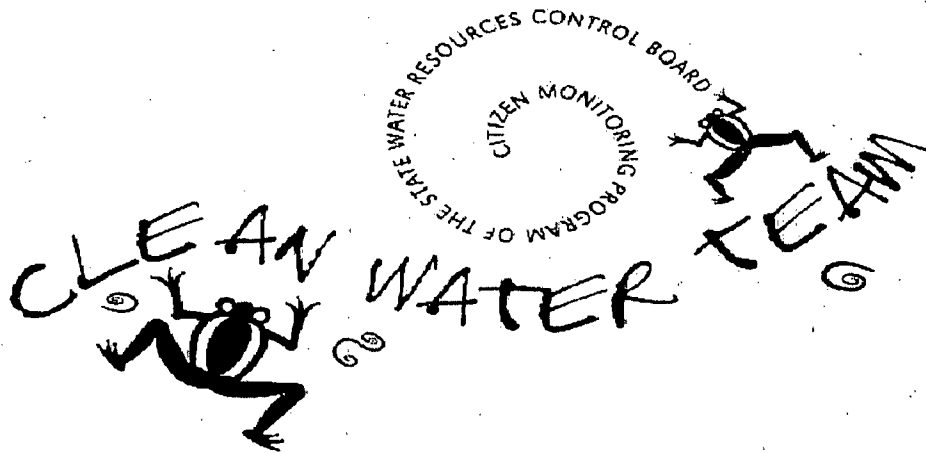


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Russian River First Flush Summary Report

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RK 4/4/03

DISCLAIMER

The data contained in this report has been collected by citizen volunteers or generated from samples collected by volunteers. The results that are reported have been measured and documented in good faith and to the best of the volunteers' abilities. Nothing in this report should be used to the detriment of the volunteer/property owner, their property, or the program in which they are involved. It should also be understood that volunteers collect information voluntarily and there are limitations on the use of their data. Data can serve as a preliminary source of information only to be followed up, when necessary, with more formal types of monitoring.

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1.0 Introduction

Volunteer monitoring has become an integral part of the effort to assess the health of our nation's waters. It promotes stewardship of local waters, and provides an educational tool to teach citizens about the importance of environmental quality. In addition, government agencies have found that properly run volunteer programs can provide high quality information to supplement their own monitoring programs.

On November 7th 2002, over 100 citizen monitors conducted field measurements and collected water samples at multiple locations within the Russian River (RR) Watershed during the first runoff event of the rainy season. It was the local watershed groups that made it happen, led by the dedicated Volunteer Coordinator who worked with members of the Russian River Watershed Council, Resource Conservation Districts, volunteers from Cities and other local agencies, and many citizen groups. The idea sprang up a few months earlier when the Scientific Coordinator, a Clean Water Team member and a First-Flush 'pro', talked with folks at the Regional Water Quality Control Board and heard a wish to collect First Flush (FF) samples in this watershed.

The Russian River First Flush (RRFF) monitoring was intended to characterize the runoff in different parts of the watershed and identify sources of potential pollutants (Please note that stormwater 'constituents' such as ammonia, metals, or sediments are not considered 'pollutants' if it has not been shown that they cause a problem, as in "innocent until proven guilty"). In other words, the objective of sampling at multiple tributaries was to gather information from the various drainages and develop some perspective on the occurrences of the major constituents. Information gleaned from this characterization effort can help citizens, local agencies, and regulators prioritize future management options. Although limited in geographical coverage, the event provided an opportunity to pose some specific questions, such as:

- Where in the RR watershed does the first rain event of the season yield runoff?
- What are the highest concentrations of stormwater constituents in urban areas in the RR watershed?
- Are there sources of diazinon in the RR watershed?
- Are the E.coli counts during First Flush in the RR watershed at the same order of magnitude as the First Flush counts in other watersheds?

A unique partnership between citizen groups, academia, and public agencies – local, State, and Federal - was established to accomplish data collection. The citizen coordinators in charge of field activities conducted an outreach campaign, recruited more than 100 citizens, arranged training sessions and transfers of equipment & samples, and constructed a phone tree to spread the rain alerts among participating field crews. Citizens also participated in lab analyses and data entry, working shoulder to shoulder with agency staff. The Regional Citizen Monitoring Coordinator of the Clean Water Team (the Citizen Monitoring Program of the State Water Resources Control Board) provided technical support, training, in-house nutrient analysis guidance, laboratory liaison, and data quality management tools/guidance. Folks from Sonoma State University, Sotoyome Resource Conservation District, and UC Cooperative Extension

helped with hydrological information, station selection, and weather watch. North Coast Regional Water Quality Control Board (RB1) staff and interns provided technical input, in-house lab space, in-house lab management and analytical support, and budget for metal analysis. EPA Region IX staff lent monitoring equipment to the effort and provided lab analyses of bacteria and pesticides, and the City of Santa Rosa contributed analytical budget for pesticide confirmation testing.

This unique combination of community outreach and technical support contributed to the success of the event in its dual achievements: water pollution awareness, and good data. In other words, word got out into the community regarding how our daily activities may be sources of constituents, and the technical effort yielded reliable data of known quality.

2.0 Study plan and logistics

In semi-arid, Mediterranean climate zones where summers are dry and rain falls only in winter, the term 'First Flush' is often used to describe the stormwater runoff that flows into creeks after the first rain of the winter has washed the landscape. Research has shown that this First Flush runoff is often laced with constituents that have accumulated over the land during summer, and thus represents 'the worst case scenario' in terms of storm water pollution in many cases. RRFF study plan was constructed to capture these 'worst case scenario' conditions in order to learn about the severity of pollution problems in the watershed.

2.1 Study Intent, Sampling Design, and Power: Theory and practice.

A Monitoring Plan includes elements that communicate the "why, what, where, when, how, and who" of the study. The term 'study intent' as used here refers to the 'why monitor' part of the plan, and basically implies "what do we want to know?". RRFF study plan was geared towards two major questions: Are there hot spots (i.e., the intent is characterization), and where are they (i.e., the intent is source ID).

The term 'sampling design' is used here in the narrow sense, meaning the approach used to deliberately select timing and locations for sampling (Please note that here the word 'sampling' includes both field measurement and sample collection). We chose the 'deterministic', i.e., knowledge-based approach, rather than the 'probabilistic' i.e., random approach. This 'directed' sampling design principle led us to build the study logistics based on what we already know about FF, i.e., in a way that will enable sampling during the first two hours of runoff. It also led us to choose locations based on our knowledge of what each tributary represents.

Application of this 'directed' approach yielded a long list of sampling locations that provides a good representation of all the land uses and activities in the Russian River Watershed. Monitoring these Stations should generate a dataset that will answer our questions, that was the theory and it was certainly correct. However, in practice we had to cut down the list based on a number of logistical considerations, the major one being time limitation. For this event we could only accommodate sample collection within the first 10 hours of the rain event, because all samples had to be shipped on one batch and be analyzed within a short holding time. The list of potential sampling locations was therefore shrunk to contain sites that had high probability of generating runoff soon after the rain starts. These sites were mostly in urban, highly paved and roofed landscapes, and the study question was amended to specify this. Other constraints, stemming from recruitment realities, were related to the number of available teams and to their whereabouts; this narrowed the list even more. Health and safety constraints, legal constraints, and other criteria were also instrumental in determining locations.

On top of all this, please recall that First Flush sampling efforts, by their very nature, always include a combination of established sampling design principles and some unpredicted, opportunistic, or responsive element (for example, catch runoff samples

where runoff happens). Thus, the spatial sampling design was based on deliberate decisions where possible, but in some cases the availability of crews – and runoff! - determined where samples were actually collected. The temporal sampling design was based on decisions triggered by actual field conditions meeting “Runoff Criteria” (see below) and was successful in targeting the first hours of runoff.

The power of a dataset depends on the number of samples collected and on what each sample represents. By collecting three consecutive runoff samples (i.e. a sample triad) at each Station, the RRFF dataset provides confirmation that detection of high constituent concentrations was not an artifact or a case of a transient spike. Sample triads also provide information on the extent of change over time in a given Station during the sampling period (which was not even the entire event in our case).

2.2 Station Locations

As mentioned above, a list of sampling Stations at locations that are safe, accessible, legal, and useful to the data users was prepared. This list included locations offered by citizens living in the watershed. A subset of Stations that have a high likelihood of having runoff during the first storm of the season were selected from that list. Citizen volunteers were assigned to these Stations where possible. **Figures 2-1 and 2-2** show the RRFF Stations on a map of the northern and southern parts of the watershed, respectively. The map includes creek stations (white squares) and outfalls (dark squares) sampled by RRFF volunteers, as well as creek stations visited by Santa Rosa City crews (white circles). The Stations were numbered sequentially, from the mouth upstream. **Table A-1** (Appendix A) provides detailed information about each Station. Of the locations visited by volunteers on November 7th 2002, most (21) yielded runoff.

Russian River First Flush 2002 Monitoring Stations

SAMPLING LOCATIONS

- 26 - FOS20
- 27 - FOS30
- 28 - GB20
- 29 - 2WFRR
- 30 - 3EFRR

Streams

Major Highways

HEALDSBURG

Highway 301

Foss Creek

Healdsburg Ave

26

27

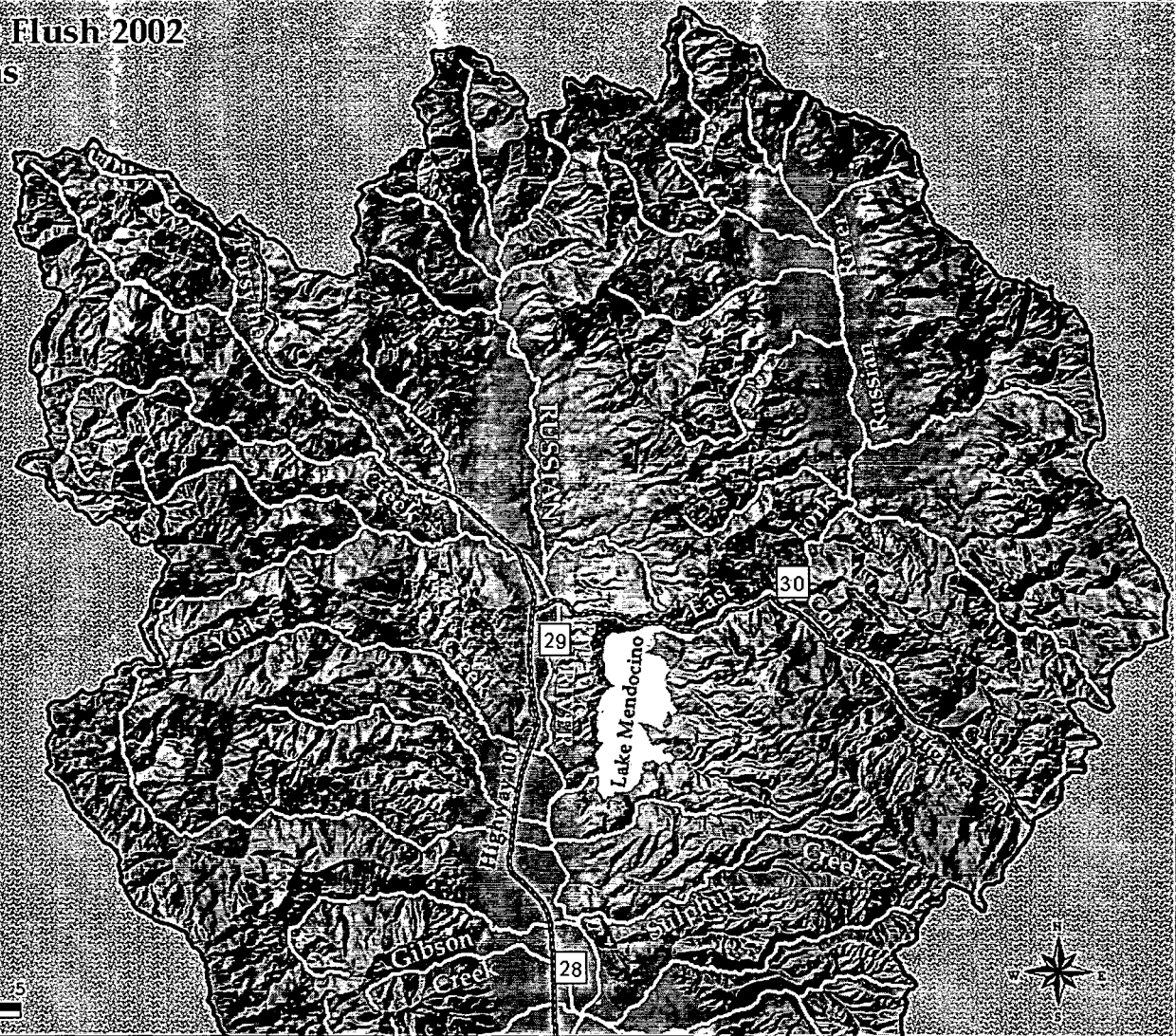


Figure 2-1: Sampling locations in the northern portion of the Russian River Watershed

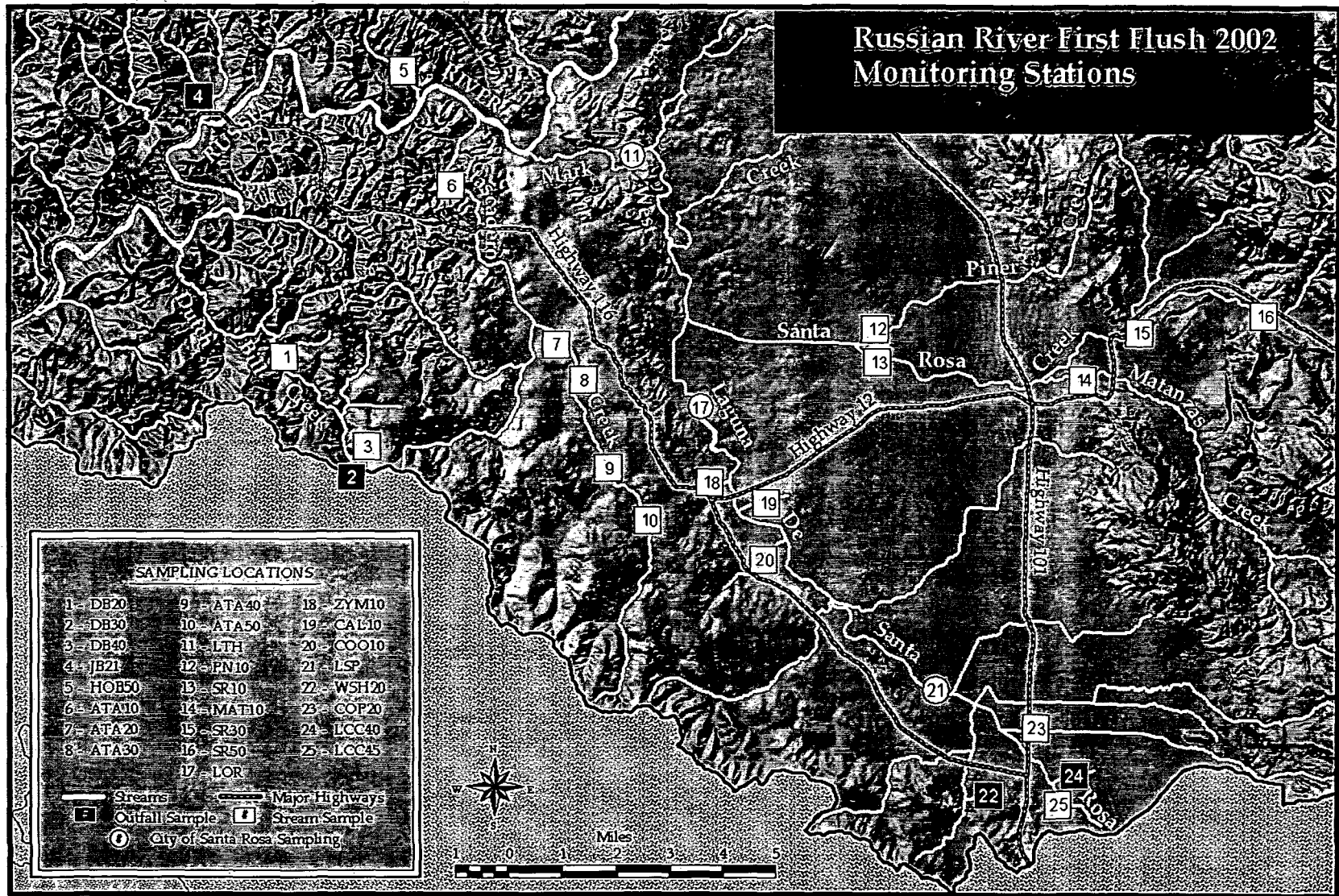


Figure 2-2: Sampling locations in the southern portion of the Russian River Watershed

2.3 Event Logistics

The event was coordinated through an 'Event Center' and several 'Hubs', each associated with several Teams of field operators. The Hubs served as centers for coordination and transfer of information, alerts, equipment, and samples. Hubsters interacted with the event organizers (Volunteer Coordinator, Scientific Coordinator, and RB1 Lab liaison) on one side and with their Captains (Team Leaders) on the other side to create the needed links. The Sotoyome RCD served as the Event Center (from which all samples were sent to EPA and RB1 labs) and coordinated four Hubs in the southern part of the watershed (Dutch Bill, Santa Rosa, Cotati/Rohnert Park, and Healdsburg). Each of these four Hubs had contact with two or more Teams. In the north, the Ukiah Hub was associated with three Teams that were active in their specific area. [Please note that during preparation for the event some of these Hubs were referred to as 'sub-hubs'].

Preparation for sampling was performed by the Scientific Coordinator and involved technical liaison with EPA lab, borrowing instruments and gathering pre-cleaned sampling containers from different sources, purchasing and decontaminating sampling devices, preparing Field Data sheets and data quality management tools, and planning. The Scientific Coordinator was also in charge of deciding when to mobilize and of preparing the samples for shipping after the event.

2.4 Training

Two training sessions were organized by the Hubsters and taught by the Scientific Coordinator, one in each Hub. Agenda items included (a) an introduction about the importance of FF sampling, what will be done with the samples and how the data will be used; (b) overview of the Project logistics; (c) demonstration of the sampling kit items and how to use them, how to label the samples and record information on the Field Data Sheet; (d) hands-on session; (e) Team and Stations assignment and construction of a phone tree (organizers helped with this task); and (f) distribution of field equipment assemblage to teams and loan documentation (Hubsters helped with this task). Consecutive training sessions were held later, taught by Hubsters who had participated in the initial training.

