Salmon Creek Watershed Sediment Reduction and Water Conservation Project

Quarterly Water Quality Monitoring Report, March to June, 2011

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Summary

This quarterly report summarizes data collected by the Gold Ridge Resource Conservation District (GRRCD) from March 2011 to May 2011 under the Salmon Creek Sediment Reduction and Water Conservation Project, funded by the North Coast Integrated Regional Watershed Management Program. The data period included three monthly sampling events (March 28, 2011, April 26, 2011 and May 30, 2011). Due to the fact that the nutrient data from the 2/17/11 storm sampling event wasn't available at the time of the last quarterly report, the results are included in this report along with the 12/8/10 storm sampling event for comparison. Storm monitoring rainfall criteria requires a forecasted storm that will deliver 0.5" rainfall in a 12 hour period and/or 1" of rainfall in a 24 hour period) and the two events that were sampled this winter were 12/8/10 and 2/17/11.

Gold Ridge RCD staff and SCWC volunteer monitors have been working together to coordinate monitoring efforts, standardize water quality data collection, and increase the frequency of sampling for the Salmon Creek Watershed. This report also includes data collected by the Salmon Creek Watershed Council citizen monitors for several stations during the data period. All reported data was collected in adherence with the quality control measures outlined in the "Quality Assurance Project Plan for Collection of Hydrologic Monitoring in the Salmon Creek Watershed" (Gold Ridge Resource Conservation District, Revised 2010).

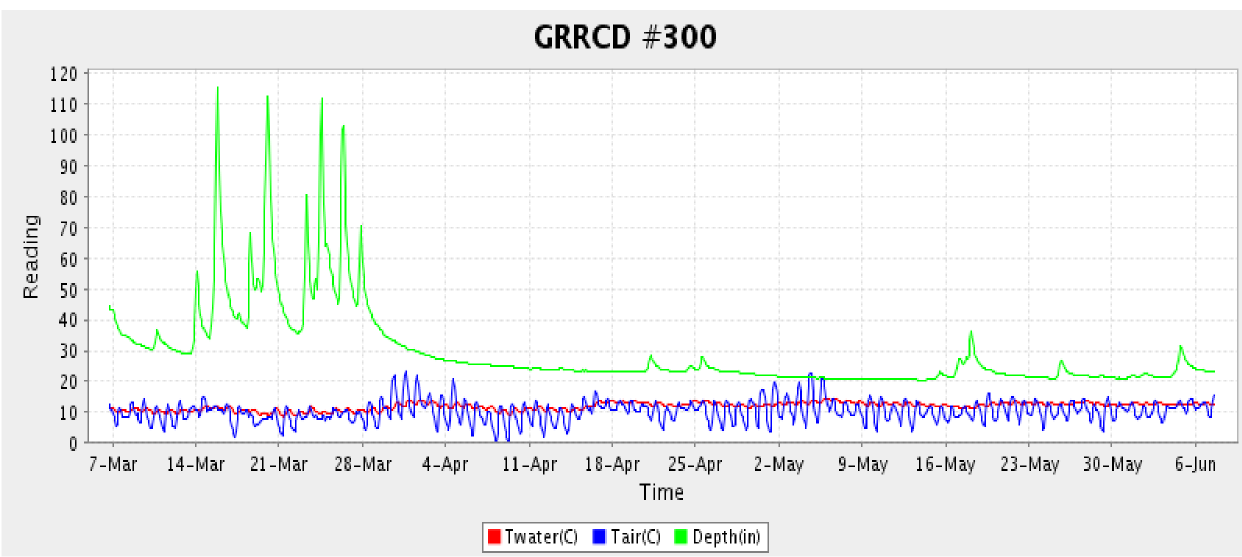
Salmon Creek at the Salmon Creek School Observation Deck during early March 2011

GRRCD staff sampling upper Salmon Creek in late March 2011

Weather Summary

The first significant rainfall event of water year[1] 2011 occurred on October 23-24, 2010 and delivered between 8 and 12 inches of rainfall in the Salmon Creek Watershed. The early months of the water year were relatively wet with higher than average rainfall. Late March saw a number of rainfall events that resulted in significant streamflow response. Late May and early June have also been unseasonably wet with cool, showery weather. To date, the watershed has received approximately 46 inches of cumulative rainfall.

Figure 1: Hydrograph of Salmon Creek from March 6 to June 6, 2011



[1] Water Year 2011 extends from October 1, 2010 through September 30, 2011.

