Little Susitna Water Quality Monitoring Report

(March 2005 – April 2006)

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by

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Abstract

Water quality and physical habitat were evaluated within the Little Susitna River and its major tributaries upstream from the U.S. Geological Survey (USGS) gauging station. The investigation was conducted to provide background information prior to proposed development and to evaluate reports of acidic conditions. Weekly water samples were collected from 8 locations from May through June, monthly from June through October of 2005 and in January, February, and March of 2006. Samples were analyzed for pH, turbidity, and specific conductance. Water samples from 3 of the mainstem sites representing the upper end, middle and bottom of the sampling reach also were analyzed for total fecal coliform bacteria, total and total dissolved phosphorus, nitrate plus nitrite nitrogen, ammonia nitrogen, and alkalinity. Discharge was measured within the upper Little Susitna River, Archangel Creek, and Fishhook Creek when wadeable. Water temperature data loggers also were placed at upper, middle, and lower locations. Macroinvertebrate samples were collected in October from the upstream and downstream mainstem sites and the two major tributaries: Archangel Creek and Fishhook Creek. Measures of channel geometry and substrate size distribution were also collected from these locations.

All water chemistry parameters were within normal limits and did not exceed State Water Quality Standards. Maximum water temperatures were near 14°C in August. Maximum nitrate nitrogen levels were recorded in the spring during snowmelt and were below detection limits during base flow conditions. Alternately, ammonia nitrogen, total phosphorus and total dissolved phosphorus were greatest during base flow. Reduced water quality was indicated by changes in the macroinvertebrate community in both Archangel Creek and Fishhook Creek. The upper Little Susitna River provides 60% of the mainstem flow relative to Archangel Creek during most of the year; however, during snowmelt, Archangel Creek flow was greater. Stream flow at the Gold Mint Trailhead Parking area was generally 60 to 70% of flows recorded at the USGS gauging station located 5.3 miles downstream, with a minimum of 30% during early breakup.

Continued annual measures of the macroinvertebrate community are recommended including sampling within the mainstem below the confluence of Archangel Creek and the Little Susitna. Additional water sample analyses for metals or mercury likely to be released during mining or ore processing could be conducted as a potential cause for differences in the macroinvertebrate communities. The size distribution of fine sediment deposited along the stream margin may be an additional measure that could be useful in evaluating sediment input from construction activities. Continued sampling for total fecal coliforms and ammonia nitrogen should be continued to monitor for development associated groundwater loading. In addition, we would recommend obtaining some measures of petroleum hydrocarbons during both snowmelt and base flow conditions, which may increase with motor increased motor vehicle use and parking following resort development.

Introduction

The Little Susitna River is an Alaska Clean Water Action (ACWA) high priority protection water. It is a popular recreational salmon fishery; in 2004, 20,000 angler days were spent harvesting 45,000 coho salmon, which is the second highest harvest level in south central Alaska. The river is also used for canoeing, rafting, power boating, camping, hunting and other recreation. The headwaters supported historical mining in an area that now provides considerable tourism opportunities. The lower river flows through residential communities under continued development. The economic benefits from the Little Susitna River's uses, particularly its fishery, are clearly substantial.

The Little Susitna River's headwaters begin at the Mint Glacier in the Talkeetna Mountains in Hatcher Pass outside of Palmer and Wasilla in the Matanuska-Susitna Borough (MSB). The Hatcher Pass area is a historic gold mining district and there are still active mines within the area. Most of the gold mining on the Little Susitna side of Hatcher Pass is historic with the most recent mining occurring in the 1970's. There has been some recent interest in reactivating some of the hard rock mines located outside of the 20-acre Independence Mine State Historical Site located on upper Fishhook Creek. The area geology is mostly diorite and granite. Most of the gold in the area is associated with granite seams. There is some pyrite (which is associated with sulphides and acid mine or rock drainage) but it is not high. Most of the gold mining on the Little Susitna side of Hatcher Pass was done with tunnels. Alaska Department of Natural Resources (ADNR) Division of Mining Land and Water, does not know if any of the old tunnels are leaking or if they connect to groundwater and/or tributaries to the Little Susitna River.

The Little Susitna River is a high gradient stream in the upper watershed and several tributaries flow into it. The Hatcher Pass area is experiencing increased development for tourism in the area, including plans for a new ski area, residential community and commercial village. The window of opportunity to collect background water quality information in the Little Susitna River's upper watershed is narrow. The ski resort development has applied for water rights (864,000 gallons/day or 1.33 cfs) for the Little Susitna and some of its tributaries for making snow during the winter months. The development is currently authorized under a 6-year water use permit for withdrawal from an infiltration gallery adjacent to the river from October through March 31. The Department of Fish & Game (ADFG) has concerns with how this may impact the fisheries and the Department of Environmental Conservation (ADEC) is concerned with how lower flow may concentrate possible pollutants. The ADFG has applied for and received instream flow reservations for multiple Little Susitna reaches. Instream flow reservations vary for each reach. Reservations within the upper reach, from the USGS site to Archangel Creek range from 21 cfs during low flows to 240 cfs in July. Below the USGS site instream flow reservations vary from a low of 20 cfs during winter to 240 cfs in July.