2.5 Alerts, Mobilization, and Runoff Criteria

The Volunteer Coordinator developed a Phone Tree comprised of contact information for each participant to assure that word gets out from the Organizers to the Event Center and through the Hubs to individual Teams. An email list of RRFF participants was also gathered and used to disseminate information. The two RRFF 'weathermen' watched weather models since early October, and the information was used to make rain alert decisions at three levels: yellow, orange, and red. Yellow alert meant "we are watching a weather system that may come in within 2-4 days"; Orange alert: "a system with >40 percent chance of bringing >0.2" of rain is forecast within 24 hours"; and Red alert meant "we have mobilized! Go to your Stations" (it also meant we are expecting to collect samples and deliver them to the lab within less than 24 hours).

The Phone Tree was activated to spread the Yellow alert on November 3rd. Orange alert was called on November 5th, and when it looked like rain was certain and imminent, Red Alert was called on November 6 and spread through the Phone Tree during the late evening before the rain began. This gave the teams a chance to get ready. Upon Red alert, the volunteers were instructed to wait for the rain, watch for the effect of rain in their area, and mobilize when they see water moving from the street surface to the street gutter (in urban areas) or when they see water ponding on the ground (rural areas).

Once they arrived at the Station, they used the following Runoff Criteria to identify stormwater runoff:

- When it rains, any flow from an outfall or in a previously dry creekbed is probably runoff, particularly if the water is murky and has cigarette butts floating in it.
- In creeks that already have base flow, stormwater runoff may be present when one can see (a) significant drop in conductivity, (b) visible increase in murkiness, and/or (c) visible rise in water level (stage).

These conditions were observed in 21 Stations, and were followed by collection of three consecutive samples at roughly 30 minute intervals at each station. In five of the 26 Stations runoff was not observed during the 12 hours of RRFF event, and only one sample, representing base flow, was collected in each of these Stations.

2.6 Data Acquisition, Field Measurements, and Laboratory Analyses

The parameter package for RRFF is based on pre-determined design where possible and on availability where not. Given that the effort was run essentially without budget, field measurements were limited to available instruments and analytical work was limited to an in-house laboratory or laboratory services provided to volunteers at no cost.

(1) Rainfall was gleaned from precipitation reports of three weather stations in the southern part of the RR watershed. RRFF weatherman obtained these data after the event.

The following parameters were measured in the field:

(2) Stage – water level - was read from staff or wire gauges (or measured directly where access permitted) at selected time periods during the hours of field activity. Some teams were able to evaluate **flow discharge** using the float method.

(3) Electrical conductivity and **(4) pH** were measured in the field using pocket conductivity meters and pH strips provided by SWRCB/EPA. **(5) Temperature** was measured by some of the teams using their own equipment. Water **(6) murkiness** was observed and recorded frequently during the hours of field activity.

Water samples were collected in previously decontaminated sampling devices. On site, the devices were rinsed in creek water three times prior to sample collection. Each sample was transferred into three pre-cleaned or sterile containers, all sharing the same Sample ID. This process was repeated every 30 minutes, yielding three independent

samples - packed in a total of nine containers - at each Station. Most Teams measured and recorded conductivity, pH, temperature, and stage while – or immediately after – the sample containers were filled. Some Teams also collected field duplicates or equipment blanks while in the field.

All samples were delivered to the Event Center at the Sotoyome RCD in Santa Rosa, logged into the chain of custody forms, and split into two sets of coolers (ice chests); one made ready for the RB1 lab and the other for the EPA lab.

The first set of sample coolers (with ‘wet’ ice, see glossary) was delivered to RB1 for in-house analyses. (7) **Ammonia** and (8) **ortho-phosphate** concentrations were determined by wet-chemistry with a calibration curve and a spectrophotometer, while (9) **nitrate** was measured (for selected samples) using field kits.

Evaluation of suspended sediments included (10) **turbidity** (measured with a turbidimeter), and (11) **total suspended solids** (determined gravimetrically by filtering and weighing of the dry residue).

The second set of sample coolers (with ‘blue’ ice) was delivered to the EPA lab in Richmond for analyses by EPA staff.

The pesticide (12) **diazinon**, a widely used insecticide, was measured by the enzyme-linked immunosorbent assay (ELISA) method.

Bacterial counts evaluated (13) *E. coli* and (14) **Total Coliform** using the enzyme-substrate Colilert reagent in Quantitrays.

The ecological significance and the regulatory benchmarks for each parameter are often site-specific and related to a specific beneficial use. In addition, the sources of the different constituents may vary depending on land use, and the severity of impact may depend on ambient conditions. All this information has been provided in numerous documents, and could not be detailed in this report. Some background facts are provided in the Results section where possible. Materials for further reading are available with the Project’s Scientific Coordinator, and the reader is referred to Appendix A, Table A-2, for her contact information.

2.7 Data Quality management

All information related to the RRFF efforts has been packaged in the DQM Project File established for the RRFF Project. The Project File is an Excel workbook with multiple spreadsheets that hold all the bits of information that the QA/QC officer and the data user will want to see in order to be able to validate, qualify, and use the Results. It allows for the first and most basic function of a data management system, data documentation, and for streamlined QA/QC review and data validation. The file also communicates information on the sampling intent, monitoring questions, and sampling design. Appendix B of this report provides specific information about how the different qualifiers have been derived and where to find what within the Project File.

3.0 Results and Interpretation

3.1 Data Inventory

The first storm of the 2002-2003 rainy season hit the Russian River watershed on 11/6/02 just before midnight. **Figure 3-1** shows the cumulative rainfall at three weather stations in the Russian River watershed. The rainfall data, provided through California Data Exchange Center website, were compiled and plotted by David J. Lewis (UC Extension). The first wave was intense in some locations but not throughout the watershed, and produced runoff in 21 out of the 26 sites monitored by RRFF volunteers.

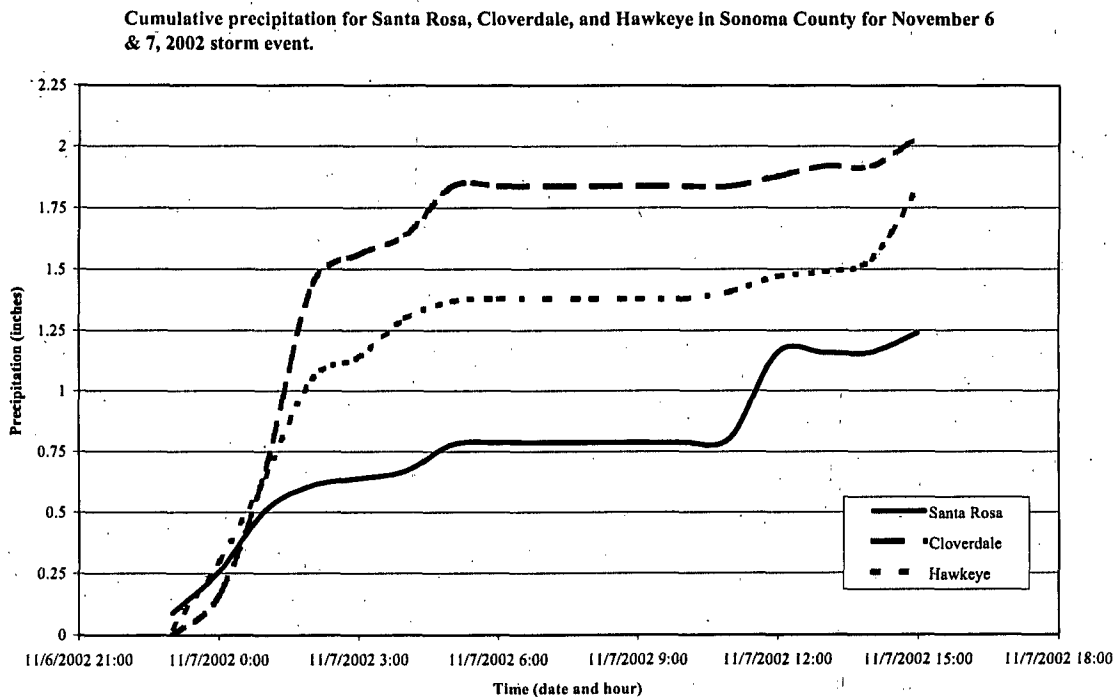


Figure 3-1: Cumulative precipitation at three RR Locations during the first 12 hours of the November 6-8, 2002 storm event.

The RRFF sample inventory is made of four types of samples:

- 5 “base flow” samples, collected at Stations that did not yield runoff
- 63 runoff samples, collected at the Stations that had runoff (three per Station, roughly 30 minutes apart)
- 4 Field Duplicates, i.e., an additional sample taken at the same time as the first runoff sample, were collected in selected Stations
- 4 Equipment (Field) Blanks, containing clean water that passed through the sampling device, were collected by selected crews.

The total of number of samples (including field duplicates and blanks) was 80, and each sample was analyzed for all of the parameters except for a few cases. **Table 3-1** shows summary of all results. Stations are listed in the same order as the map numbers sequence, from the mouth up. The "holes" in the table are due to one of several reasons: (a) logistics (e.g., at CAL10 the crew did not have sampling containers for nutrients, turbidity and TSS); (b) volume or material limitations (e.g., samples with low turbidity and small volume did not contain the 2 mg of suspended solids needed for a reliable TSS measurement); or (c) lack of field equipment to measure temperature or pH (which were optional parameters).

In the RB1 lab, turbidity was measured first and the results were used to decide which samples need to be filtered for nutrients, which samples have enough particulate matter for TSS, etc.

The Result table (Table 3-1) contains all Sample results but also the analytical results for the Field Duplicates and Equipment (Field) Blanks. Field duplicates (marked with "dup" attached to the Sample ID) provide a measure of the reproducibility of our entire sampling and analysis procedure. Equipment Blanks (marked "blnk" attached to the Sample IDs ending with number 4, except WSH20-4) provide proof that our samples were not contaminated. It is obvious that the duplicate Results are very close to each other, and that the Blanks came out very clean. Further discussion about the quality of the data is provided in Section 4 below.

The City of Santa Rosa collected grab samples at the Trenton-Healdsburg Road location on November 7, 2002 at 12:05, 12:35, and 1:05 p.m. The results of those samples are presented separately in Table 3-2, below. The only notable changes were a decrease in total suspended solids and a spike in total phosphorus at 12:35 p.m. Additional data, covering the period of noon on November 6 to noon on November 13, 2002 are presented in Appendix D.

Table 3-1. Russian River First Flush sampling results, November 2002.

Number on Map	Sample/Measureme nt ID	Collection Date	Collection Time	Stage (cm, not always from bottom)	Conductivity (uS, Field)	pH (Field)	Temperature (C) - Field	Total ammonia-nitrogen (mg-N/l)	Ortho-phosphate as P (mg-P/l)	Nitrate as N (mg-N/l)	Turbidity (TUN) RB1	TSS (mg/l)	E. coli (MPN/100 ml)	Total coliform (MPN/100 ml)	Diazinon (ng/l)
01	DB20-1	7-Nov	2:00 AM	13.8	260	7	10	0.06	0.26	0.1	4	nan	58000	240000	ND
01	DB20-2	7-Nov	2:30 AM	15.0	240	7	10	ND	0.29	0.1	4	nan	46000	>240000	ND
01	DB20-3	7-Nov	3:00 AM	15.0	240	6.8	10	ND	0.27	0.1	4	nan	46000	240000	ND
01	DB20-3dup	7-Nov	3:00 AM	nm	nm	nm	nm	ND	0.27	0.1	3	nan	69000	>240000	ND
02	DB30-1	7-Nov	1:04 AM	13	60	6	13	0.27	0.36	0.3	40	77	46000	>240000	100
02	DB30-2	7-Nov	1:34 AM	5.5	70	6	13	0.25	0.43	0.5	35	56	58000	>240000	50
02	DB30-3	7-Nov	2:04 AM	8	80	6	12	0.41	0.61	0.5	12	15	46000	>240000	60
03	DB40-1	7-Nov	1:32 AM	20.5	60	7.5	12	0.27	0.22	ND	24	63	1200	240000	ND
03	DB40-2	7-Nov	2:02 AM	14	110	7	13	0.21	0.29	0.3	15	28	860	200000	40
03	DB40-3	7-Nov	2:32 AM	21.3	80	7	14	0.23	0.16	ND	23	72	740	100000	ND
04	JB21-1	7-Nov	4:10 AM	9.8	110	6	15	0.09	0.71	ND	23	66	1600	>240000	160
04	JB21-2	7-Nov	4:40 AM	9.8	110	6	15	0.21	0.58	ND	16	50	520	>240000	120
04	JB21-2dup	7-Nov	4:40 AM	nm	nm	nm	nm	0.21	0.55	ND	17	50	410	>240000	130
04	JB21-3	7-Nov	5:10 AM	9.8	120	5.5	15	0.19	0.54	ND	18	49	860	>240000	140
05	HOB50-1	7-Nov	5:30 AM	Ref0	430	7.5	12	0.05	0.32	0.8	10	nan	3300	28000	ND
05	HOB50-2	7-Nov	6:00 AM	ref+0.3	430	7.5	12	ND	0.31	0.3	7	nan	1900	15000	30
05	HOB50-3	7-Nov	6:30 AM	ref+0.3	440	7.5	12	ND	0.32	0.5	7	nan	2300	22000	30
06	ATA10-1	7-Nov	8:15 AM	nm	320	nm	nm	0.05	0.27	0.2	9	nan	2100	69000	ND
06	ATA10-2	7-Nov	8:45 AM	nm	350	nm	nm	ND	0.24	0.5	10	nan	1500	41000	ND
06	ATA10-3	7-Nov	9:15 AM	0	330	nm	nm	ND	0.29	nan	6	nan	1900	39000	ND
07	ATA20-1	7-Nov	4:30 AM	7.5	460	7	12	ND	0.88	nan	7	nan	520	23000	ND
07	ATA20-2	7-Nov	5:05 AM	8.8	480	7	12	ND	0.83	nan	5	nan	1200	39000	ND

Table 3-1. Russian River First Flush sampling results, November 2002.

Number on Map	Sample/ Measurement ID	Collection Date	Collection Time	Stage (cm, not always from bottom)	Conductivity (uS, Field)	pH (Field)	Temperature (C) - Field	Total ammonia-nitrogen (mg-N/l)	Ortho-phosphate as P (mg-P/l)	Nitrate as N (mg-N/l)	Turbidity (TUN) RB1	TSS (mg/l)	E. coli (MPN/100 ml)	Total coliform (MPN/100 ml)	Diazinon (ng/l)
07	ATA20-2dup	7-Nov	5:05 AM	nm	nm	nm	nm	ND	0.83	nan	5	nan	310	21000	ND
07	ATA20-3	7-Nov	5:35 AM	11.3	480	7	10.5	ND	0.86	nan	6	nan	980	25000	ND
08	ATA30-1	7-Nov	1:00 AM	7.5	nm	nm	nm	ND	0.25	nan	4	nan	100	21000	ND
08	ATA30-2	7-Nov	1:50 AM	12.5	nm	nm	nm	0.48	0.44	0.3	22	108	1300	>240000	30
08	ATA30-3	7-Nov	2:20 AM	10.0	380	nm	nm	0.40	0.39	ND	14	40	1300	>240000	40
09	ATA40-1	7-Nov	9:15 AM	25	220	6.5	nm	ND	0.21	nan	4	nan	410	2600	ND
10	ATA50-1	7-Nov	10:30 AM	nm	nm	nm	nm	0.51	0.48	0.5	16	145	2800	>240000	90
12	PN10-1	7-Nov	1:35 AM	nm	490	6.5	nm	0.52	0.25	0.2	19	26	5600	76000	90
12	PN10-2	7-Nov	2:00 AM	nm	490	6.5	nm	0.40	0.27	0.1	10	20	36000	170000	50
12	PN10-3	7-Nov	2:30 AM	nm	410	6.5	nm	0.52	0.46	1.0	13	55	170000	>240000	70
13	SR10-1	7-Nov	12:50 AM	17	470	7	nm	0.50	0.15	ND	7	nan	98000	200000	40
13	SR10-2	7-Nov	1:20 AM	19	400	7	nm	0.26	0.14	ND	14	54	98000	240000	40
13	SR10-3	7-Nov	1:50 AM	20	460	7	nm	0.10	0.12	0.3	7	nan	31000	170000	50
14	MAT10-1	7-Nov	8:00 AM	15.0	240	6.8	14	0.41	0.45	0.1	25	55	55000	>240000	100
14	MAT10-2	7-Nov	8:45 AM	22.5	240	6.8	14	0.39	0.43	0.3	22	52	52000	>240000	100
15	SR30-1	7-Nov	12:30 AM	2.5	460	7	nm	0.06	0.13	nan	2	nan	310	740	30
15	SR30-2	7-Nov	1:00 AM	2.5	470	7.5	nm	0.07	0.12	nan	2	nan	200	1400	40
15	SR30-3	7-Nov	1:28 AM	4.4	470	7	nm	0.08	0.13	nan	2	nan	410	2500	40
15	SR30-4blnk	7-Nov	1:28 AM	na	nm	nm	nm	ND	ND	nan	< 1	nan	<100	<100	ND
16	SR50-1	7-Nov	1:45 AM	2.5	460	7.5	14	0.08	0.22	nan	2	nan	960	10000	ND
16	SR50-2	7-Nov	2:30 AM	5.0	450	7.5	14	0.13	0.27	nan	3	nan	1700	26000	ND
16	SR50-3	7-Nov	3:08 AM	5.0	420	7.5	14	0.11	0.28	nan	3	nan	2800	87000	ND
16	SR50-4blnk	7-Nov	3:20 AM	na	nm	nm	nm	ND	ND	nan	< 1	nan	<100	<100	ND

Table 3-1. Russian River First Flush sampling results, November 2002.

