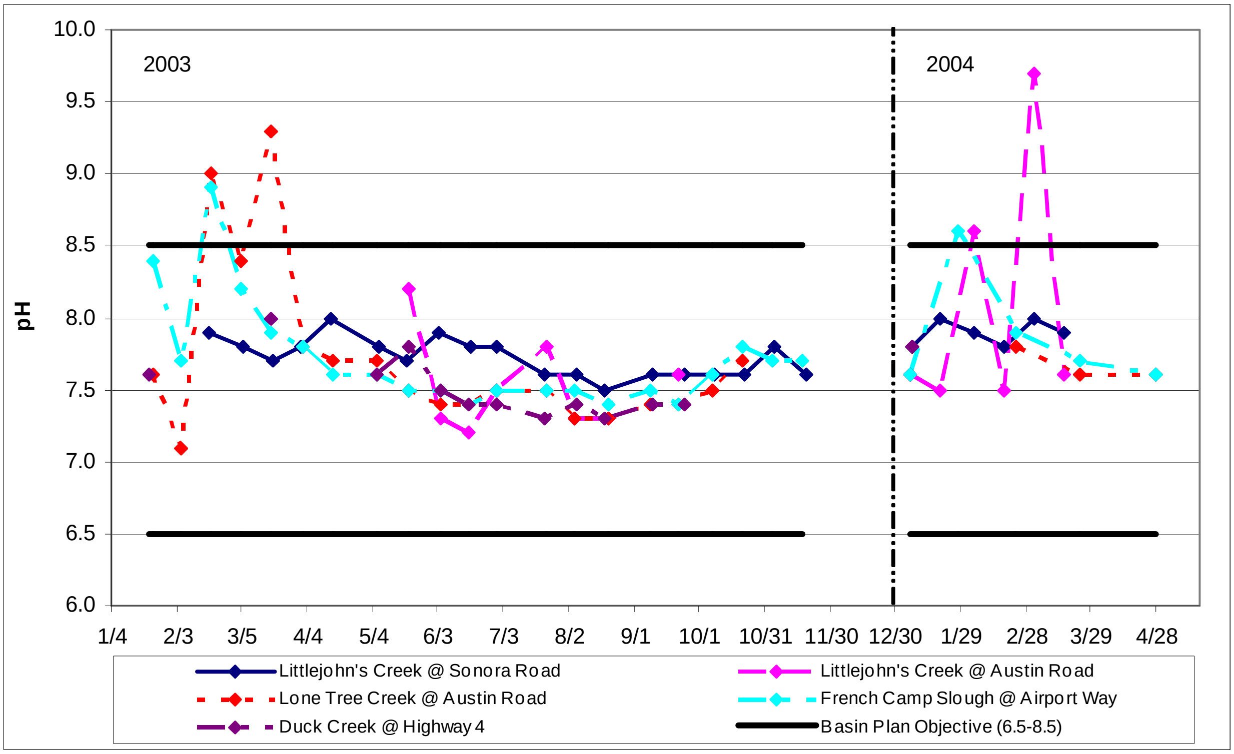


Figure 52 Biweekly pH: Valley Floor Drainage Area, January 2003 - April 2004

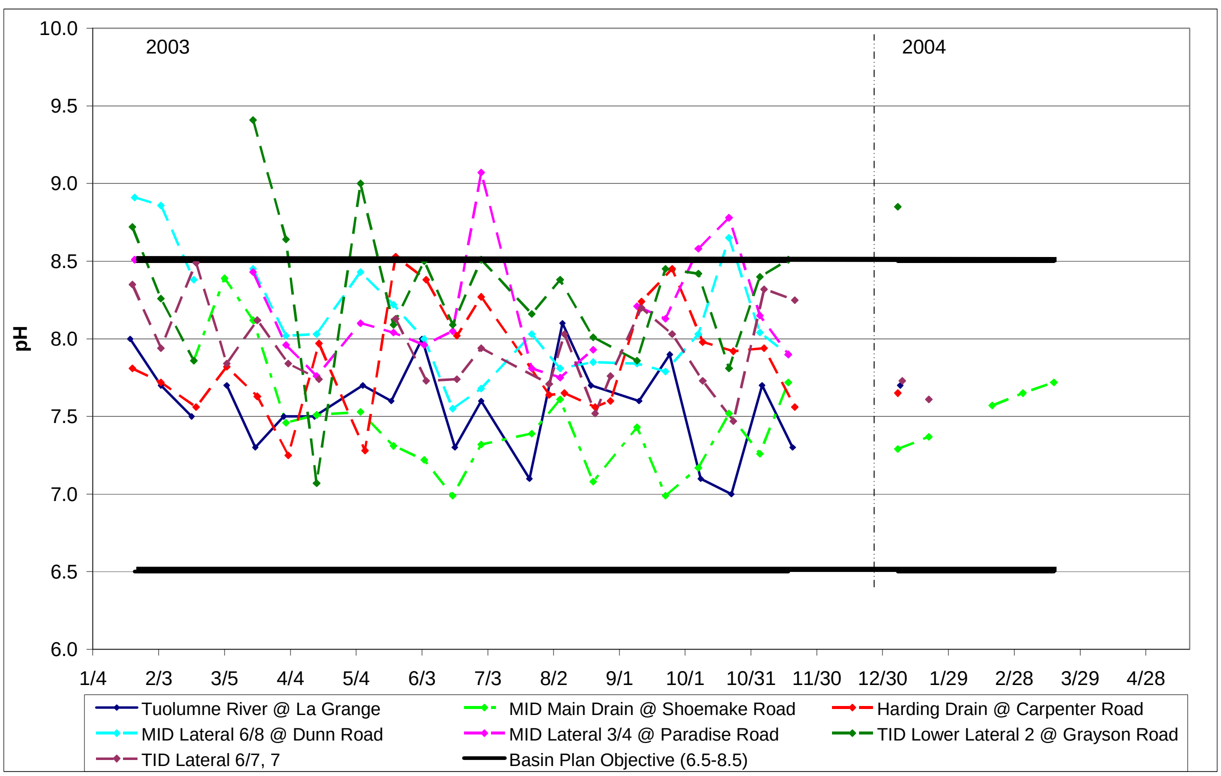


Figure 53 Summary Turbidity: Farmington Drainage Area, January 2003 - April 2004

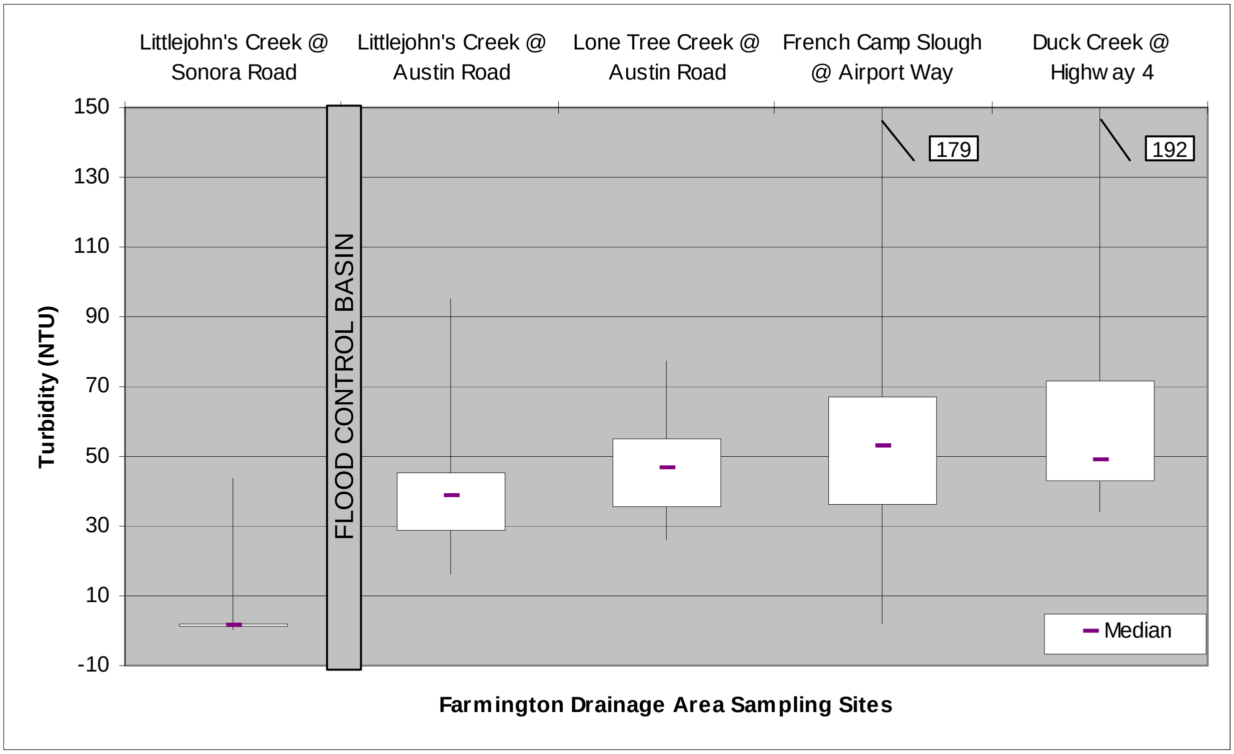


Figure 54 Summary Turbidity: Valley Floor Drainage Area, January 2003 - April 2004

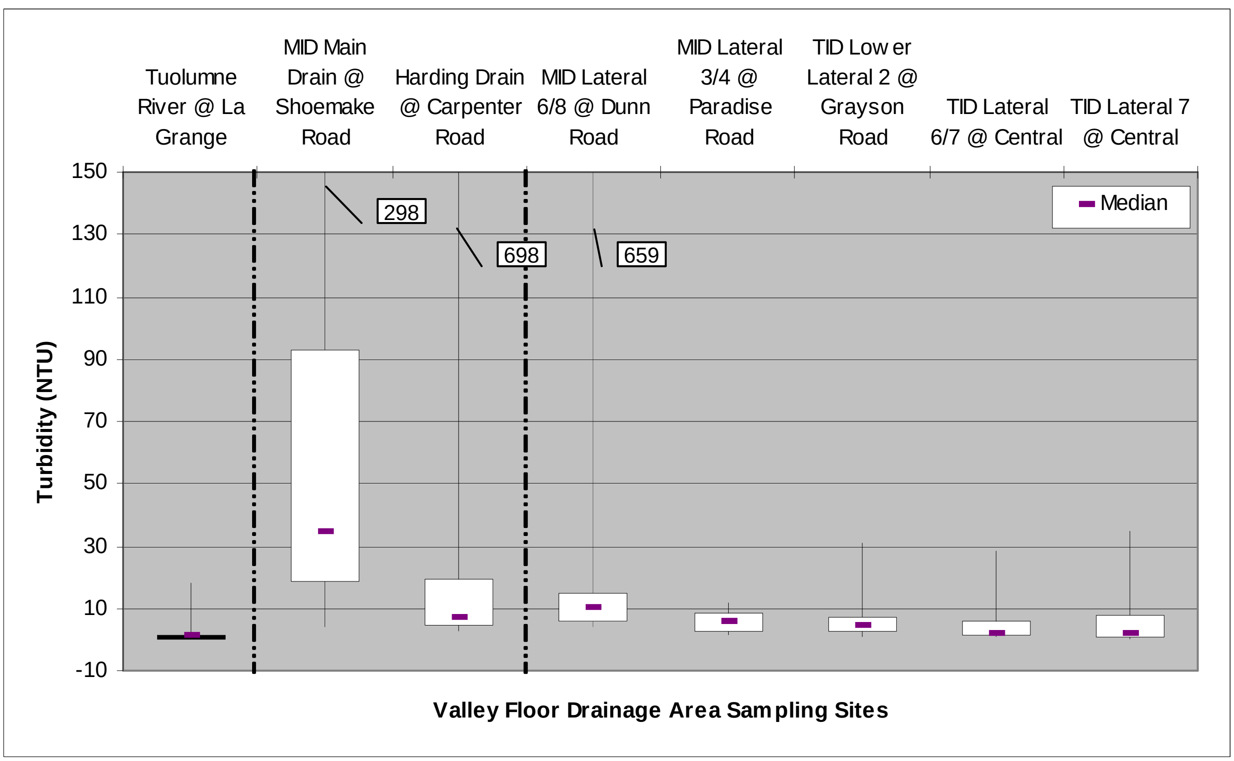


Figure 55 Biweekly Turbidity: Farmington Drainage Area, January 2003 - April 2004

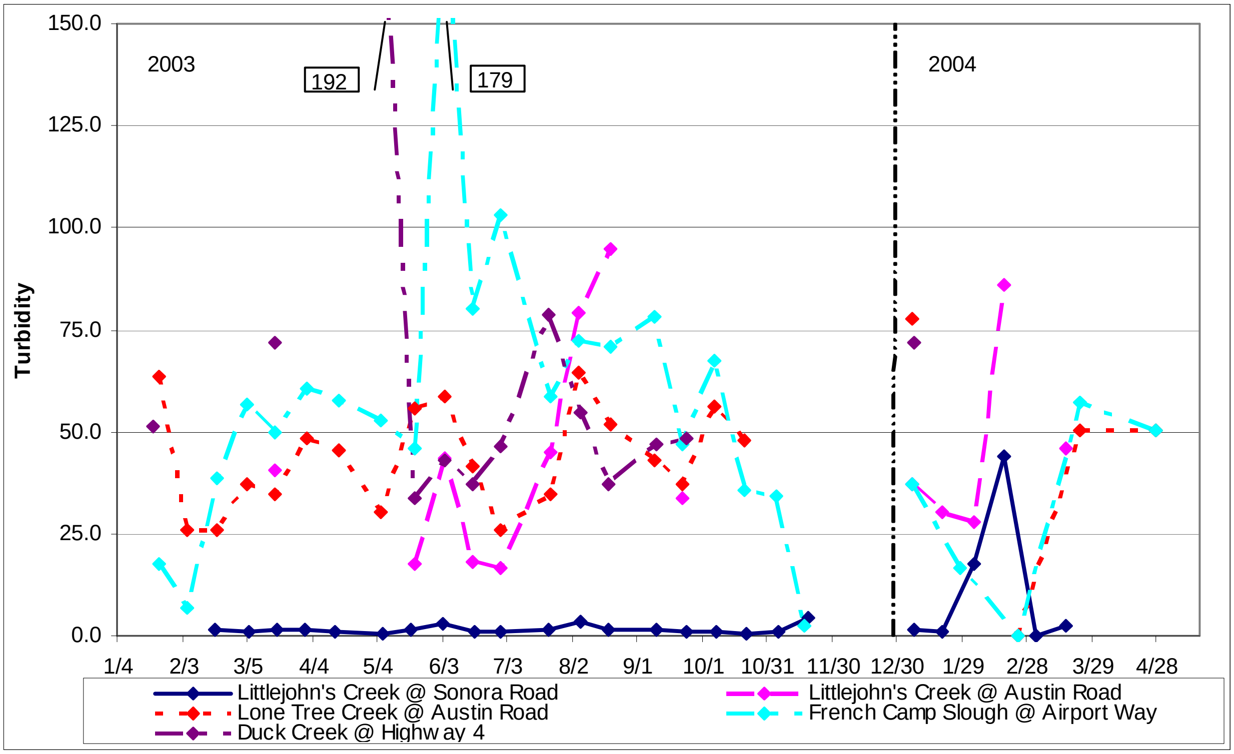


Figure 56 Biweekly Turbidity: Valley Floor Drainage Area, January 2003 - April 2004

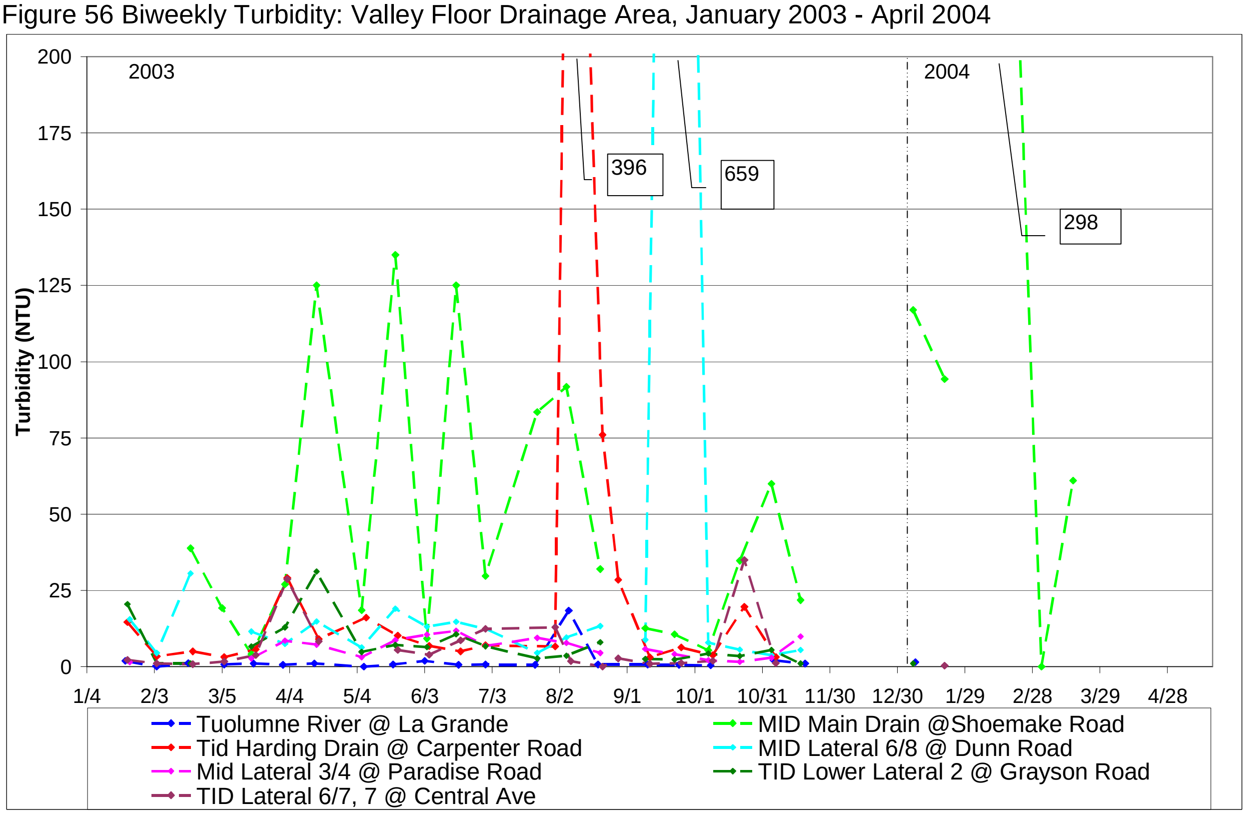


Figure 57 Summary Total Coliform: Farmington Drainage Area, January 2003 - April 2004

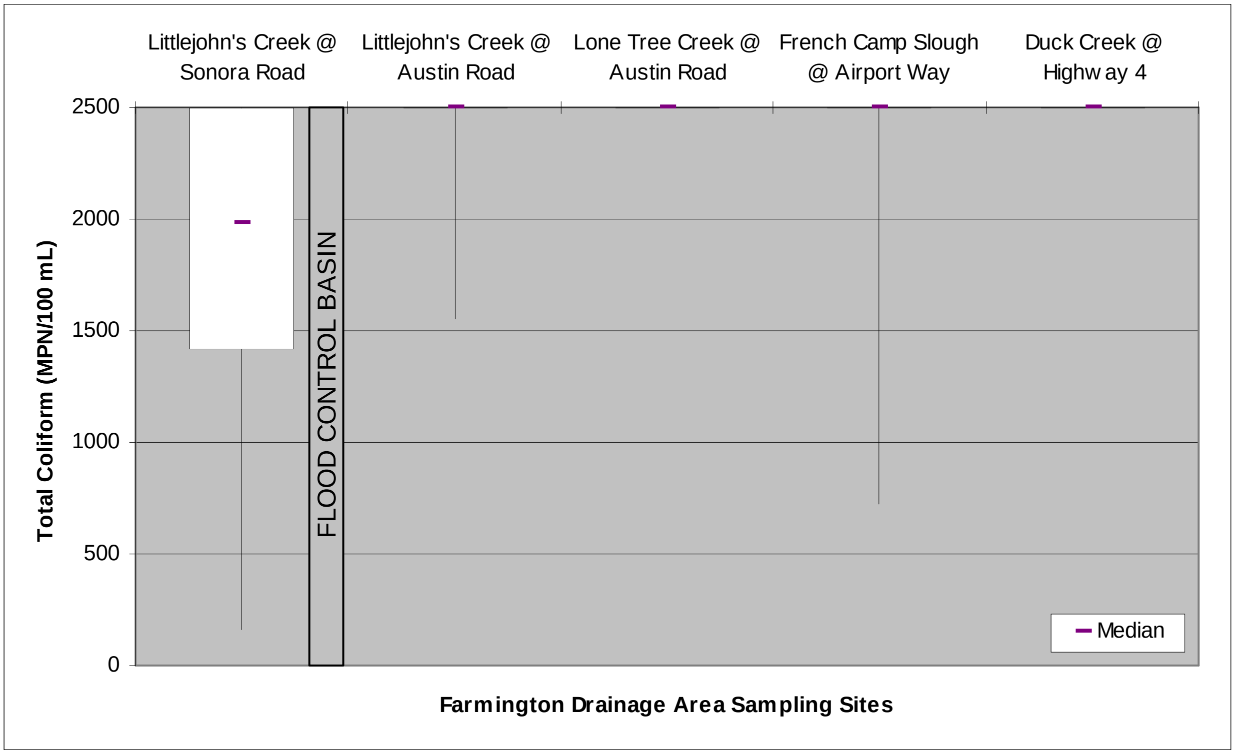


Figure 58 Summary Total Coliform: Valley Floor Drainage Area, January 2003 - April 2004

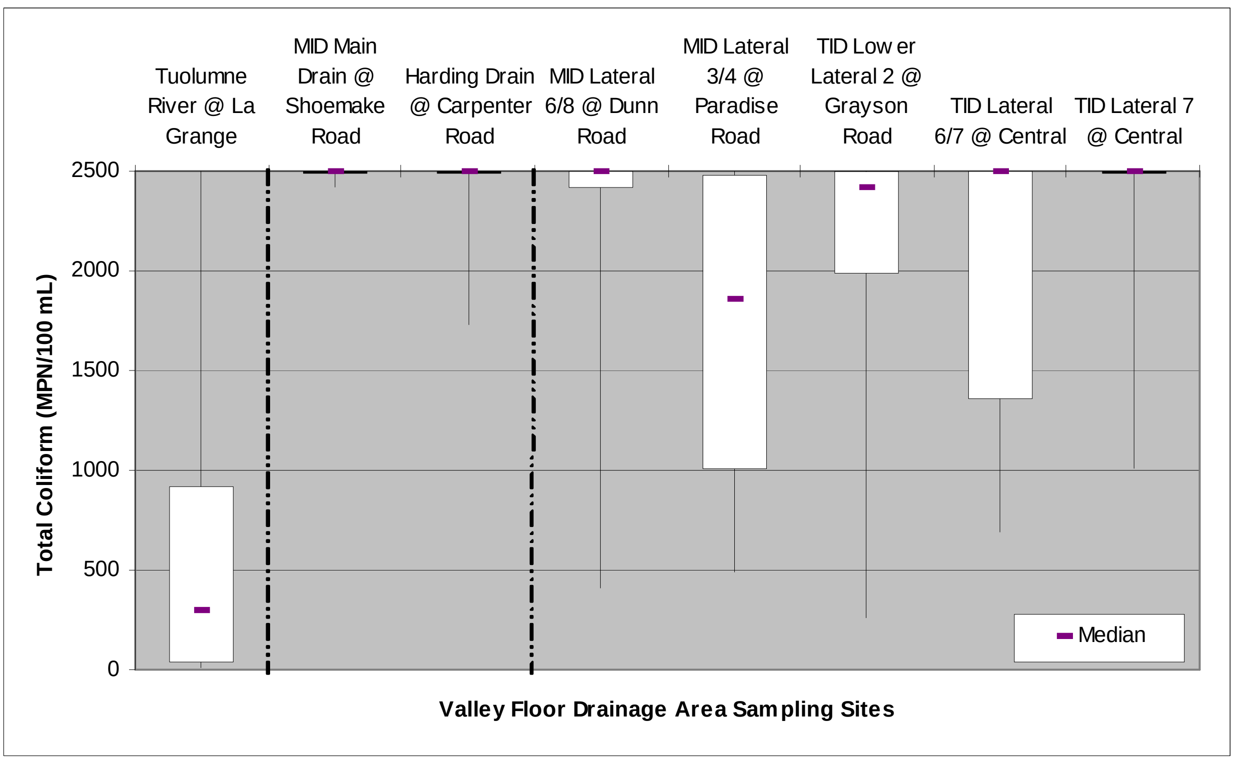


Figure 59 Summary ***E. coli:*** Farmington Drainage Area, January 2003 - April 2004

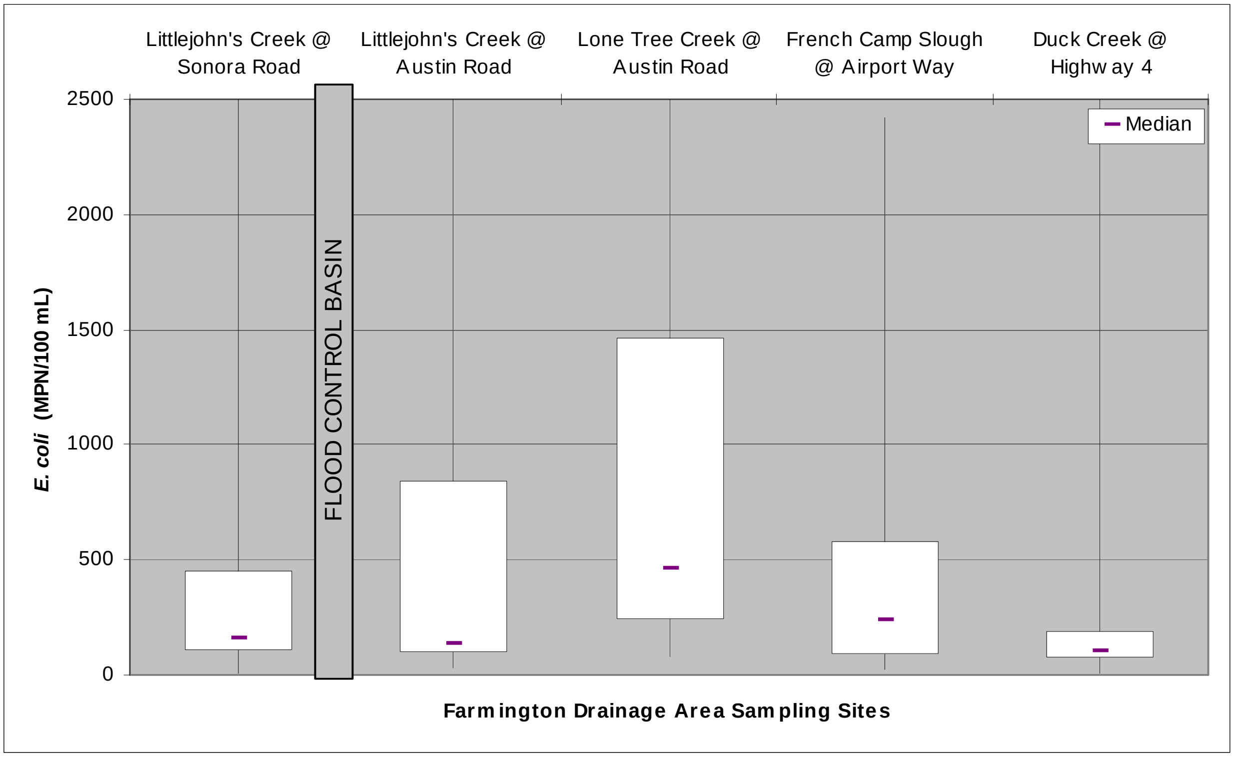


Figure 60 Summary ***E. coli***: Valley Floor Drainage Area, January 2003 - April 2004