Recently, the road into Hatcher Pass, which runs along the Little Susitna for several miles to the Gold Mint Trailhead parking area by the Motherlode Lodge, has been straightened and paved with several pullouts developed for parking, picnicking and camping. The 113 mile river then flows through suburban areas outside of Wasilla and Houston and the mouth empties into Cook Inlet. The Little Susitna River is anadromous supporting five native salmon species as well as Dolly Varden and rainbow trout. Most of the spawning and rearing takes place north of the Parks Highway. The Chinook and coho salmon spawn and rear up to the headwaters of the Little Susitna including tributaries and sloughs.

Water quality monitoring in the upper portion of the Little Susitna watershed is very sparse and consists of a few sampling points from a volunteer water quality monitoring program and a few sampling points with unknown quality assurance or quality control from a MSB contractor over the past year (2004). The sampling conducted by the MSB contractor showed pH levels in the 4.76 – 3.28 unit range during their three sampling events. This is well below the Water Quality Standard of 6.5 pH units minimum (18 AAC 70.020(6)(C)). Follow-up monitoring over various flow scenarios with documented QA/QC is critical to determine if there is a pH problem. There is an active USGS gauging station (15290000) with 56 years of record downstream of the bridge on Palmer Fishhook road as the river exits the Hatcher Pass area. The gauging station measures discharge and gauge height.

Methods

Eight sampling sites were selected along the Little Susitna River from above Archangel Creek (Site 1) to the USGS sampling station approximately one mile upstream of the Edgerton Park Road (Site 8) (Figure 1 and Table 1). Two of the eight sites were located in tributary streams, Site 2 in Archangel Creek and Site 5 in Fishhook Creek.

Table 1. Little Susitna River and tributary sampling site locations and descriptions.

	Latitude	Longitude	Description
Site 1	61.78270	-149.18808	Little Susitna just upstream from the Archangel Creek confluence.
Site 2	61.78251	-149.18964	Archangel Creek just upstream from the Little Susitna confluence.
Site 3	61.77837	-149.19522	Little Susitna at the Gold Mint Trailhead parking lot. Hatcher Pass Road Mile 13.7
Site 4	61.75800	-149.22847	Little Susitna just upstream from Fishhook Creek. Hatcher Pass Road Mile 12.0.
Site 5	61.75800	-149.22847	Fishhook Creek upstream of culvert. Mile 11.9.
Site 6	61.78924	-149.23184	Little Susitna at pullout below Fishhook Creek. Hatcher Pass Road Mile 11.3.
Site 7	61.74149	-149.23302	Downstream from picnic area and across from ski road. Hatcher Pass Road Mile 10.9
Site 8	61.70357	-149.23618	Downstream from Fishhook Road Bridge at USGS gauging station. Hatcher Pass Road Mile 8.4