Number on Map	Sample/ Measurement ID	Collection Date	Collection Time	Stage (cm, not always from bottom)	Conductivity (uS, Field)	pH (Field)	Temperature (C) - Field	Total ammonia-nitrogen (mg-N/l)	Ortho-phosphate as P (mg-P/l)	Nitrate as N (mg-N/l)	Turbidity (TUN) RB1	TSS (mg/l)	E. coli (MPN/100 ml)	Total coliform (MPN/100 ml)	Diazinon (ng/l)
18	ZYM10-1	7-Nov	12:53 AM	40.0	280	6.5	16	1.83	0.59	nan	65	259	13000	>240000	270
18	ZYM10-2	7-Nov	1:32 AM	77.5	90	6.5	16	0.52	0.37	nan	42	159	5900	170000	120
18	ZYM10-3	7-Nov	2:03 AM	40.0	90	6.5	16	0.60	0.37	nan	47	206	7400	120000	110
18	ZYM10-4 4blk	7-Nov	2:06 AM	na	nm	nm	nm	ND	ND	nan	< 1	nan	<100	<100	ND
19	CAL10-1	7-Nov	8:02 AM	nm	140	6.5	17	nan	nan	nan	nan	nan	27000	>240000	80
19	CAL10-2	7-Nov	8:32 AM	nm	140	6.5	17	nan	nan	nan	nan	nan	34000	>240000	80
19	CAL10-3	7-Nov	9:02 AM	nm	150	6.5	17	nan	nan	nan	nan	nan	16000	>240000	70
20	COO10-1	7-Nov	1:40 AM	nm	190	7	17	ND	0.27	nan	4	nan	100	5600	ND
20	COO10-2	7-Nov	2:10 AM	nm	170	7.5	17	ND	0.27	0.3	5	nan	300	8400	30
20	COO10-3	7-Nov	2:50 AM	nm	180	7	17	ND	0.32	nan	5	nan	520	12000	120
22	WSH20-1	7-Nov	3:35 AM	nm	560	7	14	ND	0.46	1.5	nan	92	nan	nan	40
22	WSH20-2	7-Nov	1:17 PM	4	250	7.2	16	0.43	0.35	nan	nan	337	nan	nan	30
22	WSH20-3	7-Nov	1:50 PM	4	240	7.2	16	0.38	0.32	nan	nan	173	nan	nan	30
22	WSH20-4	7-Nov	2:20 PM	1	270	nm	nm	ND	0.29	1.0	nan	83	nan	nan	ND
23	COP20-1	7-Nov	7:00 AM	12.2	400	7	14	0.83	0.68	1.0	7	nan	17000	>240000	180
23	COP20-2	7-Nov	7:30 AM	15.2	410	7	14.0	0.78	0.79	0.8	6	nan	26000	>240000	230
23	COP20-3	7-Nov	8:00 AM	18.2	350	7	15	0.88	0.60	0.8	7	nan	22000	>240000	110
23	COP20-3 3dup	7-Nov	8:00 AM	nm	nm	nm	nm	0.75	0.59	0.3	7	nan	16000	>240000	110
24	LCC40-1	7-Nov	2:15 AM	31	90	6.5	13	1.01	0.45	0.4	21	77	6200	>240000	480
24	LCC40-2	7-Nov	3:00 AM	31	100	7	13	1.51	0.47	1.0	13	27	4600	240000	450
24	LCC40-3	7-Nov	3:30 AM	30	110	6.5	13	1.45	0.43	0.4	11	33	4500	240000	420
25	LCC45-1	7-Nov	2:50 AM	28	250	7	12	1.76	0.61	1.0	34	61	11000	>240000	120
25	LCC45-2	7-Nov	3:15 AM	28	240	6.5	13	1.70	0.79	1.0	35	52	31000	>240000	150
25	LCC45-3	7-Nov	3:45 AM	20	240	6.5	13	1.45	0.78	1.0	31	45	41000	>240000	120

Table 3-1. Russian River First Flush sampling results, November 2002.

Number on Map	Sample/Measureme nt ID	Collection Date	Collection Time	Stage (cm, not always from bottom)	Conductivity (uS, Field)	pH (Field)	Temperature (C) - Field	Total ammonia-nitrogen (mg-N/l)	Ortho-phosphate as P (mg-P/l)	Nitrate as N (mg-N/l)	Turbidity (TUN) RB1	TSS (mg/l)	E. coli (MPN/100 ml)	Total coliform (MPN/100 ml)	Diazinon (ng/l)
25	LCC45-4blnk	7-Nov	4:45 AM	na	nm	nm	nm	ND	nan	nan	1	nan	<100	100	ND
26	FOS20-1	7-Nov	12:57 AM	62	280	6.8	14	2.26	1.01	1.0	47	125	61000	>240000	200
26	FOS20-2	7-Nov	1:27 AM	75	70	6.5	13	0.83	0.44	0.5	41	128	17000	240000	100
26	FOS20-3	7-Nov	1:57 AM	73	90	7	13	0.81	0.40	0.8	36	103	14000	240000	100
27	FOS30-1	7-Nov	12:59 AM	31	500	6	16	0.63	0.37	0.5	130	339	14000	>240000	630
27	FOS30-2	7-Nov	1:30 AM	39	170	6.5	13	0.49	0.30	0.8	170	570	25000	>240000	710
27	FOS30-3	7-Nov	2:03 AM	43	140	6.5	13	0.27	0.29	0.8	120	259	26000	>240000	780
28	GB20-1	7-Nov	5:40 AM	18.2	90	7	13	0.58	0.70	0.8	11	25	6900	240000	120
29	2WFRR-1	7-Nov	7:30 AM	nm	330	7.5	nm	ND	0.05	nan	27	22	740	10000	60
29	2WFRR-4blnk	7-Nov	7:50 AM	nm	nm	nm	nm	ND	ND	nan	< 1	nan	<100	<100	ND
30	3EFRR-1	7-Nov	7:00 AM	0	170	7	nm	ND	0.05	nan	2	nan	200	2200	30

nm = not measured
nan = not analyzed
ND = not detected

Table 3-2. City of Santa Rosa water quality results for the three grab samples on November 7, 2002, Laguna de Santa Rosa at Trenton-Healdsburg Road.

Measured Parameter	Units	Lab/Field	Method	Results at Sampling Times		
				12:05	12:35	13:05
Specific Conductance	uS (umho/cm)	Field	Probe	499	495	496
pH	Std. units	Field	Electrode	7.8	7.8	7.8
Water Temperature	° C	Field	Probe	11.6	11.7	11.8
Ammonia Nitrogen	mg-N/L	Laguna Env., Santa Rosa	Automated electrode	0.88	0.9	0.9
Ortho Phosphate	mg-P/L	Laguna Env., Santa Rosa	Persulfate digestion	0.44	0.42	0.44
Nitrate Nitrogen	mg-N/L	Laguna Env., Santa Rosa	Ion chromatograph	0.8	0.8	0.8
Turbidity	NTU	Field	Nephelometric	19	18	21
Total Suspended Solids	mg/L	Laguna Env., Santa Rosa	Gravimetric	76	48	58
E. coli	MPN/100 ml	BioVir, Benicia	Multiple Tubes	16000	16000	16000
Total Coliform	MPN/100 ml	Laguna Env., Santa Rosa	Multiple Tubes	≥16000	≥16000	≥16000
Diazinon by ELISA	ng/L	USEPA, Richmond	Immunoassay	140	120	120
Diazinon by EPA 8141A	ng/L	Appl Inc., Fresno	Separation and quantification	100	90	70
Dissolved Oxygen	mg/L	Field	Electrode	6.8	6.8	6.7
Total Phosphorus	mg-P/L	Laguna Env., Santa Rosa	Persulfate digestion	0.51	1.58	0.54
Total Organic Carbon	mg C/L	Sequoia Labs	Combustion/ Oxygenation	22	19	19
Fecal Coliform	MPN/100 ml	Laguna Env., Santa Rosa	Multiple Tubes	≥16000	≥16000	≥16000

3.2 Major Findings

3.2.1 Data Limitations

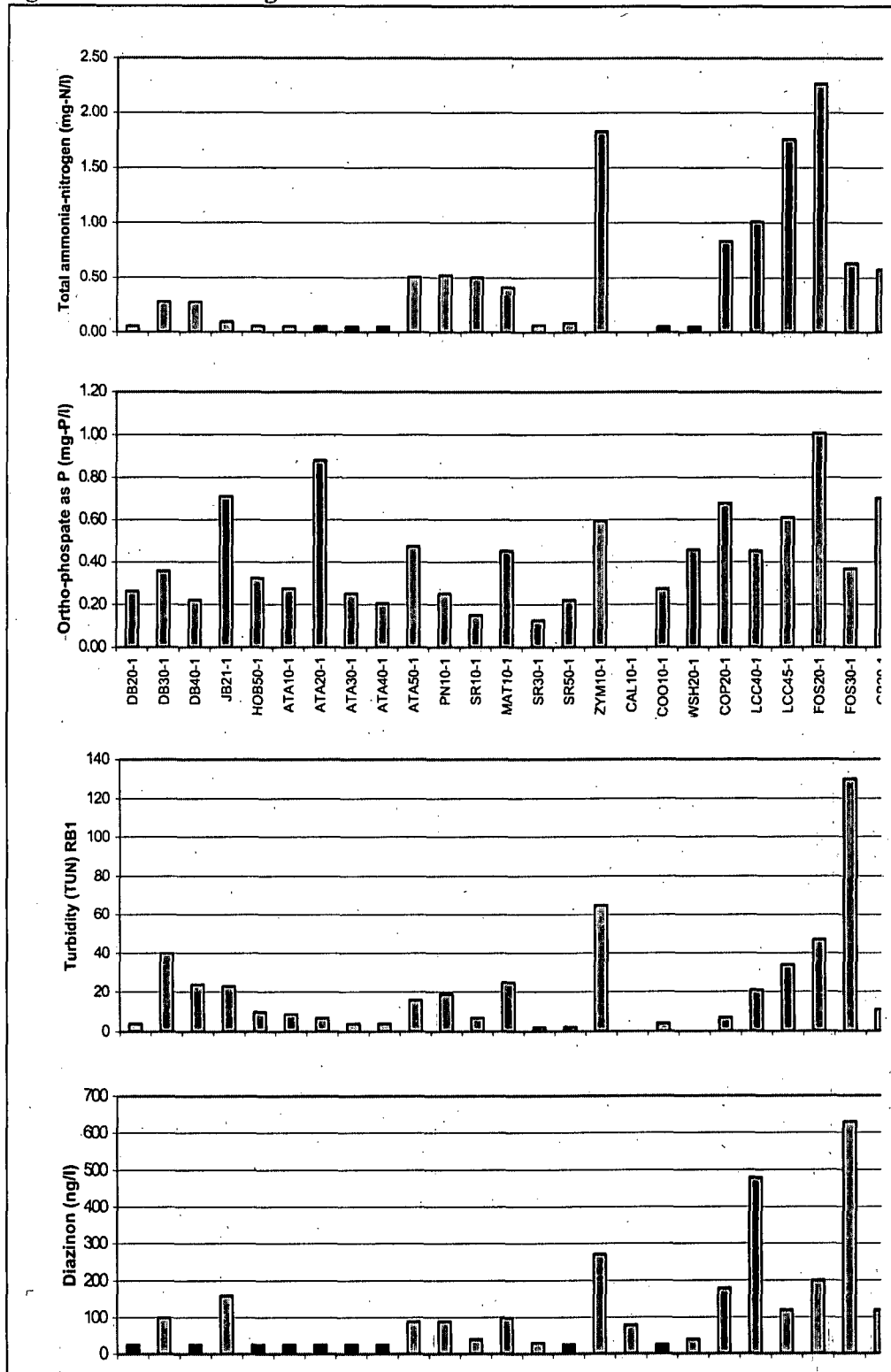
The quality of RRFF constituent measurements makes the Results good for practically any use, with exceptions; these exceptions are related to individual Result points and they are well-marked (flagged) in the Project File (see Section 4 and Appendix B for further information). Data interpretation, however, should be done with caution because of limited representativeness, both in time (we have only sampled a fraction of the entire storm event) and in space (we do not have comprehensive coverage of the watershed). Because we do not really know how well our samples represent RRFF, we can only use the data as a “spotlight” moving across the watershed and illuminating parts of it. However, the data we do have are reliable and the picture emerging from them is useful in targeting our next questions and generating valuable recommendations for future efforts.

3.2.2 Watershed-Scale Observations

Figure 3-2 shows a set of four bar-graphs, each showing concentrations of one parameter as a function of Sample ID. Note that the naming convention used to generate Sample ID includes the Station ID and a serial number, and the results shown in these graph represent only the first Sample collected at

each Station, not all three. By placing the graphs one under the other in a way that they share the same Sample IDs, we can view the relationship between the different parameters as well. Figure 3-2 shows a high variability in concentrations at different watershed locations at the same time. It also indicates that areas with high concentrations of one constituent (parameter) are not necessarily a major source of other constituents (e.g., a "hot spot" for nutrients was not necessarily high in diazinon, high PO₄ was not necessarily associated with high ammonia).

Figure 3-2: Monitoring Results in Russian River First Flush Stations



Another way to look at the data of a particular parameter is organizing the data points in order highest to lowest and plotting as a bar graph, as shown for diazinon as an example in **Figure 3-3**. The Figure shows the concentrations of diazinon in all samples in which it was detected. Foss Creek and the outfall into Cotati Creek are pointed out as having the highest concentrations. The graph also shows that a large number of samples had concentrations that exceeded the value of 90 ng/l. That value is recommended by USEPA and CDFG as the maximum that aquatic organisms can “tolerate” for 1-hour (acute) exposure; higher concentrations may pose a threat. The finding is not surprising, and is not unique to the Russian River area. Diazinon is often found in urban creeks in California at concentrations that cause toxicity to small crustaceans, aquatic insects, and other sensitive organisms.

To compare the sub-watersheds to each other, we pooled all the results 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. **Figure 3-4** presents the diazinon “box and whisker plot” which 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.

Again, Foss Creek and Cotati Creek stand out, with the box representing 25th to 75th percentiles hanging clear above the other sub-watersheds’ boxes (which indicate that a statistical comparison would probably find them significantly higher).

3.2.3 Creek-Scale Observations

Foss Creek samples contained relatively high concentrations of several constituents. To get a sense of what these samples represent, we need a closer look at the changes over time and along the creek. **Figure 3-5** shows the changes in water level (stage) and conductivity at the central Healdsburg Station FOS20 during the sampling period; a similar picture was seen at FOS30, further upstream at the edge of town. The Figure shows that sampling was conducted during the rising limb and the peak of the hydrograph, when water level was increasing and conductivity was decreasing till they stopped changing for a while. Of the 21 Stations that had runoff during RRFF02 sampling event, eight (8) were sampled during the rising limb of the hydrograph, four (4) during peak, two (2) during what appeared to be a trough in the hydrograph, and one (1) during the falling limb. The hydrograph phase is unknown for the five (5) remaining Stations.

Diazinon (above PQL)

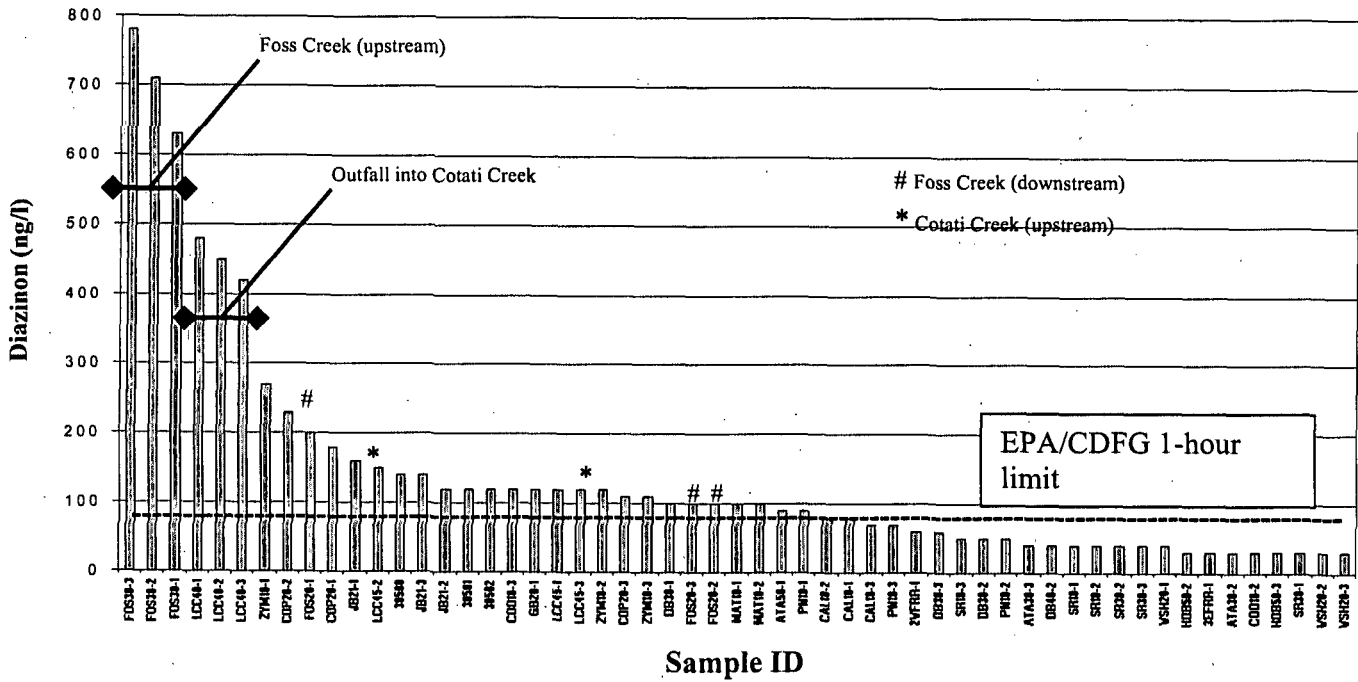


Figure 3-3: Concentrations of Diazinon detected in the Russian River First Flush samples, organized from highest to lowest.