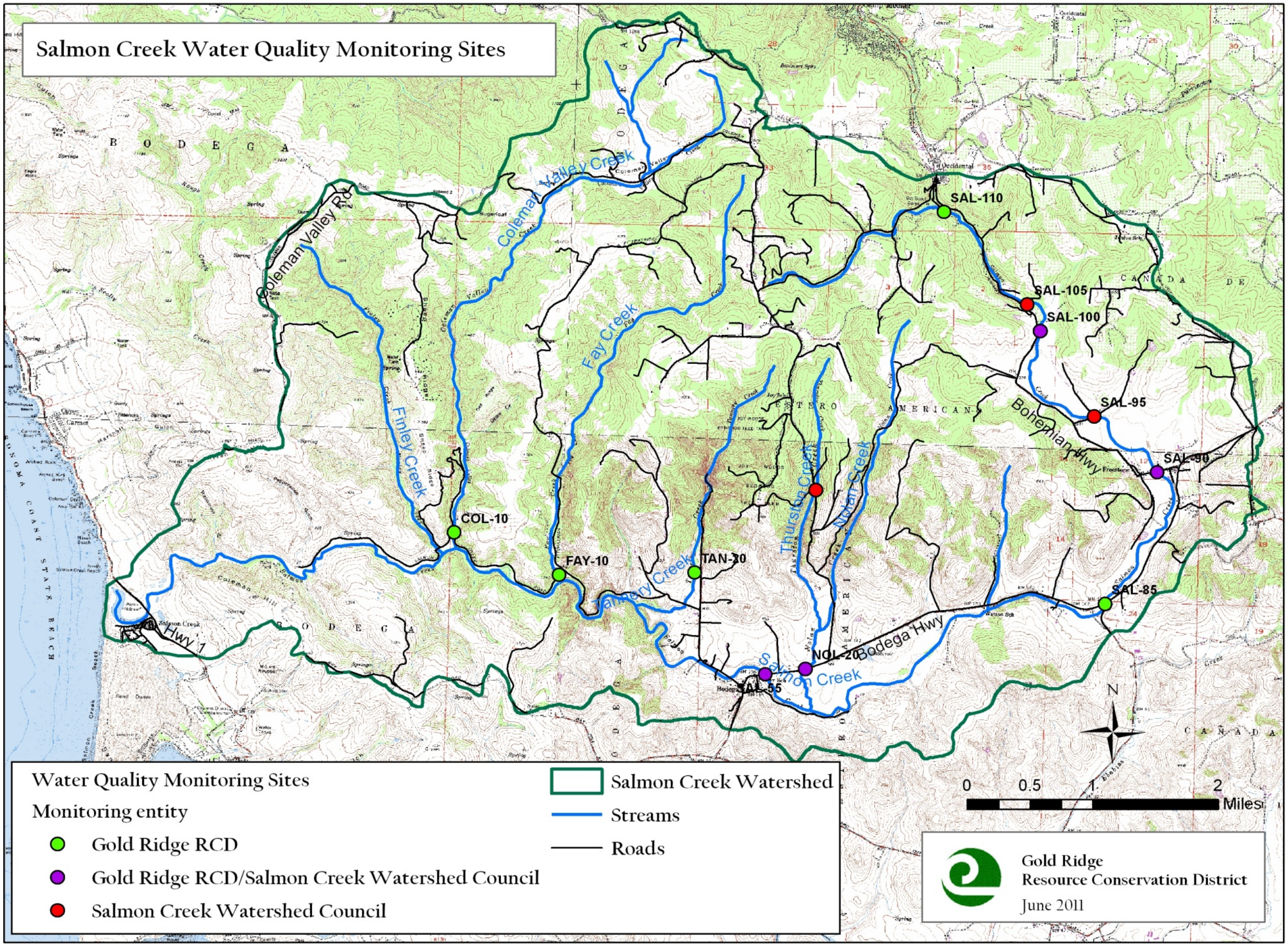
Sampling Locations

The sampling locations have been renamed to comply with SWRCB naming convention. See the table below and the associated attached map.

Table 1: Revised monitoring station IDs sampled by GRRCD staff

Station ID	Monitoring Entity	Description
SAL-110	GRRCD	Salmon Creek off of Scouts Camp Road
SAL-105	SCWC	Salmon Creek at Bohemian Lane
SAL-100	GRRCD/SCWC	Salmon Creek from the Salmon Creek Elementary School entrance bridge
SAL-95	SCWC	Salmon Creek at Freestone Flat Road bridge
SAL-90	GRRCD/SCWC	Salmon Creek at the Bohemian Hwy bridge in Freestone
SAL-85	GRRCD	Salmon Creek at Bodega Hwy bridge adjacent to Valley Ford-Freestone Road
NOL-20	GRRCD/SCWC	Nolan Creek at Bodega Hwy bridge
THU-30	SCWC	Thurston Creek at Joy Road bridge
SAL-55	GRRCD/SCWC	Salmon Creek at Bodega Hwy bridge at the upstream end of the town of Bodega
SAL-50	GRRCD/SCWC	Salmon Creek at the Salmon Creek Road bridge
TAN-20	GRRCD	Tannery Creek off of Tannery Creek Road on private property
FAY-10	GRRCD	Fay Creek at Salmon Creek Road bridge
COL-10	GRRCD	Colman Creek at Salmon Creek Road bridge

Figure 2: Salmon Creek Watershed map with GRRCD monitoring stations



Water Quality Objectives/Targets

As with previous GRRCD evaluations of water quality in the Salmon Creek Watershed, the Water Quality Objectives or comparative thresholds are listed in the table below. The North Coast Regional Water Quality Control Board (NCRWQCB) has not set numeric standard water quality objectives for the Salmon Creek Watershed, which falls into the "Bodega Bay" water body description (NCRWQCB, 1994). Statewide criteria set by the US Environmental Protection Agency (EPA), Region 9(US Environmental Protection Agency, 2000) and/or the objectives for the nearby Russian River water body by the NCRWQCB (NCRWQCB, 1994) have been used as targets and are outlined in Table 2 below.

Table 2. Water Quality Objectives.

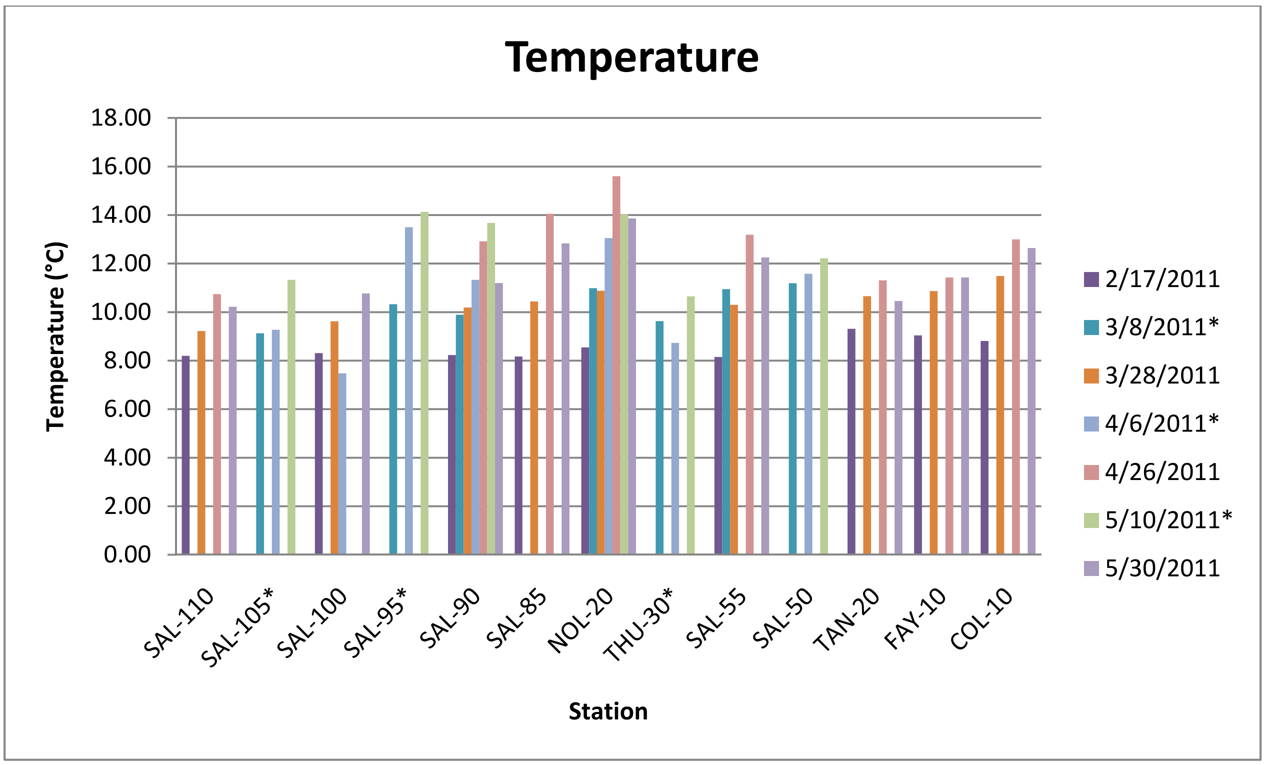
Parameter (reporting units)	**Water Quality Objectives**	**Source of Objective**
Dissolved Oxygen (mg/l or ppm)	Not lower than 7	North Coast Region Basin Plan Objective for Cold Water Fish
pH (pH units)	Not less than 6.5 or more than 8.5	General Basin Plan objective
Water Temperature (°C)	Not to exceed 21.1	USEPA (1999) 20-22 range, supported by Sullivan (2000)
Conductivity (uS)	None established	N/A
Nitrate as N (mg/l)	Not to exceed 1.0	
Ammonia-Nitrogen (mg N/l)	Not to exceed 0.5	USEPA (2009)
Orthophosphate (mg/l)	Not to exceed 0.10	USEPA(2000)
Turbidity	1.Not to exceed 25 NTUs during low flow; not to exceed 150 NTUs during storm events	GRRCD selected threshold, 1. Supported by Sigler (1984); 2. supported by Newcombe (2003)

