Cottonwood Creek Water Quality Monitoring Report 2005-2006

Developed for:

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Introduction

The Idaho Association of Soil Conservation Districts (IASCD) collected water quality data from Cottonwood Creek and several of its tributaries from February 2005 through March 2006.

This monitoring project was initiated to evaluate water quality in the Cottonwood Creek watershed. The Total Maximum Daily Load (TMDL) for the Cottonwood Creek Watershed was finalized in May of 2000.

This report reviews monitoring results for the following parameters:

-Total Phosphorus (TP)
-Orthophosphorus (OP)
-Bacteria (*Escherichia coli)*
-Nitrogen Components—NO_2, NO_3, NH_3
-Total Suspended Solids (TSS)
-Instantaneous Water Temperature
-Turbidity
-Dissolved Oxygen (DO)
-Percent (%) Saturation
-Total Dissolved Solids (TDS)

The University of Idaho Analytical Science Laboratory (UIASL) conducted all inorganic parameter testing and Anatek Labs, Inc. performed bacteria analysis. Ken Clark (IASCD Moscow) performed all other measurements.

Cottonwood Creek Subbasin

The Cottonwood Creek subbasin, 5th field hydrologic unit code (HUC) # 1706030513 drains approximately 124,439 acres in Idaho County, Idaho. Cottonwood Creek is a fourth order tributary to the South Fork Clearwater River. It originates in the steep, forested lands of Cottonwood Butte and flows eastward across the rolling cropland of the Camas Prairie and into the deep canyons found in the eastern portion of the watershed, where it then enters the South Fork Clearwater River near Stites, Idaho.

Cottonwood Creek flows from an elevation of 5,730 feet to an elevation of 1,332 feet. Land uses consist of cropland (74%), pastureland (7%), rangeland (13%), forestland (6%), and urban areas (<1%). The City of Cottonwood and a small portion of the City of Grangeville are found within the watershed.

There are five major tributaries of Cottonwood Creek: Stockney Creek, Shebang Creek, Red Rock Creek, Long Haul Creek and South Fork Cottonwood Creek. Cottonwood Creek and its five tributaries are all listed in the *Integrated §303(d)/ §305(b) Report* as water quality limited from their headwaters to their mouths. Red Rock Creek is located on the Nez Perce Indian Reservation and is currently being monitored on a quarterly basis by the Nez Perce Tribe, along with 2 sites on the mainstem of Cottonwood Creek. Waterfalls that have been identified as fish barriers are found on Cottonwood Creek and Red Rock Creek at 3.6 miles and nine miles, respectively.

Climate

Climate in the Cottonwood Creek basin is characterized by cool, moist winters and warm dry summers. Air temperatures in the basin typically decrease as elevation increases.

Average annual precipitation ranges from 20-25 inches across most of the basin with over 30 inches falling in the Cottonwood Butte area. Monthly precipitation averages are greatest from March to June and the least during July, ranging from 2-3 inches a month in the spring to 1-2 inches per month during the rest of the year. Total precipitation in 2001 and 2005, the two IASCD sampling periods, were very similar, coming in at 19.95 and 19.42 inches, respectively.

Parts of the Cottonwood Creek basin are intermittently covered with snowpack from November - March. Average annual snowfall ranges from 22 inches per year in Kooskia to 60 inches per year across the Camas Prairie.

Rain accompanied by warm Chinook winds is a common occurrence in the winter and early spring and often results in high intensity runoff events. These high flow events account for the majority of Cottonwood Creek's streamflow. During the winter, an intermittent snowpack may cover parts of the basin from November - March, providing additional runoff during rain events.

Background

Water quality monitoring was previously conducted by the IASCD on four major tributaries to Cottonwood Creek from May, 2001 to May, 2002. Tributaries monitored were South Fork of Cottonwood Creek, Long Haul Creek, Stockney Creek and Shebang Creek. Some findings of the initial sampling period were:

- Sediment and turbidity only exceeded recommended levels during spring runoff.
- Nutrients were consistently elevated throughout the watershed.
- Temperature exceedances were common throughout the watershed.
- The tributaries of Cottonwood Creek were identified as impaired by excess nutrients, although dissolved oxygen level exceedances were only observed on streams that were nearly dry.
- Pathogen levels exceed water quality standards during summer months.

The Cottonwood Creek Watershed Advisory Group (WAG) and supporting agencies created a TMDL implementation plan. This plan provides the framework necessary to implement best management practices (BMPs) aimed at improving water quality through practices such as riparian restoration, bank stabilization, animal waste systems, grassed waterways, conservation cropping and tillage practices, and livestock exclusion.

The Environmental Protection Agency (EPA) approved the Cottonwood Creek TMDL in June of 2000.

Table 1 lists specific pollutant targets identified in the TMDL as necessary to improve water quality to the degree where beneficial uses are being achieved. State of Idaho Water Quality Standards apply where no other target is specifically designated.

Although there is no numeric standard in place, some literature claims that numbers above 0.30 mg/L could cause excessive plant growth and possible eutrophication (Cline, 1973 & Golterman, 1975). For the analysis in this report, 0.30 mg/L will be used as the water quality target.

Table 1. Pollutant targets for streams identified in the Cottonwood Creek TMDL

Pollutant of Concern	Pollutant Targets for Cottonwood Creek TMDL
Temperature	13 ^{o}C instantaneous and 9 ^{o}C daily average during salmonid spawning period (January15th through July 15th); 22 ^{o}C instantaneous and 19 ^{o}C daily average the rest of the year in the main stem of Cottonwood Creek.
Total Phosphorus	0.1 mg/L from April-October
Total Suspended Solids (TSS)	50 mg/L monthly average from January – May.
Ammonia	1.24 mg/L (November – April); 0.16 mg/L (May – October).

Monitoring Site Descriptions

Four of the monitoring sites (TCC-1, TCC-2, TCC-3, TCC-4) selected for this project were sites where data were initially collected by IASCD personnel in 2001. The remaining sites were established to collect additional baseline data that will be used to evaluate water quality trends in the future. Below is a general description of the site locations; these sites are also illustrated graphically in Figure 1.

TCC-1 Located near the mouth of South Fork Cottonwood Creek just above State Route 7.

TCC-2 Located near the mouth of Long Haul Creek at the Day Road crossing.

TCC-3 Located near the mouth of Stockney Creek at the Center Road crossing.

TCC-4 Located near the mouth of Shebang Creek at the Kube Road crossing.

TCC-5 Located on Red Rock Creek, above the canyon, approximately 4 miles from its mouth.

TCC-6 Located on Cottonwood Creek near the headwaters.

TCC-7 Located on Cottonwood Creek downstream of the City of Cottonwood wastewater treatment ponds.

TCC-8 Located on Cottonwood Creek at the Tribal Reservation boundary.

TCC-9 Located near the mouth of Cottonwood Creek

IASCD Cottonwood Creek Watershed Monitoring Sites

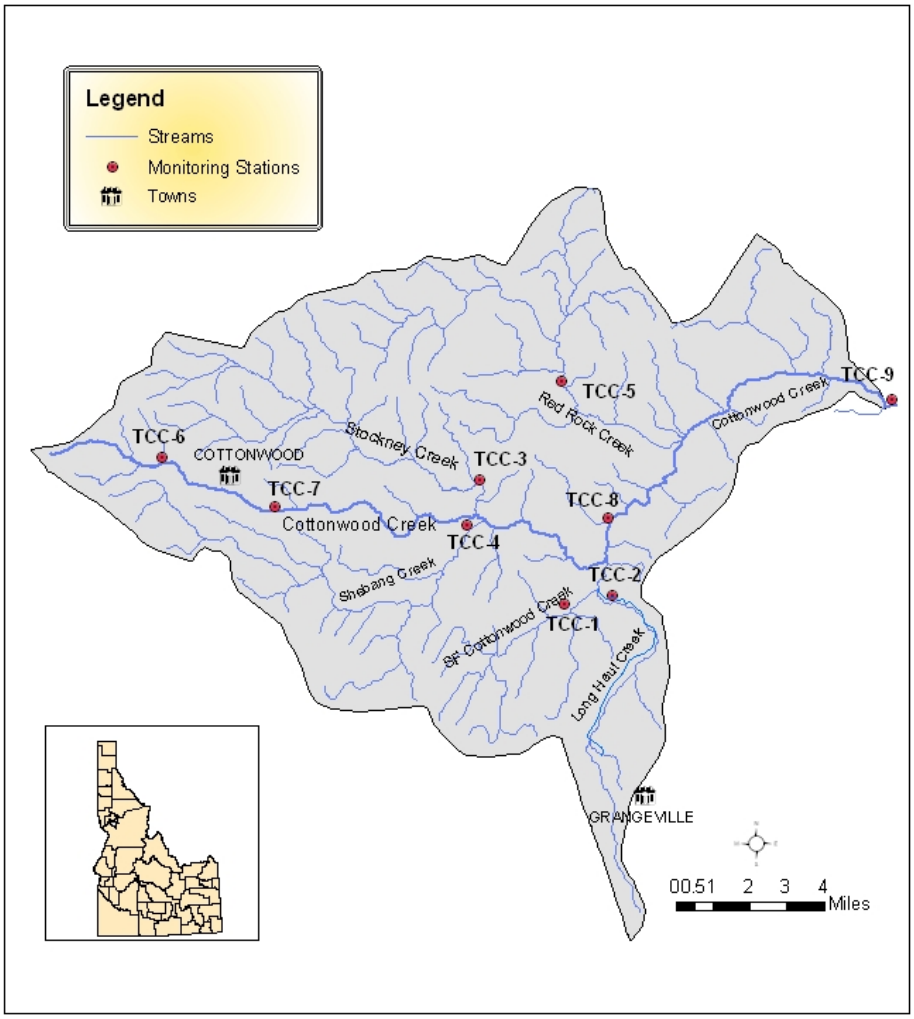

Figure 1. Cottonwood Creek watershed and IASCD monitoring sites.

Methods and Materials

Water Quality Limited Segments

The Clean Water Act (CWA) requires restoration and maintenance of the chemical physical, and biological integrity of the nation's water (Public Law 92-500 Federal Water Pollution Control Act Amendments of 1972). Section §303 (d) of the CWA establishes requirements for states to identify and prioritize waterbodies that are water quality limited (i.e. do not meet water quality standards). All streams in this study are listed as water quality limited in Idaho's Integrated §303(d)/ §305(b) Report.

Sampling Protocols

Approximately four liters of stream water were collected at each site, using a DH-81 depth-integrating suspended-sediment sampler. The samples were collected and transferred into a 2.5-gallon polyethylene churn splitter. The polyethylene churn splitter was rinsed with ambient water at each location prior to sample collection. The resultant composite sample was thoroughly homogenized before filling the appropriate sample containers. Water samples requiring preservation (NO_2+NO_3, NH_3, and TP) were transferred into preserved (H_2SO_4 pH <2) 500 mL sample containers. Water quality samples (TSS, NO_2+NO_3, NH_3, and TP) were then analyzed at the UIASL in Moscow, Idaho.

Bacteriological samples (*E. coli*) were collected directly from the thalweg into sterile sample containers. The samples were delivered to Anatek Labs, Inc. in Moscow for analysis. Most probable number (MPN) multiple tube fermentation was used to determine *E. coli* levels in the water sample.

A list of parameters, sample sizes, preservation, holding times, and analytical methods are displayed in Table 2. All sample containers were labeled with waterproof markers with the following information: station location, sample identification, date of collection, and time of collection. Samples were placed on ice and transported to the laboratory the same day as collection. Chain-of-custody forms accompanied each sample shipment.

Table 2. Water Quality Parameters

Parameters	Sample Size	Preservation	Holding Time	Method
Non Filterable Residue (TSS)	1L	Cool 4°C	7 Days	EPA 160.2
Nitrogen Components: NO_3+NO_2 Ammonia	60 mL 60 mL	Cool 4°C, H_2SO_4 pH < 2	28 Days	EPA 353.2 EPA 350.1
Total Phosphorus	100 mL	Cool 4°C, H_2SO_4 pH < 2	28 Days	EPA 365.4
Escherichia coli	100 mL	Cool 4°C	30 Hours	MPN

Field Measurements

At each location, field parameters for dissolved oxygen, specific conductance, pH, temperature, turbidity, and total dissolved solids were measured. Calibration of all field equipment was in accordance with the manufacturer specifications. Field measurement parameters, equipment and calibration techniques are shown in Table 3.

Table 3. Field Measurements

Parameters	Instrument	Calibration
Dissolved Oxygen	YSI Model 55	Ambient air calibration
Temperature	YSI Model 55	Centigrade thermometer
Conductance & TDS	Orion Model 115	Specific Conductance (25°C standard)
pH	Orion Model 210A	Standard buffer (7,10) bracketing for linearity
Turbidity	Hach Model 2100P	Formazin Primary Standard

All field measurements were recorded in a field notebook along with pertinent observations about the site, including weather conditions, flow rates, personnel on site, and any problems observed that might affect water quality.

Flow Measurements

Flow measurements were collected at each site using a Marsh McBirney Flow Mate Model 2000 flow meter. The six-tenths depth method (0.6 of the total depth from the surface of the water surface) was used. A transect line was established at each monitoring station, across the width of the stream at an angle perpendicular to the flow, for the calculation of cross-sectional area. Discharge was computed by summing the products of the partial areas (partial sections) of the flow cross-sections and the average velocities for each of those sections. Stream discharge was reported as cubic feet per second (cfs).

Quality Assurance and Quality Control (QA/QC)

The UIASL utilizes methods approved and validated by the EPA. A method validation process, including precision and accuracy performance evaluations and method detection limit studies, is an element of UIASL Standard Methods. Method performance evaluations include quality control samples analyzed with a batch to ensure sample data integrity. Internal laboratory spikes and duplicates are part of UIASL's quality assurance program. Laboratory QA/QC results generated from this project can be provided upon request.

QA/QC procedures from the field-sampling portion of this project included a duplicate sample and a blank sample (one set per sampling day). The field blanks consisted of laboratory-grade deionized water, transported to the field and poured off into the appropriate sample containers. The blank sample was used to determine the integrity of the field teams handling of samples, the condition of the sample containers and deionized water supplied by the laboratory and the accuracy of the laboratory methods. Duplicate samples were obtained by filling two sets of sample containers with homogenized composite water from the same sampling site. The duplicate and blank samples were not identified as such to laboratory personnel to ensure laboratory precision.

Data Handling

All of the field data and analytical data generated from each survey were reviewed in the Moscow field office and then submitted to the Idaho State Department of Agriculture (ISDA) in Boise for further review. These reviews ensure that all necessary observations, measurements, and analytical results were properly recorded. The analytical results were evaluated for completeness and accuracy. Any suspected errors were investigated and resolved, if possible. The data were then stored electronically and made available to any interested entity upon request.

Data Analysis

Analysis of the data was done, and descriptive statistics such as maximum, minimum, median, and mean values for each parameter measured were determined. The number of exceedances per year was calculated based on the number of sampling events whose respective values exceeded TMDL targets or State of Idaho water quality standards, whichever was more restrictive. These descriptive statistics are presented per subwatershed, as are statistical comparisons between the 2001 and 2005 data sets, when possible.

Most of the data collected during these monitoring projects do not fit a normal distribution, and contain numerous instances of censored data and outliers. Censored data can cause problems when using parametric methods of statistical analysis because these methods often require that all data have numerical values. Nonparametric methods often deal with the ranking of the data, not the data themselves. For example, with data "below the detection limit," any value that is less than the smallest value of all the data being analyzed can be assigned. This assignment does not affect the ranking of the data even though the exact value of the "below the detection limit" is unknown. Nonparametric procedures are also less affected by outliers (Spooner, 1994).

Data sets were first tested for normality using the Kolmogorov-Smirnov test. If the data were normally distributed, an unpaired *t*-test was performed; if the data were not normally distributed, a Mann-Whitney Rank Sum test was employed. The Rank Sum test ranks all the observations from smallest to largest without regard to which group each observation comes from. The ranks for each group are summed and the rank sums compared. If there is no difference between the two groups, the mean ranks should be approximately the same. If they differ by a large amount, one may conclude that there is a statistically significant difference between the groups that is not attributable to random sample variation.

All data were analyzed using this method, although only the data sets where a difference of statistical significance occurred are shown in this report.

Box plots were used to graphically illustrate the differences between the 2001 and 2005 data sets. Box plots graph data as a box representing statistical values. The boundary of the box closest to zero indicates the 25th percentile, a line within the box marks the median, and the boundary of the box farthest from zero indicates the 75th percentile. Whiskers above and below the box indicate the 90th and 10th percentiles. Outlying points are also shown in most of the graphs.

Results and Discussion

Subwatershed Current and Comparative Analysis

South Fork Cottonwood Creek (TCC-1)

The South Fork of Cottonwood Creek drains 12,557 acres of land, of which 10,989 acres are cropland, 1,091 acres are pastureland, 452 acres are rangeland, 16 acres are forested, and 9 acres are urban/industrial land. All 12,557 acres of land are held in private ownership.

Vegetative communities along the South Fork are dominated by Reed Canarygrass (*Phalaris arundinacea*), with a variety of other herbaceous and woody trees and shrubs as sub-dominates.

Table 4 presents descriptive statistics for the South Fork Cottonwood Creek site and Table 5 compares select parameters from the 2001 and 2005 data sets.

Table 4. Descriptive statistics for South Fork Cottonwood Creek monitoring site, 2005.