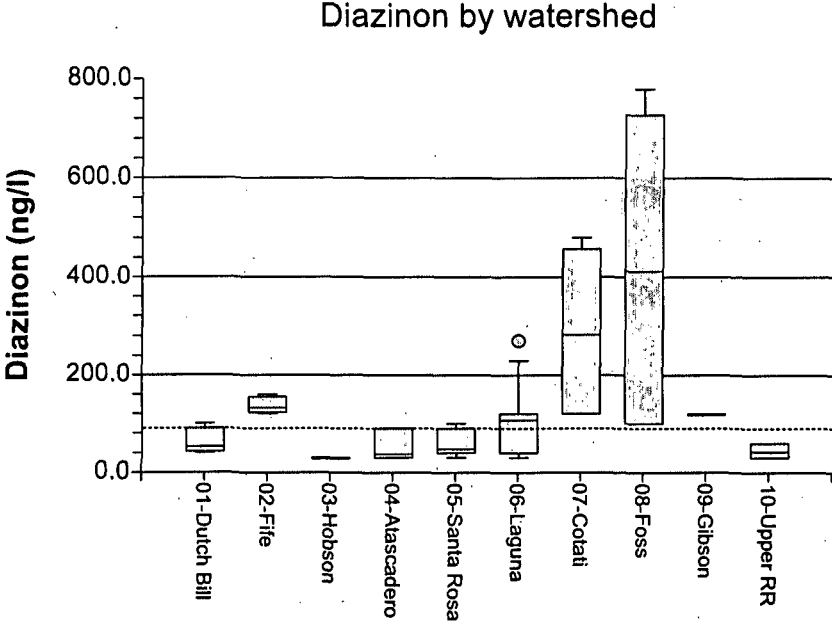


Figure 3-4: Box and Whisker plots of diazinon concentrations by sub-watershed.

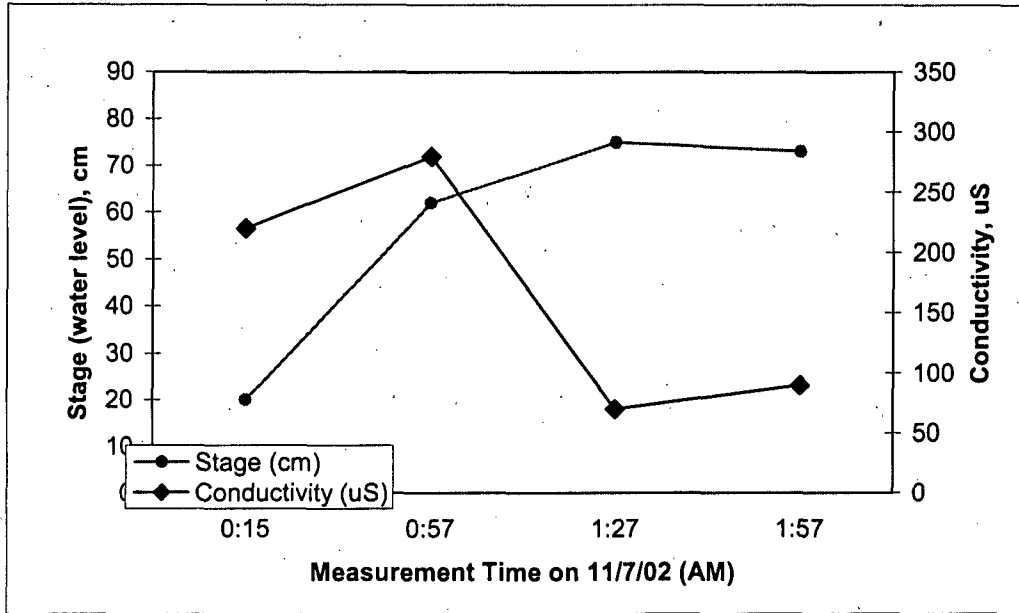


Figure 3-5: Changes in conductivity and water level in Foss Creek at FOS20 during the 11/7/02 rain event

The changes in concentrations of selected constituents over time at the two Foss Creek Stations is presented in **Figure 3-6**. The figure shows different patterns of change over time, the most prevalent being diminishing concentrations; this was probably due to dilution. A similar pattern was observed in other creeks, particularly in the creeks that were sampled during the rising limb of the hydrograph.

The RRFF volunteers slept little on the night of November 7, as is evident from the sample collection times. Sixteen stations with runoff were sampled before 6 AM, and the other stations were visited during the night but were not sampled because the conditions did not meet the 'Runoff Criteria'. It is important to note that not all of the field measurements and analytical results in the RRFF samples have the characteristic trends shown in **Figures 3-5** and **3-6**. This observation points to the inherent variability in rain distribution, terrain, and hydrology within a watershed.

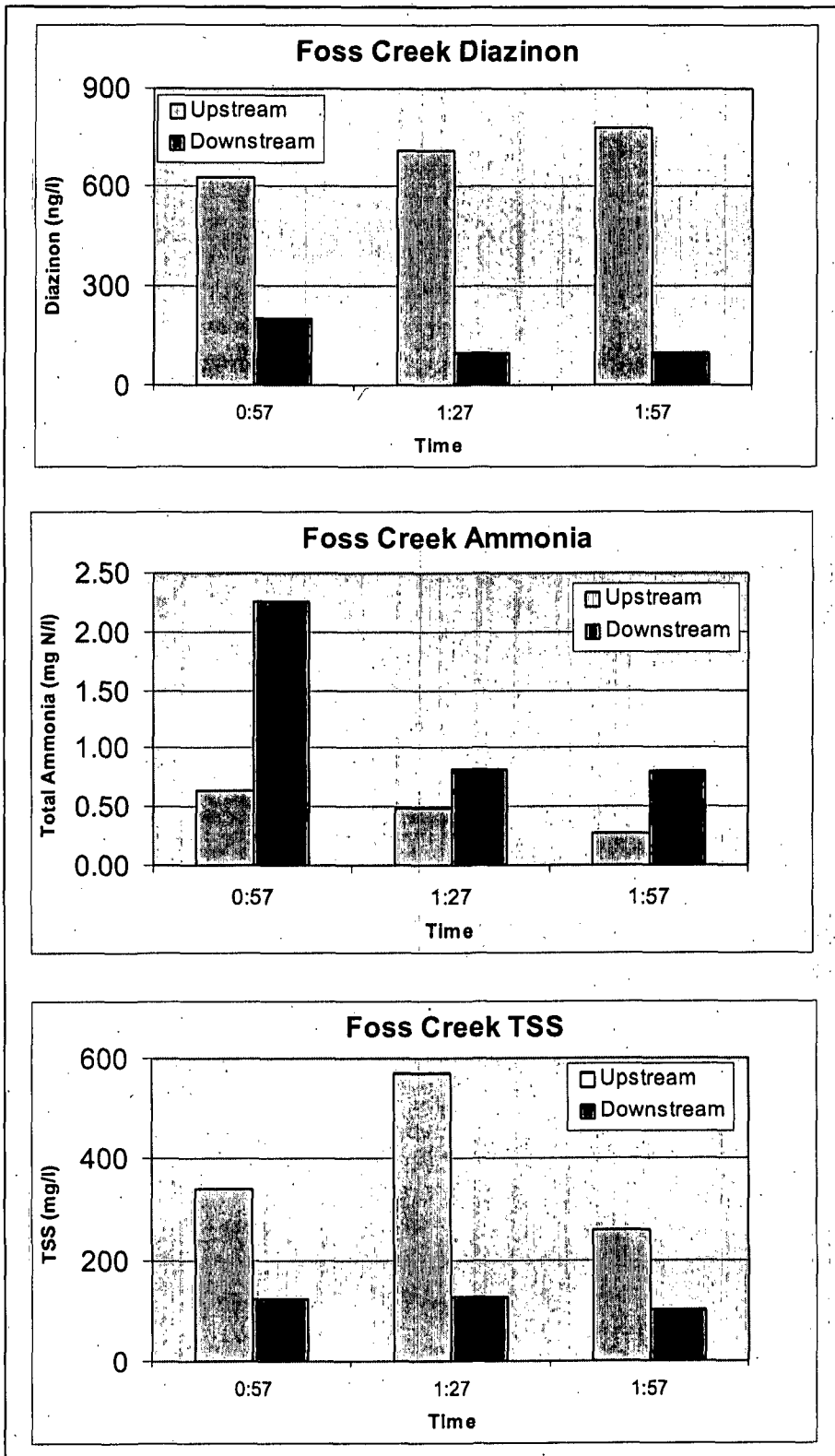


Figure 3-6: Concentrations of diazinon, ammonia, and total suspended solids at Foss Creek during the rising limb of the hydrograph.

4.0 Data Quality Overview

There are many attributes of data quality, and each of them means something different about the data. It helps to break these attributes into major groups, dealing with different aspects separately. The following sections provides a discussion of RRFF data quality as related to the following:

1. Quality of the measurement (e.g., accuracy);
2. Sample integrity;
3. Fidelity of information transfer and data entry;
4. Reliability and validity;
5. Representativeness; and
6. Usability.

4.1 Measurement Quality

RRFF data are reported with the range of error associated with each Result, so that any data user can 'factor in' the uncertainty when they use the data for decision-making. We communicate the error by providing measures of **accuracy** and **precision**, which describe how far we may have been from the 'absolute true value' (that's accuracy) and how far our results are from each other when we repeat our measurements (precision). Measures of accuracy and precision are often lumped together to generate a cumulative **range of error**. The sensitivity of our methods also matters, so we have to specify the **detection limit** (the lowest value we can report with confidence that it is actually a positive result) and the **resolution** (the smallest increment that our method or instrument can discern). The instruments or kits we use to make the measurements will determine the 'attainable' quality, but in reality a lot depends on the skills and actions of the operators. For example, the resolution of our ammonia and phosphate kits was greatly improved when we used the kit's reagents with an array of samples and a calibration curve, and read the absorbance in a spectrophotometer. The detection limits of these analyses were also improved (i.e., lowered), by using thick test tubes which provided for a longer light path within the spectrophotometer and enabled detection of significant signals at lower color intensity.

Field and lab operators were given guidance and tools to Control, Check, Record, and Report (CCRR) the quality of their measurements and analyses. Essentially, '**Control**' is about things we can do to improve accuracy and precision (resolution, detection limit, and range are usually a 'given' for a given instrument but there are ways to improve them as well, see above). '**Check**' is for things we cannot control but need to know. '**Record**' is about the language we use to express our findings and about entering these findings into the 'placeholders' on our forms or spreadsheet. '**Report**' is about the way we calculate the measures of accuracy and precision so they can be shared with others. Note that each type of instrument or kit requires its unique CCRR actions (that cannot be generalized for all measurement devices), the step-by-step instructions for these actions were provided in the instrument-specific standard operating procedures (SOP).

Detailed information regarding measurement quality by parameter or group of parameters, in the field and in the lab, is provided in Appendix B of this report and in the in the RRFF Project File (see Section 2.7 above). In a nutshell, measurement quality is partially known for selected field measurements (e.g., conductivity and pH) for which we have documentation, and is in the range of 10 to 20% error. Laboratory analyses were fully documented; the error around ammonia, ortho-phosphate, and TSS Results was 10% or less, while turbidity and diazinon data were associated with 10-20% error and nitrate bacterial counts were associated with up to 50% error (which is excellent for *E. coli* and total coliform data).

The sensitivity (resolution and detection limit) of RRFF data was within the measurement quality objectives set for each parameter and method, and was adequate for the purpose of monitoring (Appendix B).

4.2 Sample Integrity

Sample integrity is about lack of contamination and lack of deterioration. We assure lack of contamination through a number of **control** actions; we decontaminate sampling equipment and keep everything clean to avoid contamination of the probes used for field measurements, the sampling devices, the sample containers, the lab reagents, etc. We prevent sample deterioration by keeping the samples in coolers or in the refrigerator at all times and by analyzing within the specified 'holding time'. RRFF sampling and analyses work included application of all these control measures. To **check** sample integrity we collect and analyze equipment blanks (sampling devices, containers, and sample filtration devices), and we measure temperatures when relinquished at EPA lab. These checks showed that RRFF sample results were not due to contamination. To avoid contamination of bacterial samples within the coolers we used blue ice, and consequently the samples sent to EPA lab arrived at 10 C. This temperature is slightly higher than recommended shipping temperature, but the excursion from recommended temperature was very short (less than 2 hours) and probably did not compromise sample integrity.

4.3 Fidelity of information transfer and data entry

Data 'fidelity' means correct transfer of information from observer to 'scribe' and correct recording during field work, as well as data copying and data entry into electronic formats later in the process. The fidelity of information transfer in the field has not been assessed; however it is not so relevant to the laboratory results generated with the samples. As for data entry, most field data was entered by citizen volunteers directly into the Project File and the review by the Scientific coordinator showed that it was entered with >99% fidelity. Raw data from RB1 in-house lab analysis was entered by citizen volunteers and RB1 Lab liaison into special worksheets, with >95% fidelity.

4.4 Reliability and Validity

The credibility and validity of monitoring data go hand-in-hand in the way they are assessed, and they both require complete documentation of the measurements (instruments, QAQC, etc.), the station location, the sampling design, and other bits of essential information. Reliability implies honest reporting by field operators and a high probability that the reported value indeed falls within the range of error specified for it. Validity means the test, assay, or analysis used to collect the data was valid and that the target data quality objectives have been achieved. Note that knowledge about the quality of the measurement itself (see below) is essential for labeling a dataset 'reliable and valid'.

RRFF Results are associated with a high level of documentation, with very few 'holes' in the matrix of supporting information. Measurement quality is known for most of the data points. All the data have been reviewed, and each Result is presented to the users with qualifying information on the level of documentation, the extent of measurement error, and the data validation outcome.

4.5 Representativeness

As mentioned above, RRFF data have limited representativeness, both in time (we have only sampled a fraction of the entire storm event) and in space (we do not have comprehensive coverage of the watershed). However, having datasets with three consecutive samples provides information about

what each sample represents within the sampling period. Likewise, having several stations along one waterway increases our understanding of what each Station represents within that creek. The principles used in planning for three consecutive samples and multiple creek locations can and should be utilized in designing future studies and 'zooming in' on particular segments of the Russian river Watershed.

4.6 Usability

Most of the Results collected by RRFF teams are usable in the sense that they can answer some very relevant questions. They are comparable to other data sets in terms of sampling design and data quality, they are scientifically defensible, and they are reported and documented in formats that can be easily read, understood, and shared. For the regulators, these data – although they should not be used for litigation - provide information that will help prioritize future investigation. Local agencies in charge of pollution prevention can benefit from the knowledge when they allocate resources to management measures. The watershed groups can use the data to educate neighbors, students, and the community at large. Last but not least, information gleaned from the results can and should be used to design the next studies done in the watershed.

5.0 Summary and recommendations

First Flush storm runoff samples were collected by citizen volunteers in 21 Stations in urban drainages within the Russian River watershed on 11/7/02. Five additional stations, representing base flows (non-runoff), were sampled as well. Sampling efforts yielded 80 samples which were analyzed for a number of constituents, including bacteria, nutrients, suspended solids, and the insecticide diazinon. The quality of RRFF constituent measurements makes the Results good for practically any use, with exceptions that are well-marked (flagged).

RRFF data are of limited representativeness, both in time (only a fraction of the entire storm event was sampled) and in space (coverage of the watershed was not comprehensive). Therefore, data interpretation should be done with caution.

Three urban drainages stood out as laced with potentially problematic concentrations of some stormwater constituents. The situation in other locations was not as severe, although several additional inputs of stormwater constituents have been identified.

Phosphate and Nitrate were detected in the majority of samples tested; however their sources may be natural (these nutrients often run off pristine landscapes during the first runoff event after a long dry season). Suspended solids concentrations and bacterial counts were within the range normally encountered in urban runoff, and the presence of diazinon and ammonia pollution (i.e., at concentrations thought to pose a risk to aquatic life) is also familiar.

The dataset provides an initial 'big picture' that can help develop some perspective on the occurrences of the major constituents. Information gleaned from this characterization effort can help citizens, local agencies, and regulators prioritize future management options.

RRFF efforts brought together many professionals, and a network of technically-savvy folks has formed. It is recommended to maintain this network within the RRFF contact list and apply it to future monitoring efforts in the watershed.

Citizens participating in RRF have learned that many monitoring activities are actually 'doable', they now feel empowered to proceed with monitoring in their localities with help from the local technical network folks.

Observations and conclusions gleaned from the data can focus future efforts around a given area and to design additional studies tailored to answer specific questions. These additional studies can be performed by citizens. Examples: fine mapping of sub-basins; relationship between what was found in a creek during RRF and what flows or stands in that creek during dry weather; what practices characterize that specific drainage; are there BMPs that work well; etc.

It is highly recommended to consider the lessons learned when planning future efforts. For example, Study Design could benefit from a set of Stations focused around a small section of the watershed, and from a temporal sampling schedule that spans the entire hydrograph.

Repetition of First Flush monitoring in subsequent years will help create a more robust body of information, even if conducted only in the urban sectors of the Russian River watershed. The citizens of the Russian River Watershed have expressed their wish to capture the first flush again in the fall of 2003. Interested parties are encouraged to contact the volunteer coordinator (see Appendix table A-2).

6.0 Glossary

Accuracy: How close is our measurement to the real truth: the extent of agreement between an observed value (measurement result) and the accepted, or true, value of the parameter being measured.

Accuracy Check: Comparison of the reading, or output, of a measurement device with a value believed the 'true' value. The 'true' value may be represented by known natural conditions (e.g., freezing point) or by an established Standard. An 'Accuracy Check' is different from a Calibration, since it is only a comparison and does not result in an adjustment (calibration) of an instrument or procedure.

Blank (Sample): A sample that contains pure water and is analyzed concomitantly with a set of environmental samples. Blanks usually include field blanks and trip blanks to assure that there was not contamination during sampling and shipping, as well as laboratory method blanks and reagent blanks, tested within the analytical procedures

Blue Ice (vs wet ice): A pre-frozen device used to chill objects (e.g., full sample containers), inside an insulated chest, without melting.

Calibration: The action of adjusting the readings of an instrument to have them match a 'true' value as represented by known natural conditions (e.g., freezing point) or by a Standard Solution (e.g., Standard pH buffer).

Data Quality Objectives (DQOs): Statements about the level of uncertainty in data that a decision-maker is willing to accept to support a particular decision. DQOs include measurement quality objectives (precision, accuracy, detection limit, and resolution) as well as measures of completeness, representativeness, and comparability.

Data Validation: The process to assure data meets requirements and quality objectives and that the test or analysis used to generate the data was valid.

Data Users: The group(s) that will be applying the monitoring results for decision making or other purpose. Data users can include the monitors themselves as well as government agencies, schools, universities, businesses, watershed organizations, and community groups.

Database: A computerized system for managing, storing, and retrieving data.

Diazinon: A wide-range insecticide used for control of pests in yards and gardens. Diazinon is highly toxic to many species of crustaceans and aquatic insect larvae.

