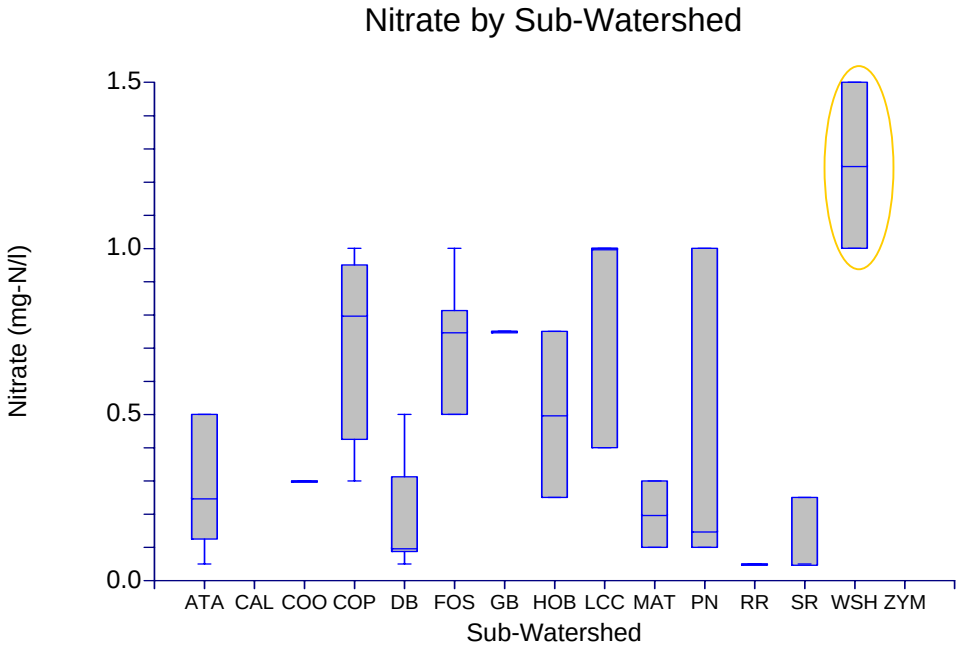
Appendix D

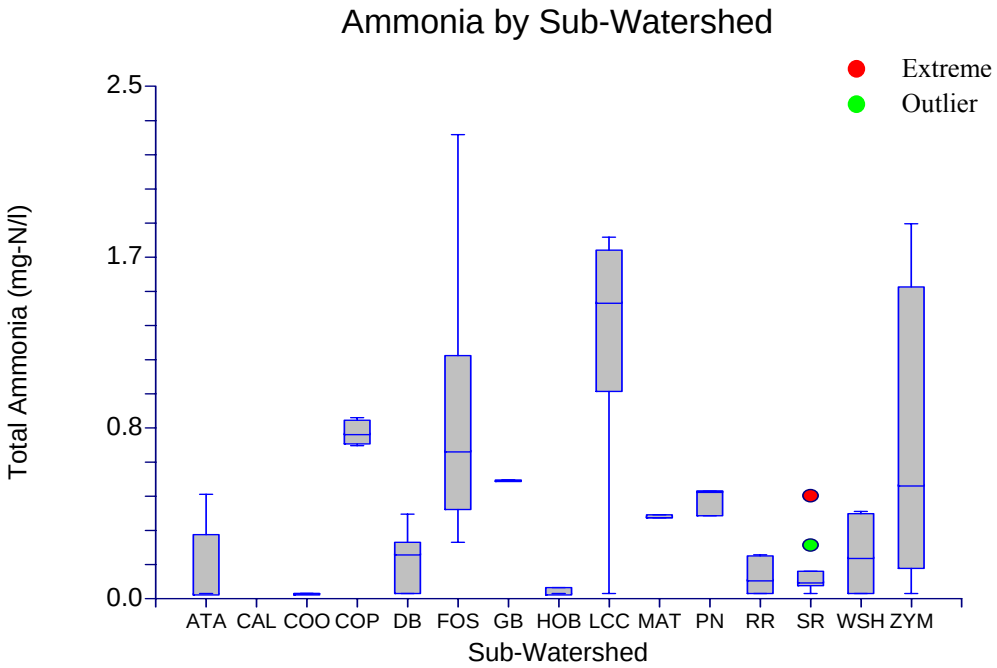
First Flush results graphics not presented in the First Flush report

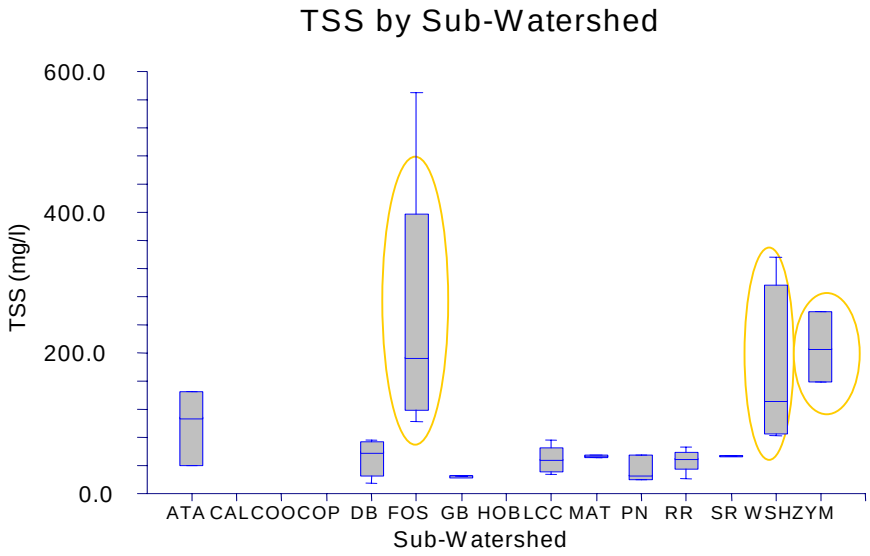
This appendix includes graphics not presented in the report, but pertinent to the First Flush effort. Results from the City of Santa Rosa's datasonde deployments and sample collection in the Laguna de Santa Rosa also are included.

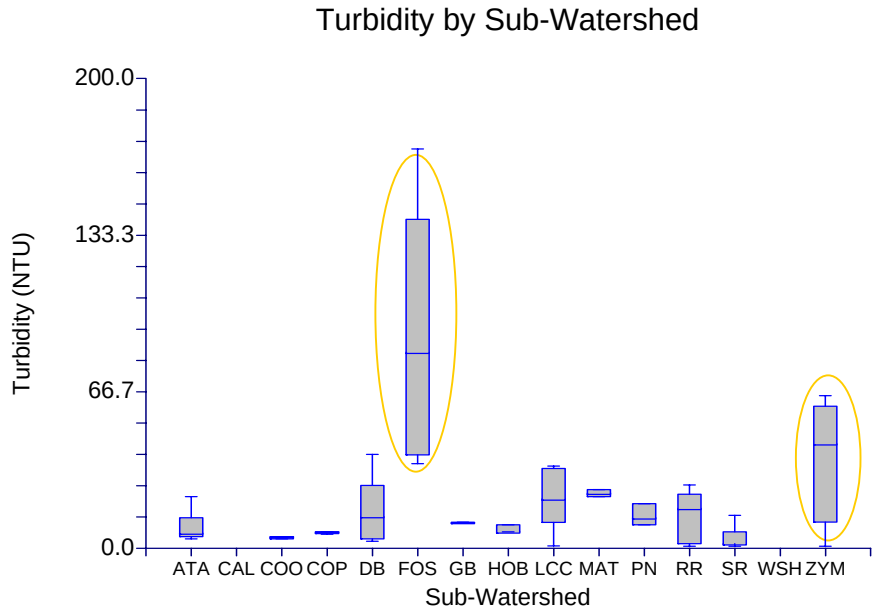
Box and Whisker Plots by Subwatershed

To compare the sub-watersheds to each other, we pooled all the result of a given parameter from each sub-watershed (including non-detects, for which we assigned a value of half the detection limit), and used a "box and whisker plot" to visualize how they relate to each other. The "box and whisker plot" shows the distribution of the data as a box (25th and 75th percentiles) with a median inside (50th percentile), and "whiskers" that reach from the 5th to the 95th percentiles. Outliers are indicated by dots outside the whiskers. Where the boxes overlap, there is likely little practical (and statistical) difference in concentrations. Where the boxes do not overlap, the opposite is the case. For example, Washoe Creek subwatershed stands out in terms of nitrate concentrations.



