Upper Teton River Subbasin Monitoring Report 2004

Developed for:

Teton Soil Conservation District
Idaho Soil Conservation Commission
Idaho State Department of Agriculture

Prepared by:

Christine Fischer
Water Quality Analyst
Idaho Association of Soil Conservation Districts
Pocatello, Idaho 83201

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Technical Results Summary CFF-upTet-01

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Acknowledgements

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Executive Summary

The Teton River subbasin, HUC 17040204, is a tributary to the Henry's Fork of the Snake River. Several tributaries in the Teton River subbasin are listed on the state of Idaho's §303(d) list for having water quality limited segments. The tributaries to the Teton River in the upper portion of the subbasin are listed for sediment, flow alteration or temperature. The Teton River is listed for nutrients in addition to sediment and flow alteration.

Idaho Association of Soil Conservation Districts began monitoring in the upper Teton River tributaries in March 2002. The data included in this report includes data through the 2003 field season. Sampling was conducted weekly on six tributaries until they dried up later in the year. Badger, Spring, South Leigh and Packsaddle creeks are fed primarily through snow melt. The creek beds are dry early in the year and begin discharging with the commencement of snow melt. These streams will then dry up in late July due to lack of snow melt and from water diverted for irrigation. Fox and Darby creek are spring fed streams. They tend to have a small amount of water year round and have a higher discharge during runoff. Once the non-spring fed sites become dry, monitoring continues on the spring fed streams once a month, until the streams become inaccessible during the winter months.

All monitoring sites were sampled for total suspended solids, total volatile solids, total phosphorus, ortho-phosphorus, nitrate + nitrite and ammonia. Dissolved oxygen, water temperature, specific conductance, total dissolved solids, pH and stream flow were measured in the field.

Sediment, measured as total suspended solid, and total phosphorus concentrations do not seem to present a problem to water quality in the upper Teton River subbasin. The mean concentration levels for total suspended solid and total phosphorus were well below the target set by Idaho Department of Environmental Quality. Once during the spring runoff, a single total phosphorus concentration exceeded the 0.10 mg/L target on Spring Creek in 2002. In 2003, at the same site, a single total suspended solid concentration exceeded the 80 mg/L target.

The mean concentration for nitrate + nitrite exceeded the 0.30 mg/L target at five of the six monitoring sites. Only Packsaddle Creek, which flows from the west side of the valley, did not exceed the target. Every other site flows from the east side of the valley, out of the Teton Mountain Range. These five sites all exceeded the target. Badger Creek barely exceeded the target at 0.38 mg/L, while Fox Creek was five times the target at 1.56 mg/L.

Monitoring will continue in the subbasin through 2004 to gather additional data to evaluate the nitrogen concentrations and sources on Fox Creek. This will include working with other organizations to fill data gaps in the subwatershed, looking at the headwaters of Fox Creek and the springs that feed into it.

Introduction

The Idaho Association of Soil Conservation Districts (IASCD) monitors several tributaries located in the upper Teton River subbasin in Teton County. Monitoring began in March 2002 and will continue through October 2004. The project provides water quality data to the Teton Soil Conservation District (SCD) in determining pollutant loads on tributaries to the Teton River based on the Teton River Total Maximum Daily Load (TMDL). The data will be used to plan implementation of voluntary agricultural best management practices (BMP) throughout the upper Teton subbasin. IASCD has worked cooperatively with Idaho State Department of Agriculture (ISDA), Teton SCD, Natural Resources Conservation Service (NRCS) and Friends of the Teton River (FTR) to implement this project. Several tributaries in the upper Teton subbasin are listed on the state of Idaho's §303(d) list for being water quality limited.

Subbasin Description

The Teton River, hydrologic unit code (HUC) 17040204, is located in eastern Idaho and is a tributary to the Henry's Fork of the Snake River. The Teton River subbasin, shown in Figure 1, is approximately 1,133 sq mi (IDEQ, 2002). The subbasin is located in Wyoming and Idaho. Idaho contains 806 sq mi of the subbasin, while the remaining 327 sq mi is located in Wyoming. The Teton Valley is approximately 5 miles wide and 20 miles long (IDEQ, 2002).

The Teton River originates from streams located in the Big Hole, Teton and Snake River mountain ranges (IDEQ, 2002). The river flows for approximately 64 miles where it confluences with the Henry's Fork. Several tributaries flow into the Teton River in the upper subbasin, while few tributaries enter the river in the lower subbasin. Warm, Pine and Drake creeks confluence together to form the Teton River just east of the town of Victor. Trail Creek enters the river directly below this confluence. Trail Creek flows parallel to Highway 22 from Jackson Pass. Fox, Darby, Teton, South Leigh, North Leigh, Badger and Bitch creeks flow from the eastern side of the valley from the Teton Range. Patterson, Henderson, Mahogany, the Twin Forks, Horseshoe and Packsaddle creeks flow from the western side of the valley from the Big Hole Mountains. Badger, Bitch, Milk and Canyon creeks flow into the river as it flows through the basalt canyon. The Teton River splits into North and South Forks directly north of the town of Teton. Moody Creek enters the South Fork of the Teton River just north of the city of Rexburg.

There are several dams located in the Teton River subbasin (IDEQ, 2002). At one time, three dams existed on the Teton River, one on Fox Creek and one on Moody Creek. The Felt Dam Hydroelectric Project is the only operating dam located on the Teton River. The Linderman Dam, near the Teton River's confluence with Milk Creek, was built for irrigation in the 1950s. The Webster Dam on Moody Creek was built around 1900 and has since filled with sediment providing a fish barrier. The Fox Creek Dam was used as a settling pond for a quarry operation. The Teton Dam was constructed in the canyon and completed in 1975. It then collapsed, sending an approximate discharge of 1.7 million cfs towards the Snake River Plain, in 1976. A large portion of the earth filled dam remains in the channel, however, it does not hinder fish passage.

The primary land uses in the subbasin are agriculture and recreation (IDEQ, 2002). Approximately 75% of the Teton River subbasin in Idaho is privately owned (Figure 1). Caribou-Targhee National Forest owns approximately 21%, while the state of Idaho and Bureau of Land Management split the remaining 4% of the land in Idaho. In Teton County approximately 67% is private land, federally managed land makes up 33% in Teton County. The state of Idaho manages approximately one percent of the land in Teton County.

