Final Upper Teton Water Quality Monitoring Report

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Technical Report Summary
ARJ-Tet-05

April 2005
Pocatello, Idaho

Introduction

The Idaho Association of Soil Conservation Districts (IASCD) recently completed a monitoring project on tributaries to the Upper Teton River in eastern Idaho. The Teton River originates from streams located in the Big Hole, Teton and Snake River mountain ranges (IDEQ 2003a). The river flows for approximately 64 miles before it joins with the Henry's Fork of the Snake River. Several tributaries flow into the Teton River in the upper subbasin, while few tributaries enter the river in the lower subbasin. This monitoring project concentrated on six tributaries in the Upper Teton subbasin: Badger, Spring (below confluence with North Leigh Creek), South Leigh, Packsaddle, Darby and Fox creeks. All of these streams except Packsaddle Creek flow from the Teton Range on the east side of the valley. Packsaddle Creek flows from the Big Hole Mountains on the west side of the valley.

The Teton River TMDL was written by the Idaho Department of Environmental Quality (DEQ) and approved by the Environmental Protection Agency (EPA) in February 2003. Several tributaries in the Teton River subbasin are listed on the state of Idaho's §303(d) list for having water quality limited segments. Badger, Spring, S. 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 also listed for temperature and North Leigh Creek is listed for an unknown pollutant. The beneficial uses that these streams are to support are cold water aquatic life (CWAL) and salmonid spawning (SS).

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

Pollutant of Concern	Pollutant Targets for Teton 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
Temperature (salmonid spawning)	Not to exceed 13°C (May - June 30, Sept. 15-Nov. 15)
Temperature (cold water aquatic life)	Not to exceed 22°C (June 22 - Sept. 21)
E. coli (for secondary contact recreation)	Not to exceed 576 colonies/100 mL

This monitoring project was initiated at the request of the Teton Soil Conservation District (SCD). The project goal was to provide water quality data to the District to allow for identification of potential pollutant sources and to quantify pollutant concentrations in the tributaries. The data will be used to plan implementation of voluntary agricultural best management practices (BMPs) throughout the Upper Teton River subbasin. IASCD has worked cooperatively with Idaho State Department of Agriculture (ISDA) and the Teton SCD to implement this project.

Monitoring Schedule and Site Descriptions

Monitoring began at six sites in the Upper Teton subbasin in March 2002 and continued through November 2004. Monitoring sites were located near the confluence with the Teton River (Figure 1).

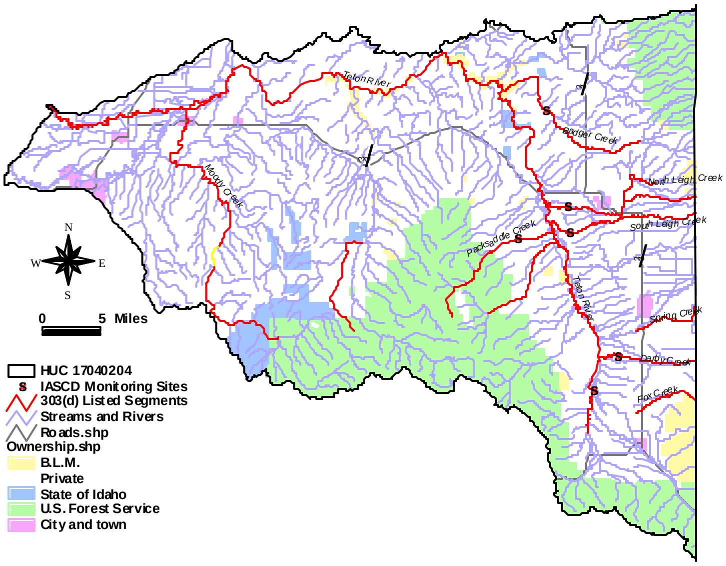

Figure 1. IASCD monitoring locations in the Upper Teton River subbasin.