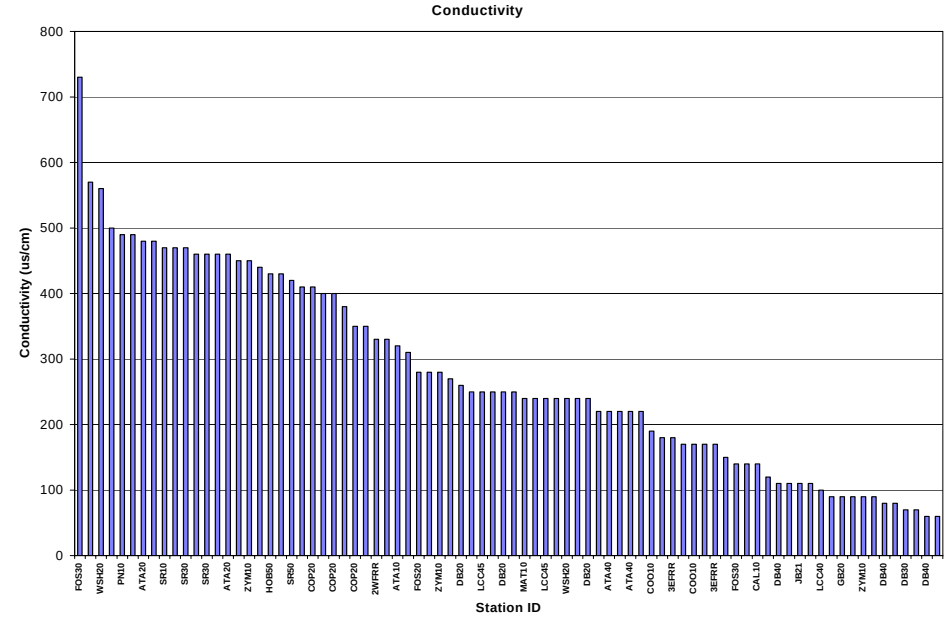


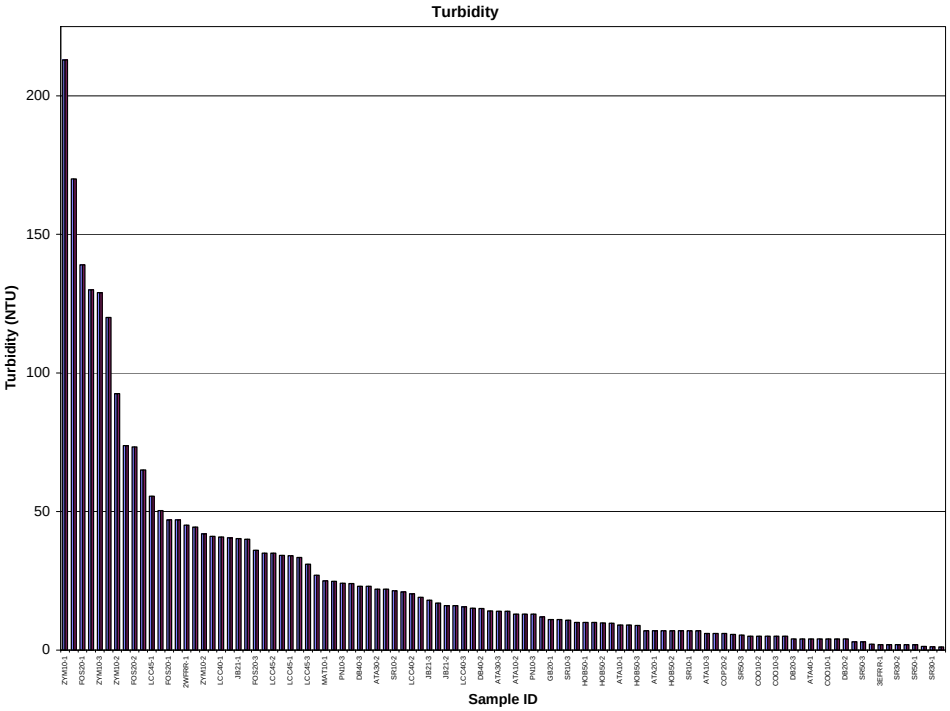

TSS by Sub-Watershed
600.0
400.0
200.0
0.0
TSS (mg/l)
ATA CAL COO COP DB FOS GB HOB LCC MAT PN RR SR WSH ZYM
Sub-Watershed

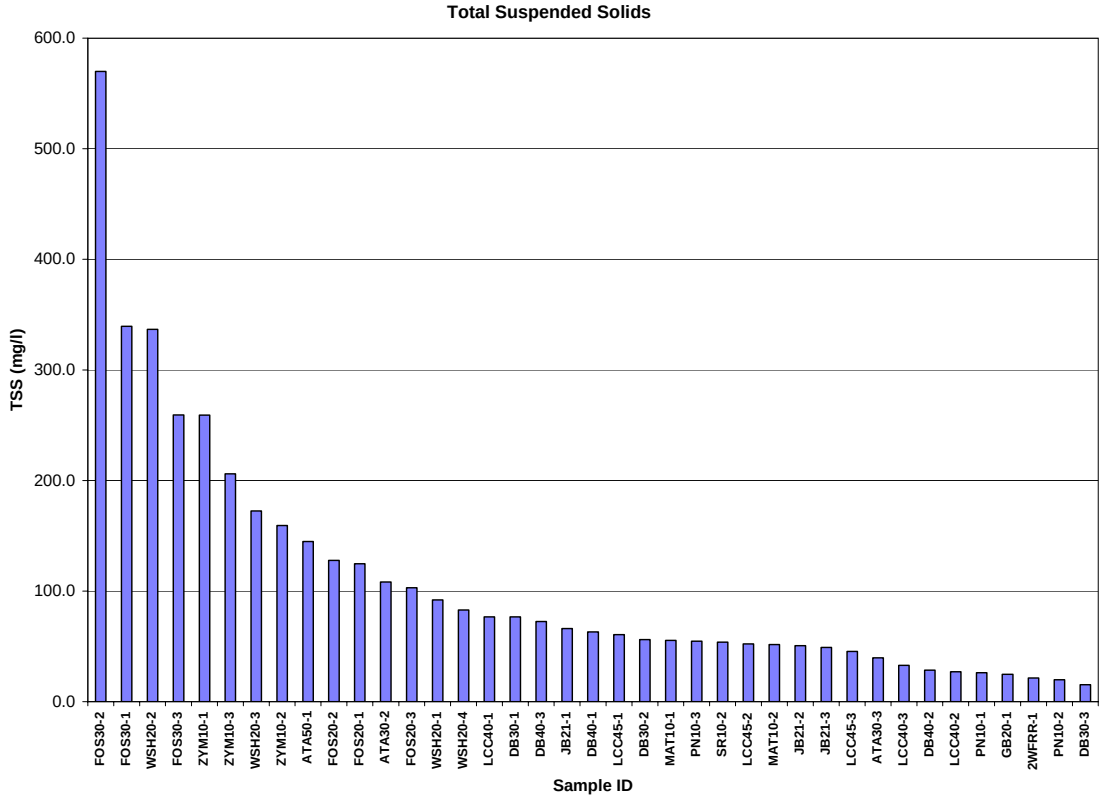

Turbidity by Sub-Watershed
200.0
133.3
66.7
0.0
Turbidity (NTU)
ATA CAL COO COP DB FOS GB HOB LCC MAT PN RR SR WSH ZYM
Sub-Watershed