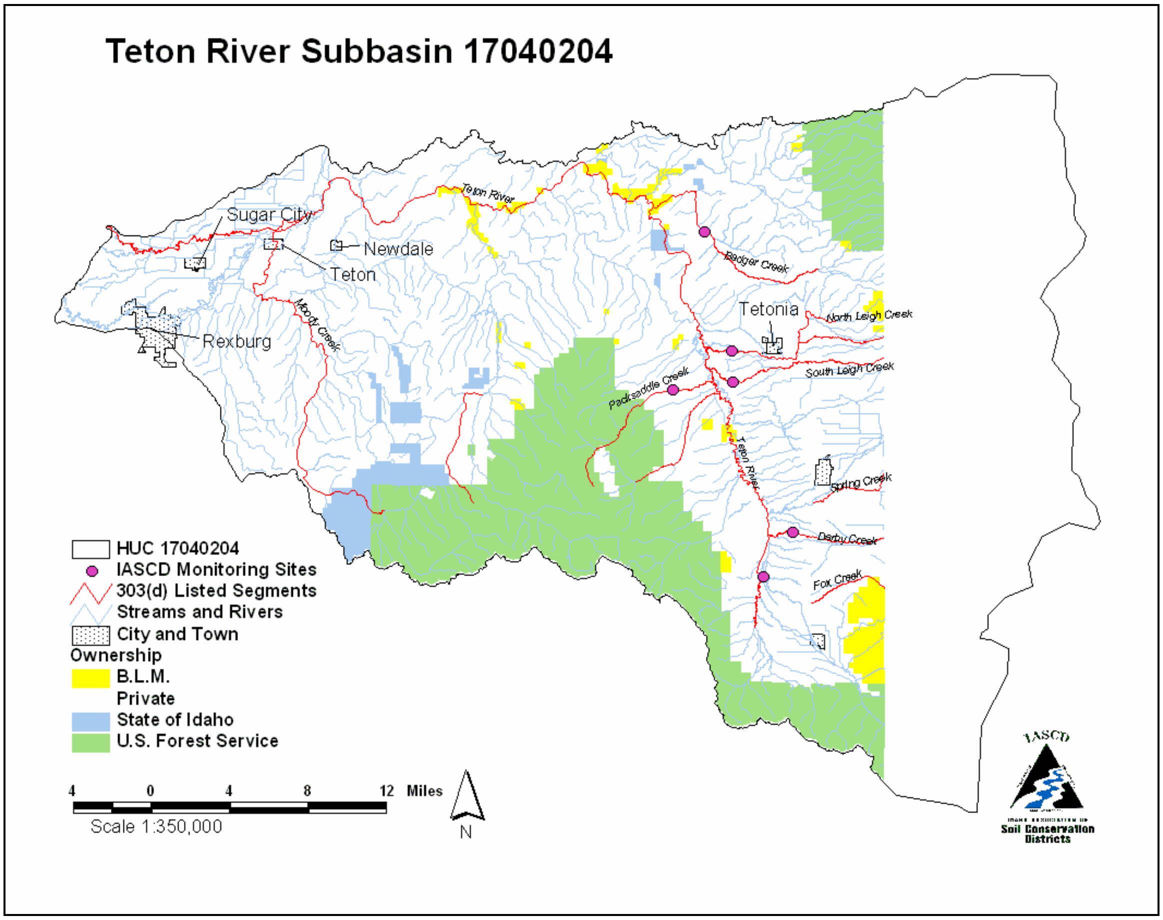

Figure 1. Teton River subbasin and the upper subbasin IASCD monitoring site locations.

The Teton River TMDL

The Teton River TMDL was written by the Idaho Department of Environmental Quality (IDEQ) and by the Environmental Protection Agency (EPA) in February 2003. There are 13 water quality limited segments located in the Teton subbasin. The Teton River is divided into four segments and is listed for nutrients, sediment and habitat alteration (IDEQ, 1998). Moody Creek is the only tributary listed for nutrients. Badger, Spring, South Leigh, Packsaddle, Darby and Fox creeks are listed for sediment. Spring, Packsaddle, Horseshoe, Darby and Fox creeks are listed for flow alteration. Spring and Fox creeks are listed for temperature and North Leigh Creek is on the §303(d) list, but the pollutant is unknown.

IDEQ (2002) has written several water quality targets for the Teton River subbasin. Sediment has three different targets listed for three different types of measurements. The turbidity target is to be "not greater than 50 Nephelometric Turbidity Units (NTU) instantaneous or 25 NTU for more than 10 consecutive days above baseline background, per existing Idaho water quality standard; chronic levels not to exceed 10 NTU at summer base flow." Currently IASCD does not conduct turbidity monitoring in eastern Idaho. Total suspended solids (TSS) criteria are "not to exceed 80 milligrams per liter (mg/L), regardless of season." This is the measurement that IASCD does use to sample for sediment, so this will be the target evaluated by IASCD. The final measurement is for subsurface sediment. "For those streams with subsurface fine sediment (i.e., particles less than 6.3 mm in diameter) less than 27%, do not exceed the existing fine sediment volume level." Subsurface sediment sampling is not currently conducted by IASCD, but it is something that may be incorporated into the sampling protocols in the future. Total phosphorus (TP) is not to exceed 0.10 mg/L in flowing streams to prevent biological nuisance. Total nitrate is not to exceed 0.30 mg/L and total nitrogen in not to exceed 0.60 mg/L. IASCD samples for nitrate + nitrite (NO_3+NO_2). The targets sampled by IASCD are summarized in Table 1.

Table 1. Pollutant targets for §303(d) listed segments in the Teton River TMDL sampled by IASCD.

Pollutant of Concern	Proposed Pollutant Targets for Teton River TMDL
Total Suspended Solids	Not to exceed 80 mg/L, regardless of season
Total Nitrate + Nitrite	Not to exceed 0.30 mg/L
Total Phosphorus	Not to exceed 0.10 mg/L

Monitoring Site Locations

IASCD established water quality monitoring sites on six tributaries within the upper Teton subbasin starting in March 2002. Badger, Spring, South Leigh, Packsaddle, Darby and Fox creeks each had a monitoring site located on it as close to the confluence with the Teton River. These monitoring sites were established to monitor for private land influences on surface water quality.

The headwaters of Badger Creek are located in the Caribou-Targhee National Forest on the east side of the Teton Valley. Approximately 40 percent of Badger Creek subwatershed is located in Wyoming (IDEQ, 2002). The remaining subwatershed, located in Idaho, is approximately 80 percent private land. The Badger Creek monitoring site is located below the confluence with Bull Elk Creek, but above where the creek flows in to a canyon. The confluence with the Teton River is approximately four to fives miles below the monitoring site.

The Spring Creek subwatershed includes North Leigh Creek. The headwaters of North Leigh Creek are located in Wyoming while Spring Creek originates from a spring-fed pond in Idaho (IDEQ, 2002). The monitoring site for these tributaries is below their confluence. Spring Creek is monitored approximately one and a half miles above the confluence with the Teton River.

South Leigh Creek originates from lakes located in Wyoming. It then flows through the Caribou-Targhee National Forest into Idaho and through private land before entering the Teton River. The South Leigh Creek monitoring site is located approximately one and a half miles above the confluence with the Teton River.

Packsaddle Creek is located on the west side of the Teton Valley. The headwaters are located in the Caribou-Targhee National Forest, in the Big Hole Mountains. Packsaddle Creek flows for approximately three miles from the forest boundary to the confluence with the Teton River. The Packsaddle Creek monitoring site is located approximately one and a half miles above the confluence.