Results and Discussion

Temperature

Over the data period, temperature measurements varied from 7.48 to 15.60 °C, none of which exceeded the threshold of 21 °C. Since the collected measurements were grab samples, this information is not conclusive that the stream conditions never exceeded the water temperature objective, though considering the spring ambient air conditions it isn't likely.

Figure 3: Temperature Measurements

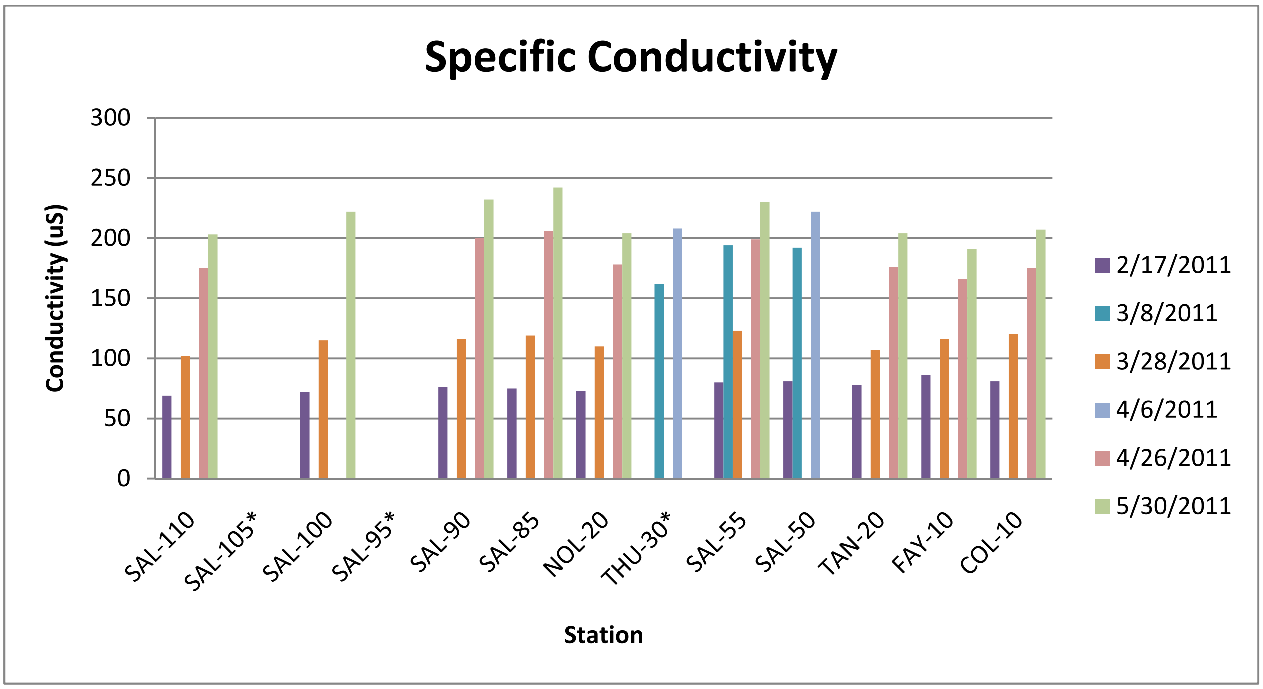


Conductivity

Conductivity is a measure of water's capacity for conducting electricity and is a measure of the ionic (dissolved) constituents present in the sample. While there is no specific water quality objective for conductivity, conductivity can be used as a potential indicator of pollutant levels.

Over the data period, conductivity ranged from 69 to 242 uS. As expected, specific conductivity levels dropped during the 2/17/11 storm event in response to the influx of storm water. Since the conductivity results remained low throughout the storm event, this serves as an indication that there was not delivery of high levels of pollutants through storm runoff. As the streamflow receded to spring baseflow levels, the conductivity increased likely in response to less dilution and increased contact/exposure to the substrate.