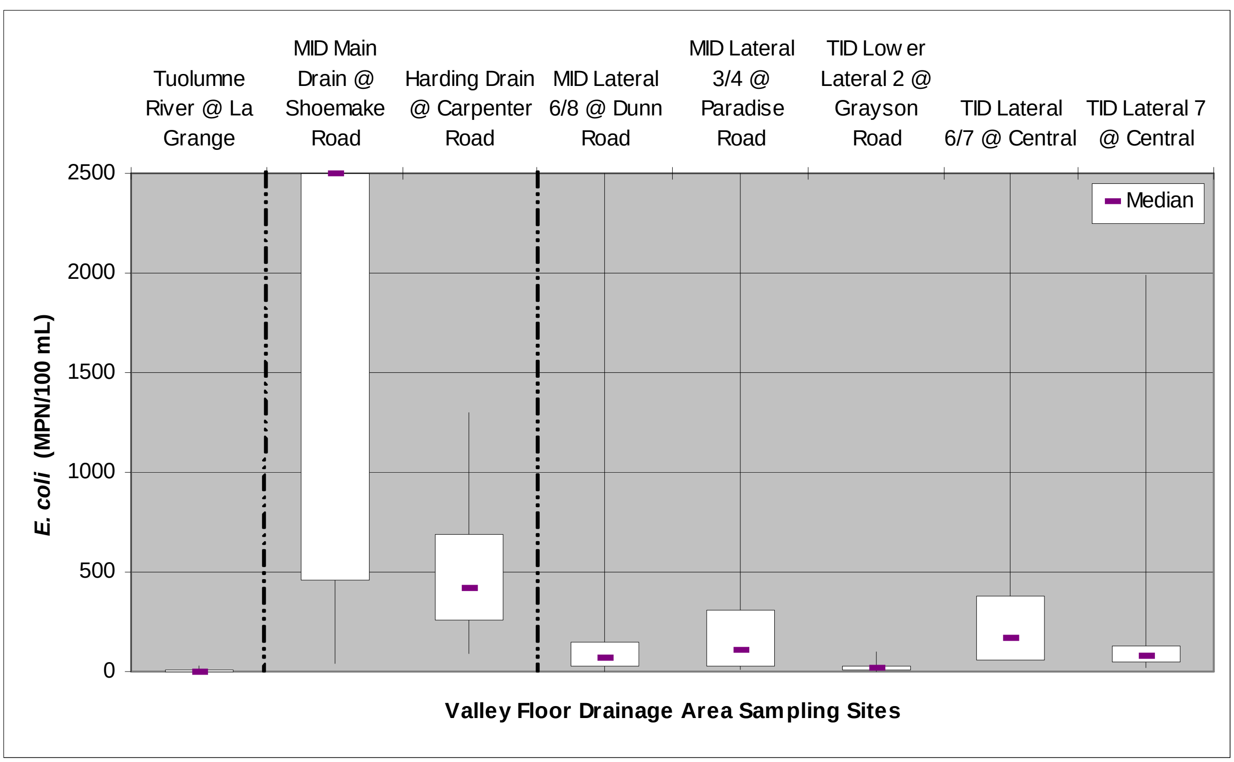


Figure 61 Biweekly ***E. coli:*** Farmington Drainage Area, January 2003 - April 2004

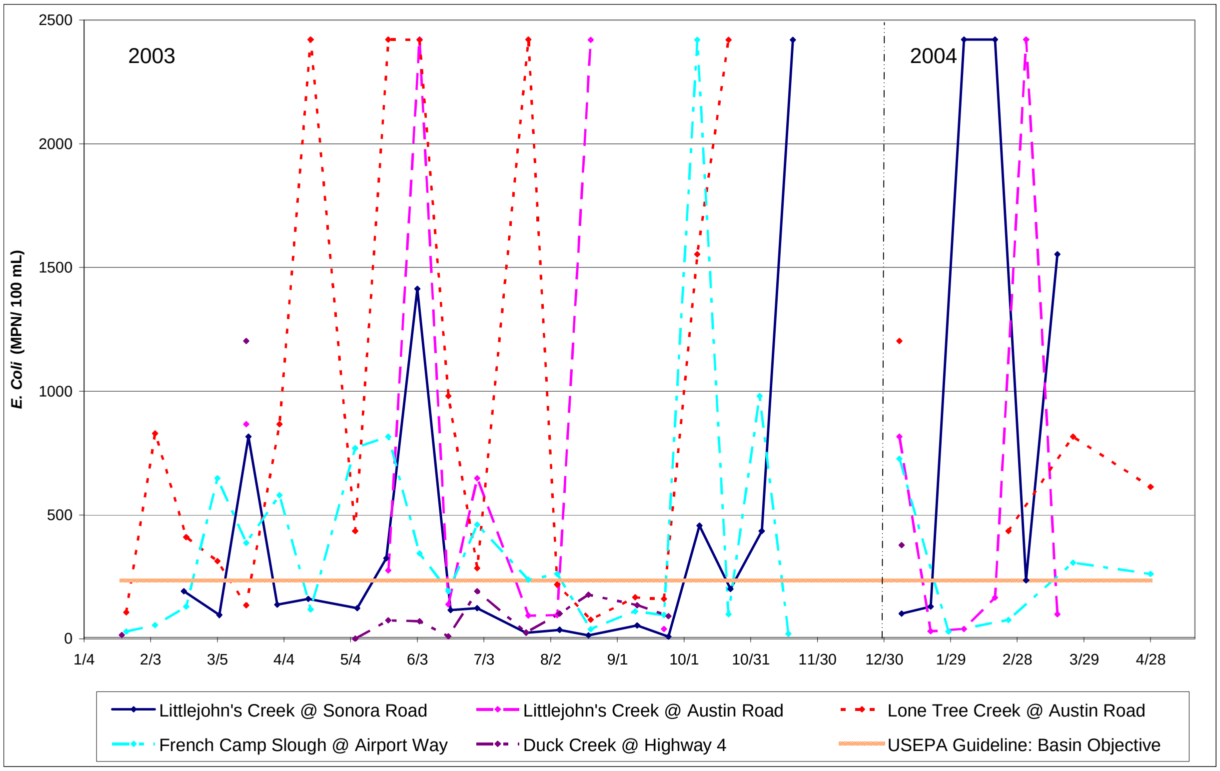
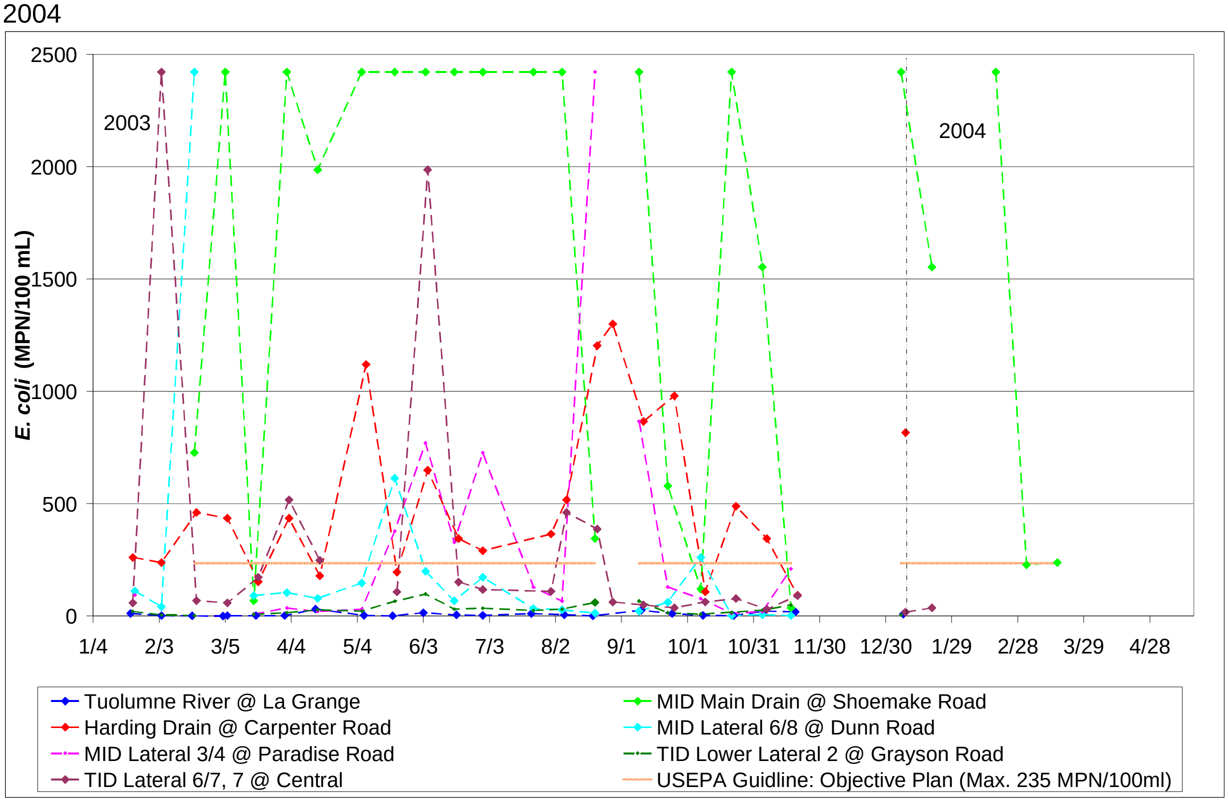


Figure 62 Biweekly ***E. coli:*** Valley Floor Drainage Area, January 2003 - April 2004



8.2 Interbasin Comparisons

One of the purposes of this study was to determine spatial differences in water quality and the potential influence of various land uses. In all three major river watersheds sampled, the area above the major reservoirs (the upper watershed) is dominated by native vegetation (timber and grassland), with scattered rural communities. Below the reservoirs, the lower watershed areas transition from native barren and vacant (developable open lands, flood control channels, etc.) areas to areas dominated by agricultural uses. The land uses referenced are classifications made by Department of Water Resources studies (Standard Land Use Legend, 1993). To evaluate the differences, site selection was targeted both above and below the reservoirs to allow a general comparison between the geographic zones.

A major land use below the reservoirs is agriculture. Therefore, additional sites were targeted to determine water quality in lower elevation water bodies draining directly into the San Joaquin, Stanislaus, and Tuolumne Rivers.

The Eastside Basin represents slightly more than one third of the entire San Joaquin River watershed drainage, causing discharge from this Basin to have a large potential to influence water quality in the SJR. Key constituents are compared across the discharges from each sub-basin (Stanislaus, Tuolumne, and Merced River Watersheds; as well as Farmington and Valley Floor Drainage Areas) into the SJR.

And finally, input from local stakeholders during the design of the overall monitoring effort indicated their interest in the potential influence of rural, residential development on a local stream, as well as potential influence of drainage from an agriculturally dominated subwatershed on a main river channel.

For the purpose of analysis, sampling sites were broken into categories as follows:

Comparing general water quality moving downstream in major river watersheds:
- Comparable sites within the Stanislaus, Tuolumne, and Merced Watershed.
    - Upper watershed integrator: Above major regulating reservoirs and/or broad areas with little man induced alteration.
    - Discharge from impoundments (major regulating reservoirs), which essentially serves as the headwaters for the lower basins.
    - Lower watershed integrator: Located at the mouth of the river, representing the entire watershed.

Evaluating lower elevation water bodies discharging to the San Joaquin and Stanislaus Rivers:
- Comparable sites between lower elevation drainage areas that eventually discharge directly to the San Joaquin River or to one of the three major tributaries.
    - Source: Located at a source to the drainage area that supplies a discharge point that was included in this study.
    - Discharges to rivers: Located within supply and drain channel just upstream of their discharge to Rivers.
        - Agriculturally dominated drains: largely dirt lined, with discharges from small communities and agricultural use
        - Agriculturally dominated laterals: includes concrete lined sections that receive municipal flows (storm water and treated discharge) as well as agricultural supply, operational spill and some tailwater

Comparing discharges to the SJR from each sub-basin (Stanislaus, Tuolumne, and Merced River Watersheds; and Farmington and Valley Floor Drainage Areas)

Special Studies per stakeholder requests
- Potential impact of residential construction in a rural community (Sonora)
- Potential impact of an agriculturally dominated subwatershed (Dry Creek) on the Tuolumne River

The figures in this section include both the summary data (minimum, 1st quartile, 3rd quartile, maximum) and medians of the various constituents by site and grouped into the targeted categories listed above. Minimum and maximum values are indicated by the end of the lines extending from the boxes.

Interquartiles are displayed by the box made up of the 1st quartile at the bottom of the box and 3rd quartile at the top of the box. Median values are represented by the dash. The concentrations are identified on the left side of the figure.

8.2.1 Comparing General Water Quality Moving Downstream in Major River Watersheds

Table 13: Site Categories for Discussion of Comparison of Upper Watershed, Discharge from Impoundment, and Lower Watershed Integrator Sites

EASTSIDE BASIN			
Site Code	Site Description	Identifier - Discussion Figures	Watershed
Upper Watershed Integrator			
TUO202	Woods Creek at Mill Villa Drive	Woods	Tuolumne
TUO207	Sullivan Creek at Algerine Road	Sullivan	Tuolumne
MAR203	Merced River at Bagby Rec. Area	Bagby	Merced
Discharge from Impoundments			
STC201	Stanislaus River at Knight's Ferry	Knight's Ferry	Stanislaus
STC210	Tuolumne River at La Grange Road	La Grange	Tuolumne
MER209	Merced River at Merced Falls	Merced Falls	Merced
Lower Watershed Integrator			
STC514	Stanislaus River at Caswell Park	Caswell	Stanislaus
STC513	Tuolumne River at Shiloh Fishing Access	Shiloh	Tuolumne
MER546	Merced River at River Road	River Road	Merced

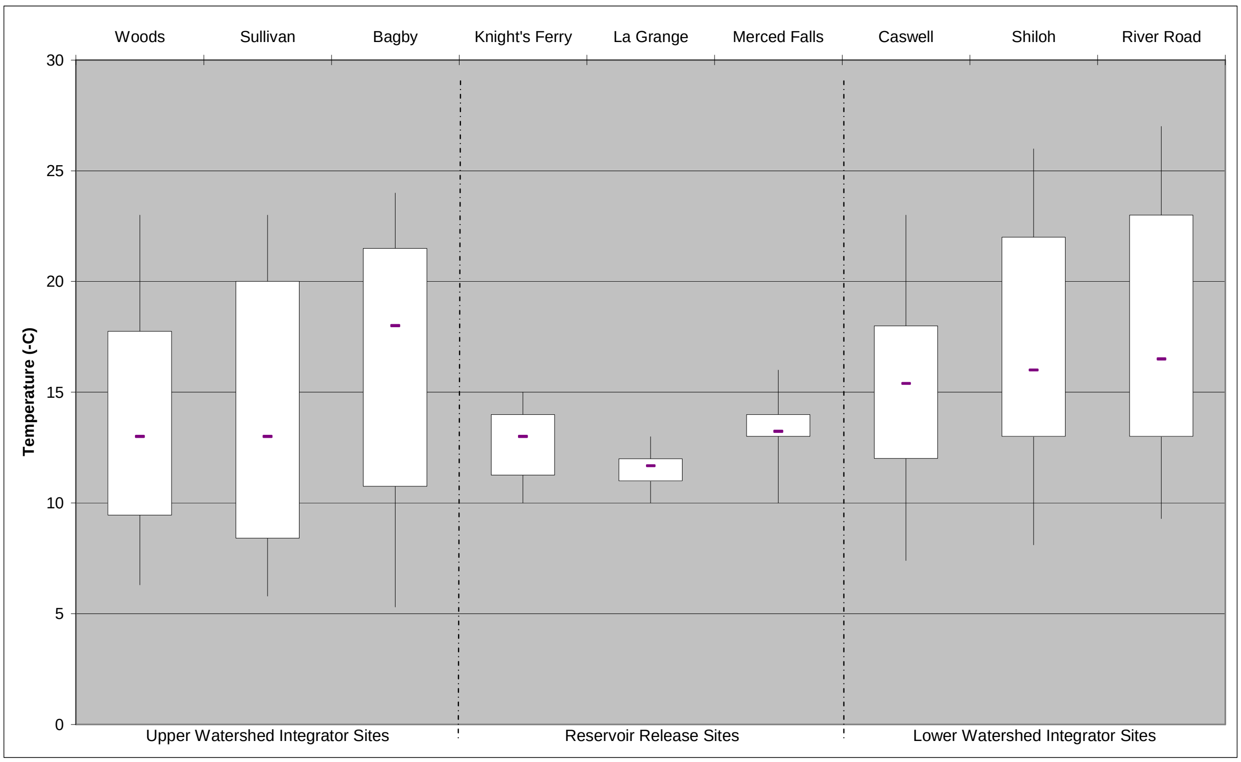
In an attempt to characterize water quality draining from the upper and lower watersheds, “integrator” sites were identified. Integrator sites are located near discharge points of large watersheds that are characterized by heterogeneous land uses and are used to characterize the cumulative contribution of contaminants from the target watershed. In making such a comparison, we do recognize that there are different land uses and flow patterns in each of the watersheds.

In the upper watersheds, sites were initially chosen along the main stem of each river. However, safety and logistical concerns resulted in the sampling site in the upper Stanislaus River to be dropped with no replacement. Additionally, the upper Tuolumne River sampling site had to be dropped, but two sites along small streams with low flows and urban influences remained. The Merced River sampling site was only slightly modified, but always remained on the main stem. Upper watershed sites in the Tuolumne and Merced Watersheds are integrator sites that were monitored at least quarterly. Possible influences to water quality in the upper Tuolumne watershed include the communities of Sonora, Soulsby and Twain Harte, as well as grazing, wildlife, and timber harvest activities. In the upper Merced watershed, communities with potential to influence water quality are smaller and further upstream than in the upper Tuolumne watershed. Water quality at this site is more likely influenced by management of National Forest land.

Samples were collected in all three watersheds at reservoir release sites. As was seen during monitoring in the Northeast Basin (Graham, 2009), reservoirs affect water quality immediately downstream by stabilizing constituent concentrations. Data ranges tend to be smaller than concentrations from upper and lower watershed sites, and concentrations for constituents such as electrical conductivity, ***E. coli***, and total organic carbon tended to be the lowest at these sites.

Integrator sites in the lower watershed were a culmination of water quality draining the entire watershed. As each of the rivers flowed downstream, water quality was influence by various inflows. However, each of the sites was influenced most readily by activities immediately upstream. In the Stanislaus watershed, the lower watershed integrator site was located just upstream of an overnight camping site. Potential influences upstream of the site include the city of Ripon (population of 11,651 in 2003) and agricultural drainage as well as operational spill from the Modesto Irrigation District. The lower Tuolumne watershed site was located at a fishing access site, adjacent to a motor home park. Upstream of this site was the City of Modesto (population of 203,859 in 2003). The lower Merced watershed site was located within the George Hatfield State Recreation Area. There are several unincorporated communities (where populations are undocumented) upstream of this site, along with the city of Livingston (population of 11,127 in 2003)

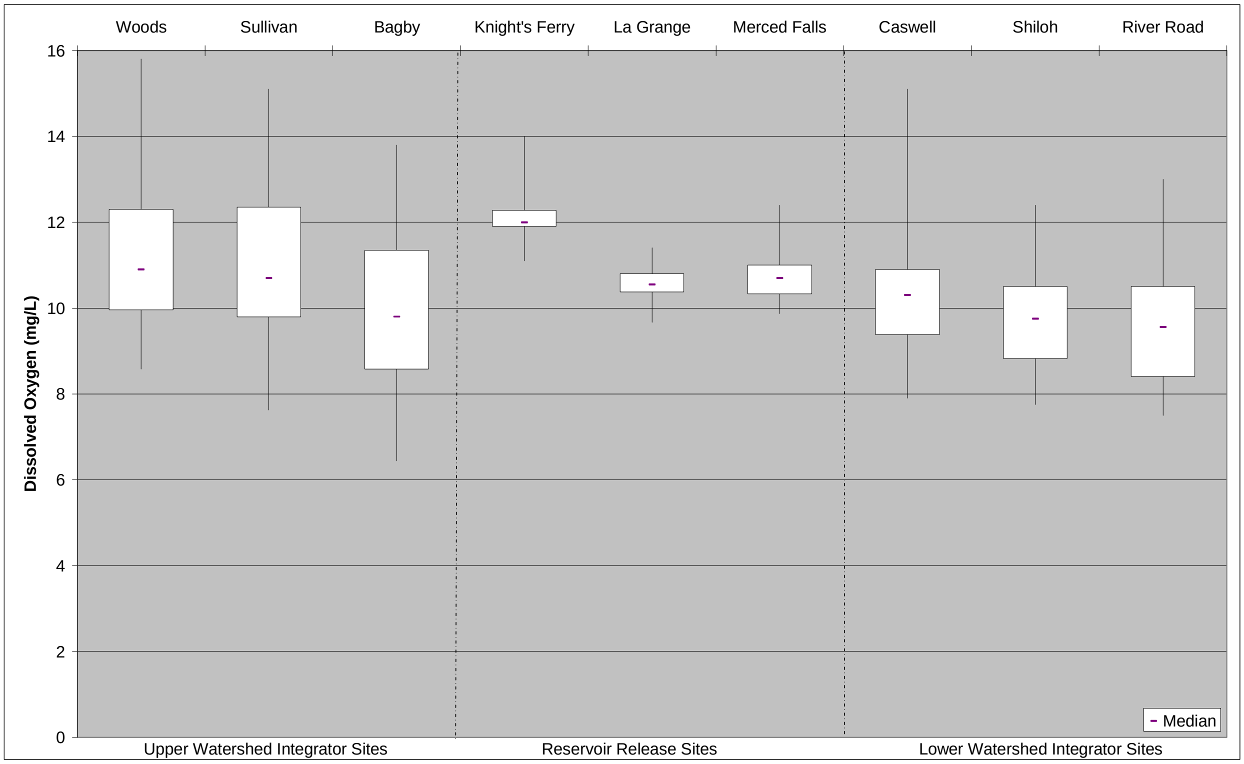
Figure 63 Eastside Basin Watershed Integrator Sites: Temperature



<u>Temperature</u>

The first and third temperature quartiles in the Tuolumne and Merced upper watersheds ranged from 8 to 22 -C, with minimum and maximum temperatures ranging from 5 to 24 -C. Median temperature in the Merced watershed was higher than in the Tuolumne watershed. Temperatures from the reservoir release sites were less variable and generally cooler than both the upper watershed and lower watershed integrator sites, having first and third quartiles ranging from 11 to 14 -C with minimum and maximums ranging from 10 to 16-C. The majority of temperature results collected at the Stanislaus reservoir release site were higher and more variable than the Tuolumne site, while the Stanislaus lower watershed integrator site temperatures were lower and less variable than the Tuolumne site. Lower watershed integrator mean temperatures increased moving north to south.

Figure 64 Eastside Basin Watershed Integrator Sites: Dissolved Oxygen

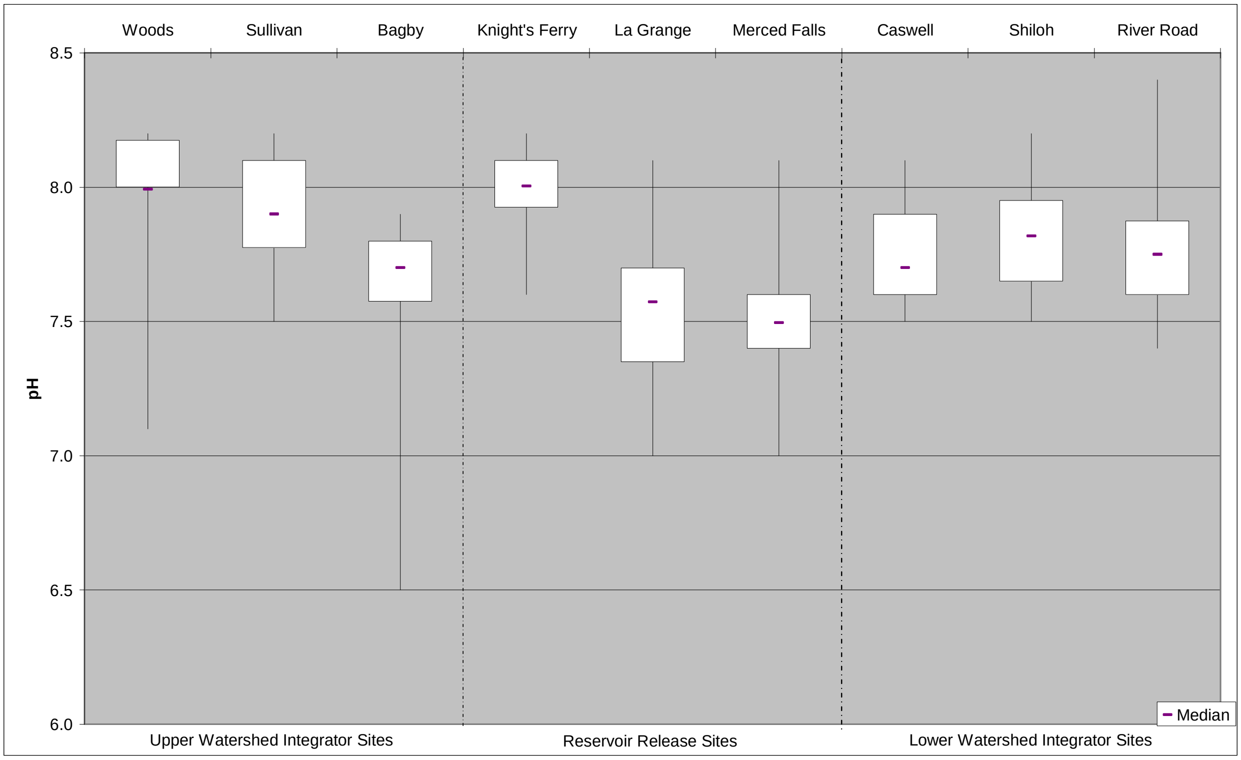


<u>Dissolved Oxygen (DO)</u>

The DO concentrations in the upper Tuolumne watershed ranged from 7.6 to 15.8 mg/l. Median concentrations were similar in Woods and Sullivan Creeks. Median concentration in the Merced watershed was lower than both of the Tuolumne watershed sites, with overall concentrations similar to the lower watershed sites. Minimum and maximum concentrations in the Stanislaus watershed were 11.1 and 14.0 mg/l, respectively, while minimum and maximum concentrations in the Tuolumne and Merced watersheds were 9.7 and 9.9 mg/l, and 11.4 and 12.4 mg/l, respectively.

In general, dissolved oxygen throughout the watersheds was reported between 8.41 to 12.3 mg/L. Mean dissolved oxygen concentrations decreased moving north to south in the upper and lower watershed. Concentrations from the reservoir release sites fell within both the upper and lower watershed general concentrations, although ranges in DO were least variable downstream of reservoir releases.

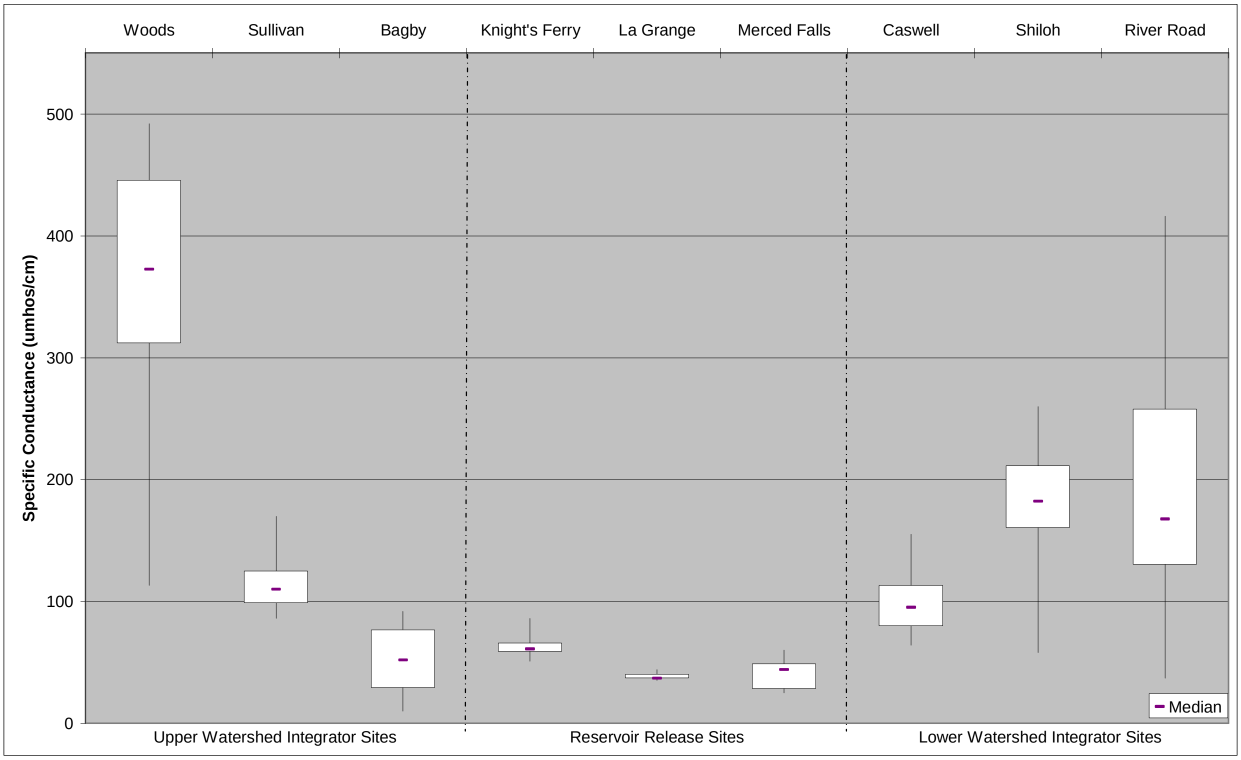
Figure 65 Eastside Basin Watershed Integrator Sites: pH



<u>The pH</u>

The pH throughout all the watersheds typically ranged from 7.4 to 8.2. Outliers in the upper watershed were skewed to lower (acidic) concentrations, dropping to a pH of 6.5. Median upper watershed pH values ranged from 7.6 to 8.0. Reservoir release medians from the Tuolumne and Merced Watersheds were around 7.5, however, medians from the Stanislaus reservoir release site was higher - 8.0. The pH concentrations were similar between watersheds in the lower watershed integrator sites, with medians at all sites at approximately 7.8.