Darby Creek is located on the east side of the valley. The headwaters of Darby Creek are located in Wyoming. Once entering Idaho, it flows for approximately six miles to the confluence with the Teton River. Darby Creek flows through Idaho in several channels depending on the amount of water. It does not form one channel until near the confluence with the Teton River. The Darby Creek monitoring site is located approximately one mile downstream from the county road just west of Highway 33.

Fox Creek originates from the east side of the Teton Valley. The headwaters start in Wyoming then flow into Idaho. It splits into several intermittent channels in Idaho (IDEQ, 2002). Near the confluence with the Teton River, several springs add water to Fox Creek. The Fox Creek monitoring site is located on the Idaho Department of Fish and Game (IDFG) Teton River/Fox Creek access. This site is located on Fox Creek directly above the confluence with the Teton River. This site is inaccessible during winter months.

Project Objectives

The project scope of work was discussed and approved by representatives of Teton SCD, ISDA, NRCS and IDEQ. IASCD worked cooperatively with these agencies in an attempt to complete the following objectives:

- Identify those creeks that exceed water quality targets.
- Evaluate the impact of crop, pasture and range lands and recreation on the tributaries of the Teton River.
- Evaluate the water quality and discharge rates at various locations within these creeks.
- Attempt to determine which areas contribute to the greatest level of loading with respect to TMDL parameters.
- Locate future areas where BMPs may be implemented to reduce sediment loads and riparian evaluations implemented on stream bank condition.
- Use this data to increase public awareness.

Methods

Sampling Schedule and Parameters

Sampling of the tributaries in the upper Teton River subbasin began on March 28, 2002. The data included in this report goes through the 2003 field season. Sampling was performed weekly starting in April and continuing through September. The streams in the upper Teton are typically dry until the snow starts to melt during spring runoff. Water will filtrate into the underlying gravels during mid summer, resulting in dry channels. The sites are snow filled or inaccessible during the winter months, so samples were not collected.

Samples were collected and field measurements taken for the parameters listed in Table 2. Samples were delivered to IAS-EnviroChem Laboratory in Pocatello, Idaho within the appropriate holding times.

Table 2. Water Quality Parameters and Field Measurements

Water Quality Parameters	**Laboratory Method**
Total suspended solids (TSS)	EPA 160.2
Total volatile solids (TVS)	EPA 160.4
Total phosphorus	EPA 365.4
Ortho phosphorus	EPA 365.2
Nitrate	EPA 300
Nitrite	EPA 300
Ammonia	EPA 350.3
Field Measurements	**Instrument**
Dissolved oxygen	YSI Model 55
Water temperature	YSI Model 55
Conductivity	Orion Model 115
Total dissolved solids	Orion Model 115
pH	Corning 313
Stream flow	Marsh McBirney Flo-Mate Model 2000

Sampling Methods

Sample collection techniques followed approved United State Geological Survey (USGS) methods (Shelton, 1994). All analytical testing followed either EPA or Standard Methods for the Examination of Water and Wastewater approved methods. Quality control samples, duplicates and blanks, comprised at least 10% of the sample load during this program. Quality Assurance and Quality Control (QA/QC) results are in Appendix A. Duplicate and blank samples were stored and delivered with the normal sample load for analytical testing. For project tracking, chain-of-custody protocols were followed for all sample handling.

A comparison of the mean and standard deviation for duplicate samples are shown in Appendix A, Table 4. Results from the calculated relative percent difference (RPD) for the duplicates are also in Appendix A, Table 5.

Flow Measurements

Flow measurements were collected with a Marsh McBirney Flo-Mate Model 2000 flow meter. The six-tenth-depth method (0.6 of the total depth below water surface) was used when the depth of water was less than or equal to three feet. When the water was over three feet deep, an average of the two-tenth and eight-tenth-depth method (0.2 and 0.8 of the total depth below water surface) was measured. A transect line was set up perpendicular to flow across the width of each creek and the mid-section method for computing cross-sectional area along with the velocity-area method was used for discharge determination. The discharge was computed by summation of the products of the partial areas of the flow cross-sections and the average velocities for each of those sections.

Water Quality

Samples for water quality analysis were collected by grab sampling directly from the stream on wadable sites. For shallower sites (<1 ft) grab samples were collected by hand using a clean one-liter stainless steel container. A DH-81 integrated sampler was used at wadable sites with water depths greater than 1 foot. For each method, individual samples were collected at equal intervals across the entire width of the stream. Each discrete sample was composited in a 2.5 gallon polyethylene churn sample splitter from which homogenized samples were poured off into sample containers.

Field Measurements

Field measurements for dissolved oxygen, percent saturation and water temperature were taken directly in the streams from well-mixed sections, near mid-stream at approximately mid-depth. Measurements for specific conductance, pH and dissolved solids were taken from the churn splitter composite sample, immediately following collection. Calibration of all field equipment was in accordance with the manufacturers specifications. All field measurements were recorded in a bound logbook along with pertinent observations about the site, including weather conditions, flow rates and personnel on site.

Data Handling

The field data and analytical data generated from each survey were reviewed by IASCD and ISDA personnel. Each batch of data was reviewed to insure that all observations, measurements and analytical results have been properly recorded. The analytical results were evaluated for completeness and accuracy. Any suspected errors were investigated and resolved, if possible. The data was then stored electronically and made available to any interested entity.

Results and Discussion

All the tributaries sampled by IASCD in the upper Teton subbasin are listed for sediment. The Teton River is listed for nutrients in addition to sediment. Since these streams flow into the river, nutrients are a concern on the tributaries. Nutrients are measured as nitrate + nitrite (NO_3+NO_2) and total phosphorus (TP). In addition to NO_3+NO_2 and TP, ammonia (NH_3) and ortho phosphorus (OP) were measured. Sediment was measured as total suspended solids (TSS). The mean concentrations for TSS, NO_3+NO_2, TP and discharge (Q) are summarized in Table 3.

Table 3. Mean Values for 2002 and 2003 Water Quality Data

Site	TSS mg/L	NO_3+NO_2 mg/L	TP mg/L	Q cfs	n
Badger	7.72	0.38	0.03	74.6	18
Spring	20.3	1.00	0.04	23.6	18
S. Leigh	4.50	0.62	0.03	15.7	16
Packsaddle	18.8	0.09	0.04	10.2	11
Darby	7.25	0.81	0.03	11.8	20
Fox	8.97	1.56	0.03	41.4	34

Stream Discharge

Most of the tributaries sampled are snow filled January through March. Fox and Darby creeks are the only streams in this project which have some amount of water in them year round. These two streams are spring fed. During the winter and early spring months Fox Creek is inaccessible and Darby Creek has very low flows until the runoff begins to recharge the springs.