Dissolved Oxygen (DO): Oxygen dissolved in water and available for living organisms to use for respiration, usually expressed in milligrams per liter or percent of saturation.

Duplicate Samples: two samples taken at the same time from the same site (but into separate containers) that are carried through all assessment and analytical procedures in an identical manner. Duplicate samples are given separate (and unique) Sample IDs. Results of duplicate samples are used to evaluate the Repróducibility of the measurements.

Field Operator: The Project person who conducts monitoring activities in the field, including measurements, calibrations and/or accuracy checks, and sampling.

Hydrograph: a plot showing the stage (water level) in a creek as a function of time. The 'storm Hydrograph' shows one or more peaks.

Instrument: a probe, electrode, reagent kit, indicator strip, or any other type of device used for field or laboratory measurements.

Parameter: A property or substance to be measured within a medium. Parameters include properties such acidity (pH) or electrical conductivity, particulates such as suspended solids or bacteria, and analytes such as ammonia or heavy metals.

pH: Numerical measure of the hydrogen ion concentration used to indicate the alkalinity or acidity of a substance. Measured on a scale of 1.0 (acidic) to 14.0 (basic); 7.0 is neutral

Precision: A measure of how close repeated measurements are to each other.

Project: A data collection effort, performed by one or more organizational entities, which is limited in space and time.

Project File: An Excel workbook with multiple spreadsheets that include all the results, result descriptors, and supporting documentation relevant to one Project.

Replicate Samples: two or more test tubes taken from the same sample container and analyzed in parallel, or repeated titrations of the same fixed sample (i.e., measurements relating to a common Sample ID). 'Split samples' are replicates because they originate from a common container and represent the same 'chunk' of water. Results of replicate samples are used to evaluate the Repeatability of the measurements.

Result: The outcome of a measurement or an observation. Results can be expressed in numbers, words ('verbal categories'), or ranges or numbers ('numeric range categories').

Resolution: The smallest increment that can be discerned on the scale of a measuring device, or the capability of a method to discriminate between measurement responses.

Significant digits - digits in a numerical Result that have a number that is meaningful. In most cases three significant digits are fine, e.g., 10.4 mg/l DO (all three digits are significant) or 1560 uS (the first three are significant, the last one provides the order of magnitude but the difference between zero and, say, 2, is not significant).

Split Samples - Two or more Replicates that have originated from a common Sample container and thus represent the same 'chunk' of water. Split Samples are often used to compare performance of different laboratories, in what is commonly termed 'round robin tests'.

Standard Operating Procedure (SOP): A written document providing step-by step instructions for performing a procedure (sampling, measurement, or other).

Standard Solution: A solution containing a known concentration of a substance, prepared or purchased for use in the analytical laboratory or in the field. It is used in calibrations and in quality control checks on procedures and instruments. This category includes 'Calibrator Standards' used for calibration of adjustable pH and conductivity meters (etc.), usually as the 'Resident Standards' that each monitoring entity uses, as well as SRMs and 'External Standards' such as those used in regional Intercalibration Exercises. Each bottle of these types of Standards has to have a unique ID.

Total Suspended Solids (TSS): The amount of all particulate matter suspended in the water, expressed as dry weight per volume, e.g., mg/l.

Turbidity: A property of the water, often due to tiny particles suspended in it, that causes absorbance of light and loss of clarity.

Water Quality Parameters: Any of the measurable properties, qualities or contents of water.

Wet Ice: Unpacked blocks or chunks of ice that yield water when melted. When used in ice chests to cool environmental samples, the containers have to be protected from intrusion of melt water.

APPENDIX A

Russian River First Flush station and participant information

Table A-1. Russian River First Flush Station Information.

# on Map	Station ID	Waterbody	Latitude *	Longitude *	Station Location
Dutch Bill Creek sub-watershed					
1	DB20	Dutch Bill Creek	38.43566	-122.97342	Camp Meeker/ Alliance Redwoods
2	DB30	Outfall into Dutch Bill Creek	38.41070	-122.94939	Graton Rd @ Bohemian Hwy
3	DB40	Dutch Bill Creek	38.41072	-122.94876	Dutch Bill Hdwaters@ Graton Rd
Fife Creek sub-watershed					
4	JB21	Outfall into Fife Creek	38.50210	-123.00190	Fife Creek @ Highway 116
Hobson Creek sub-watershed					
5	HOB50	Hobson Creek	38.51344	-122.93307	McPeak & Skyline
Green Valley / Atascadero Creek sub-watershed					
6	ATA10	Green Valley Creek	38.48332	-122.91551	Martinelli Rd
7	ATA20	Atascadero Creek	38.44431	-122.87700	Grren Valley Rd Bridge
8	ATA30	Graton Critch	38.43526	-122.87122	Graton Critch @ Railroad Ave
9	ATA40	Atascadero Creek	38.41091	-122.86178	Mill Station @ Atascadero
10	ATA50	Atascadero Creek	38.39747	-122.84820	Bodega Highway
Mark West Springs sub-watershed					
11	LTH	Mark West Springs	38.49420	-122.85307	Laguna @ Trenton/Healdsburg Rd
12	PN10	Piner Creek	38.44853	-122.76941	Piner Crk @ Fulton Rd
13	SR10	Santa Rosa Creek	38.44172	-122.76948	Santa Rosa Crk @ Fulton Rd
14	MAT10	Matanzas Creek	38.43890	-122.69980	Doyle Park
15	SR30	Santa Rosa Creek	38.45120	-122.67978	Santa Rosa Crk @ Yulupa Ave
16	SR50	Santa Rosa Creek	38.45615	-122.63746	Santa Rosa Crk @ Melita Rd
Laguna de Santa Rosa sub-watershed					
17	LOR	Laguna de Santa Rosa	38.42567	-122.82871	Laguna @ Occidental Rd
18	Zym10	Zymfin Creek	38.40668	-122.81990	Zymfin Creek @ Morris St
19	CAL10	Calder Creek	38.40391	-122.81021	Radota Trail Sebastopol
20	COO10	Cooper Creek	38.38814	-122.80311	Cooper Creek @ Cooper Road
21	LSP	Laguna de Santa Rosa	38.35227	-122.74145	Laguna @ Sebatopol Rd
22	WSH20	Outfall into Washoe Creek	38.32483	-122.73412	Vineyard Ditch @ Washoe Crk
23	COP20	Copeland Creek	38.34312	-122.71196	Copeland Creek @ Commerce Blvd
24	LCC40	Outfall into Cotati Creek	38.32793	-122.70365	Cotati Creek north of E Cotati Ave
25	LCC45	Cotati Creek	38.32715	-122.70306	Cotati Creek @ E Cotati Ave
Foss Creek sub-watershed					
26	FOS20	Foss Creek	38.61111	-122.87188	Foss Creek Downtown
27	FOS30	Foss Creek	38.64313	-122.87190	Upper Foss Creek
Gibson Creek sub-watershed					
28	GB20	Gibson Creek	39.14539	-123.19202	Gibson Crk @ Gobbi St
West Fork Russian River					
29	2WFRR	Russian River	39.23120	-123.20135	West Fork Russian River
East Fork Russian River					
30	3EFRR	Russian Riyer	39.24805	-123.12242	East Fork Russian River

* Datum NAD83 / WGS84

Table A-2. Russian River First Flush Participants

	Last name	First name	Role	Affiliation		Last name	First name	Role	Affiliation
1	Andrews	Betty	Hubster, Captain		24	Churchill	Susan		
2	Austin	Tom			25	Clemens	Bob		
3	Barclay	Mary			26	Cornelius	Sarah	Captain	
4	Bauer	Rich	EPA ELISA lab liaison	USEPA Reg IX	27	Cullen	Reg	Advisor (Heavy Metals)	RB1
5	Beck	David			28	Cumberland	Catherine		
6	Belew	Wade			29	Curry	Linda	Captain	
7	Bender	Jerry			30	Cushman	Douglas		
8	Bentz	Jo	Captain		31	Dean	Cheryl		
9	Berman	David	Captain		32	Dekker	Lucinda		
10	Bjorkquist	Bob			33	DeMars	John		
11	Blaker	Jenny	Hubster, Captain		34	Derry	Tim	Hubster, Captain	
12	Bleifuss	Alistair	Captain		35	DeVilliers	Fred	Captain	
13	Brewer	Jim			36	Dickerson	Rob		
14	Bunnell	Andy			37	Dix	Jerome		
15	Canfield	Patricia			38	Dolman	Brock	Hubster, Captain	
16	Cantor	Sierra	Event Center host, Hubster	Sotoyome RCD	39	Doms	Juliana		
17	Cantua	Tara			40	Erickson	Dave	Captain	
18	Carpenter	Leha	Captain		41	Essman	John		
19	Carrieri	Chris			42	Evans	Robert		
20	Chinlund	Donna			43	Ferguson	Colleen	Captain	
21	Chocholak	Dianne	Captain		44	Flynn	Francesca		
22	Christensen	Judy			45	Foshee	Katherine		
23	Christopher	Linda			46	Gaddis	Roger		

Table A-2 (cont'd.). Russian River First Flush Participants

	Last name	First name	Role	Affiliation			Last name	First name	Role	Affiliation
47	Garn	John				73	Lichty	Robert		
48	Gay	Jana				74	Lieberman	Dayna		
49	Gledhill	Katherine				75	Lincoff	Andy	EPA bacteria lab liaison	USEPA Reg IX
50	Gourley	Heather		SSU		76	Luna	Michele		
51	Hancock	Neil				77	Maddock	Peggy		
52	Hanson	Larry				78	Mann	Dale		
53	Harris	Karen				79	Marchetti	Sharon	Lab Crew, Lab & Data Management coordinator	
54	Harrison	Kat				80	Marcus	Laurel	Advisor	Laurel Marcus & Associates
55	Hayes	Bridget				81	McEnhill	Don	Weatherman, Captain, Hubster	
56	Heckman	Trathen				82	Meentemeyer	Ross		
57	Heckman	Trey				83	Meyers	Priscilla		
58	Herron	Elizabeth				84	Michaud	Jennifer	Captain	
59	Hocker	Lauren	RB1 Lab liaison	RB1		85	Middleton	Jess		
60	Hope	David				86	Minervini-Zick	Glenn		
61	Jensen	Andrew				87	Miranda	Willow		
62	Johnson	Eric				88	Miranda	Manuel		
63	Kates	Larry				89	Moratto	Jack and Sharon		
64	Keiran	Paul	Captain			90	Newton	Judy		
65	Kelley	Linda				91	Nibblett	Duane	Captain	
66	King	Rene				92	Nosera	Jim		
67	Klamt	Robert	Advisor	RB1		93	O'Connor	Kristen		
68	Lamont	Darlene				94	Otis	Peter	Advisor	RB1
69	Lease	Karin				95	Palmer	Kathleen		
70	Lemmer	Amy				96	Perlman	Peter		
71	Levis	A J				97	Perretty	Paula		
72	Lewis	David	Weatherman and Advisor	UC Cooperative Extension		98	Peterson	Linda	Captain	

Table A-2 (cont'd.). Russian River First Flush Participants

	Last name	First name	Role	Affiliation		Last name	First name	Role	Affiliation
99	Pyeha	John			113	Tischler	Jim	Lab Crew	RBI
100	Robinson	Beth			114	Vaugh	Chuck		
101	Rogers	Dave			115	Verdone	Lily		
102	Rowland	Cher			116	Visnu			
103	Sandler	Mike			117	Vogel	Karen		
104	Shaeffer	Sarah	Captain, Lab Crew		118	Vossen	Denny		
105	Shane	Helen			119	Waters	Joan		
106	Sherron	Mike	Captain		120	Weeks	Roger		
107	Siegle	Alan			121	Wiebe	Roland	Captain	
108	Sklar	Carol			122	Williams	Bert		
109	Slota	Dennis	Mendocino Co. Water Agency		123	Williams	Brian		
110	Smith	Samuel			124	Wright	Dale		
111	Smith-Heisters	Skaidra			125	Zabinsky	Ben		
112	Stelter	Wayne	Captain		126		Fritz		

Project Contacts									
	Contact Last name	Contact First name	Contact Role	City	Work Phone	Mobile Phone	Home Phone	Fax	email
128	Swijtink	Zeno	Volunteer Coordinator	Sebastopol	(707) 664-3192		(707) 823-1726		swijtink@sonoma.edu
129	Katznelson	Revital	Scientific Coordinator	Oakland	(510) 622-2470	(916) 947-4816		(510) 622-2460	rk@rb2.swrcb.ca.gov

Appendix D

First Flush results graphics not presented in the First Flush report

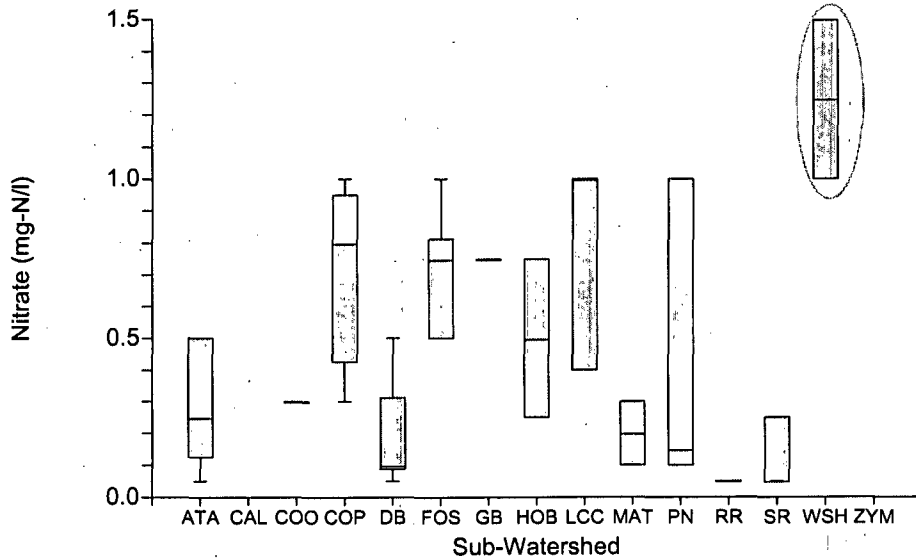
This appendix includes graphics not presented in the report, but pertinent to the First Flush effort. Results from the City of Santa Rosa's datasonde deployments and sample collection in the Laguna de Santa Rosa also are included.

Item	Page
Box and Whisker Plots by Subwatershed	2
Data Ranked by Constituent	4
Individual Stream Plots	8
Turbidity vs Suspended Solids relationship	11
Laguna de Santa Rosa sampling by the City of Santa Rosa	12

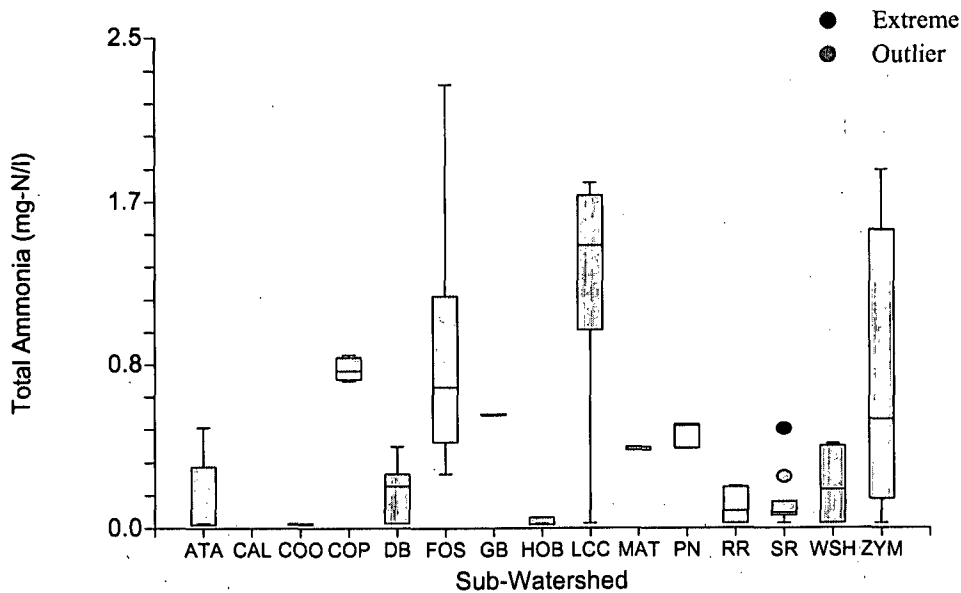
Box and Whisker Plots by Subwatershed

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.