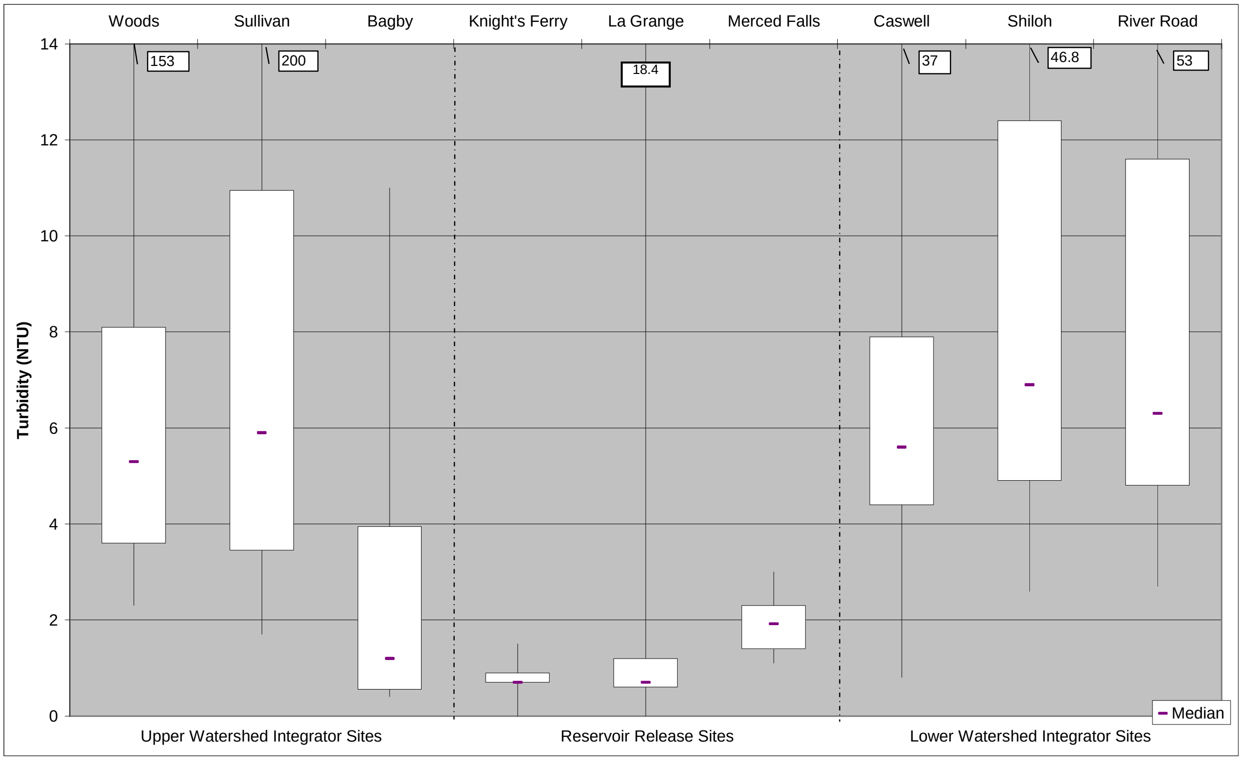
Figure 66 Eastside Basin Watershed Integrator Sites: Specific Conductance



Specific Conductance (SC)

Specific conductance in the upper watersheds was variable, ranging from 20 to 445 umhos/cm. SC was most variable and highest overall at Woods Creek. Reservoir release sites were the least variable, with concentrations generally ranging from 29 to 86 umhos/cm. In the lower watersheds, SC concentrations grew more variable moving from north to south. Median concentrations in the lower Stanislaus integrator site (99 umhos/cm) was almost half that of the median concentrations in the Tuolumne and Merced integrator sites, but all lower watershed medians were above the maximums reported for the reservoir releases.

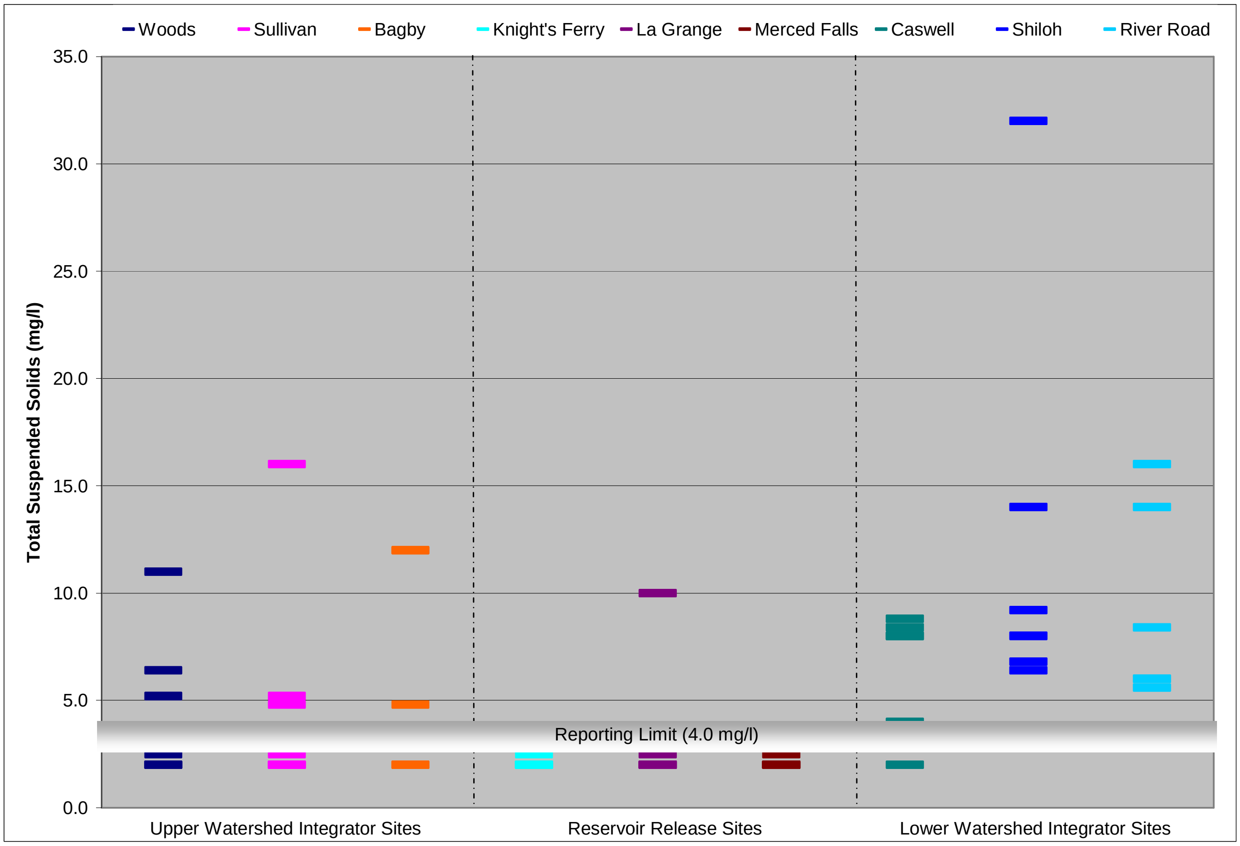
Figure 67 Eastside Basin Watershed Integrator Sites: Turbidity



Turbidity

Turbidity at most sites, regardless of location, generally stayed under 12 NTU, but outliers reached as high as 200 NTU. Outliers were higher in the upper watershed sites than the lower watershed sites. Turbidity was lowest in the reservoir release sites in all three watersheds, with the majority of concentrations under 3 NTU. Outliers in the Tuolumne Watershed were highest, at 18.4 NTU. Concentrations in the lower watershed integrators were higher than concentrations from the reservoir release sites. Maximum NTU outliers in the lower watershed increased moving north to south.

Figure 68 Eastside Basin Watershed Integrator Sites: Total Suspended Solids



Total Suspended Solids (TSS)

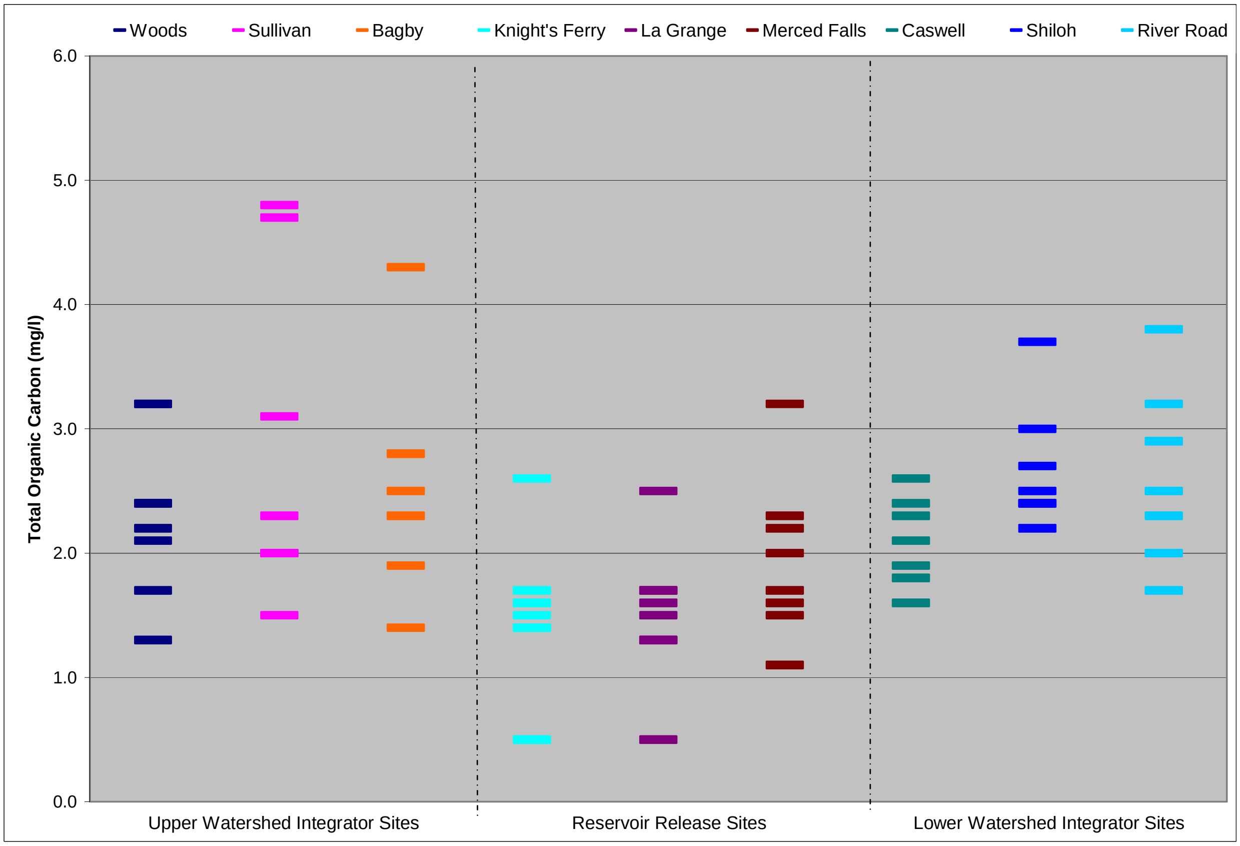
Total suspended sediment (TSS) samples were collected from midway in March through the end of June 2003, with no more than five samples per site. Reporting limits were 5.0 mg/l for samples collected in March and 4.0 mg/l for all other samples. In Figure 68, results below the reporting limit are shown at half the applicable limit.

Median values were below reporting limits at Woods Creek at Mill Villa Drive, Sullivan Creek at Algerine Road, Stanislaus River at Knight's Ferry, Tuolumne River at La Grange, Merced River at Merced Falls, Stanislaus River at Caswell Park, Tuolumne River at Shiloh, and Merced River at River Road. Minimum concentrations where results were below the reporting limit are shown using half the lowest reporting limit.

Total suspended solid (TSS) concentrations in the upper watersheds ranged from below reporting limits (<4.0 mg/L) to 16 mg/L. Concentrations at the reservoir release sites were generally below reporting limits (<4.0 and <5.0 mg/L). The one exception was a sample collected at Tuolumne River at La Grange that had a TSS concentration of 10 mg/L. The TSS concentrations were highest in each of the lower watersheds. Concentrations generally ranged from 5.0 to 14.0 mg/L, while median concentrations ranged from 6.5 to 10 mg/L.

Elevated TSS concentrations did not follow a consistent temporal pattern.

Figure 69 Eastside Basin Watershed Integrator Sites: Total Organic Carbon



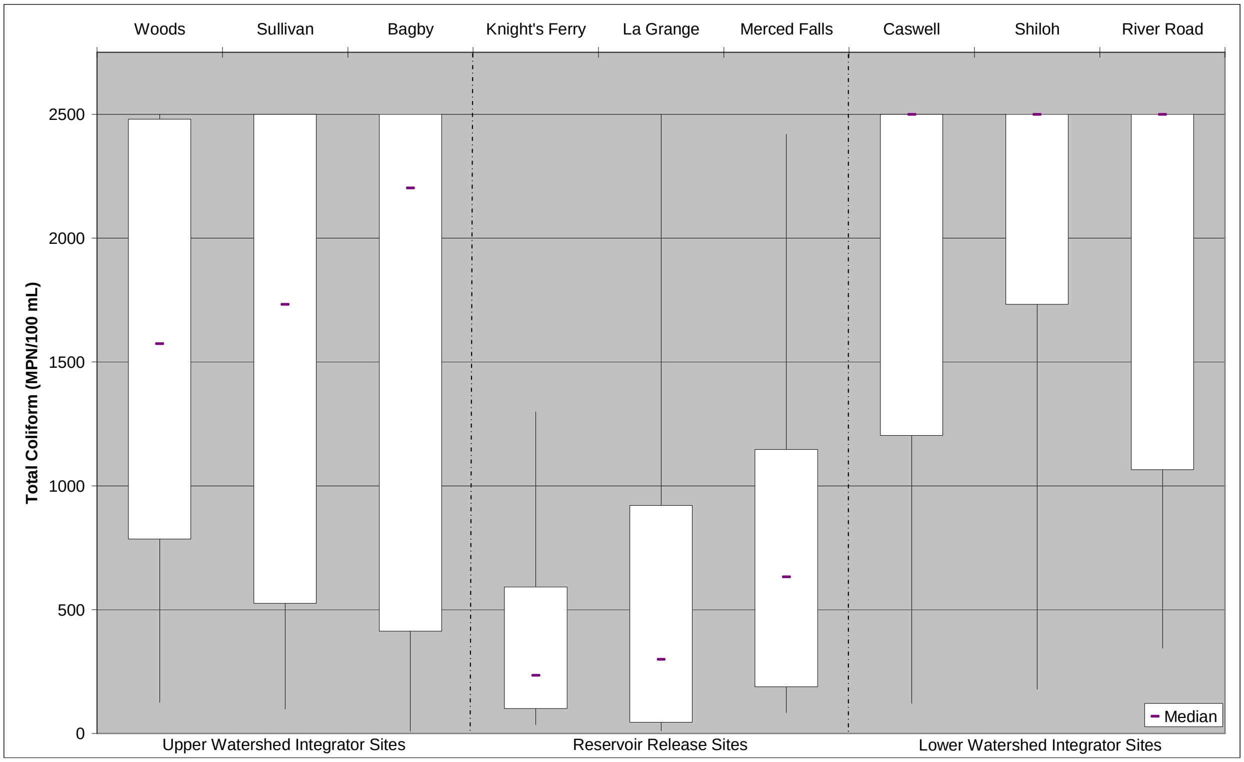
Total Organic Carbon (TOC)

Total organic carbon (TOC) samples were collected from midway in March through the end of June 2003. The reporting limit was 1.0 mg/l. Values reported at <1.0 mg/L have been depicted at 0.5 mg/l.

Overall TOC concentrations were lower in the reservoir release sites than the upper or lower watershed sites.

Median concentrations from the upper and lower watershed integrator sites were similar to each other. The average of the three Tuolumne upper watershed median concentrations was 2.9 mg/L, while the concentration at the lower watershed site was 2.7 mg/L.

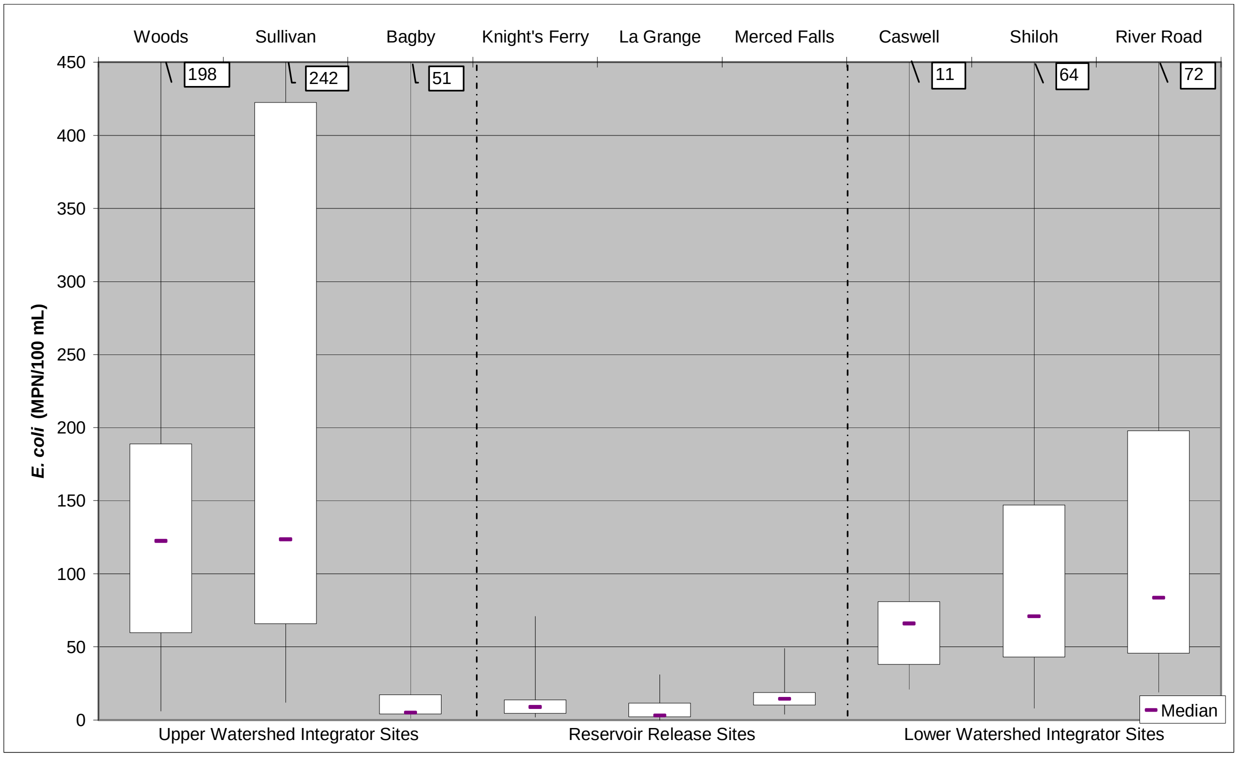
Figure 70 Eastside Basin Watershed Integrator Sites: Total Coliform



Total Coliform

Total coliform concentrations ranged from 10-MPN/100ml to above reporting limits (>2420-MPN/100mL) in both the upper and lower watershed sites. However, median concentrations in upper watershed sites ranged from 1574 to 2203 MPN/100 mL while median concentrations in the lower watershed sites exceeded the 2420 MPN/100ml reporting limit. Concentrations at the reservoir release sites were much lower, with medians ranging from 235 to 633 MPN/100 mL, and increased moving from north to south. Although Total coliform concentrations decreased substantially at the reservoir releases, with only one sample exceeding the upper reporting limit, the lower watershed integrator sites were highest throughout the watershed.

Figure 71 Eastside Basin Watershed Integrator Sites: *E. coli*



E. coli

The upper watershed sites showed great variability between each individual site, with Sullivan Creek demonstrating both the greatest individual variability and highest concentration for all the Basin sites, while Bagby reflected the consistently lower concentrations (<20 MPN/100ml) of the reservoir releases. The Tuolumne upper watershed sites receive drainage from a number of small communities, grazing, and wildlife, while drainage in the uses upstream of the upper Merced Watershed site is dominated by forestland, with human use being limited to recreation.

E. coli concentrations in the lower watershed were consistently elevated above the reservoir releases with medians near 75 MPN/100ml, but did not demonstrate the variability between sites seen in the upper watershed.

8.2.2 Evaluating Lower Elevation Water Bodies Discharging to the San Joaquin and Stanislaus Rivers

Sites discussed within this section are located in the lower elevations of the basin (below 250-feet) and eventually discharge directly to the San Joaquin River, rather than to the Stanislaus, Tuolumne, or Merced Rivers, with the exception of MID Lateral 6/8, which drains to the Stanislaus River. Two sub-basins were identified below 250 feet for this evaluation: the Farmington Drainage Area and the Valley Floor Drainage Area. The Valley Floor was further divided into drains and supply laterals. Descriptions of each of these sub-basins can be found in Section 3.0 Study Area. Table14 groups the sites by background water and direct discharge to the San Joaquin River (or Stanislaus River as in the case of MID Lateral 6/8).

Background sites that have been included for comparison are the furthest upstream sites in each sub-basin that were included in this study. Detailed water quality at these sites was addressed in section 3.2. The Tuolumne River is the source for the majority of the Valley Floor Drainage Area, while Littlejohns Creek at Sonora Road may not be the primary source for Littlejohns Creek at Austin Road. However, both sites characterize water quality in their respective upper watersheds. Therefore, Littlejohns Creek at Sonora Road and Tuolumne River at La Grange will be discussed as background water quality.

Two sites represent the Farmington Drainage Basin: Littlejohn's Creek represents background water quality and French Camp Slough represents drainage to the SJR.

French Camp Slough at Airport Way, an agriculturally dominated and partially reconstructed water body, was the furthest downstream site in the Farmington Flood Control Basin before discharging to the SJR. The Farmington area was first developed as a flood control measure to protect the Stockton area. Channels in this area also carry agricultural tailwater, and urban wastewater. Since the mid 1990s, the area has also been studied for its potential for groundwater recharge. Currently there are no groundwater recharge facilities in the area included in this study.

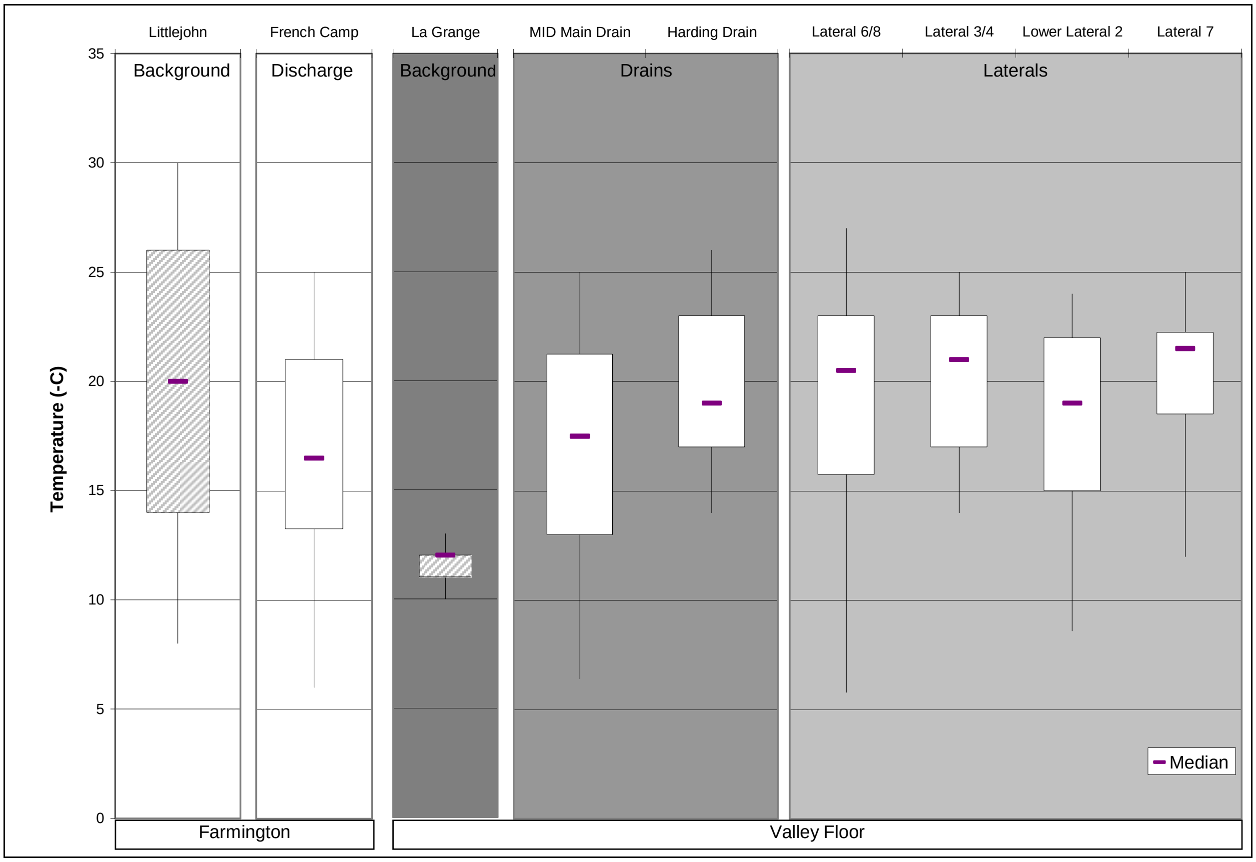
The Valley Floor discharges are a combination of drains and laterals from the Modesto Irrigation District and Turlock Irrigation District. The drain sites (MID Main Drain at Shoemake Road, and Harding Drain at Carpenter Road) are dominated by agricultural tailwater but may be seasonally influenced by urban storm runoff and wastewater. The lateral sites (MID Laterals 6/8 at Dunn Road, MID Laterals ¾ at Paradise Road, TID Lower Lateral 2, and TID Lateral 7 at Central Avenue) are dominated by operational spills, undelivered irrigation water that makes it to the terminal ends of the laterals that may consist of a mixture of Tuolumne River water, ground water, and lesser amounts of agricultural tailwater and urban storm runoff.

Table 14 Site Categories for Discussion of Comparison of Valley Floor Drainage Areas

EASTSIDE BASIN			
Site Code	Site Description	Identifier - Discussion Figures	Drainage Area
Valley Floor Background Water			
STC212	Littlejohns Creek at Sonora Road	Littlejohn	Farmington Flood Control Basin
STC210	Tuolumne River at La Grange Road	La Grange	Valley Floor
Valley Floor Discharges to Major Rivers			
SJC504	French Camp Slough at Airport Way	French Camp	Farmington Flood Control Basin
Valley Floor Discharge Points - Drains			
STC211	MID Main Drain at Shoemake	MID Main Drain	Valley Floor
STC501	TID Harding Drain at Carpenter Road	Harding Drain	Valley Floor

EASTSIDE BASIN			
Site Code	Site Description	Identifier - Discussion Figures	Drainage Area
Valley Floor Discharge Points - Laterals			
STC203	MID Lateral 6/8 at Dunn Road (Drains to Stanislaus River)	Lateral 6/8	Valley Floor
STC204	MID Lateral 3/4 at Paradise Road	Lateral 3/4	Valley Floor
STC208	TID Lower Lateral 2 at Grayson Road	Lower Lateral 2	Valley Floor
MER203	TID Lateral 7 at Central Avenue	Lateral 7	Valley Floor

Figure 72 Eastside Basin Valley Floor Integrator Sites: Temperature



Temperature

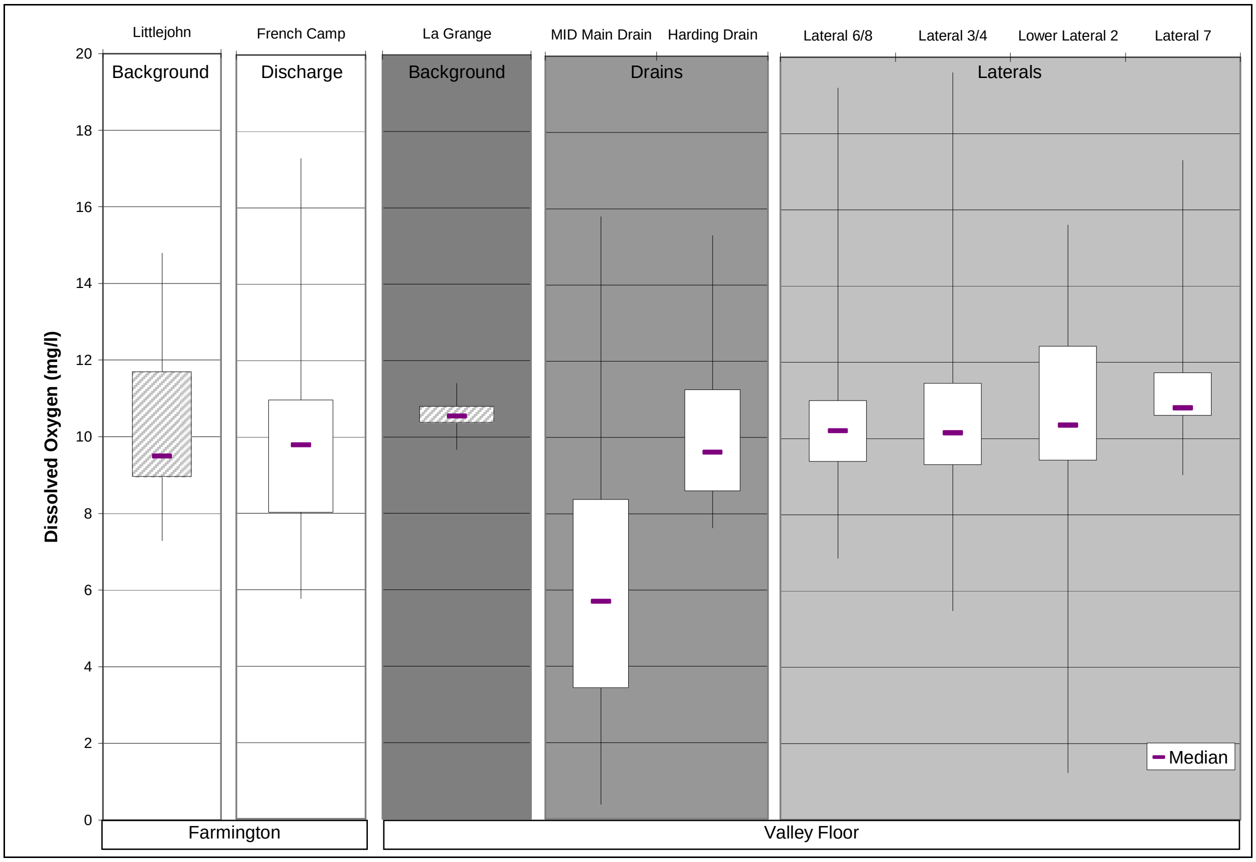
When comparing source water sites, the Farmington Drainage Area site was highly variable, with an interquartile range that was 12 times greater than that of the Valley Floor Drainage Area, and range between minimum and maximum temperatures that was over 7 times greater. Median temperatures varied by 8 –C. While temperature at these source sites had different patterns, this did not seem to influence temperatures at the discharge sites.