The soils in the valley are well drained and are formed in alluvium and loess over a gravel and sandy layer. Water will infiltrate, from the channels, under ground to recharge the streams, resulting in a dry channels starting mid July. Water is also diverted out of the channels during irrigation season, speeding up this process. Most of the streams begin flowing in late April and early May. The peak runoff typically occurs mid to late May. The streams then begin to dry up in mid to late July. Hydrographs for these streams are presented in Figure 2. The amount of runoff from 2002 to 2003 seemed to decrease. This is the result of the lack of snow pack for the 2002/2003 winter. Precipitation from November through May was 33% less in the 2003 water year than in the 2002 water year (USDA, 2004).

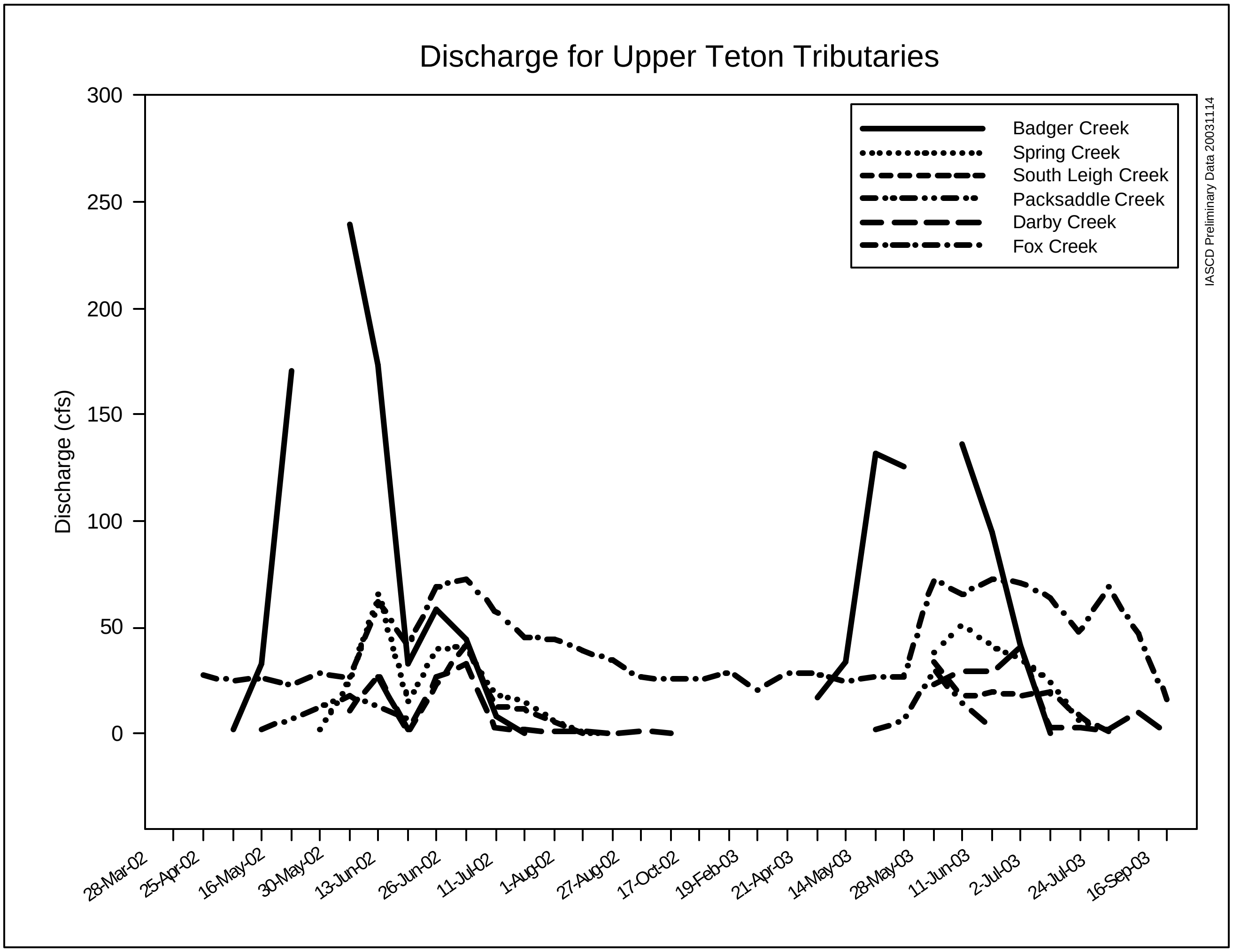

Figure 2. Discharge measurements for upper Teton River tributary monitoring sites.

Total Suspended Solids

All six tributaries have sediment listed as a pollutant of concern. None of the sites exceeded 80 mg/L when the TSS concentrations were averaged for the entire sampling period (Table 3). During base flow periods, TSS concentrations were below 50 mg/L. During spring runoff, only once did the concentration of TSS exceed the 80 mg/L target in Spring Creek. All the other tributaries stayed well below the target throughout the water year.

There are steep and cut banks that have the potential to introduce sediment into the creek during a higher water year. Natural processes of stream flow and snow melt have had impact on stream banks in the subwatershed. In some areas where there is no grazing, the stream banks are vertical and vegetated but still are sloughing into the creek. Grazing has impacted Spring and Packsaddle creeks in some isolated areas resulting in bank erosion. Even with these streambanks eroding, TSS levels are relatively low in these subwatersheds.

Other sources of sediment in these tributaries could come from roads and recreation. Several roads traveled by IASCD to the monitoring sites are dirt and gravel. Fishing, camping and off-road vehicles have the potential to impact the creek on private, state and federal lands. These activities could result in additional sediment being introduced into the creek.