The monitoring site on Badger Creek was located below the confluence with Bull Elk Creek, approximately four to fives miles from the Teton River. Spring Creek was monitored below the confluence with North Leigh Creek. Spring Creek drains into the Teton River approximately one and a half miles below the site. The S. Leigh Creek monitoring site was located upstream of Haden Road, approximately one and a half miles above 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. The monitoring site was located directly above the confluence with the Teton River at the Idaho Department of Fish and Game (IDFG) Teton River/Fox Creek access. Packsaddle Creek was monitored about one and a half miles above the Teton River.

IASCD monitored twice a month throughout most of the year and once a month during winter. During each visit, samples were collected for total suspended solids (TSS), total volatile solids, total phosphorous (TP), orthophosphorus, nitrate + nitrite, ammonia and *Escherichia coli* (*E. coli*). Field measurements were taken for stream discharge, temperature, dissolved oxygen, pH and conductivity.

Results

Discharge

Discharge rates in many of the streams fluctuated seasonally as is common in systems that are largely influenced by snow melt. Stream flow peaked during spring months and declined to base flows for the remainder of the year (Figure 2). Fox Creek was the exception to this trend. Discharge in Fox Creek is largely influenced by springs and the resulting hydrograph indicated relatively constant flows.

Stream discharge rates in the tributaries were also influenced by irrigation diversions (DEQ 2002). During the irrigation season flow may be diverted on all six tributaries. The creeks that drain from the east side of Teton valley are classified as perennial at their upper reaches, but become intermittent streams due to irrigation diversions and surface water percolating into the ground. These streams reemerge as perennial streams near their confluence with the Teton River due to groundwater inputs. Packsaddle Creek is completely diverted 0.5 miles downstream from the Forest Service boundary and does not connect with the Teton River during the irrigation season.

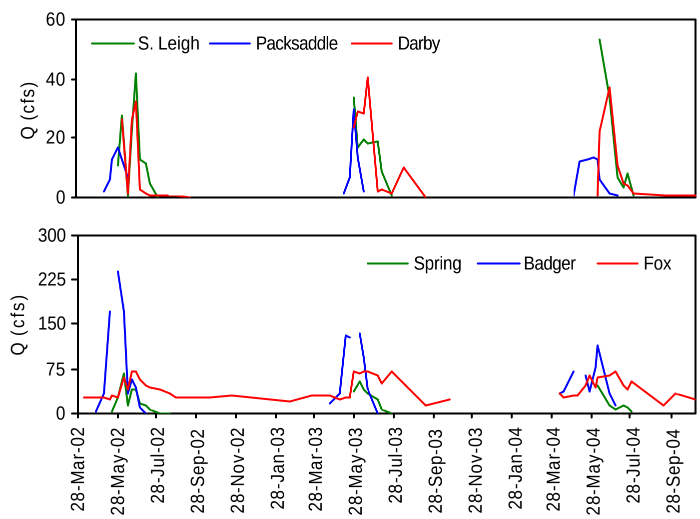

Figure 2. Stream discharge (cfs) at the six monitoring sites.

Five of the six tributaries were dry or inaccessible for most of the year (Figure 2). Badger, Spring, S. Leigh and Packsaddle creeks held water for one to three months out of the year. Darby Creek had flows for about 4 months out of the year and Fox Creek was never observed to dry up during the course of this project. However, sampling on Fox Creek was often impossible during the winter and early spring months because the site was inaccessible.

Discharge rates were highest in Badger Creek and lowest in Packsaddle Creek (Table 2). Stream discharge in Badger and Fox creeks was significantly greater than in the other four tributaries ($p < 0.0001$). Flows in Spring Creek were significantly higher than flows in Packsaddle Creek ($p = 0.011$) and stream discharge rates in S. Leigh, Packsaddle and Darby creeks were not significantly different from each other.

Table 2. Mean, minimum and maximum stream discharge (cfs) and 95% confidence intervals.