Figure 4: Specific Conductivity Measurements

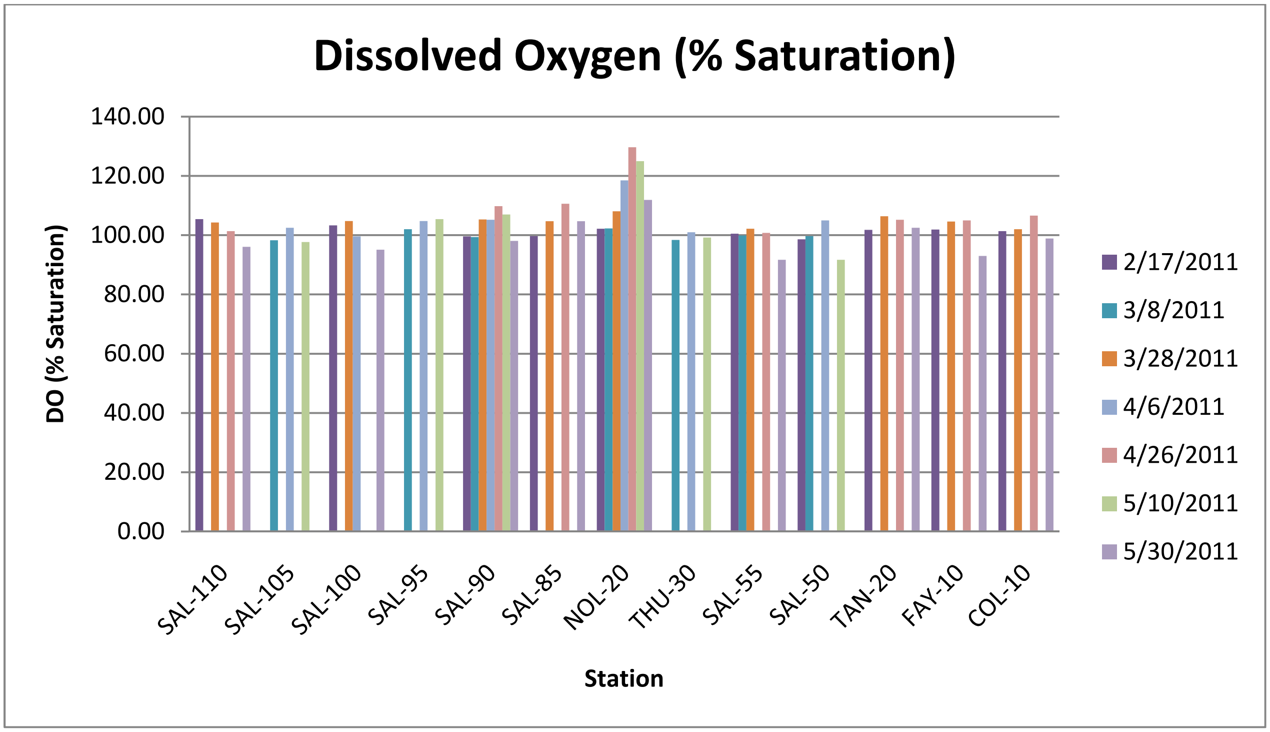


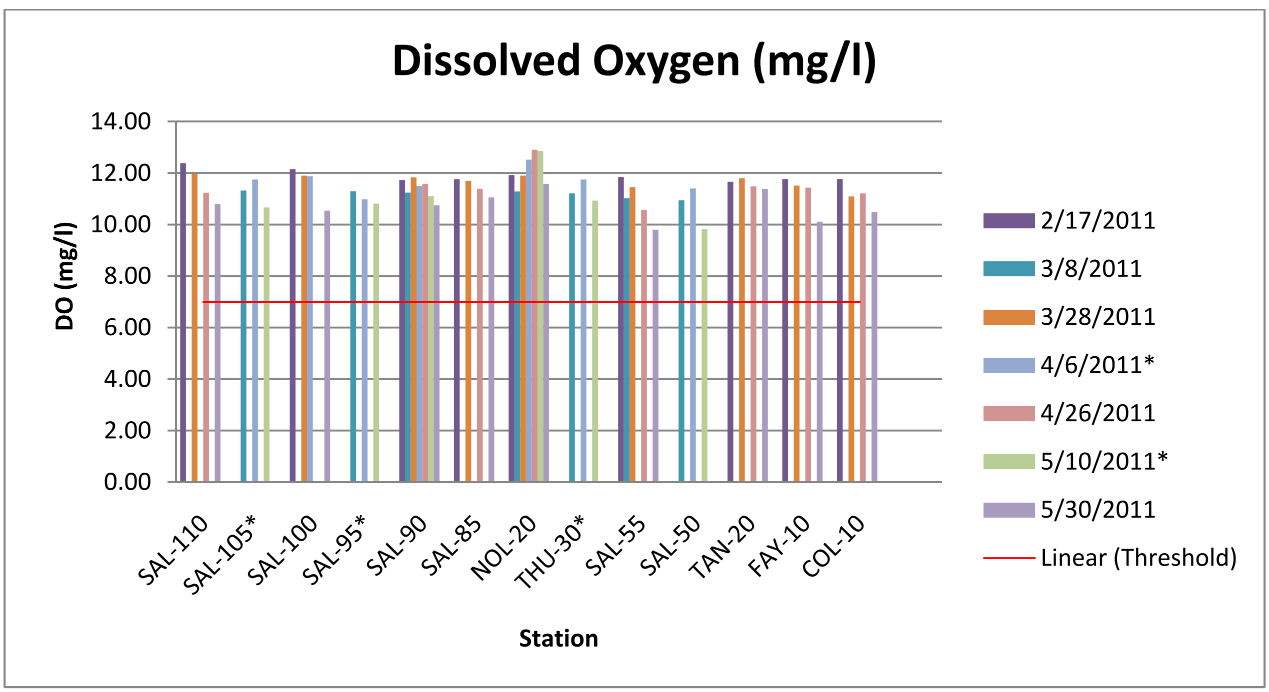
Dissolved oxygen

Dissolved oxygen (DO) refers to the amount of oxygen dissolved in water and available to aquatic organisms. Dissolved oxygen is added to water through diffusion from air, turbulence, and photosynthesis of aquatic plants, and removed through respiration of aquatic organisms, decomposition of organic material, and other chemical reactions that use oxygen.

As expected during winter and spring flow conditions, dissolved oxygen levels met water quality objectives and remained high throughout the sampling period. Super-saturated conditions exceeding 100% were measured due to high flows and resulting turbulent conditions.

