**California Department of Parks and Recreation**
**Natural Resources Division**

# Water Quality Monitoring of Streams at Wilder Ranch State Park

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**by**
**Craig Swolgaard**
**Environmental Services Intern**
**Natural Heritage Section**
**Inventory, Monitoring, and Assessment Program**
**1416 9th Street, room 923**
**Sacramento, CA 95814**
**(916) 653-6656**
**email:** cswol@parks.ca.gov

## I.) Introduction

One of the missions of the California Department of Parks and Recreation is to preserve the natural biodiversity of parklands. In keeping with this mission, the goal of the Inventory, Monitoring, and Assessment Program (IMAP) is to have a clear idea of the natural resources contained in each state park and to monitor them regularly. As part of a comprehensive program to inventory and monitor these natural resources, it is very important to adopt an ecosystem approach and to view the whole in terms of the relationships between its parts. Each stream has its own inherent water chemistry, influenced by variables such as local geology, water flow and benthic conditions. Since human activities appear to have the most severe effect on the viability of ecosystems, part of this monitoring should include these potential influences on the park resources. Streams passing through parklands, especially those adjoining private land uses, are susceptible to these influences and thus to disturbances in the aquatic ecosystem. There can be a variety of tolerances among aquatic organisms to physical and chemical ranges (Resh, et al. 1996), so knowing the baseline abiotic conditions in streams will serve as a standard for comparison when monitoring for ecosystem health. Being selective in which chemical or physical parameters are used in monitoring streams will help to clarify the source of resulting problems among the stream biota.

Wilder Ranch State Park is notable because it encloses two other properties: the Santa Cruz City Landfill and Granite Rock Sand Quarry. Also, agriculture is practiced year round on 600 leased acres of the parkland between Highway 1 and the Pacific Ocean. Adjoining the northeastern boundary of the park is the University of California, Santa Cruz campus. The surface water of the park includes three permanent streams and two intermittent streams: Majors Creek, Baldwin Creek, Lombardi Creek, Sandy Flat Gulch Creek, and Wilder Creek. The potential for negative impact on the aquatic ecosystem is apparent for all streams. One of the goals of water quality monitoring of these streams is to be vigilant for any trends in water chemistry that might adversely effect the ecosystem over time.

One person trained in basic water analysis and sampling methods collected water quality data monthly over a five-month period in 2001 (June-October). All sampling was restricted to Wilder Ranch State Park. The main questions addressed by this study include:

1.) What are the monthly trends (baseline data) in the water quality parameters?
2.) Are the levels within the limits set by the RWQCB Basin Plan, or within known tolerances of native biota?
3.) If levels are above the Basin Plan or tolerance limits, is it possible to determine the cause?
4.) Are human or animal activities in the park affecting the health of its streams?

Typically, water quality monitoring objectives either focus on getting baseline data or on evaluating potential impacts on the streams (Davis, et al. 2001). The

objective of this includes both: to establish baseline data for water quality parameters in the streams of Wilder Ranch State Park, and to watch for possible future impacts. This data will be used as a standard of measure for aquatic ecosystem functioning and as a basis of comparison for future water quality monitoring. Sample site choice is designed to detect any future impacts on water quality.

Other water quality monitoring projects are ongoing in California, including a Regional Water Quality Control Board program within the Central Coast area. The Central Coast Ambient Monitoring Program (CCAMP) seeks to gather water quality data from the Central Coast region and works with volunteer groups and state agencies to standardize methodologies and centralize databases. The Channel Coast District of California Department of Parks and Recreation is tailoring their own water quality monitoring program to the example set by CCAMP. The North Coast Watershed Assessment program has also been implemented as an interagency effort to monitor North Coast rivers and streams. All these projects carefully follow EPA and Standard Methods protocols, which should be the standard for all sampling and analysis. For information and contacts, see Appendix 1.

## II.) Methods

### A.) Development of Methodologies

The methods developed were based on guidelines developed by

1.) Regional Water Quality Control Board/ Central Coast Ambient Monitoring Program (CCAMP)
2.) California Dept. of Parks and Recreation (DPR)/ Channel Coast District
3.) National Park Service (NPS)/ Water Resources Division and Servicewide Inventory & Monitoring Program

For information and contacts, see Appendix 1. In developing the methods, it is important to consider communication across regions and agencies, as well as conformity to state and federal EPA protocols. The more standardized the methods, the more easily data can be compared regionally.

### B.) Site Selection

Sites were selected so as to maximize sample reproducibility and to be as representative of stream conditions as possible. Since the sampling locations represent the stream conditions upstream from the site, care was used in choosing sites immediately downstream from major tributaries, thus maximizing a representative view of the watershed. A minimum distance of five stream widths downstream from tributaries allows for mixing of waters (Stednick & Gilbert 1998). Also factored into the choice was any land use (e.g., agriculture) that may

impact the chemistry of the stream. For instance, pesticide analysis was to be done on samples taken downstream from areas of the park where agricultural chemicals were applied. Currently, this would include Baldwin and Lombardi Creeks. In the case of nutrients, measurements upstream and downstream from agricultural activity were taken for a base of comparison. Several sites were chosen because of their proximity to reaches used in the aquatic invertebrate monitoring study (see separate IMAP report), since data evaluation is done in the context of stream biota. Once the site location was selected, the area was searched for the best place where a water sample could be taken easily. The water depth needs to be sufficient for use of the water quality meter probe. A minimum of six inches is satisfactory. The best spots are pools, just below a riffle.