TCC-1	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	14.52	26.00	9.04	459.00	11	0.95	0.21	1.1	220.00	1119.90
Minimum	7.02	1.20	7.63	4.37	0.05	0.05	0.02	0.045	2.00	0.05
Mean	11.87	10.14	8.47	72.08	1.91	0.11	0.1	0.225	33.62	142.72
Median	12.49	7.90	8.55	15.30	1.3	0.05	0.08	0.13	9.80	14.60
# exceedance	0.0	4.0	0.0		16	1	4	6	3.0	2.00
% exceedance	0.0%	23.5%	0.0%		94.1%	5.9%	57.1%	85.7%	17.6%	13.3%
# sampling events	17.0	17.0	15.0		17	17	7	7	17.0	15.00

Table 5. Comparison of 2001 and 2005 data for South Fork Cottonwood Creek.

Parameters	Median		Minimum		Maximum	
	2001	2005	2001	2005	2001	2005
pH	7.90	8.50	7.09	7.63	8.92	9.04
TP (mg/L)	0.155	0.130	0.050	0.045	0.360	1.100
E. coli (cfu/ 100mL)	55.0	14.6	10.0	0.05	9000.0	1119.9
TSS (mg/L)	8.00	9.80	2.00	2.00	60.0	220.0
Turbidity	11.90	15.30	1.85	4.37	113.0	459.0
NO_2+NO_3	1.20	1.30	0.05	0.05	19.0	11.0

Below is a comparison of *E. coli* data sets from 2001 and 2005. Listed are the results of the Kolmogorov-Smirnov test for normality, the statistical interpretation, and accompanying graphical illustrations. The dashed red line in Figures 2 and 3 indicates the

applicable 576 organisms/ 100m/L criteria set by the DEQ for secondary contact recreation (SCR).

Mann-Whitney Rank Sum Test

Normality Test: Failed (P < 0.050)

Group	N	Missing	Median	25%	75%
E-Coli (2001)	24	0	55.000	20.000	500.000
E-Coli (2005)	15	0	14.600	6.300	56.875

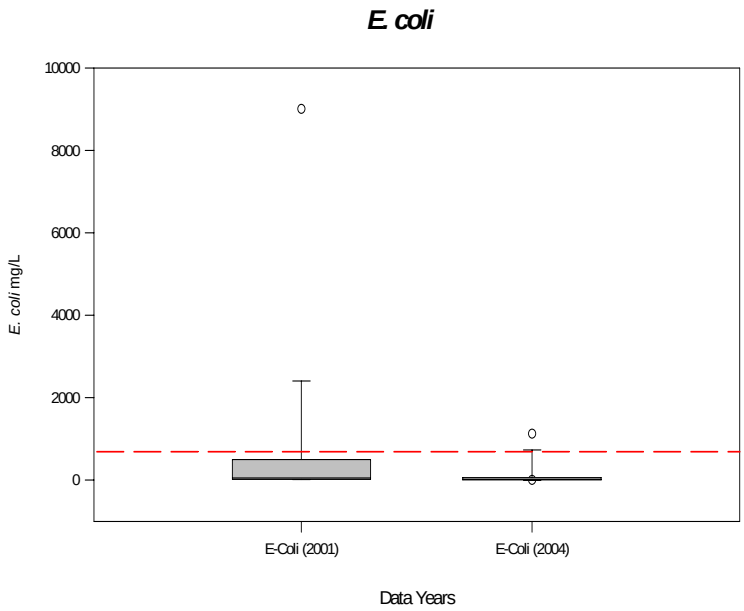

Figure 2. Comparison of SF Cottonwood Creek *E. coli* data. The dashed red line indicates the applicable 576 organisms/100 mL criteria for SCR.

The difference in the median values between the two groups is greater than would be expected by chance; there is a statistically significant difference (P = 0.020). There was a 73% decrease in the median level of E. coli from 2001 to 2005 (Figure 2).

A statistically significant increase was also noted in DO levels in the South Fork Cottonwood Creek. More significantly, there were no exceedances of the State of Idaho DO standard of 6 mg/L during the 2005 monitoring season. Figure 3 shows the difference in DO levels from 2001 to 2005.

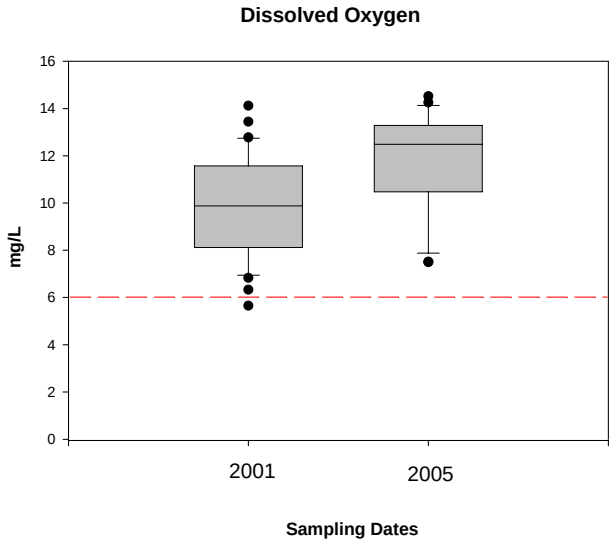

Figure 3. Comparison of SF Cottonwood Creek dissolved oxygen data. The dashed red line indicates the applicable 6 mg/L criteria for DO.

TP exceeded the 0.1 mg/L target set in the TMDL 85.7% of the time in 2005, during the "growing season" of April-October (n=7). This is up from the 2001 study, where the criteria was exceeded 73.3% of the time (n=15).However, median TP levels for the year decreased 13%.

It should be noted that the mean discharge during the 2005 growing season was 4.61 cfs, while the mean discharge in 2001 during that same period was 0.51 cfs. This disparity was cause by two large rain events in April and May of 2005 that were absent in 2001. In 2005, sampling was stopped in early July due to lack of flow, and didn't resume until mid October. In 2001, flows were very low, but the stream never completely dried up.

Phosphorus is not particularly mobile in soil; instead it tends to adhere to soil. Highest phosphorus rates were observed during spring runoff, when soil becomes highly mobile within stream systems and carries the phosphorus load with it. The continued sampling in 2001 of the stream during very low flow, or no flow conditions is the most likely reason that TP levels are lower (i.e. TP is often carried by sediment, which is mobilized by high flows). If those extremely low flow sampling dates are taken out of the 2001 data set, the exceedance percentage rises to 90%.

TSS levels exceeded the TMDL target of 50.0 mg/L three times in 2005, while only exceeding the criteria once in 2001. Figure 5 graphically illustrates the relationship between TSS and TP. A Pearson's Product-moment correlation coefficient of 0.957 shows that there is a clear relationship between the two parameters.

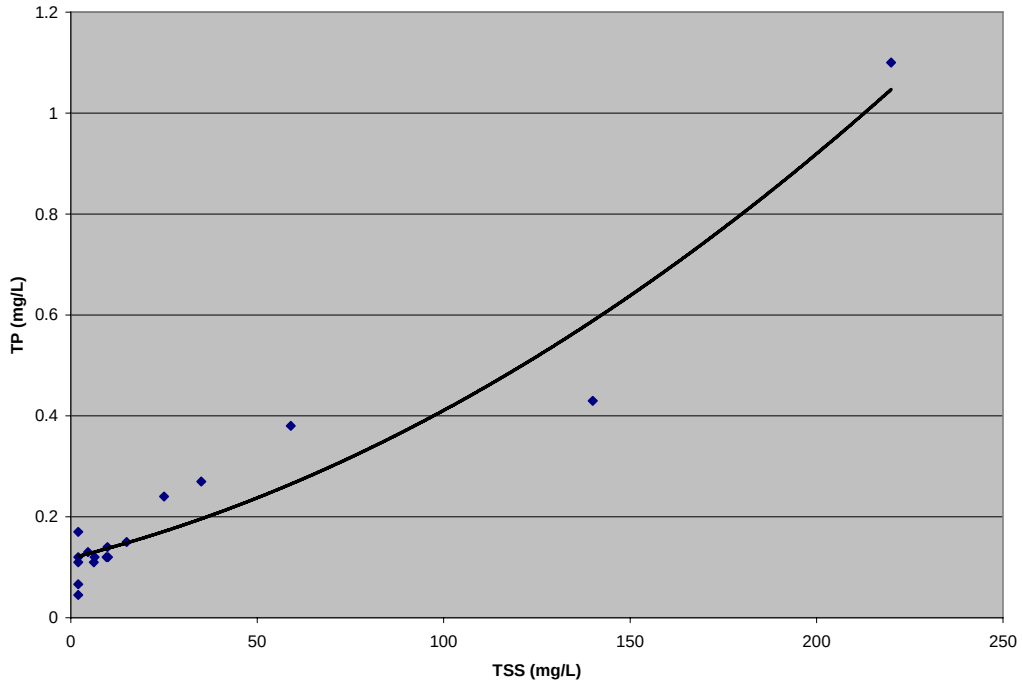

Figure 4. South Fork Cottonwood Creek scatter plot and trend line for TP and TSS.

South Fork Cottonwood Creek Summary:

- In the 2001 study, there was flow in the stream year-round. However, in the 2005 study, flow stopped in late July and didn't resume until early October. Large pools of standing water were found along the length of the stream and served as refugia for aquatic invertebrates and fish.
- The 22 ^{o}C instantaneous temperature standard was violated twice (11.8%) during the 2005-2006 sampling period. These exceedences were observed in late June and early July, right before flow ceased in the stream. There were no temperature exceedences documented in the 2001 data set.
- TSS concentrations in 2005 exceeded the 50 mg/L target three times and the 2005 TSS median was 25 % higher than the 2001 median.
- A correlation coefficient of 0.957 shows that there is a clear relationship between TP and TSS in 2005. However, the relationship between TP and TSS in 2001 was not as pronounced (0.704).
- TP levels exceeded the 0.1 mg/L TMDL target 6 times during the 2005 growing season of April - October (n=7). Overall, there was a 13% reduction in annual median TP levels and a 37% rise in mean TP levels from 2001 to 2005. This rise in mean levels was caused by a single event on 4/13/05, when TP was measured at 1.1 mg/L and TSS was 220 mg/L. If this outlier is removed, mean TP levels in 2005 are very similar to 2001.
- NO_2+NO_3 levels were consistently elevated in this stream, with 94.1% of the 2005 samples exceeding the target of 0.3 mg/L. In 2001, the median NO_2+NO_3

level was 1.2 mg/L; in 2005-2006, the median level was 1.3 mg/L. Application of nitrogen fertilizers may be partially responsible for the elevated numbers.

- Although the instantaneous bacteria target was violated twice during this study the median *E. coli* count was reduced by 75 % from 2001 to 2005-20006.

Long Haul Creek (TCC-2)

Long Haul Creek drains 8,872 acres of land, of which 6,940 acres are cropland, 905 acres are pastureland, 100 acres are rangeland, 250 acres are forested and 677 acres are considered urban/industrial. All 8,872 acres are privately owned.

Heavy grazing has limited woody vegetation in significant parts of the drainage. One stream survey found that only 55% of the stream banks within the Long Haul Creek were considered to be in stable condition. (Idaho County SWCD, 2000).

Table 6. Descriptive statistics for Long Haul Creek monitoring site, 2005.

TCC-2	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	14.77	29.10	9.80	224.00	4.9	1.2	0.27	0.53	46.00	1299.70
Minimum	6.47	0.50	8.10	2.04	0.05	0.05	0.01	0.028	2.00	1.00
Mean	10.34	12.30	8.55	37.80	0.73	0.15	0.13	0.216	10.47	289.40
Median	10.21	10.50	8.47	15.10	0.08	0.05	0.1	0.205	6.45	177.90
# exceedance	0.0	6.0	2.0		0.8	0	8	11	0.0	4.00
% exceedance	0.0%	27.3%	10.0%		36.4%	0.0%	66.7%	91.7%	0.0%	20.0%
# sampling events	22.0	22.0	20.0		22	22	12	12	22.0	20.00

Table 7. Comparison of 2001 and 2005 data for Long Haul Creek.

Parameters	Median		Minimum		Maximum	
	2001	2005	2001	2005	2001	2005
pH	8.21	8.47	7.32	8.10	9.30	9.80
TP (mg/L)	0.130	0.205	0.050	0.028	0.280	0.530
E. coli (cfu/ 100mL)	95.0	177.9	10.0	1.0	3000.0	1299.7
TSS (mg/L)	4.00	6.45	2.00	2.00	66.0	46.0
Turbidity (NTU)	6.6	15.1	1.51	2.04	171.0	224.0
NO_2+NO_3	0.05	0.075	0.05	0.05	5.90	4.90

Median *E. coli* levels were 87 % higher in 2005 than in 2001, and the State of Idaho instantaneous criteria of 576 organisms/ 100mL for SCR was exceeded three times in 2005, as opposed to twice in 2001. Figure 5 illustrates the increase in *E. coli* levels.

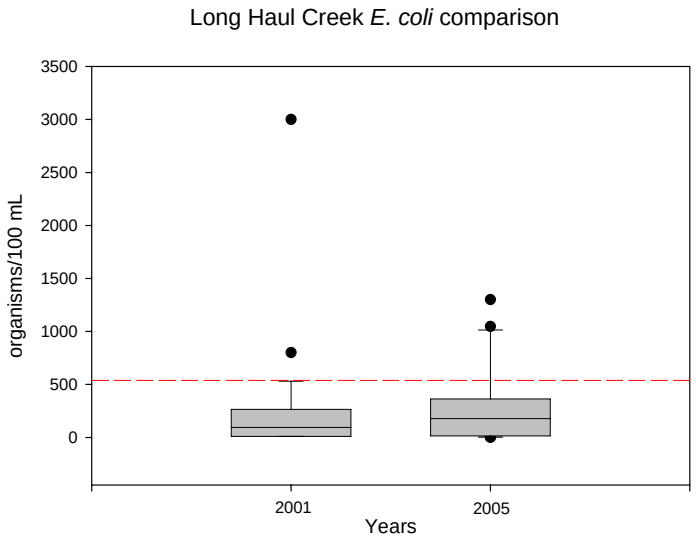

Figure 5. Comparison of Long Haul Creek *E. coli* data. The dashed red line indicates the applicable 576 organisms/100mL criteria for SCR.

There was also a 58% increase in annual median TP levels from 2001 to 2005, with 91.7% of the samples exceeding the 0.1 mg/L target, during the "growing season" of April-October (n=12). This represents an increase from the 2001 study, where the criteria was exceeded 75.0% of the time (n=16) during the growing season. Figure 6 shows the increase in TP levels from 2001 to 2005.

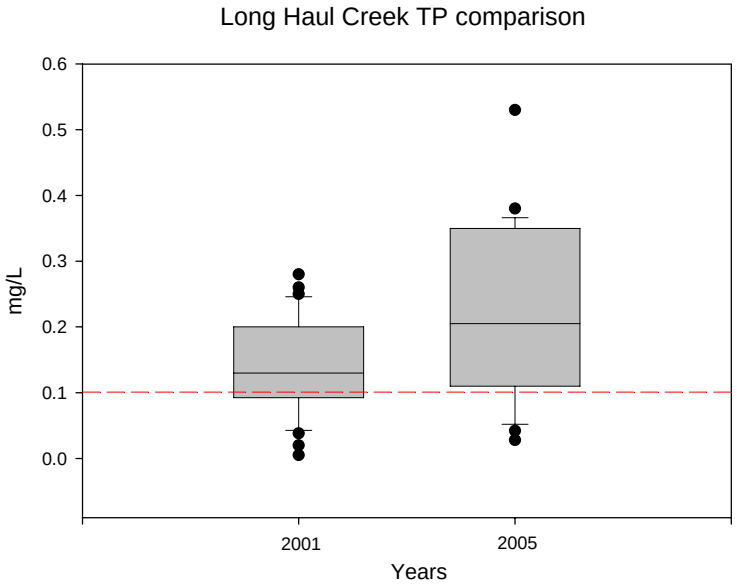

Figure 6. Comparison of Long Haul Creek Total Phosphorus data. The dashed red line indicates the applicable 0.1 mg/L target for TP.

Mean NO_2 + NO_3 levels dropped approximately 25% from 2001 levels, although median levels were slightly higher. This is due to the fact that there were several very large spikes in nitrogen levels during 2001, which raised the mean, while the more constant levels of nitrogen in 2005 translated into a more moderate mean. To offset the effect of

these outliers in the 2001 data set, it may be more useful to use the median as the measure of central tendency for this site. The number of exceedances of the 0.3 mg/L target was quite similar for both years, with nine (33.3%) in 2001 and eight (36.4%) in 2005. Figure 7 gives a visual representation of NO_2 + NO_3 levels in Long Haul Creek in 2001 and 2005.

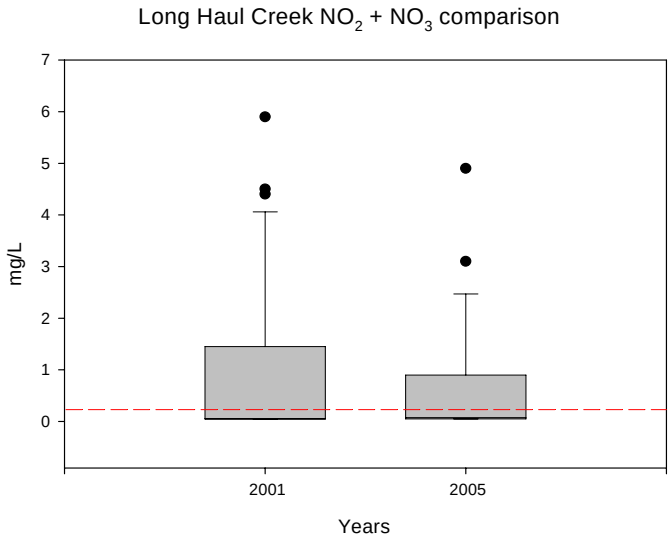

Figure 7. Comparison of Long Haul Creek NO_2+NO_3 data. The dashed red line indicates the applicable 0.3 mg/L target for NO_2+NO_3.