Figures 5 & 6: Dissolved Oxygen Measurements



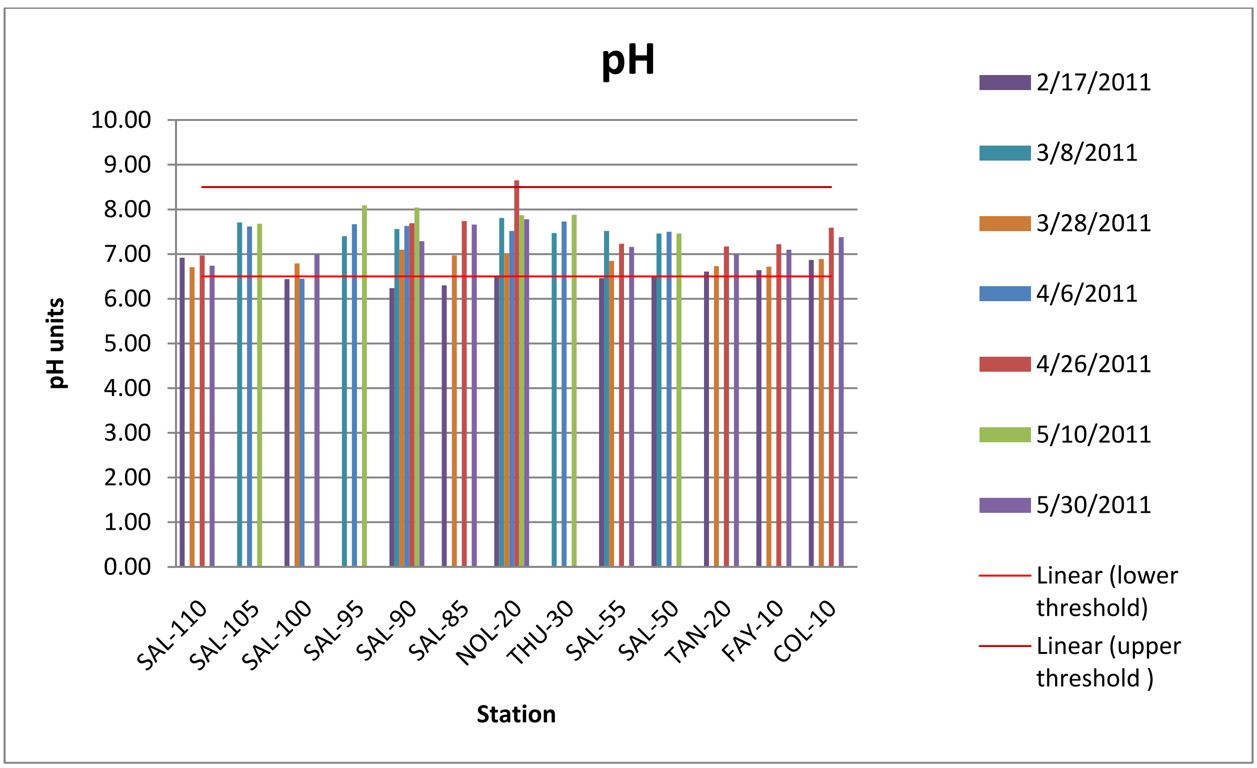


pH

pH refers to the concentration of hydrogen ions in water and determines the acidity or alkalinity of water. Natural pH levels are affected by geology, vegetation, and soil types in the streambed and surrounding the stream, and the availability of carbon dioxide. Changes in pH can have critical effects on water chemistry and the biological systems dependent on the aquatic environment. For example, the solubility and toxicity of metal compounds and nutrients changes greatly with pH.

The pH measurements generally fell within the Water Quality Objectives with the exception of several acidic results during the 2/17/11 storm sampling and one alkaline result at NOL-20 on 4/26/11. The acidic conditions during the 2/17/11 storm sampling ranged from 6.24 to 6.49, were only observed on the mainstem Salmon Creek stations, and generally became less acidic in a downstream direction. Two weeks later, and at all subsequent sampling events, conditions at these sites met water quality objectives. As for the alkaline exceedence of 8.65 at NOL-20 during the 4/26 sampling event, the condition didn't continue downstream to the next station, nor persist during future sampling events.

Figure 7: pH Measurements

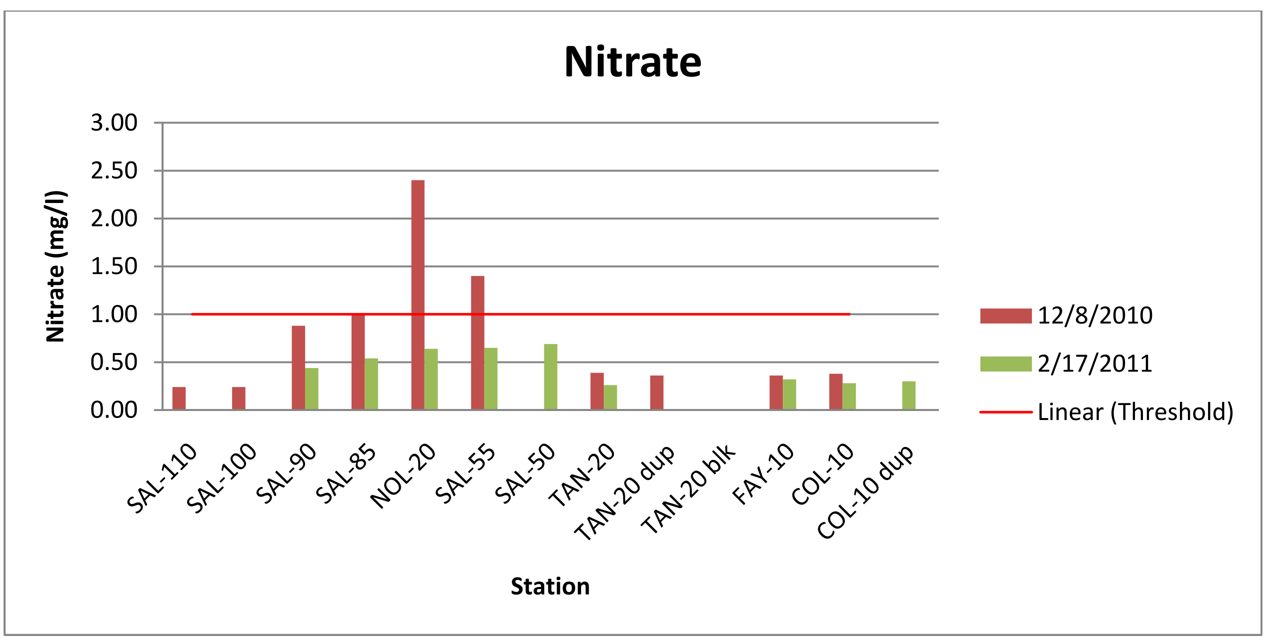


Nutrients

As per the Monitoring Plan for this project, nutrients are measured several times a year to characterize seasonal conditions when they may have water quality impacts. No nutrient samping was conducted during the data period of this quarterly report. Since the nutrient results from the February 17, 2011 storm sampling event were not available for the last quarterly report, they are summarized here, along with a comparison to the previous storm sampling event on December 8, 2010. Nitrate (NO_3) is an inorganic form of nitrogen that is soluble and therefore subject to leaching and biological uptake. Nitrate results ranged from 0.24 to 2.40 mg/l, with two occurrences exceeding the 1.0 mg/l Water Quality Objective. There was a general trend of increased nitrate concentration in a downstream direction, with the highest result from NOL-20. A second Salmon Creek mainstem sampling location downstream of the town of Bodega (SAL-50) was added to the 2/17/11 storm sampling event to evaluate if nitrate concentration continues to increase downstream. It would be desirable to add an additional mainstem sampling location downstream of the Coleman Creek confluence, but no publicly accessible locations are currently available.

Total ammonia is composed of two forms; ionized ammonia (NH_4^+), and un-ionized ammonia (NH_3). Un-ionized ammonia, which primarily results from decomposition of manure and other organic debris by microbes, can be toxic to aquatic organisms in small concentrations. The percent of total ammonia in the harmful un-ionized form increase with higher temperatures and pH values. No ammonia was detected at any of the sampling locations during the 12/8/10 or 2/17/11 sampling events.