C.) Water Quality Parameters

The choice of water quality parameters was based on standards set by California Regional Water Quality Control Board and other watershed monitoring projects (DPR/Channel Coast District, CCAMP, and NPS). These parameters are believed to reflect various aspects of the biological health of streams, as well as their beneficial uses. Evaluation of water quality data should be guided both by limits of tolerance set for biota, and by the Regional Water Quality Control Board's Basin Plan. A copy of the Central Coast Basin Plan is included in the CD accompanying this report, under the file: Basin Plan. See chapter 3 for parameter limits, set for different beneficial uses of surface waters. An explanation of the importance of each water quality parameter can be found in Appendix 2 of this report. The following parameters were measured for all sample sites on all five streams at Wilder Ranch State Park:

Measured in the field (on a monthly schedule)

| Parameter (units) | Measured by |
|---|---|
| • Air temperature (°C) | Horiba U-10 Water Quality Meter |
| • Water Temperature (°C) | " |
| • Water Flow Velocity (meters/sec) | Global Water Flow Meter |
| • pH (scalar) | Horiba U-10 Water Quality Meter |
| • Conductivity (mS/cm) | " |
| • Dissolved oxygen (mg/L) | " |
| • % $O_2$ Saturation | Converting dissolved oxygen data |
| • Turbidity (NTU) | Horiba U-10 Water Quality Meter |
| • Salinity (%) | " |
| • Nitrate-N (ppm) | LaMotte Test Kit |
| • Ammonia-N (ppm) | " |
| • Unionized Ammonia (ppm) | Converting ammonia-N data |
| • Phosphate (ppm) | LaMotte Test Kit |
| • Estimated % Algal Cover | Visual Estimation |
| • Estimated % Vegetation Cover | " |

| Parameter (units) | Measured by |
|---|---|
| • Estimated % Canopy Cover | Spherical Densiometer |
| • Water transparency (scale of 0-5) | Visual Estimation |
| • Water color | " |
| • Additional observations | " |

Dissolved oxygen can be converted to % $O_2$ saturation and total ammonia-N can be converted to unionized ammonia. Conversion charts are found in Appendix 2.

Measured in the lab (once per year)

| Parameter | Measured by |
|---|---|
| • Alkalinity | EPA method 310.1 |
| • Chlorophyll a | Standard Method 10200 H (1,2) |
| • Anions ($NO_3$, $SO_4$, $PO_4$ Cl, F) | EPA method 300 |
| • Cations (Ca, Mg, Na, K) | Dionex Corp. Ion Chromatography |
| • Total Kjeldahl Nitrogen | EPA method 351.4 |
| • Total Ammonia | EPA method 350.3 |
| • Total dissolved solids | EPA method 160.1 |
| • Total suspended solids | EPA method 160.2 |
| • pH (to compare with field data) | EPA method 150.1 |
| • Fecal coliform | Standard method 9222 D (1,2) |
| • Pesticides | Various EPA methods |
| • Trace metals | EPA method 200.7 |

The Santa Cruz County Environmental Health Services Water Quality Lab was contracted to do the analysis on all parameters, except pesticides and trace metals. In order to determine which pesticides should be measured for surface water samples, the Ag Commissioner for Santa Cruz County was contacted (831-763-8080) and a list of applied pesticides for the year 2000 was secured. From this list, the agricultural chemicals applied were listed and later discussed with the manager of the OSPR Water Pollution Control lab. The chemicals known to be most toxic to aquatic organisms and most persistent in the environment were chosen to be analytes. Sampling for pesticides and trace metals were planned for within 24 hours of the first heavy rain (1" or more) in the fall or winter of 2001. Unfortunately, this part of the analysis was unable to be completed. In lieu of that, results from a 1982 study of pesticide use in Wilder Ranch State Park will be included in the "results" section of this report. Also, included in this section are historical data from a 1953 analysis of Majors and Baldwin Creeks that include some trace metals analysis.

D.) Equipment Used

The field technician took the following equipment to the sampling sites every month to perform water quality analysis:

- Horiba U-10 Water Quality Meter

- LaMotte test kits for nitrate-N, ammonia-N, and total phosphate
- Global Water Flowmeter
- Spherical Densiometer
- Clipboard with datasheets, pencils
- Water for cleaning the probes
- Container for wastewater

The following was used on the first site visit:

- Garmin GPS unit
- Compass
- Canon Digital Camera
- Ice chest with cold packs (when sampling for lab-measured parameters)
- Chain of custody forms (when sampling for lab-measured parameters)

Written protocols for operation of field equipment are found in Appendix 3.

E.) On-Site Water Quality Analysis

After site selection, during the first visit to the site, the following preliminary tasks were done:

1.) The site location was referenced using a Garmin GPS unit, and a data file was created for later downloading on computer.
2.) The UTM coordinate and data file designations were both recorded on the data sheet.
3.) Four reference photos were taken in a clockwise succession: upstream (12 o'clock), 90° clockwise (3 o'clock), downstream (6 o'clock), and 90° clockwise (9 o'clock). Upstream is then referenced directionally with a compass. The compass coordinate was recorded on the data sheet.
4.) A small map was drawn, along with a written description of the site location.

The following tasks comprised a monthly procedure that was followed:

1.) Before going to the sites, the Horiba U-10 Water Quality Meter was calibrated, using the one-point auto-calibration solution. This was done before each sampling day began.
2.) At the site, preliminary information was written on the data sheet (name, date, time, etc.).
3.) The water quality meter was taken out of its case and the power turned on.
4.) Air temperature was measured first, while the probe was dry.
5.) The probe was placed in the water (a pool, just below a riffle is the best spot to put the probe). The probe was immersed fully, but so the sensors avoided contacting the bottom of the stream. If the probe is not immersed properly, inaccurate turbidity readings can result. If the water level is too low for the probe, do not test the water. The probe was rinsed with clean water between sites.
6.) The following parameters were measured: water temperature, salinity, pH, conductivity, dissolved oxygen, and turbidity, following the instructions for

the Horiba U-10 Water Quality Meter. All measurements were written on the data sheet. Calculations for % $O_2$ saturation were done at the office.

7.) The three LaMotte kits were opened. Instructions were followed for each of the tests ($NO_3$-N, $NH_3$-N, and $PO_4$) and the results recorded on the data sheet. Samples were taken from close to midstream, at about 3-cm depth. Wastewater was disposed of in a separate, labeled container. Calculations for total $NH_3$ and unionized $NH_3$ were done at the office. If the water was too turbid, testing was not done.
8.) Water flow was measured from midstream, following the instructions of the flow meter. The resulting measurement, average velocity in meters/second, was recorded on the data sheet.
9.) Stream conditions were recorded for the section of stream approximately 10 meters upstream and downstream from the site. In-stream water color, water transparency, % algae cover and % vegetation cover were estimated from visual observation. Percent canopy cover was estimated, using a spherical densiometer. Protocols for these can be found in Appendix 3. Any additional observations of stream conditions, flora, or fauna were also recorded. Strong or unusual odors should be recorded there too.