There was an increase of almost three degrees Celsius in both mean and median water temperatures from 2001 to 2005 (Figure 8). The number of exceedances over the 22 ^{o}C instantaneous maximum criteria also increased, going from zero in 2001 to three in 2005. It should be noted that most of the temperature measurements were taken prior to late afternoon, when stream temperatures typically reach their peak, and should therefore be considered conservative.

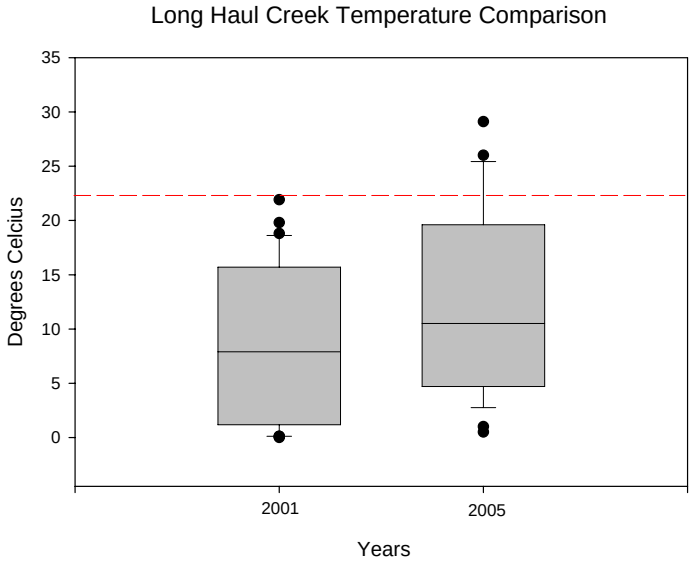

Figure 8. Comparison of Long Haul Creek temperature data. The dashed red line indicates the applicable 22 ^{o}C maximum threshold for Cold Water Biota.

Long Haul Creek Summary:

- *E. coli*, TP and temperature were all considerably higher in 2005 than in 2001. Increased presence of cattle was evident during the 2005 season and seems to be a likely source for the increases in the aforementioned parameters. Numerous cases of cattle directly accessing the stream were observed and vegetation was mostly absent along the streambanks near the monitoring station.
- TSS did not violate the 50 mg/L monthly average criteria in 2005, although both turbidity and TSS were quite high during spring runoff in May.
- $NO_2 + NO_3$ levels were quite similar in 2005 to the 2001 data set. Exceedances of the 0.3 mg/L target were measured 36.4% of the time in 2005 and occurred primarily during winter/spring runoff events.

Stockney Creek (TCC-3)

Stockney Creek drains 19,917 acres of land, of which 16,364 acres are cropland, 897 acres are pastureland, 2,094 acres are rangeland, 558 acres of land are forested and four acres are urban/industrial. 19,516 acres of this watershed are privately owned and 401 acres are owned by the Nez Perce Tribe.

There have been numerous impacts to the stream channel and vegetation throughout most of the length of Stockney Creek. The upper reaches were channelized and vegetative communities have changed, most likely from willow (*Salix spp*) dominated communities to vegetation dominated by reed canarygrass (*Phalaris arundincea*) (Idaho County SWCD, 2000).

Table 8. Descriptive statistics for Stockney Creek monitoring site, 2005.

TCC-3	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	16.83	19.30	8.90	105.00	4.5	0.36	0.23	0.42	47.00	613.10
Minimum	5.70	0.10	7.97	3.16	0.05	0.05	0.02	0.044	2.00	2.00
Mean	11.69	7.16	8.37	17.57	1.18	0.08	0.09	0.155	12.46	129.08
Median	12.58	4.55	8.32	8.68	0.78	0.05	0.08	0.12	5.60	40.60
# exceedance	1.0	3.0	0.0		15	0	7	8	0.0	1.00
% exceedance	5.6%	16.7%	0.0%		83.3%	0.0%	87.5%	100.0%	0.0%	6.3%
# sampling events	18.0	18.0	16.0		18.0	18.0	8.0	8.0	18.0	16.0

Table 9. Comparison of 2001 and 2005 data for Stockney Creek.

Parameters	Median		Minimum		Maximum	
	2001	**2005**	**2001**	**2005**	**2001**	**2005**
pH	8.01	8.32	6.95	7.97	8.45	8.90
TP (mg/L)	0.150	0.120	0.073	0.044	0.330	0.420
E. coli (cfu/100mL)	70.00	41.30	10.00	2.00	2400.00	613.10
TSS (mg/L)	8.00	5.60	2.00	2.00	32.00	47.00
Turbidity (NTU)	10.30	8.68	3.80	3.16	124.00	105.00
NO_2+NO_3	0.90	0.78	0.05	0.05	9.90	4.50

Median and mean TP levels dropped slightly from 2001 to 2005, although the 0.1 mg/L target set in the TMDL was violated 100% of the time in both years, during the "growing season" of April through October. Variability of TP values in 2005 was greater as well. Figure 9 illustrates the TP comparison between years.

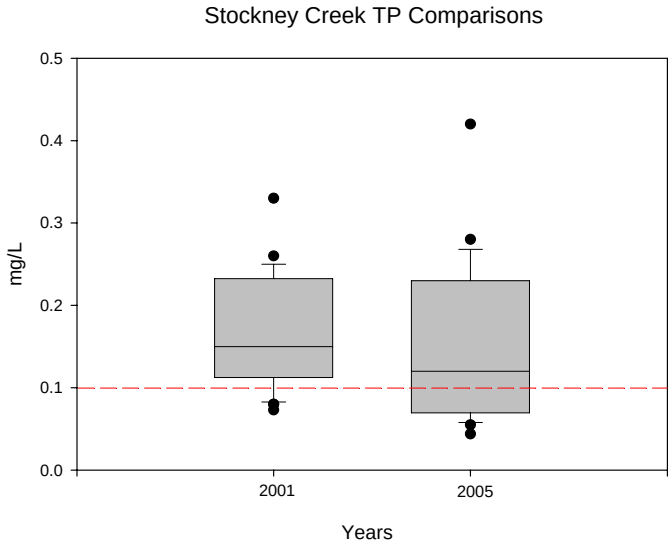

Figure 9. Comparison of Stockney Creek Total Phosphorus data. The dashed red line indicates the applicable 0.1 mg/L target.

Median *E. coli* levels decreased 41% from 2001 to 2005 (Figure 10) and the number of exceedances over the 576 org/100 mL criteria decreased from three in 2001 (n=22) to one in 2005 (n=16).

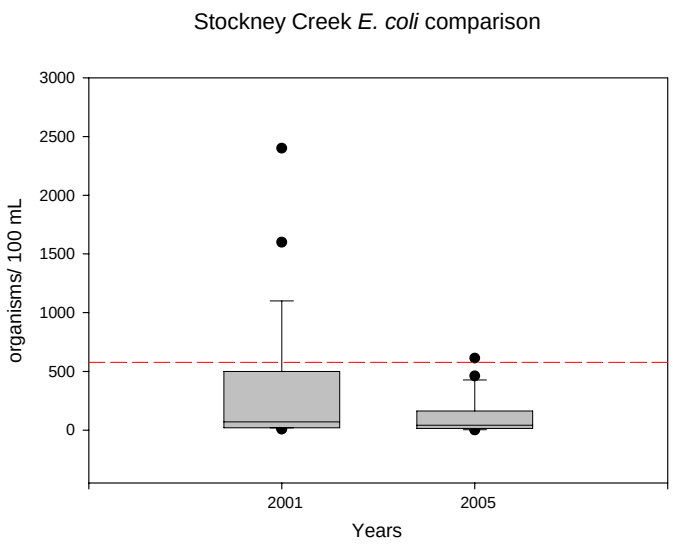

Figure 10. Comparison of Stockney Creek *E. coli* data. The dashed red line indicates the applicable 576 organisms/100m/L criteria for SCR.

Although 83% of the NO_2+NO_3 samples collected in 2005 still exceeded the 0.3 mg/L nutrient target (n=18), a 22% decrease in median levels occurred, and the seasonal peaks observed in the 2001 study were less pronounced in 2005 (Figure 11).

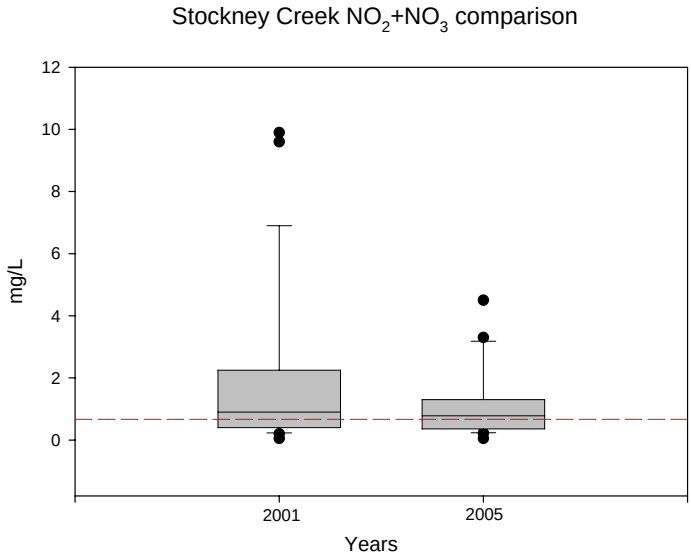

Figure 11. Comparison of Stockney Creek NO_2+NO_3 data. The dashed red line indicates the applicable 0.3 mg/L target for NO_2+NO_3.

Stockney Creek Summary:

- TP levels in 2005 were quite similar to 2001 levels, with both data sets exceeding the "growing season" nutrient target of 0.1 mg/L 100% of the time.
- *E. coli* levels decreased 43% from 2001 levels and only one exceedance was witnessed during the 2005 study.
- Median NO_2+NO_3 levels dropped slightly from 2001 to 2005, but 83% of the samples collected still exceeded 0.3 mg/L criteria.
- TSS did not exceed the 50 mg/L monthly average criteria, but both turbidity and TSS were quite high during spring runoff in May.

Shebang Creek (TCC-4)

Shebang Creek drains 18,332 acres of land, of which 15,790 acres are cropland, 1,408 acres are pastureland, 754 acres are rangeland, 318 acres of land are forested and 62 acres are urban/industrial. All 18,332 acres are privately owned.

The upper surveyed reaches of Shebang Creek are in relatively good condition and have a high potential for restoration of quality aquatic habitat. These reaches also had the best vegetative communities, with over 50% of the reach dominated by *Carex spp.* communities (Idaho County SWCD, 2000). The lower reaches of Shebang Creek have been much more impacted by livestock and channelization.

Table 10. Descriptive statistics for Shebang Creek monitoring site, 2005.

TCC-4	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	16.30	22.20	8.44	331.00	6.7	0.25	0.24	0.34	87.00	1413.60
Minimum	7.40	0.50	7.71	2.05	0.05	0.05	0	0.024	2.00	5.20
Mean	11.26	8.17	8.18	32.73	1.97	0.08	0.05	0.113	9.82	227.04
Median	11.97	5.60	8.18	5.40	0.63	0.05	0.03	0.061	2.00	42.05
# exceedance	0.0	4.0	0.0		12	1	2	6	1.0	2.00
% exceedance	0.0%	23.5%	0.0%		70.6%	5.9%	28.6%	85.7%	5.9%	14.3%
# sampling events	17.0	17.0	15.0		17.0	17.0	7.0	7.0	17.0	14.0

Table 11. Statistical comparison of 2001 and 2005 data for Shebang Creek.

Parameters	Median		Minimum		Maximum	
	2001	2005	2001	2005	2001	2005
DO (mg/L)	10.25	11.97	2.05	7.40	14.29	16.30
TP (mg/L)	0.115	0.061	0.025	0.024	1.5	0.34
E. coli (cfu/ 100mL)	170.0	42.1	10.0	5.2	5000.0	1413.6
TSS (mg/L)	8.5	2.0	2.0	2.0	700.0	87.0
Turbidity (NTU)	8.28	5.40	2.24	2.05	103.0	331.0
NO_2+NO_3	0.385	0.630	0.05	0.05	8.50	6.70

Median *E. coli* levels decreased 75% from 2001 to 2005, as seen in Figure 12. The number of exceedances over the 576 organisms /100 mL criteria decreased from six in 2001 (n=23) to two in 2005 (n=14).

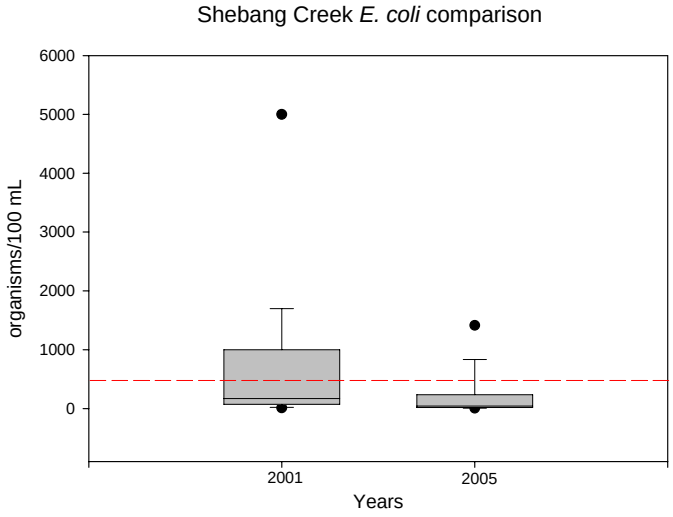

Figure 12. Comparison of Shebang Creek *E. coli* data. The dashed red line indicates the applicable 576 organisms/100 mL criteria for SCR.

Median TP levels decreased 47% from 2001 to 2005, as seen in Figure 13. 2005 TP levels exceeded the 0.1 mg/L "growing season" criteria 85.7% of the time (n=8), as opposed to 66.7% of the time in 2001 (n=15).

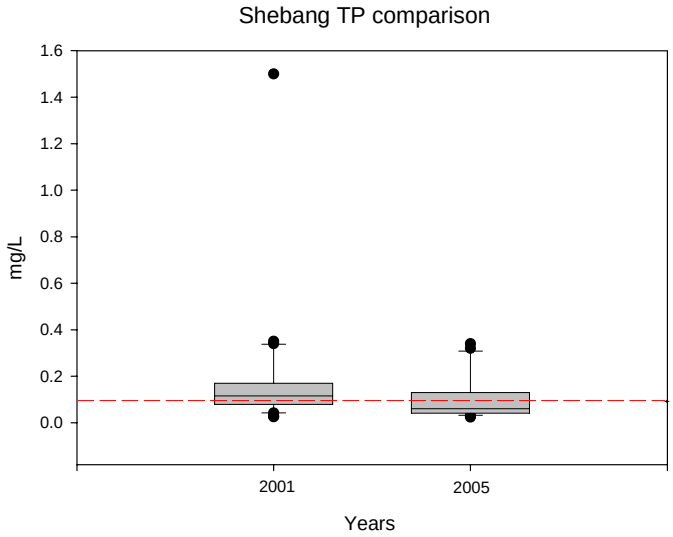

Figure 13. Comparison of Shebang Creek TP data. The dashed red line indicates the applicable 0.1 mg/L criteria.

Median NO_2+NO_3 increased 64% from 2001 to 2005, as seen in Figure 14. The percentage of samples exceeding the 0.3 mg/L guideline also increased, from 56% in 2001 to 71% in 2005.

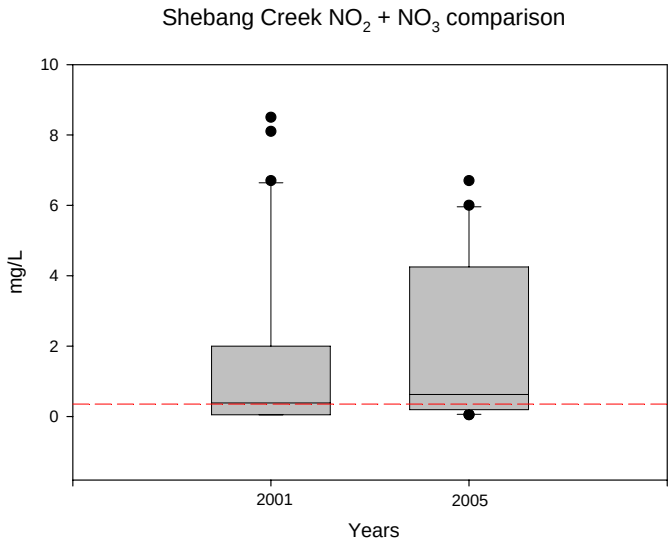

Figure 14. Comparison of Shebang Creek NO_2+NO_3 data. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

Shebang Creek Summary:

- The stream was dry from early July until October.
- DO levels were well above the 6.0 mg/L criteria.
- Median NO_2+NO_3 levels increased 64% from 2001 to 2005 and exceeded the 0.3 mg/L guideline 71% of the time in 2005. The highest levels were observed from January to March, when rain on snow events may have mobilized residual nitrogen fertilizer that was applied in the fall. Over-application of fertilizer and the resultant runoff seem to be a likely cause for the elevated concentrations.
- Median TP levels decreased 47% from 2001 to 2005, likely as a result of fewer cattle accessing the creek.
- Median *E. coli* readings were 75% lower than those observed in 2001, also likely a result of cattle exclusion from the creek.
- One temperature violation occurred in early July, right before the creek went dry.