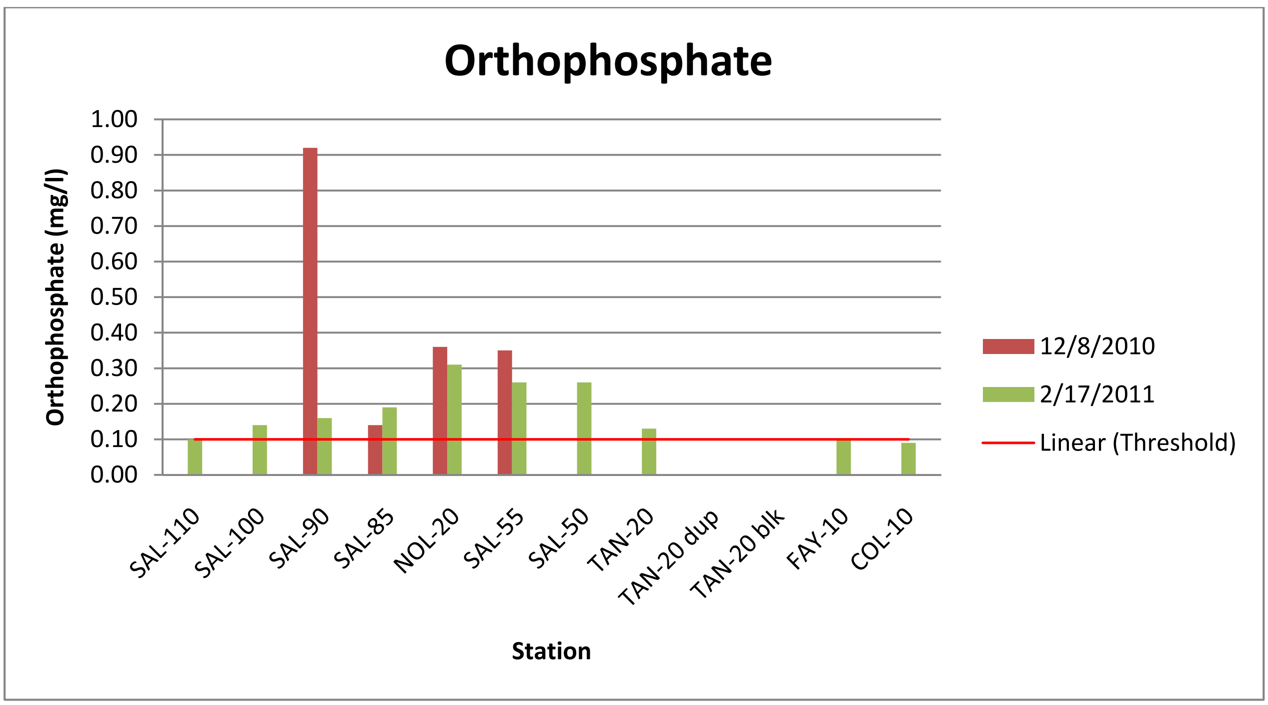
Figure 8: Nitrate Measurements



Nitrate-nitrogen, phosphate and phosphorous are not directly toxic to aquatic organisms but, where sunlight is available, these chemical nutrients act as biostimulatory substances that stimulate primary production. Excessive inputs of these nutrients, known as eutrophication, can result in abundant plant growth and resulting decay which depletes dissolved oxygen and can degrade habitat quality.

Orthophosphate results ranged from <0.02 (not detected) to 0.92 mg/l. Detectable concentrations were measured at four of the nine sites, all of which exceeded the 0.10 mg/l Water Quality Objective. As opposed to the observations of nitrate, the highest orthophosphate concentration was measured near the upstream extent of the sampling area and decreased in concentration downstream. The highest result was observed in the town of Freestone and may be due to soaps and detergents from residential uses. Considering the high flows and low water temperatures, algal growth is not a concern during winter months.

Figure 9: Orthophosphate Measurements



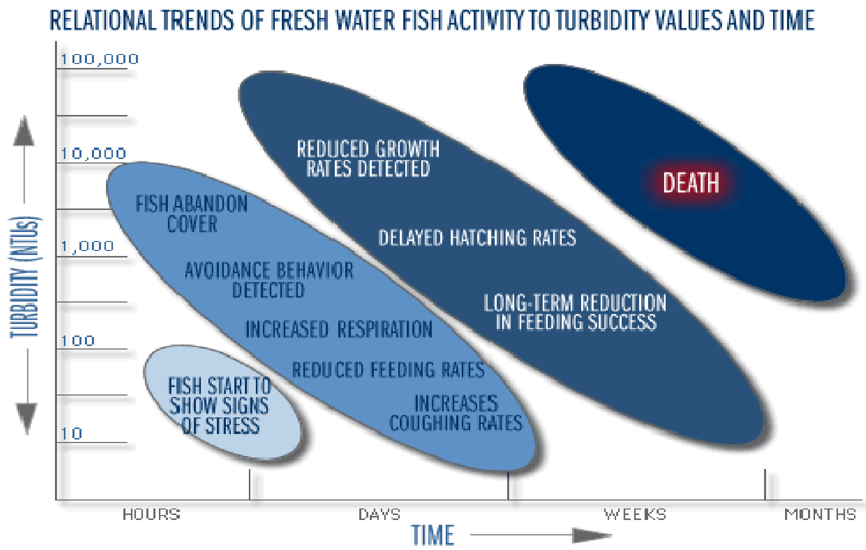
Turbidity and Total Suspended Solids

Turbidity, which can make water appear cloudy or muddy, is caused by the presence of suspended and dissolved matter, such as clay, silt, finely divided organic matter, plankton and other microscopic organisms. Sources of turbidity include soil erosion, streambank erosion, animal waste, road and urban runoff, and excessive algal growth.

Excess turbidity reduces light, which decreases aquatic plant life, reducing benthic organisms and ultimately fish populations. High turbidity levels increase water temperatures due to suspended particles absorbing heat. High turbidity levels also affect aquatic organisms by causing reduced feeding rates, reduced growth rates, damage to gills, and fatality.

Water quality objectives for turbidity and Total Suspended Solids (TSS) are not definitively established for the Salmon Creek Watershed. While the North Coast Regional Water Quality Control Board mandates that turbidity levels not be increased more than 20% above naturally occurring background levels (NCRWQCB, 2007), when a background level has not been established (as is the case with Salmon Creek), this objective is difficult to use. Since the recovery of coho salmon is a primary goal for the watershed, clear water fishery objectives have been employed. Newcombe (Newcombe, 2003) described the detrimental impacts to clear water fishes at several turbidity levels. Two turbidity thresholds are depicted on the graphs, 55 NTUs and 150 NTUs. Newcombe states that turbidity levels of 55 NTUs caused significant impairment to fish after one day and severe impairment after four months, while turbidity levels of 150 NTUs caused significant impairment after three hours and severe impairment after two weeks.

Figures 10 & 11: Representations of impairment relationships between turbidity and fresh water fish



"Figure 8: Idealized model of fish response to increased suspended sediments. Schematic source of above figure is unknown; it is a generic, un-calibrated impact assessment model based on Newcombe, C. P., and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16: 693-727. Reprinted, with permission, from: http://wow.nrri.umn.edu/wow/under/parameters/turbidity.html" (Berry, 2003).