Stream	Mean (cfs)	Min (cfs)	Max (cfs)	+/- 95% CI
Badger	67.6	0.4	239.3	23.2
Darby	10.7	0.0	40.8	4.8
Fox	41.1	12.1	73.0	5.0
Packsaddle	9.2	0.8	30.0	3.3
S. Leigh	16.3	0.2	53.8	6.1
Spring	21.4	0.3	65.5	7.5

Total suspended solids

Total suspended solids (TSS) concentrations in the six tributaries fluctuated on a seasonal basis. As is common in snowmelt dependent systems, suspended solids levels increased significantly during peak runoff events and declined to low levels throughout the rest of the year (Figure 3). S. Leigh and Fox creeks exhibited an increase in TSS during peak runoff in 2003, but not in 2002 or 2004. Overall, TSS concentrations at each site were low. The DEQ target of 80 mg/L was exceeded only one time during this project; at Spring Creek during peak runoff.

Mean TSS concentrations at the six sites were well below the DEQ target of 80 mg/L (Table 3), but differences between the six sites were detectable. TSS levels were significantly higher in Spring and Packsaddle creeks than in the other four tributaries ($p = 0.020$). TSS concentrations in Badger, S. Leigh, Darby and Fox creeks were not significantly different from each other. The relatively high levels of TSS in Spring Creek may be reflective of land use practices above the monitoring site. Spring Creek in this reach is grazed by livestock and there is limited vegetation associated with the riparian zone. The high concentrations in Packsaddle Creek may be due to the relatively steep gradient of the stream and the increased erosivity of the surrounding soils due to land use practices during the growing season. While all sites met the DEQ target for TSS, further reductions in TSS levels could be achieved by implementing sediment reduction best management practices (BMPs) in the subbasin.

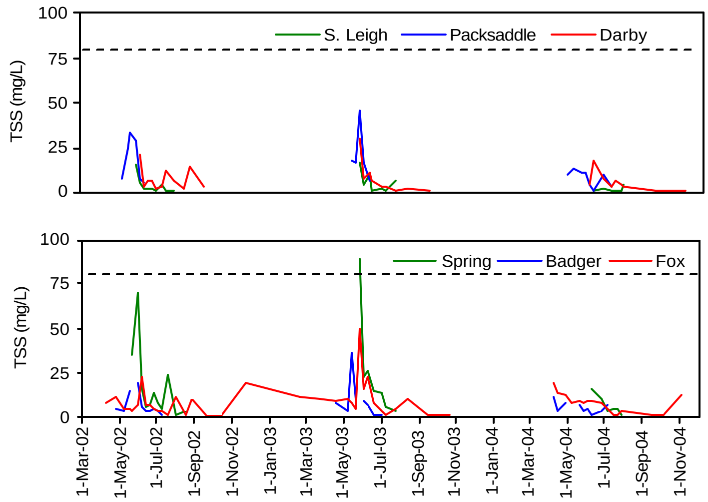

Figure 3. Total suspended solids (TSS) measured at the six monitoring sites from March 2002 to November 2004. The horizontal dashed lines represent the DEQ target of 80 mg/L.

Table 3. Mean, minimum and maximum TSS concentrations (mg/L) and 95% confidence intervals.

Stream	Mean (mg/L)	Min (mg/L)	Max (mg/L)	+/- 95% CI
Badger	6.9	1.0	36.0	2.7
Darby	6.4	1.0	30.0	2.4
Fox	8.5	1.0	50.0	2.3
Packsaddle	14.1	1.0	45.0	5.1
S. Leigh	3.7	1.0	16.0	1.8
Spring	16.8	1.0	90.0	8.6

Total phosphorus

Total phosphorus (TP) concentrations in the tributaries were often elevated during spring months, but the lack of data during base flow periods makes it difficult to reliably determine if TP was seasonally variable (Figure 4). TP at Fox Creek was relatively constant and exhibited a peak during spring 2003, but not in 2002 or 2004. Overall, TP concentrations were low at all tributaries and only one measurement (Spring Creek) over the three years exceeded the target of 0.1 mg/L.