Red Rock Creek (TCC-5)

Red Rock Creek is the last major tributary to come into Cottonwood Creek, before its confluence with the South Fork of the Clearwater River. The creek drains 26,482 acres, of which 20,899 acres are cropland, 944 acres are pastureland, 3,777 acres are rangeland, 833 acres are forested and 29 acres are urban/industrial. 24,586 acres of this watershed are in private ownership and 1,896 acres are owned by the Nez Perce Tribe.

The upper reaches of the creek show a variety of impacts, including stream channelization, livestock grazing, degradation of streambank vegetation, and erosion. The lower portion of the stream is more stable than the upstream portion, since it is protected by a bedrock, boulder and cobble substrate. Although fewer livestock are present in the lower section of the creek, they may still be having an impact on stream-side vegetation.

This is the first year of IASCD monitoring on this stream, so all data will be considered baseline data.

Table 12. Descriptive statistics for Red Rock Creek monitoring site, 2005.

TCC-5	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	15.87	25.70	9.20	1000.00	12	1.3	0.64	2.7	1200.00	2419.20
Minimum	8.12	0.10	8.15	44.66	0.05	0.05	0.05	0.087	2.00	24.00
Mean	10.91	12.18	8.72	65.53	2.03	0.15	0.17	0.325	69.51	689.64
Median	10.64	9.45	8.70	9.32	1.2	0.05	0.15	0.195	9.90	410.60
# exceedance	0.0	4.0	0.0		20	1	9	10	2.0	8.00
% exceedance	0.0%	18.2%	0.0%		90.9%	4.5%	75.0%	83.3%	9.1%	42.1%
# sampling events	22.0	22.0	22.0		22.0	22.0	12.0	12.0	22.0	19.0

Four violations of the instantaneous temperature criteria occurred in 2005, as illustrated in Figure 15. As one would expect, temperatures began to rise in mid-June and peaked in July and August. Most instantaneous temperature measurements performed at this site were done in the morning hours, before maximum temperatures were likely reached. Therefore, the values presented should be considered conservative.

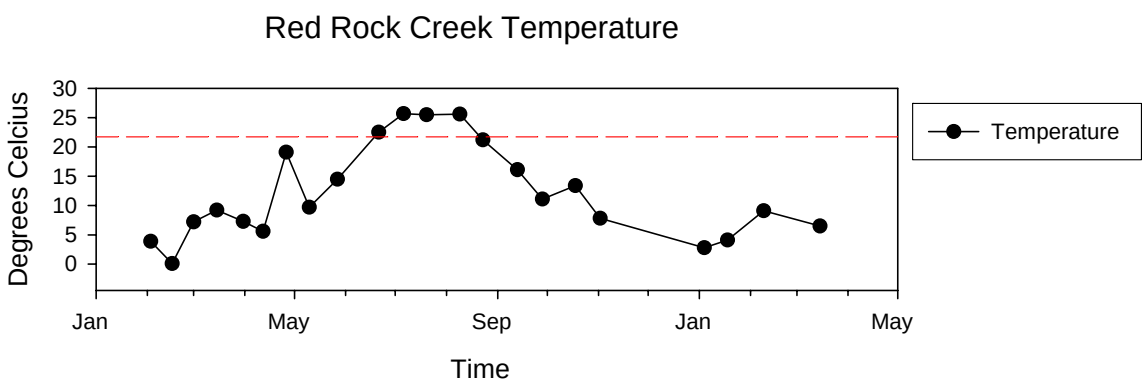

Figure 15. Instantaneous temperature data from Red Rock Creek, 2005. The dashed red line indicates the applicable 22 ^oC temperature criteria.

TSS and turbidity were quite high at this site, especially during spring runoff. TSS violated the 50 mg/L target twice during spring runoff. There was a strong correlation between TSS and turbidity at this site, as well as between TSS and TP. The Pearson Product-moment correlation coefficient for TSS and turbidity was 0.96. The correlation coefficient for TSS and TP was 0.9, also indicating a strong relationship between these two parameters. These correlations are shown in Figure 16 and Figure 17, respectively.

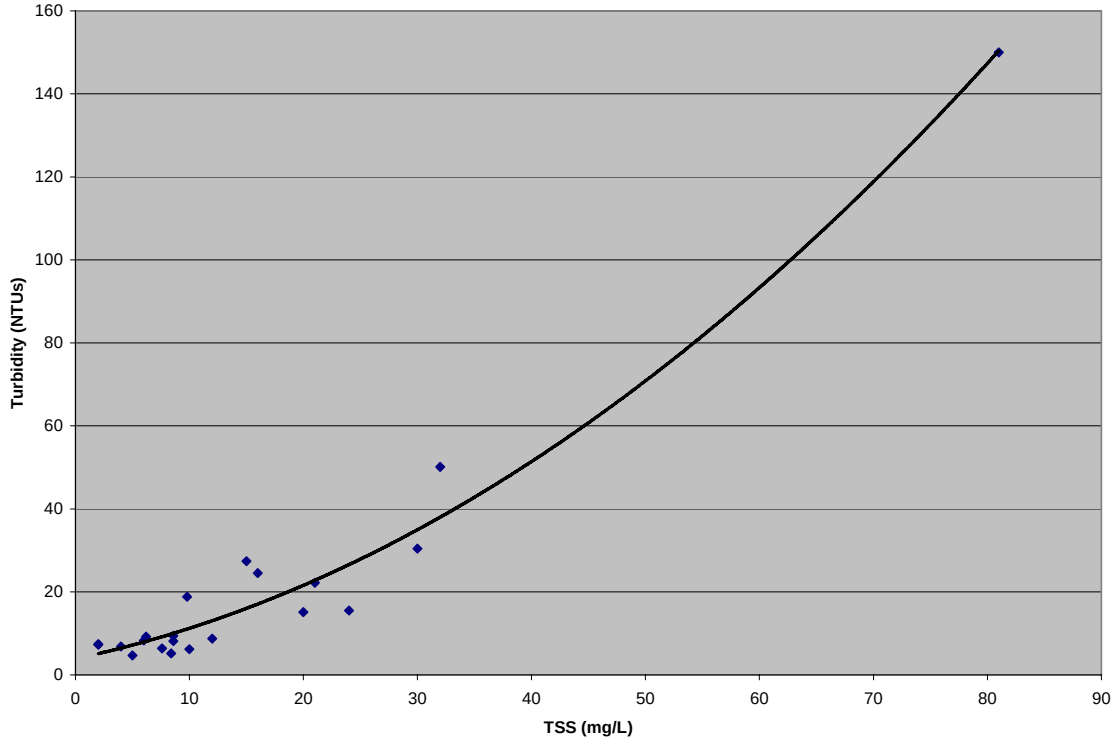

Figure 16. Red Rock Creek scatter plot and trend line for turbidity and TSS.

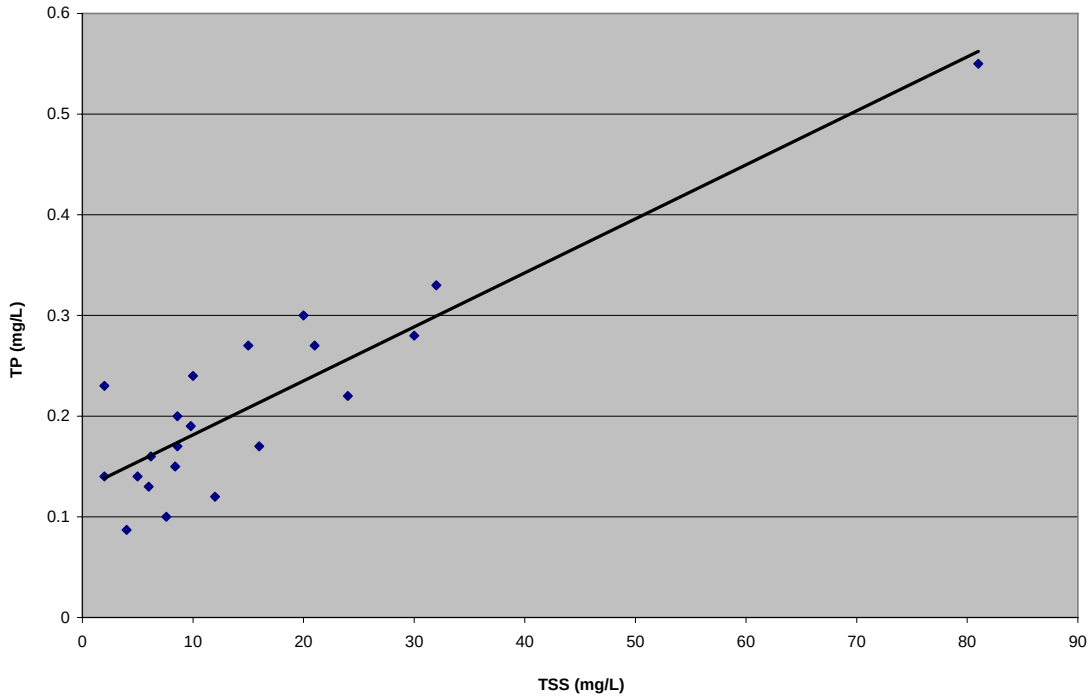

Figure 17. Red Rock Creek scatter plot and trend line for TP and TSS.

Excessive nutrient levels were noted in this stream year round. NO_2+NO_3 levels exceeded the 0.3 mg/L target 90.9% of the time (n=22) and TP violated the 0.1 mg/L target, during the "growing season" of April through October, 83.3% of the time (n=12). Figure 18 shows NO_2+NO_3 levels and Figure 19 shows TP levels in 2005.

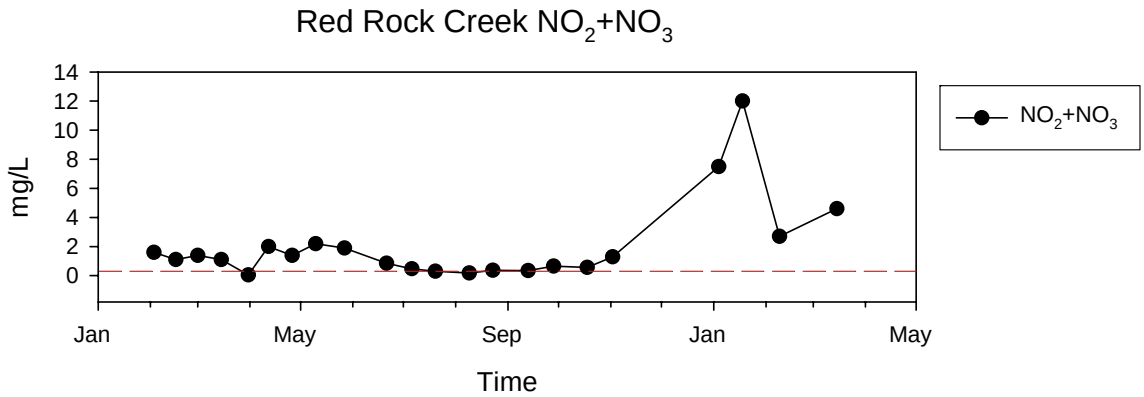

Figure 18. 2005-2006 NO_2+NO_3 data for Red Rock Creek. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

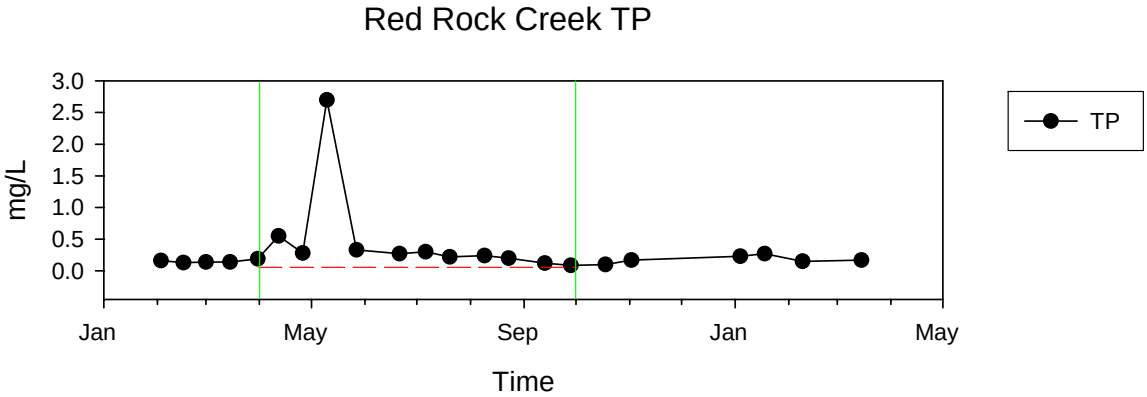

Figure 19. 2005-2006 TP data for Red Rock Creek. The dashed red line indicates the applicable 0.1 mg/L criteria during the growing season of April through October; the green bracket delineates the growing season.

Red Rock Creek Summary:

- TP readings were consistently elevated at this site, violating the 0.1 mg/L TMDL target 83.3% of the time, during the growing season.
- TSS readings were generally moderate throughout the year, although two exceedances of the 50 mg/L monthly average were observed during spring runoff.
- *E. coli* levels were quite high during this study and violated the 576 organisms/ 100 mL threshold for SCR nearly 50% of the time during this study. Cattle were observed in and directly adjacent to the stream on a regular basis and are likely contributing to the high *E. coli* readings.

- Temperatures were high from June through August and several violations of the 22° C temperature criteria were observed.

Cottonwood Creek (TCC-6, TCC-7, TCC-8, & TCC-9)

Four monitoring sites were located directly on the mainstem of Cottonwood Creek. TCC-6 was located as close to the headwaters as access would allow. TCC-7 was located below the discharge pipe for the City of Cottonwood waste water treatment plant (WWTP). TCC-8 was located at "Columbia Crossing", which delineates the Nez Perce Tribal boundary. TCC-9 was located at the mouth of Cottonwood Creek and is the only site accessible to anadromous fish. Below is an analysis of the data collected for each site in 2005-2006.

TCC-6

This monitoring station was located on the mainstem of Cottonwood Creek, several miles east of the City of Cottonwood. Both TCC-6 and TCC-7 are located in the "Upper Cottonwood Creek Subwatershed", as defined in the TMDL. This subwatershed drains 10,098 acres, of which 5,689 acres are cropland, 1,578 acres are pastureland, 405 acres are rangeland, 2,062 acres are forestland and 364 acres are considered urban/industrial. 10,094 acres of the subwatershed is in private ownership, while 4 acres are owned by the Bureau of Land Management (BLM).

The land above this particular site is primarily forested, with small areas of pastureland interspersed. One homestead was located directly above the monitoring station and cattle on that property had access to the creek during certain periods of the year.

Table 13. Descriptive statistics for Cottonwood Creek monitoring site TCC-6, 2005.

TCC-6	D.O. (mg/L)	Temp (^{o}C)	pH (H^{+})	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	14.08	19.60	8.27	55.00	4.1	0.28	0.05	0.13	31.00	2419.20
Minimum	8.54	0.00	7.88	7.11	0.05	0.05	0.02	0.044	2.00	44.30
Mean	11.62	5.67	8.10	19.61	0.86	0.08	0.03	0.08	13.67	664.22
Median	12.50	2.50	8.15	17.20	0.15	0.05	0.03	0.081	13.00	218.70
# exceedance	0.0	3.0	0.0		4	0	0	2	0.0	4.00
% exceedance	0.0%	20.0%	0.0%		26.7%	0.0%	0.0%	33.0%	0.0%	30.8%
# sampling events	15.0	15.0	13.0		15.0	15.0	15.0	6.0	15.0	13.0

TP levels exceeded the 0.1 mg/L criteria twice during the growing season (n=6). Figure 20 shows TP levels throughout the year.

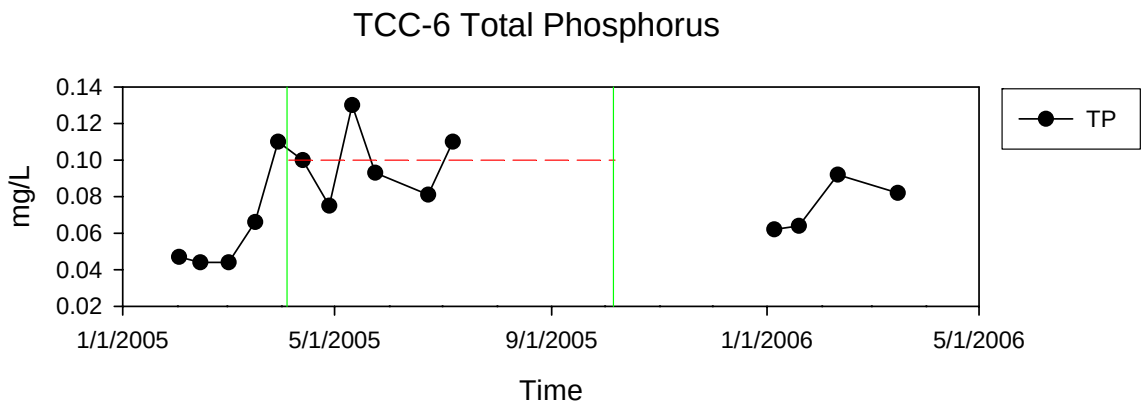

Figure 20. 2005-2006 TP data for TCC-6. The dashed red line indicates the applicable 0.1 mg/L criteria during the growing season of April through October; the green bracket delineates the growing season.