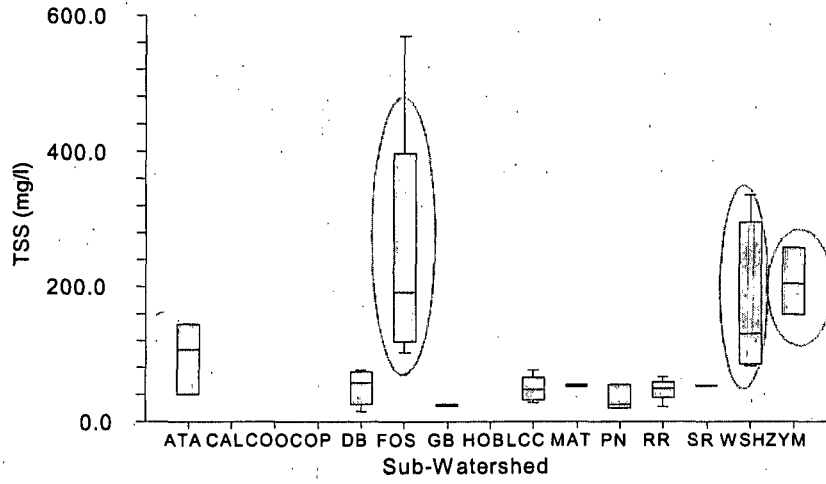
Nitrate by Sub-Watershed



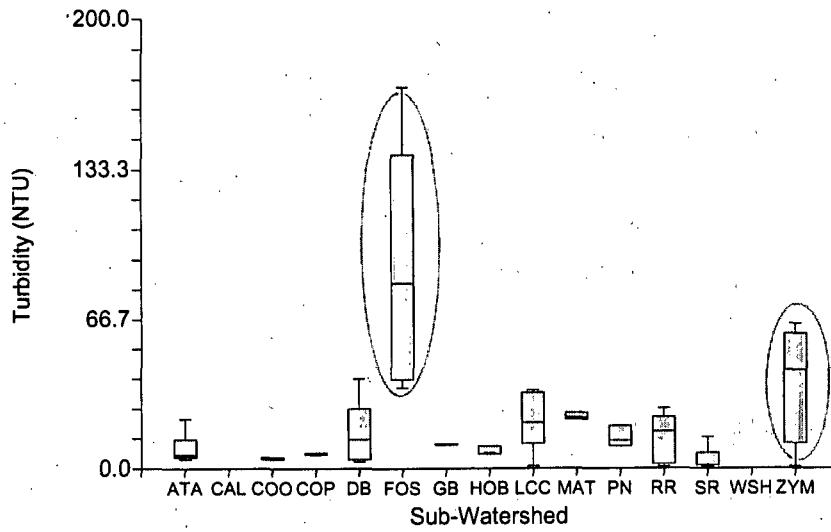
Ammonia by Sub-Watershed



TSS by Sub-Watershed

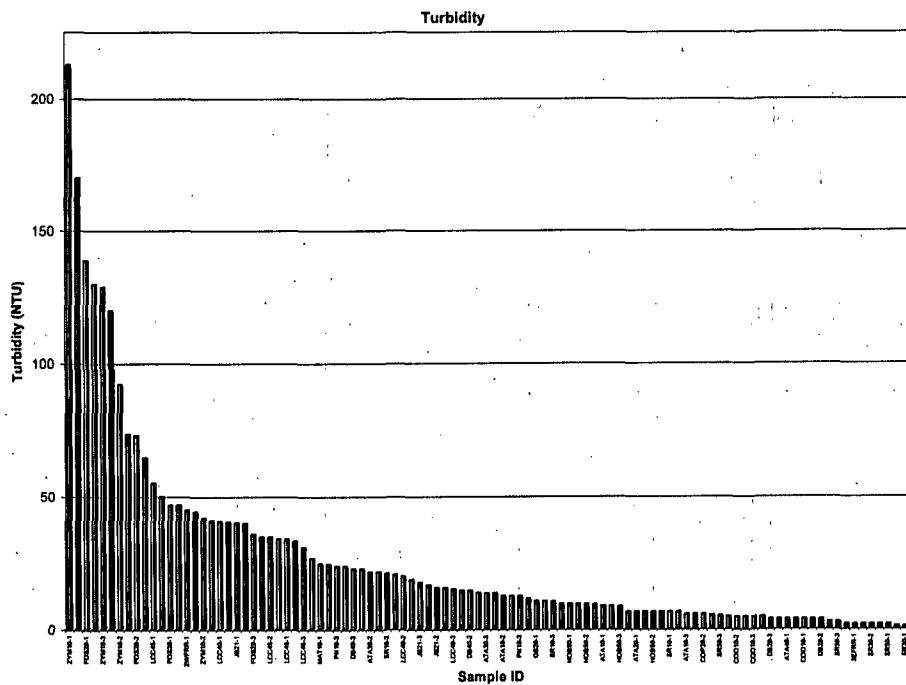
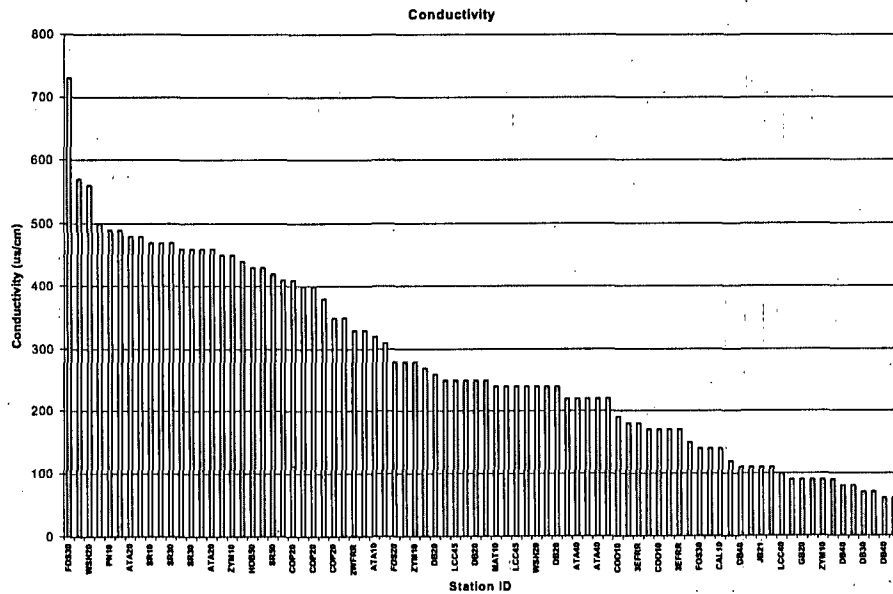


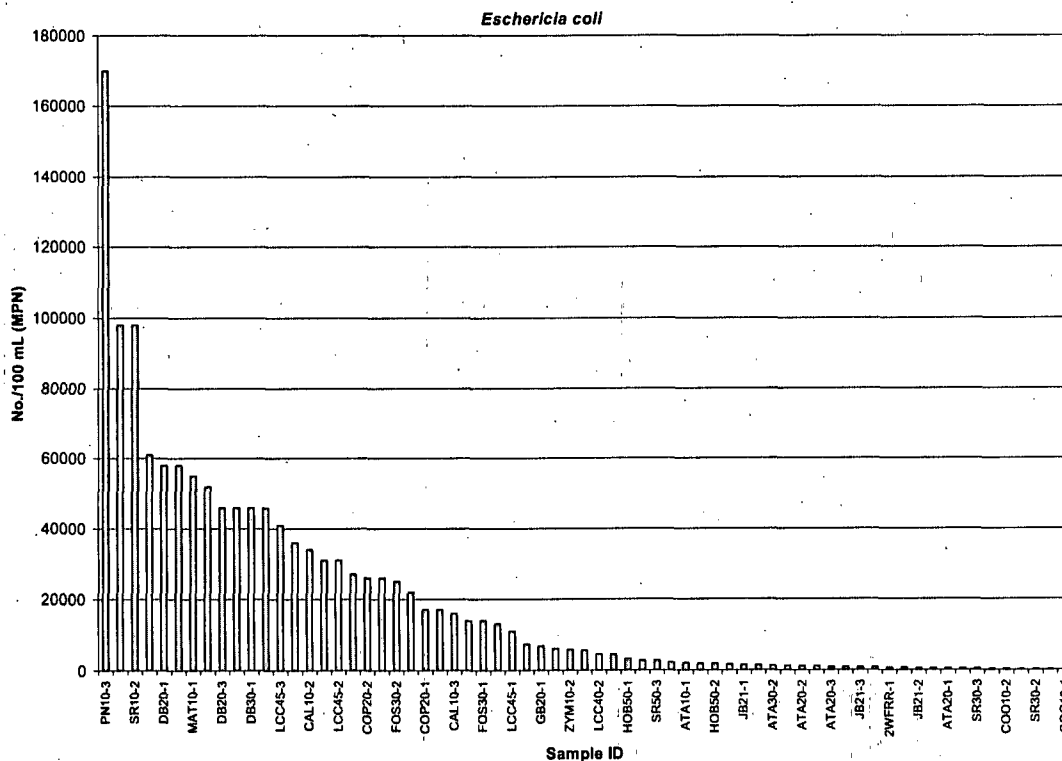
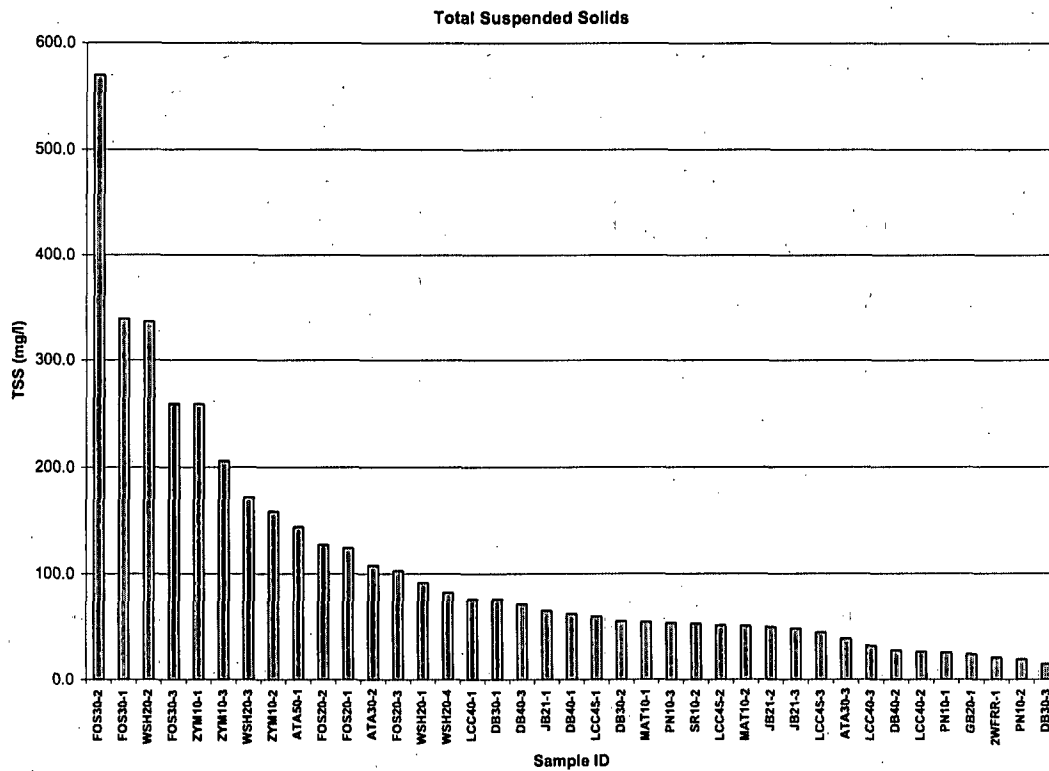
Turbidity by Sub-Watershed

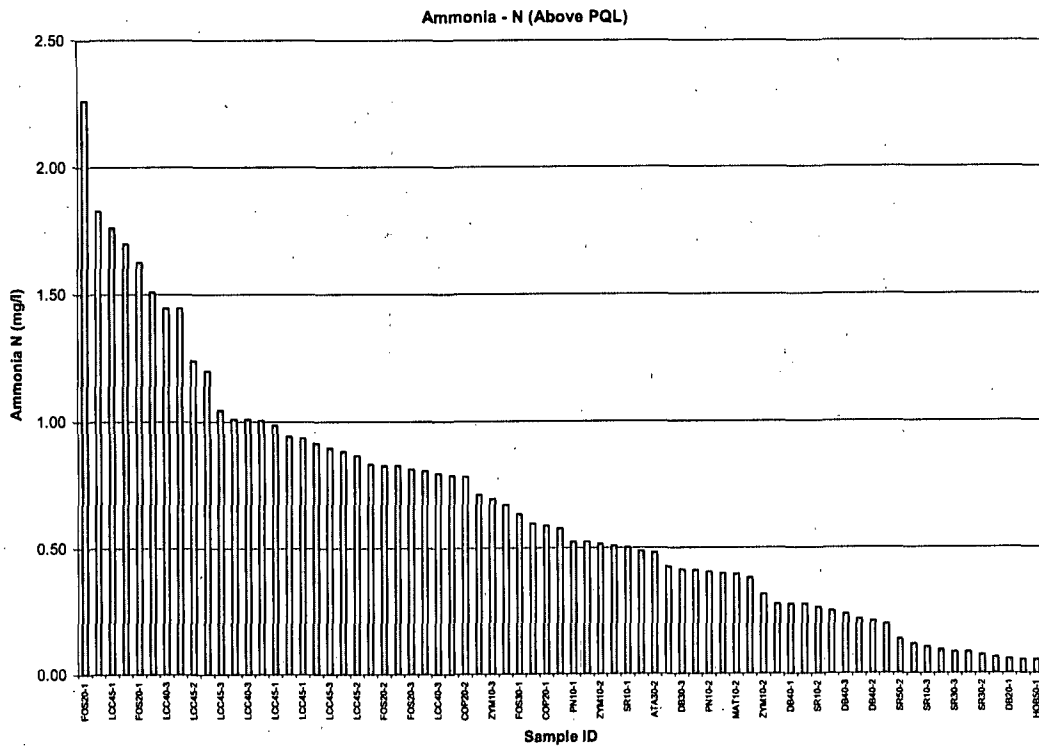
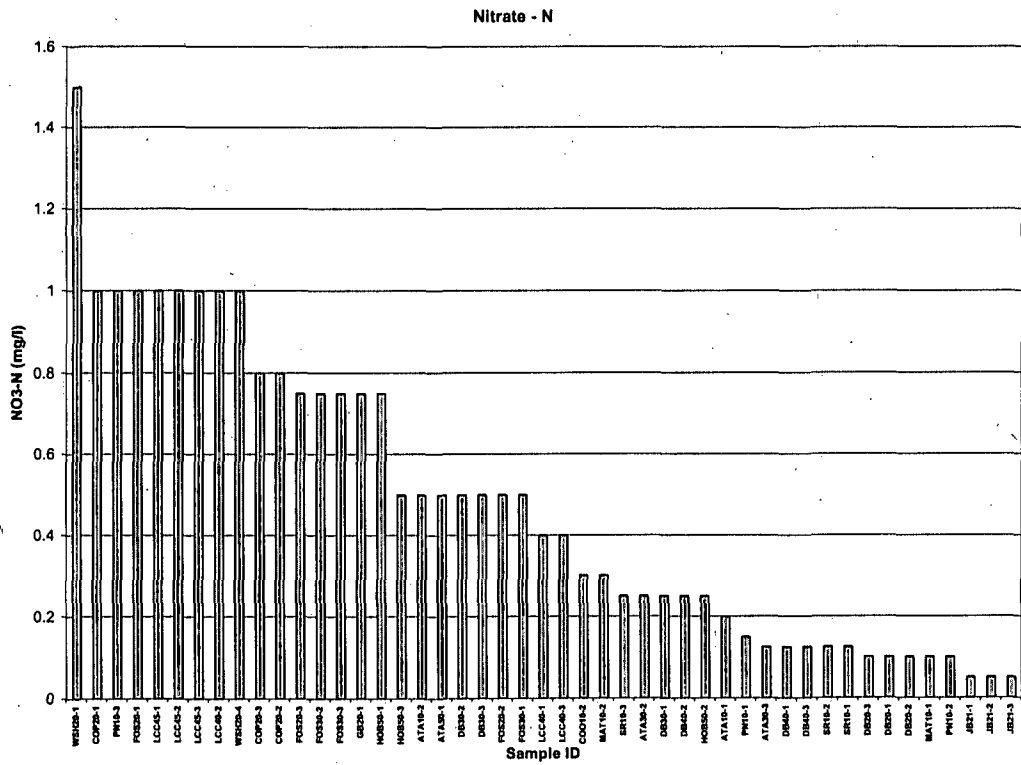


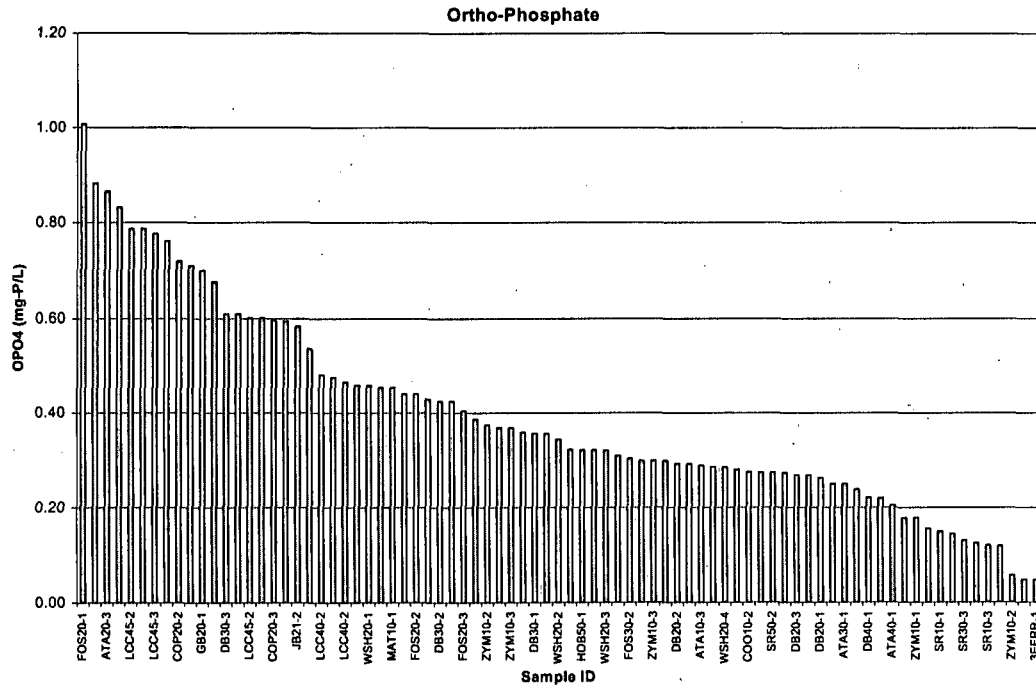
DATA RANKED BY CONSTITUENT

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.