F.) Lab-Measured Water Quality Sampling

For all lab-measured parameters, the following protocol was followed:

1.) Before going to the sites, the contracted lab was consulted, to choose the correct sample containers for each of the parameters chosen. In some cases, one container was designated for more than one parameter. Each parameter also has a holding time (i.e., allotted time in which the sample must be analyzed). The containers were placed in an ice chest with ice or cold packs, chilled to 4°C. *Note*: it is important to know beforehand what EPA methods the lab will use, so the correct containers are taken, and so any necessary preservatives can be added.
2.) The containers were labeled and given unique written identities with waterproof pens. In this case, different colored tapes matched each container to a parameter or set of parameters.
3.) Chain of custody forms were filled out and signed by the sampler.
4.) After arriving at the site, the stream water was sampled for the lab-measured parameters first, before the water quality meter was used.
5.) Containers without preservatives were rinsed twice with water from the stream and an aliquot was taken from midstream where possible, at 3-cm depth. Containers with preservatives were not rinsed!
6.) All samples were stored in the ice chest, until they arrived at the lab. Samples were delivered to the lab on the same day they were taken because of short holding times for some parameters. Consult Appendix 4 for EPA designated holding times.
7.) Upon arrival to the lab, the chain of custody was given to the lab technician to sign. A copy was kept for records. The lab technician received the samples.

G.) Quality Control

An important component to a water quality monitoring program is quality control (QC). Previously mentioned projects that followed EPA or Standard protocols were reviewed to create a simple, yet thorough QC component for this study. It is advisable to have state-certified lab contracted ahead of time, before the monitoring program is set in place. Quality controls measures were taken in this study for all aspects of water quality analysis, including:

- Making sure that all water quality probes or test kits measured parameters within EPA approved detectable limits. Specifications of all products were reviewed and customer service inquiries were made before purchase.
- Chain of custody forms (Appendix 4) were used for all lab-measured samples.
- All instruments used were calibrated regularly, according to product specifications.
- Several parameters (pH, nitrate, ammonia and phosphate) were measured both in the field and in the lab to compare results and assure accuracy.
- The lab was consulted concerning correct sample containers and/or preservatives to be used for each lab measured parameter. The lab was also consulted concerning required holding times, or field blanks and duplicates that may be necessary for certain analyses.

## III.) Findings

A.) Sample Site Locations

- Wilder Creek Down

UTM Coordinates: N 4090360 / E 582075

Directions: From the Wilder Ranch SP entrance, take Hwy 1 south about ½ mile and turn right at the farm housing (751 Highway 1). Drive through the housing area, keeping right and continue along the dirt road on the perimeter of the field. Cross the railroad tracks and park well off the road, to avoid disturbing farm operations. Walk toward the ocean, with the fence on your right until encountering the second breach. Go through the hole in the fence and down the hill into a marshy area, adjacent to Wilder Beach. Cross the opening between two stands of willows, then to the left toward Wilder Creek. The sample site is at an open spot by the creek. A red flag marks the spot.

- Wilder Creek Up

UTM Coordinates: N 4091270 / E 581567

Directions: From the Wilder Ranch SP entrance, drive past the fee kiosk and straight downhill to the Cultural Center. Turn left and pass through the buildings, keeping left. Pass under the freeway and veer right at the fork, dropping down to the corral area. Park across from the corral before passing the cabin and barn. The creek will be on the right, with a large oak stump at the fence line. Enter the creek area by passing around the oak stump, and stay to the right while approaching the creek. Access the creek through a clearing and cross it to a small sandy area.

- Wilder Creek Reach

UTM Coordinate: N 4093610 / E 582593 (note: estimated from GIS map)
Directions: Enter the park through the Twin Gates entrance and follow the dirt road to the first fork. Take the left fork (Long Meadow Trail) and stay on this road until reaching the Lime Kiln area (4 – 5 km). Park and walk down the trail toward Wilder Creek. This trail passes by the old kilns and goes downhill to Wilder Creek (~3/4 km). The site is about 30 meters downstream from the confluence of Cave Gulch and Wilder Creek. It is also used as a reach for the aquatic invertebrate study.

- Sandy Flat Gulch Creek Down

UTM Coordinates: N 4090250 / E 580882
Directions: From the Wilder Ranch SP entrance, drive into the park, turning right at the first gravel road. Follow this road downhill and turn right immediately after the railroad tracks. The road veers left and up a small incline. Make a sharp left at the top and follow the road with Sandy Flat Gulch on the left, and an agricultural field on the right. Park the car off the road where a sign points to a trail which descends down the slope toward the beach. At the bottom, the trail traverses a rocky shelf next to the creek. This is the site.

- Lombardi Creek Down

UTM Coordinates: N 4091095 / E 578986
Directions: From the Wilder Ranch SP entrance, drive into the park, turning right at the first gravel road. Follow this road downhill and turn right immediately after the railroad tracks. The road veers left and up a small incline. Go straight on this road, keeping the tracks to the right. After crossing Lombardi Creek, turn left and follow the road toward the ocean bluffs. Park at the bluff, above the beach. Take the trail downhill and go to the marshy area on the left. The site is at the water's edge, across from a large, fallen tree trunk.

- Baldwin Creek Down

UTM Coordinates: N 4091555 / E 578053
Directions: From the Wilder Ranch SP entrance, take Hwy 1 north about 4 km, crossing Baldwin Creek. Turn left to a green metal gate, across Hwy 1 from Four Mile Produce (a vegetable stand). After entering, drive across the railroad track, turning left, and go straight. After crossing over Baldwin Creek, turn right at the first dirt road, down toward the beach. Park and walk toward the beach, crossing over a small culvert. The site is to the right, just downstream from where the culvert joins the creek.

- Baldwin Creek Up

UTM Coordinate: N 4092212 / E 578023
Directions: From the Wilder Ranch SP entrance, take Hwy 1 north about 4 km. Before crossing Baldwin Creek, pull off to the right and park where a gated driveway goes down toward a private residence. Walk through the gate and

downhill, turning right onto a trail that hugs the fence line of the residence. Take the trail toward the ravine where the creek is. Pass an old barn and a fenced corral on the left. About 25 meters past the end of the property, there is a clearing between the trail and the creek. Descend there, crossing the fence. The site is right there, at a small pool. This is also a reach for the aquatic invertebrate study.