NO_2+NO_3 levels exceeded the 0.3 mg/L target four times during this project (n=15). Levels of NO_2+NO_3 were relatively low in 2005, but increased substantially in the spring of 2006. It is likely that fertilizer application in 2006 was responsible for the large spike in spring nutrient levels, since fertilizer application was occurring during the period of time that levels were highest. Figure 22 shows NO_2+NO_3 levels for TCC-6.

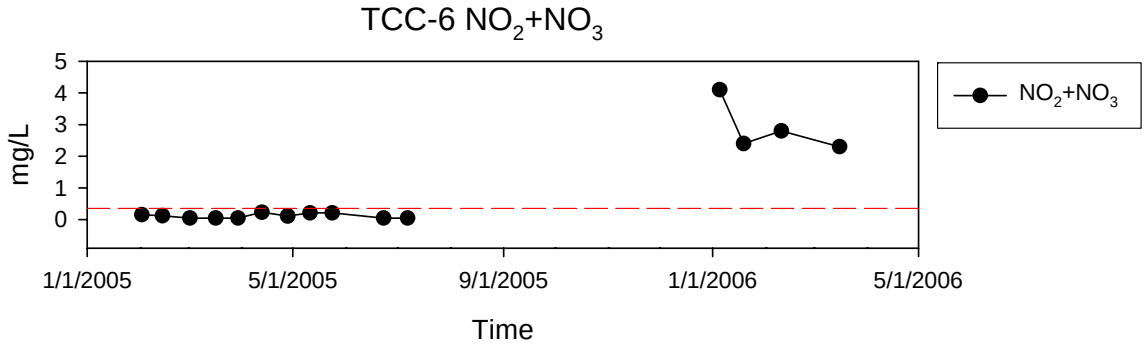

Figure 21. 2005-2006 NO_2+NO_3 data for TCC-6. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

Four exceedances of the State criteria for *E. coli* occurred during this project (n=13). There was seasonal usage of the creek and adjacent pasture by a small number of cattle and a house was located directly above the sampling site. These are both likely causes of the elevated *E. coli* results. Figure 22 shows *E. coli* levels for TCC-6.

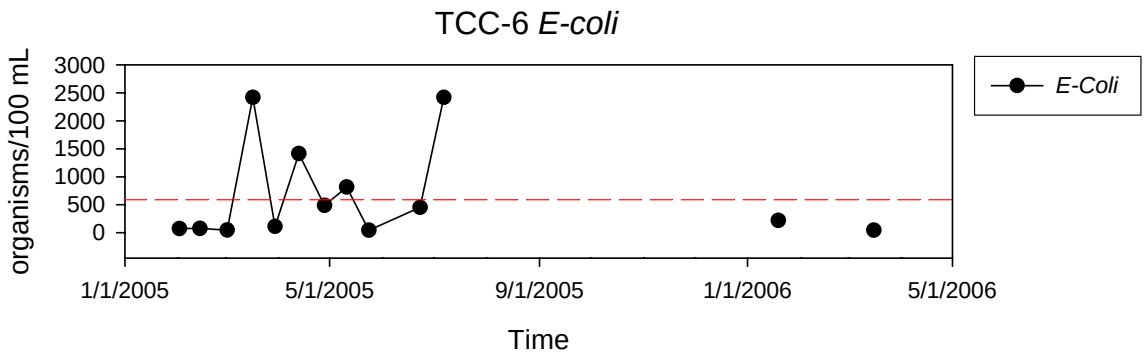

Figure 22. 2005-2006 *E. coli* data for TCC-6. The dashed red line indicates the applicable criteria of 576 organisms/100mL for SCR.

The mainstem of Cottonwood Creek is listed for salmonid spawning from the source to the mouth. Therefore, the Idaho water quality instantaneous criterion of 13° C for salmonid spawning is applicable for the stream from January 14th to July 15th. The 22° C instantaneous criterion is applicable for the rest of the year. TCC-6 exceeded the 13° C target three times during this project, as illustrated in Figure 23.

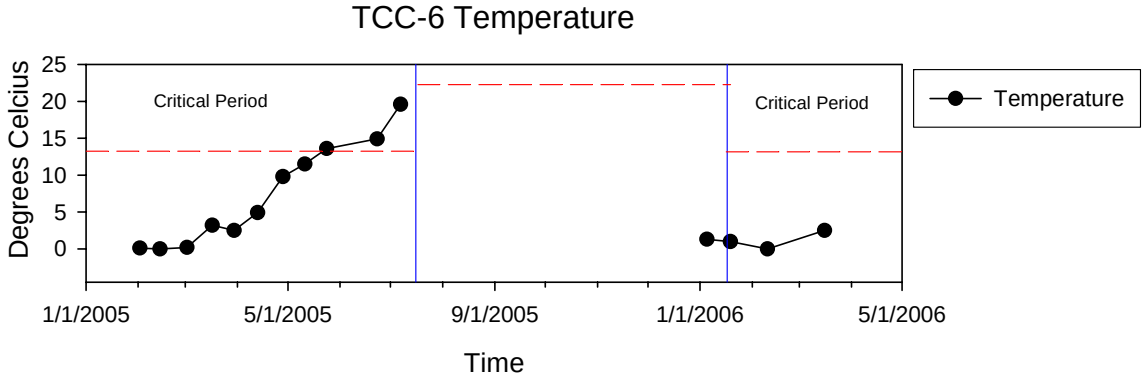

Figure 23. Instantaneous temperature data from TCC-6, 2005. The blue line delineates the period of the year deemed critical to salmonid spawning (January 14th – July 15th). The dashed red lines represent the 13° C and 22° C targets, as they apply.

TCC-6 Summary:

- There was no flow in the stream from mid July until late December. However, there were pools to be found throughout the stream reach, where aquatic organisms were observed.
- DO levels were well above the State criterion throughout this monitoring project.
- TP readings violated the 0.1 mg/L TMDL target 33.3% of the time, during the growing season. The nutrient enrichment may have been seen as a result of cattle accessing the creek and/or contributions from a nearby septic system.
- TSS readings were well below the TMDL target throughout the year.
- *E. coli* levels violated the 576 organisms/100mL threshold for SCR four times during this study. Cattle were observed in and directly adjacent to the stream

several times and may be responsible for the *E. coli* exceedances. A nearby septic system may also be a contributing factor.

- Temperatures violated the 13° C temperature criteria for salmonid spawning three times during this study.

TCC-7

This monitoring station was located on the main stem of Cottonwood Creek, just below the section of stream that the City of Cottonwood's WWTP discharges into. As described in the previous section, this site is also located in the upper Cottonwood Creek subwatershed. The land use is primarily cropland upstream of this site, although the stream also flows through the City of Cottonwood. Table 14 presents the descriptive statistics for 2005.

Table 14. Descriptive statistics for Cottonwood Creek monitoring site (TCC-7) below City of Cottonwood waste water treatment plant, 2005.

TCC-7	D.O. (mg/L)	Temp (^{o}C)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	16.50	20.30	9.00	64.60	4	2.6	0.59	0.75	47.00	648.80
Minimum	8.74	0.10	7.89	4.63	0.3	0.05	0.01	0.057	2.00	1.00
Mean	12.09	7.56	8.40	16.30	1.6	0.64	0.15	0.239	10.09	198.69
Median	12.25	5.15	8.33	8.75	1	0.47	0.08	0.17	4.55	63.80
# exceedance	0.0	3.0	0.0		17	3	3	5	0.0	2.00
% exceedance	0.0%	16.7%	0.0%		94.4%	16.7%	37.5%	62.5%	0.0%	11.8%
# sampling events	18.0	18.0	16.0		18.0	18.0	8.0	8.0	18.0	17.0

Water temperatures at TCC-7 exceeded the 13 ^{o}C target three times during this project, as illustrated in Figure 25. All three violations occurred during the period deemed critical for salmonid spawning.

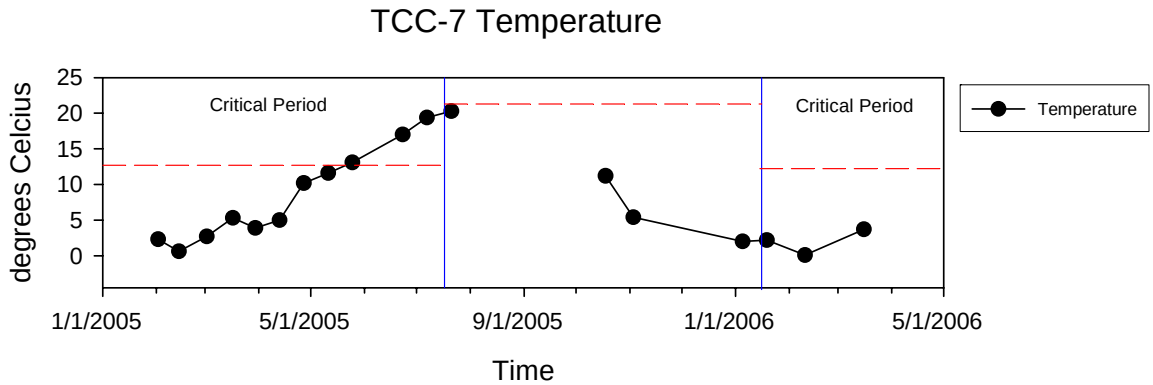

Figure 24. Instantaneous temperature data from TCC-7, 2005. The blue line delineates the period of the year deemed critical to salmonid spawning (January 14th – July 15th). The dashed red lines represent the 13° C and 22° C targets, as they apply.

NO_2+NO_3 levels exceeded the 0.3 mg/L target 17 times during this project (n=18). Although levels were elevated year round, a significant spike occurred in early 2006, likely as a result of fertilizer laden runoff. Figure 25 shows NO_2+NO_3 levels for TCC-7.

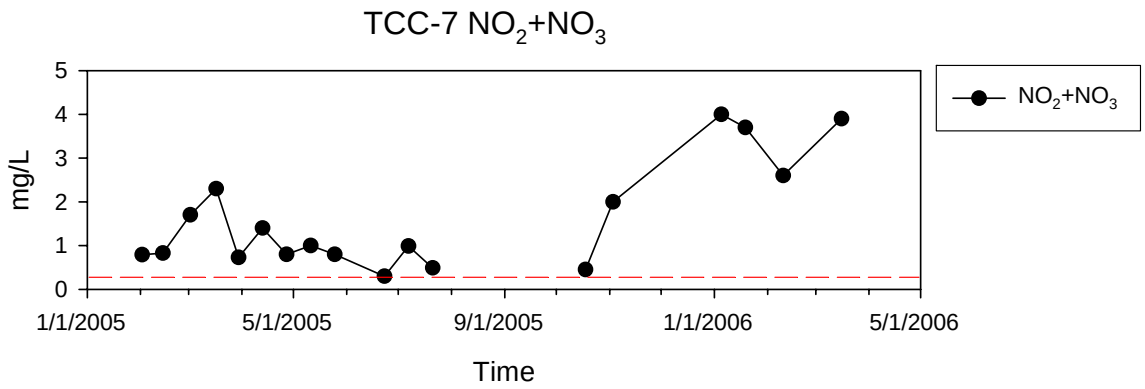

Figure 25. 2005-2006 NO_2+NO_3 data for TCC-7. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

The Cottonwood Creek TMDL also specified targets for ammonia levels in Cottonwood Creek. The target selected for the critical April – October time period was 0.16 mg/L. The target selected for the October – April time period, was 1.24 mg/L. Three violations of these targets occurred during this project, one during the critical period. Figure 27 shows NH_3 levels for TCC-7.

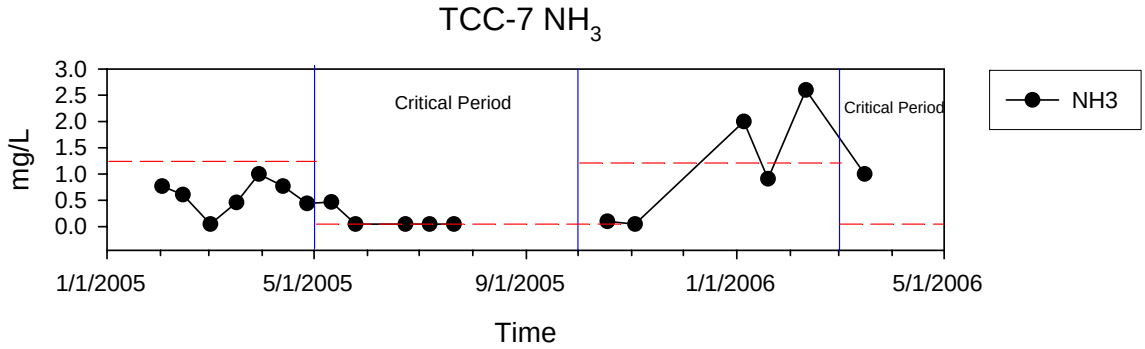

Figure 26. 2005-2006 NH_3 data for TCC-7. The dashed red line indicates the 0.16 mg/L and 1.24 mg/L targets, where applicable.

TP levels exceeded the 0.1 mg/L criteria five times during the growing season (n=8). Figure 27 shows TP levels throughout the year.

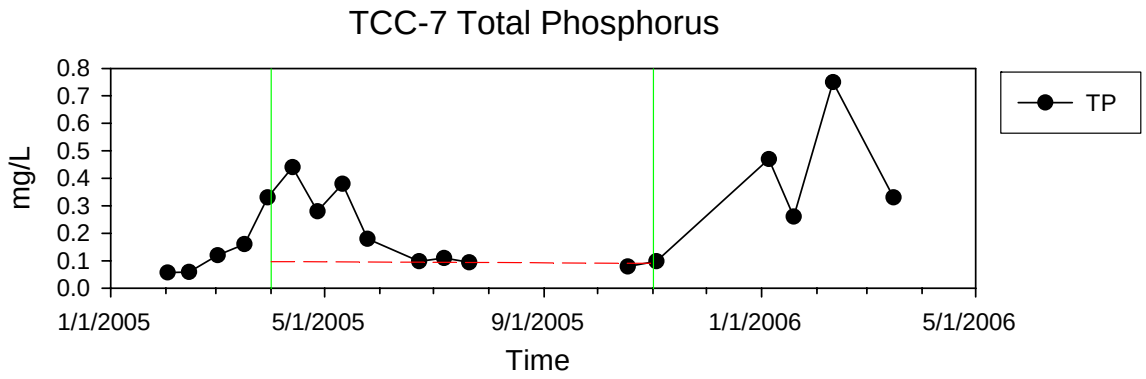

Figure 27. 2005-2006 TP data for TCC-7. The dashed red line indicates the applicable 0.1 mg/L criteria during the growing season of April through October; the green bracket delineates the growing season.

There were two *E. coli* violations of the 576 organisms/100mL for SCR during this project (n=17). Figure 28 shows the yearly *E. coli* levels measured at TCC-7.

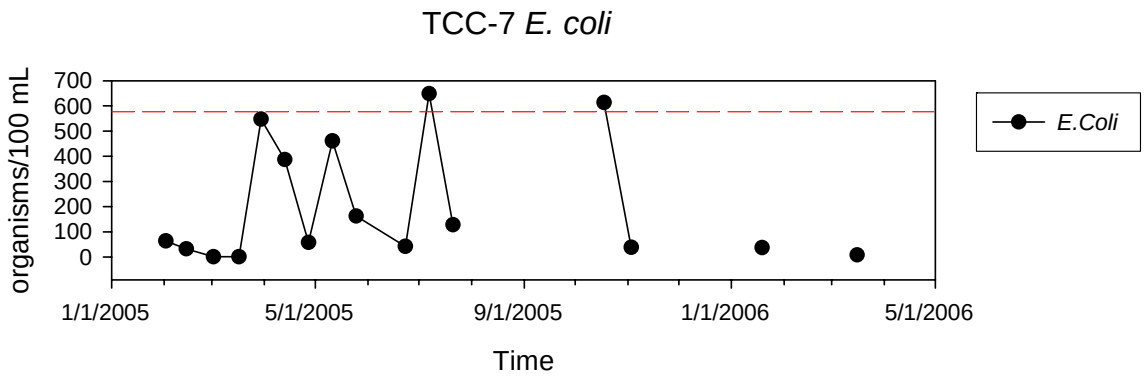

Figure 28. 2005-2006 *E. coli* data for TCC-7. The dashed red line indicates the applicable criteria of 576 organisms/100mL for SCR.

TCC-7 Summary:

- NO_2+NO_3 levels were very high at this site and exceeded the 0.3 mg/L guidance criteria 94.4% of the time. Ammonia levels were also quite high and exceeded the TMDL target nearly 17% of the time. This site's proximity to the WWTP discharge pipe is one likely reason that these numbers are so elevated; fertilizer over-application is another potential cause.
- This section of Cottonwood Creek was dry from late August to late September.
- TP and OP were also elevated at this site, and TP violated the 0.1 mg/L TMDL target 62.5% of the time.
- Two violations of the *E. coli* criteria occurred at this site during this study.