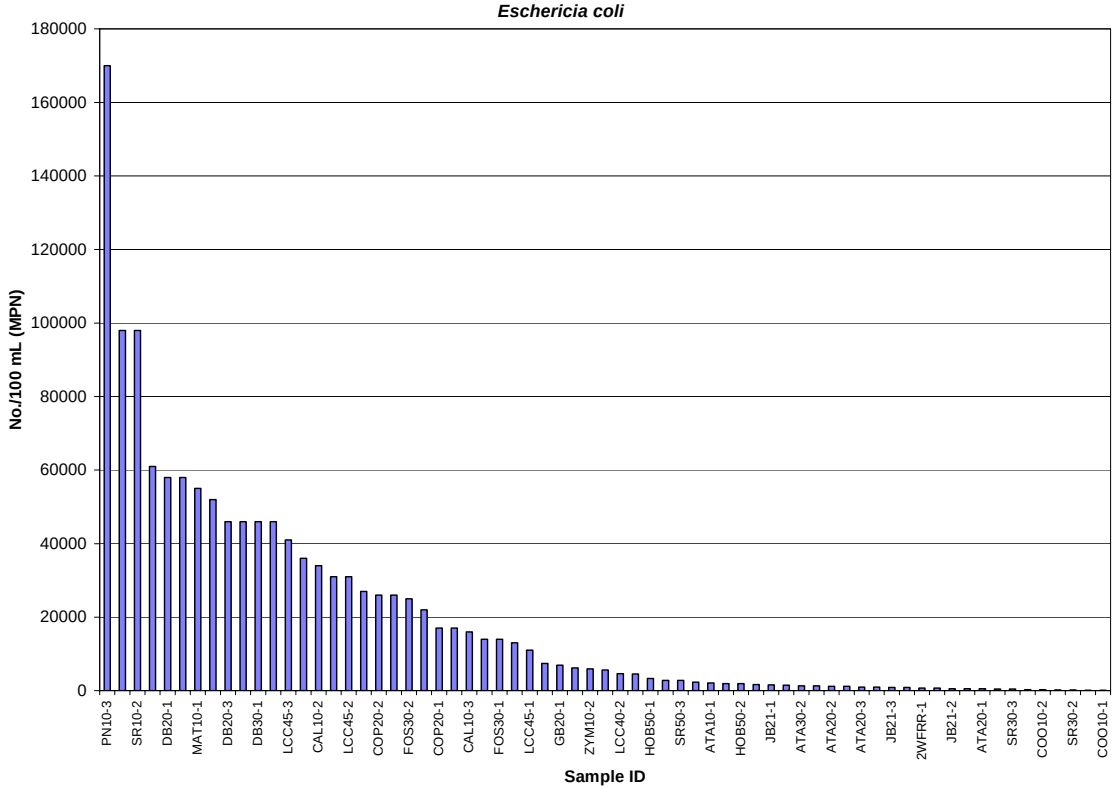
DATA RANKED BY CONSTITUENT

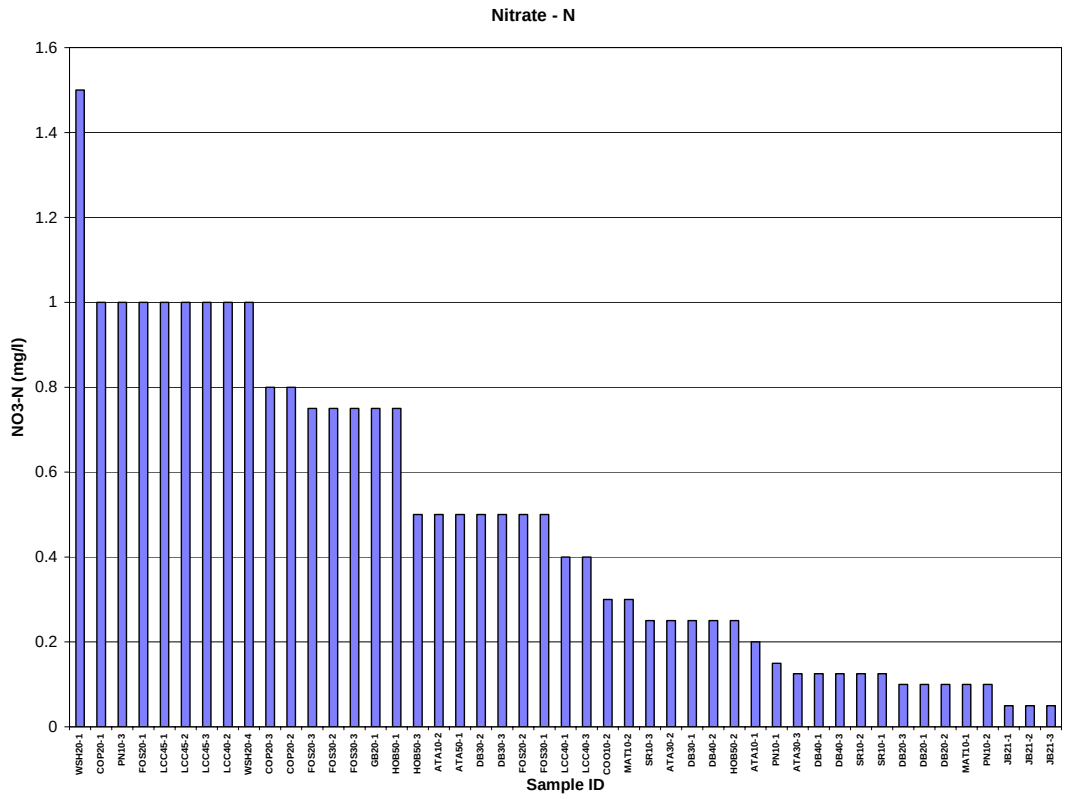
A first-cut examination of the data involves organizing the data points in order of highest to lowest and plotting as a bar graph. These figures display the concentrations of a constituent in all samples in which it was detected, and provide some insight into the distribution of the data. For example, the plot for conductivity is a rather uniform data array, with the sample at FOS30 standing out. However, the turbidity plot indicates a group of samples at a break point of 50 NTU (on the steep portion of the plot). There are a couple of break points in the plot of total suspended solids. These plots are provided for the reader to visually examine the distribution of the data.

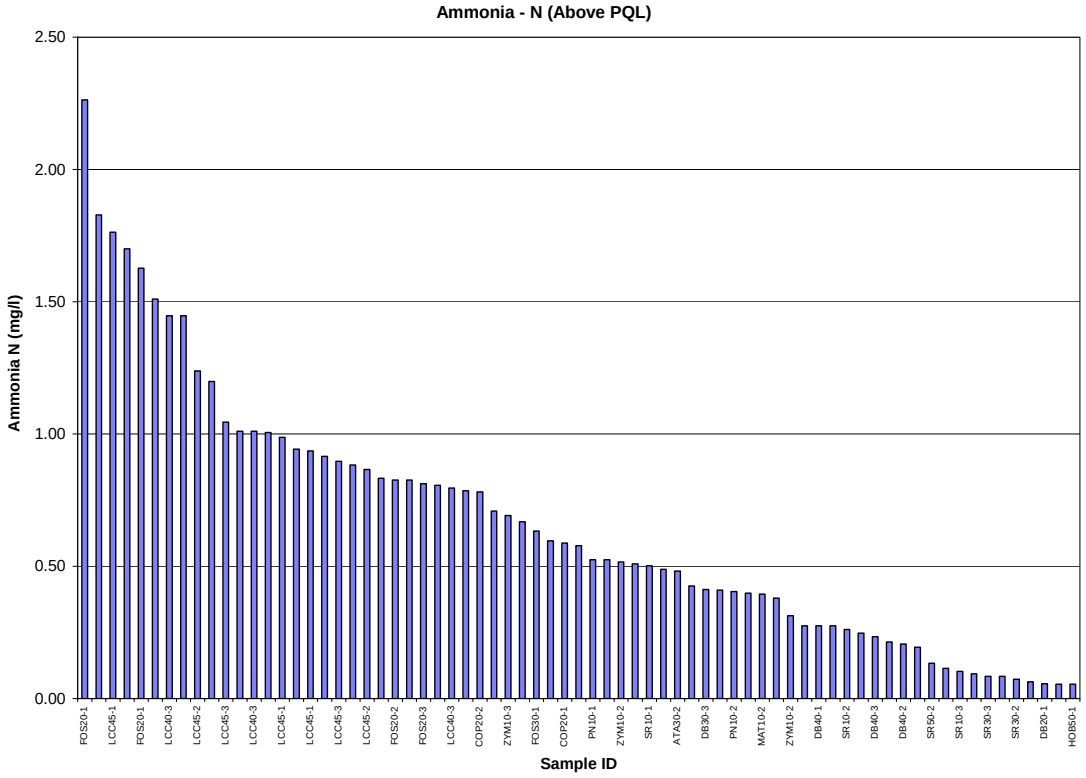


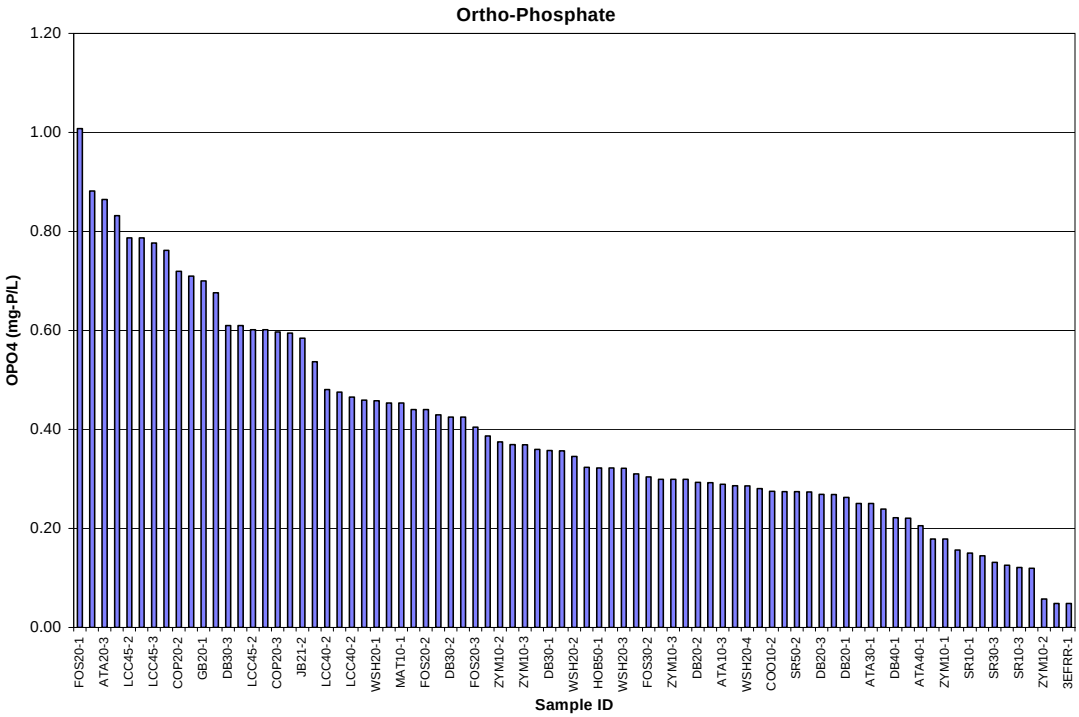



Total Suspended Solids
TSS (mg/l)
600.0
500.0
400.0
300.0
200.0
100.0
0.0
FOS30-2
FOS30-1
WSH20-2
FOS30-3
ZYM10-1
ZYM10-3
WSH20-3
ZYM10-2
ATA50-1
FOS20-2
FOS20-1
ATA30-2
FOS20-3
WSH20-1
WSH20-4
LCC40-1
DB30-1
DB40-3
JB21-1
DB40-1
LCC45-1
DB30-2
MAT10-1
PN10-3
SR10-2
LCC45-2
MAT10-2
JB21-2
JB21-3
LCC45-3
ATA30-3
LCC40-3
DB40-2
LCC40-2
PN10-1
GB20-1
2WFRR-1
PN10-2
DB30-3
Sample ID


Eschericia coli
No./100 mL (MPN)
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
PN10-3
SR10-2
DB20-1
MAT10-1
DB20-3
DB30-1
LCC45-3
CAL10-2
LCC45-2
COP20-2
FOS30-2
COP20-1
CAL10-3
FOS30-1
LCC45-1
GB20-1
ZYM10-2
LCC40-2
HOB50-1
SR50-3
ATA10-1
HOB50-2
JB21-1
ATA30-2
ATA20-2
ATA20-3
JB21-3
2WFRR-1
JB21-2
ATA20-1
SR30-3
COO10-2
SR30-2
COO10-1
Sample ID