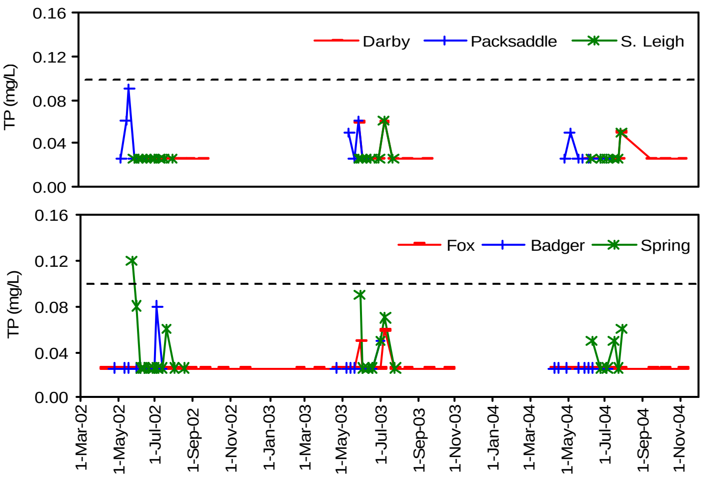

Figure 4. Total phosphorus (mg/L) measured at the six sites from March 2002 to November 2004. The horizontal dashed lines represent the DEQ target of 0.1 mg/L.

On average, TP concentrations at the six sites were well below the DEQ target (Table 4), but differences between monitoring sites were observed. TP levels in Spring Creek were significantly higher than in Badger, S. Leigh, Darby and Fox Creeks ($p = 0.050$).

Table 4. Mean, minimum and maximum TP concentrations (mg/L) and 95% confidence intervals.

Stream	Mean (mg/L)	Min (mg/L)	Max (mg/L)	+/- 95% CI
Badger	0.03	0.03	0.08	0.00
Darby	0.03	0.03	0.06	0.00
Fox	0.03	0.03	0.06	0.00
Packsaddle	0.04	0.03	0.09	0.01
S. Leigh	0.03	0.03	0.06	0.00
Spring	0.04	0.03	0.12	0.01

Phosphorus concentrations in Packsaddle Creek were higher than in Fox Creek ($p = 0.004$), but were not significantly different from the other sites. Implementation of best management practices (BMPs) that addressed water quality during spring runoff events could help reduce concentrations of both TSS and TP.

Nitrogen

Nitrogen (nitrate + nitrite, mg/L) concentrations measured in Badger, Spring, S. Leigh, Darby and Fox creeks were often in excess of the DEQ target level of 0.3 mg/L. There were no obvious spatial or temporal trends in nitrogen levels (Figure 5). Every nitrate + nitrite concentration measured in Fox and Spring creeks exceeded the target, regardless of season or year. Packsaddle Creek exceeded the target only once during the three year period.

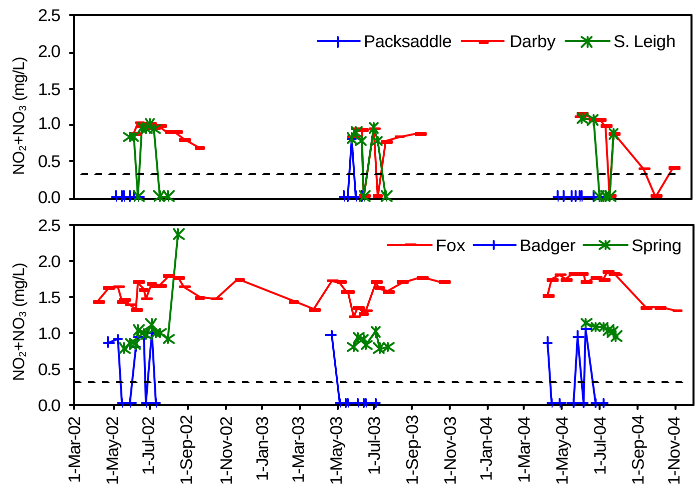

Figure 5. Nitrogen levels (nitrate + nitrite, mg/L) measured at the six sites in the Upper Teton subbasin from March 2002 to November 2004. The horizontal dashed lines represent the DEQ target of 0.3 mg/L.