TCC-8

This monitoring station was located on the main stem of Cottonwood Creek, at "Columbia Crossing", which constitutes the Nez Perce Tribal Reservation boundary. This monitoring station is located in the "Middle Cottonwood Subwatershed", as defined in the TMDL. This subwatershed drains 12,061 acres, of which 8,929 acres are cropland, 689 acres are pastureland, 1,597 acres are rangeland, and 846 acres are forestland. 11,298 acres are privately owned, 44 acres are owned by the BLM, and 719 acres are owned by the Nez Perce Tribe. Table 15 presents the descriptive statistics for 2005.

Table 15. Descriptive statistics for Cottonwood Creek monitoring site (TCC-8) located at the Nez Perce Tribal boundary, 2005.

TCC-8	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	14.26	23.50	9.17	212.00	4.1	0.83	0.2	0.45	80.00	1299.70
Minimum	8.20	0.00	8.35	3.13	0.05	0.05	0.02	0.042	2.00	1.00
Mean	11.42	11.16	8.84	24.07	1.14	0.09	0.1	0.165	9.53	2108.43
Median	11.41	9.20	8.84	8.45	0.62	0.05	0.09	0.16	4.25	62.70
# exceedance	0.0	7.0	0.0		19	0	9	11	1.0	2.00
% exceedance	0.0%	31.8%	0.0%		86.4%	0.0%	75.0%	91.7%	4.5%	10.0%
# sampling events	22.0	22.0	20.0		22.0	22.0	12.0	12.0	22.0	20.0

Exceedances of the instantaneous water temperature criteria occurred seven times at site TCC-8, as seen in Figure 30.

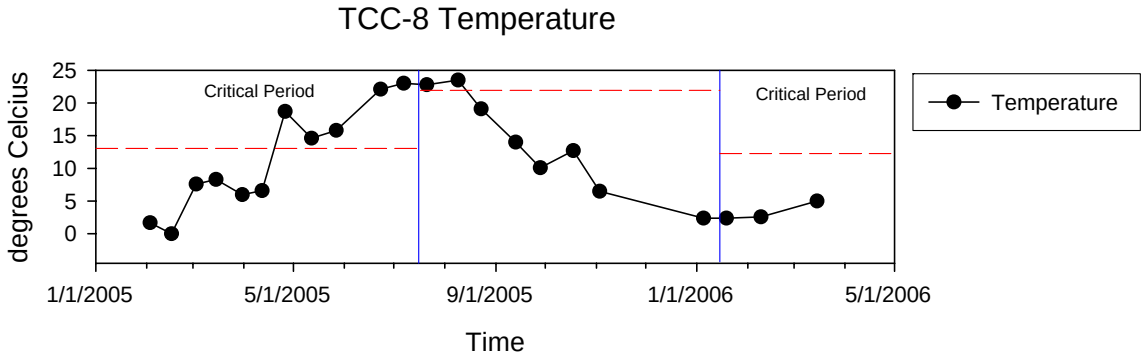

Figure 29. Instantaneous temperature data from TCC-8, 2005. The blue lines delineate the salmonid spawning period (January 14th – July 15th). The dashed red lines represent the 13° C and 22° C targets, as they apply.

NO_2+NO_3 levels exceeded the 0.3 mg/L target 19 times during this project (n=22). Levels were moderately elevated year round, but a significant spike occurred in early 2006, once again a probable result of crop rotation cycles and over fertilization. Figure 30 shows NO_2+NO_3 levels for TCC-8.

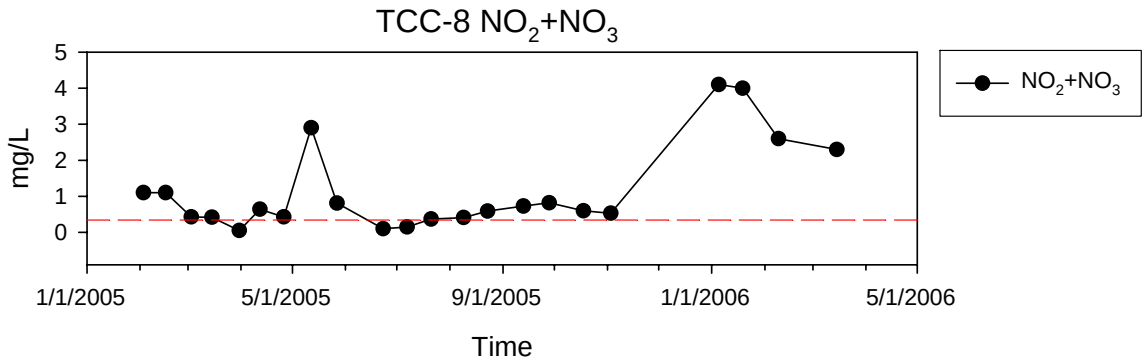

Figure 30. 2005-2006 NO_2+NO_3 data for TCC-8. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

TP levels exceeded the 0.1 mg/L criteria 11 times during the growing season (n=12). Figure 31 shows TP levels throughout the year.

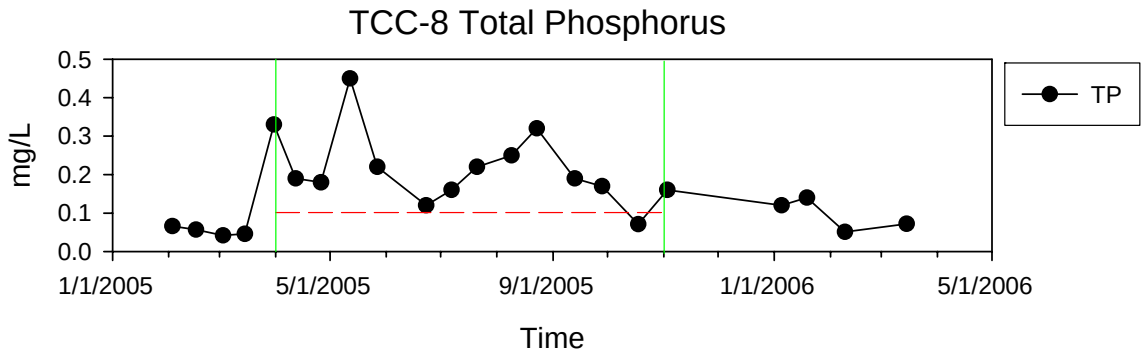

Figure 31. 2005-2006 TP data for TCC-8. The dashed red line indicates the applicable 0.1 mg/L criteria during the growing season of April through October; the green bracket delineates the growing season.

E. coli levels exceeded the 576 organisms/100 mL instantaneous criteria for SCR twice during this study, as shown in Figure 32.

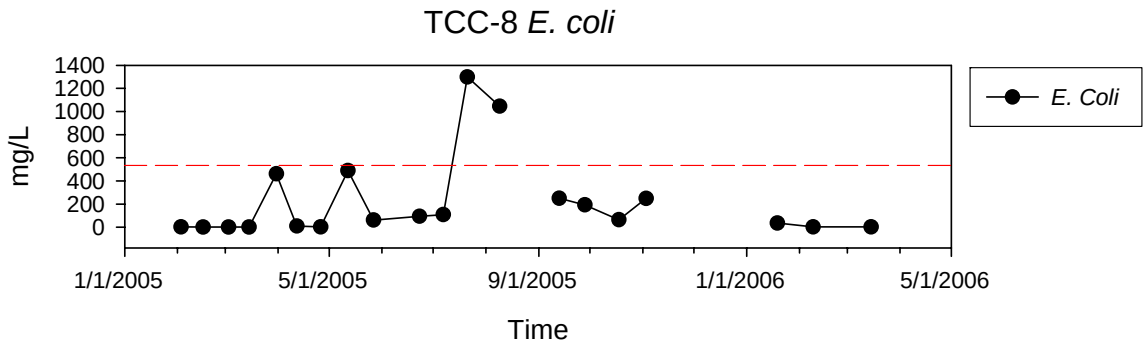

Figure 32. 2005-2006 *E. coli* data for TCC-8. The dashed red line indicates the applicable criteria of 576 organisms/100mL for SCR.

TCC-8 Summary:

- NO_2+NO_3 levels were very high at this site and exceeded the 0.3 mg/L guidance criteria 86.4% of the time (n=22). Ammonia levels were generally quite low, never exceeding the TMDL targets.
- TP and OP were also elevated at this site, and TP exceeded the 0.1 mg/L TMDL target 91.7% of the time. Relatively large concentrations of cattle are frequently present upstream of this site and could be a cause of this nutrient enrichment.
- Two violations of the *E. coli* criteria occurred during this study.
- DO levels were very high at this site and never approached the 6.0 mg/L criteria for cold water aquatic life (CWAL).

TCC-9

This monitoring station was located on the main stem of Cottonwood Creek, near its confluence with the South Fork Clearwater River. This monitoring station is located in the "Lower Cottonwood Subwatershed", as defined in the TMDL. This subwatershed drains 16,120 acres, of which 6,188 acres are cropland, 993 acres are pastureland, 6,755 acres are rangeland, and 2,184 acres are forestland. 14,121 acres are privately owned, 399 acres are owned by the BLM, and 1,600 acres are owned by the Nez Perce Tribe.

Lower Cottonwood Creek differs significantly, both hydrologically and geologically, from the upper portion of the creek. As the creek leaves the Camas Prairie, it flows into and through a relatively narrow stretch of canyon, where stream gradients can be as high as 5%. Cobble and boulder substrate dominates this canyon reach, as opposed to the sand and silt typically found in the prairie reaches. As the creek approaches its confluence with the South Fork of the Clearwater River, the gradient drops to less than one percent. The substrate in this lower stream reach is dominated by cobble and gravel, likely being transported from the upper reaches, and aggradation of the stream bed appears to be occurring. Vegetation in this reach is comprised primarily of weed species and graminoids, with scattered Cottonwood (*Populus trichocarpa*) stands found in the adjacent floodplain. Table 16 presents the descriptive statistics for 2005.

Table 16. Descriptive statistics for Cottonwood Creek monitoring site (TCC-9) located at the mouth of Cottonwood Creek, 2005.

TCC-9	D.O. (mg/L)	Temp (^oC)	pH (H^+)	Turbidity (NTU)	NO_2 +NO_3 (mg/L)	NH_3 (mg/L)	OP (mg/L)	TP (mg/L)	TSS (mg/L)	*E-coli* (coli/100mL)
Maximum	13.77	27.00	9.13	198.00	6.2	0.79	0.21	0.49	83.00	2419.20
Minimum	8.65	2.40	8.08	1.86	0.05	0.05	0.03	0.055	2.00	12.00
Mean	11.08	12.41	8.75	22.82	1.04	0.1	0.13	0.174	8.76	312.90
Median	11.05	10.20	8.88	5.67	0.21	0.05	0.14	0.15	2.00	59.70
# exceedance	0.0	7.0	0.0		11	0	12	12	1.0	3.00
% exceedance	0.0%	31.8%	0.0%		50.0%	0.0%	100.0%	100.0%	4.5%	15.8%
# sampling events	22.0	22.0	20.0		22.0	22.0	12.0	12.0	22.0	19.0

Exceedances of the instantaneous water temperature criteria occurred seven times at site TCC-8 (n=22), as seen in Figure 33.

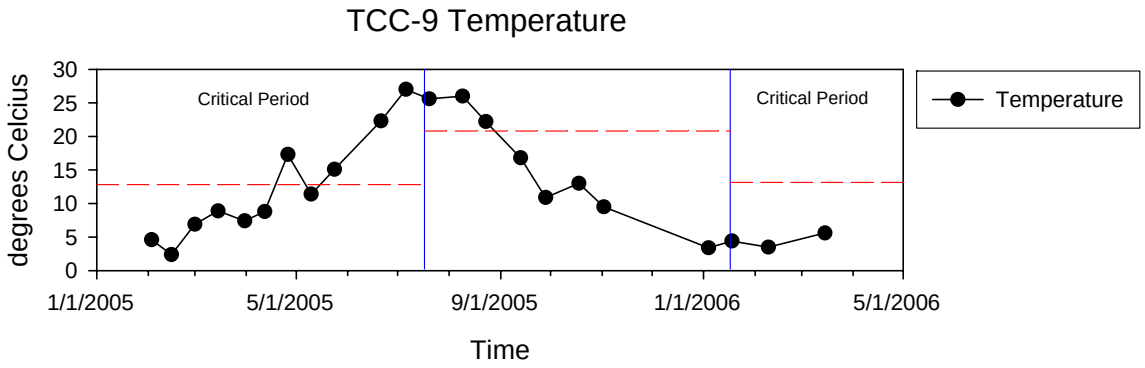

Figure 33. Instantaneous temperature data from TCC-9, 2005. The blue line delineates the period of the year deemed critical to salmonid spawning (January 14th – July 15th). The dashed red lines represent the 13° C and 22° C targets, as they apply.

NO_2+NO_3 levels exceeded the 0.3 mg/L target 11 times during this project (n=22). With the exception of a few spikes in spring of 2005, NO_2+NO_3 levels were relatively low at this site until January of 2006, when a significant increase occurred. This spike in January coincided with a rain on snow even that raised streamflows significantly and may have mobilized nitrogen, laid down as fertilizer, from surrounding agricultural lands; livestock manure may have also played a significant role in raising nitrogen levels. Figure 34 shows NO_2+NO_3 levels for TCC-9.

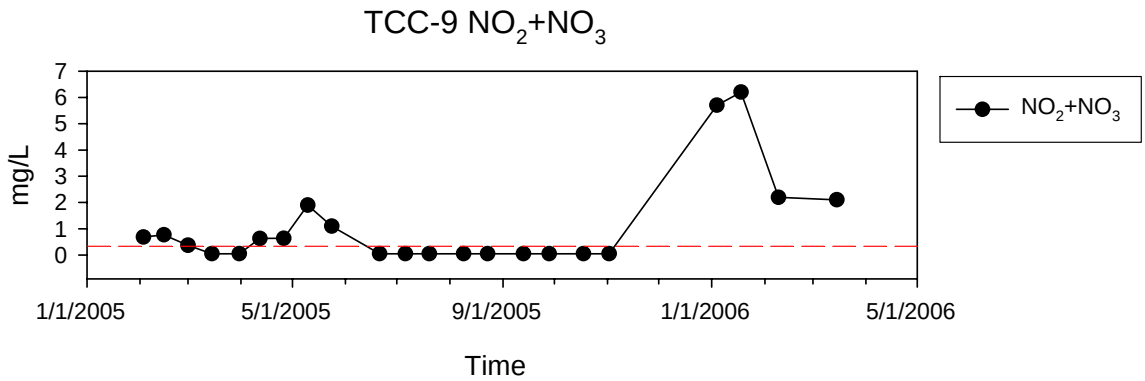

Figure 34. 2005-2006 NO2+NO3 data for TCC-9. The dashed red line indicates the applicable 0.3 mg/L guidance criteria.

Both TP and OP samples exceeded the 0.1 mg/L target 100% of the time, during this sampling period. There are two large cattle operations directly above this site and they may contribute to the elevated phosphorus readings. Figure 35 shows the TP measurements for TCC-9.

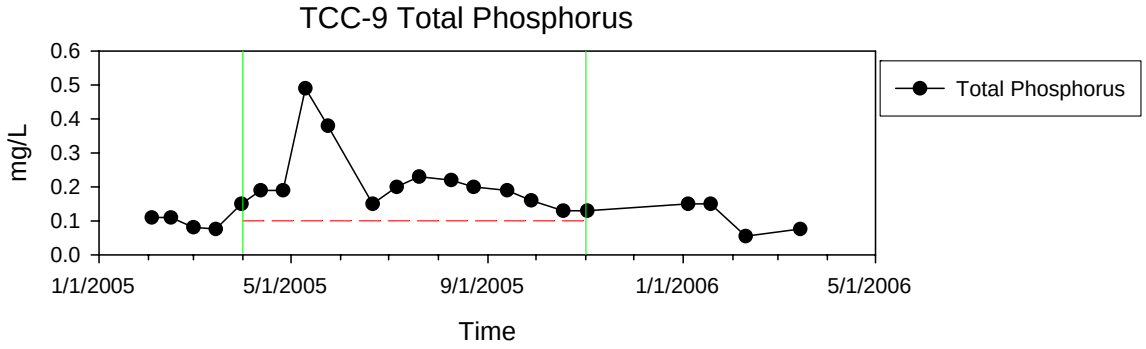

Figure 35. 2005-2006 TP data for TCC-9. The dashed red line indicates the applicable 0.1 mg/L criteria during the growing season of April through October; the green bracket delineates the growing season.

E. coli levels exceeded the 576 organisms/100 mL instantaneous criteria for SCR three times during this study, as shown in Figure 36.