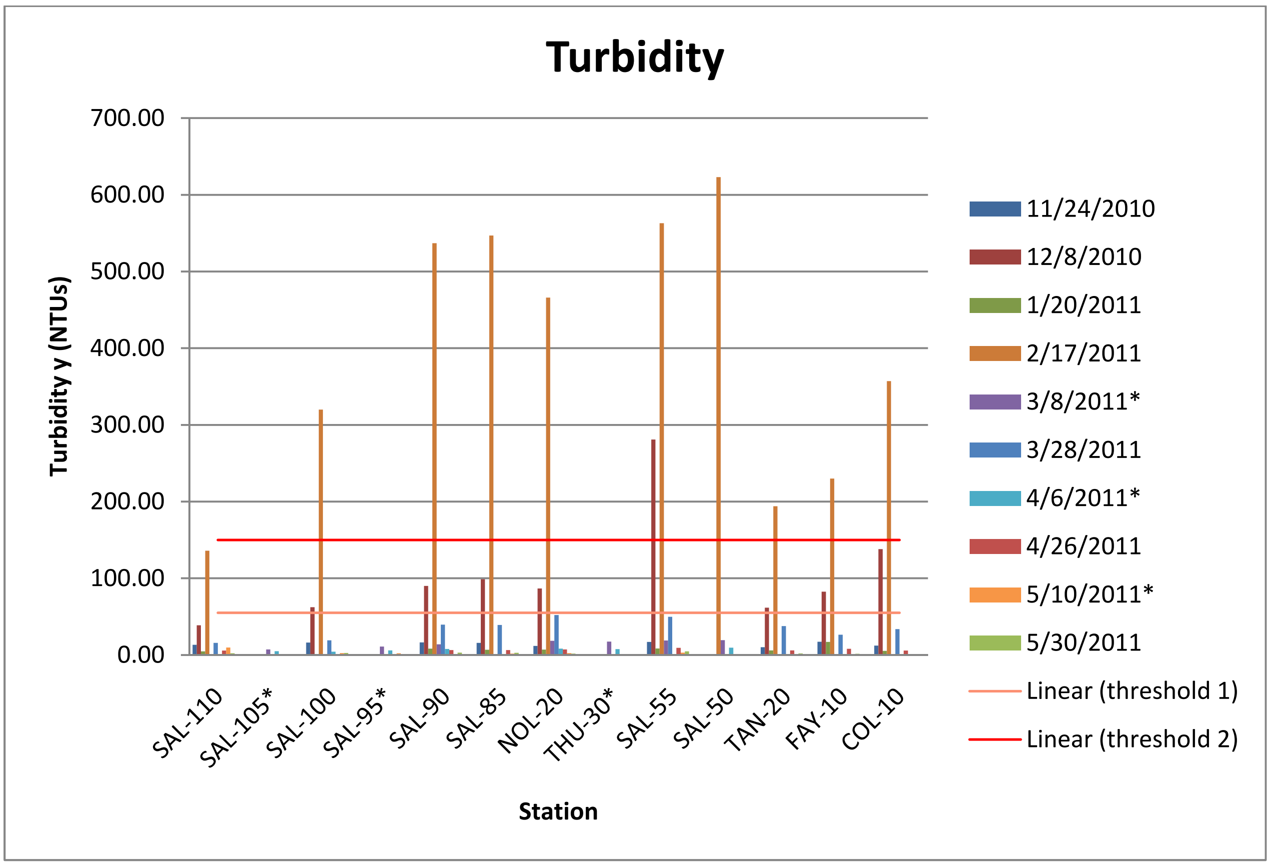
Impact Assessment Model for Clear Water Fishes Exposed to Conditions of Reduced Water Clarity

Visual clarity of water (yBD) and related variables: alternate		preferred		Duration of exposure to conditions of reduced VISUAL CLARITY ($\log_e$ hours)											Fish reactive distance: calibrated for trout		
				0	1	2	3	4	5	6	7	8	9	10			
NTU ($\Delta ntu_{\Sigma,\Lambda}$)	zSD (m)	BA (m^{-1})	yBD (m)	Severity-of-ill-effect Scores (SEV) -- Potential: SEV = - 4.49 + 0.92($\log_e$ h) - 2.59($\log_e$ yBD)											ψ_{BD} (cm)	xRD (cm)	
1100	0.01	500	0.010	7	8	9	10	11	12	13	14				1		O
			0.014	7	7	8	9	10	11	12	13	14			1		N
400	0.03	225	0.02	p6*	7	7	8	9	10	11	12	13	14		2		M
			0.03	4	5	6	7	8	9	10	11	12	13	14	3		L
150	0.07	100	0.05	3	p4*	p5*	6	7	8	9	10	11	12	13	5		K
			0.07	2	3	4	5	6	7	8	9	10	11	11	7		J
55	0.15	45	0.11	p1*	2	3	4	5	6	7	8	9	10	10	11	6	I
			0.16	0	1	2	3	4	5	6	7	8	9	9	16	17	H
20	0.34	20	0.24	0	p0*	p1*	2	3	4	5	6	7	8	8	24	30	G
			0.36	0	0	0	1	2	3	4	5	6	6	7	36	42	F
7	0.77	9	0.55	0	p0*	0	0	1	2	3	4	4	5	6	55	55	E
			0.77	0	p0*	p0*	0	0	1	2	3	4	4	5	77	66	D
3	1.53	4	1.09	0	p0*	0	0	0	0	1	2	3	4	5	109	77	C
			1.69	0	0	0	0	0	0	0	1	2	2	3	169	90	B
1	3.68	2	2.63	p0*	p0*	p0*	0	0	0	0	0	0	1	2	263	104	A
				1	3	7	1	2	6	2	7	4	11	30			
				Hours			Days			Weeks		Months					
				a	b	c	d	e	f	g	h	i	j	k			

"Figure 9: Matrix of impairment levels by turbidity level and duration. Yellow indicates slight impairment with changes in feeding and other behaviors, orange indicates significant impairment with altered fish growth and habitat quality, and red indicates severe impairment with physiological condition changes and habitat alienation (Newcombe 2001, 2003)" (Gold Ridge RCD, 2010).

Turbidity results from November 2010 to May 2011 are depicted on the graph below, including two storms sampling events on December 8, 2010 and February 17, 2011. Based on the turbidity for all sites sampled during this water year, results ranged from 4.69 under winter base flow conditions to 623 NTUs during storm flow conditions; and for the past quarter, results ranged from 1.10 NTU to 52.10 NTU under spring base flow conditions. As is expected, turbidity levels spiked during peak flows of storm events. In general, under both storm and baseflow conditions, mainstem Salmon Creek sites showed a trend of increasing turbidity in downstream direction, with the highest measured result at the downsteam-most station, SAL-50. Again, additional mainstem sampling locations downstream of SAL-50 would be instrumental in showing the cumulative impacts of fine sediment in the Salmon Creek Watershed.