- Baldwin Creek Reach

UTM Coordinate: N 4094150 / E 579372 (note: estimated from GIS map)
Directions: Enter the park through the Twin Gates entrance and follow the dirt road to the first fork. Take the right fork (Chinquapin Trail) and stay on this road until reaching the eucalyptus grove. Turn right and follow for about 1 km until reaching the intersection of the Enchanted Loop trail. Park and follow the Enchanted Loop trail northward, where it eventually descends to Baldwin Creek. After almost 1 km, the trail enters a forest of redwood and tanoak. Stay on the trail another 100 meters or so, turning right where another trail drops down to cross the creek. The site is about 15 meters upstream, where the creek cuts into the bank. This is also used as a reach for the aquatic invertebrate study.

Majors Creek Up
UTM Coordinate: N 4093174 / E 576703 (taken at a fork in the road)
Directions: From the Wilder Ranch SP entrance, take Hwy 1 north about 5 or 6 km. After crossing Majors Creek, across from Scaroni Road, turn right onto a dirt road with a wooden gate. A key is needed to unlock the gate and permission should be asked to enter the property. Both can be acquired at the campground located across Hwy 1 and down Scaroni Road to the beach. Ask for Ralph, the owner. After opening the gate, drive down to a fork in the road (the UTM coordinate). Park and take the right fork to where the road crosses Majors Creek. The site is at the downstream side of the crossing, where the water drops off somewhat.

- Majors Creek Reach

UTM Coordinate: N 4094862 / E 578057 (note: estimated from GIS map)
Directions: From the Wilder Ranch SP entrance, take Hwy 1 north about 5 km. Before crossing Majors Creek, turn right onto a paved road that passes through a metal gate and onto the park. Take this road uphill about 1 km. At the fork in the road, turn left. Follow the road as it descends into Majors Creek canyon. The road ends at the City of Santa Cruz water supply reservoir. Park and go downstream about 100 meters from the dam. The site is just upstream from a tangle of tree trunks, at a small pool. This is also used as a reach for the aquatic invertebrate study.

Sample site map

The following map shows the locations of all ten sampling sites used in the monitoring study. The key is as follows:

| Sample Site | Symbol |
|---|---|
| Wilder Creek Down | WCD |
| Wilder Creek Up | WCU |
| Wilder Creek Reach | WCR |
| Sandy Flat Gulch Creek Down | SFGCD |
| Lombardi Creek Down | LCD |
| Baldwin Creek Down | BCD |
| Baldwin Creek Up | BCU |
| Baldwin Creek Reach | BCR |
| Majors Creek Up | MCU |
| Majors Creek Reach | MCR |

Sample site photos

Following the map is a series of photographs, showing the equipment used and some sample sites.

B.) Field Data Forms

A copy of the field data form used in the study is presented on the following page.

C.) Summary of Data

Following the field data form are the results of all water quality analyses done in Wilder Ranch State Park by IMAP, and past data from other agencies.

They are presented in the following order:
1.) Spreadsheets of the data from the 2001 field season by IMAP
2.) Graphs of some of the data from the 2001 field season by IMAP
3.) A list of pesticides used in the 2000 growing season
4.) STORET analytical data of both Baldwin and Majors Creeks from 1953
5.) A short review of a 1982 pesticides study at Wilder Ranch State Park

On the CD that accompanies this report will be found a GIS map, showing the sample site locations, roads, and boundaries of the watersheds in the park. Each watershed can be broken up into individual catchment basins. These Arcview themes will assist the user in visualizing the origins of surface water and may help in tracing the possible sources of contaminants.

## 1982 Pesticide Study

In 1982 the California Department of Food and Agriculture reported the results of a two-year study to determine the presence or absence of pesticide residues in the air, soil, and water of Wilder Ranch State Park. Several samples were taken from Baldwin and Wilder Creeks, both upstream and downstream from agricultural activity, after the 1981 and 1982 growing seasons. Both water column and sediment samples were analyzed for the major groups of pesticides being used. These included chlorinated hydrocarbons, organophosphates, and carbamates. In both streams, no pesticide residues were detected at any time during the study.

D.) Statistical Analysis: 2001 Stream Data

Air Temperature:
Seasonal Mean for Wilder Ranch State Park = 16.8 °C

Water Temperature:
(Seasonal Mean)

| | |
|---|---|
| Majors Creek Reach- 13.3 (°C) | Lombardi Creek Down- 22 (°C) |
| Majors Creek Up- 13.6 (°C) | Sandy Flat Gulch Down- 17.7 (°C) |
| Baldwin Creek Reach- 13.7 (°C) | Wilder Creek Reach- 13.0 (°C) |
| Baldwin Creek Up- 13.8 (°C) | Wilder Creek Up- 15.0 (°C) |
| Baldwin Creek Down- 21.8 (°C) | Wilder Creek Down- 19.2 (°C) |

pH:
(Seasonal Mean/ Range)

| | |
|---|---|
| Majors Creek Reach- 8.1 / 7.8-8.4 | Lombardi Creek Down- 7.7 / 7.3-8.2 |
| Majors Creek Up- 7.9 / 7.7-8.2 | Sandy Flat Gulch Down- 7.6 / 7.4-7.9 |
| Baldwin Creek Reach- 8.0 / 7.8-8.2 | Wilder Creek Reach- 7.9 / 7.7-8.1 |
| Baldwin Creek Up- 7.9 / 7.6-8.2 | Wilder Creek Up- 8.0 / 7.7-8.3 |
| Baldwin Creek Down- 8.8 / 8.1-9.5 | Wilder Creek Down- 8.0 / 7.8-8.2 |

Conductance (mS/cm):
(Seasonal Mean/ Range)

| | |
|---|---|
| Majors Creek Reach- 0.31 / 0.31-0.31 | Lombardi Creek Down- 2.1 / 1.6-3.2 |
| Majors Creek Up- 0.39 / 0.36-0.41 | Sandy Flat Gulch Down- 2.7 / 1.3- 4.2 |
| Baldwin Creek Reach- 0.43 / 0.42-0.43 | Wilder Creek Reach- 0.43 / 0.42-0.43 |
| Baldwin Creek Up- 0.42 / 0.39-0.43 | Wilder Creek Up- 0.42 / 0.41-0.43 |
| Baldwin Creek Down- 6.7 / 1.7-9.0 | Wilder Creek Down- 0.93 / 0.44-2.7 |