Median temperatures at the discharge, drains and laterals had a range of 4 –C. The lowest median was in the Farmington Drainage Area site, while the median temperature at both drains was slightly higher, and medians at the lateral sites were highest. Interquartile ranges were generally consistent from site to site, typically ranging between 6.0 – 8.3 –C, with the exception of TID Lateral 7, which had a more consistent temperature (interquartile range of 3.75 –C, approximately half that of the other sites).

Minimum temperatures showed the greatest variation, but could not be classified by matrix. That is, minimum temperature in the Farmington Drainage Area discharge site was similar to the minimum temperature in only half the Valley Floor drains and laterals.

Temperature range and actual values found at the Farmington Drainage Area discharge site were most closely reflected at the MID Main Drain.

Figure 73 Eastside Basin Valley Floor Integrator Sites: Dissolved Oxygen

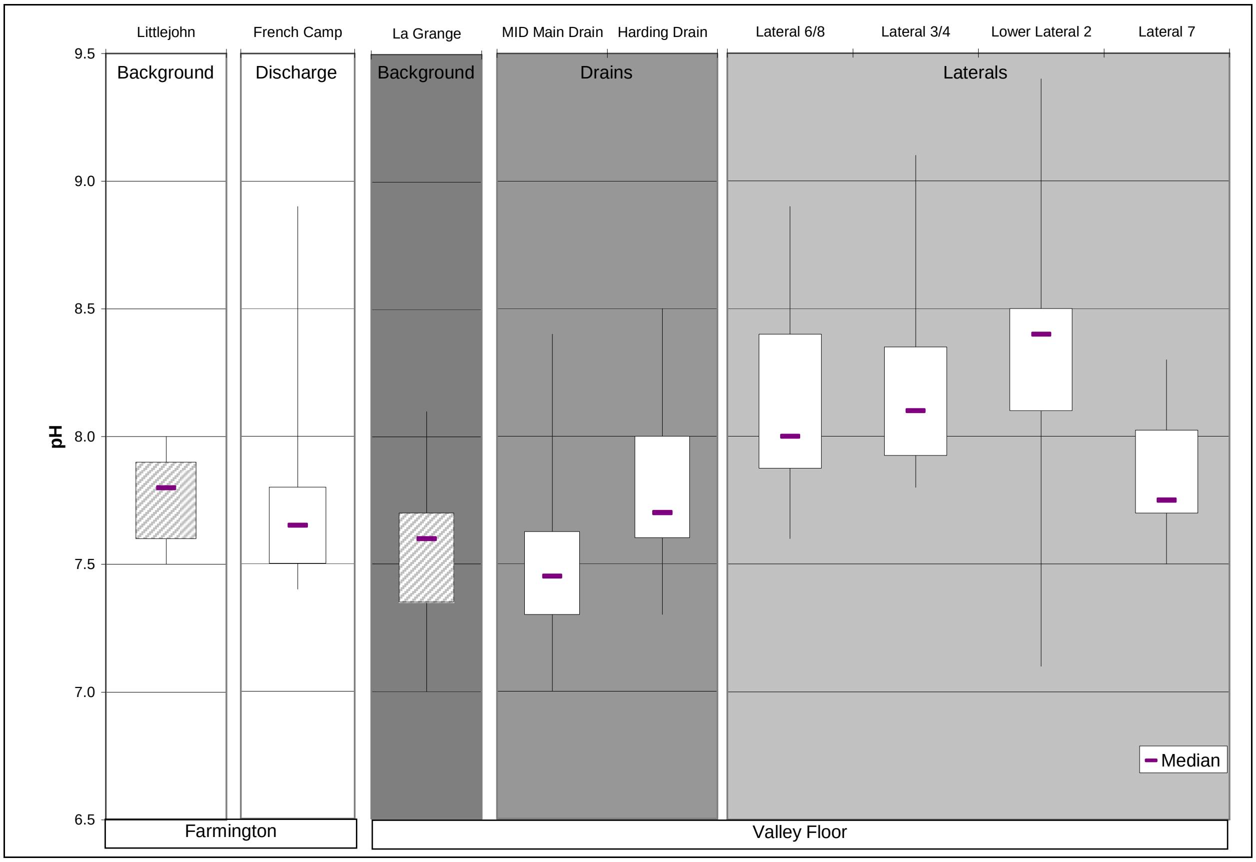


Dissolved Oxygen (DO)

Median DO at the two source sites were approximately within 1 mg/l of each other. However, ranges in values were different, with a minimum/maximum range of 8 mg/l at the Farmington source site, and a minimum/maximum range of 1.73 mg/l at the Valley Floor Drainage Area source background site.

Median DO results at the discharge sites were generally similar to the sources, with the exception of the MID Main Drain median, which was almost half the concentration of the source. The range of discharge site medians was generally within 1 mg/l. However, while DO concentrations at the Farmington source was more variable than the Valley Floor source, concentrations at the discharge sites were not consistently more variable in the Farmington Drainage Area.

Figure 74 Eastside Basin Valley Floor Integrator Sites: pH



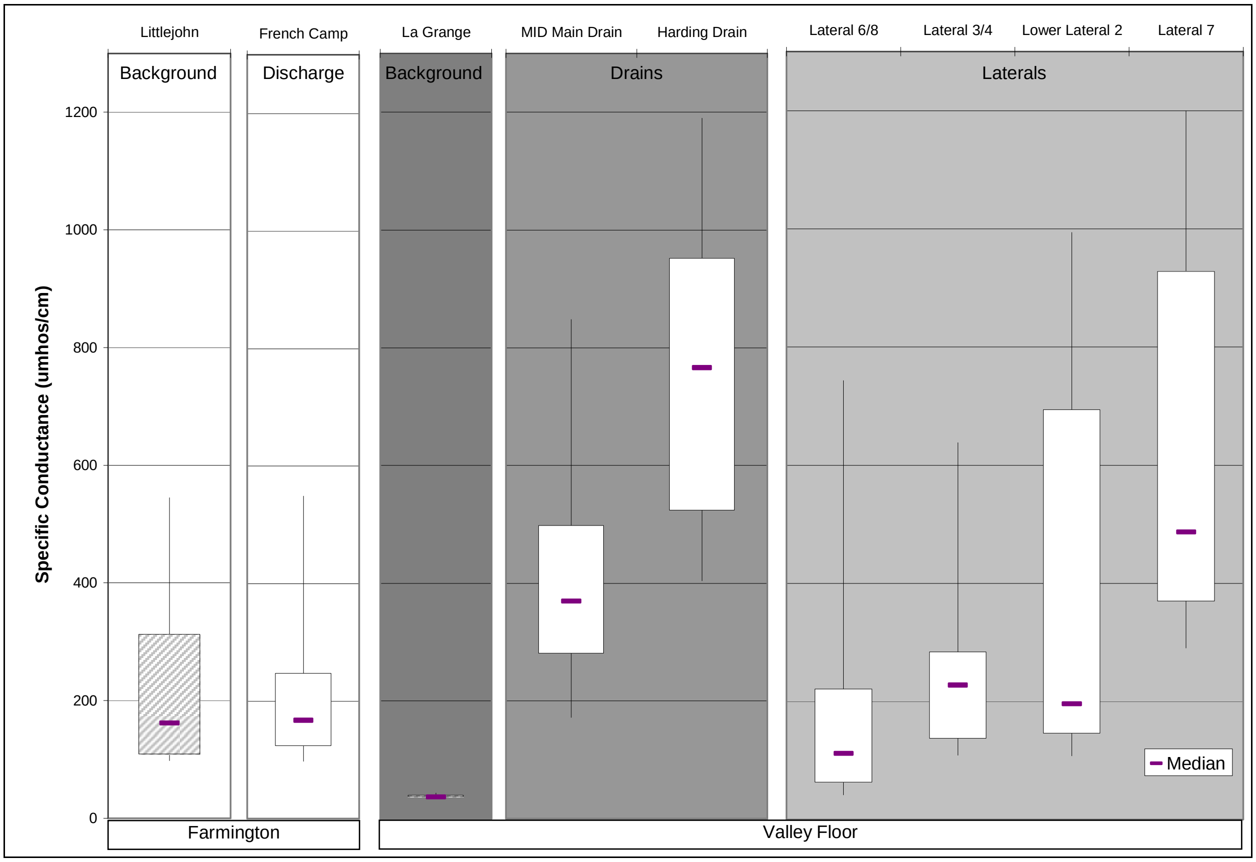
The pH

Median values at the two source sites were similar, with both differing by less than half a pH unit. Variation between the sites was apparent with the range between minimum and maximum at the Valley Floor site was twice that of the Farmington site.

Similar to the sources, discharge from Farmington was similar to the Valley Floor Drains, with medians varying by less than 0.2 mg/l. Medians at the drains and Farmington site generally were lower than medians in the laterals, though minimum/maximum ranges varied by less than 1 pH unit.

The main difference was in the actual values. In the Farmington Drainage area, the pH concentrations at the discharge site was generally lower, with occasional high concentrations. In the Valley Floor Drainage area, except for the MID Main Drain, the Harding Drain and all laterals were generally more basic than the Farmington Drainage area site.

Figure 75 Eastside Basin Valley Floor Integrator Sites: Specific Conductance



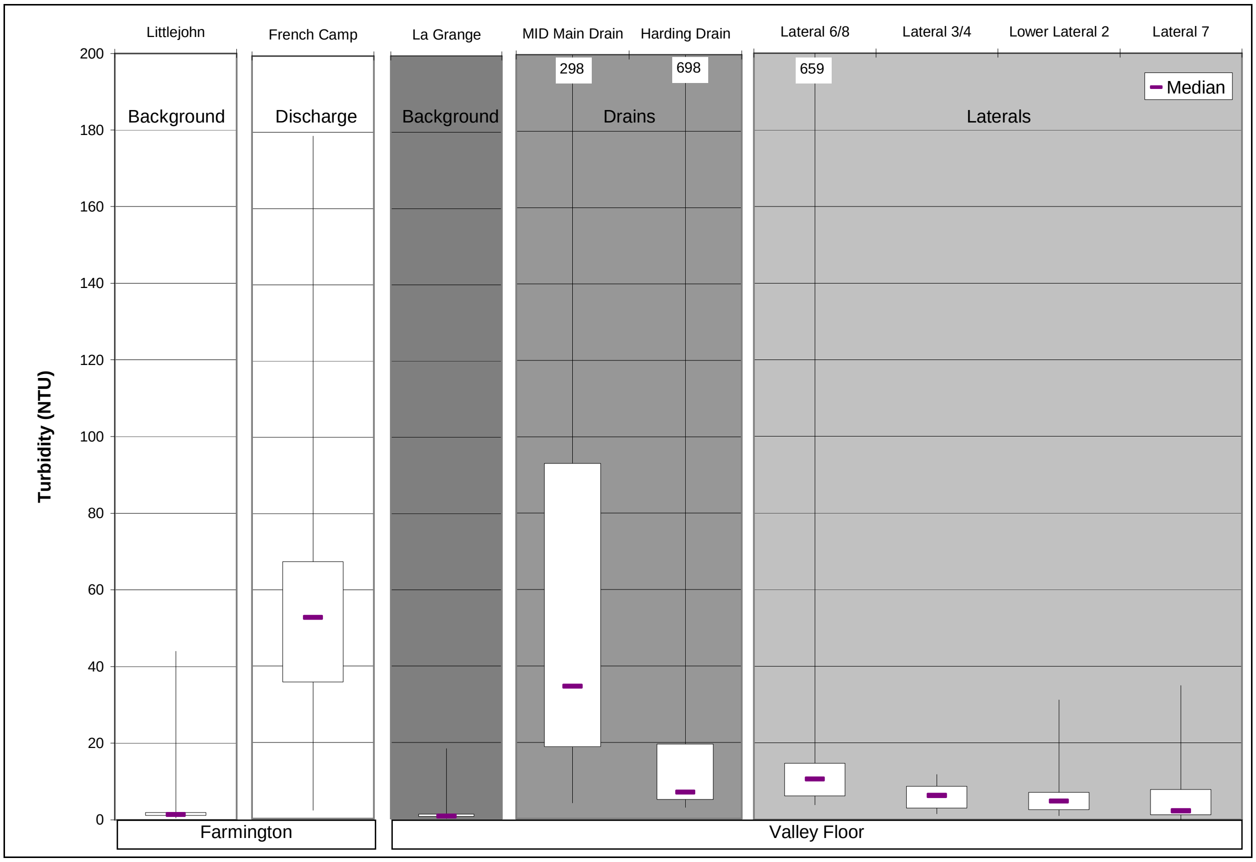
Specific Conductance (SC)

Results from both source sites remained below 600 umhos/cm. The median at the Farmington site was four times greater than at the Valley Floor site. All Farmington concentrations were higher than the Valley Floor source concentrations.

Concentrations at the Farmington discharge site site did not vary as much as the background site. In contrast, interquartile ranges at the Valley Floor sites were approximately 1-4.5 times greater than the Farmington Drainage area discharge site.

Median concentrations at most of the Valley Floor laterals were similar to concentrations at the Farmington Drainage area, varying by less than 60 umhos/cm, except for Lateral 7. Lateral 7 and the Valley Floor drains median SC's were two to four times higher (370 umhos/cm at the MID Main Drain and 766 umhos/cm at the Harding Drain) than the discharge from the Farmington Area.

Figure 76 Eastside Basin Valley Floor Integrator Sites: Turbidity

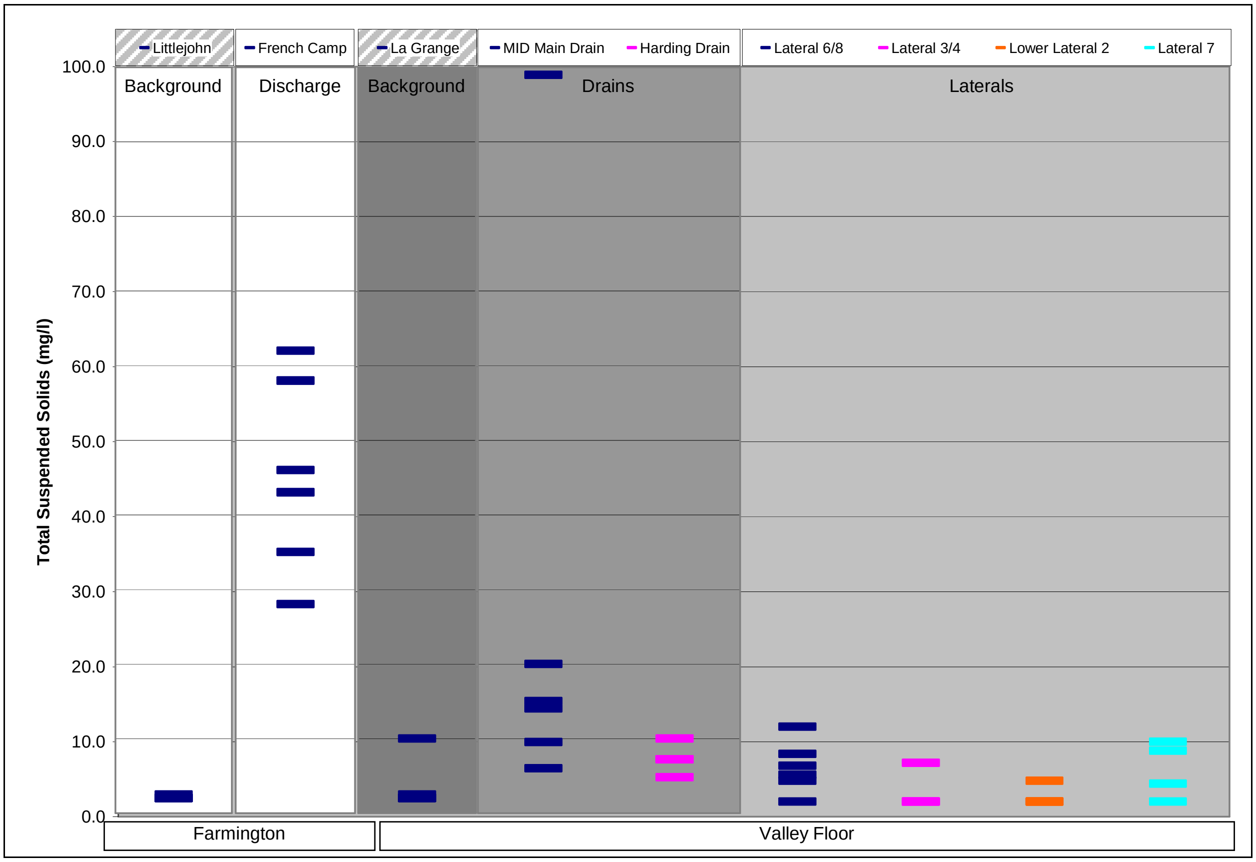


<u>Turbidity</u>

Minimum and median turbidity concentrations at the two source sites differed by less than 1 NTU. While the maximum value at the Farmington Drainage area source site was approximately twice that of the maximum at the Valley Floor source site, the rest of the data was similar. Concentrations at these sites were generally low, with medians under 5 NTU at both source sites, and less than the medians from any of the discharge sites.

Turbidity concentrations at the drain sites were generally higher than lateral integrators, and may have been influenced by the channel lining. Concentrations at MID Main Drain at Shoemake, a dirt lined channel, was consistently higher than the rest of the sites, and most similar to the Farmington discharge sites, which is a modified slough. Harding Drain, a rip rap/dirt lined channel, was also higher than most of the lateral sites, partly due to two spikes of 698 on 3/25/03 and 396 NTU on 8/7/03. Turbidity at MID Lateral 6/8, concrete lined, was comparable to concentrations at Harding Drain, and had a spike of 659 NTU on 9/22/03. Even without the spikes at Harding Drain and MID Lateral 6/8, the mean concentrations would have been approximately twice as high as the three remaining lateral integrator sites, all of which were concrete lined, and had means ranging from 6.1 to 6.8 NTU.

Figure 77 Eastside Basin Valley Floor Integrator Sites: Total Suspended Solids



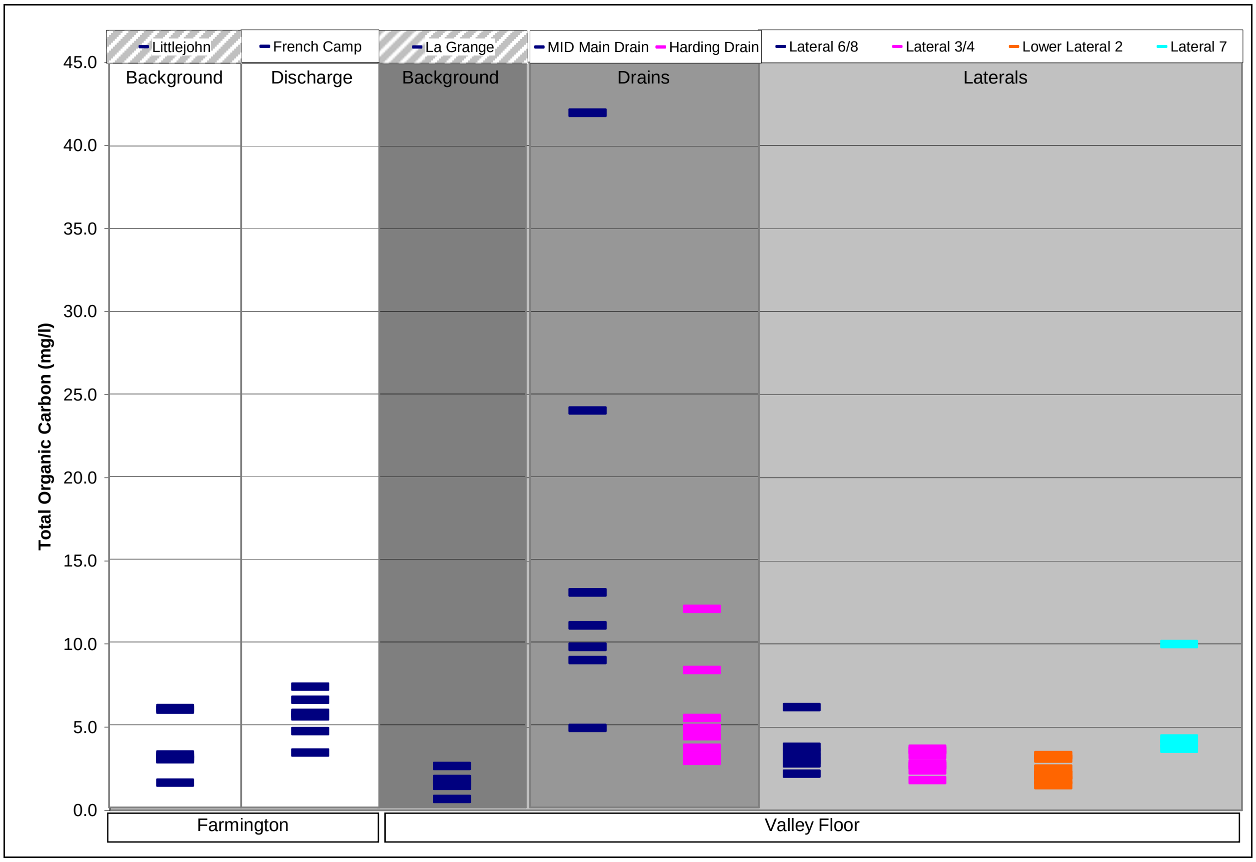
Total Suspended Solids (TSS)

A limited number of samples (4-7 depending on the site) were analyzed for TSS. Most results at both source locations were below reporting limits (<4.0 mg/l), with exception of a single result at the Valley Floor site that was at 10 mg/l.

Most concentrations at the discharge sites were higher than the source sites, although laterals were generally below 10 mg/l. Median concentrations ranged from below reporting limits (<4.0) to 14.5 mg/l at the Valley Floor sites to 44.5 at the Farmington site. Similar to turbidity, concrete lined channels had lower overall TSS than the earthen French Camp Slough and MID Main Drain.

Given the limited data collected in this study, none of the TSS result trends from the Valley Floor sites were as varied as results from the Farmington drainage site nor as high.

Figure 78 Eastside Basin Valley Floor Integrator Sites: Total Organic Carbon



<u>Total Organic Carbon (TOC)</u>

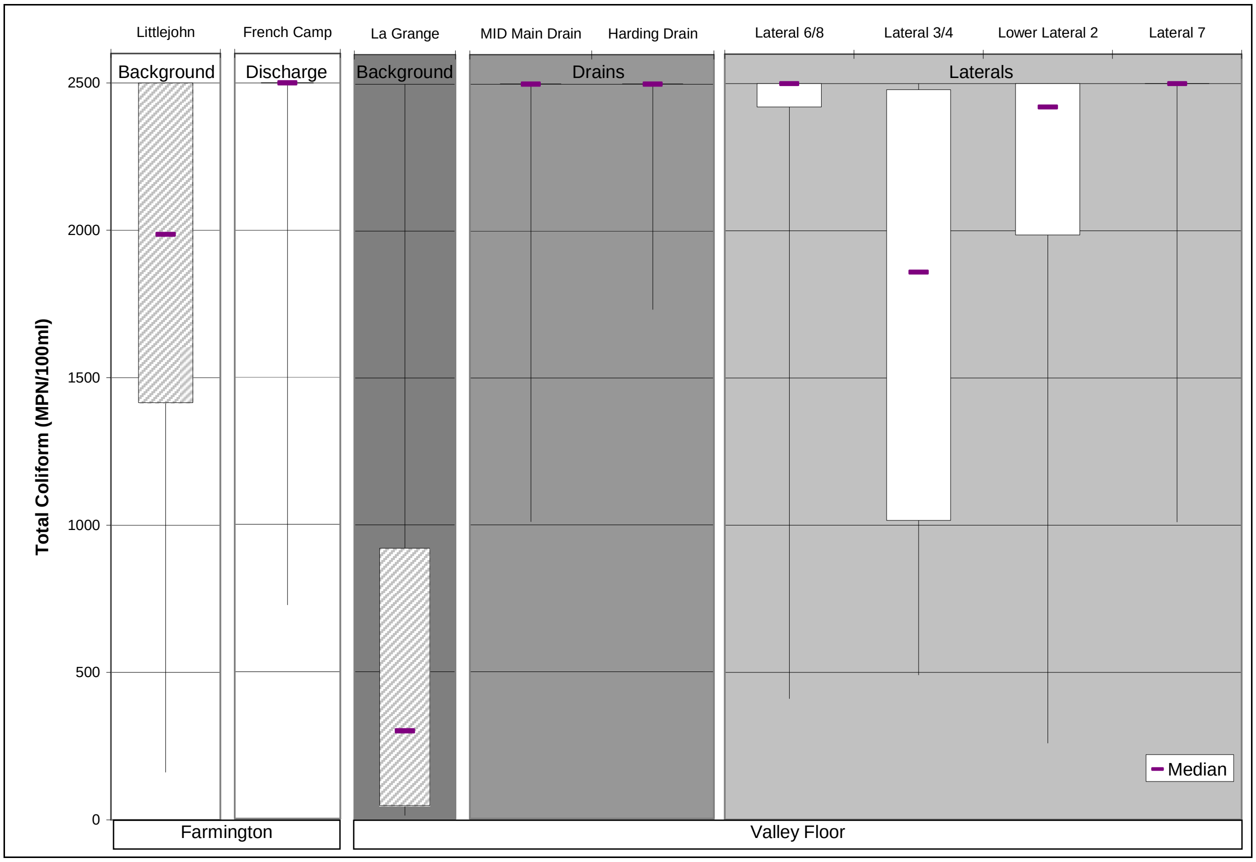
A limited number of samples (4-8, depending on the site) were analyzed for TOC. The minimum reporting limit for TOC was 1 mg/l. Only at the Tuolumne River at La Grange did this limit become applicable for this discussion.

Median concentrations at the Farmington source were approximately twice as high as the concentration of the Valley Floor source, with concentrations somewhat more variable.

The median concentrations at all discharge sites were higher than the backgrounds by varying degrees. In the Farmington Drainage area, the median was almost 2 times higher at the discharge site. In the Valley Floor drains, median concentrations were 3 and 6.9 times higher than the source, while at the laterals, median concentrations ranged up to two times higher than the source.

Concentrations at the MID Lateral ¾ and TID Lower Lateral 2 were the least variable of the lateral sites (difference of 1.9 mg/l and 1.8 mg/l, respectively, between the maximum and minimum concentrations). The range at MID Main Drain was approximately 21 times higher (37.2 mg/l) than these Lateral sites.