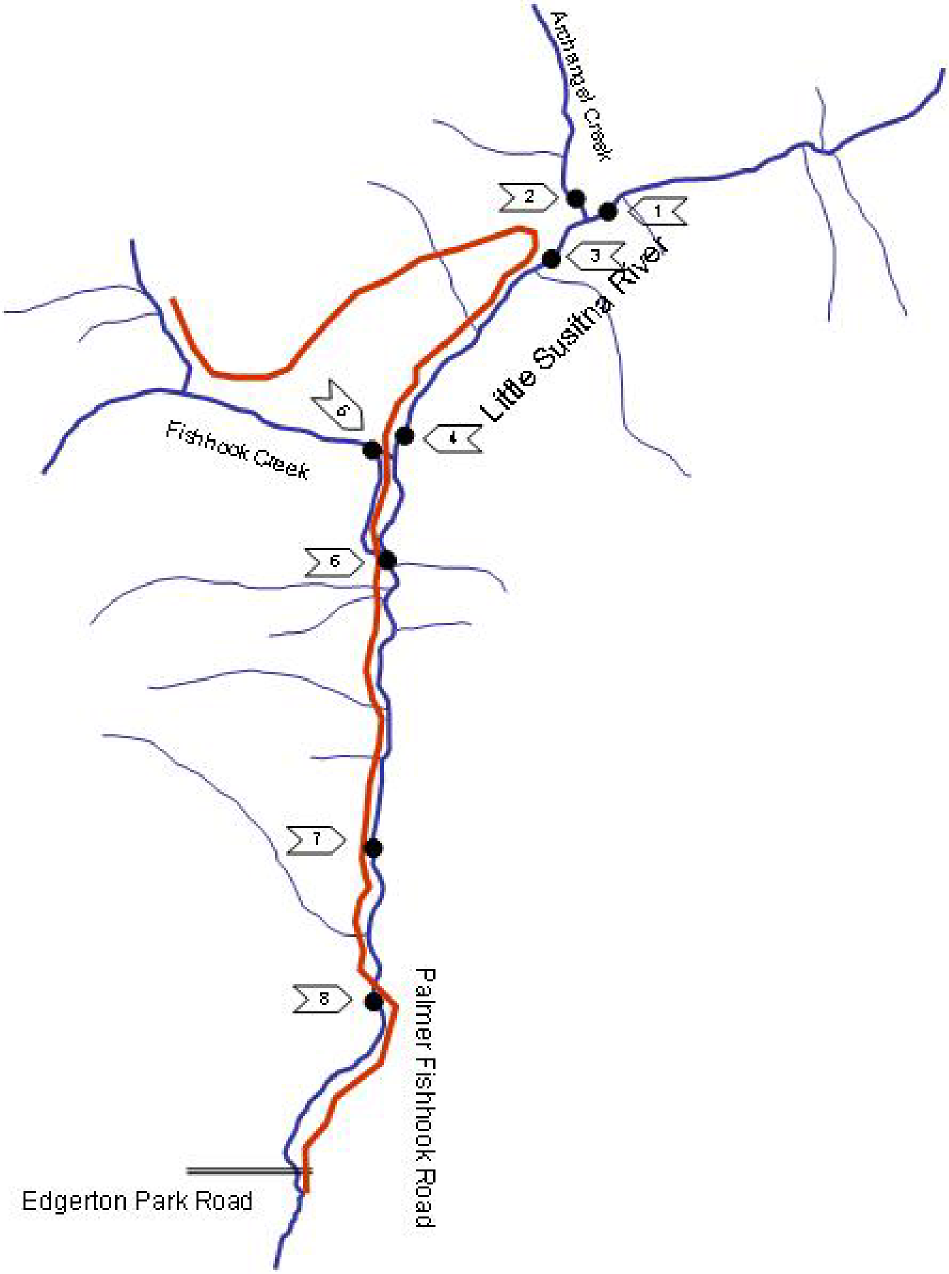


Figure 1. upper Little Susitna River water sampling sites.

Water samples were collected weekly from all eight sites from April 27 through May 16, monthly June through October of 2005, and January, February, and March of 2006. Water samples from the mainstem sites 1, 7, and 8 were submitted to analytical laboratories for total fecal coliform and chemical analyses. Laboratory chemical analyses included alkalinity, total phosphorus, total dissolved phosphorus, nitrate plus nitrite nitrogen and ammonia nitrogen. Water samples from all sites were analyzed for pH, specific conductance, and turbidity. Dissolved oxygen and temperature were measured in the field at all sampling locations.

Stowaway data loggers were placed at sites, 3, 7, and 8 on April 22, 2005 to obtain continuous (at 1 or 2 hour intervals) water temperature data. The temperature logger at Site 3 was lost after downloading on May 15, 2005. The replacement logger was placed at Site 1 on June 16, 2005. The data loggers were removed from the stream on October 20, 2005.

Discharge was measured when the stream was wadeable and ice absent at sites 1, 2, and 5. Discharge was calculated for Site 3 and for Site 1 (during high flows) using Site 2 discharge and differences in specific conductance using the following equation:

$$Q_3C_3 = Q_2C_2 + Q_1C_1$$

Where *Q* is discharge and *C* is specific conductance and the subscripts denote the sampling site. Site 8 discharge was downloaded from the USGS web site (http://nwis.waterdata.usgs.gov/ak/nwis/dv/?site_no=15290000&agency_cd=USGS). Weather data for the 24 hour preceding sampling dates was downloaded from the National Climate Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html) for the Palmer Airport.

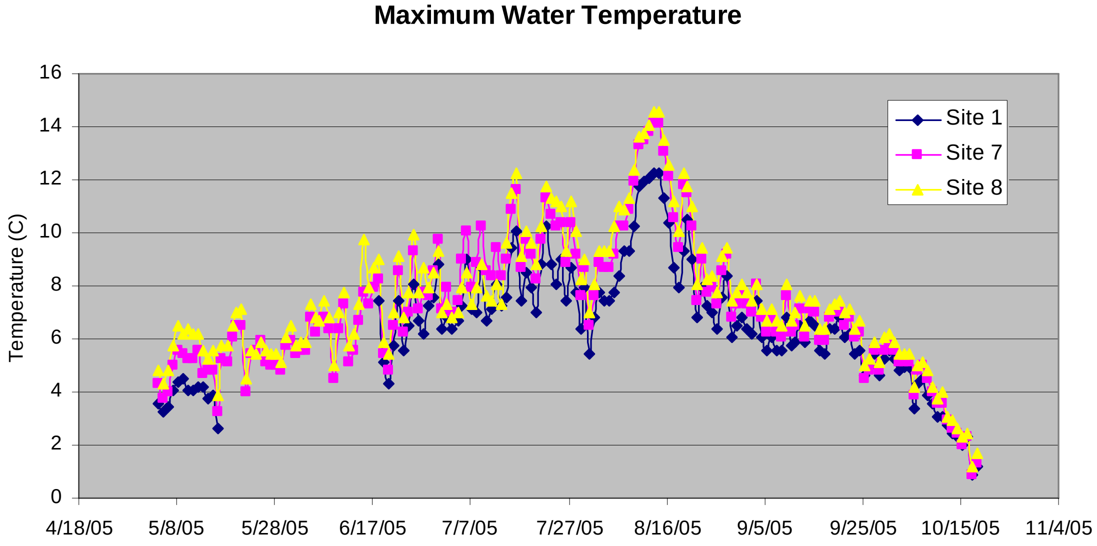
Macroinvertebrates were collected from Sites 1, 2, 5, and 8 on October 3 and 4, 2005. Measurements of channel characteristics, substratum size distribution, and woody debris were concomitant with invertebrate samples. Site 8 macroinvertebrate and channel measurements were taken approximately 1.5 km downstream from the U.S.G.S. gauging station, just upstream from where a power transmission line crosses the channel.