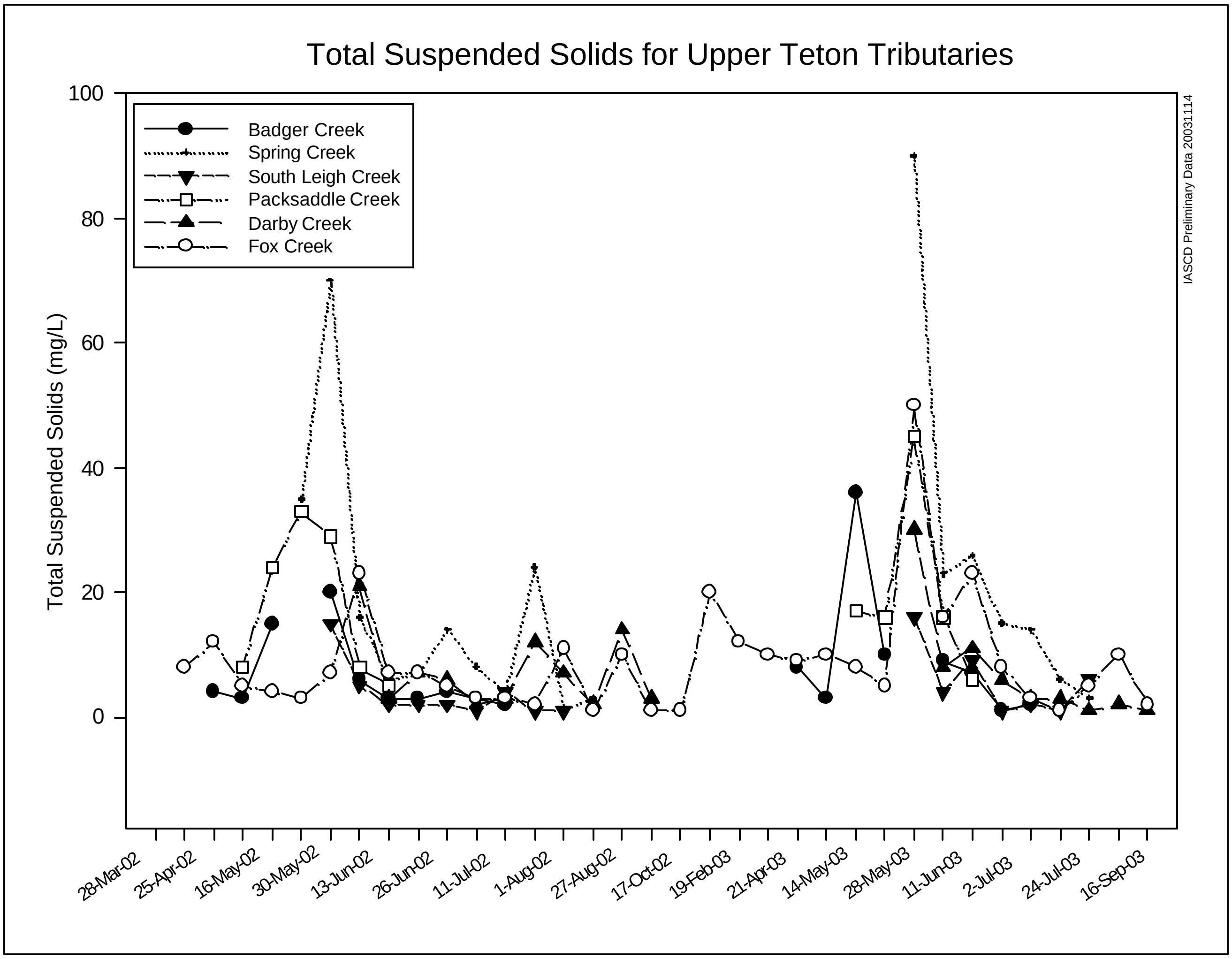

Figure 3. Total suspended solid concentrations for upper Teton monitoring sites.

Nitrate + Nitrite

In the upper Teton subbasin, only the Teton River is listed for nutrients. The mean NO_3+NO_2 concentration for Badger, Spring, South Leigh, Darby and Fox creek sites are over the TMDL target of 0.30 mg/L (Table 3). Packsaddle Creek is the only tributary that does not have a mean concentration above the 0.30 mg/L target (0.09 mg/L) and only once did it exceed the target. Packsaddle Creek is the only stream IASCD monitors that flows from the west, out of the Big Hole Range. All the other streams sampled flow from the Teton Range.

Badger Creek is just above the target with a mean concentration of 0.38 mg/L. Spring, South Leigh and Darby creeks are two to three times the target concentration with 1.00 mg/L, 0.62 mg/L and 0.81 mg/L. Fox Creek has the highest concentration of NO_3+NO_2 with a mean concentration of 1.56 mg/L. Fox Creek has the most ground water influence since it is primarily spring fed. These concentrations can all be seen in Figure 4.

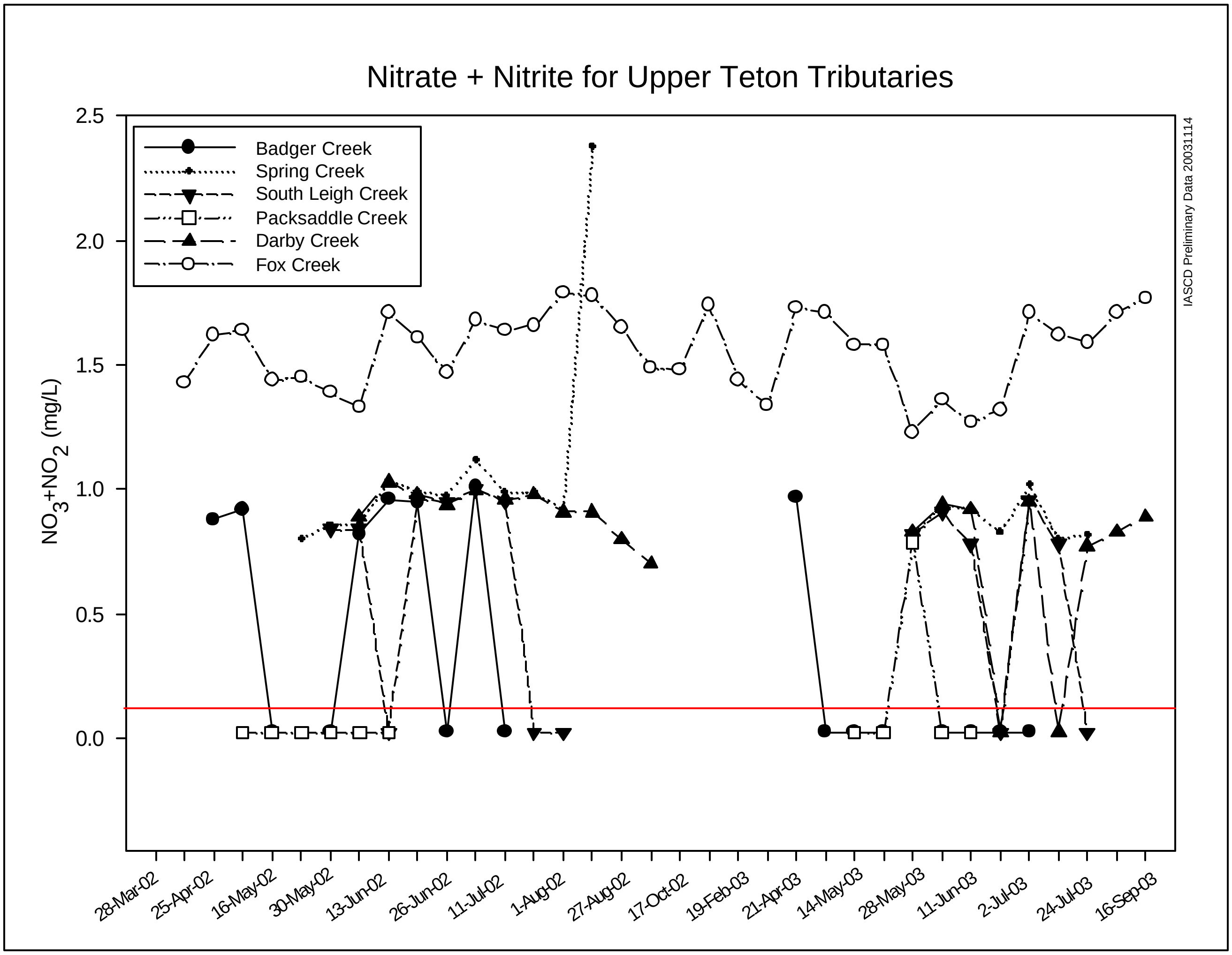

Figure 4. Nitrate + Nitrite concentrations for upper Teton monitoring sites. The red line indicates the 0.30 mg/L target.