Figure 12: Turbidity Measurements to date for Water Year 2011



Looking at the Turbidity results from the non-storm sampling events from March 8 to May 30, 2011, none of the conditions recorded exceeded Water Quality Objectives. The highest Turbidity conditions were measured during the 3/28 sampling event just after a series of late March rains. While the March 28 sampling didn't catch the rising limb of the hydrograph to serve as storm sampling, it did occur during falling limb at the end of the storm event and showed that Turbidity values in exceedence of the lower 50 NTU threshold did not persist post-storm.

Additionally, a smaller rainfall event in late April (4/26/11 sampling data) that did not meet storm criteria, did not yield Turbidity conditions that exceeded the Water Quality Objective, most likely due to drier soil conditions throughout the watershed soaking up the rainfall without yielding much runoff.

Figure 13: Turbidity Measurements for March through May 2011

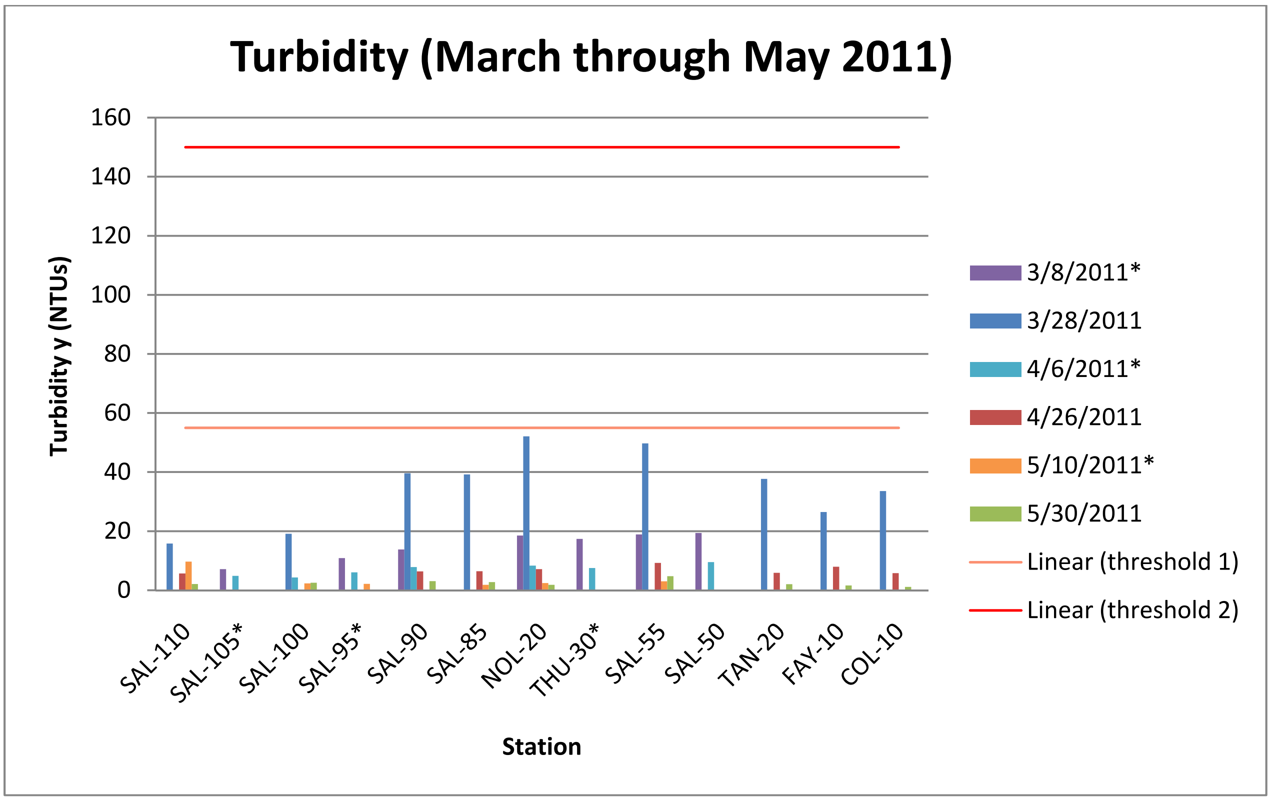
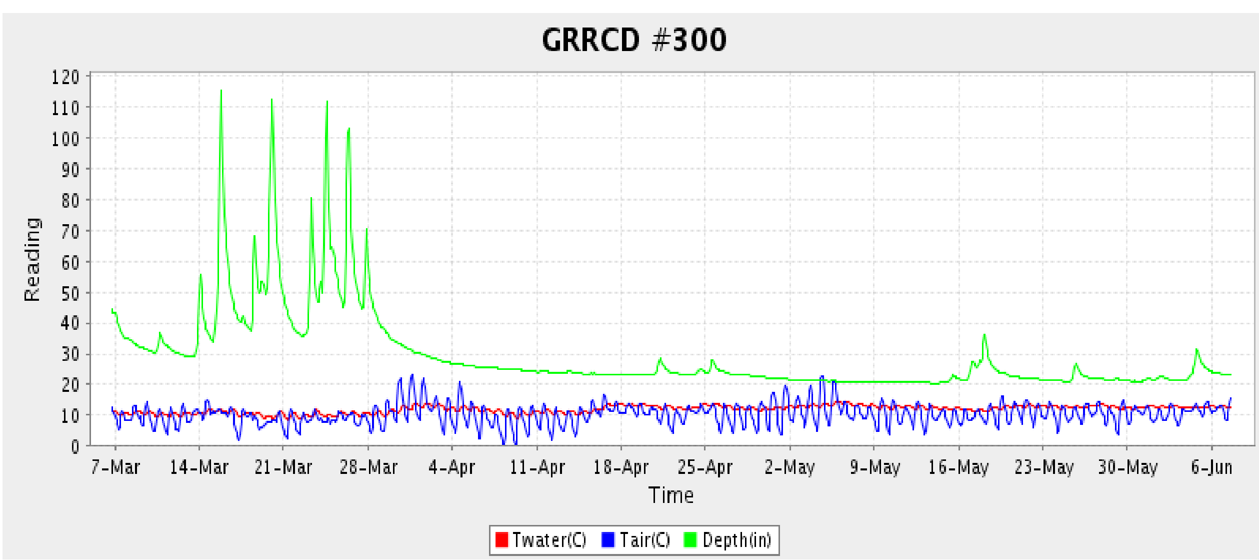


Figure 14 Hydrograph of Salmon Creek from March 6 to June 6, 2011



List of Works Cited

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Newcombe, C. (2003). Impact assessment model for clear water fishes exposed to excessively cloudy water. Journal of the American Water Resources Association (JAWRA) 39(3):529-544.