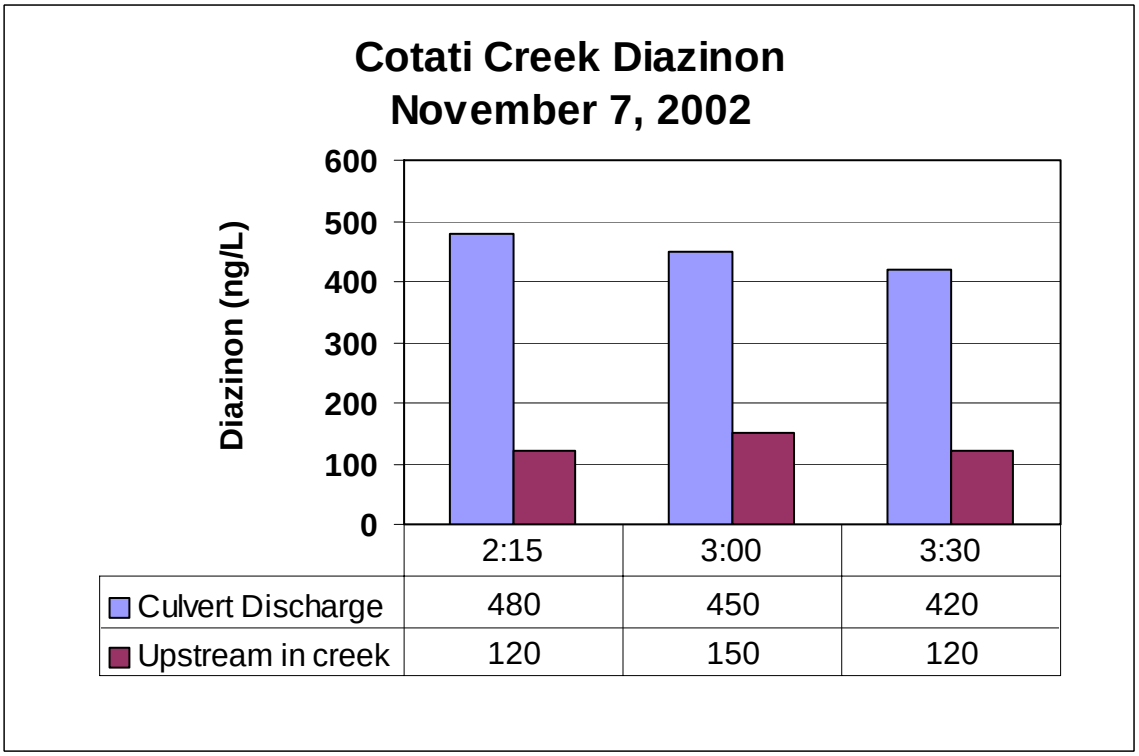

Nitrate - N
NO3-N (mg/l)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
WSH20-1 COP20-1 PN10-3 FOS20-1 LCC45-1 LCC45-2 LCC45-3 LCC40-2 WSH20-4 COP20-3 COP20-2 FOS20-3 FOS30-2 FOS30-3 GB20-1 HOB50-1 HOB50-3 ATA10-2 ATA50-1 DB30-2 DB30-3 FOS20-2 FOS30-1 LCC40-1 LCC40-3 COO10-2 MAT10-2 SR10-3 ATA30-2 DB30-1 DB40-2 HOB50-2 ATA10-1 PN10-1 ATA30-3 DB40-1 DB40-3 SR10-2 SR10-1 DB20-3 DB20-1 DB20-2 MAT10-1 PN10-2 JB21-1 JB21-2 JB21-3
Sample ID

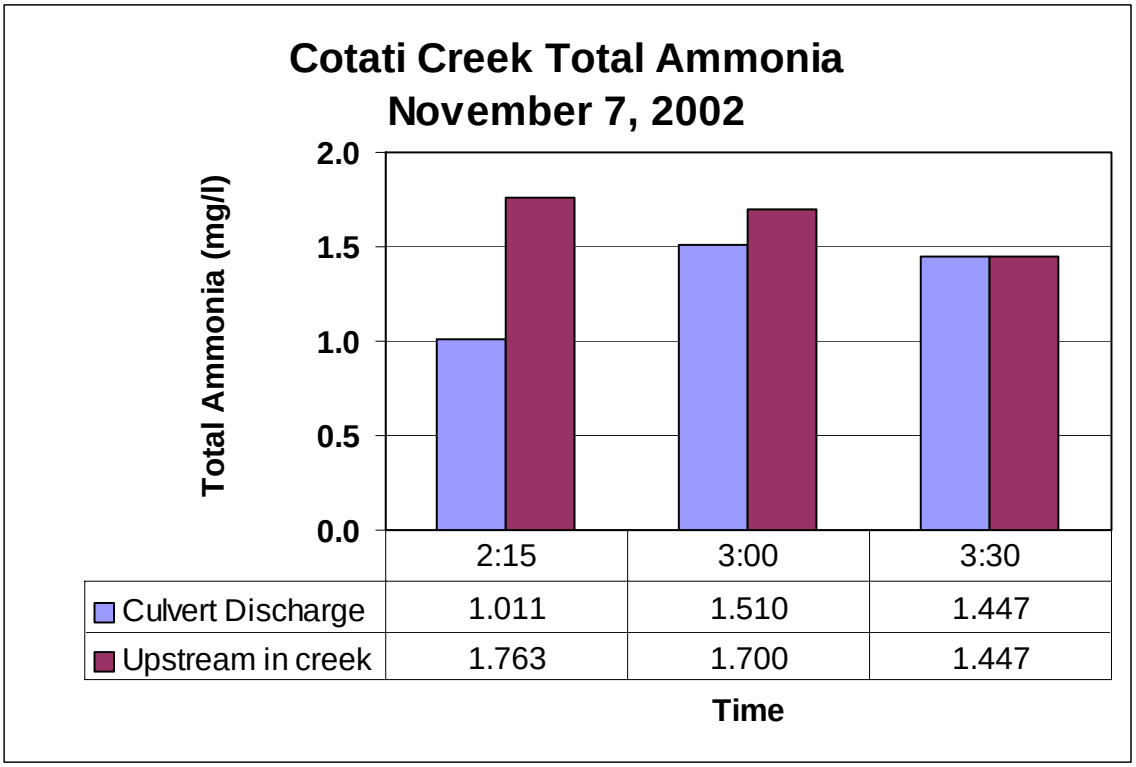

Ammonia - N (Above PQL)
Ammonia N (mg/l)
2.50
2.00
1.50
1.00
0.50
0.00
FOS20-1 LCC45-1 FOS20-1 LCC40-3 LCC45-2 LCC45-3 LCC40-3 LCC45-1 LCC45-1 LCC45-3 LCC45-2 FOS20-2 FOS20-3 LCC40-3 COP20-2 ZYM10-3 FOS30-1 COP20-1 PN10-1 ZYM10-2 SR10-1 ATA30-2 DB30-3 PN10-2 MAT10-2 ZYM10-2 DB40-1 SR10-2 DB40-3 DB40-2 SR50-2 SR10-3 SR30-3 SR30-2 DB20-1 HOB50-1
Sample ID

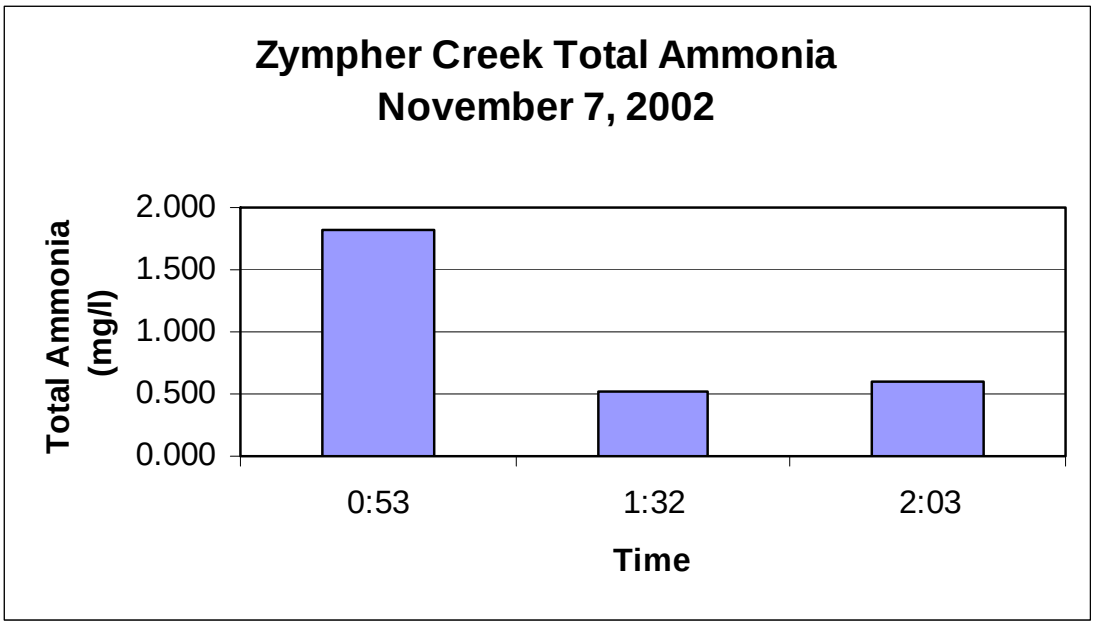

Ortho-Phosphate
OPO4 (mg-P/L)
1.20
1.00
0.80
0.60
0.40
0.20
0.00
FOS20-1
ATA20-3
LCC45-2
LCC45-3
COP20-2
GB20-1
DB30-3
LCC45-2
COP20-3
JB21-2
LCC40-2
LCC40-2
WSH20-1
MAT10-1
FOS20-2
DB30-2
FOS20-3
ZYM10-2
ZYM10-3
DB30-1
WSH20-2
HOB50-1
WSH20-3
FOS30-2
ZYM10-3
DB20-2
ATA10-3
WSH20-4
COO10-2
SR50-2
DB20-3
DB20-1
ATA30-1
DB40-1
ATA40-1
ZYM10-1
SR10-1
SR30-3
SR10-3
ZYM10-2
3EFRR-1
Sample ID