Average nitrate + nitrite concentrations at every site except Packsaddle exceeded the DEQ target (Table 5). Significant differences in nitrogen levels were observed between the five sites that experienced high nitrogen concentrations. Nitrate + nitrite concentrations in Fox Creek were significantly higher than the other five streams ($p < 0.0001$) and concentrations in Spring Creek were higher than the remaining four streams ($p = 0.010$). Levels in Darby Creek were significantly higher than in Badger Creek ($p = 0.002$), but not different than S. Leigh Creek (p = 0.090). Nitrogen levels in Packsaddle Creek were significantly lower than the other five creeks (p = 0.010).

The high nitrogen levels are likely the result of land use practices, the dominant land use being irrigated and dry cropland. Irrigation diversions are primarily responsible for the intermittent nature of the streams in the Upper subbasin. The five streams on the east side of Teton Valley are perennial at their headwaters , intermittent in their mid-sections and reemerge as perennial streams due to groundwater inputs in the lower reaches. Nitrates move readily in groundwater and the recurring high nitrogen concentrations at the monitoring sites may have been due to surface inputs as well as groundwater inputs at the lower reaches of the streams. The introduction of nitrates into the groundwater is likely the product of agricultural practices as well as domestic and municipal waste systems in the valley. Reduction of nitrogen in the system should be a water quality priority in the Upper Teton subbasin and could be accomplished by implementation of BMPs that target nutrient sources.

Table 5. Mean, minimum and maximum nitrate + nitrite concentrations and 95% confidence intervals.

Stream	Mean (mg/L)	Min (mg/L)	Max (mg/L)	+/- 95% CI
Badger	0.36	0.03	1.07	0.17
Darby	0.78	0.80	1.15	0.12
Fox	1.60	0.03	1.86	0.05
Packsaddle	0.07	0.03	0.79	0.08
S. Leigh	0.59	0.03	1.09	0.19
Spring	1.02	1.23	2.38	0.12

Temperature

Stream temperatures at the six sites exhibited a seasonal pattern. As expected, temperatures were highest during summer months and declined during fall and winter (Figure 6). No temperature measurements exceeded the target for cold water aquatic life (CWAL, = 22°C) during the project. There were exceedances of the temperature target during salmonid spawning periods (SS, = 13°C). Stream temperatures in Fox Creek exceeded the SS target 20% of the time, in Packsaddle Creek measurements exceeded the target 16% of the time and in Spring Creek 4% of the measurements were above the target. The 13°C target for SS was not exceeded in Badger, S. Leigh or Darby Creeks during the three years.

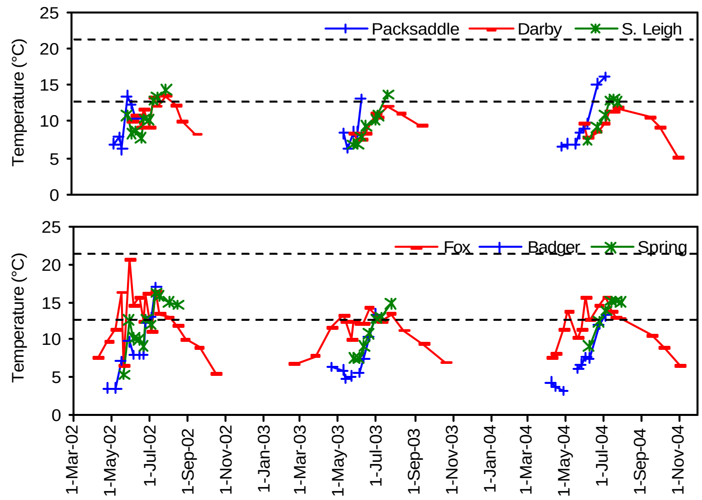

Figure 6. Stream temperature measured at the six sites in the Upper Teton subbasin from March 2002 to November 2004. The horizontal dashed lines represent the DEQ target for cold water aquatic life (22°C) and salmonid spawning (13°C).