More detailed description of sampling methods and quality control procedures are contained within the attached Quality Assurance Project Plan (Appendix A).

Results

Temperature

Stream water temperatures within the Little Susitna River were below 15 °C at all sites, increasing gradually from the end of April through mid August. Water temperatures were highest at Sites 7 and 8 and Lowest in the Upper River at Site 1. The largest difference between Site 1 and Site 8 was 3.10°C. At Site 1 the highest water temperature was 12.23°C and the greatest daily change in water temperature was 5.56°C. At Site 8 the maximum water temperature was 14.56°C with a maximum daily change of 5.88°C.



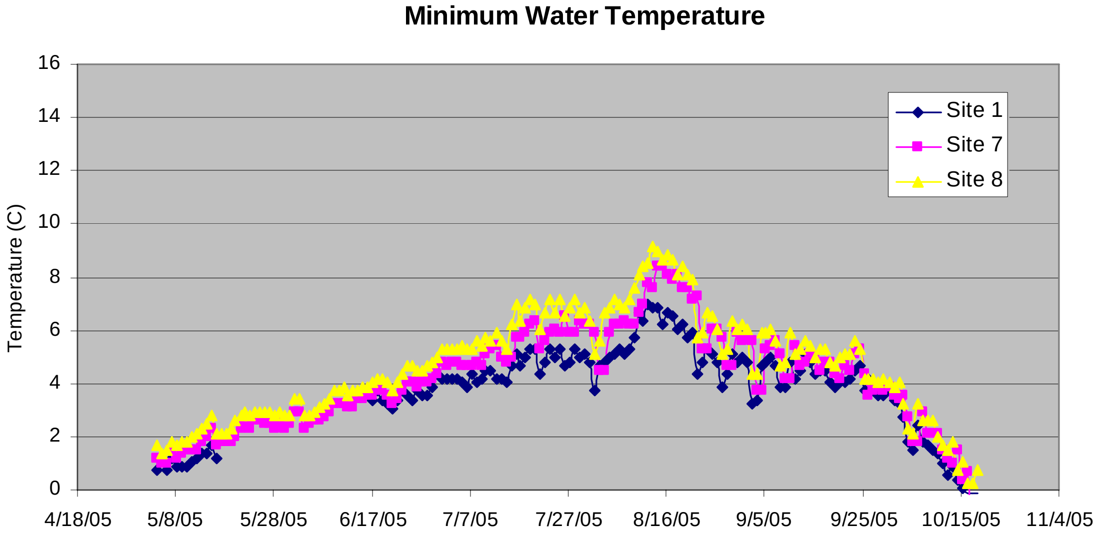


Figure 2. Maximum and minimum water temperature for three Little Susitna locations.

Highest daily water temperatures were around 19:00 and lowest near 07:00. Based upon water temperature measurements associated with chemical sampling, temperatures in Fishhook Creek were generally 1 to 2 degrees warmer than the main channel. Water temperature in Archangel Creek was cooler than the Little Susitna in April and May, but approximately 1°C warmer from June through September.

Discharge

Peak flows in the Little Susitna River at the USGS gauging station occurred during spring snow melt (in mid June) and during fall precipitation events in September (Figure 3).