Dissolved Oxygen (mg/L):
(Seasonal Mean/ Range)

| | |
|---|---|
| Majors Creek Reach- 9.5 / 8.4-11 | Lombardi Creek Down- 14 / 8.0-17 |
| Majors Creek Up- 9.0 / 7.6-10 | Sandy Flat Gulch Down- 11.8 / 6.2-20 |
| Baldwin Creek Reach- 8.4 / 8.1-9.0 | Wilder Creek Reach- 9.3 / 9.3-9.6 |
| Baldwin Creek Up- 7.5 / 6.3-8.6 | Wilder Creek Up- 7.8 / 6.5-10 |
| Baldwin Creek Down- 10.7 / 6.4-15 | Wilder Creek Down- 8.7 / 7.1-11 |

% Oxygen Saturation:
(Seasonal Mean/ Range)

| | |
|---|---|
| Majors Creek Reach- 91 / 82-105 | Lombardi Creek Down- 162 / 83-209 |
| Majors Creek Up- 87 / 74-95 | Sandy Flat Gulch Down- 123 / 62-206 |
| Baldwin Creek Reach- 81 / 77-87 | Wilder Creek Reach- 93 / 89-100 |
| Baldwin Creek Up- 72 / 61-83 | Wilder Creek Up- 78 / 67-97 |
| Baldwin Creek Down- 121 / 69-168 | Wilder Creek Down- 92 / 73-118 |

Turbidity (NTU):
(Seasonal Mean/ Range; sites not included had a mean of 0 NTU)
Baldwin Creek Down- 7.6 / 4-10
Lombardi Creek Down- 63 / 32-110
Sandy Flat Gulch Down- 43 / 30-60
Wilder Creek Down- 3.2 / 1-10

E.) Discussion

The pH levels for the three permanent streams are within the limits set by the Basin Plan for most water uses, however their ranges are high enough to go over those limits during the late summer. The dissolved oxygen levels were good in streams above sea level, but the estuaries of Baldwin and Lombardi Creeks were extremely high for most of the summer. As the summer progresses the water flow is reduced, the water temperature increases, as does the algae levels (see chlorophyll-a results). Since aquatic plants produce oxygen during photosynthesis, dissolved oxygen levels would be expected to be higher during the afternoon than in the morning. Data from Baldwin Creek Down appears to confirm this (see August and September).

High levels of TDS, chloride, and sodium were expected for the estuary portions of the streams, being in contact with marine waters. The nutrient levels were low all summer for all streams in Wilder Ranch State Park. One exception was the phosphate level of Baldwin Creek Down. During the months of August- October, the phosphate level was 1-7 ppm (mg/L). In October, the reservoir just upstream from the sampling site was tested and found to be <1ppm, while at the sampling site it measured 1 ppm. The fecal coliform levels in Wilder and Baldwin Creeks were fairly high when tested in June. It is thought that the feral pig activity upstream may have been a factor.

## IV.) Data Management

All data was recorded at the sampling site. Care is taken to include units in recording data. Before returning, the sampler reviews the data, checking for errors or missing data. Copies were made of the field data when the sampler returned to the office and are stored in separate files. The original data was transferred to a Microsoft Excel spreadsheet and stored on the computer's hard drive. A copy of the spreadsheet is stored on a separate hard drive.

In addition to this printed report is a CD containing:

- a copy of the report.
- a folder containing Internet references for water quality programs.
- all databases.
- a copy of the Central Coast Basin Plan (.pdf file).
- all photos of sample sites (.jpeg files).

- GIS map of Wilder Ranch State Park with water quality sample sites (in "Wq_av" folder, under project: *water_quality.apr*. All associated files, required for running Arcview, are included.
- GPS rover files (.shp files)- these have the actual corrected UTM coordinates.

## V.) Future Monitoring

### A.) Suggested Modifications in Methodology

- It may be a good idea to add a couple sampling stations on the intermittent streams. Monitoring could be done monthly during the wet season, when water is flowing. One station, located on Sandy Flat Gulch Creek, upstream from the sand quarry, where Wilder Ridge Loop trail crosses would add baseline data to that part of the stream within the park boundary, and would serve as a base of comparison with the SFGCD data. If accessible, a station along Lombardi Creek, upstream from the city dump could serve the same purpose for that stream.
- During the study, a calibration log was not used for the water quality meter. This would be a good quality assurance idea, for keeping a record of both one-point and two-point calibrations.
- It was not possible to take samples from the middle of Wilder Creek Down because of its width and depth. Use of waders or an extension pole for sampling would help.
- As a part of the monthly monitoring, it is recommended that water depth also be measured for each stream, at a strategically placed site. A permanent depth gauge should be put in place. This would be especially useful at the downstream estuary sites, where water flow is not detected, but water levels do fluctuate throughout the year. Another site at a higher elevation would also be useful.
- Because dissolved oxygen levels fluctuate throughout the day, be sure to stagger the testing times between morning and afternoon, especially for the estuaries.
- The methodologies for % algal cover and % vegetation cover may need to be improved upon, using some means of metric measure.

### B.) Practical Recommendations

- On-site sampling of the ten sites at Wilder Ranch State Park should be done on a monthly basis.
- Lab measured parameters should be tested for once a year, preferably in spring. If two people work together, all sampling would take one day.
- It is recommended that Baldwin and Lombardi Creeks both be tested once for pesticide residues and that all creeks be tested once for trace metals. Costs may be prohibitive.
- Once the personnel are habituated to use of the water quality meter and test kits, one person can test all sampling sites in 10-12 hours.

- If for any stream, parameters measure above the Basin Plan limits, they should be remeasured and monitored more closely (i.e. on a daily basis, for one week). If at any time unusual stream conditions are observed (fish kills, sudden increase in turbidity), the water should be tested immediately, both at the disturbance site and several upstream reference sites. It is a good idea to have several clean 1 L sample bottles on hand in case a sample needs to be rushed to a lab.

## References

Literature:

Davis, Jeffery C., et al. 2001. Monitoring wilderness stream ecosystems. Gen. Tech. Rep. RMRS-GTR-70. Ogdon, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.
(Available from Rocky Mountain Research Station, 970- 498-1392 or email: rschneider@ fs.fed.us)

Resh, Vincent H, Mailyn J. Meyers, and Morgan J. Hannaford. 1996. Macroinvertebrates as biotic indicators of environmental quality. *In* Methods in stream ecology, (Hauer, F. Richard and Gary A. Lamberti, eds.). Academic Press. New York, NY.