Figure 79 Eastside Basin Valley Floor Integrator Sites: Total Coliform



<u>Total Coliform</u>

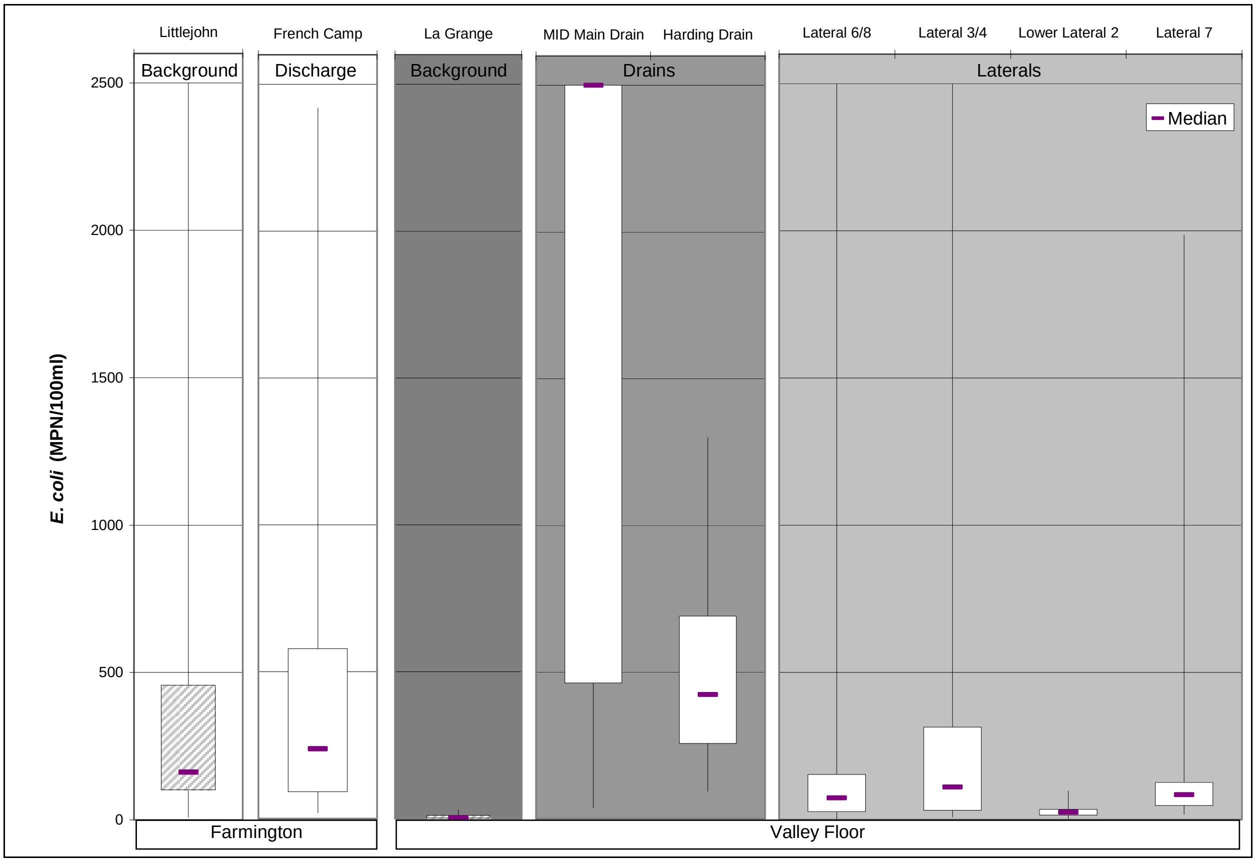
This discussion and the following discussion for ***E. coli*** are based on the data that could be quantified, even though it is understood the actual values may be much greater than the maximum reporting limit. Where summary data was above reporting limits (>2420 MPN/100ml), the value in the figures was set at 2500 MPN/100 ml to differentiate from the highest quantifiable value, which is 2420 MPN/100ml. The 2500 MPN/100ml was also used in calculating 1st and 3rd quartile values.

The relative ranges between minimum and maximum concentrations, and interquartile values at the two source sites were similar, however, the median at the Farmington site was over 6 times higher than the median at the Valley Floor site (1986 MPN/100ml vs. 299 MPN/100ml, respectively).

Total coliform median concentrations at most discharge sites were generally above the reporting limit. MID Laterals ¾ and TID Lower Lateral 2 were the exceptions, with median concentrations at 1860 and 2420 MPN/100ml, respectively. Farmington discharge and Valley Floor drains almost consistently reported total coliform values above the maximum reporting limit.

The laterals were more variable, with Lateral ¾ showing comparable concentrations to the Farmington Area source water.

Figure 80 Eastside Basin Valley Floor Integrator Sites: *E. coli*



E. coli

E. coli concentrations between the source sites were as varied as the total coliform concentrations, though substantially lower. The Farmington source site was more varied and had higher actual values than the Valley Floor site, with a minimum-maximum range that was at least 81 times greater, an interquartile range that was 38 times greater, and median that was 54 times higher (median concentrations at 162 MPN/100ml versus 3 MPN/100ml, respectively).

Concentrations at the Farmington source were similar to the downstream discharge, with medians of 162 and 397 MPN/100ml, respectively. ***E. coli*** concentration in the Farmington Drainage area were higher than the Valley Floor laterals but lower than the drains. Interquartile ranges were generally low in the Valley Floor laterals, ranging from 20 to 283 MPN/100ml. The highest concentrations and most variation were seen in the Valley Floor drains. Harding Drain had a median of 423 MPN/100ml, and the MID Main Drain had a median of >2420 MPN/100ml.

Lower Elevation Discharges to the San Joaquin River Summary

The Valley Floor drains were overall higher in all constituents measured except temperature, pH and DO. The laterals generally had the highest concentrations of those parameters, matched by Farmington for DO.

At the source sites, results were more variable at the Farmington site than Valley Floor for temperature, DO, SC, turbidity, ***E. coli,*** and TOC. Results at the Farmington site were generally higher for temperature, pH, SC, turbidity, total coliform (values of interquartile ranges), ***E. coli,*** and TOC. In some instances, results reflected similarities between the two sites, such as the median DO concentrations being within 1 mg/l of each other, pH median values and interquartile ranges being within half a pH unit of one another, minimum and median turbidity concentrations varying by less than 1 NTU and TSS concentrations at both sites generally being below reporting limits.

Water quality at the Farmington Drainage area discharge site had the lowest median temperature of all the discharge sites. The DO median was within 1 mg/l of all Valley Floor discharge site median concentrations. The pH median was similar to medians at the drains, all of which were lower than the laterals. Also, interquartile pH ranges were within 0.23 pH units of each other, regardless of drainage type and minimum/maximum ranges varied by less than 1 pH unit. The SC interquartile range was less variable than the Valley Floor, and the Farmington discharge site results were similar to source SC results. The ***E. coli*** median was also similar to source (less than 100 MPN difference). The median TOC was 2 times higher than the source and had a similar relative interquartile range.

The Valley Floor drains results often reflected results at the Farmington Drainage area discharge site. At Harding Drain, these results include the range and actual values for DO, pH, and turbidity. Results from the MID Main Drain most closely reflected results from the Farmington Drainage area for temperature, turbidity, minimum total coliform, ***E. coli*** interquartile range (while median was closest, second only to Lateral 3/4), and median TOC.

At both drain sites, SC was higher in concentration and more variable than Farmington, turbidity generally higher than laterals, and median TOC showed most variation from the source, being at least 3 times higher.

Water quality in the laterals displayed the highest median temperatures. The pH was generally more basic than Farmington Drainage area. Interquartiles and actual values for SC at both MID laterals were similar to concentrations at the Farmington discharge site. The TID Laterals showed greater variation, although Lower Lateral 2 had a similar median to Farmington site. Median turbidity concentrations were generally less than 10 NTU, and TSS was generally below 10 mg/l. Minimum total coliform at Lateral 7, along with the MID Main Drain, was most similar to Farmington site. Median ***E. coli*** values were somewhat similar to source, with variation of less than 100 MPN/100ml. Median at MID Lateral 3/4 was most similar to Farmington site. Median TOC at the laterals was 1.35 – 2.06 times higher than source, within the laterals, medians were generally similar, varying by less than 0.7 mg/l, and interquartile ranges varying by less than 0.15 mg/l, with exception of Lateral 7. Interquartile range at Lateral ¾, and minimum – maximum range at Lateral 6/8 were most similar to Farmington

8.2.3 Sub-basin Discharge to the San Joaquin River

Section 8.1 discussed spatial differences in water quality within individual sub-basins. In this section, water quality from discharges to the River from each sub-basin is compared.

The Eastside Basin consists of two distinct types of sub-basins: the larger river watersheds that included both areas above major reservoirs and below major reservoirs (Stanislaus, Tuolumne and Merced) and the smaller drainage areas that consisted of areas in the lower elevation valley floor (Farmington and Valley Floor). Descriptions of each sub-basin can be found in section 3.3.

Water quality data used for comparison came from the following monitoring sites:

Farmington Drainage Area: French Camp Slough at Airport Way

Valley Floor Drainage Area: Summary of combined Drain Site results
- MID Main Drain at Shoemake
- Harding Drain at Carpenter Road

Summary of combined Lateral results draining directly to SJR
- MID Lateral ¾ at Paradise Road
- TID Lower Lateral 2 at Grayson Road
- TID Lateral 7 at Central Avenue

Stanislaus River Watershed: Stanislaus River at Caswell Park

Tuolumne River Watershed: Tuolumne River at Shiloh

Merced River Watershed: Merced River at River Road

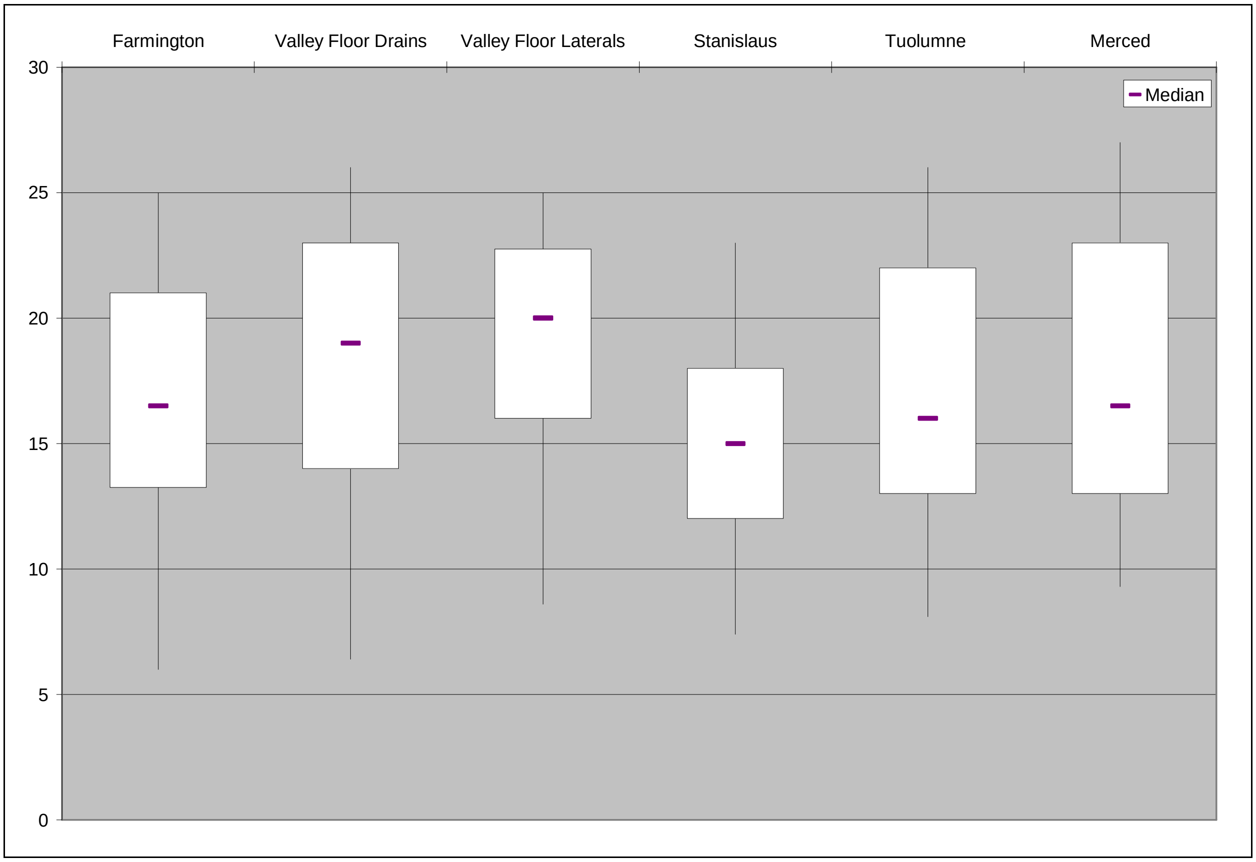
Key constituents (temperature, SC, turbidity, TOC, and ***E. coli***) draining from each sub-basin into the SJR are compared using the box and whisker format. Table 15 provides a summary of the results for this discussion and Figures 81-85 provide visual description of these results.

Table 15 Summary Results: Sub-basin Discharge to the San Joaquin River

		Farmington	Valley Floor		Stanislaus	Tuolumne	Merced
			Drains	Laterals			
Temperature (-C)	Min	6.0	6.0	8.6	7.0	8.0	9.3
	Median	17	19	20	15	16	17
	Max	25	26	25	23	26	27
	Q1	13	14	16	12	13	13
	Q3	21	23	23	18	22	23
	Count	26	53	62	27	27	30
Specific Conductance (umhos/cm)	Min	98	170	110	64	58	37
	Median	170	530	320	95	180	170
	Max	550	1200	1200	160	260	420
	Q1	120	380	190	80	160	130
	Q3	250	810	750	110	210	260
	Count	26	53	62	27	27	30
Turbidity (NTU)	Min	2.2	3.0	0.0	0.8	2.6	2.7
	Median	53	19	4.2	5.6	6.9	6.3
	Max	180	700	35	37	47	53
	Q1	36	6.6	1.9	4.4	4.9	4.8
	Q3	67	61	8.3	7.9	12	12
	Count	25	50	60	27	25	25
Total Organic Carbon (mg/l)	Min	3.3	2.8	1.5	1.6	2.2	1.7
	Median	5.6	8.3	3.2	2.1	2.5	2.5
	Max	7.3	42	10	2.6	3.7	3.8
	Q1	na	na	na	na	na	na
	Q3	na	na	na	na	na	na
	Count	7	15	20	7	7	7
E. coli MPN/100ml)	Min	20	37	2	21	8	19
	Median	240	550	60	66	71	84
	Max	2420	2500	2500	1100	650	730
	Q1	91	270	25	38	43	46
	Q3	580	2400	130	81	150	200
	Count	25	50	62	25	25	26

Data rounded to two significant figures

Figure 81 Eastside Sub-basin Discharge to the San Joaquin River: Temperature



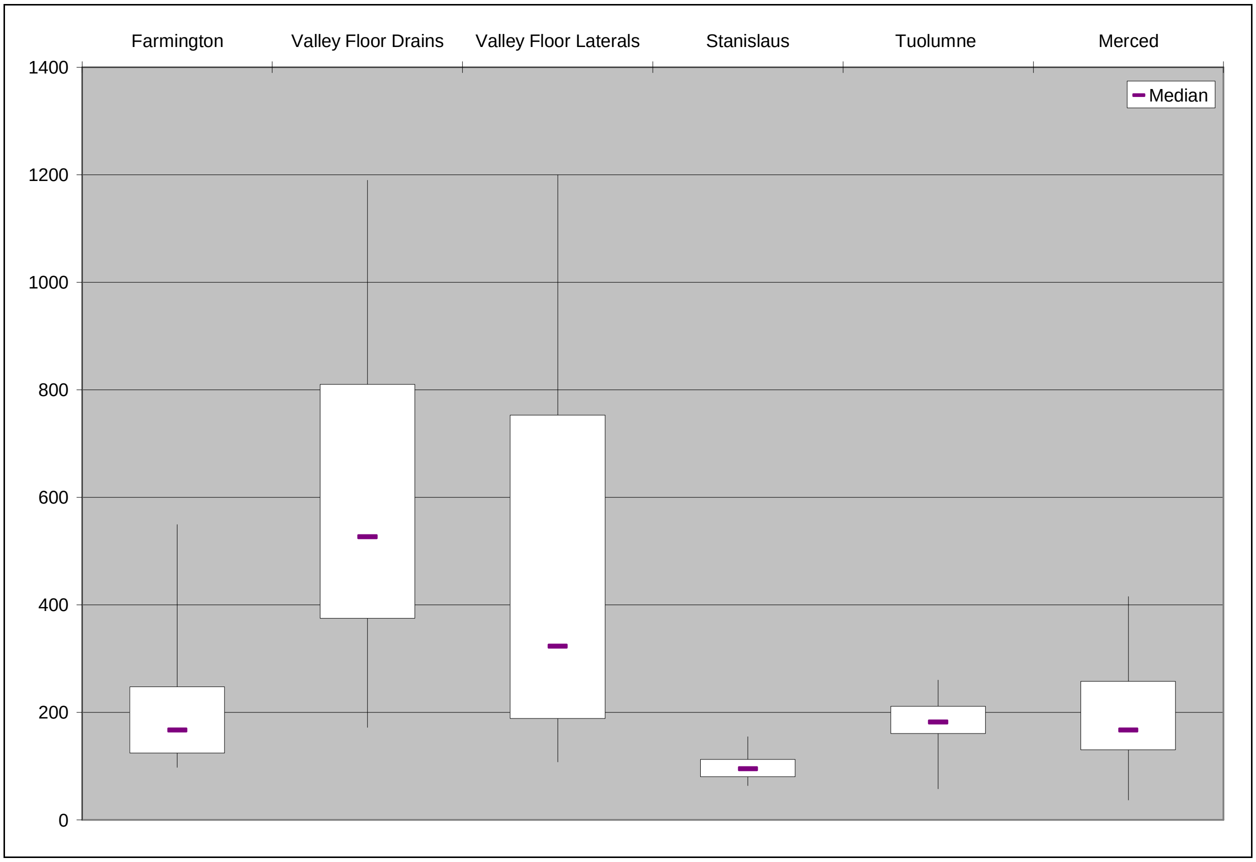
Temperature

Overall, temperature ranged from 6-C at Farmington and the Valley Floor Drains to 23-C at The Valley Floor Drains and Laterals and the Merced site. In comparing each of the summary results across the sub-basins, there was little variation (no more than 5-C), as shown in Figure 81 and Table 15.

Median temperatures were lower at the watershed sites than drainage area sites by as little as 0.5-C, when comparing Merced to Farmington, to 5-C when comparing Stanislaus to the Valley Floor Laterals. Median temperatures between the watershed sites were slightly less variable (1.5 –C) than the Drainage Area sites (3-C).

Temperature at the Stanislaus watershed site was the least variable, with the difference between the minimum and maximum temperatures of 16-C. While the Valley Floor Drains had the most variation between minimum and maximum temperatures (20-C), it did not have the largest variation between the 1st and 3rd quartiles (middle 50% of data) (9-C). The largest variation between the 1st and 3rd quartiles was at the Merced Watershed site (10-C), which had a range between minimum and maximum temperatures of 17.7-C.

Figure 82 Eastside Sub-basin Discharge to the San Joaquin River: Specific Conductance



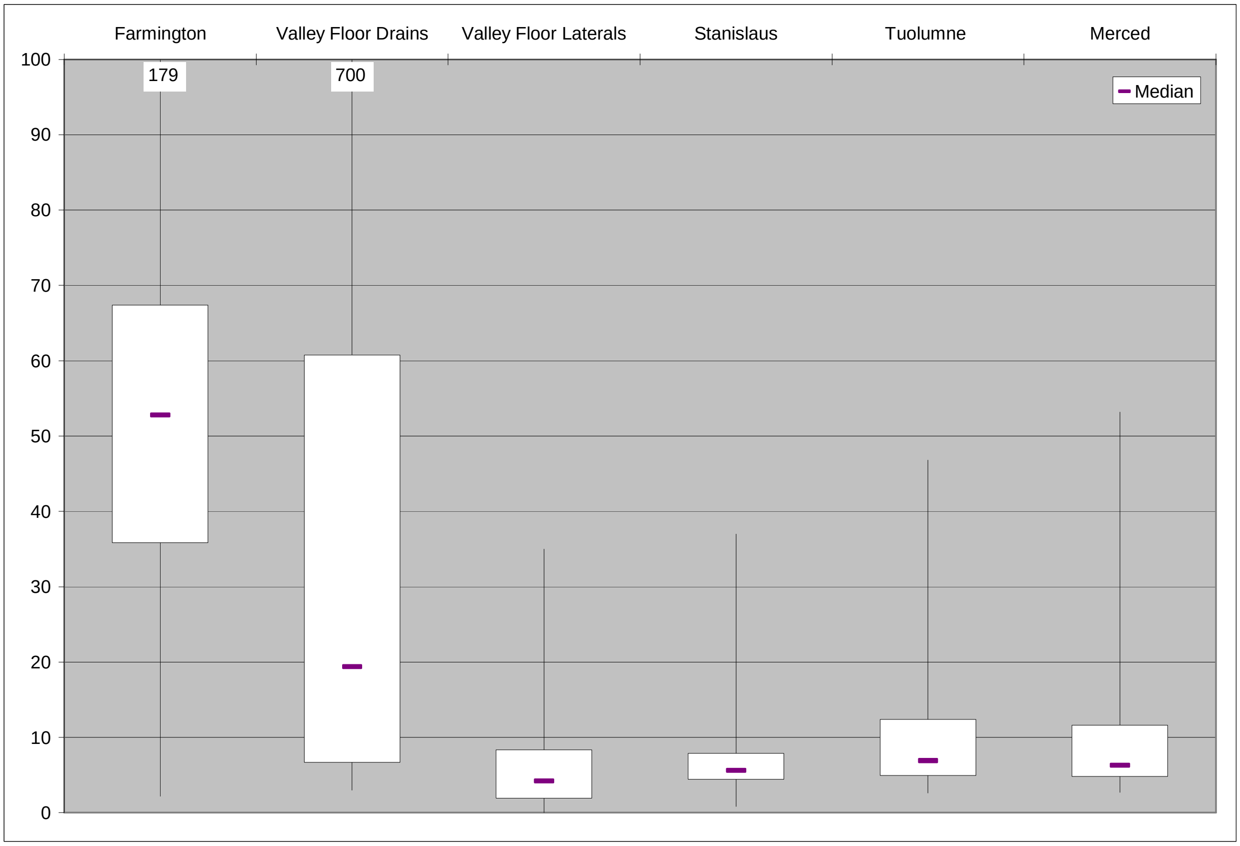
Specific Conductance

Specific Conductance ranged from 37 – 1200 umhos/cm. Minimum SC varied by as much as 135 umhos/cm when comparing the Merced site (37 umhos/cm) to the Valley Floor Drains (172 umhos/com). Maximum SC varied by as much as 1045 umhos/cm when comparing the Stanislaus site (155 umhos/cm) to the Valley floor Laterals (1200 umhos/cm).

Median SC was highest in the Valley Floor Drains (527 umhos/cm) and Laterals (323 umhos/cm). Between the watershed sites and the Farmington Drainage Area, the median SC varied by less than 90 umhos/cm (95 umhos/cm at Stanislaus site and 182 at the Tuolumne site).

The difference between minimum and maximum at each site ranged from 91 umhos/cm at the Stanislaus Watershed site to 1092 at the Valley Floor Laterals site. The Stanislaus and Tuolumne sites demonstrated the least variability, while the Merced site was similar to the Farmington site and the Valley Floor Drains were similar to the Laterals.

Figure 83 Eastside Sub-basin Discharge to the San Joaquin River: Turbidity



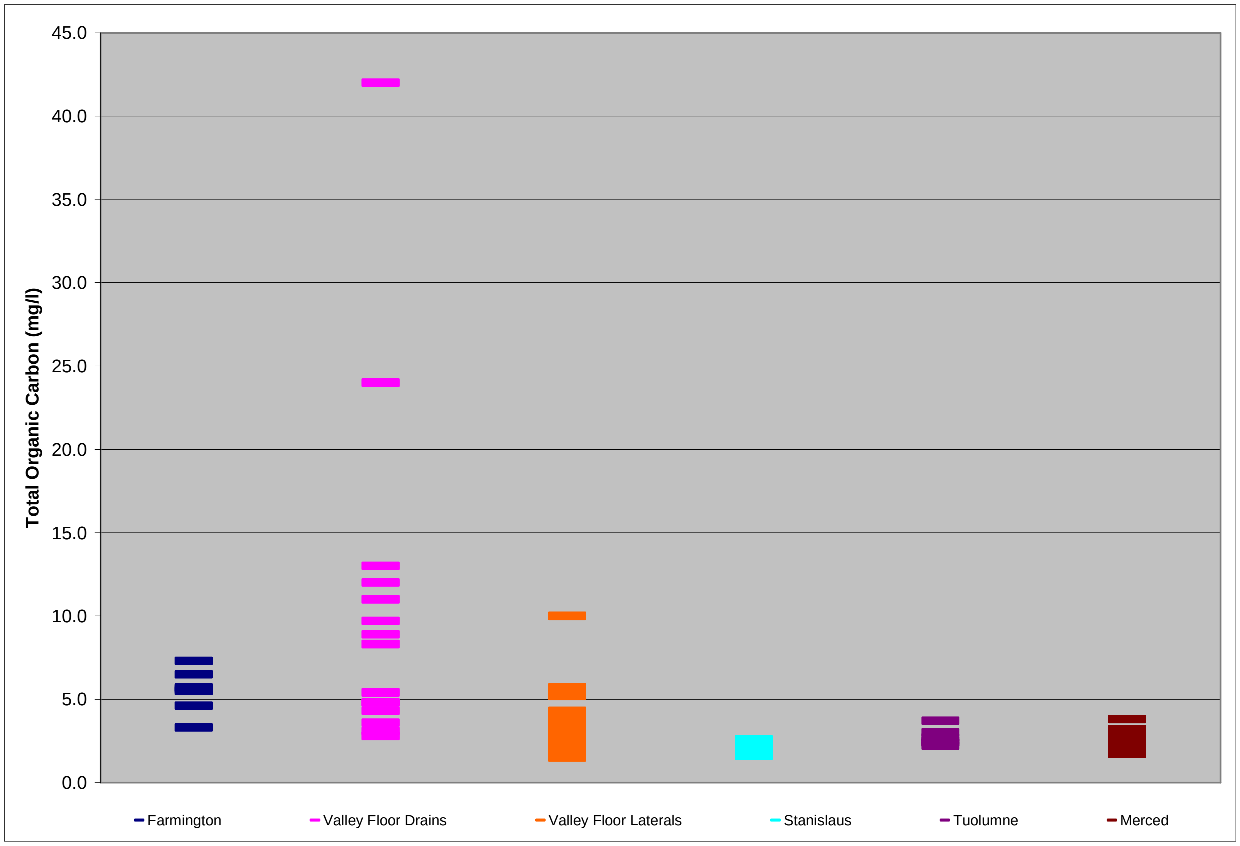
Turbidity

Turbidity ranged from 0 NTU at the Valley Floor Laterals to 698 NTU at the Valley Floor Drains. Minimum concentrations were similar between the sub-basins, varying by less than 3 NTU. All other summary results were more variable: 1st quartiles varied up to 34 NTU, 3rd quartiles varied up to 60 NTU, and maximum concentrations varied up to 663 NTU between all the sites.

Median turbidity was highest in the Farmington Drainage area at 52.8 NTU. Medians were similar (varied by less than 3 NTU) between the Valley Floor Laterals, and Stanislaus, Tuolumne, and Merced watersheds.

The range between minimum and maximum was similar in the Valley Floor Laterals and River Watersheds (35 - 51 NTU, respectively). Ranges were highest at the Farmington Drainage area site (177 NTU) and Valley Floor Drain sites (695 NTU).

Figure 84 Eastside Sub-basin Discharge to the San Joaquin River: Total Organic Carbon



Total Organic Carbon

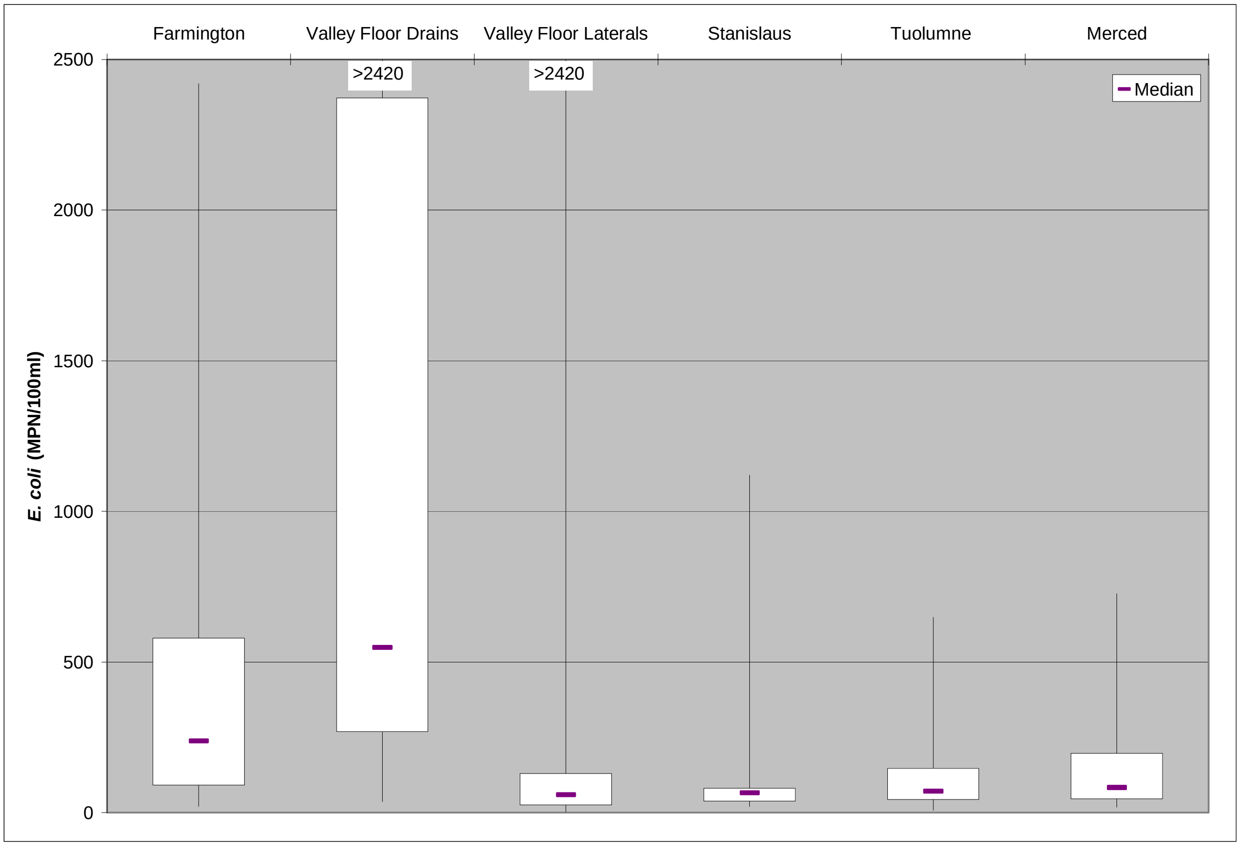
Samples were analyzed for TOC from March through June 2003, with the number of samples ranging from 7 to twenty per sub-basin discharge.