The source of nitrogen is difficult to pinpoint. Nitrogen can come from precipitation that has fallen directly onto the stream surface, fixation in the water and sediments and input from surface and groundwater (Wetzel, 1983). Wetzel also notes that snow, rather than rain, contains a higher content of nitrogen, and could contribute up to half the total influx during a year.

Ground water could be a contributor of NO_3+NO_2 into the surface water. Fertilizer and decomposed manure or plant residue can leach into the ground water over time, or runoff directly into the river or creeks during a rainstorm or spring runoff. Some plant residue can cause elevated levels of nutrients in the water. During the winter, aquatic plants may decompose elevating the NO_3+NO_2 concentrations.

There is a non-profit organization located in the upper Teton subbasin call the Friends of the Teton River (FTR). A goal of FTR is “protecting the water resources of the Teton

Basin." In 2001, FTR began monitoring for water quality on the Teton River in several locations. Since then, they have been monitoring Teton, Darby and Fox creeks in their head waters and Fox Creek closer to a spring source. FTR uses the same protocols and analytical laboratory as IASCD.

FTR has two monitoring sites located on Fox Creek, one directly downstream from a spring (FTR Fox 1), approximately two miles above the IASCD Fox Creek monitoring site, and the other is near the headwaters of Fox Creek near the forest service and Wyoming border (FTR Fox 2). These additional monitoring sites will allow IASCD to better determine where the high concentrations of NO_3+NO_2 are located. FTR Fox 1, directly below a spring, has the highest concentrations of NO_3+NO_2 at a mean of almost seven times the target (1.93 mg/L). FTR Fox 2, located above private agriculture, has a mean concentration three times the target at 0.90 mg/L. The IASCD Fox Creek site falls between the two with a mean concentration of 1.56 mg/L. The three concentrations for Fox Creek can be seen in Figure 5. It appears that there are high levels of NO_3+NO_2 located in this subwatershed, since at the forest boundary the concentrations are still three times the target. These concentrations may occur naturally. There is some grazing located in the Fox Creek drainage on Forest Service land. There is also a quarry located above FTR Fox 2. The high concentrations on FTR Fox 1 show that the majority of the NO_3+NO_2 seem to come from a ground water component.

It appears that the springs have elevated the NO_3+NO_2 concentrations at FTR Fox 1 and are actually diluted with the surface water flowing in Fox Creek at the IASCD Fox monitoring site. The dotted line in Figure 5 is the discharge measurement from the IASCD Fox Creek monitoring site. When the discharge gathered at the IASCD Fox site increases, the NO_3+NO_2 concentration at the IASCD Fox site decreases. This could indicate that the surface water is diluting the high NO_3+NO_2 from the springs.

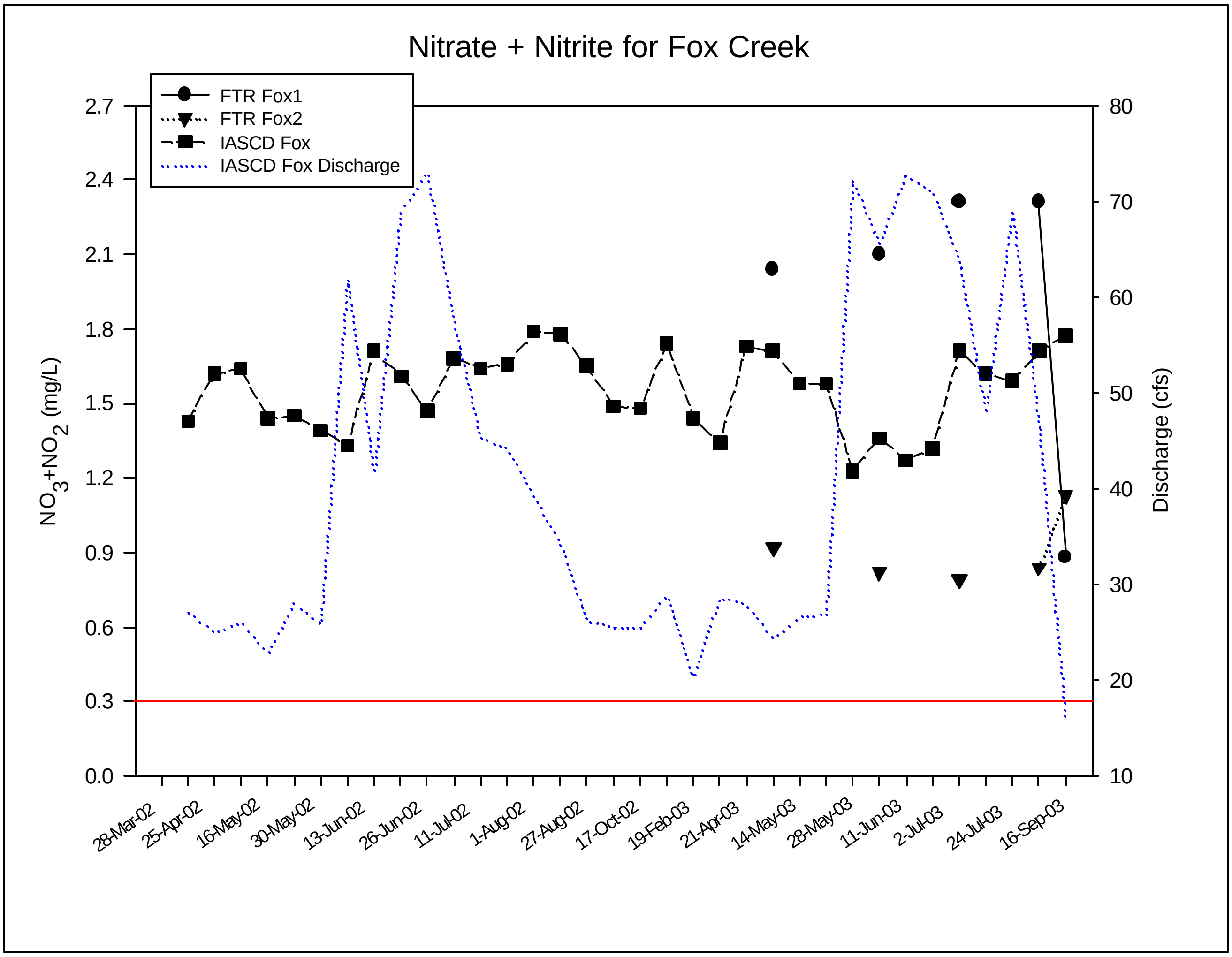

Figure 5. Nitrate + Nitrite data for Fox Creek at the IASCD and FTR monitoring sites. The red line indicates the 0.30 mg/L target.