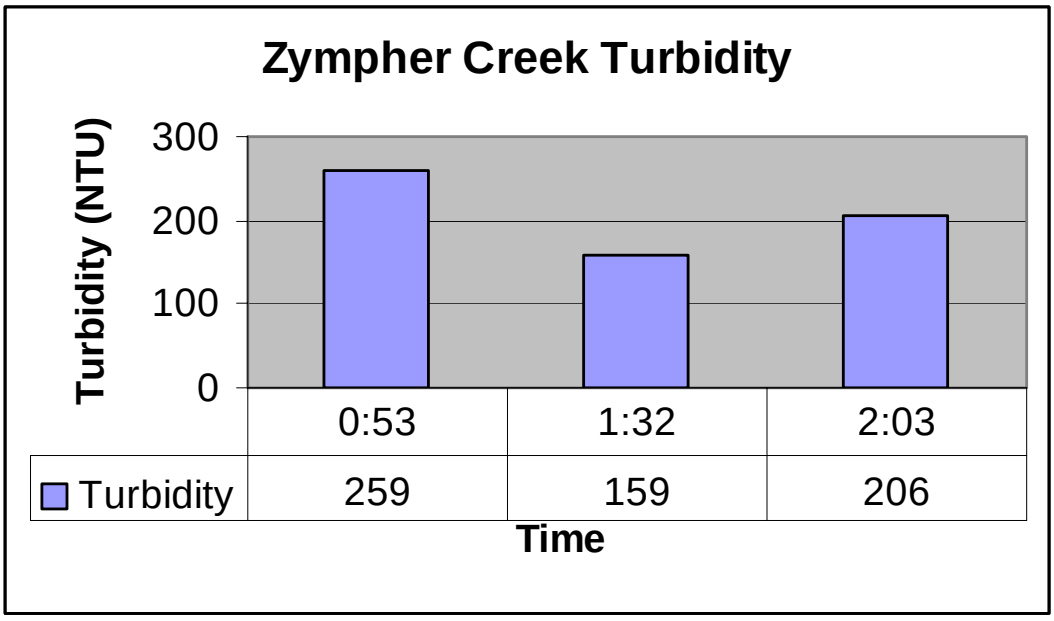
INDIVIDUAL STREAM PLOTS

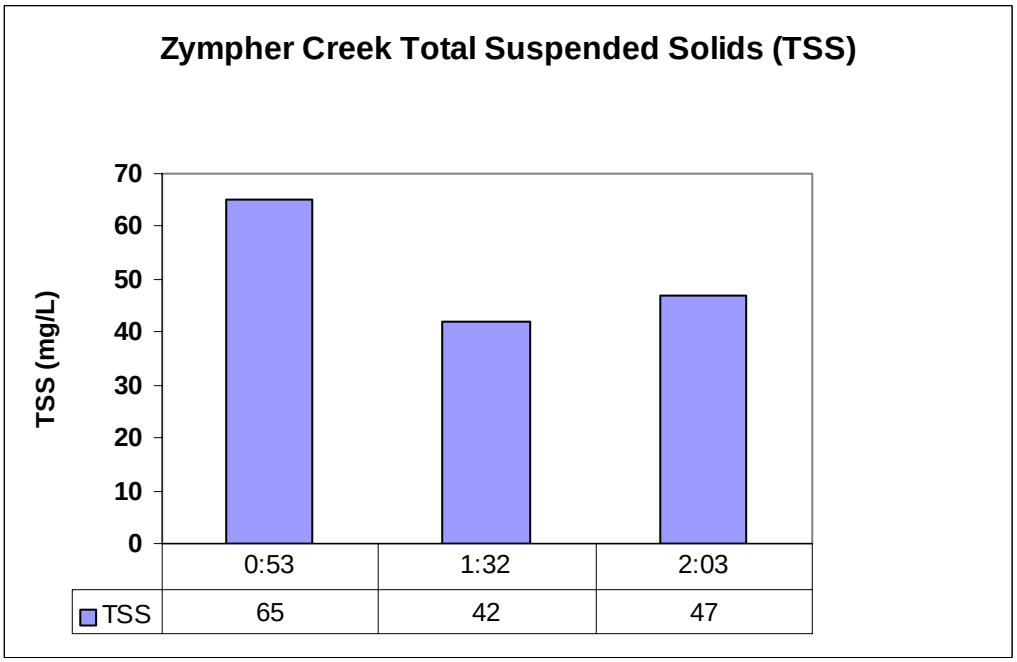
As data analysis leads one to a particular subwatershed or stream, plots of individual parameters for those streams help evaluate changes over time and between locations. In the examples below, we see a slight decrease in diazinon in the culvert samples, probably due to dilution from runoff from other areas. However, in the ammonia plot, we see ammonia increasing in the culvert discharge during the storm event (probably a source area), and decreasing in the stream, probably from dilution from runoff from other areas.

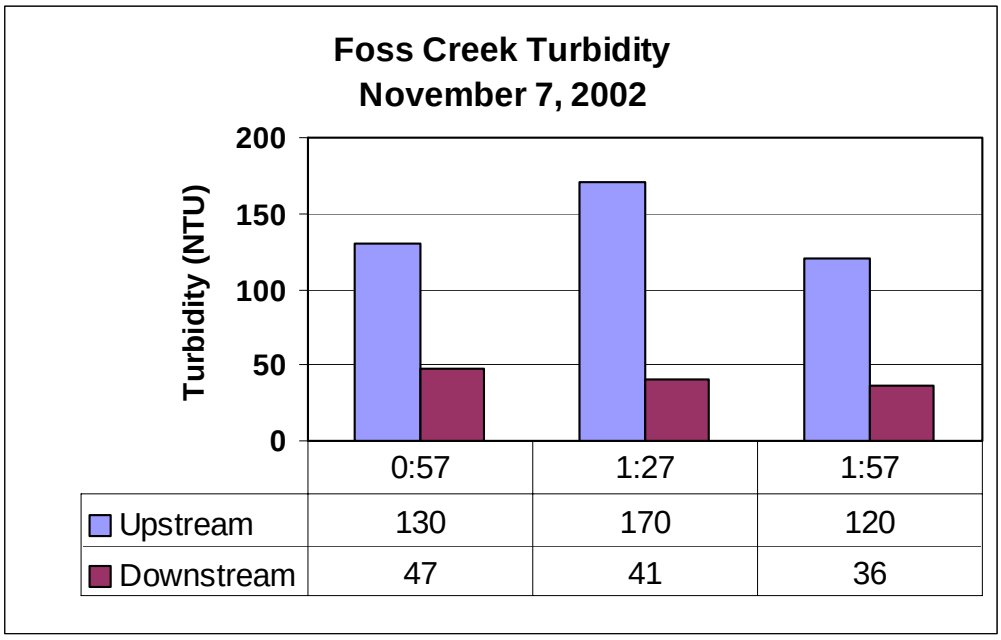





Zympher Creek Total Ammonia
November 7, 2002
Total Ammonia (mg/l)
2.000
1.500
1.000
0.500
0.000
0:53
1:32
2:03
Time


Zympher Creek Turbidity
Turbidity (NTU)
300
200
100
0
0:53
1:32
2:03
Turbidity
259
159
206
Time


Zympher Creek Total Suspended Solids (TSS)
TSS (mg/L)
70
60
50
40
30
20
10
0
0:53
1:32
2:03
TSS
65
42
47

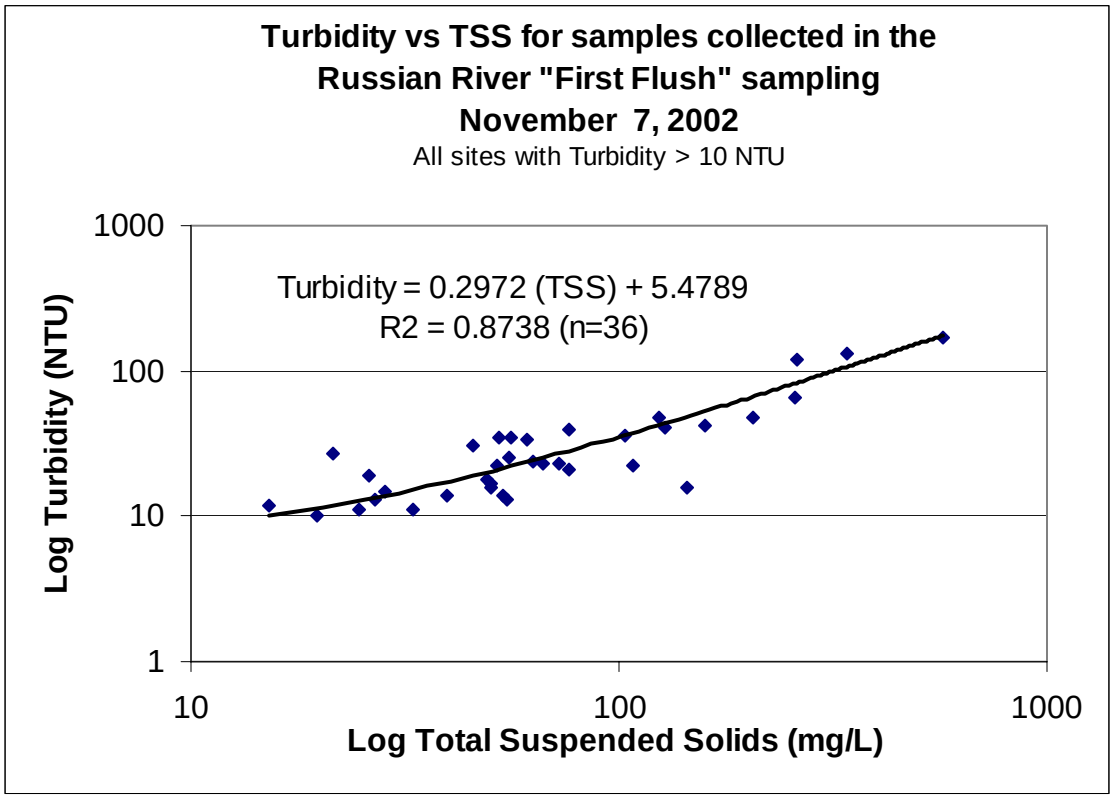

Foss Creek Turbidity
November 7, 2002
Turbidity (NTU)
200
150
100
50
0
0:57
1:27
1:57
Upstream
130
170
120
Downstream
47
41
36