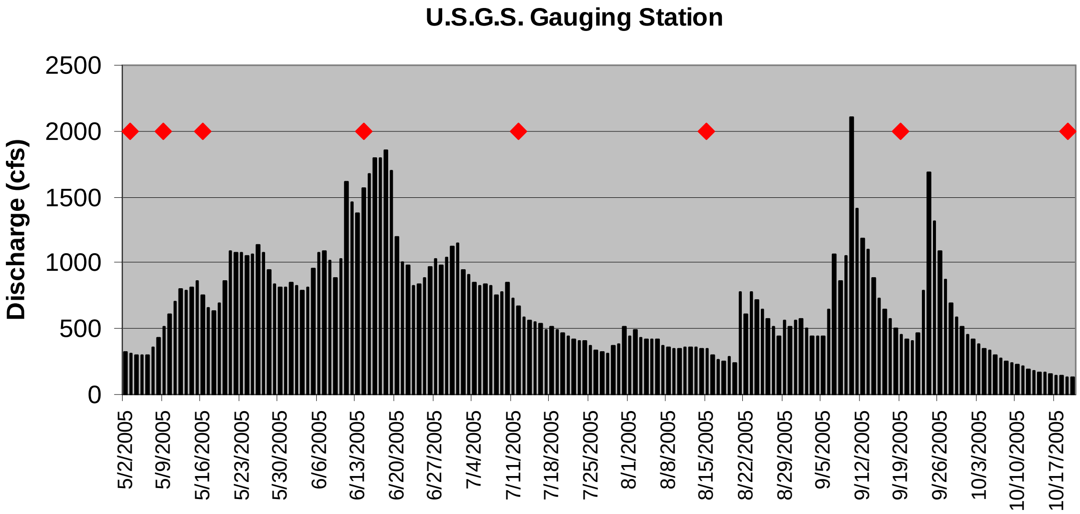


Figure 3. Little Susitna discharge measured at the gauging station by the U.S.G.S. Diamonds indicate water sampling dates.

Table 2. Discharge (cfs) for upper river and tributary streams. Percent Archangel and percent Little Susitna are the portion of flow from these two sources contributing to mainstem flow at Site 3. Site 2 is Archangel Creek and Site 5 is Fishhook Creek.

Site	**5/9**	**5/16**	**5/18**	**6/14**	**7/13**	**8/15**	**10/3**	**10/19**	**1/11**	**2/15**	**3/27**
Site 1	55		136	410	180	164	160	42			
Site 2	86		179	707	155	96.5	77	41			
Site 3	141		315	1117	335	260.5	237	83			
Site 5	54	95		192	46	28	56	25			
Site 8	448	769	621	1450	581	343	383	137			
% Arch	60.99		56.83	63.29	46.27	37.04	32.49	49.40	33.90	40.16	37.04
% L Su	39.01		43.17	36.71	53.73	62.96	67.51	50.60	66.10	59.84	62.96
Site 3 to Site 8	31.47		50.72	77.03	57.66	75.95	61.88	60.58			

Peak discharge at the Upper River and tributary sites was on June 14, 2005. Discharge in the upper river at Site 3, which was located at the Gold Mint Trailhead parking area, was compared to discharge measured at the USGS gauging station, 5.3 miles downstream. Upper river flow ranged from 31% of flow at the USGS gauging station on May 9 to 77% on June 14 (Table 2). Similar comparisons were made between the Little Susitna and Archangel Creek. During snowmelt flow was greater in Archangel Creek; however, following the June 14 sampling date, the majority of flow (approximately 60%) came from the Little Susitna River.

Water Chemistry

Tables of water chemistry analytical results and precision calculations are provided in Appendix B. Precision objectives for some analyses (20%) were not met on all sampling dates. Laboratory ammonia standards and replicates were within 10 to 20%, while the precision for ammonia-N field replicates ranged from 16 to 150% for dates when concentrations were above detection limits. The most likely source of error is from atmospheric nitrogen dissolving into acidified samples (Kathy Fugial, AM Test, Inc.). Sample containers should be filled to the top to minimize this source of error. Ammonia-N values are still reported within this study. Where duplicate measures were obtained the lowest value is reported.

The precision calculations for field replicates of nitrate-N did not meet project objectives on two sampling dates. The largest precision value was 114% representing a difference between replicates of 0.08 mg/L. For nitrate-N the primary cause of error is due to the presence of organic acids, which bind with cadmium, resulting in incomplete nitrate reduction and low concentration determinations. Therefore, for nitrate, the higher of the two values is reported when replicate samples differ.

Total phosphorus precision marginally exceeded project objective on two occasions with the maximum precision calculation of 26%. The difference between replicate field samples was 0.003 mg/L. Total dissolved phosphorus did not meet precision objectives on one sampling date where values were 114%. This represented a difference between field replicates of 0.010 mg/L. AM Test, Inc. believes that the primary cause of error are small contaminants incorporated during filter construction. For total dissolved phosphorus, the lower value was reported on this sampling date.

Turbidity of the Little Susitna and tributaries was low with the exception of a very small increase of short duration during breakup and slight increases during summer due to glacial input. There was a small increase in turbidity below Site 3 on April 28, 2005, which would have been missed on the weekly sampling frequency. On this date, the water had a brown appearance and turbidities increased from below 1.0 on April 26 to 2.2 to 11.5 on April 28 with the maximum value at Site 6. Turbidity remained above 1.0 at Sites 7 and 8 on May 3, but was again below 1.0 by May 9. In June, however, the water color appeared grey and had a glacial appearance. Turbidity increased at all mainstem sites in June, July and August, with a maximum value of 9.8 at Site 1 in August. By September, the water no longer had a glacial appearance and turbidities were near or below 1.0 NTU.

Stream pH remained within a fairly constant range between a minimum of 7.04 and a maximum of 7.73 (Figure 4 and Appendix B). Stream water pH was lowest during snow melt and during increasing discharge following September storms. There was also a drop in pH in January. There were no consistent differences in pH among mainstem sites or between the mainstem and its tributaries. The alkalinity measured at mainstem sites was very low indicating limited buffering capacity (Figure 5). Alkalinity varied seasonally, decreasing during the growing season but did not appear to vary with discharge.