Concentrations ranged from 1.5 mg/l in the Valley Floor Laterals to 42 mg/l in the Valley Floor drains. Minimum concentrations from all sites varied by less than two mg/l. Because of high spikes at the Valley Floor Drains, maximum concentrations vary by up to 39 mg/l. However, when the Valley Floor Drains are removed, maximum TOC varies by less than 7.5 mg/l.

Median TOC was lowest at the Watershed sites (2.1 – 2.5 mg/l). Concentrations at the Farmington site were consistently about twice as high as concentrations at the Watershed sites.

Variation between the minimum and maximum at the watershed sites was very small, ranging from 1.0 at the Stanislaus Watershed site to 2.1 at the Merced Watershed site. Variation at the Farmington site, while slightly higher, was still relatively small, at 4.0 mg/l. In the Valley Floor Laterals, a single sample with the concentration of 10 mg/l resulted in variation of 8.5 mg/l between the minimum and maximum concentrations. However, when this sample is removed from the data set, the variation drops to 4.2 mg/l. Variation between minimum and maximum concentrations at the Valley Floor Drains was more variable, with a range of 39.2 mg/l. Even with the removal of the highest concentration from the dataset, variation remains at least five times higher than variation at the Watershed sites.

Figure 85 Eastside Sub-basin Discharge to the San Joaquin River: *E coli*



E. coli

Minimum ***E. coli*** concentrations ranged from 2 MPN/100ml at the Valley Floor Laterals to 37 MPN/100ml at the Valley Floor Drains. The maximum concentrations had much higher variability, ranging from 649 MPN/100 ml at the Tuolumne River site to >2420 MPN/100ml at the Valley Floor drains and laterals.

Median concentrations ranged from 60 MPN/100 ml at the Valley Floor Laterals to 548 MPN/100ml at the Valley Floor Drains. Medians at the Watershed sites were somewhat similar to the Valley floor Laterals, with a difference of no more than 24 MPN/100ml between the sub-basins. The median at the Farmington site was approximate 3 times higher than at the Valley Floor Laterals and Watershed sites, while the Valley Floor site median was approximately 6.5 times higher.

The range of the middle 50% of data (difference between the 1st and 3rd quartiles) was smallest in the watershed sites and the Valley Floor Laterals, ranging from 43 MPN/100 ml in the Stanislaus site to 152 at the Merced Watershed site. The range of the middle 50% of data at the Farmington site was over three times greater (488 MPN/100ml) than the Merced Watershed site. The range of the middle 50% of data was greatest at the Valley Floor Drains (2103 MPN/100ml).

In summary, temperature values and ranges were somewhat consistent between the six sub-basins. Concentrations and ranges for specific conductance, turbidity, total organic carbon, and ***E. coli*** were lowest at the three watershed sites. Concentrations were lowest and least variable in the Stanislaus Watershed. For turbidity and ***E. coli***, the Valley Floor Laterals were similar to the watershed sites, and for specific conductance, the Farmington site was similar to the watershed sites. The Valley Floor Drains consistently had higher results and were more variable for SC, turbidity, TOC and ***E. coli***.

8.3 Special Studies

Prior to collecting samples, stakeholders within the Eastside Basin were contacted to identify concerns that could be evaluated during this study. From this input, two special study areas were included: Woods Creek in Sonora, and Dry Creek in Modesto. Both Creeks are tributary to the Tuolumne River, Woods Creek in the upper watershed and Dry Creek in the lower watershed. Data used in the following comparisons are shown in Appendix G. Also included in Appendix G are the relative percent differences (RPD)[1] for all data between the sampling points. RPD's of 25% or greater were considered significant. The differences and absolute differences are also provided. Differences that are positive reflect concentrations increasing moving from upstream to downstream. Negative differences reflect concentrations decreasing moving from upstream to downstream. Where only one result was outside reporting limits, data was set to the reporting limit. When the RPD was over 25%, the RPD box was shaded red and identified as NA. Where the RPD was under 25%, the RPD box was shaded gray and identified as NA. This method was also used in evaluating differences, but only to determine if concentrations were increasing or decreasing.

Maps for this section were downloaded from the EPA Envirofacts website to provide visual display for all facilities in the study areas. Most facilities were included in the Envirofacts hazardous waste database. Sampling sites were chosen to minimize the amount of interferences (e.g. water discharger and hazardous waste facilities) to the objectives of each study. In Figures 86 and 87, sampling sites are identified by a 5 point star and site description label. Locations registered under the National Pollutant Discharge Elimination System (NPDES), where point sources discharge to waters of the United States, are identified by a seven point star. All other facilities (hazardous waste, Superfund, toxic releases, etc.) are identified by a small square. Based on historic review, there were no documented discharges anticipated to impact the sampling sites during the period of this study.

<u>8.3.1 Potential Impact of Residential Construction in a Rural Community (Woods Creek Study)</u>

The Woods Creek watershed encompasses approximately 29 square miles, and extends approximately 8.6 miles from its headwaters to Don Pedro Reservoir. The headwaters start at the base of the northern slopes of Yankee Hill and the southern slopes of Biewetts Point. From Yankee Hill, Woods Creek meanders to the south and traverses through the towns of Martinez, Squabbletown, and Browns Flat along the western base of Bald Mountain. At Browns Flat, Woods Creek parallels highway 49 and traverses the western edge of downtown Sonora, where it is channelized before its confluence with Dragon Gulch. Base flows within Woods Creek become year-round in Sonora and are partly attributed to irrigation-return flows from Sonora during the summer months. Within the City of Sonora, Sonora Creek joins Woods Creek immediately upstream of the sampling site located at the Mother Lode Fairground. Below Sonora, Woods Creek eventually empties into Don Pedro Reservoir. (ESA, 2006)

Stakeholders had expressed concern about rapid growth in the Sierra community of Sonora, therefore sites were chosen along Woods Creek upstream and downstream of a new, single family home development. The upstream site was coordinated with Tuolumne County and approximately a mile above the downstream site, so some overland flow from rural, residential, commercial, and grazing activities may also influenced water quality between the sampling sites. The construction site was located just upstream of the Mill Villa Road crossing.

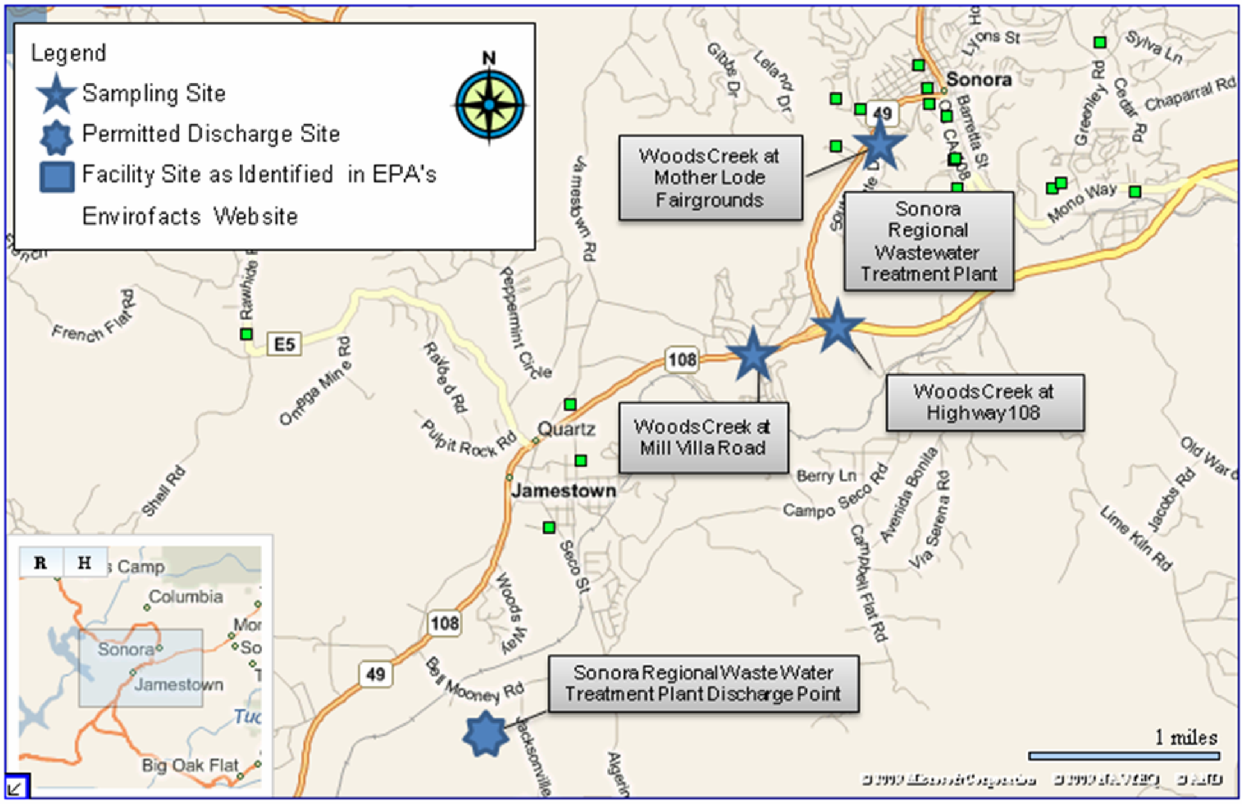
The only facility with a permit to discharge water in the area was the Tuolumne Utility District's Sonora Regional Wastewater Treatment Plant. The plant itself is located on Southgate Drive and pipes discharge to Quartz Reservoir, downstream of Jamestown. Overflow from the Treatment Plant holding ponds, while prohibited, may enter the creek above the Mill Villa site, although no overflows were

[1] Relative Percent Difference is a measure of precision used when comparing two values with one another, where the outcome is expected to be the same. The formula used is:

$$RPD = \frac{|X1-X2|}{((X1+X2)/2)} \quad X100$$

reported during this study period. The holding ponds are located just north east of the Woods Creek at Highway 108 sampling site. During the period of this study, 287 violations in Tuolumne County were addressed by the Central Valley Water Board, including an unauthorized discharge and violations of permitted effluent water quality. None of these violations occurred between the upstream and downstream sites in this study.

Figure 86 Facilities located near Sonora and Jamestown, as identified in EPA Envirofacts.



The focus of this study addressed the following objectives:

- Is there a significant change in water quality of Woods Creek above and below the construction site
- What trends were present in overall water quality

The following discussion compared results from upstream of the construction site (Woods Creek at Mother Lode Fairgrounds or Woods Creek at Highway 108) to results downstream of the construction site (Woods Creek at Mill Villa Road).

When comparing results from the Woods Creek upstream and downstream sites, the RPD for all DO, pH, and temperature sampling points were not significant.

The RPD for specific conductance (SC) was significant in 7 out of twenty four samples. On 3/19/03, 7/22/03, and 10/8/03, the differences in EC jumped to 163, 120, and 172 umhos/cm, respectively (RPDs of 45%, 31%, and 73%, respectively). Each of these sampling events occurred after the first significant (greater than 0.5-inch) rainfall after a dry period. The SC was consistently higher at the downstream site, Woods Creek at Mill Villa Drive.

Overall, 14 of 23 sample pairs for turbidity showed significant RPDs. Downstream increases were most common during the drier period of May through August. During the winter rain in February through March

2004, measurements were most consistently similar between upstream and downstream, with no events showing significant increases moving downstream.

Seven total suspended solids samples sets were analyzed between 3/19/2003 and 6/30/2003. Two of the samples sets were below reporting limits for both the upstream and downstream sites. Of the remaining five sample sets, only two of the sample sets, collected on 5/20/03 and 6/3/03, had significantly different results and indicated decreasing TSS moving downstream.

Total organic carbon concentrations varied by no more than 0.8 mg/L between the upstream and downstream site during each of the eight sampling events. RPD's were generally not significant, except for the sample set collected the day prior to a rain event, on 4/1/30, that had a downstream decreasing RPD of 27%.

Total coliform concentrations were above reporting limits at both the upstream and downstream sites during 7 of the 24 sample sets. In all sample sets were RPD's could be evaluated, all were significantly different, with quantifiable RPD's ranging from 29 – 151%. Where at least one result was within the reporting limit, total coliform concentrations consistently decreased moving downstream.

All but four RPD's for ***E. coli*** were significantly different, ranging from 39-185% overall. The four results that were not significantly different all occurred between February and April. Similar to total coliform, ***E. coli*** concentrations generally decreased (20 out of 24 sample sets) moving downstream. On two occasions, 5/7/03 and 6/18/03, concentrations downstream were significantly higher than upstream by 865 and 326 MPN/100 ml, respectively, translating to 100 and 62% RPD, respectively. While there had been precipitation prior to the sampling event on 5/7/03, there was none prior to collecting the sample on 6/18/03. The Tuolumne County Water Quality Plan identifies failing septic systems and unobstructed grazing practices as causes of high coliform concentrations in Sonora and Woods Creeks. (ESA, 2007)

Trace elements (arsenic, chromium, lead, nickel, mercury, cadmium, zinc, copper) and minerals (chloride, sulfate, calcium, hardness, boron, magnesium) were collected between 3/19/03 and 6/30/03. Five sample sets were collected. All results for arsenic, chromium, lead, nickel, and mercury were below reporting limits.

Concentrations consistently increased moving downstream for calcium, chloride, sulfate, hardness, and cadmium samples. All sulfate and cadmium samples had significant RPD's. None of the RPD's for hardness were significant. The RPD's for calcium and chloride were generally not significant. However, for both constituents, the RPDs were significant on 3/19/03. There had been light rain (0.05 inches) the day prior to sampling, and heavier precipitation three days prior.

Magnesium concentrations significantly decreased during the 3/19/03 sampling event. Precipitation was measurable during the days prior.

Copper and zinc concentrations significantly increased downstream in four of the five samples collected, with RPD's over 100% in three of the samples for each of the constituents, though not on the same days.

Potential Impact of Residential Construction in a Rural Community (Woods Creek Study) summary

The main focus for this special study was to examine the effects of growth in a Sierra community by analyzing water quality upstream and downstream of a residential construction site. As identified through Central Valley Water Board resources and the EPA Envirofacts, there are a number of facilities surrounding the study area, but none that should have directly influenced results evaluated for this study.

In summary:

- The following constituents were significantly different between the upstream and downstream sites (numbers in parentheses indicate number of significant findings per total sampling events):

- Increasing concentrations: SC (7/24), turbidity (11/23), ***E. coli*** (2/24), boron (1/5), calcium (1/5), chloride (1/5), sulfate (4/4), copper (4/5), cadmium (5/5), zinc (4/5)
- Decreasing concentrations: turbidity (3/23), TSS (2/7), TOC (1/8), total coliform, ***E. coli*** (18/24), magnesium (1/5)

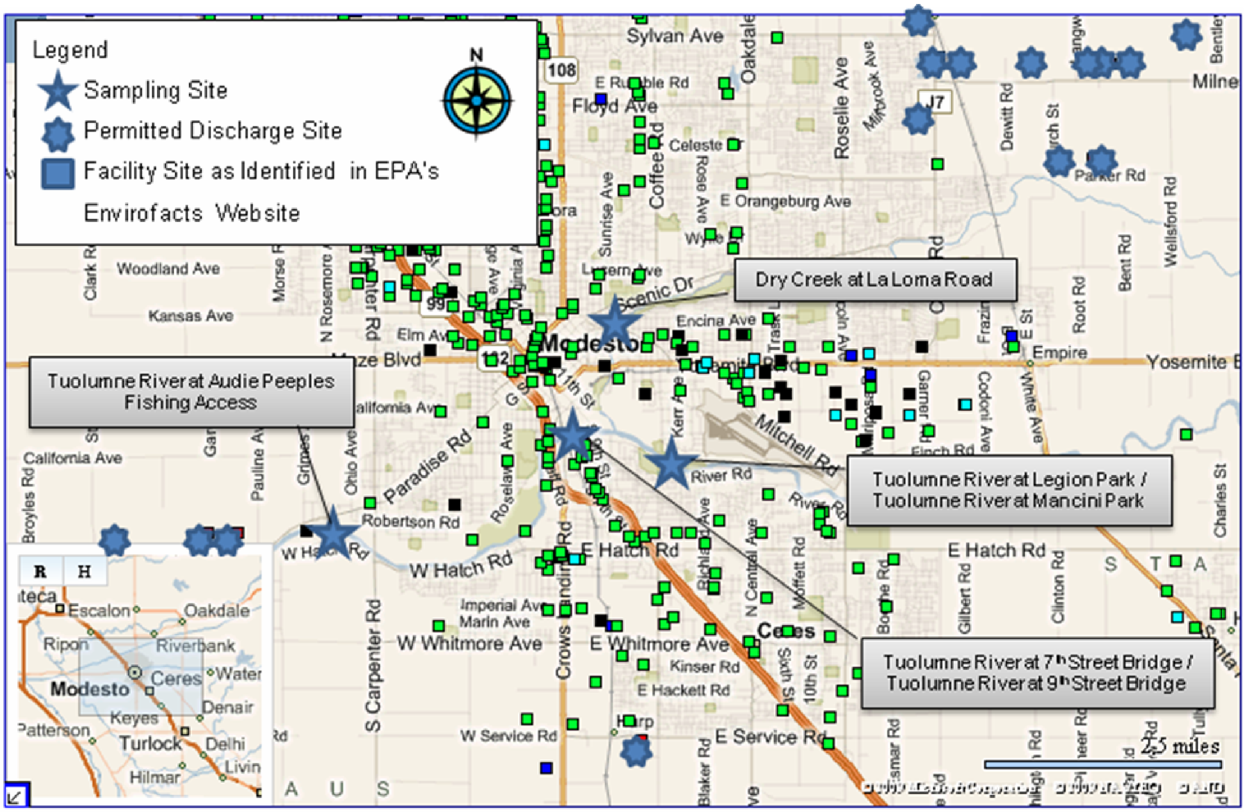
- Overall trends
  - Consistent changes moving downstream,
    - Increasing concentrations: SC, calcium, chloride, sulfate, hardness, cadmium, copper, zinc
    - Decreasing concentrations: pH, total coliform, ***E. coli***, TOC
  - Seasonally,
    - DO generally decreased downstream from March through August, but then increased the rest of the year
    - SC spikes occurred after the first significant rainfall after dry periods
    - Downstream increases in turbidity were most common during the drier period from May through August

8.3.2 Potential Impact of an Agriculturally Dominated Subwatershed (Dry Creek) on the Tuolumne River

Dry Creek is the main tributary of the Tuolumne River downstream of Don Pedro Reservoir, and drains a largely agricultural watershed of approximately 192 square miles with some storm drain outlets from the City of Modesto (estimated population of 210,088 (DOF, 2009a)) at its confluence with the Tuolumne River. This watershed contains large cattle grazing areas, orchards, and other irrigated agriculture directly adjacent to the waterway. Dry Creek has also been identified as a major contributor of fine sediment to the Tuolumne River (EDAW, 2001). This creek has carried tremendous winter flood flows in the past and has been extensively rechannelized and leveed along its lower 12-mile reach as it passes through the City of Modesto before discharging to the Tuolumne River. The water quality in the Tuolumne River can become visibly impaired by Dry Creek's muddy effluent below the confluence (EDAW, 2001), although this condition did not occur during this study period. Information from a combination of flow data from Tuolumne River at La Grange, Dry Creek at Clause Road, and Tuolumne River at 9th Street Bridge, indicate that flow from Dry Creek may at times come to a stop, or even allow the Tuolumne River to backflow up the Dry Creek channel, provided the ratio of Tuolumne River flow to Dry Creek flow is high enough. Backflow did not occur during the period of this study.

EPA Envirofacts identified 768 facilities within the Modesto city limits. While there were no facilities with permits to discharge waste to water between the sampling sites included in this study, there were a number of other facilities, such as hazardous waste generators, located between the sampling sites and facilities permitted to discharge stormwater could be found upstream and downstream of this study area (see Figure 87). In addition, the City of Modesto storm drain system includes approximately 30 outfalls to Dry Creek, with approximately 18 downstream of the sampling site. Approximately 13 stormwater outfalls are located on the Tuolumne River between the Legion Park and Audie Peeples sampling sites (Waste Discharge Requirement, NPDES No. CAS083526, Order No. R5-2008-0092). Surface water discharges occur generally in the older areas of the City or those areas immediately adjacent to the Tuolumne River, Dry Creek or irrigation canals, primarily during storm events and may receive other urban flows. Twenty percent of the City's storm water discharges directly into either the Tuolumne River or Dry Creek, with the rest discharging to detention/retention basins, MID laterals/drains, and rock wells. No discharger violations located between the sites for this study were identified during the period of this study.

Figure 87 Facilities located near Modesto, as identified in EPA Envirofacts.



Similarly, a report by the Central Valley Water Board from 1989 also indicated that there were no direct discharges to or diversions from the Tuolumne River between the Highway 99 Bridge and the Audie Peeples Fishing Access. These findings suggest that there are minimal influences to water quality in the Tuolumne River between the Highway 99 Bridge and the Audie Peeples sampling site.

Sites were chosen on Dry Creek upstream of the confluence with the Tuolumne River, and along the Tuolumne River upstream and downstream of the confluence to answer the following questions:

- Does Dry Creek cause a significant change in water quality of the Tuolumne River below the confluence?
- How significant is the difference in water quality between the Tuolumne River and Dry Creek?
- What trends were present in overall water quality?

Sampling sites upstream of the confluence included Tuolumne River at Mancini Park (STC205) and Tuolumne River at Legion Park (STC216). Sampling sites downstream of the confluence included Tuolumne River at 9th Street, (STC207), Tuolumne River at 7th Street (STC214), and Tuolumne River at Audie Peeples Fishing Access (STC215). Although flooding and safety concerns necessitated the replacement of initial sites (Tuolumne River at Legion Park, Tuolumne River at 9th Street Bridge, and Tuolumne River at 7th Street Bridge) along the Tuolumne River, all sampling sites are used in this discussion because together they provide a more complete seasonal description of the study areas. A comparison of data from these sites is presented in Appendix G.

Temperature, DO, and pH did not significantly change in the Tuolumne River between the upstream and downstream sites, and were not significantly different between Dry Creek and the Tuolumne River.

None of the RPDs for specific conductance between the upstream and downstream Tuolumne River sites were significantly different. When comparing Dry Creek to the Tuolumne River sites, results generally were not significantly different except for both of the Tuolumne River sites on 3/5/03 and 3/17/04, the upstream site on 10/21/03, and the downstream site on 4/16/03 (no upstream site sampled that day). In all these instances, concentration in Dry Creek was higher, and none of these instances occurred on a day where there were identified violations of spills or water quality effluent. Additionally, precipitation did not appear to influence the results. While most results were not significantly different, trends are present. The SC downstream of the confluence was lower than the upstream site from 1/23/03 – 4/2/03 and Dry Creek from 1/23/03 – 5/21/03. After these dates, the downstream site was consistently higher in measured SC than the upstream site and Dry Creek. This difference could have been the result of moving sampling sites or seasonal variation. The SC between the upstream site and Dry Creek did not show a trend.

Turbidity results were significantly different upstream and downstream of the Dry Creek confluence in about half the sample sets (12 out of 25), typically with increased concentrations at the downstream site. Most results were also significantly different between Dry Creek and both the upstream (21 out of 24) and downstream (22 out of 25) sites, with concentrations generally higher in Dry Creek. Overall, concentrations were higher downstream of the confluence, however, from May through September, the later portion of the Turlock Irrigation District irrigation season, upstream concentrations were occasionally higher. Turbidity was generally higher in Dry Creek than in the Tuolumne River.

The evaluation for total coliform comparisons is limited due to a large amount of the results being above the reporting limit (>2420 MPN/100ml). Where only one result in the sample set was above the reporting limit, the sample that was above the reporting limit was set to 2420 to evaluate whether the results were significantly different. Approximately one third of the sample sets (5 out of 14) between the Tuolumne River upstream and downstream sites were significantly different, while approximately half were significantly different when comparing upstream Tuolumne River to Dry Creek (8 out of 13) and downstream Tuolumne River to Dry Creek (4 out of 8). When comparing all upstream and downstream Tuolumne River concentrations where at least one result was quantifiable, concentrations tended to increase moving downstream, with decreases moving downstream January through March. Concentrations in Dry Creek were generally higher than in the Tuolumne River.

The ***E. coli*** RPD between upstream and downstream Tuolumne River sample results was significant in approximately half the sample sets (17 out of 26). However, results were significantly different in the majority of the sample sets when comparing the upstream and downstream Tuolumne River concentrations to concentrations in Dry Creek. Concentrations were generally higher in the Tuolumne River below the Dry Creek confluence than above the confluence, although in May through October, there were occasional increased concentrations upstream. Concentrations in Dry Creek were generally higher than concentrations both upstream and downstream of the confluence, with three instances (7/23/03, 8/5/03, and 10/7/03) where Tuolumne River concentrations were higher. From June through August, it appeared that Dry Creek inflows did noticeably increase concentrations of ***E. coli*** in the Tuolumne River since during this time Dry Creek ***E. coli*** concentration was significantly higher than the upstream site, but was not significantly higher than the downstream site.

For the remaining constituents, monitoring was limited to March through June 2003. The maximum number of sample sets for each constituent was five, except total suspended solids, which included a maximum of six sample sets for comparing Dry Creek to the downstream Tuolumne River site.

Samples analyzed for TSS were below the reporting limit (<4.0 mg/l) in three of the five upstream Tuolumne River samples. All other samples were quantifiable, and results below the reporting limit were evaluated at 4.0 mg/l to determine significant difference. Two of the four sample sets were significantly different in comparing the Tuolumne River upstream and downstream sites, and downstream concentrations were higher in all sample sets. Four of the upstream Tuolumne River sample sets were significantly lower than Dry Creek, while only two of the five downstream Tuolumne River sample sets were significantly lower than Dry Creek.

Of the five sample sets were analyzed for TOC upstream and downstream of the confluence, only one had a significant downstream increase, although concentrations did consistently increased in the

Tuolumne River downstream of the confluence. The concentrations in Dry Creek were consistently significantly higher than either site in the Tuolumne River.

For metals and minerals, all results were below reporting limits for boron, cadmium, mercury, arsenic, lead and nickel. One result for chromium in Dry Creek was within reporting limits, but was not significantly higher than the Tuolumne River sites.

None of the remaining metals and minerals (calcium, magnesium, hardness, sulfate, chloride, zinc, and copper) showed a significant difference between the upstream and downstream Tuolumne River sites.

Calcium, magnesium, and hardness only showed significant differences between Dry Creek and the Tuolumne River downstream of the confluence. This difference only occurred once, on 4/16/03, when all three constituents were higher in Dry Creek. On this day, there was no upstream sample collected and no violations occurred that would have affected these results. There had been rain the three days before and day of this sampling event. In the remaining samples, although not significantly different, all three of these constituents followed matching trends.

Results for sulfate analysis also only showed significant differences between Dry Creek and the Tuolumne River downstream of the confluence. Two out of five sample sets were significantly lower in Dry Creek than the Tuolumne River downstream of the confluence. On these days, RPDs between samples from the Tuolumne River upstream of the confluence and Dry Creek were also high, but not significant.

Chloride and zinc both had significant RPDs when comparing Dry Creek against the Tuolumne River upstream and downstream of the confluence. Chloride was significantly higher in the Tuolumne River in one of the four sample sets between the upstream Tuolumne River and Dry Creek sites, and in four of the five sample sets between the downstream Tuolumne River and Dry Creek sites. Zinc was significantly higher in Dry Creek in all the sample sets between Dry Creek and the Tuolumne River.