Table 6. Mean, minimum and maximum stream temperatures and 95% confidence intervals.

Stream	Mean (°C)	Min (°C)	Max (°C)	+/- 95% CI
Salmonid Spawning				
Badger	8.8	4.8	13.6	1.3
Darby	9.0	5.2	11.6	0.8
Fox	12.4	5.7	20.7	1.4
Packsaddle	10.1	6.1	16.1	1.5
S. Leigh	9.0	6.7	10.9	0.8
Spring	10.4	5.4	14.0	1.2
Cold water aquatic life				
Badger	14.6	13.2	17.1	2.5
Darby	11.0	8.2	13.5	0.7
Fox	11.8	5.7	16.5	1.2
Packsaddle	16.1	16.1	16.1	
S. Leigh	12.6	10.3	14.4	0.9
Spring	14.8	12.0	16.4	0.7

Average stream temperatures at the six sites were below the CWAL and SS targets, although differences between sites were observed (Table 6). During the critical period for CWAL (June 22 –

September 21) there was only one temperature measurement recorded from Packsaddle Creek, therefore Packsaddle Creek could not be statistically compared to the other five sites. Among the five sites, temperatures were significantly higher in Spring Creek than in S. Leigh, Darby and Fox creeks ($p = 0.0011$), but not different from Badger Creek. Stream temperatures in Badger and S. Leigh creeks were higher than temperatures in Darby Creek ($p = 0.012$), but not Fox Creek. During SS periods (May 1 – June 30, September 15 – November 15), temperatures in Fox Creek were significantly higher than in the other five streams ($p = 0.038$). No significant differences in stream temperature were detected among the other five sites during SS periods.

E. coli

Concentrations of *E. coli* were measured at the six sites from October 2003 to November 2004. IASCD began monitoring *E. coli* levels because elevated concentrations of *E. coli* were discovered in other areas of the Upper Teton subbasin (DEQ 2003b). In this study *E. coli* levels appeared to increase during summer months, although conclusive evidence of a seasonal pattern would require further sampling. None of the 62 *E. coli* samples collected during this project exceeded EPA's standard (not to exceed 576 colonies/100 mL) for secondary contact recreation (Figure 7).

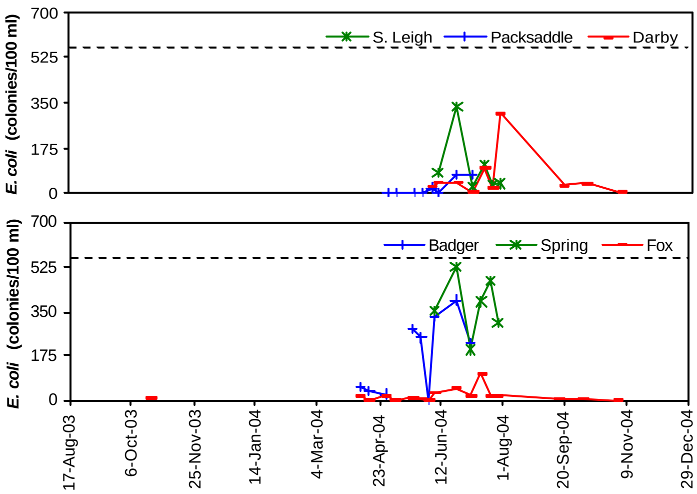

Figure 7. *E. coli* levels (colonies/100 mL) measured at the six sites in the Upper Teton subbasin from October 2003 to November 2004. The horizontal dashed lines represent the EPA standard of 576 colonies/100 mL.