Stednick, John D. and David M. Gilbert. 1998. Water quality inventory protocol: riverine environments. Tech. Report NPS/NRWRD/NRTR-98/177, National Park Service, Water Resources Division, Fort Collins, CO.
(Available from National Park Service, 970-225-3500 or 303-969-2130)

Internet:

A directory of helpful Internet websites has been added to CD accompanying this report.

# Appendix 1

# Contacts

The following is a list of people that were contacted for guidance in developing the methodologies or for lab analysis of stream water samples:

Karen Worcester: Regional Monitoring Program Coordinator (for CCAMP), Central Coast Regional Water Quality Control Board
She is invaluable as a resource for monitoring strategies and assessment of water quality measurements. She was the main contact for questions and advice concerning water quality parameters and methodologies.
Phone: (805) 549-3147
Email: kworcest@rb3.swrcb.ca.gov

Virginia Gardener: Associate State Park Resource Ecologist, Channel Coast District, California Department of Parks and Recreation
She has been working on a surface water monitoring project since the year 2000. She provided IMAP with a binder of information, including protocols with lots of good ideas.
Phone: (805) 899-1412
Email: vgard@parks.ca.gov

John Ricker: Environmental Health Laboratory Supervisor, Santa Cruz County Environmental Health Services
He was contacted first to see if their water quality lab could do analysis. He agreed to do lab work on a "one-time" basis.
Phone: (831) 454-2022

Robert Golling: Water Quality Chemist, Santa Cruz County Environmental Health Services
He is the chemist who did the lab work and who was consulted with concerning sample containers, etc.
Phone: (831) 454-4624
Email: Env031@co.santa-cruz.ca.us

Ray Oslowski: Director of Sales and Marketing, California Laboratory Services
Ray was contacted to get a quote for lab work. California Laboratory Services is a high quality, state certified environmental lab operating in the Sacramento area.
Phone: (800) 638-7301

Rachel Wilcox: Client Services Representative, BSK Analytical Laboratories
I spoke with her to get a quote for lab work. This lab is in Fresno.
Phone: (800) 877-8310

Dave Crane: Director, Water Pollution Control Lab (OSPR), California Department of Fish and Game
He was consulted with concerning lab analysis for pesticides and metals, and was very knowledgeable and helpful.
Phone: (916) 358- 2859
Email: DCrane@ospr.dfg.ca.gov

# Appendix 2

# Water Quality Parameters

The following information is an excerpt from *EPA Volunteer Monitoring: A Methods Manual* (Internet version: http://www.epa.gov/volunteer/stream/index.html)

## *What is turbidity and why is it important?*

Turbidity is a measure of water clarity how much the material suspended in water decreases the passage of light through the water. Suspended materials include soil particles (clay, silt, and sand), algae, plankton, microbes, and other substances. These materials are typically in the size range of 0.004 mm (clay) to 1.0 mm (sand). Turbidity can affect the color of the water.

Higher turbidity increases water temperatures because suspended particles absorb more heat. This, in turn, reduces the concentration of dissolved oxygen (DO) because warm water holds less DO than cold. Higher turbidity also reduces the amount of light penetrating the water, which reduces photosynthesis and the production of DO. Suspended materials can clog fish gills, reducing resistance to disease in fish, lowering growth rates, and affecting egg and larval development. As the particles settle, they can blanket the stream bottom, especially in slower waters, and smother fish eggs and benthic macroinvertebrates. Sources of turbidity include:

- Soil erosion
- Waste discharge
- Urban runoff
- Eroding stream banks
- Large numbers of bottom feeders (such as carp), which stir up bottom sediments
- Excessive algal growth.

## *Why is phosphorus important?*

Both phosphorus and nitrogen are essential nutrients for the plants and animals that make up the aquatic food web. Since phosphorus is the nutrient in short supply in most fresh waters, even a modest increase in phosphorus can, under the right conditions, set off a whole chain of undesirable events in a stream including accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain fish, invertebrates, and other aquatic animals.

There are many sources of phosphorus, both natural and human. These include soil and rocks, wastewater treatment plants, runoff from fertilized lawns and cropland, failing septic systems, runoff from animal manure storage areas, disturbed land areas, drained wetlands, water treatment, and commercial cleaning preparations.

**Forms of phosphorus**

Phosphorus has a complicated story. Pure, "elemental" phosphorus (P) is rare. In nature, phosphorus usually exists as part of a phosphate molecule ($PO_4$). Phosphorus in aquatic systems occurs as organic phosphate and inorganic phosphate. Organic phosphate consists of a phosphate molecule associated with a carbon-based molecule, as in plant or animal tissue. Phosphate that is not associated with organic material is inorganic. Inorganic phosphorus is the form required by plants. Animals can use either organic or inorganic phosphate.

Both organic and inorganic phosphorus can either be dissolved in the water or suspended (attached to particles in the water column).

Phosphorus cycles through the environment, changing form as it does so. Aquatic plants take in dissolved inorganic phosphorus and convert it to organic phosphorus as it becomes part of their tissues. Animals get the organic phosphorus they need by eating either aquatic plants, other animals, or decomposing plant and animal material.
As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic phosphorus gets back into the water column when the bottom is stirred up by animals, human activity, chemical interactions, or water currents. Then it is taken up by plants and the cycle begins again.
In a stream system, the phosphorus cycle tends to move phosphorus downstream as the current carries decomposing plant and animal tissue and dissolved phosphorus. It becomes stationary only when it is taken up by plants or is bound to particles that settle to the bottom of pools.
In the field of water quality chemistry, phosphorus is described using several terms. Some of these terms are chemistry based (referring to chemically based compounds), and others are methods-based (they describe what is measured by a particular method).
The term "orthophosphate" is a chemistry-based term that refers to the phosphate molecule all by itself. "Reactive phosphorus" is a corresponding method-based term that describes what you are actually measuring when you perform the test for orthophosphate. Because the lab procedure isn't quite perfect, you get mostly orthophosphate but you also get a small fraction of some other forms.
More complex inorganic phosphate compounds are referred to as "condensed phosphates" or "polyphosphates." The method-based term for these forms is "acid hydrolyzable."