Copper was significantly higher in Dry Creek than the Tuolumne River in all four sample sets. Where results were below reporting limits (6/17/03 and 6/30/03 at the upstream site), values were set to 1 ug/l to calculate for significant RPD. In the samples collected on 3/18/03, 6/17/03 and 6/30/03, the lowest concentrations were upstream of the confluence and increased below the confluence. However, on 5/21/03, increased flow in the Tuolumne River appeared to dilute any potential impact from Dry Creek.

Potential Impact of an Agriculturally Dominated Subwatershed (Dry Creek) on the Tuolumne River Summary

The main focus for this special study was to examine the effects of an agriculturally dominated subwatershed (Dry Creek) on the Tuolumne River. A number of facilities were identified through EPA Envirofacts that were located within the study area, none of which should have directly influenced results evaluated for this study. However, unidentified sources of constituents could have affected results, as reflected in trends for SC after the downstream sampling site was moved on 5/6/03 and results for chloride, where downstream Tuolumne River results were higher than upstream results, regardless of the Dry Creek inflow. Pesticides from crops in the Dry Creek watershed were also identified as a stakeholder concern, but were outside the scope of this study for evaluation.

Some constituents (boron, cadmium, mercury, arsenic, lead, nickel, and chromium) were below reporting limits for all results and therefore could not be evaluated. Additionally, total coliform data was often above reporting limits, and therefore limited data could be evaluated.

In summary:

- Dry Creek appeared to cause a significant increase in about half the turbidity and ***E. coli*** concentrations of the Tuolumne River downstream of its confluence.

- Dry Creek had significantly higher concentrations of the following constituents than the Tuolumne River (numbers in parentheses indicate number of significant findings per total sampling events)
  - Upstream of confluence: SC (3/25), turbidity (18/24), TSS (4/5), TOC (6/6), total coliform, ***E. coli*** (18/25), chloride (1/4), copper (4/4), zinc (4/4).
  - Downstream of confluence: SC (3/26), turbidity (18/25), TSS (2/5), TOC (6/6), total coliform, ***E. coli*** (9/26), calcium (1/5), magnesium (1/5), chloride (1/5), hardness (1/5), copper (5/5), zinc (5/5).

- Overall, concentrations increased downstream between the two Tuolumne River sites for TSS, TOC, sulfate, calcium, magnesium, zinc, copper, and chloride. Dry Creek concentrations were higher than both Tuolumne River sites for turbidity, TOC, ***E. coli,*** copper and zinc, but lower for temperature and DO. Chloride was higher in the upstream Tuolumne River site than in Dry Creek. There were no identifiable trends between the Tuolumne River sites for hardness, pH, temperature, and DO; and between Dry Creek and the River sites for sulfate, calcium, and magnesium.

8.4. Evaluation of Beneficial Uses

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

1. Drinking water (Salt/Specific Conductivity, Minerals, Total Organic Carbon, Trace Elements, ***E. coli***);
2. Aquatic life (pH, Temperature, Dissolved Oxygen, Turbidity, Toxicity, Trace Elements);
3. Irrigation water supply (Salt/Specific Conductivity); 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 6.2. Appendix C4 provides the exceedance/elevated levels tables which compare the total number of samples collected with the total number of samples with results above the applicable objective, goal, or target. Criteria used to set trace element limits for cadmium, copper, lead, nickel and zinc 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 C4 and the discussion here. Constituents in Appendix C4 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. However, in general, sites monitored in this study were not associated with specific point sources. Due to the absence of specific objectives, ranges in turbidity concentrations were used for comparison purposes.

The following discussion highlights information from Appendix C4 to assess potential beneficial use concerns in the SJR Basin. Table 22 in Section 9.0 provides a summary of potential water quality concerns when compared to numeric objectives, targets, and goals listed in Appendices C1 and C2, and identified by site as applicable in Appendix C3.

<u>Drinking Water (Specific Conductance (salt), Minerals, Total Organic Carbon (TOC), Trace Elements, bacteria)</u>

Indicators used to evaluate a potential impact to drinking water (sources of municipal and domestic supply) included salt measured as specific conductance (umhos/cm), total organic carbon (TOC), selected trace elements (total arsenic, cadmium, copper, mercury, nickel, lead and zinc), and bacteria (***E. coli*** as an indicator of potential pathogens). For all of the indicators except ***E. coli***, there are specific numeric objectives or goals that results can be evaluated against. The presence of ***E. coli*** indicates that the water should to be treated prior to consumption but there are no specific numeric criteria for source water related to consumption.

Sites in the Valley Floor Drainage Area were exempt from Basin Plan objectives for this evaluation because they consisted of constructed drainage conveyance facilities, per sources of drinking water policy (State Board Resolution No. 88-63 and Basin Plan, 2006).

Salt (Specific Conductance)

The drinking water recommended level for short term exposure for specific conductance (SC) is 2200 umhos/cm. All samples collected in the Eastside Basin were within this limit, with the highest concentration of 614 umhos/cm at Littlejohns Creek at Austin Road.

Chloride and Sulfate

The recommended maximum contaminant levels for chloride and sulfate is 250 mg/L, with an upper limit of 500 mg/L and short-term exposure of 600 mg/L. All samples were under the maximum contaminant levels for both chloride and sulfate.

Total Organic Carbon

The TOC goal of 3.0 mg/L is based on the Bay Delta Authority's target for source water quality in the Sacramento-San Joaquin Delta (CALFED Water Quality Program Plan, 2000). This indicator was chosen to help identify potential sources of TOC to the Delta since all waterbodies monitored flow into the San Joaquin River and ultimately the Delta. Due to limited funding, TOC was only collected at most sites during March, April, May and June 2003.

Forty three percent of the samples collected had TOC concentrations higher than the Bay Delta target. Seventy one percent of the samples with concentrations greater than 3.0 mg/l were located in the Drainage Areas. The highest concentrations were from samples taken at MID Main Drain at Shoemake Road, which ranged from 4.8 to 42 mg/L TOC. In the river sites, the elevated levels were not as high as the Drainage Areas, and ranged from 3.2 to 11 mg/L. Dry Creek in the Tuolumne Watershed was consistently higher than the Bay Delta Authority's target, ranging from 5.4 to 11 mg/L. Concentrations above the target also occurred in April in the Upper Tuolumne Watershed and Merced River at River Road and again in June throughout both watersheds.

Figure 88 indicates, by watershed, the number of samples collected, percent of samples collected that were above the Bay-Delta target, and the number of individual concentrations that were above the target. Figure 89 spatially displays the sites with medians above the target.

Figure 88. Drinking Water Beneficial Use Evaluation: Total Organic Carbon (TOC), compared to Bay-Delta Target of <3.0 mg/l

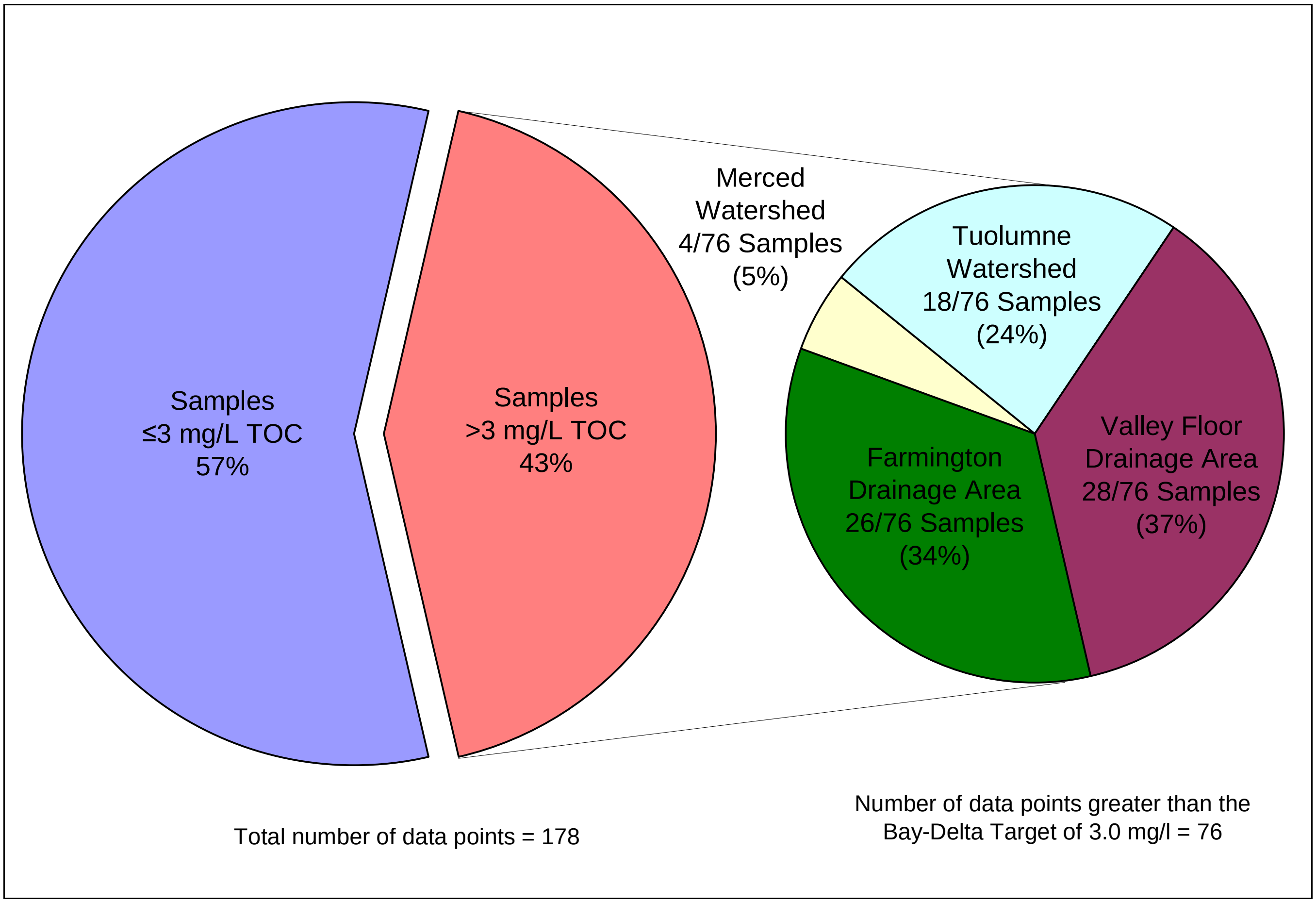
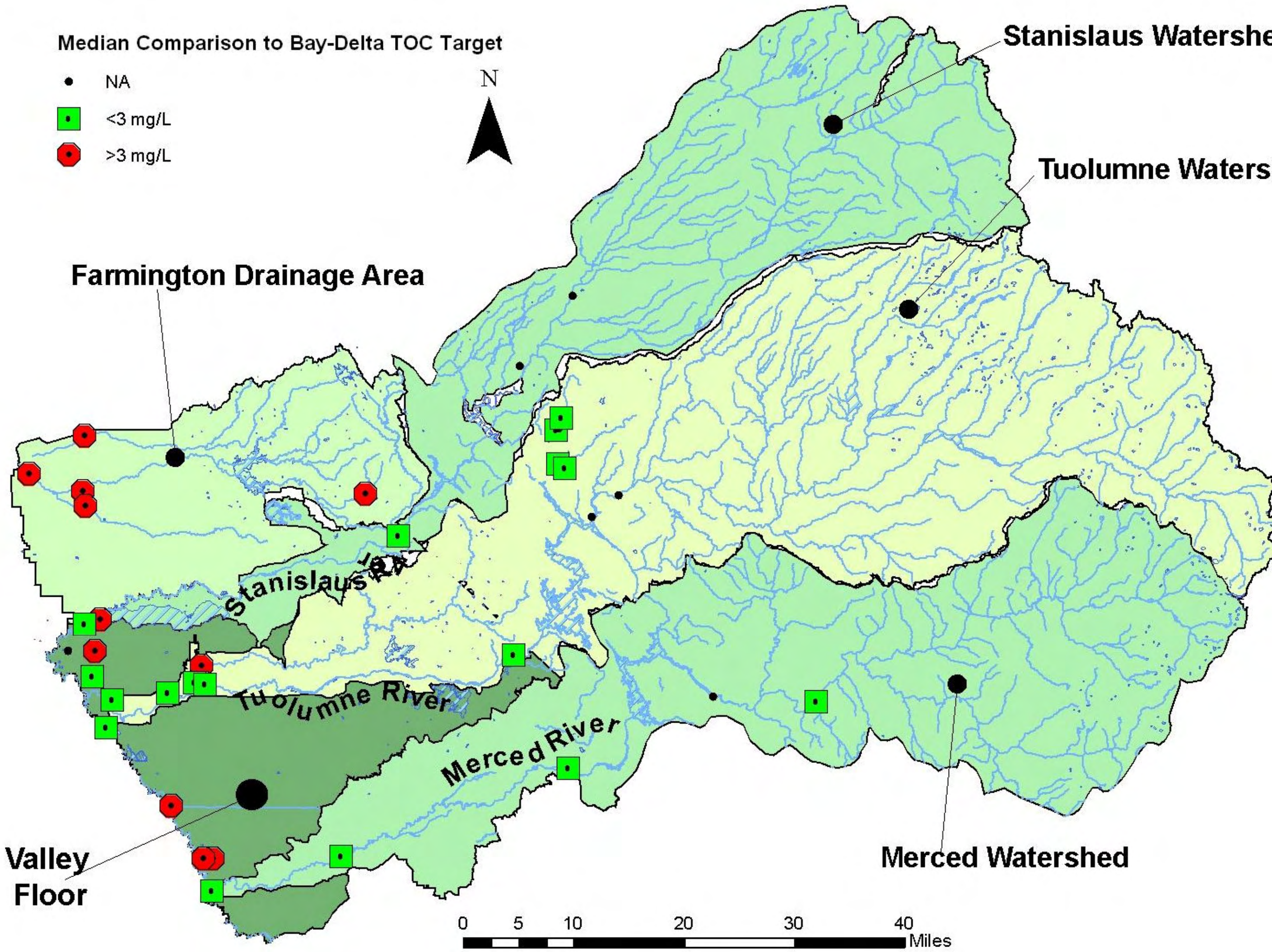


Figure 89. Drinking Water Beneficial Use Evaluation: Sites with Medians Above the Bay Delta Authority's Target for Total Organic Carbon (Potential Sources to Delta)



Trace Elements

Monitoring for specific trace elements was also limited due to funding, and consisted of 5-sampling events in March through June 2003. Most results were within the California Public Health Goals for drinking water. Exceptions were most common in upper watershed sites: Littlejohn's Creek at Sonora Road and Woods Creek at Mill Villa Drive. The following table identifies where and when exceedances occurred, and water quality goals for each exceedance. Shaded squares indicate that results that were below the indicated objective or goal. Only arsenic and cadmium reported concentrations at levels of potential concern.

Table 16 Drinking Water Beneficial Use Evaluation: Trace Elements

Site Code	Site Description	Date	California Public Health Goals for Drinking Water	
			Arsenic (0.004 ug/L)	Cadmium (0.04 ug/L)
STC212	Littlejohn's Creek @ Sonora Road	5/20/03	4	
		6/30/03	6.8	
TUO202	Woods Creek @ Mill Villa Drive	3/19/03		0.39
		4/15/03		0.23
		5/20/03		0.33
		6/18/03		0.50
		6/30/03		0.76

E. coli

E. coli was monitored as a pathogen indicator. For drinking water, pathogen criteria are typically set at the tap and are recommended at zero. No specific numeric criteria exist for source water. ***E. coli*** was detected in 99% of bacteria samples analyzed. Median concentrations in the Drainage Areas ranged from 25 MPN/100 mL to above reporting limits (>2420 MPN/100ml), while medians from the watershed sites ranged from 2 – 461 MPN/100 mL. Based on the findings, water from the Eastside basin should be treated for pathogens prior to drinking water use, as required by the US EPA Surface Water Treatment Rule, which requires public water systems that use surface water or groundwater under the direct influence of surface water and serve at least 10,000 people to disinfect water that will be used for municipal purposes.

Drinking Water Summary

Overall, water quality in the Eastside basin generally met municipal and domestic supply objectives or goals. All samples collected in the Eastside Basin were within the recommended limit for short term exposure for specific conductance. Trace elements were generally within water quality goals and objectives, with specific sites having high concentrations of certain elements, such as Woods Creek having high concentrations of cadmium at Mill Villa Drive. The high percent of elevated TOC concentrations (35% of samples collected) makes TOC the highest potential drinking water concern in the Eastside Basin, especially in the drainage areas and lower watershed tributaries. ***E. coli*** presence in most samples analyzed indicates possible presence of pathogens and a requirement of treatment prior to use for municipal supply, a requirement per the US EPA Surface Water Treatment Rule.

<u>Aquatic Life (pH, Temperature, Dissolved Oxygen, Turbidity, Water Column Toxicity and Trace Elements)</u>

The pH

For those water bodies designated for COLD or WARM beneficial uses, the Basin Plan specifies both numeric and narrative pH water quality objects. The numeric WQO identifies a specific range of 6.5 to 8.5 units, while the narrative indicates that changes in normal ambient pH levels shall not exceed 0.5 units. Six hundred samples were analyzed, with almost 97% within acceptable limits. The pH from the river sites generally fell within the acceptable range. The exceptions were found in upper watershed tributary sites. More commonly, exceedances were found in both drainage area sites. Data outside the numeric range was skewed to higher (more alkaline) concentrations, ranging from 8.6 to 9.7. In general, the majority of exceedances occurred at sites in the lower Farmington and Valley Floor Drainage Areas and the upper Tuolumne Watershed early in the calendar year, during the late storm season (January – May), as indicated in Table 17.

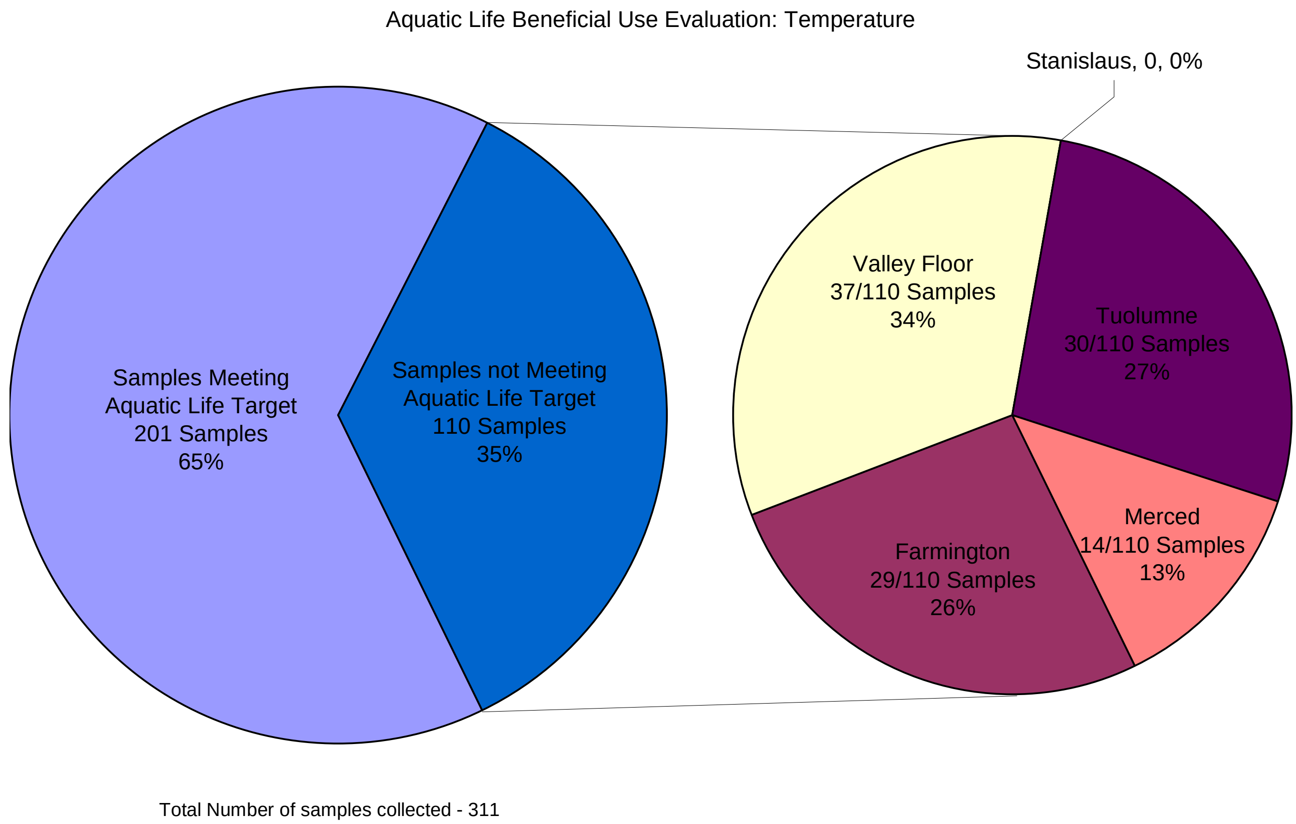
Table 17 Aquatic Life Beneficial Use Evaluation: pH

Site Code	Site Description	Date	pH
SJC213	Littlejohn's Creek @ Austin Road	02/04/04	8.6
		03/03/04	9.7
SJC503	Lone Tree Creek @ Austin Road	02/19/03	9.0
		03/18/03	9.3
SJC504	French Camp Slough @ Airport Way	02/19/03	8.9
		01/28/04	8.6
STC203	MID Lateral 6/8 @ Dunn Road	01/23/03	8.9
		02/04/03	8.9
		10/21/03	8.7
STC204	MID Lateral 3/4 @ Paradise Road	06/30/03	9.1
		10/07/03	8.6
		10/21/03	8.8
STC208	TID Lower Lateral 2 @ Grayson Road	01/22/03	8.7
		03/18/03	9.4
		04/02/03	8.6
		05/06/03	9.0
		01/06/04	8.9
TUO208	Woods Creek @ Motherlode Fairgrounds	03/17/04	8.6
TUO209	Curtis Creek @ Algerine Road	01/20/04	8.7
		03/17/04	8.7

Temperature

Samples were evaluated against the Bay-Delta Authority Target of 20-degree C from April 1 to June 30 and/or September 1 to December 31 for Aquatic Life Beneficial Use. Figure 90 shows the overall comparison of samples that met the Bay-Delta Authority Target versus the percent of samples that were above the Target and the breakdown of the percent of elevated samples by watershed. Approximately 60% of the elevated temperatures occurred in the Drainage Areas, while no elevated temperatures were identified in the Stanislaus Watershed.

Figure 90 Aquatic Life Beneficial Use Evaluation: Overall temperature as compared to the Bay-Delta Authority Target of 20 degrees Celsius from April 1 to June 30 and/or September 1 to December 31



Figures (91a-e) shows graphical individual watershed comparisons for the number of samples meeting and elevated above the Bay Delta Authority Target of 20 degrees Celcius from April 1 to June 30 and/or September 1 to 30 December. In the Tuolumne and Merced watershed, samples were above the Bay Delta Authority Target in 26-28% of the samples. In the Valley Floor and Farmington subbasins, temperature results were above the guideline in approximately half the samples.

Figure 91 Aquatic Life Beneficial Use Evaluation: Temperature by Watershed as Compared to the Bay-Delta Aquatic Life Target of 20 degrees Celsius from April 1 to June 30 and/or September 1 to December 31

Figure 91a Farmington Temperature

(49 Samples)

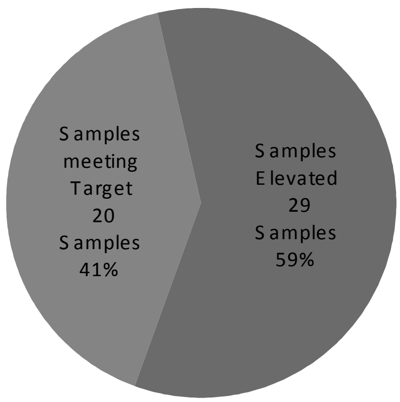


Figure 91b Valley Floor Temperature

(77 Samples)

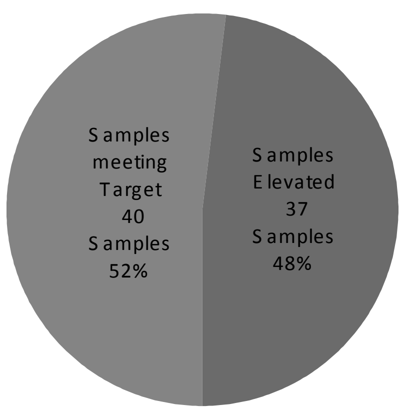


Figure 91c Stanislaus Watershed Temperature (26 Samples)

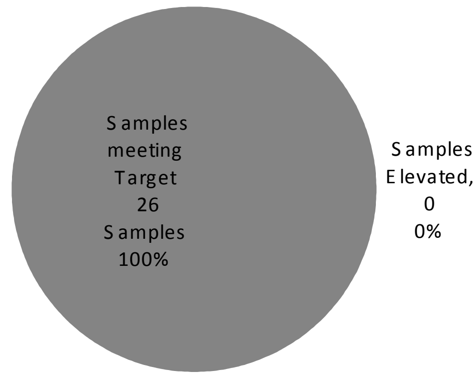


Figure 91d Tuolumne Watershed Temperature

(106 Samples)

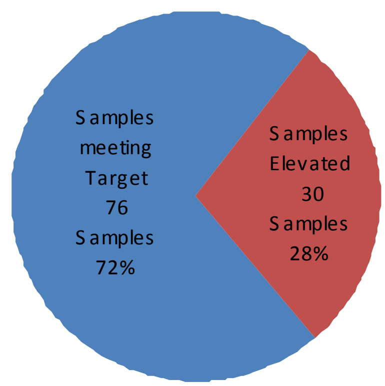
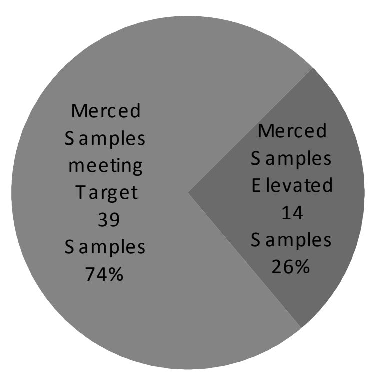


Figure 91e Merced Watershed Temperature

(53 samples)



Dissolved Oxygen

Exceedances to the Basin Plan dissolved oxygen (DO) objective (minimum of 7.0 mg/l) only occurred at sites in the Farmington and Valley Floor Drainage Areas and lower Merced Watershed.

Seasonally, dissolved oxygen (DO) typically follows a pattern of being high in cooler winter months and low during the warm summer months. At some sites such as at Duck Creek and French Camp Slough, the values below the water quality objective of 7.0 mg/L followed this trend with the lowest concentrations occurring in July and August. Some sites also had occasional lows during the cooler winter months, such as Lone Tree Creek, which dropped to 5.8 mg/L in January. The site with the most concentrations below 7.0-mg/L, as well as lowest overall, was MID Main Drain at Shoemake Road. Samples at the MID Main Drain at Shoemake Road dropped as low as 0.4 mg/L during May, and had a median of 5.7 mg/L. Below is a detailed list of DO concentrations less than 7.0 mg/l:

Table 18 Aquatic Life Beneficial Use Evaluation: Dissolved Oxygen

Site Code	Site Description	Date	DO (mg/L)
		06/04/03	5.9
		06/17/03	6.7
SJC201	Duck Creek @ Highway 4	07/22/03	6.6
		06/30/03	3.7
SJC213	Littlejohn's Creek @ Austin Road	08/20/03	5.8
		01/23/03	5.8
		01/29/03	6.1
		02/05/03	6.1
		06/04/03	6.5
SJC503	Lone Tree Creek @ Austin Road	08/20/03	6.5
		06/04/03	6.5
		06/30/03	6.4
		07/23/03	5.8
SJC504	French Camp Slough @ Airport Way	08/20/03	6.3
STC203	MID Lateral 6/8 @ Dunn Road	10/21/03	6.9
		04/02/03	3.6
		04/16/03	6.6
		05/06/03	6.4
		05/21/03	0.4
		06/04/03	1.8
		06/17/03	1.1
		06/30/03	3.6
		07/23/03	4.8
		08/20/03	2.2
		09/09/03	6.3
		09/22/03	3.0
		10/07/03	1.8
		10/21/03	4.8
		11/04/03	5.2
		01/06/04	5.4
STC211	MID Main Drain @ Shoemake Road	01/20/04	6.0
STC204	MID Lateral 3/4 @ Paradise Road	10/21/03	5.5
STC208	TID Lower Lateral 2 @ Grayson Road	02/19/03	2.4

Site Code	Site Description	Date	DO (mg/L)
		04/16/03	1.2
STC206	Dry Creek @ La Loma Road	08/20/03	6.0
MAR203	Merced River @ Bagby	06/18/03	6.4
MER202	Merced River @ Highway 99	09/09/03	6.7

Turbidity

Turbidity objectives are based on relationships between background conditions and discharges. Samples collected from the Eastside Basin help to characterize background conditions. The highest concentrations occurred in the Drainage Areas. High concentrations also were found in samples from the upper Tuolumne Watershed and occasionally in the lower Merced River Watershed. Table 19 identifies the percent of samples at each site that fell within specified turbidity ranges. Sites are listed within each sub-basin moving downstream. While the data does indicate increasing turbidity moving downstream and provides some basin wide background information, development of natural background criteria proved beyond the scope of this project. Such criteria would require the continuous recording of turbidity at selected reference sites in order to identify potential background conditions.