Although average *E. coli* concentrations were well below the EPA standard at the six sites, differences between sites were observed (Table 7). *E. coli* concentrations were significantly higher in Spring Creek than the other five creeks ($p = 0.018$). Badger Creek experienced the next highest *E. coli* levels and concentrations in Badger were higher than in Fox ($p = 0.0002$) and Packsaddle ($p = 0.012$) creeks. *E. coli* levels in S. Leigh Creek were significantly greater than in Fox Creek ($p = 0.009$) and levels in Fox, Darby and Packsaddle creeks were not significantly different from each other.

The presence of *E. coli* in surface water indicates fecal contamination from human or animal sources. Efforts to reduce human caused contamination (from rangeland, domestic septic systems) should be made.

Table 7. Mean, minimum and maximum *E. coli* concentrations and 95% confidence intervals.

Stream	Mean (#/100mL)	Min (#/100mL)	Max (#/100mL)	+/- 95% CI
Badger	176.9	1.0	395.0	97.7
Darby	62.2	4.0	310.0	56.3
Fox	18.3	1.0	108.0	12.4
Packsaddle	22.4	1.0	72.0	21.6
S. Leigh	102.5	28.0	334.0	94.2
Spring	374.2	198.0	524.0	93.5

Conclusions and Recommendations

The results of this monitoring project indicate that water quality targets are being met for TSS, TP and *E. coli* in Badger, Spring, S. Leigh, Packsaddle, Darby and Fox creeks. Nitrogen was the only pollutant measured that consistently exceeded DEQ's targets.

The seasonal elevation of total suspended solids is common in snowmelt dependent systems. Despite the seasonal fluctuations, TSS levels at all six sites were well below the DEQ targets. The streams in this project were originally listed for sediment and each stream received a sediment TMDL from DEQ. According to DEQ, each of the six streams required sediment load reductions (38 - 72% reductions) to meet their TMDLs. Contrary to DEQ's findings, this monitoring project has demonstrated that TSS concentrations were below the DEQ target at all six of these streams. The lower than expected sediment concentrations measured throughout this project may be the result of conservation efforts that have occurred in the Upper Teton subbasin. Over 100,000 acres of private land in the Upper Teton subbasin have been treated thus far and work continues to occur in the subbasin to decrease sediment inputs (Erling and Pappani 2005). This project documented that TP concentrations in the six streams were well below the water quality target. TSS and TP are often highly correlated and best management practices (BMPs) that have been implemented to reduce TSS inputs into the system may have additionally worked to reduce TP loads.

Excess nitrogen is a chronic problem in streams in the Upper Teton subbasin. All sites we monitored exceeded the target for nitrate + nitrite (mg/L) at some point during the monitoring. Packsaddle Creek was the only stream that on average did not exceed the DEQ target.

Irrigated and dry cropland are the dominant land uses in the Upper subbasin and are a likely contributor of nitrate to the system. Surface runoff from cropland may be contributing high levels of nitrate to surface water. Also, the streams on the east side of the valley are highly influenced by groundwater and leaching of nitrate from cropland to the groundwater supply may be a pathway for nutrient addition to the streams. In addition to agricultural sources of nitrogen, domestic and municipal waste systems may be contributing to increased nitrogen concentrations.

The results of this monitoring project should be used to prioritize conservation efforts in the subbasin. Any attempts to decrease nitrogen inputs into the Upper Teton subbasin should benefit the system. Efforts to decrease nitrogen inputs into the system should be made by conducting nutrient management planning, irrigation water management planning and constructing wetlands for minimizing the impact of irrigation returns to the creeks. Additionally, prioritization may occur at the subwatershed level. Spring Creek often experienced significantly higher pollutant loads than the other streams and conservation efforts on Spring Creek may result in the greatest net benefit to the Teton River system.

Acknowledgements

Many thanks to Christine Waite who collected much of the data presented in this report during her time with IASCD. I appreciate the assistance given by Kirk Campbell in drafting this document and for the comments of Gary Bahr and Jenifer Clawson. Thanks to the Teton Soil and Water Conservation District for providing insight and information regarding the Upper Teton subbasin.

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