TURBIDITY vs SUSPENDED SOLIDS RELATIONSHIP

Turbidity and suspended solids often correlate well during storm flow events: as suspended solids concentrations rise, so do turbidity values. A good relationship can be used as a predictive tool, using the much easier turbidity measurement to estimate suspended solids. This relationship should be applied on a watershed basis, based on geology and soils.

However, for purposes of illustrating the general relationship, we plotted turbidity measurements against total suspended solids for all "first flush" samples which had a turbidity of more than 10 NTU. The following plot shows that relationship.

Note: For predictive purposes the "X" and "Y" data would be switched, so the equation would read "TSS = b (turbidity) + a."



LAGUNA DE SANTA ROSA SAMPLING BY THE CITY OF SANTA ROSA

The City of Santa Rosa collected water quantity and quality data from two sites on the Laguna de Santa Rosa, and one site in Mark West Creek: the Laguna at Stony Point Road and Occidental Road, and Mark West Creek at Trenton-Healdsburg Road. Continuous data (every 15 minutes) from noon on November 6 to noon on November 13, 2002, were collected for dissolved oxygen (DO), specific conductance (SC), pH, and water temperature. Stream stage height also was measured continuously at the TH site. Additionally, the City of Santa Rosa collected "first flush" samples (pesticides, nutrients, solids, and coliform bacteria) three times at the TH site. Summaries of the data follow:

Trenton-Healdsburg Road

The hydrograph (stage height over time) showed three flow peaks during the period of November 6-13. All "first flush" samples were collected on the descending limb of the first peak, from 1205 to 1305.

Conductance, pH, and dissolved oxygen decreased after the first peak, and as the second, larger flow peak developed. The pH dropped about 0.5 units from the pre-storm range of 7.8 to 8.0. Conductance and dissolved oxygen were more dramatic, with conductance dropping from a pre-storm range of 500-510 umho/cm to a low of 216, then leveling off at 250-300 before rising again.

Dissolved oxygen dropped to near 0 mg/L throughout the period from a pre-storm level of 7.3-8.0 mg/L.

Water temperature rose from 10 C to about 15 C during that same time, then oscillated between 14 and 15 C as the flow dropped off and leveled.

Turbidity followed the hydrograph, reaching a high of 95 NTU during the main flow peak.

First flush samples for bacteria, nutrients, solids, organic carbon, and diazinon expressed some relationships over the one-hour sampling period (Table D-1). Total phosphorus increased then decreased. Phosphorus tends to bind to soil particles, however the suspended solids results showed an inverse relationship, decreasing then increasing.

Table D-1. City of Santa Rosa water quality results for the three grab samples on November 7, 2002, Laguna de Santa Rosa at Trenton-Healdsburg Road.

	Sample Time			
Measured Parameter	**12:05**	**12:35**	**13:05**	**Units**
Specific Conductance	499	495	496	umho/cm
pH	7.8	7.8	7.8	Std. units
Water Temperature	11.6	11.7	11.8	^{o} C
Ammonia Nitrogen	0.88	0.9	0.9	mg-N/L
Ortho Phosphate	0.44	0.42	0.44	mg-P/L
Nitrate Nitrogen	0.8	0.8	0.8	mg-N/L
Turbidity	19	18	21	NTU
Total Suspended Solids	76	48	58	mg/L
E. coli	≥1600	≥1600	≥1600	MPN/100 ml
Total Coliform	≥16000	16000	16000	MPN/100 ml
Diazinon by ELISA	140	120	120	ng/L
Diazinon by EPA 8141	100	90	70	ng/L
Dissolved Oxygen	6.8	6.8	6.7	mg/L
Total Phosphorus	0.51	1.58	0.54	mg-P/L
Total Organic Carbon	22	19	19	mg C/L
Fecal Coliform	≥16000	≥16000	≥16000	MPN/100 ml

Diazinon, ortho phosphate, ammonia, nitrate, and organic carbon varied little among sample times. The bacterial counts were high for all three tests and all three sample times. Ammonia concentrations were below the USEPA recommended maximum 1-hour concentration to protect aquatic organisms from acute exposures (8.11 mg-N/L at pH 7.8).

Occidental Road

While we do not have good hydrograph data for this site, we have water depth as recorded by the data logger that provides us with an idea of the depth changes for the November 6-13 period. The pH, conductance, and dissolved oxygen all increased slightly as the flows came up, then decreased dramatically about mid-way up the hydrograph (as flow increased to a peak). Those values then peaked as flow neared its highest value for the period, and dropped dramatically again at the peak flow, and stayed lower through the period.

Water temperatures rose from 12 C steadily through the period, oscillating between 14.5 and 15.2 C by the third day (November 10). Turbidity oscillated between 35 and 45 NTU, creeping higher as the flows peaked, then dropping dramatically to less than 10 NTU after the peak flow passed. No chemical measurements were obtained for this site.

Stony Point Road

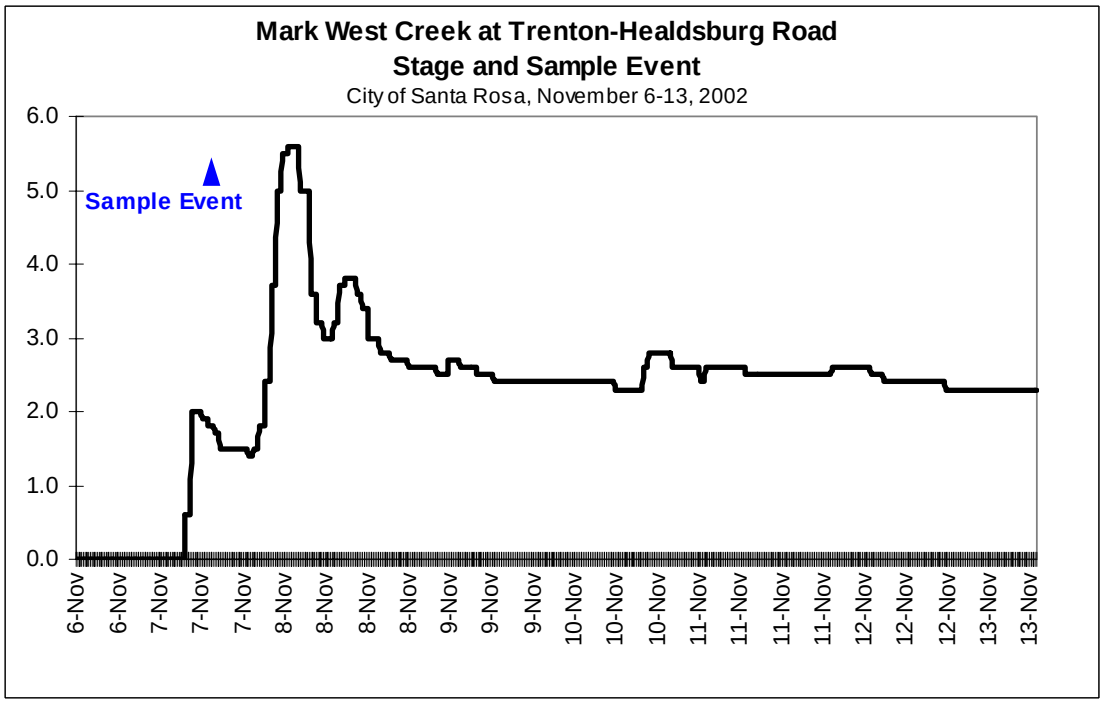
We have sampler depth for this site, as well, which gives us a rough hydrograph for the November 6-13 period. The pH dropped slightly through the period, while conductance dropped from 950-1000 umho/cm to under 200 umho/cm. Conductance peaked to 800 umho/cm for a short period at the height of the flow, returning under 200 umho/cm before slowly rising during the rest of the period.