Table 19 Aquatic Life Beneficial Use Evaluation: Turbidity

Site Code	Count	0-5 NTU	5-50 NTU	50-100 NTU	>100 NTU
Farmington Drainage Area					
STC212	24	92%	8%		
SJC201	13		54%	38%	8%
SJC213	14		79%	21%	
SJC503	22		59%	41%	
SJC504	25	4%	44%	44%	8%
Valley Floor Drainage Area					
STC203	20	15%	80%		5%
STC202	2		50%	50%	
STC211	23	4%	52%	22%	22%
STC204	18	44%	56%		
STC208	21	52%	48%		
STC501	25	28%	56%	8%	8%
MER201	7	71%	29%		
MER203	14	64%	36%		
Stanislaus River Watershed					
CAL201	1	100%			
TUO201	2	100%			
STC201	22	100%			
STC514	27	41%	59%		
Tuolumne River Watershed					
TUO208	22	64%	27%	5%	5%
TUO205	2	50%	50%		
TUO202	25	44%	52%		4%
TUO207	23	43%	52%		4%
TUO209	9	67%	11%	11%	11%
TUO203	1	100%			

Site Code	Count	0-5 NTU	5-50 NTU	50-100 NTU	>100 NTU
TUO204	2	50%	50%		
STC210	21	95%	5%		
STC205	7	100%			
STC216	18	67%	33%		
STC206	25	16%	80%	4%	
STC207	4	75%	25%		
STC214	3	33%	67%		
STC215	19	26%	74%		
STC513	25	32%	68%		
Merced River Watershed					
MAR202	3	100%			
MAR203	15	80%	20%		
MAR201	2	100%			
MER209	21	100%			
MER202	22	55%	41%		5%
MER546	25	28%	68%	4%	

Toxicity

Toxicity samples were collected in January, March, April and May 2003 for C. dubia (to represent impacts from organics such as pesticides) and fathead minnows (representing impacts from nutrients) at selected sites (Stanislaus River at Caswell Park, Tuolumne River at Shiloh Fishing Access, Harding Drain at Carpenter Road, and Merced River at River Road). Most samples resulted in 100% survival. The January sample collected from Merced River resulted in 95% survival, and the May samples from Merced River and Harding Drain resulted in 85 and 90% survival, respectively, but were not significantly toxic.

Trace Elements

Evaluating potential trace element impacts on aquatic life requires adjusting numeric objectives based on hardness (Appendix B), using applicable formulas listed in Appendix C2. In general, concentrations were within the adjusted water quality objectives available for total copper, cadmium, zinc, mercury, lead and nickel. Unlike drinking water, there are no aquatic life objectives for chromium and arsenic. Out of 125 samples for each trace element, only one (less than 1%) exceeded the zinc objectives, while 4 (3% of samples) exceeded the copper objectives.

Table 20 Aquatic Life Beneficial Use Evaluation: Trace Elements

Site Code	Site Description	Date	Aquatic Life	
			Zinc	**Copper**
SJC201	Duck Creek @ Highway 4	6/30/03		E
SJC503	Lone Tree Creek @ Austin Road	3/18/03		E
STC211	MID Main Drain @ Shoemake Road	5/21/03	E	E
STC501	Harding Drain @ Carpenter Road	3/25/03		E
MAR203	Merced River @ Bagby	5/20/03		E

E = Exceeded respective objectives adjusted for hardness.

Aquatic Life Summary

In general, water quality in the Eastside Basin was within aquatic life objectives, with occasional instances outside of objectives and guidelines. Most concerns occurred in the Farmington and Valley Floor Drainage areas, especially for pH, dissolved oxygen and trace elements. All sites had at least one sample above the temperature guidelines, except the three sites closest to the reservoir releases and sites within the Stanislaus Watershed. Dissolved oxygen concentration at MID Main Drain was below the objective throughout the study period.

Irrigation Water Supply (Salt represented by SC)

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, and therefore was not used to evaluate the grab sample data collected as part of this project.

The Water Quality Goal for Agriculture has a limit of 700 umhos/cm. Although all sites in the Farmingington Drainage Area and the watershed sites met this goal, 38 samples from the Valley Floor Drainage area, from both drains and TID Laterals 6/7 and Lateral 7, were elevated above the goal. These 38 samples represented 6% of the total 600 samples collected during this study, and 49% of the total SC samples collected in the Valley floor Drainage Area.

Recreation (Bacteria)

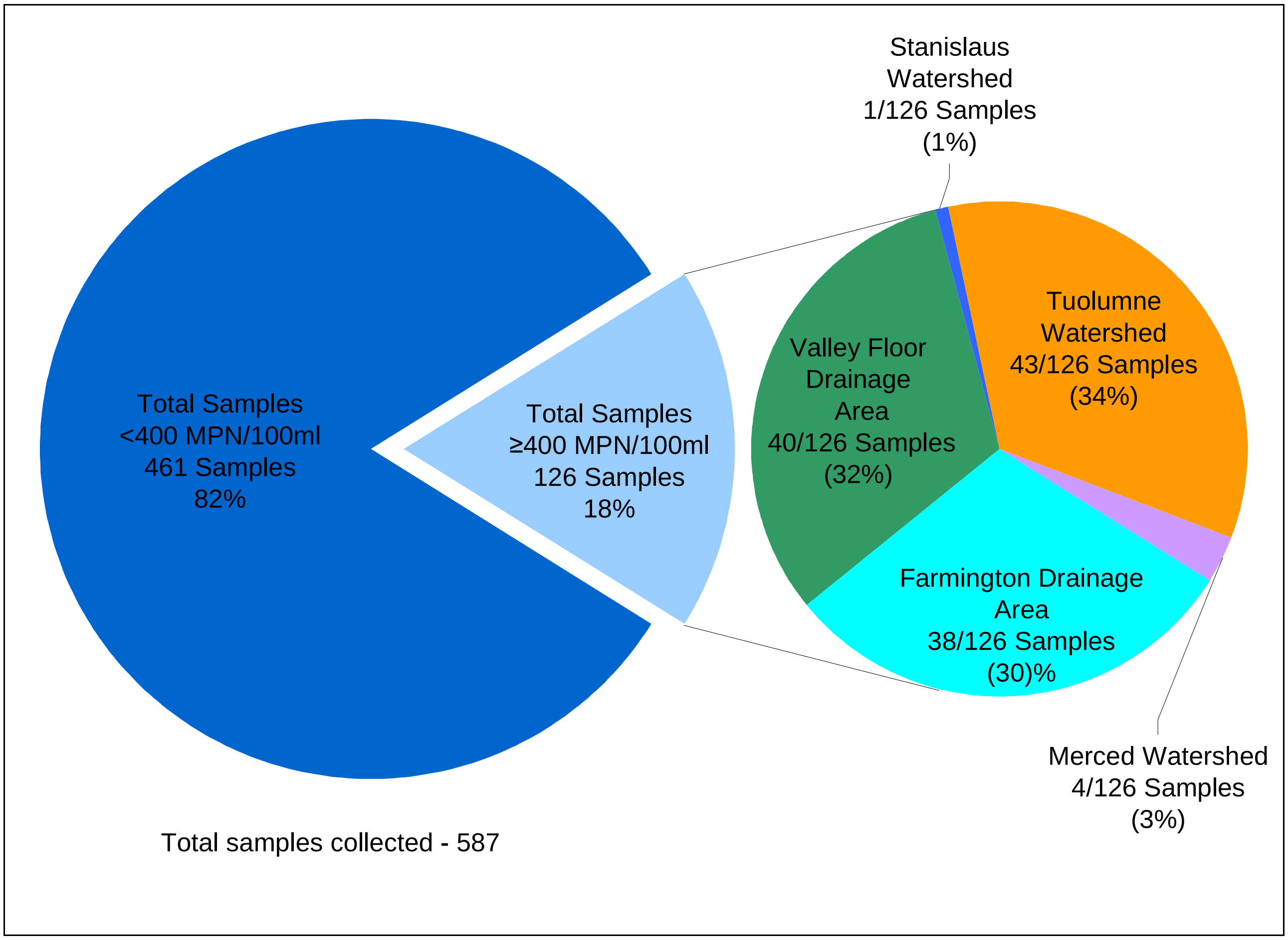
Bacteria is used as an indicator to determine likelihood of pathogens in the water column. The current Basin Plan WQO focuses on fecal coliform concentrations (<200-MPN for a 5-day geometric mean or <400-MPN for a single sample). Analyses for this study utilized ***E. coli***, a subset of fecal coliform. Use of ***E. coli*** allowed both a conservative evaluation against the Basin Plan WQO as well as a comparison to USEPA guidelines for various levels of recreational contact (listed below).

Level of Contact	USEPA ***E. Coli*** Single Sample Maximum Guideline (MPN/100ml)
Designated beach area	235
Moderate full body contact	298
Light full body contact	409
Infrequent full body contact	575

The typical contact recreation period is from May 1 to October 1; however contact recreation could occur throughout the year, regardless of beneficial use designation. Therefore, the following figure sets show comparisons to the Basin Plan objective and EPA Guidelines for both year round and typical contact recreation periods.

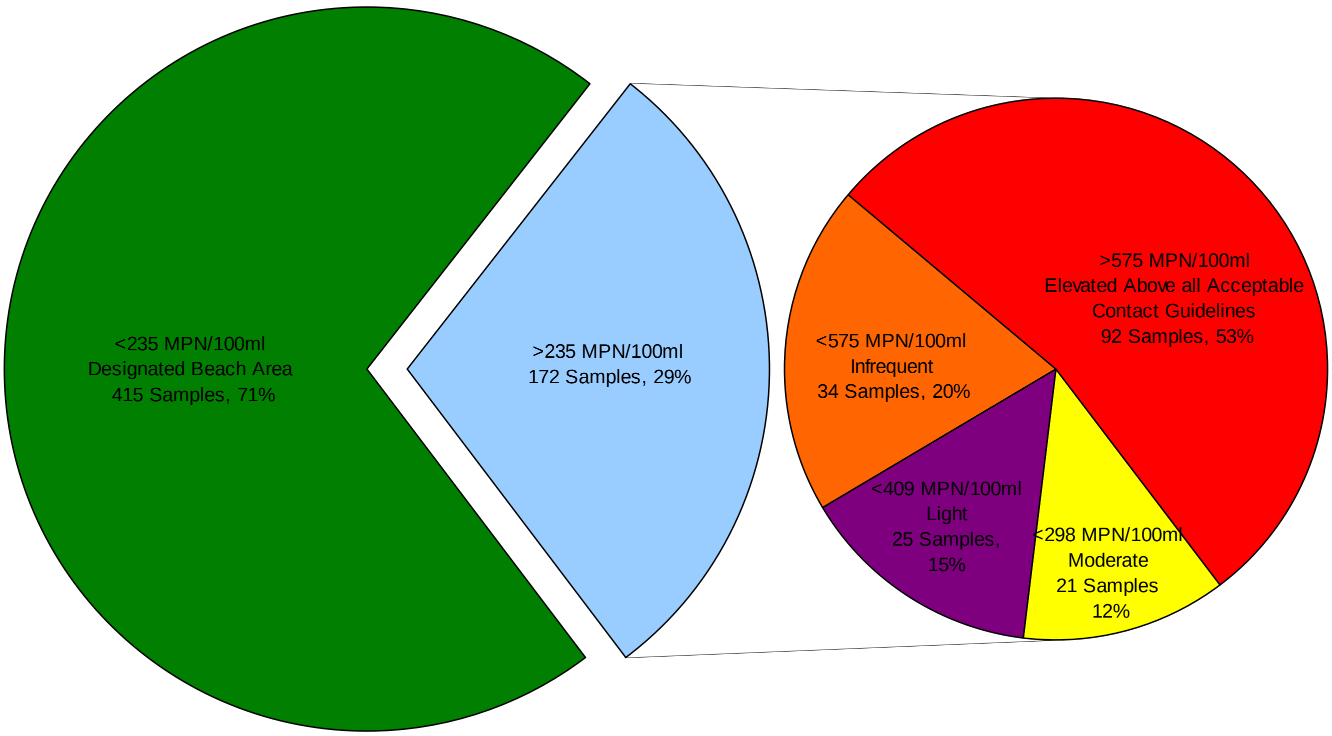
E. coli concentrations exceeded the one time fecal coliform WQO (400 MPN/100ml) in 126 of the 587 samples analyzed over the course of the entire study, see Figure 92. While, only 252 samples were analyzed during the typical swim period, distribution of samples not meeting the Basin Plan objective was similar to distribution of the year round samples. Approximately 33% of the exceedances occurred in the Drainage Areas, with 52% and 78% of the actual number of samples collected in the Valley floor and Farmington areas, respectively, exceeding 400 MPN/100ml ***E. coli.***

Figure 92 Contact Recreation Beneficial Use Evaluation: *E. coli*, A Subset of the Basin Plan Fecal Coliform Single Sample Objective (<400 MPN/100mL), Year Round data



Further assessment utilizing USEPA guidelines is delineated in Table 21. While application of these guidelines is not an exact match for the intensity of contact or non-contact recreation at each site, nor are these guidelines adopted by the Central Valley Water Board, these guidelines do provide a framework for data comparison. Table 21 categorizes each sample based on the ranges provided by the USEPA Guidelines for contact recreation. From the table, it appears that elevated ***E. coli*** concentrations from sites in the Farmington and Valley Floor Drainage areas and Tuolumne River watershed were prevalent throughout the sampling period, including the typical recreational swim period (May 1 to October 1). However, swimming is illegal in the MID and TID owned drains and laterals. In the Stanislaus Watershed, elevated concentrations were only recorded in October. In the Merced River Watershed, elevated concentrations occurred throughout the typical recreational swim period. **Figure** 93 displays distribution of all samples collected during this study, regardless of typical swim period, as compared to the USEPA Recreation Guidelines. Approximately 53% of the elevated ***E. coli*** concentrations exceeded all acceptable guidelines (>575 MPN/100ml). Each individual watershed displayed a unique distribution, as shown in figures 94a-e.

Figure 93 *E. coli* Results as Compared to the USEPA Recreational Guidelines, January 2003 - April 2004 - Eastside Basin



Total samples collected - 587

Figure 94 Comparison of *E. coli* results to USPEA Guidelines for Recreational Waters, by Watershed

Figure 94a Farmington Drainage Area

(100 total samples analyzed)

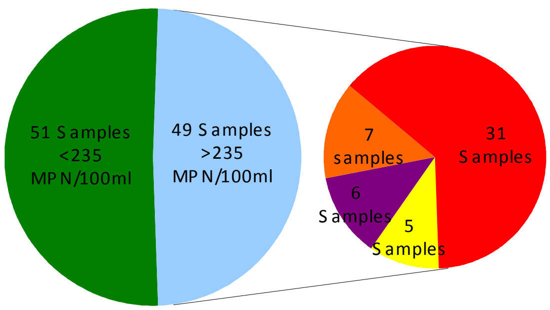


Figure 94d Tuolumne Watershed

(215 total samples analyzed)

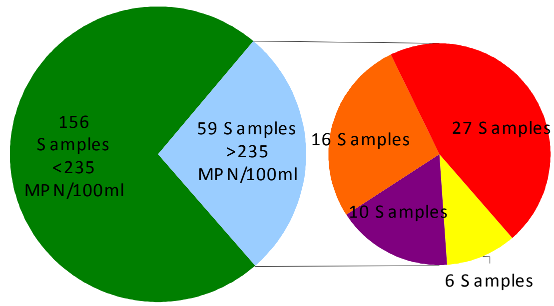


Figure 94b Valley Floor Drainage Area

(131 total samples analyzed)

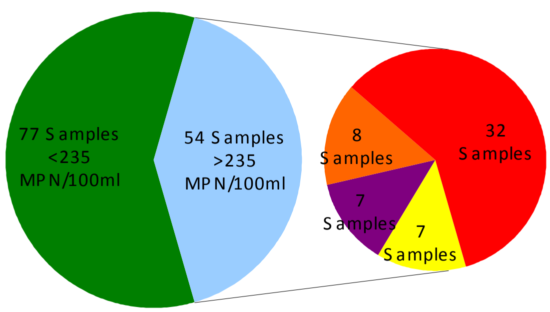


Figure 94e Merced Watershed

(91 total samples analyzed)

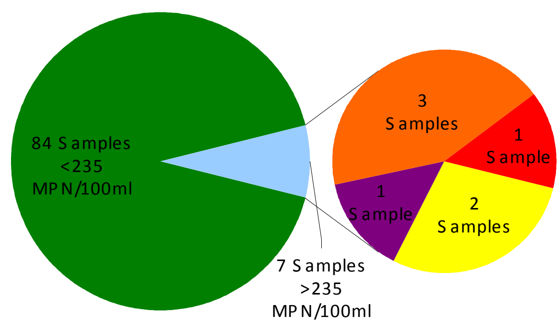


Figure 94c Stanislaus Watershed

(50 total samples analyzed)

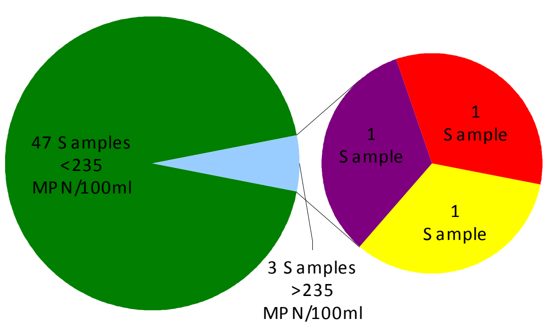


Table 21 Comparison of Bacteria Results to Environmental Protection Agency *E. coli* (MPN) Guidelines for Contact Recreation

		2003																									2004									
Site Code	Site Description	Jan		Feb		Mar		Apr		May		Jun			Jul		Aug			Sep		Oct			Nov		Jan			Feb				Mar		
Farmington Drainage Area																																				
STC212	LJ @ Sonora Rd.	X	X	X			>575				299–409	>575				X			X			410–575		X	410–575	>575			X	>575	>575	X	X	236–298	>575	X
SJC201	Duck Creek	X		X	X	X	>575	X	X	>575						X			X			X	X	X	X	X	299–409	X	X	X	X	X	X	X	X	X
SJC213	LJ @ Austin	X	X	X	X	D	>575	D	D	D	236–298	>575		>575		X		>575	X	D		X	X	X	X	X	>575		X			X	X	>575		X
SJC503	Lone Tree	X		410–575	410–575	299–409		>575	>575	410–575	>575	>575	>575	236–298	>575	X			X			>575	>575	X	X	X	>575	X	X	X	X	410–575	X	X	X	>575
SJC504	French Camp	X				>575	299–409	>575		>575	>575	299–409		410–575	236–298	X	236–298		X			>575		X	>575		>575	X		X	X		X	X	X	299–409
Valley Floor Drainage Area																																				
STC203	Lateral 6/8	X			>575	X					>575					X			X			236–298		X			X	X	X	X	X	X	X	X	X	X
STC202	Main Drain Inlet	X	299–409		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC211	Main Drain Shoemake	X	X	X	>575	>575		>575	>575	>575	>575	>575	>575	>575	>575	X	>575	299–409	X	>575	>575		>575	X	>575		>575	X	X	D	>575	X	X		236–298	X
STC204	Lateral 3/4	X		X	D	D					236–298	>575	299–409	>575		X		>575	X	>575				X			X	X	X	X	X	X	X	X	X	X
STC208	LL2 @ Grayson	X				D										X			X					X				X	X	X	X	X	X	X	X	X
STC501	Harding Drain	410–575	236–298	236–298	410–575	410–575		410–575		>575		>575	299–409	236–298	X	299–409	410–575	>575	>575	>575	>575		410–575	X	299–409		>575	X	X	X	X	X	X	X	X	X
MER201	Lateral 6/7	X		>575				410–575	236–298	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MER203	Lateral 7	X	X	X	X	X	X	X	X	X		>575			X		410–575	299–409						X					X	X	X	X	X	X	X	X
Stanislaus River Watershed																																				
CAL201	SR @ Camp Nine	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TUO201	SR @ Parrot's Ferry	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC201	SR @ Knight's Ferry	X														X			X					X				X	X	X	X	X	X	X	X	X
STC514	SR @ Caswell	X														X			X			299–409	>575	X			236–298	X		X	X		X	X	X	
Tuolumne River Watershed																																				
TUO208	Woods @ Mother Lode	X	X	X	X	X				410–575	299–409	410–575	299–409	410–575	410–575	X	410–575	236–298	X	299–409	>575	>575	299–409	X	410–575	299–409	>575	299–409	X	299–409	>575	X	X	>575		X
TUO205	Woods @ Hwy 108	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TUO202	Woods @ Mill Villa	X								>575			>575			X	299–409		X					X				X	X		>575	X	X			X
TUO207	Sullivan	X	X	X					410–575				410–575	236–298		X			X	X		>575		X	>575	410–575			X	410–575	>575	X	X			X
TUO209	Curtis	X	X	X	X	X	X	X	X	X	410–575	299–409	>575	D	D	X	D	D	X	X	D	D	D	X	D	410–575		>575	X	>575	>575	X	X			X
TUO203	TR @ Ward's Ferry	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
TUO204	TR @ Jacksonvill/River	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC210	TR @ La Grange	X														X			X					X				X	X	X	X	X	X	X	X	X
STC205	TR @ Mancini	X							X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC216	TR @ Legion	X	X	X	X	X	X	X	X	X						X	>575		X					X					X			X	X			X
STC206	Dry Creek	X					>575	>575						236–298		X	236–298	>575	X	236–298			410–575	X	>575		>575	X	X	>575	>575	X	X	>575		X
STC207	TR @ 9th	X				X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC214	TR@ 7th	X	X	X	X			>575	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
STC215	TR @ Audie Peeples	X	X	X	X	X	X	X	X							X		>575	X					X					X		410–575	X	X	236–298		X
STC513	TR @ Shiloh	X						>575	299–409			410–575				X			X					X				X		X	X	X	410–575	X	X	
Merced River Watershed																																				
MAR202	MR @ Briceburg	X	X	X	X				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MAR203	MR @ Bagby	X	X	X	X	X	X	X					410–575			X			X					X				X	X	X	X	X	X	X	X	X
MAR201	MR @ Hwy 49	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MER209	MR @ Merced Falls	X														X			X					X				X	X	X	X	X	X	X	X	X
MER202	MR @ Hwy 99	X														X			X					X				X	X	X	X	X	X	X	X	X
MER546	MR @ River	X										299–409		>575	X		236–298	236–298	410–575				410–575	X				X		X	X	X		X	X	

X = Not Sampled; D = Dry; blank (white) = <235 MPN; light grey = 236 – 298 MPN; horizontal lines = 299 – 409 MPN; vertical lines = 410 – 575 MPN; black = >575 MPN

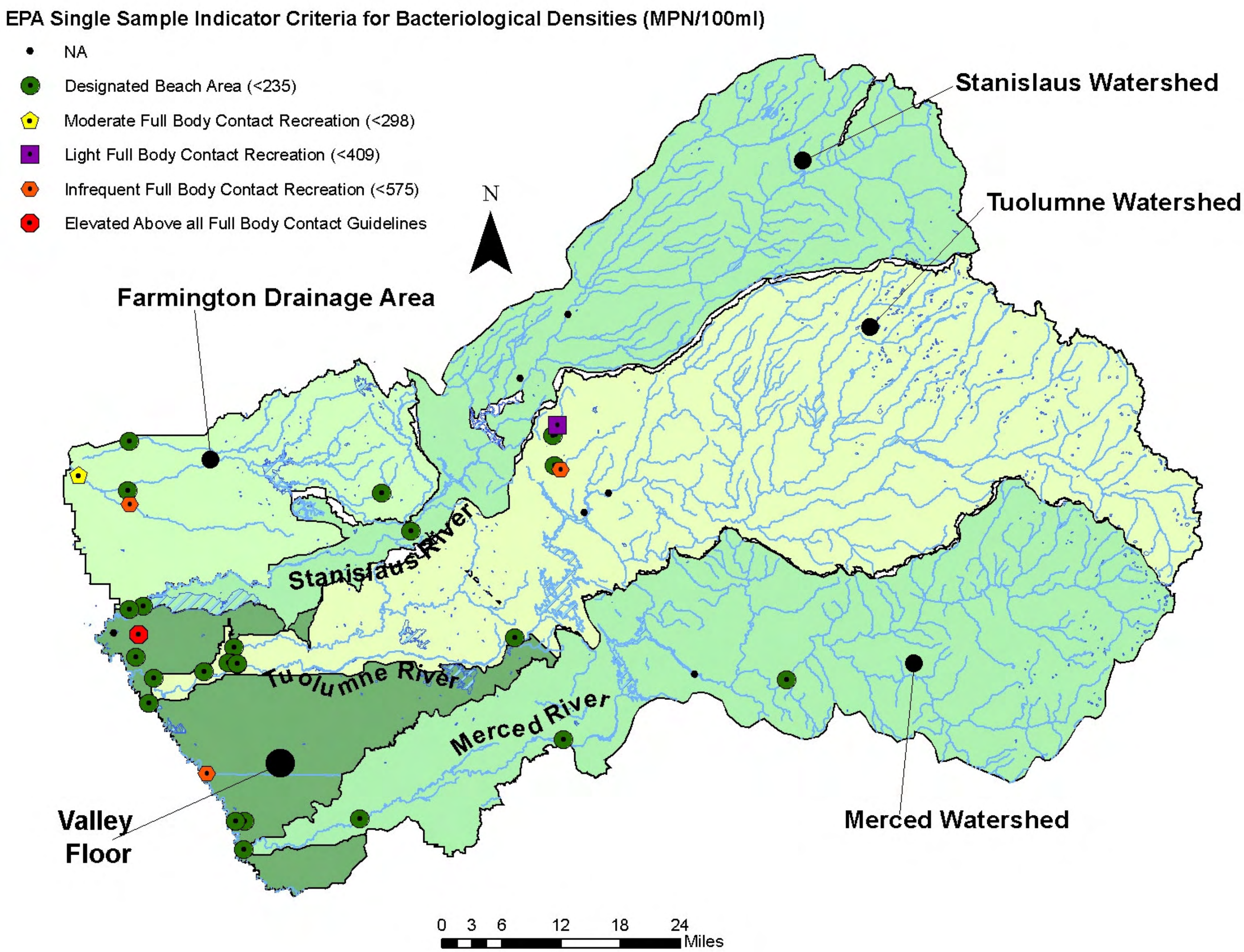
San Joaquin River Basin Rotational Sub-basin Monitoring:
Eastside Basin, January 2003 – April 2004
(Stanislaus, Tuolumne, and Merced River Watersheds and Farmington and Valley Floor Drainage Areas)

Figure 95 displays a spatial distribution of median ***E. coli*** concentrations in relation to the USEPA guidelines.

Median concentrations were generally within the acceptable level for swimming contact (<235 MPN/100ml). Exceptions included:

Site Description	USEPA Guideline Description	Site Median ***E. coli*** Concentration
French Camp Slough at Airport Way	Light Full Body Contact	397 MPN/100ml
Lone Tree Creek at Austin Road	Infrequent Full Body Contact	488 MPN/100ml
TID Harding Drain at Carpenter Road	Infrequent Full Body Contact	423 MPN/100ml
Curtis Creek at Algerine Road	Infrequent Full Body Contact	461 MPN/100ml
Woods Creek at Mother Lode Fairgrounds	Light Full Body Contact	365 MPN/100ml
MID Main Drain at Shoemake	Elevated Above All Acceptable Contact Guidelines	>2420 MPN/100ml

Figure 95. Recreation Beneficial Use Evaluation: Comparison of Bacteria Results Medians to Environmental Protection Agency *E. coli* (MPN/100ml) Guidelines for Contact Recreation



Overall Beneficial Use Summary

In summary, when data collected January 2003 – April 2004 in the Eastside Basin was compared to applicable water quality goals, targets, and objectives described in section 6.2, all watersheds had at least one potential beneficial use concern, as shown in Table 22. While Table 22 indicates that there are potential beneficial use concerns throughout the Eastside Basin, it should also be noted that in general, water quality met most objectives or goals.

Summary tables of potential concerns by watershed, beneficial use, and site are included in Appendix C5.

Table 22: Summary of Potential Beneficial Use Concerns: Eastside Basin (2003-2004)

	Sub-Basins				
Beneficial Use/Indicator	Farmington	Valley Floor	Stanislaus	Tuolumne	Merced
Drinking Water					
Specific Conductivity		NA			
Total Organic Carbon	X	NA		X	X
Trace Elements	arsenic	NA		cadmium	
E. coli	X	NA	X	X	X
Aquatic Life					
Water Column Toxicity	No Sample				
Temperature	X	X		X	X
Dissolved Oxygen	X	X			X
Trace Elements	copper	copper/zinc		copper	copper
pH	X	X		X	
Irrigation Water Supply					
Specific Conductivity		X			
Recreation (Swimming)					
E. coli	X	X		X	X

X = One or more result(s) above a goal or objective
NA = MUN designation does not apply to constructed conveyance and holding facilities.