## *What are nitrates and why are they important?*

Nitrates are a form of nitrogen, which is found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH3), nitrates (NO3), and nitrites (NO2). Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Together with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the types of plants and animals that live in the stream. This, in turn, affects dissolved oxygen, temperature, and other indicators. Excess nitrates can cause hypoxia (low levels of dissolved oxygen) and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions. The natural level of ammonia or nitrate in surface water is typically low (less than 1 mg/L); in the effluent of wastewater treatment plants, it can range up to 30 mg/L.
Sources of nitrates include wastewater treatment plants, runoff from fertilized lawns and cropland, failing on-site septic systems, runoff from animal manure storage areas, and industrial discharges that contain corrosion inhibitors.

## *What are total solids and why are they important?*

Total solids are dissolved solids plus suspended and settleable solids in water. In stream water, dissolved solids consist of calcium, chlorides, nitrate, phosphorus, iron, sulfur, and other ions particles that will pass through a filter with pores of around 2 microns (0.002 cm) in size. Suspended solids include silt and clay particles, plankton, algae, fine organic debris, and other particulate matter. These are particles that will not pass through a 2-micron filter.

The concentration of total dissolved solids affects the water balance in the cells of aquatic organisms. An organism placed in water with a very low level of solids, such as distilled water, will swell up because water will tend to move into its cells, which have a higher concentration of solids. An organism placed in water with a high concentration of solids will shrink somewhat because the water in its cells will tend to move out. This will in turn affect the organism's ability to maintain the proper cell density, making it difficult to keep its position in the water column. It might float up or sink down to a depth to which it is not adapted, and it might not survive.

Higher concentrations of suspended solids can serve as carriers of toxics, which readily cling to suspended particles. This is particularly a concern where pesticides are being used on irrigated crops. Where solids are high, pesticide concentrations may increase well beyond those of the original application as the irrigation water travels down irrigation ditches. Higher levels of solids can also clog irrigation devices and might become so high that irrigated plant roots will lose water rather than gain it.

A high concentration of total solids will make drinking water unpalatable and might have an adverse effect on people who are not used to drinking such water. Levels of total solids that are too high or too low can also reduce the efficiency of wastewater treatment plants, as well as the operation of industrial processes that use raw water.

Total solids also affect water clarity. Higher solids decrease the passage of light through water, thereby slowing photosynthesis by aquatic plants. Water will heat up more rapidly and hold more heat; this, in turn, might adversely affect aquatic life that has adapted to a lower temperature regime.

Sources of total solids include industrial discharges, sewage, fertilizers, road runoff, and soil erosion. Total solids are measured in milligrams per liter (mg/L).

## *What is total alkalinity and why is it important?*

Alkalinity is a measure of the capacity of water to neutralize acids (see pH description). Alkaline compounds in the water such as bicarbonates (baking soda is one type), carbonates, and hydroxides remove H+ ions and lower the acidity of the water (which means increased pH). They usually do this by combining with the H+ ions to make new compounds. Without this acid-neutralizing capacity, any acid added to a stream would cause an immediate change in the pH. Measuring alkalinity is important in determining a stream's ability to neutralize acidic pollution from rainfall or wastewater. It's one of the best measures of the sensitivity of the stream to acid inputs.

Alkalinity in streams is influenced by rocks and soils, salts, certain plant activities, and certain industrial wastewater discharges.

Total alkalinity is measured by measuring the amount of acid (e.g., sulfuric acid) needed to bring the sample to a pH of 4.2. At this pH all the alkaline compounds in the sample

are "used up." The result is reported as milligrams per liter of calcium carbonate (mg/L $CaCO_3$).

## What are fecal bacteria and why are they important?

Members of two bacteria groups, coliforms and fecal streptococci, are used as indicators of possible sewage contamination because they are commonly found in human and animal feces. Although they are generally not harmful themselves, they indicate the possible presence of pathogenic (disease-causing) bacteria, viruses, and protozoans that also live in human and animal digestive systems. Therefore, their presence in streams suggests that pathogenic microorganisms might also be present and that swimming and eating shellfish might be a health risk. Since it is difficult, time-consuming, and expensive to test directly for the presence of a large variety of pathogens, water is usually tested for coliforms and fecal streptococci instead. Sources of fecal contamination to surface waters include wastewater treatment plants, on-site septic systems, domestic and wild animal manure, and storm runoff.

In addition to the possible health risk associated with the presence of elevated levels of fecal bacteria, they can also cause cloudy water, unpleasant odors, and an increased oxygen demand. (Refer to the section on dissolved oxygen.)

**Indicator bacteria types and what they can tell you**

The most commonly tested fecal bacteria indicators are total coliforms, fecal coliforms, *Escherichia coli*, fecal streptococci, and enterococci. All but *E. coli* are composed of a number of species of bacteria that share common characteristics such as shape, habitat, or behavior; *E. coli* is a single species in the fecal coliform group.

Total coliforms are a group of bacteria that are widespread in nature. All members of the total coliform group can occur in human feces, but some can also be present in animal manure, soil, and submerged wood and in other places outside the human body. Thus, the usefulness of total coliforms as an indicator of fecal contamination depends on the extent to which the bacteria species found are fecal and human in origin. For recreational waters, total coliforms are no longer recommended as an indicator. For drinking water, total coliforms are still the standard test because their presence indicates contamination of a water supply by an outside source.

Fecal coliforms, a subset of total coliform bacteria, are more fecal-specific in origin. However, even this group contains a genus, *Klebsiella*, with species that are not necessarily fecal in origin. *Klebsiella* are commonly associated with textile and pulp and paper mill wastes. Therefore, if these sources discharge to your stream, you might wish to consider monitoring more fecal and human-specific bacteria. For recreational waters, this group was the primary bacteria indicator until relatively recently, when EPA began recommending *E. coli* and enterococci as better indicators of health risk from water contact. Fecal coliforms are still being used in many states as the indicator bacteria.

*E. coli* is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. EPA recommends E. coli as the best indicator of health risk from water contact in recreational waters; some states have changed their water quality standards and are monitoring accordingly.

Fecal streptococci generally occur in the digestive systems of humans and other warm-blooded animals. In the past, fecal streptococci were monitored together with fecal coliforms and a ratio of fecal coliforms to streptococci was calculated. This ratio was

used to determine whether the contamination was of human or nonhuman origin. However, this is no longer recommended as a reliable test.

Enterococci are a subgroup within the fecal streptococcus group. Enterococci are distinguished by their ability to survive in salt water, and in this respect they more closely mimic many pathogens than do the other indicators. Enterococci are typically more human-specific than the larger fecal streptococcus group. EPA recommends enterococci as the best indicator of health risk in salt water used for recreation and as a useful indicator in fresh water as well.