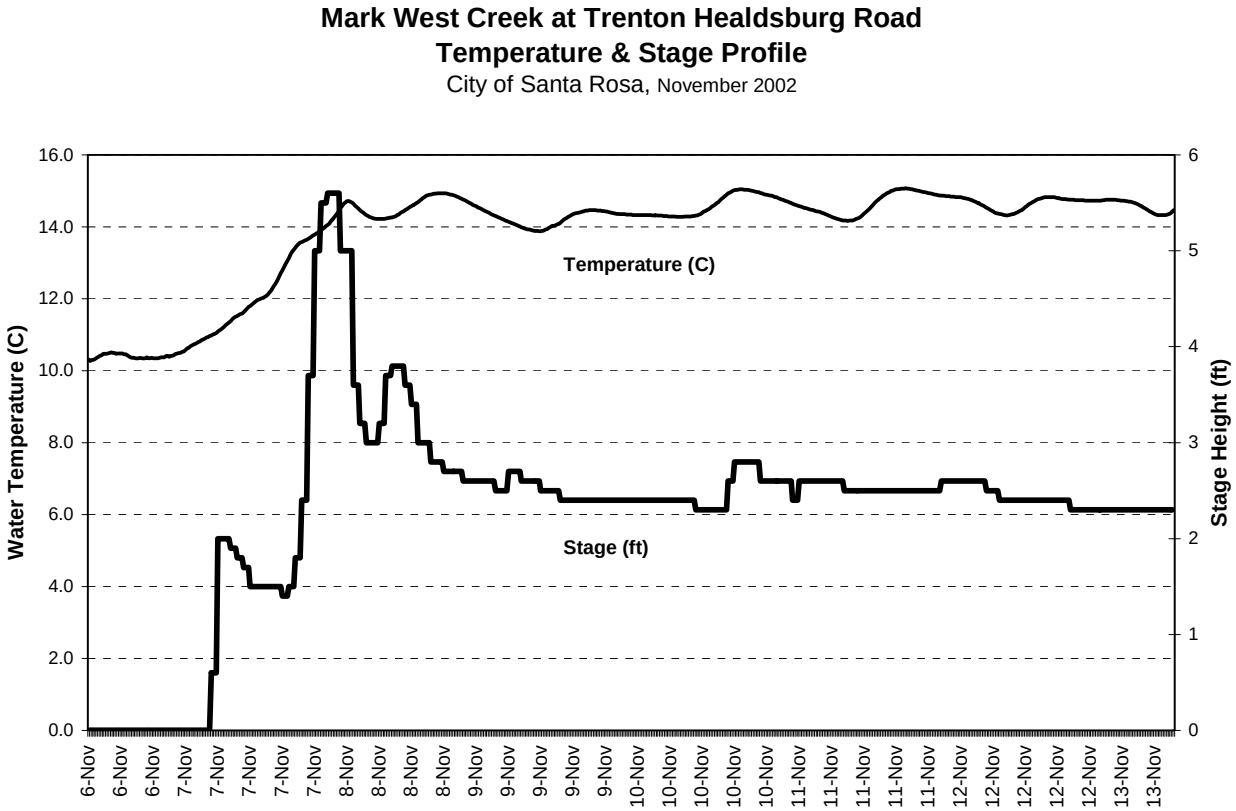
Dissolved oxygen dropped before the hydrograph peaked, going from 7-8 mg/L to near 0 mg/L. A couple of peaks were observed during the higher flows, then dissolved oxygen dropped to near 0 mg/l before beginning a slow rise late on November 11.

Turbidity increased from a pre-storm level of 5-20 NTU to over 90 NTU at the peak of the flow event. Turbidity decreased as the storm flows decreased, returning to a range of 10-20 NTU.

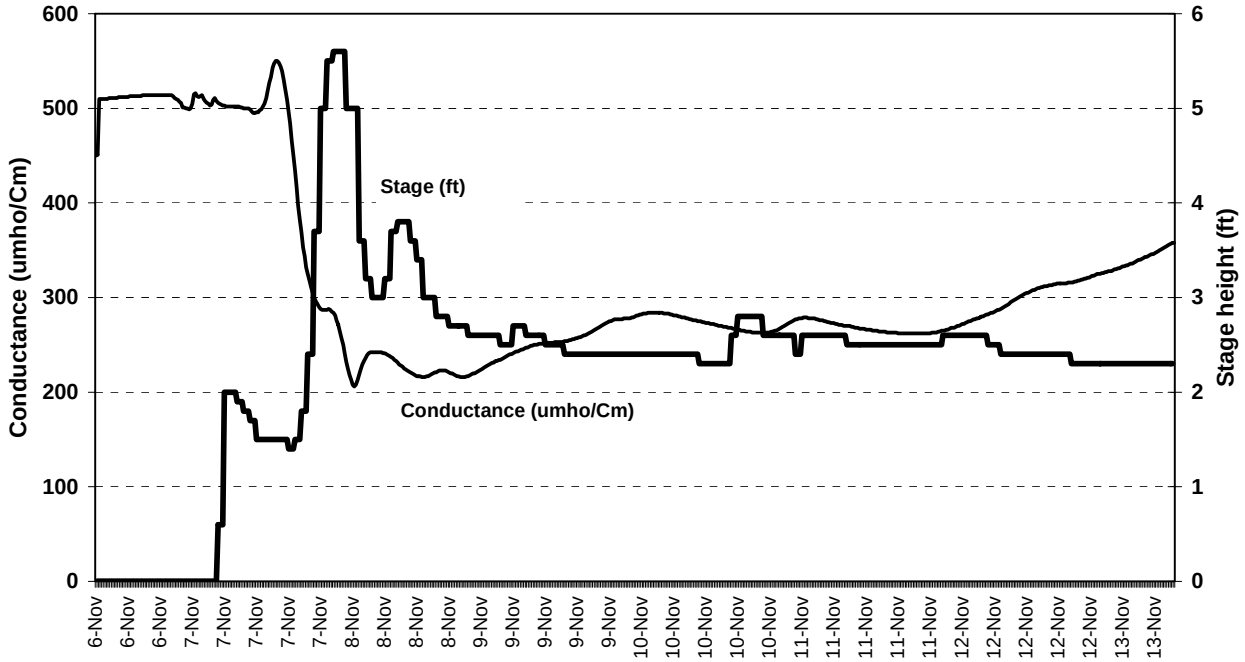
Data plots for these observations are presented on the following pages, beginning with the Laguna at Trenton-Healdsburg Road.

The **Laguna at Trenton-Healdsburg Road** datasonde collected data at fifteen-minute intervals from noon on Nov 6 to noon on Nov 13, 2002. Grab samples were collected at 12:02 p.m., 12:35 p.m., and 1:05 p.m. The plot below includes the stage height and the timing of the grab samples on that hydrograph.

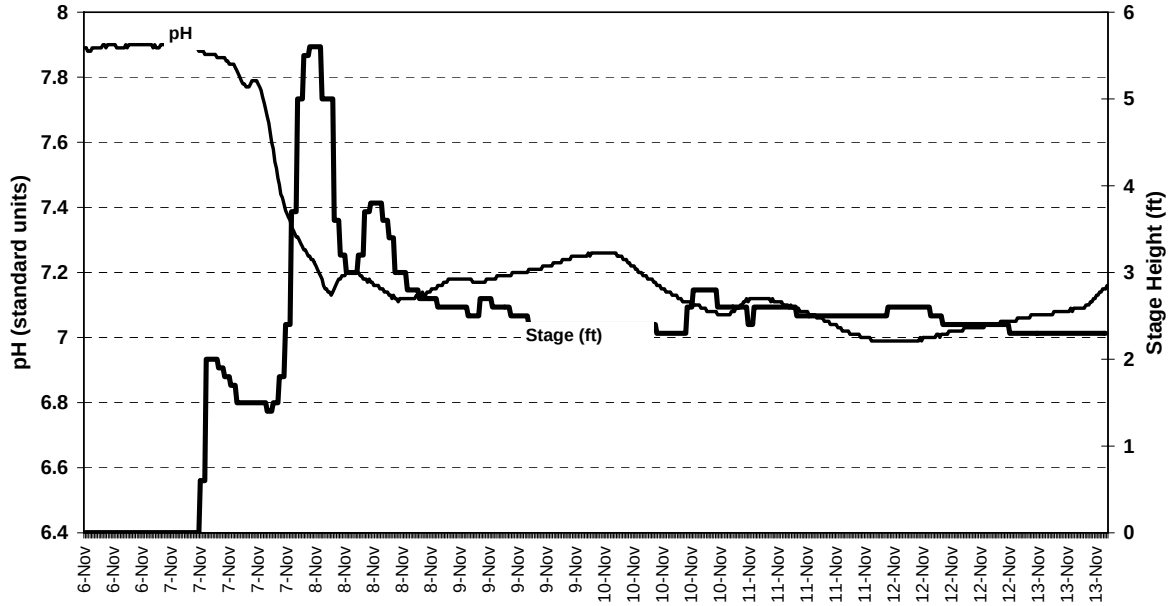




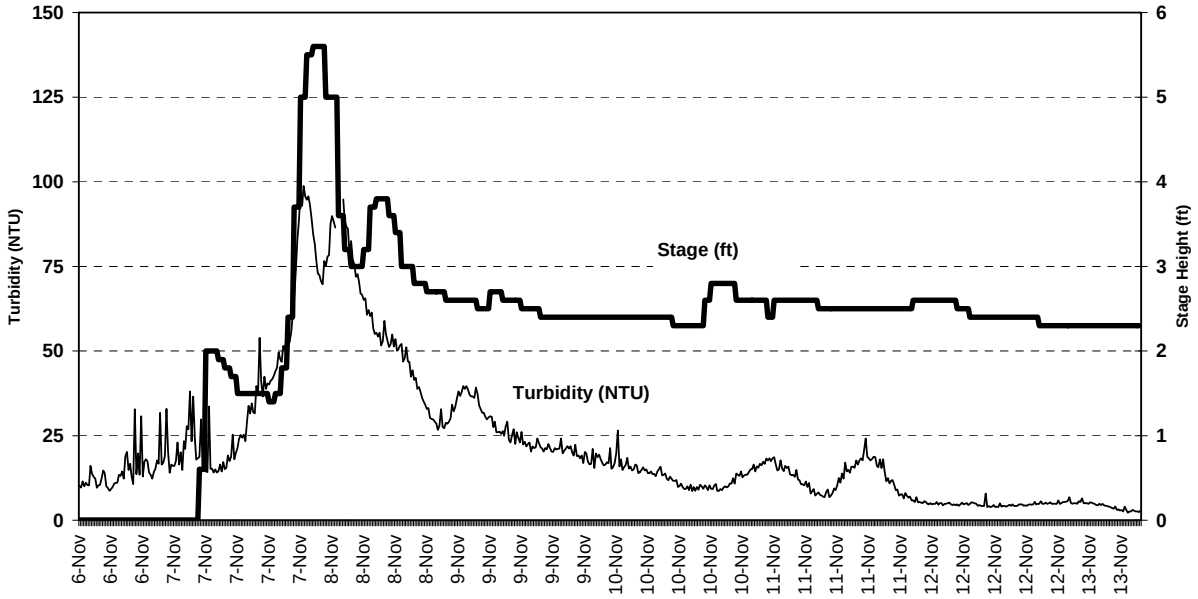
Mark West Creek at Trenton Healdsburg Road
Conductivity & Stage Profile
City of Santa Rosa, November 2002