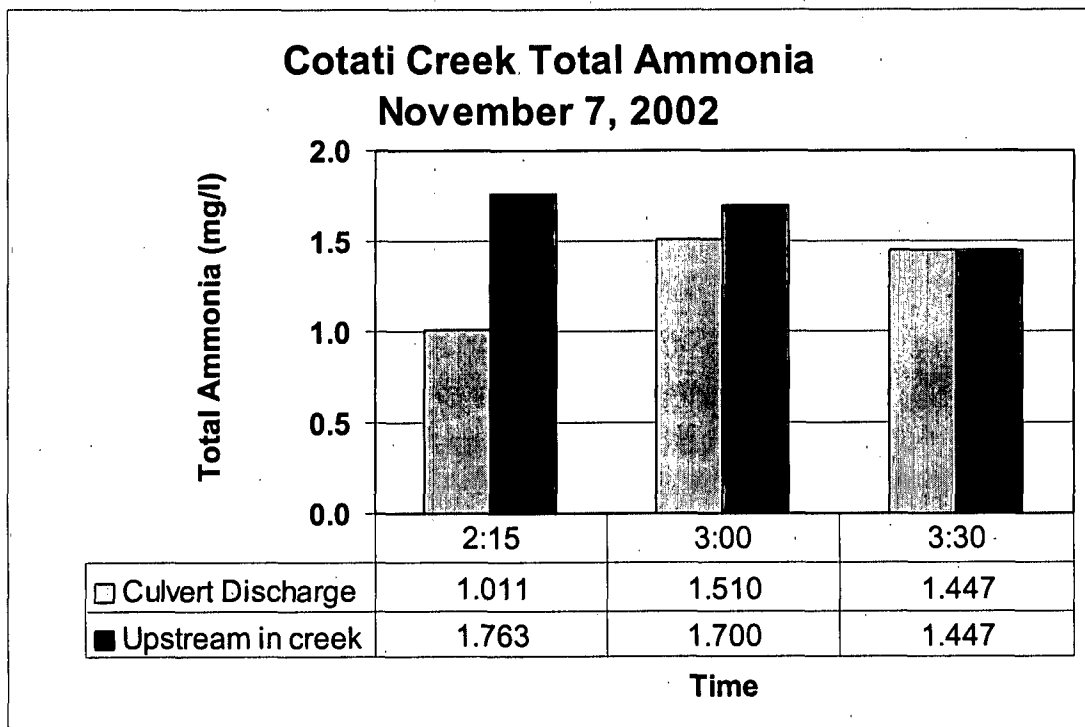
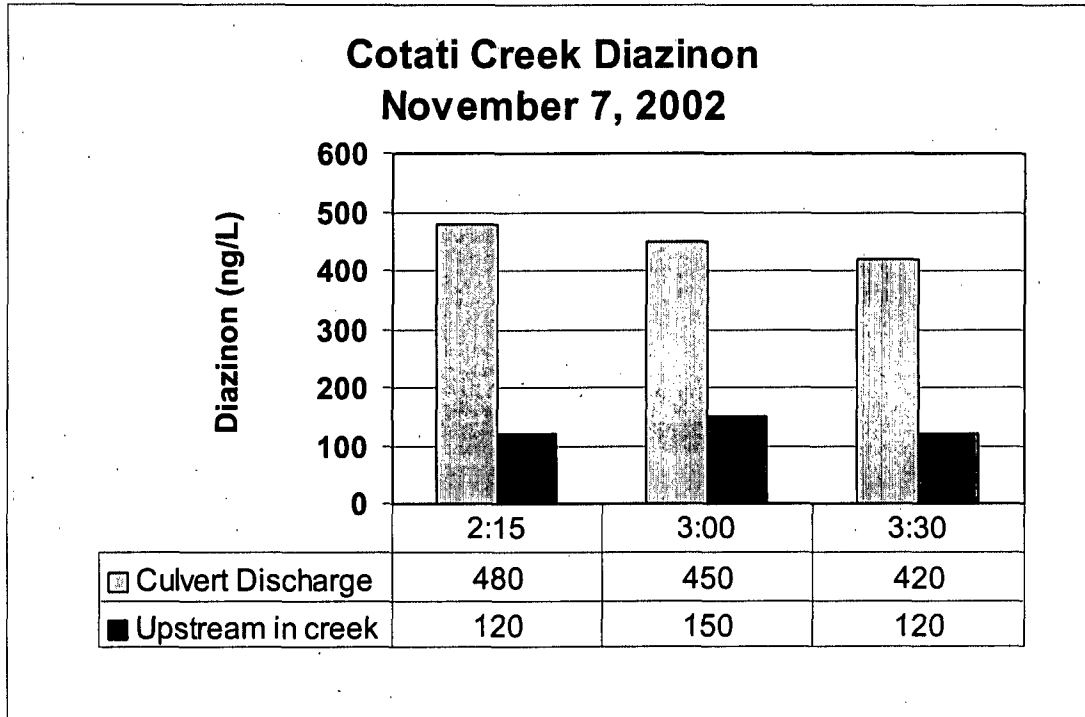


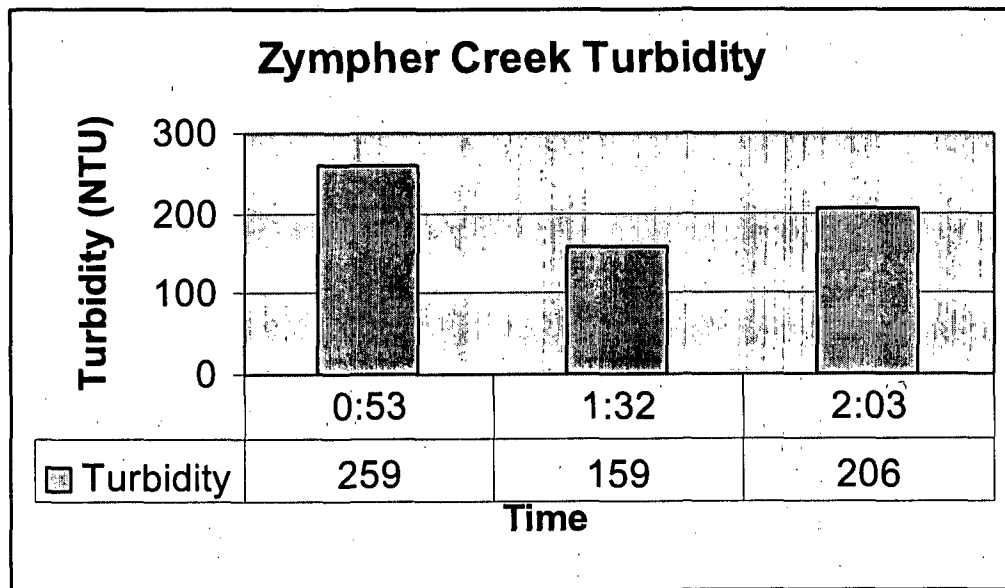
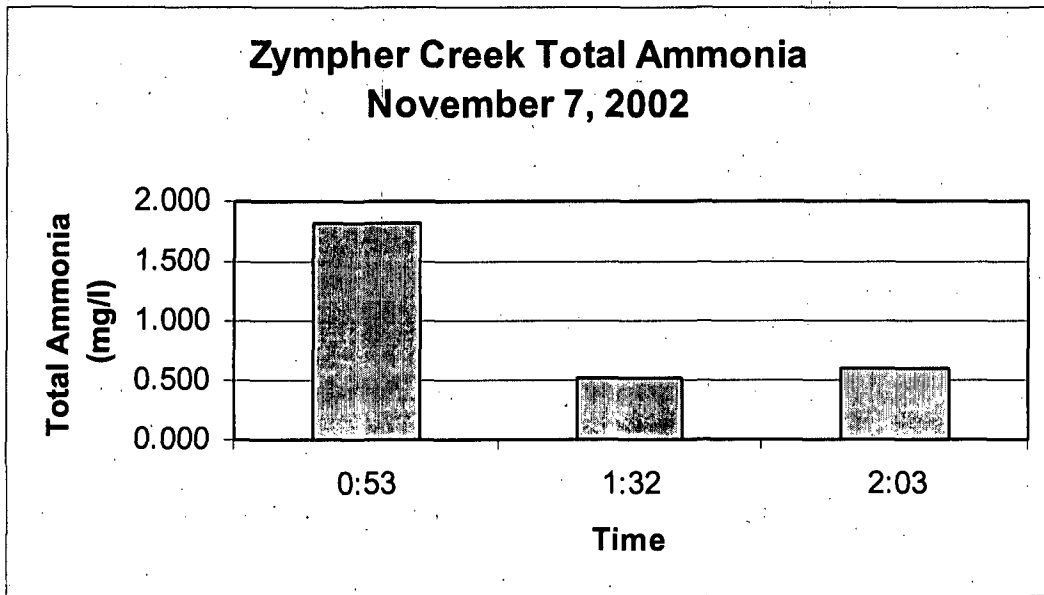


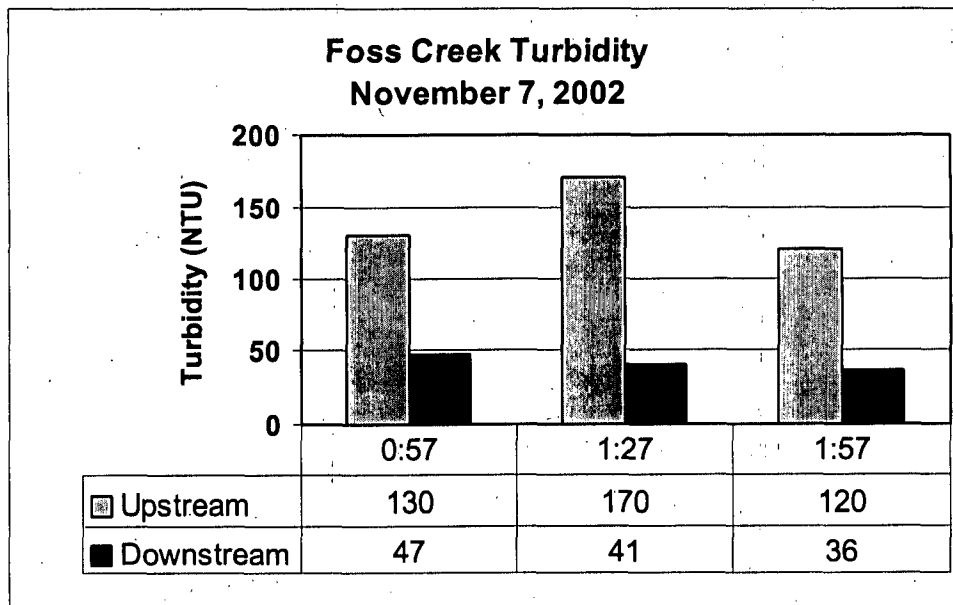
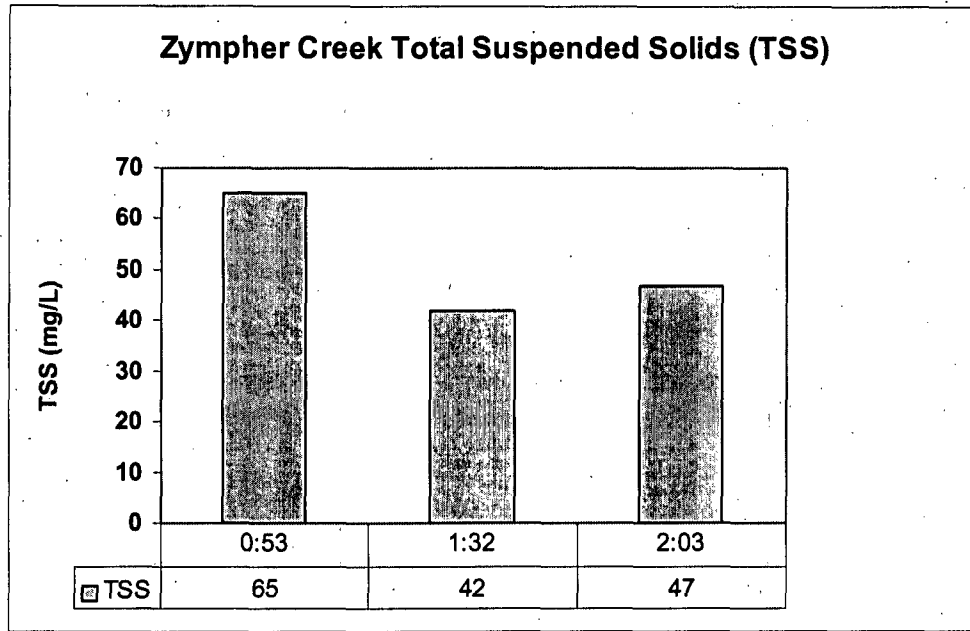


INDIVIDUAL STREAM PLOTS

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.





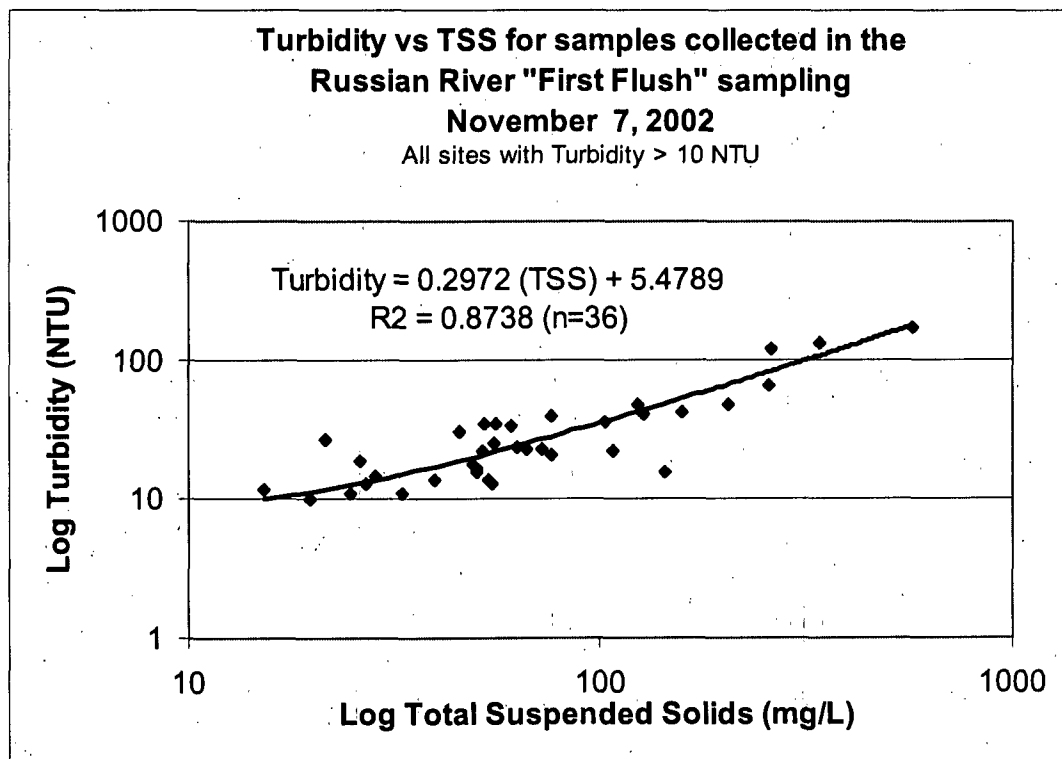


TURBIDITY vs SUSPENDED SOLIDS RELATIONSHIP

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.

Measured Parameter	Sample Time			Units
	12:05	12:35	13:05	
Specific Conductance	499	495	496	umho/cm
pH	7.8	7.8	7.8	Std. units
Water Temperature	11.6	11.7	11.8	° 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
<i>E. coli</i>	≥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

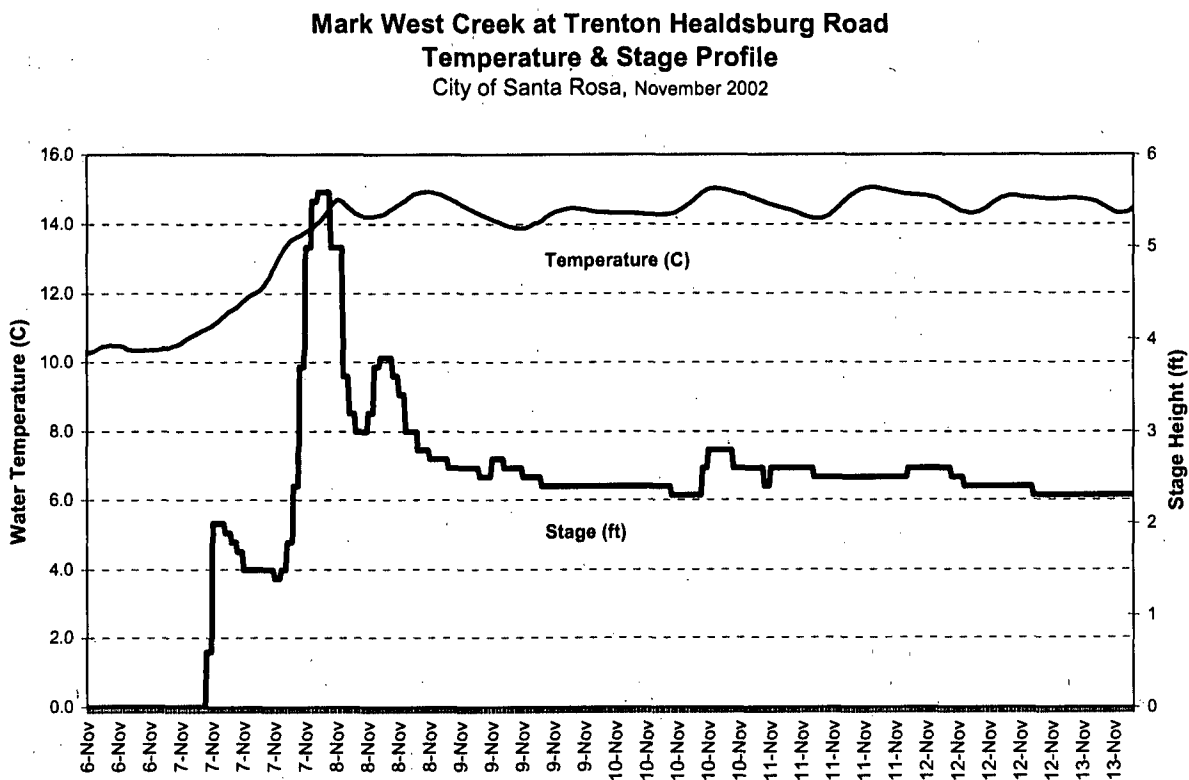
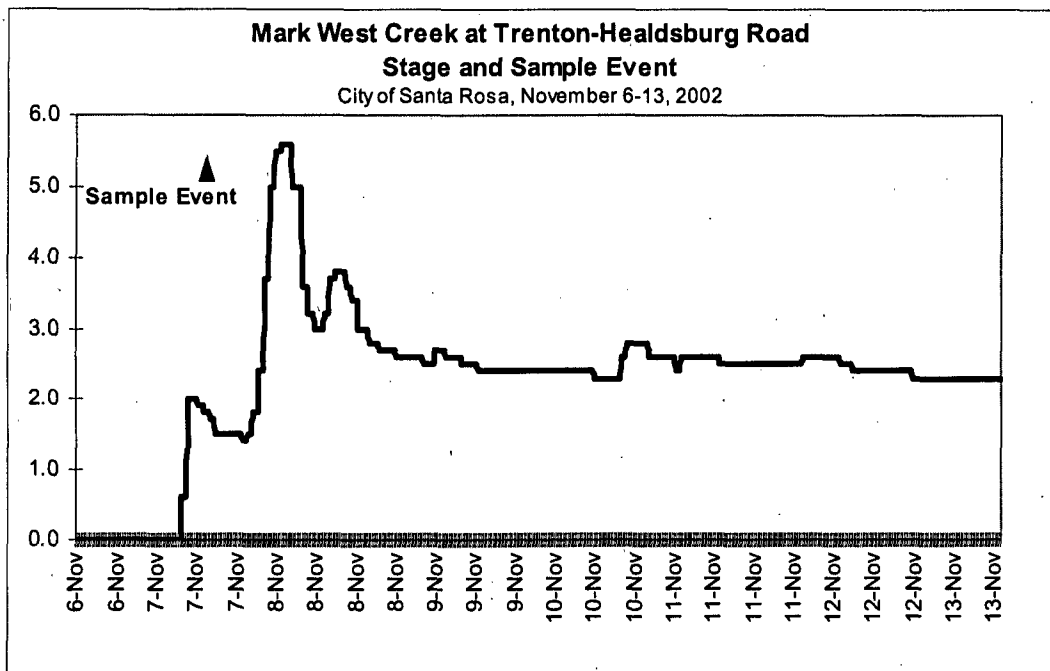
We have sampler depth for this site, as well, which gives us a rough hydrograph for the November 6-13 period. The pH dropped slightly through the period, while conductance dropped from 950-1000 umho/cm to under 200 umho/cm. Conductance peaked to 800 umho/cm for a short period at the height of the flow,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