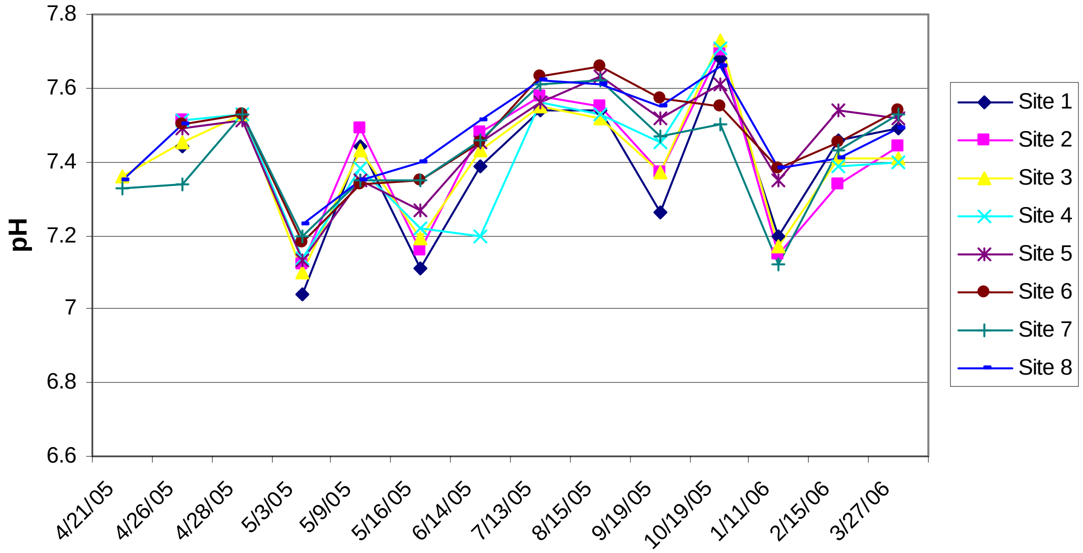


Figure 4. Stream water pH for the Little Susitna and tributary sampling stations in 2005 and winter of 2006.

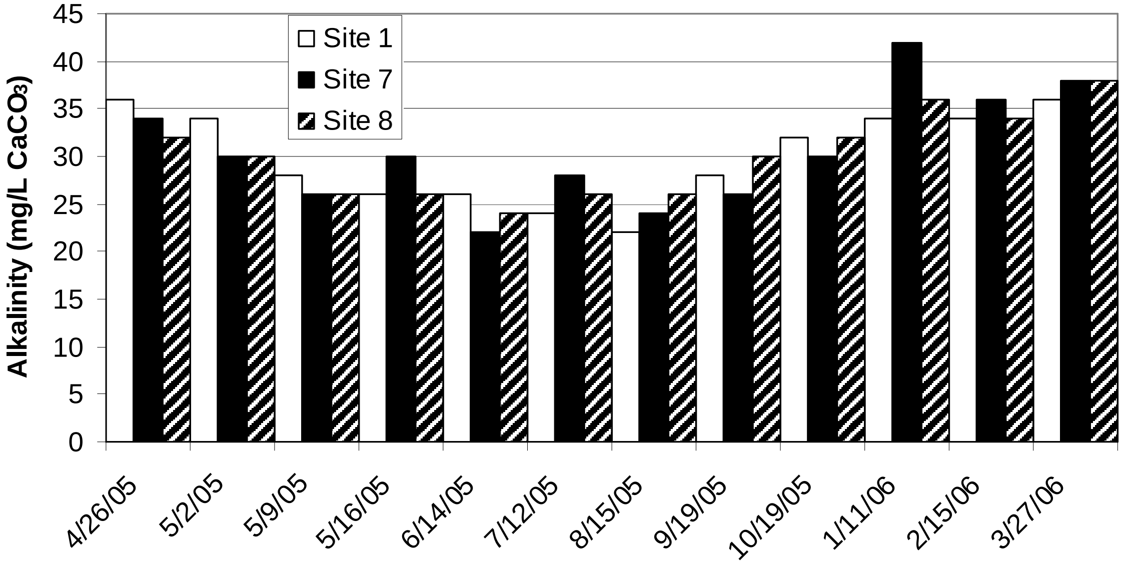


Figure 5. Alkalinity of Little Susitna River mainstem sites showing seasonal decrease.