Total Phosphorus

Total phosphorus (TP) does not appear to be a nutrient of concern in the upper Teton subbasin tributaries. The TMDL target of 0.10 mg/L of TP is based on the EPA Gold Book Criteria (USEPA, 1987). All sites are below the 0.10 mg/L target for the mean concentrations (Table 3). The TP concentrations stay below the target for all sites at all times of the year except once for Spring Creek during a spring runoff event (Figure 6). There is occasional aquatic plant growth in Darby and Fox creeks which could be a result of enriched nutrients, primarily nitrogen.

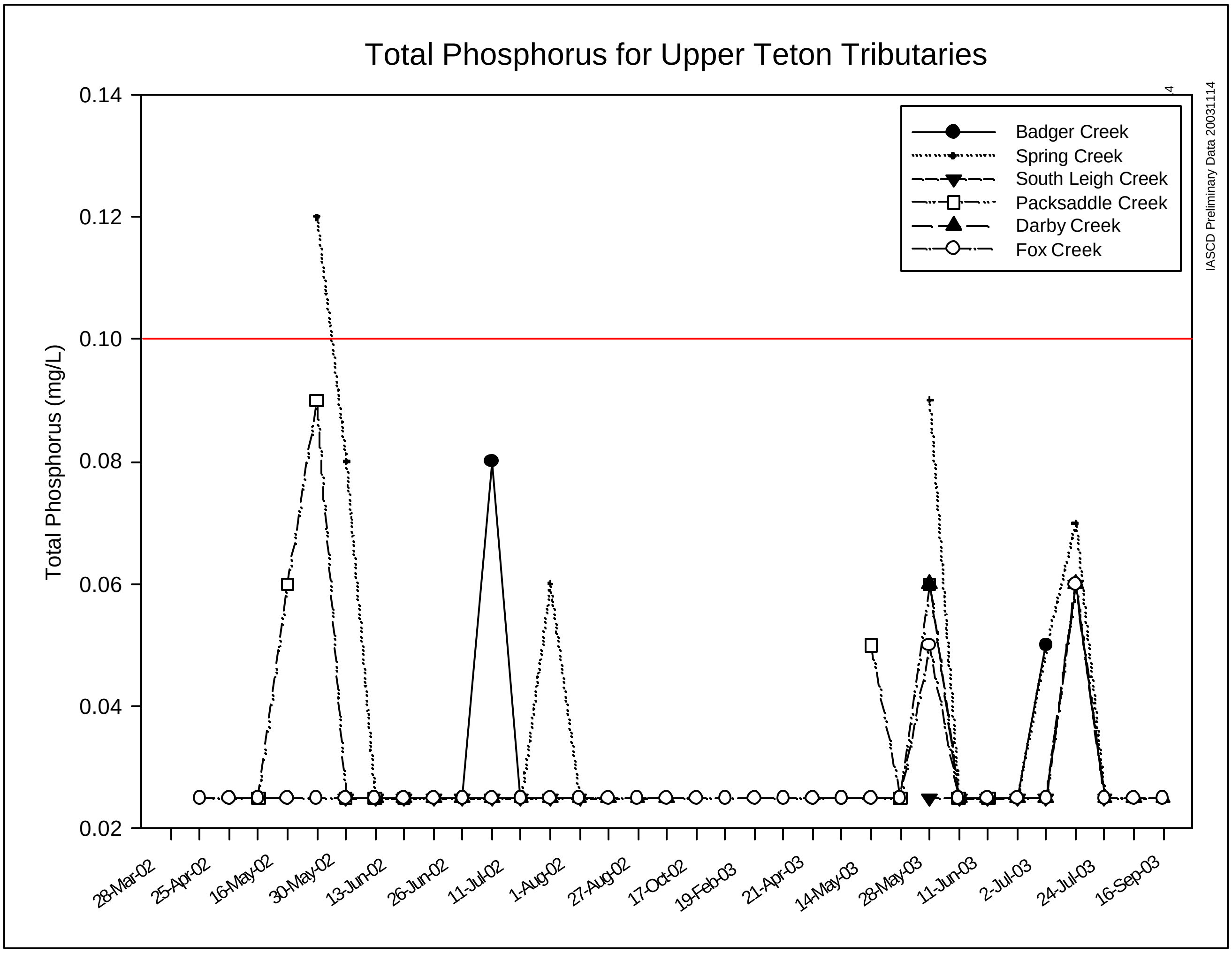

Figure 6. Total phosphorus concentrations for Moody Creek monitoring sites. The red line indicates the 0.10 mg/L target.

Conclusions

Sediment, measured as total suspended solid, and total phosphorus do not seem to present a problem in water quality in the upper Teton subbasin tributaries. Both parameters exceed their target only once during the two year data set. This exceedance occurred during a spring runoff event on Spring Creek; however, TP exceeded the target during spring runoff in 2002 while TSS exceeded the target during spring runoff in 2003.

Nitrate + nitrite concentrations appear to be the major pollutant in the upper subbasin. The monitored tributaries do not have nutrients listed as the pollutant of concern. All tributaries, but Packsaddle Creek, exceed the 0.30 mg/L target for their mean values of NO_3+NO_2. The highest concentrations occur in Fox Creek which has several springs that contribute water to the stream. Ground water in the Teton subbasin could be contributing to surface water concentrations of NO_3+NO_2. This nitrogen could also come naturally from the marsh and wetland complexes that are located in the subbasin. In some areas the higher nitrogen level could come from agricultural nutrient inputs.

Recommendations

The following recommendations should be considered:

- Collection of additional data and background research to evaluate the nitrogen concentrations and sources on Fox Creek.
- Monitoring of springs that feed into Fox Creek may be valuable in evaluating nitrogen concentrations.
- Evaluation of stream bank conditions for severe down cutting, sloughing and loss of riparian function that may contribute phosphorus and sediment during high water conditions.
- Evaluation of agricultural nutrient management practices within select areas of the entire subbasin.
- Assessment of any impact that animal grazing activities may have on the functioning condition of the tributaries riparian area.
- Identification of critical areas or critical activities that would best be addressed by implementation of BMPs.
- The SCD, NRCS, IASCD, ISCC and ISDA to work with landowners and cooperators to fund and implement projects that will improve the overall water quality of the upper Teton subbasin.
- Begin monitoring for *Escherichia coli* bacteria on tributaries to determine if there is a potential bacteria problem in the upper Teton subbasin.