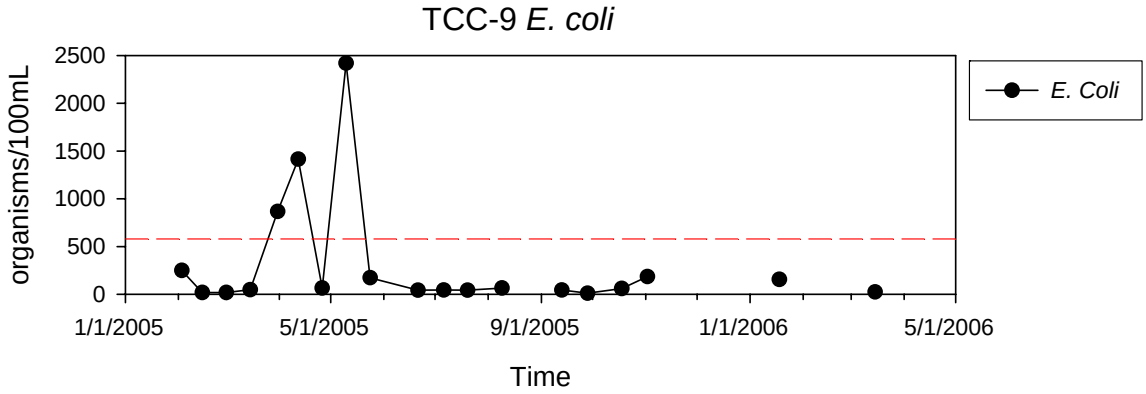

Figure 36. 2005-2006 *E. coli* data for TCC-9. The dashed red line indicates the applicable criteria of 576 organisms/100mL for SCR.

TCC-9 Summary:

- NO_2+NO_3 levels exceeded the 0.3 mg/L guidance criteria 50.0% of the time (n=22). Ammonia levels were generally quite low, never exceeding the TMDL targets.
- TP and OP both violated the 0.1 mg/L TMDL target 100.0% of the time. Large cattle operations are located directly upstream of this site and are a likely cause of this nutrient enrichment.
- Three violations of the *E. coli* criteria occurred during this study.
- DO levels were very high at this site and never approached the 6.0 mg/L criteria for CWAL.

Loadings

A TMDL or Total Maximum Daily Load is the calculation of the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards, and an allocation of that amount to the pollutant's sources. In the Cottonwood Creek TMDL, existing loads and the total load capacity were estimated. The difference between these two estimates determined the necessary load reductions per subwatershed. Existing loads are often calculated by multiplying instream concentrations of a particular pollutant (i.e. TSS, TP, etc…) by the stream's discharge rate. Load capacity is calculated using a water quality target or standard, rather than actual instream concentrations and flows.

TMDLs are inherently difficult to develop due to limited data and monitoring, unknown or legacy sources of pollutants, as well as the overall complexity of watershed systems.

The Cottonwood Creek TMDL calls for load reductions in fine sediment (TSS), temperature, total inorganic nitrogen, total phosphorus, ammonia and fecal coliform bacteria. Bacteria standards have since changed and the criteria are now based on *E. coli* levels. *E. coli* concentrations were determined during the course of this more recent study, to best evaluate conditions under current criteria, so load comparisons between the TMDL data and current data sets are not possible.

Although some challenges exist, reasonable comparisons between data sets can be made for phosphorus and sediment loads. In the DEQ study, discharge was estimated for streams in the watershed using regional regression equations developed by Kjelstrom (1998), rather than having direct discharge measurements taken. The 84th percentile TP concentration was then calculated for each month and then the mean of these values was calculated.

For the computation of the 2001 and 2005 loads, actual measured flows were used instead of estimated flow numbers. The equation used to calculate loads in this study was:

$$L = f * c * d$$

where L = load
f = units conversion factor (mg/ L to lb/ day = 5.39)
c = concentration of pollutant
d = discharge

For the sake of this comparison, numbers from the TMDL Executive Summary Loading Table (1-7) were used. As different methodologies were used to produce the given values, one should be very cautious in interpreting these comparisons.

Red Rock Creek was the biggest contributor of sediment to Cottonwood Creek, although much of that sediment load appears to drop out before reaching the South Fork Clearwater River. This is leading to aggradation of the stream bed in the reach just upstream of the mouth. TCC-6 and TCC-8 were left off the chart, because no data other than the 2005 set was available for comparative purposes.

Flows were considerably higher in 2005 than in 2001 for sites TCC-1 and TCC-2. Flows were quite similar for TCC-3 and TCC-4 in both data sets. The difference in flows likely accounts for the fluctuations in TSS loads seen in Figure 37.

Table 17. TSS load estimates from the TMDL and from IASCD monitoring in 2001 and 2005. during the critical period of January to May (units in tons per season).

Subwatershed	TMDL Load Capacity	TMDL Load Estimate	2001 Load Estimate	2005 Load Estimate
SF Cottonwood (TCC-1)	67	1,332	7	201
Long Haul (TCC-2)	74	494	21	50
Stockney (TCC-3)	206	1,720	88	41
Shebang (TCC-4)	80	401	68	82
Red Rock (TCC-5)	116	321	n/a	2,209
TCC-6	n/a	n/a	n/a	22
TCC-7	59	147	n/a	40
TCC-8	n/a	n/a	n/a	196
TCC-9	1,811	4,645	n/a	493

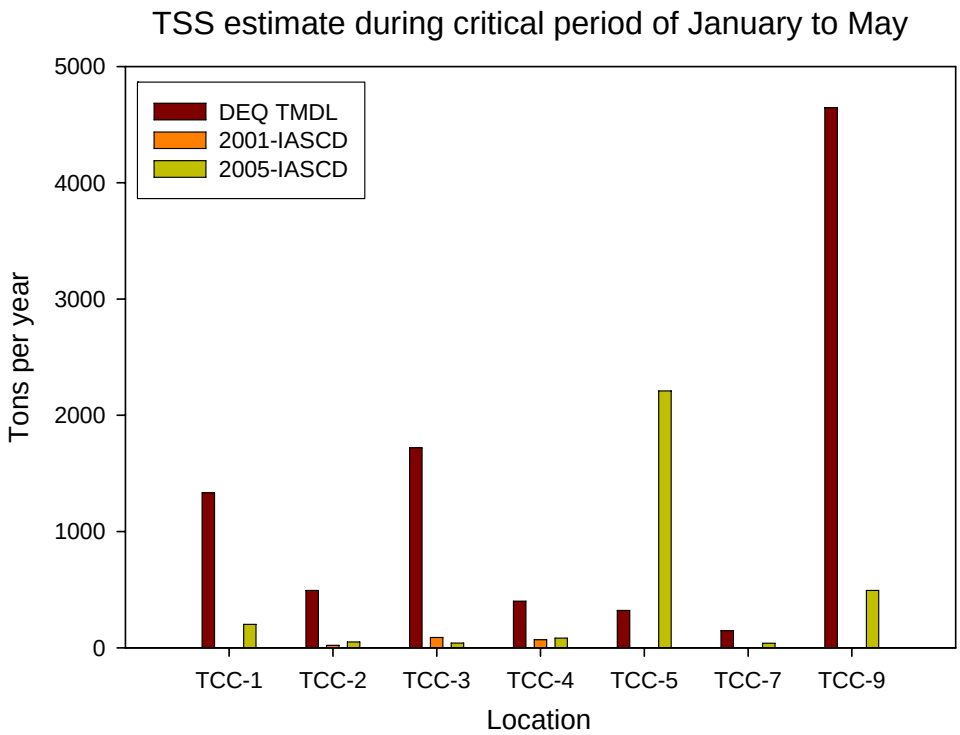

Figure 37. Annual TSS load estimates from the TMDL and from IASCD monitoring in 2001 and 2005 (units in tons per year).

TP levels were significantly higher in 2005 than in 2001. At sites TCC-1 and TCC-2, this could be partially attributable to lower flows carrying less sediment, to which total phosphorus tends to bind. TCC-3 and TCC-4 had very similar flow regimes though, so the increases are apt to be caused by other factors, such as changes in land use patterns or degradation of instream habitat.

Red Rock Creek showed the highest phosphorus levels, with calculations showing close to 10,000 pounds of TP moving through the system during the growing season. It should be noted that one event on May 10th, 2005 had a TSS rate of 1,200 mg/L, a TP measurement of 2.7 mg/L and a flow rate of 50 cfs. Because numbers are extrapolated to estimate concentrations during the period of time between site visits, this "event" caused the overall load estimate to be dramatically increased.

The mouth of Cottonwood Creek (TCC-9) also showed a significant load of phosphorus. There are two large cattle operations upstream of this site that is the likely cause of this excessive nutrient enrichment.

Table 18. Annual TP load estimates during the growing season of April-October, from the TMDL and from IASCD monitoring in 2001 and 2005 (units in pounds per season).

Subwatershed	TMDL Load Capacity	TMDL Load Estimate	2001 Load Estimate	2005 Load Estimate
SF Cottonwood (TCC-1)	251	842	17	726
Long Haul (TCC-2)	251	410	136	924
Stockney (TCC-3)	408	1,285	203	539
Shebang (TCC-4)	212	436	35	716
Red Rock (TCC-5)	279	1,045	n/a	10,123
TCC-6	n/a	n/a	n/a	114
TCC-7	212	514	n/a	518
TCC-8	n/a	n/a	n/a	2,670
TCC-9	2,157	7,104	n/a	8,724

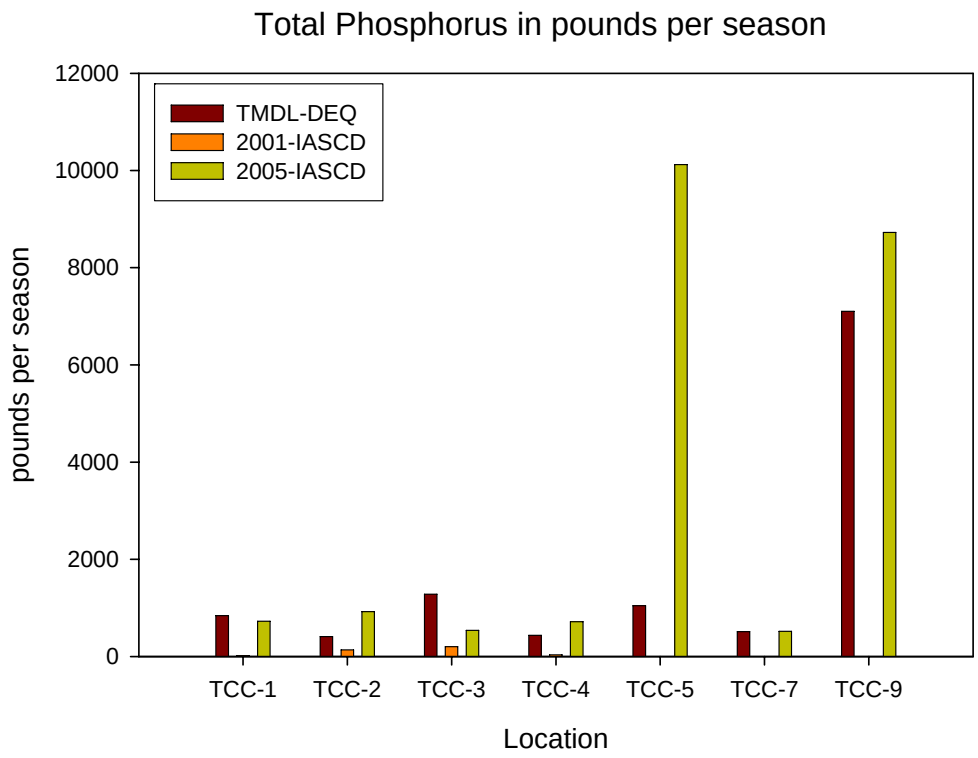

Figure 38. Annual TP load estimates from the TMDL and from IASCD monitoring in 2001 and 2005 (units in pounds per season).

Seasonal loads of TP generally peaked in spring and decreased during the summer and fall months. Increases in TP begin to occur as stream discharge rates increase. Seasonal loads of dissolved phosphorus (OP) follow the same general pattern as TP, since OP is a component of TP. The ratio of OP to TP tends to peak when stream flow is at its lowest

and, conversely, when stream flow was highest the ratio was low. This is likely because of the increase in TP that is typically associated with mobilized soil particles found during high flows. The potential for algal growth within the system increases along with increases in the ratio of OP to TP. Figure 38 shows the seasonal ratio of OP to TP.

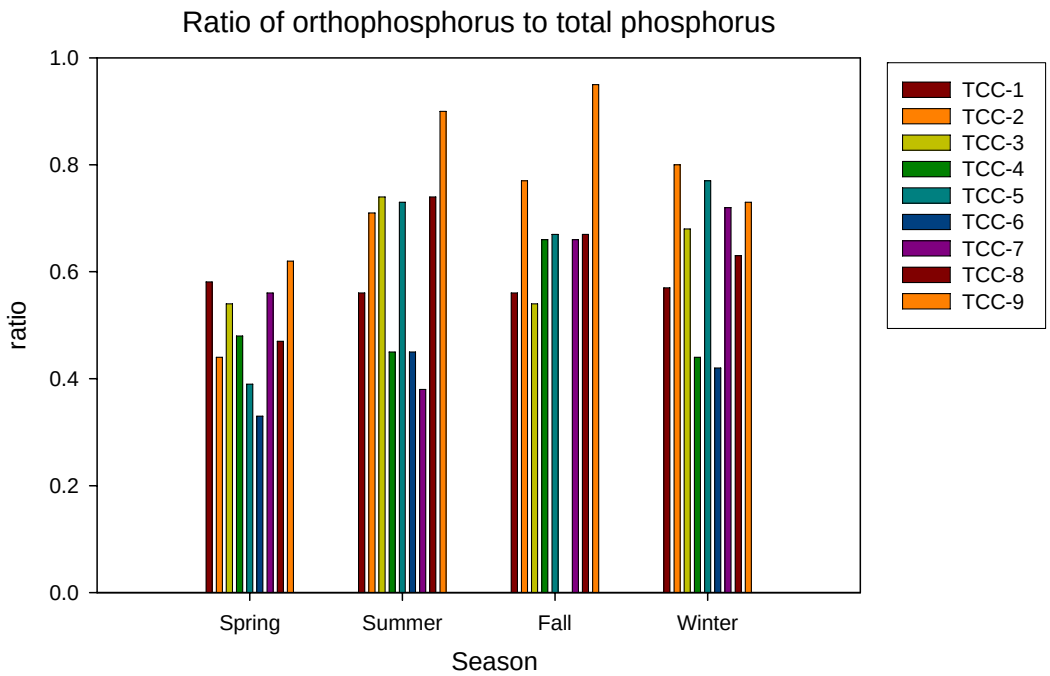

Figure 39. Seasonal ratio of dissolved orthophosphorus to total phosphorus in the Cottonwood Creek watershed.

Conclusions

The monitoring program for the mainstem and tributaries of Cottonwood Creek was successfully carried out as planned. Protocols were followed, QA/QC standards were met, and specific information per parameter for each sub-watershed was collected.

Sediment, nutrients and pathogens are the primary pollutants within the Cottonwood Creek subbasin. Water temperature standards were also violated at every monitoring location, making high water temperature a principal concern as well.

Excessive stream temperature is a concern throughout the Cottonwood Creek watershed. Aquatic organisms from microbes to fish are dependent on certain temperature ranges for their optimal health. Aquatic insects are sensitive to temperature and will move in a stream to find their optimal temperature. Temperature is also critical for fish spawning and embryo development. If stream temperatures are outside of optimal levels for prolonged periods of time, organisms become stressed and may die or be unable to reproduce. The mainstem of Cottonwood Creek has salmonid spawning listed as one of

its beneficial uses and therefore has relatively stringent temperature requirements associated with it. Every site exceeded the temperature criteria during the course of this study.

Total phosphorus loading is also a persistent issue throughout the watershed. Only the site located at the headwaters of Cottonwood Creek exceeded the State of Idaho criteria less than 50% of the time; the other sites were far higher. The average ratio of orthophosphorus to total phosphorus was 0.54, indicating that a sizeable portion of the total phosphorus load is in soluble form and can be readily taken up by aquatic vegetation. This high level of phosphorus is potentially contributing to excessive growth of algae and other aquatic plants that can cause destruction of habitat and depletion of dissolved oxygen, which usually results in the disappearance of intolerant aquatic insect species and fish. Even with the relatively high levels of phosphorus seen in this study, there was only a single event at one site where DO levels dropped below the State criterion of 6.0 mg/L.

NO_2+NO_3 levels are also very high in the mainstem of Cottonwood Creek and several of its tributaries. Excessive concentrations of nitrate and/or nitrite can be harmful to humans and wildlife. Although there is no aquatic numeric standard in place, numbers above 0.30 mg/L can cause excessive plant growth and possible eutrophication, so this value was used as a target for this analysis. (Cline, 1973 & Golterman, 1975). The data suggest that much of the nitrogen could be coming from agricultural fields in the Cottonwood Creek watershed. In this watershed, nitrogen fertilizers are often applied in the early fall for winter wheat and later in the fall for bluegrass. The spike in nitrogen levels seen in the winter of 2006 is a likely result of winter rains washing residual nitrogen off of fields and into nearby waterways. Only two sites appeared not to have a significant problem with nitrogen enrichment; those were TCC-2 (Long Haul Creek) and TCC-6 (headwaters of Cottonwood Creek). However, the Cottonwood Creek watershed appears to be a phosphorus-limited system and the high levels of nitrogen found doesn't appear to be causing excessive aquatic growth or lowering DO levels.

There were also exceedances at multiple sites of the ammonia targets set in the TMDL. The largest number of ammonia exceedances occurred at the site located below the City of Cottonwood's WWTP (TCC-7).

Escherichia coli (*E. coli)* is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. The presence of *E. coli* in water is a strong indication of recent sewage or animal waste contamination. Bacteria levels in 2005 had decreased noticeably at several sites, although exceedances of the State of Idaho instantaneous criteria for SCR still occurred at every site during this project. The presence of cattle was noticeable at those sites with the highest number of *E. coli* violations.