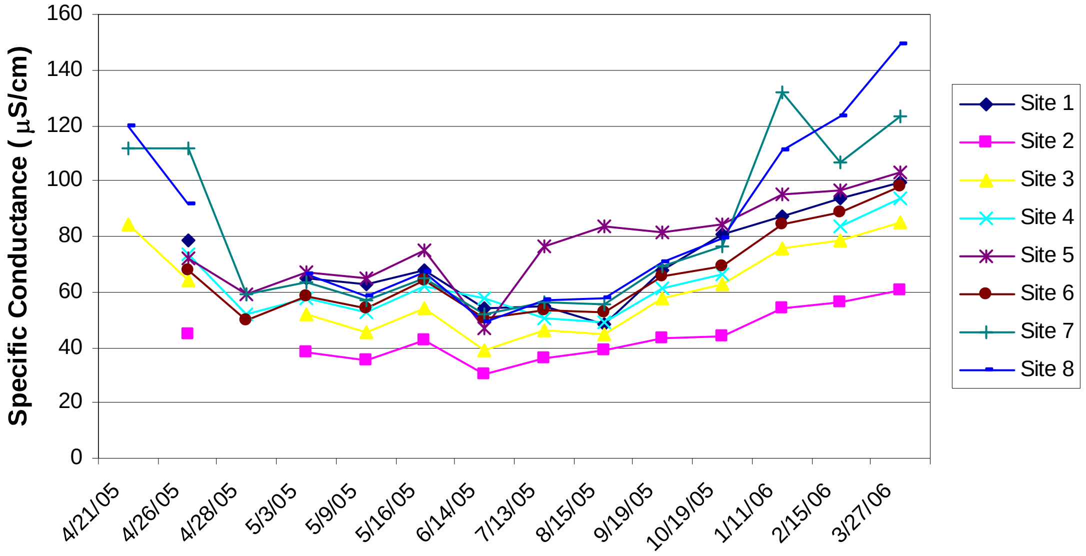


Figure 6. Specific conductance for the 8 sampling station on the Little Susitna River and major tributaries. Site 2 is Archangel Creek and Site 5 is Fishhook Creek. Site 1 is the located at the upstream end of the reach and Site 8 at the downstream end.

Specific conductance showed distinct seasonal patterns and differences within the tributaries. Specific conductance was consistently lower within Archangel Creek compared to mainstem sites (Figure 6). All sites showed an overall decline during the open water season with the lowest values during peak flows in June, after which values continued to increase slowly and did not show any drop during storm events in September. However, September sampling occurred during the declining limb of the hydrograph and may have missed any abrupt changes. Fishhook Creek (Site 5) specific conductivity was similar to mainstem sites but with a larger decrease at peak June flows.

Ammonia nitrogen varied seasonally but did not vary consistently among sites. Ammonia nitrogen appeared to increase during the growing season (Figure 7). Highest values during the summer were in July at 0.19 mg/L. Some spikes in ammonia nitrogen also occurred on May 2 during snowmelt. There was also a large spike of ammonia nitrogen at Sites 1 and 7 in January.

Nitrate nitrogen tended to respond opposite to ammonia. Nitrate nitrogen decreased as runoff increased and the growing season progressed. Nitrate nitrogen appeared to be responding to increased seasonal primary production rather than discharge as concentrations declined from May to June during increasing flows. Nitrate concentrations appeared to be increasing again in October with the senescence of plants; however, nitrate concentrations dropped below detection limits in January when ammonia concentrations were increasing.

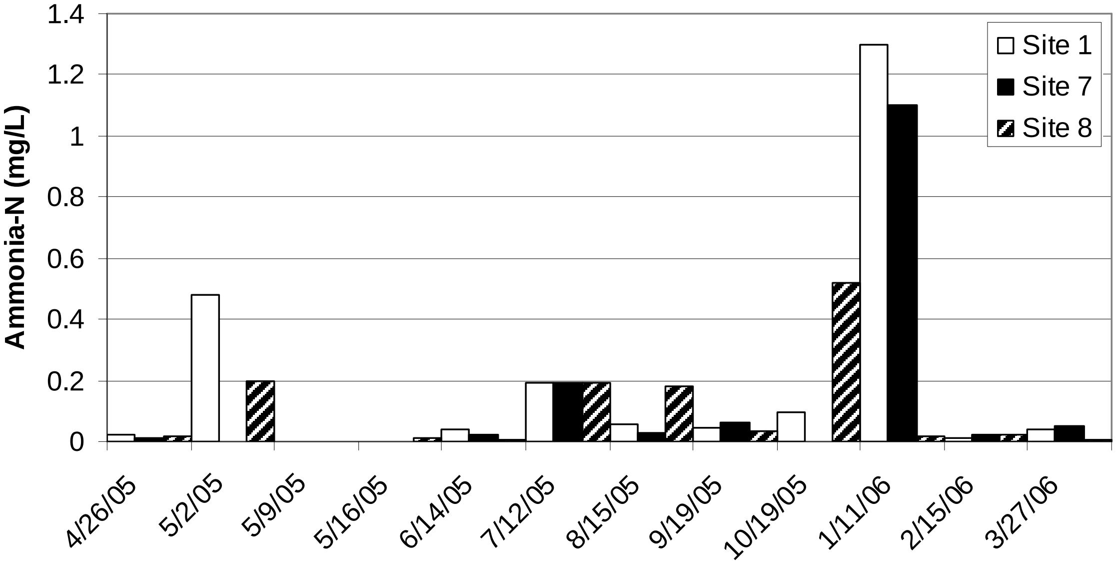


Figure 7. Ammonia nitrogen concentrations for 3 mainstem sites showing an increase during the growing season and in January.