**Which Bacteria Should You Monitor?**

Which bacteria you test for depends on what you want to know. Do you want to know whether swimming in your stream poses a health risk? Do you want to know whether your stream is meeting state water quality standards?

Studies conducted by EPA to determine the correlation between different bacterial indicators and the occurrence of digestive system illness at swimming beaches suggest that the best indicators of health risk from recreational water contact in fresh water are *E. coli* and enterococci. For salt water, enterococci are the best. Interestingly, fecal coliforms as a group were determined to be a poor indicator of the risk of digestive system illness. However, many states continue to use fecal coliforms as their primary health risk indicator.

If your state is still using total or fecal coliforms as the indicator bacteria and you want to know whether the water meets state water quality standards, you should monitor fecal coliforms. However, if you want to know the health risk from recreational water contact, the results of EPA studies suggest that you should consider switching to the *E. coli* or enterococci method for testing fresh water. In any case, it is best to consult with the water quality division of your state's environmental agency, especially if you expect them to use your data.

## Other Water Quality Parameters:

### Chlorophyll a

This measures the concentration of photosynthetic pigments ($mg/cm^3$), and is used to estimate the phytoplankton biomass. All green plants possess chlorophyll a, which constitutes 1 to 2% of the dry weight of planktonic algae. This measurement can be an indirect means of quantifying nutrients in the water, since high nutrient levels can cause blooms of algae.

### Chloride

This anion exists in high levels where seawater has intruded into fresh water bodies. One would expect to see higher levels of chloride in estuaries, or any other body of water near sea level, where saltwater intrusion is possible. High levels of chloride can also be found in some groundwater aquifers, depending on the subsurface strata.

### Sodium/ Potassium

These cations are also found in high levels where seawater has intruded into fresh water bodies, or in some groundwater. In combination with chloride, they can account for higher conductivity or salinity readings.

### Sulfate

This anion can affect the quality of drinking water in high levels. In a stream system, it can also indicate possible fertilizer pollution, or in still water can result from the putrification of organic matter. In groundwater, sulfate levels can be quite high, affecting the taste of drinking water.

# Appendix 3

# Equipment and Protocols

## IV.) Equipment

Horiba U-10 Water Quality Meter

Manufacturer: Horiba Instruments Incorporated
Irvine Facility
17671 Armstrong Ave.
Irvine, CA 92714
Phone: (714) 250-4811
Website: http://global.horiba.com/analy_e/u-10/
Purchased from: EnviRent Corporation
404 Vosseller Ave.
Bound Brook, NJ 08805
Phone: (732) 560-9620
Website: http://www.envirent.com/
Price: $2495

Calibration Solutions (for Horiba U-10) may be purchased from:
Compliance Technology
P. O. Box 31
South San Francisco, CA 94083
Phone: (800) 615-8870 or (650) 615-9100
Website: http://www.compliancetechnology.com/

Price: Auto-cal (one point)- $35/ 4L
Level Two (two points)- $73/ 1L

LaMotte test kits for nitrate-N, ammonia-N, and total phosphate

Manufacturer:
LaMotte Company
P.O. Box 329 | 802 Washington Ave.
Chestertown | Maryland | 21620 | USA
Phone: 800-344-3100 (within the U.S.A.) | 410-778-3100 or 410-778-3101
Website: http://www.lamotte.com/
Purchased from: Forestry-Suppliers, Inc.
205 West Rankin Street / P. O. Box 8397
Jackson, MS 39284-8397
Phone : (601) 354-3565
Website: http://www.forestry-suppliers.com/
Price: $NO_3$-N kit- $39.95, $NH_3$-N kit- $37.45, $PO_4$ kit- $77.60

## I. Global Water Flowmeter

Manufacturer: Global Water
11257 Coloma Road
Gold River, CA 95670
Phone: 800-876-1172 or 916-638-3429
Website: http://www.globalw.com/gwprice.html
Price: $695, best to purchase from manufacturer

Spherical Densiometer

May be purchased from: Ben Meadows Company
PO Box 5277
Janesville WI 53547-5277
Phone: 1-800-241-6401
Website: http://www.benmeadows.com
Price: $99.95

## Protocols

On the following pages are copies of various protocols used for water quality analysis of streams in Wilder Ranch State Park. They are presented in this order:

1. Horiba U-10 Water Quality Meter
2. La Motte Test Kits for Ammonia-N, Nitrate-N, and Phosphate
3. Spherical Densiometer (% Plant Cover)
4. Flow Meter (Average Stream Velocity)
5. % Algal Cover
6. % Vegetation
7. Transparency

## % Algal Cover and % Vegetation

The method used for this study was simple visual estimation. The sampler scans a segment of the stream approximately 5 meters in each direction from the sample site and visually estimates the percent coverage of algae on the surface of the water. If more than one person is being used for sampling, all samplers should go out together and practice several stream sites to preclude biased estimates.

For % vegetation, the same protocol is used, but estimating percent coverage by vascular water plants.

## Transparency

Transparency was another subjective test. Usually a secchi disc is used, but for these small, shallow streams it was unnecessary. The sampler rates water transparency on a scale of 0 – 5, zero being opaque and 5 being transparent. Again, the samplers should practice together, comparing estimations of the same site, in order to "calibrate" their judgements as best they can. If a different scale is deemed better, the important point is to stick with it and be consistent.

# Appendix 4

# Quality Control

## V.) Definitions

At times, a laboratory will require extra samples to be taken to satisfy quality control requirements. The following are some quality control checks that may be required. Consult with your lab as to which are necessary.

Field Blanks: These are sample bottles that contain deionized water. They are considered samples and are taken along with the sampler during the day of the sampling. The purpose of a field blank is to help identify any contamination in the bottles or during sample collection. Also called trip blanks.

Field duplicates: This is simply a duplicate sample that is taken from the water source, and slated for a specific parameter analysis. This helps to detect precision in sampling method or in lab analysis. All duplicates should follow preservation requirements and be labeled as a duplicate.

Spike sample: In this case, the sampler spikes a duplicate sample, after it is collected, with a known volume of the parameter to be measured. This will increase the concentration of that parameter in the sample by a known amount. Spike samples are used to test accuracy of lab analysis methods.