Total suspended solids (TSS) include both sediment and organic material suspended in water. TSS can cause problems for fish by clogging gills and for aquatic plants by limiting growth because of reduced light penetration. In addition, TSS provides a medium for the accumulation and transport of other constituents such as phosphorus and bacteria.

An abbreviated summary for each site follows. Sediment, in itself, doesn't appear to be a significant problem in this watershed and both the 2001 and 2005 data sets show considerably lower TSS rates than were estimated in the TMDL. However, although violations of the TMDL target were infrequent, sediment certainly acted as a transport mechanism for phosphorus and control of sediment levels will surely help to reduce overall phosphorus levels.

South Fork Cottonwood Creek Summary:

- In the 2005 study, flow stopped in late July and didn't resume until early October. Large pools of standing water were found along the length of the stream and served as refugia for aquatic invertebrates and fish.
- The 22 ^{o}C instantaneous temperature standard was violated twice (11.8%) during the 2005-2006 sampling period. These exceedences were observed in late June and early July, right before flow ceased in the stream.
- TSS concentrations in 2005 exceeded the 50 mg/L target three times and the 2005 TSS median was 25 % higher than the 2001 median.
- A correlation coefficient of 0.957 shows that there is a clear relationship between TP and TSS.
- TP levels exceeded the 0.1 mg/L TMDL target 6 times during the 2005 growing season of April - October (n=7).
- NO_2+NO_3 levels were consistently elevated in this stream, with 94.1% of the 2005 samples exceeding the target of 0.3 mg/L.
- The median *E. coli* count was reduced by 75 % from 2001 to 2005-20006.

Long Haul Creek Summary:

- *E. coli*, TP and temperature were all considerably higher in 2005 than in 2001. Increased presence of cattle was evident during the 2005 season and seems to be a likely source for the increases in the aforementioned parameters. Numerous cases of cattle directly accessing the stream were observed and vegetation was mostly absent along the streambanks near the monitoring station.
- TSS did not violate the 50 mg/L monthly average criteria in 2005.
- Exceedances of the 0.3 mg/L target for NO_2 + NO_3 were measured 36.4% of the time in 2005 and occurred primarily during winter/spring runoff events.

Stockney Creek Summary:

- TP levels in 2005 exceeded the "growing season" nutrient target of 0.1 mg/L 100% of the time.
- *E. coli* levels decreased 43% from 2001 levels and only one exceedance was witnessed during the 2005 study.
- Median NO_2+NO_3 levels dropped slightly from 2001 to 2005, but 83% of the samples collected still exceeded 0.3 mg/L criteria.
- TSS did not exceed the 50 mg/L monthly average criteria.

Shebang Creek Summary (TCC-4):

- The stream was dry from early July until October.
- NO_2+NO_3 levels increased 64% from 2001 to 2005 and exceeded the 0.3 mg/L guideline 71% of the time in 2005.
- Median TP levels decreased 47% from 2001 to 2005.
- Median *E. coli* readings were 75% lower than those observed in 2001.
- One temperature violation occurred in early July, right before the creek went dry.

Red Rock Creek Summary:

- TP levels violated the 0.1 mg/L TMDL target 83.3% of the time, during the growing season.
- TSS exceeded the 50 mg/L monthly average twice during spring runoff.
- *E. coli* levels violated the 576 organisms/ 100 mL threshold for SCR nearly 50% of the time during this study.
- Temperatures were high from June through August and several violations of the 22° C temperature criteria were observed.

TCC-6 Summary:

- There was no flow in the stream from mid July until late December. However, there were pools to be found throughout the stream reach, where aquatic organisms were observed.
- DO levels were well above the State criterion throughout this monitoring project.
- TP readings violated the 0.1 mg/L TMDL target 33.3% of the time, during the growing season.
- TSS readings were well below the TMDL target throughout the year.
- *E. coli* levels violated the 576 organisms/100mL threshold for SCR four times during this study.
- Temperatures violated the 13° C temperature criteria for salmonid spawning three times during this study.

TCC-7 Summary:

- NO_2+NO_3 levels were very high at this site and exceeded the 0.3 mg/L guidance criteria 94.4% of the time. Ammonia levels were also quite high and exceeded the TMDL target nearly 17% of the time.
- This section of Cottonwood Creek was dry from late August to late September.
- TP and OP were also elevated at this site, and TP violated the 0.1 mg/L TMDL target 62.5% of the time.
- Two violations of the *E. coli* criteria occurred at this site during this study.

TCC-8 Summary:

- NO_2+NO_3 levels were very high at this site and exceeded the 0.3 mg/L guidance criteria 86.4% of the time (n=22).
- TP exceeded the 0.1 mg/L TMDL target 91.7% of the time.
- Two violations of the *E. coli* criteria occurred during this study.
- DO levels were very high at this site and never approached the 6.0 mg/L criteria for cold water aquatic life (CWAL).

TCC-9 Summary:

- NO_2+NO_3 levels exceeded the 0.3 mg/L guidance criteria 50.0% of the time (n=22).
- TP and OP both violated the 0.1 mg/L TMDL target 100.0% of the time.
- Three violations of the *E. coli* criteria occurred during this study.
- DO levels were very high at this site and never approached the 6.0 mg/L criteria for CWAL.

Recommendations

Significant erosion is currently evident along a number of streams, and treatment should be applied to streams that are already undergoing the most severe erosion. Nutrients are a major problem in this watershed and controlling erosion would certainly help to decrease TP levels. Every stream in this watershed, including the mainstem of Cottonwood Creek, is water quality limited and will benefit from strategic BMP installations. Although every creek could be considered a priority area, and implementation will likely be dictated by landowner cooperation, Red Rock Creek appears to be the tributary that is contributing the highest nutrient, bacteria and sediment load to the mainstem of Cottonwood Creek. Fencing cattle away from the creek, as well as stream stabilization structures and revegetation of the streambank will help to reduce sediment transport in this problem area. Another significant problem area is located near the mouth of Cottonwood Creek itself and water quality in the South Fork of the Clearwater River, to which Cottonwood Creek is a tributary, would benefit from BMPs being developed to limit the transport of pollutants from this system to the South Fork Clearwater River.

Excessive stream temperatures are also a widespread problem within this watershed and will be a difficult issue to overcome. Perhaps the most effective strategy would be to work toward the establishment of natural full potential canopy shade. Reducing sediment loads within critical reaches will assist in reducing stream temperatures as well, since suspended particles tend to absorb more heat.

Cattle are ubiquitous in this watershed and may be the largest single factor limiting water quality. Continuing to fence cattle away from creeks and developing off-stream watering facilities is apt to be the most cost-effective method to reduce bacteria, nutrient and sediment levels throughout the watershed.

The Soil Conservation Commission (SCC) has identified 91,800 critical acres in the Cottonwood Creek watershed. BMPs have been implemented on 9,535 acres. Acres have been treated using a variety of funding sources, which include 319, Water Quality Program for Agriculture (WQPA), Environmental Quality Incentive Program (EQIP), and the Conservation Reserve Program (CRP) (Cottonwood Creek Progress Report, 2006). Appendix A graphically illustrates the treated acres in the Cottonwood Creek Watershed.

Continued implementation of targeted stream improvements to reduce sediment loads, lower temperatures, lower nutrients and lower bacteria levels will be important. Based on stream inventory and prioritization efforts, stakeholders (IASCD, ISDA, NRCS, SCC, USFS, IDL, and private land owners) should fund, devise, and construct high quality stream improvements designed to promote water quality enhancement.

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Acronyms and Abbreviations

BLM	Bureau of Land Management
BMPs	Best Management Practices
C	Celcius
cfs	Cubic feet per second
cm	centimeter(s)
CWA	Clean Water Act
CWAL	Cold Water Aquatic Life
DEQ	Idaho Department of Environmental Quality
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
GIS	Geographical Information Systems
HUC	Hydrologic Unit Code
IASCD	Idaho Association of Soil Conservation Districts
ISDA	Idaho State Department of Agriculture
mg/L	milligrams per liter
NH_3	Ammonium
NO_2+NO_3	Nitrate-Nitrite
NRCS	Natural Resource Conservation Service
OP	Ortho Phosphorus
QA/QC	Quality assurance/quality control
SCC	Soil Conservation Commission
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
USFS	United States Forest Service
UIASL	University of Idaho Analytical Science Laboratory
WAG	Watershed Advisory Group

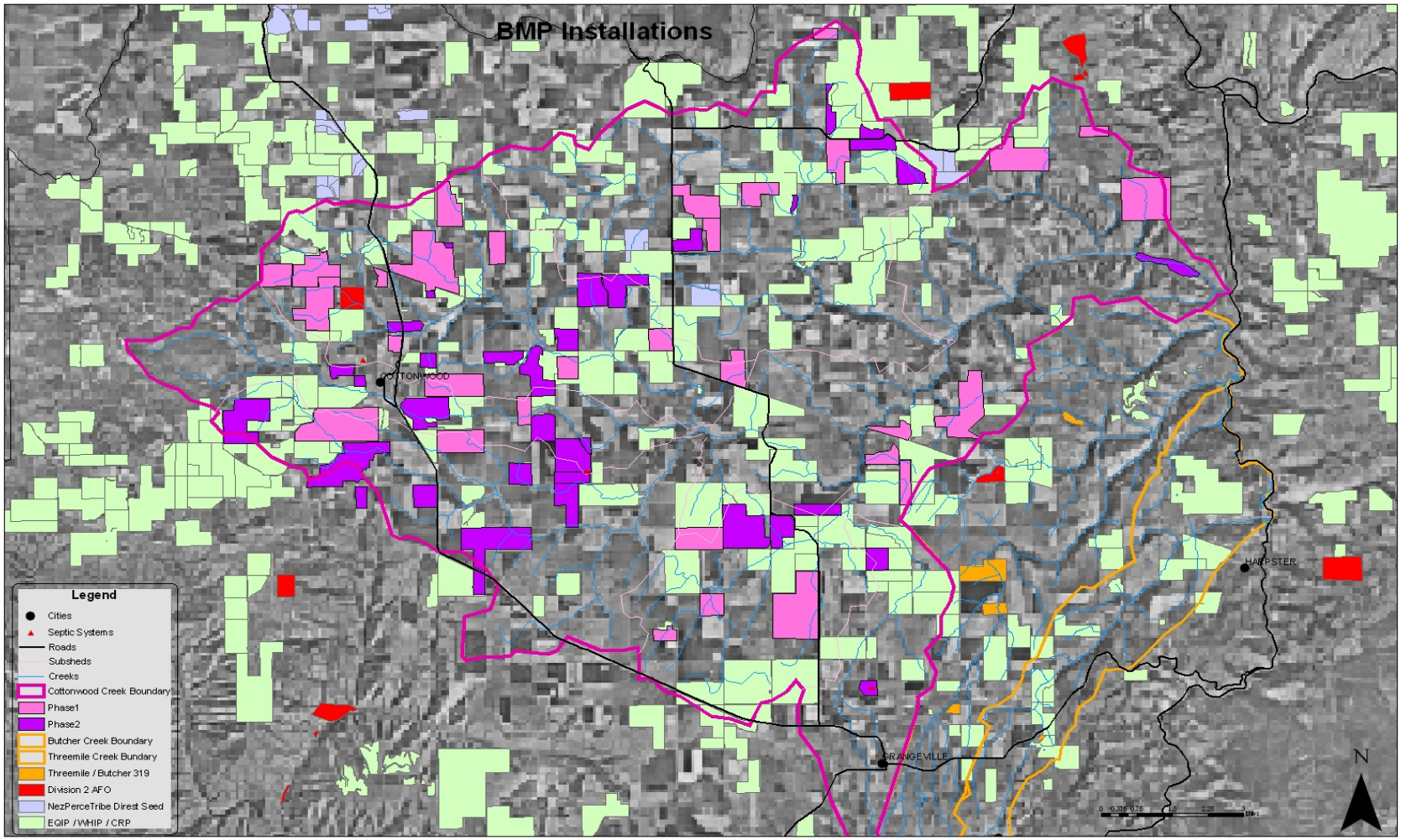
Glossary

§303(d)	Refers to section 303 subsection "d" of the Clean Water Act. 303(d) requires states to develop a list of waterbodies that do not meet water quality standards. This section also requires total maximum daily loads (TMDLs) be prepared for listed waters. Both the list and the TMDLs are subject to U.S. Environmental Protection Agency approval.
Bedload	Material (generally sand-sized or larger sediment) that is carried along the streambed by rolling or bouncing.
Beneficial Use	Any of the various uses of water, including, but not limited to, aquatic biota, recreation, water supply, wildlife habitat, and aesthetics, which are recognized in water quality standards.
Best Management Practices (BMPs)	Structural, nonstructural, and managerial techniques that are effective and practical means to control nonpoint source pollutants.
Catchment	Land area that contributes runoff (drains) to a given point in a stream or river. Synonymous with watershed and drainage or river basin.
Censored Data	Sample observations for which the complete distribution is not known. Censored data often appear in laboratory reports when the concentration being analyzed is lower than the detection limit or higher than the allowable range for a particular type of laboratory equipment or procedure.
Conductivity	The ability of an aqueous solution to carry electric current, expressed in micro (μ)

	mhos/cm at 25 °C. Conductivity is affected by dissolved solids and is used as an indirect measure of total dissolved solids in a water sample.
Criteria	In the context of water quality, numeric or descriptive factors taken into account in setting standards for various pollutants. These factors are used to determine limits on allowable concentration levels, and to limit the number of violations per year. EPA develops criteria guidance; states establish criteria.
Cubic Feet per Second	A unit of measure for the rate of flow or discharge of water. One cubic foot per second is the rate of flow of a stream with a cross-section of one square foot flowing at a mean velocity of one foot per second. At a steady rate, one cubic foot per second is equal to 448.8 gallons per minute and 10,984 acre-feet per day.
Discharge	The amount of water flowing in the stream channel at the time of measurement. Usually expressed as cubic feet per second (cfs).
Dissolved Oxygen	The oxygen dissolved in water. Adequate DO is vital to fish and other aquatic life.
E. coli	Short for *Escherichia Coli*, *E. coli* are a group of bacteria that are a subspecies of coliform bacteria. Most *E. coli* are essential to the healthy life of all warm-blooded animals, including humans. Their presence is often indicative of fecal contamination.
Exceedance	A violation of the pollutant levels permitted by water quality criteria.

Mean	Describes the central tendency of a set of numbers. The arithmetic mean (calculated by adding all items in a list, then dividing by the number of items) is the statistic most familiar to most people.
Median	The middle number in a sequence of numbers. If there are an even number of numbers, the median is the average of the two middle numbers. For example, 4 is the median of 1, 2, 4, 14, 16; and 6 is the median of 1, 2, 5, 7, 9, 11.
Nonpoint Source	A dispersed source of pollutants, generated from a geographical area when pollutants are dissolved or suspended in runoff and then delivered into waters of the state. Nonpoint sources are without a discernable point or origin. They include, but are not limited to, irrigated and non-irrigated lands used for grazing, crop production, and silviculture; rural roads; construction and mining sites; log storage or rafting; and recreation sites.
Nutrient	Any substance required by living things to grow. An element or its chemical forms essential to life, such as carbon, oxygen, nitrogen, and phosphorus. Commonly refers to those elements in short supply, such as nitrogen and phosphorus, which usually limit growth.
pH	The negative $\log_{10}$ of the concentration of hydrogen ions, a measure which in water ranges from very acid (pH=1) to very alkaline (pH=14). A pH of 7 is neutral. Surface waters usually measure between pH 6 and 9.

Point Source	A source of pollutants characterized by having a discrete conveyance, such as a pipe, ditch, or other identifiable "point" of discharge into a receiving water. Common point sources of pollution are industrial and municipal wastewater.
Pollutant	Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.
Riffle	A relatively shallow, gravelly area of a streambed with a locally fast current, recognized by surface choppiness. Also an area of higher streambed gradient and roughness.
Sediments	Deposits of fragmented materials from weathered rocks and organic material that were suspended in, transported by, and eventually deposited by water or air.
Subbasin	A smaller watershed area delineated within a larger watershed, often for purposes of describing and managing localized conditions.
Surface Runoff	Precipitation, snow melt, or irrigation water in excess of what can infiltrate the soil surface and be stored in small surface depressions; a major transporter of nonpoint source pollutants in rivers, streams, and lakes. Surface runoff is also called overland flow.
Suspended Sediments	Fine material (usually sand size or smaller) that remains suspended by turbulence in the water column until deposited in areas of

	weaker current. These sediments cause turbidity and, when deposited, reduce living space within streambed gravels and can cover fish eggs or alevins.
Thalweg	The center of a stream's current, where most of the water flows.
Total Suspended Solids (TSS)	A measure of the suspended organic and inorganic solids in water.
Tributary	A stream feeding into a larger stream or lake.
Turbidity	A measure of the extent to which light passing through water is scattered by fine suspended materials. The effect of turbidity depends on the size of the particles (the finer the particles, the greater the effect per unit weight) and the color of the particles.
Water Quality Limited	A label that describes waterbodies for which one or more water quality criterion is not met or beneficial uses are not fully supported.
Water Quality Standards	State-adopted and EPA-approved ambient standards for waterbodies. The standards prescribe the use of the waterbody and establish the water quality criteria that must be met to protect designated uses.
Watershed	1) All the land which contributes runoff to a common point in a drainage network, or to a lake outlet. Watersheds are infinitely nested, and any large watershed is composed of smaller "subwatersheds." 2) The whole geographic region which contributes water to a point of interest in a waterbody.

Appendix A. BMP Implementation Map