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Appendix A
Quality Control Results

Quality Assurance/Quality Control (QA/QC)

The QA/QC procedure for this monitoring program conformed to those outlined in the "Water Quality Sampling Plan", prepared by the IASCD.

Intermountain Analytical Services- EnviroChem utilized EPA approved and validated methods. Method performance evaluations include quality control samples analyzed with a batch to ensure sample data integrity. Internal laboratory spikes and duplicates are all part of EnviroChem's quality assurance program.

Field QA/QC protocols consisted of duplicate samples and blank samples. The field blanks consisted of laboratory grade deionized water, transported to the field, and poured off into properly prepared sample containers. For filtered constituents, deionized water was transferred into the filtration unit, filtered, and the resultant filtrate was transferred into appropriate sample containers. The blank samples were used to determine the integrity of the field teams sampling handling, the cleanliness of the sample containers, and the accuracy of the laboratory methods. There were no constituents detected (above the method detection limits) for any of the blank samples submitted during this program.

The duplicate samples consisted of two sets of sample containers filled (in the field) with the same composite water from the same sampling site. The duplicate samples were not identified as such and entered the laboratory as blind duplicates. The duplicate samples were used to determine both field and laboratory precision. All of the QC samples were stored on ice and handled with the normal sample load for shipment to the laboratory.

Table 4. Duplicate Comparison, Mean and Standard Deviation

Parameters	FC1 Mean	Duplicate Mean	FC1 Standard Deviation	Duplicate Standard Deviation
TSS	8.97	8.76	9.33	9.31
TVS	2.06	2.09	1.37	1.42
Nitrate+Nitrite	1.56	1.56	0.16	0.16
Ammonia	0.04	0.04	0.04	0.03
Total Phosphorus	0.03	0.03	0.007	0.009
Ortho-Phosphorus	0.03	0.03	0	0

Precision

Relative percent difference (RPD) is the normal measure of precision when calculated from duplicate sample. As previously mentioned, the duplicates were collected in the field. The calculation for RPD is as follows:

$$RPD = \frac{(C_1-C_2)*100}{(C_1+C_2)/2}$$

Where: RPD = relative percent difference
C_1 = Larger of the two observed values
C_2 = Smaller of the two observed values

Minnesota Pollution Control Agency (1998) recommends an RPD should have a value of less than 25% for water samples.

Table 5. Relative Percent Differences (duplicates)

Date	Original NO_3+NO_2	Duplicate NO_3+NO_2	RPD	Original TSS	Duplicate TSS	RPD	Original TVS	Duplicate TVS	RPD
28-Mar-02									
9-Apr-02	1.43		2	8		2	2		2
25-Apr-02	1.62	1.62	0	12	10	0.181	3	3	0
9-May-02	1.64	1.64	0	5	5	0	2	2	0
16-May-02	1.44	1.42	0.013	4	5	0.222	1	2	0.666
21-May-02	1.45	1.46	0.006	3	3	0	1	1	0
30-May-02	1.39	1.38	0.007	7	6	0.153	2	2	0
6-Jun-02	1.33	1.34	0.007	23	24	0.042	4	4	0
13-Jun-02	1.71	1.72	0.005	7	6	0.153	2	1	0.666
20-Jun-02	1.61	1.58	0.018	7	6	0.153	1	1	0
26-Jun-02	1.47	1.47	0	5	4	0.222	1	1	0
3-Jul-02	1.68	1.68	0	3	3	0	1	1	0
11-Jul-02	1.64	1.65	0.006	3	2	0.4	1	1	0
17-Jul-02	1.66	1.67	0.006	2	1	0.666	1	1	0
1-Aug-02	1.79	1.8	0.005	11	12	0.086	3	4	0.285
15-Aug-02	1.78	1.79	0.005	1	1	0	1	1	0
27-Aug-02	1.65	1.64	0.006	10	11	0.095	3	2	0.4
19-Sep-02	1.49	1.52	0.019	1	1	0	1	1	0
17-Oct-02	1.48	1.48	0	1	1	0	1	1	0
21-Nov-02	1.74	1.72	0.011	20	20	0	4	4	0
19-Feb-03	1.44	1.47	0.020	12	10	0.181	3	3	0
24-Mar-03	1.34	1.35	0.007	10	10	0	3	3	0
21-Apr-03	1.73	1.74	0.005	9	10	0.105	2	3	0.4
8-May-03	1.71	1.7	0.005	10	10	0	3	3	0
14-May-03	1.58	1.59	0.006	8	8	0	1	1	0
21-May-03	1.58	1.58	0	5	6	0.181	1	1	0
28-May-03	1.23	1.23	0	50	48	0.040	7	7	0
4-Jun-03	1.36	1.34	0.014	16	16	0	3	3	0
11-Jun-03	1.27	1.26	0.007	23	23	0	4	4	0
18-Jun-03	1.32	1.31	0.007	8	8	0	3	3	0
2-Jul-03	1.71	1.71	0	3	3	0	1	1	0
9-Jul-03	1.62	1.61	0.006	1	1	0	1	1	0
24-Jul-03	1.59	1.6	0.006	5	4	0.222	1	1	0
14-Aug-03	1.71	1.7	0.005	10	9	0.105	1	1	0
16-Sep-03	1.77	1.76	0.005	2	2	0	1	1	0
21-Oct-03	1.7	1.7	0	1	1	0	1	1	0

Table 5 con't. Relative Percent Differences (duplicates)

Date	Original TP	Duplicate TP	RPD	Original OP	Duplicate OP	RPD	Original NH_3	Duplicate NH_3	RPD
28-Mar-02									
9-Apr-02	0.025		2	0.025		2	0.07		2
25-Apr-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
9-May-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
16-May-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
21-May-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
30-May-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
6-Jun-02	0.025	0.03	0	0.025	0	0	0.06	0.06	0
13-Jun-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
20-Jun-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
26-Jun-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
3-Jul-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
11-Jul-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
17-Jul-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
1-Aug-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
15-Aug-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
27-Aug-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
19-Sep-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
17-Oct-02	0.025	0.03	0	0.025	0	0	0.025	0.03	0
21-Nov-02	0.025	0.03	0	0.025	0	0	0.05	0.05	0
19-Feb-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
24-Mar-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
21-Apr-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
8-May-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
14-May-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
21-May-03	0.025	0.03	0	0.025	0	0	0.06	0.07	0.153
28-May-03	0.05	0.06	0.181	0.025	0	0	0.24	0.21	0.133
4-Jun-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
11-Jun-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
18-Jun-03	0.025	0.03	0	0.025	0	0	0.04	0.04	0
2-Jul-03	0.025	0.03	0	0.025	0	0	0.05	0.03	0.666
9-Jul-03	0.06	0.06	0	0.025	0	0	0.06	0.05	0.181
24-Jul-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
14-Aug-03	0.025	0.05	0.666	0.025	0	0	0.06	0.05	0.181
16-Sep-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0
21-Oct-03	0.025	0.03	0	0.025	0	0	0.025	0.03	0