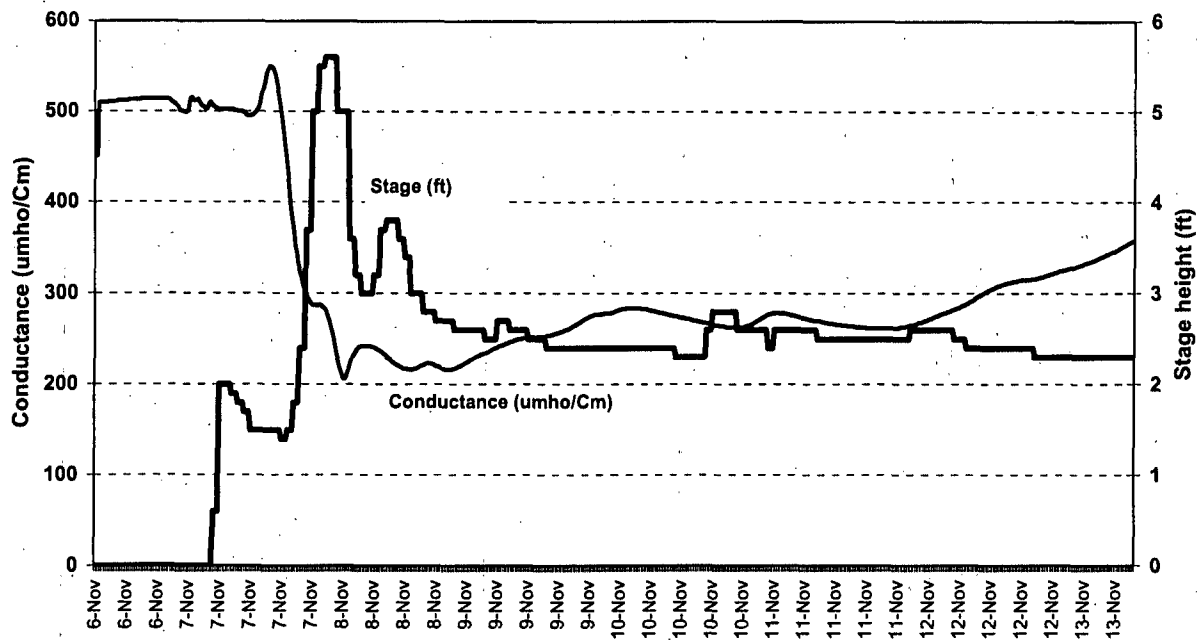
Turbidity increased from a pre-storm level of 5-20 NTU to over 90 NTU at the peak of the flow event. Turbidity decreased as the storm flows decreased, returning to a range of 10-20 NTU.

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

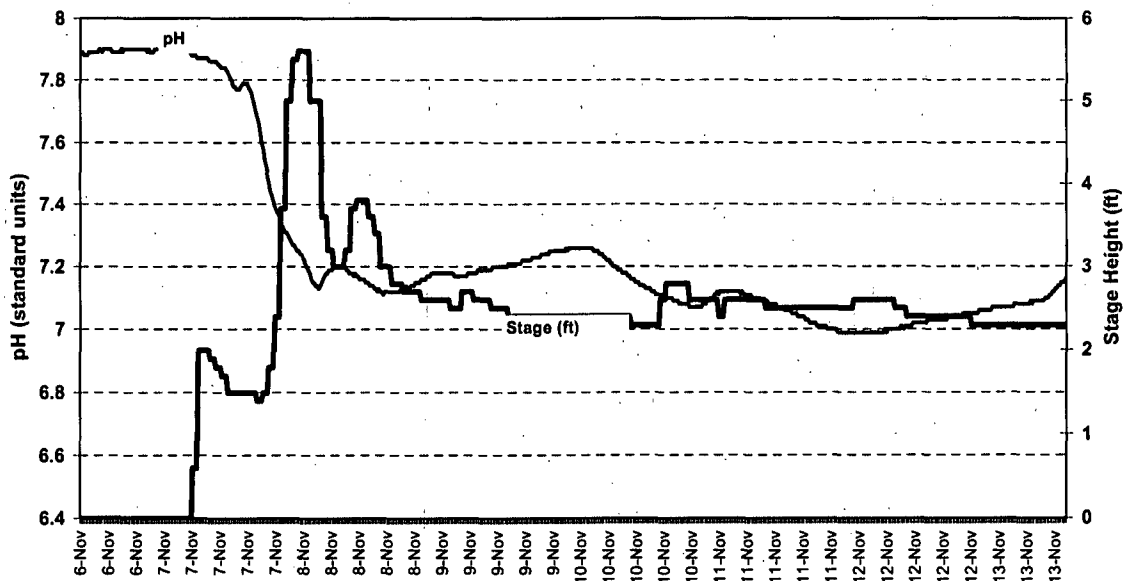
The **Laguna at Trenton-Healdsburg Road** datasonde collected data at fifteen-minute intervals from noon on Nov 6 to noon on Nov 13, 2002. Grab samples were collected at 12:02 p.m., 12:35 p.m., and 1:05 p.m. The plot below includes the stage height and the timing of the grab samples on that hydrograph.



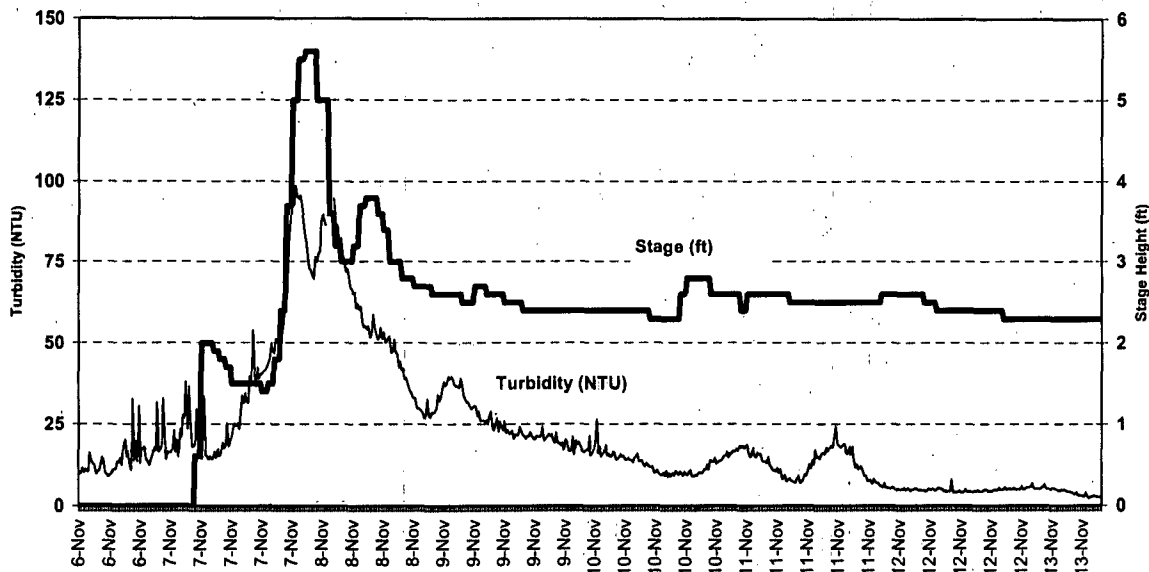
Mark West Creek at Trenton Healdsburg Road
Conductivity & Stage Profile
 City of Santa Rosa, November 2002.



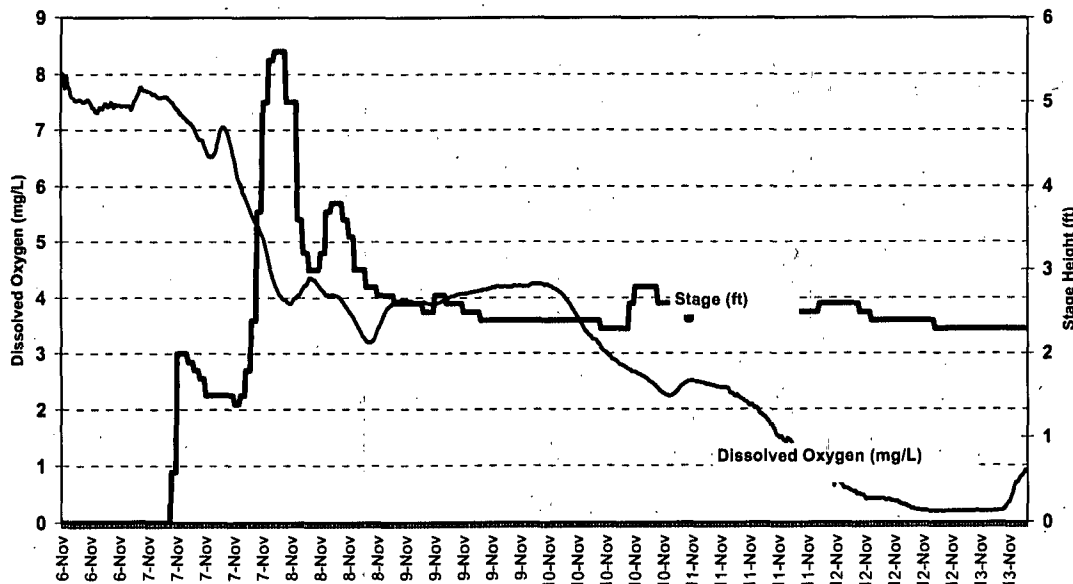
Mark West Creek at Trenton Healdsburg Road
pH & Stage Profile
 City of Santa Rosa, November 2002



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

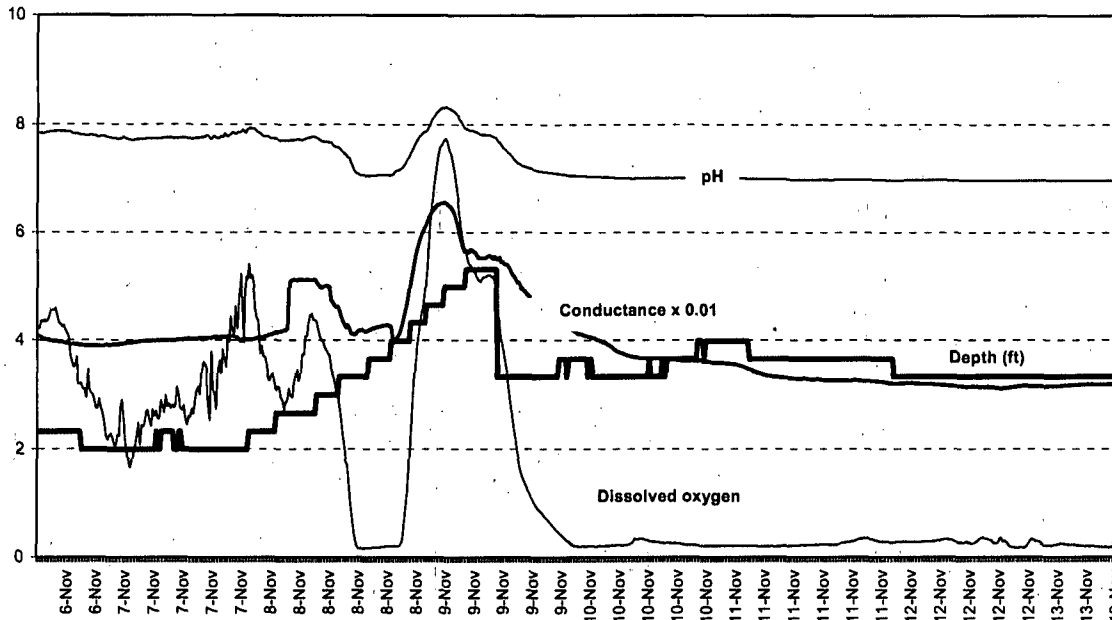


Mark West Creek at Trenton Healdsburg Road
Dissolved Oxygen & Stage Profile
 City of Santa Rosa, November 2002

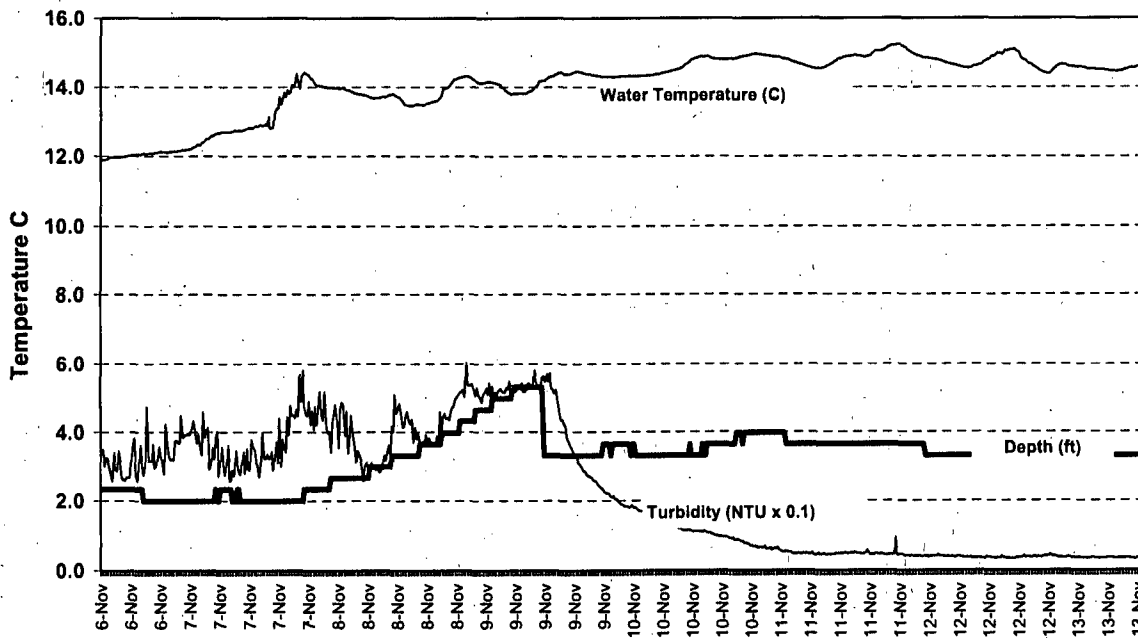


The Laguna at Occidental Road datasonde collected data at fifteen-minute intervals from 1:15 p.m. on Nov 6 to noon on Nov 13, 2002.

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

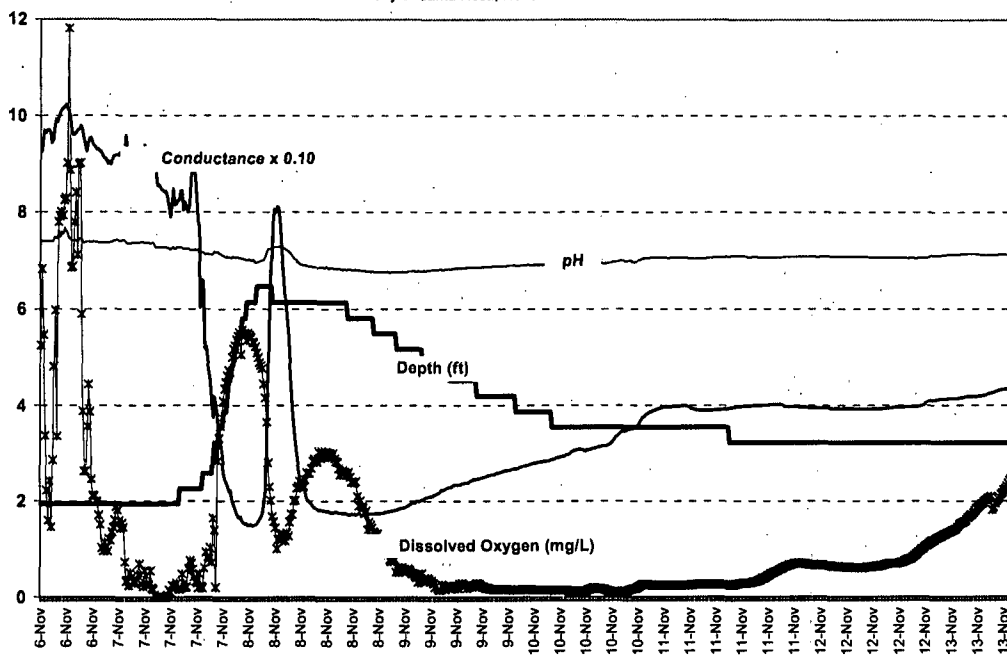


Laguna de Santa Rosa at Occidental Road
Temperature, Turbidity, and Depth
 City of Santa Rosa, November 2002



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.

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



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