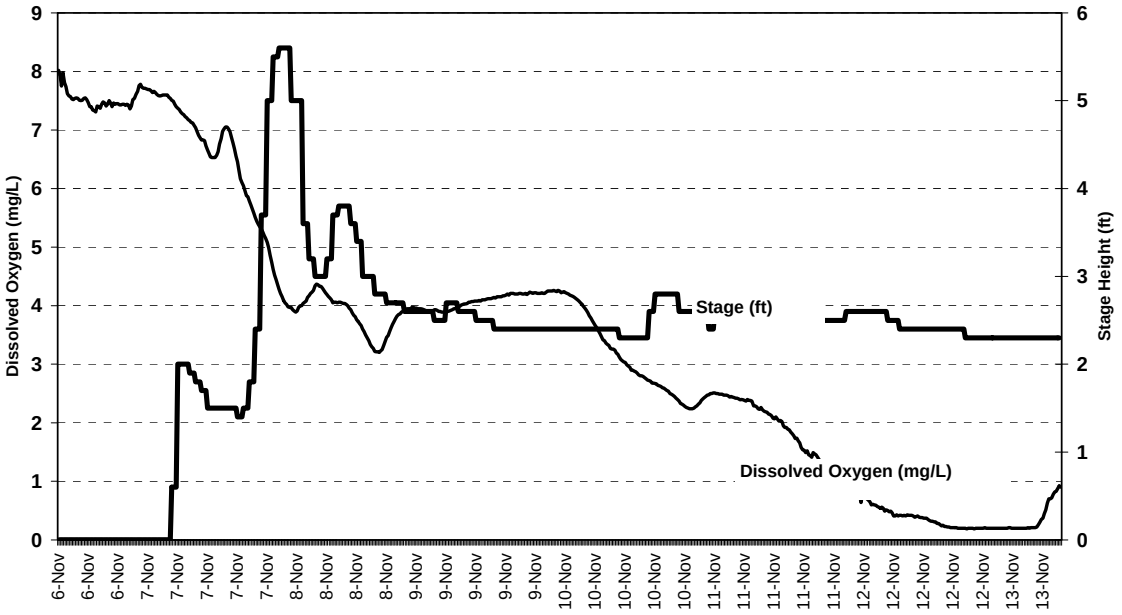
Mark West Creek at Trenton Healdsburg Road
pH & Stage Profile
City of Santa Rosa, November 2002



Mark West Creek at Trenton Healdsburg Road
Turbidity & Flow Profile
City of Santa Rosa, November 2002

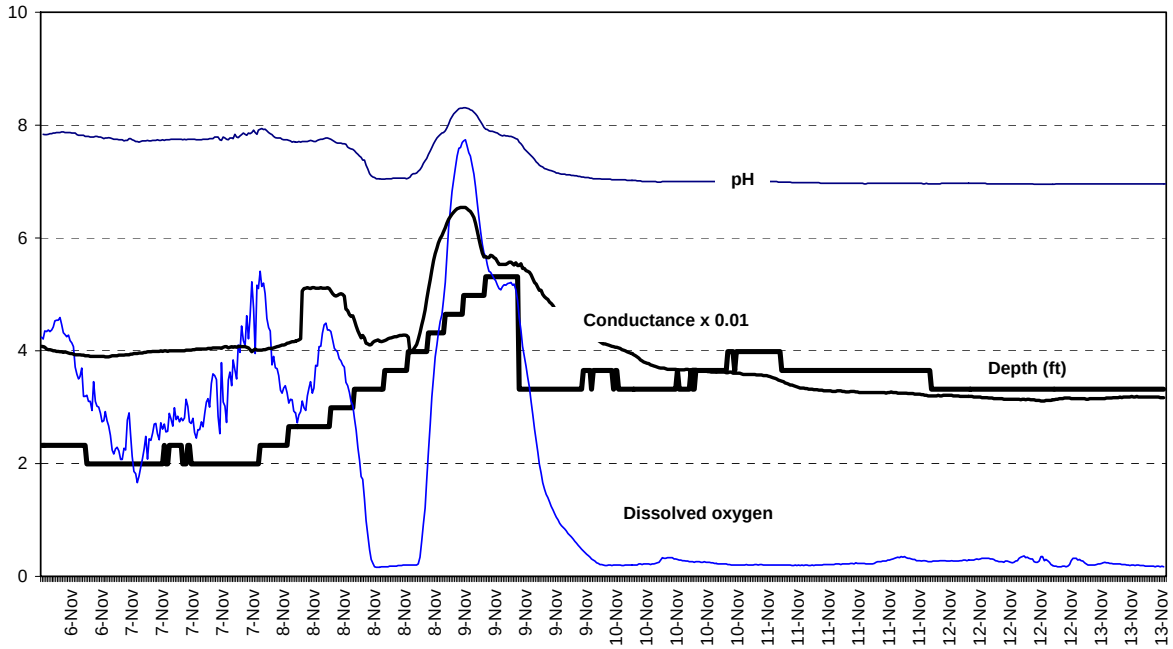


Mark West Creek at Trenton Healdsburg Road
Dissolved Oxygen & Stage Profile
City of Santa Rosa, November 2002

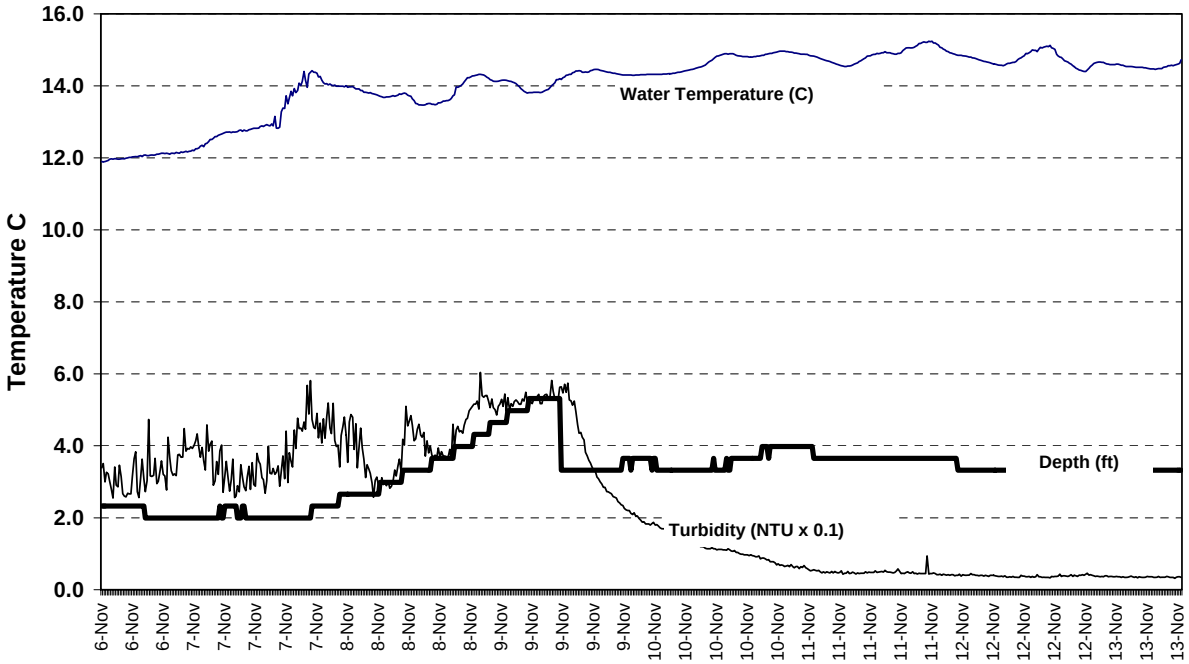


The **Laguna at Occidental Road** datasonde collected data at fifteen-minute intervals from 1:15 p.m. on Nov 6 to noon on Nov 13, 2002.

Laguna de Santa Rosa at Occidental Road
pH, Conductance, Dissolved Oxygen, Depth
City of Santa Rosa, November 2002



Laguna de Santa Rosa at Occidental Road
Temperature, Turbidity, and Depth
City of Santa Rosa, November 2002



The **Laguna at Stony Point Road** datasonde collected data at fifteen-minute intervals from 12:15 p.m. on Nov 6 to noon on Nov 13, 2002.