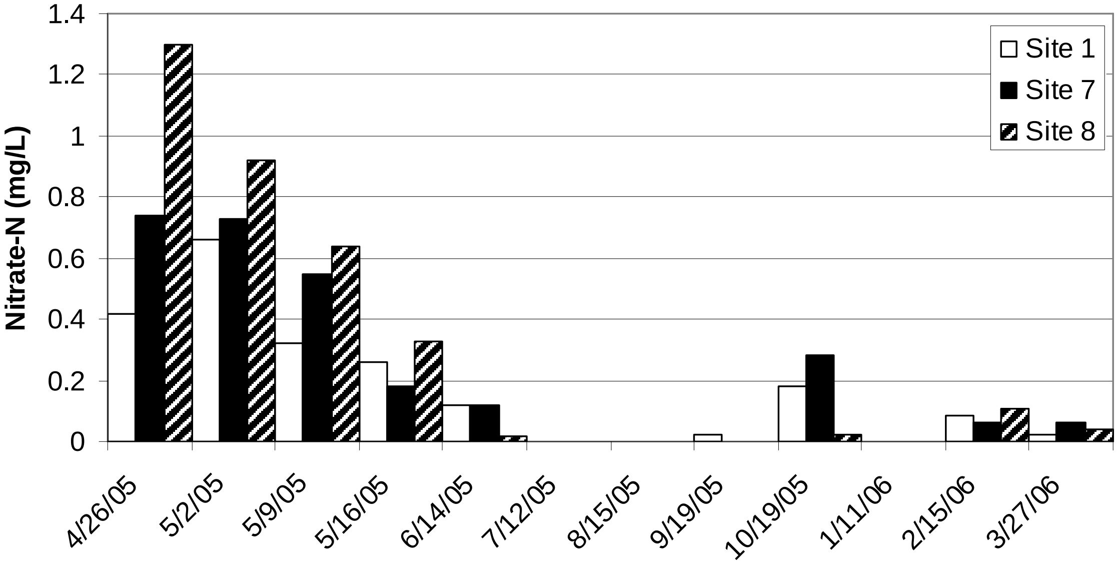


Figure 8. Nitrate nitrogen concentrations for the 3 mainstem sites showing a decrease during snowmelt and through the growing season.

Stream water concentrations of total phosphorus and total dissolved phosphorus followed a similar pattern as ammonia nitrogen. Phosphorus concentrations were generally near or below detection limits in the spring and during snowmelt. Concentrations of total phosphorus increased during peak flows in June and remained relatively constant through September (Figure 9). Total dissolved phosphorus did not increase until July through

September (Figure 10). Organically bound and particulate phosphorus dominated concentrations in June but was absent following spring runoff as dissolved phosphorus concentrations equaled total values. Phosphorus concentrations increased again in January concomitant with increases in ammonia nitrogen and decreases in pH. Total and dissolved phosphorus concentrations during January were very similar suggesting a ground water source.

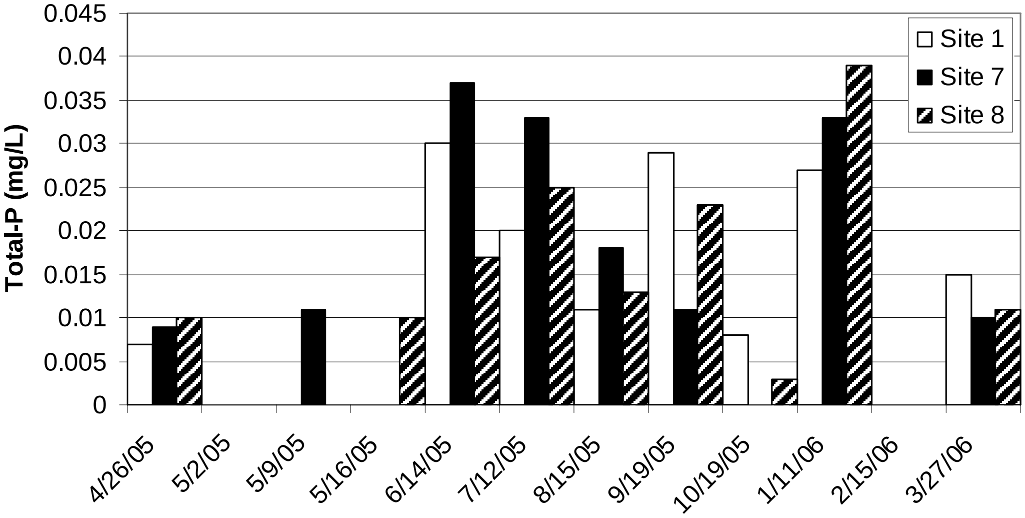


Figure 9. Total phosphorus concentrations for 3 mainstem sites showing and increase during peak flows in June, which are maintained through the growing season.

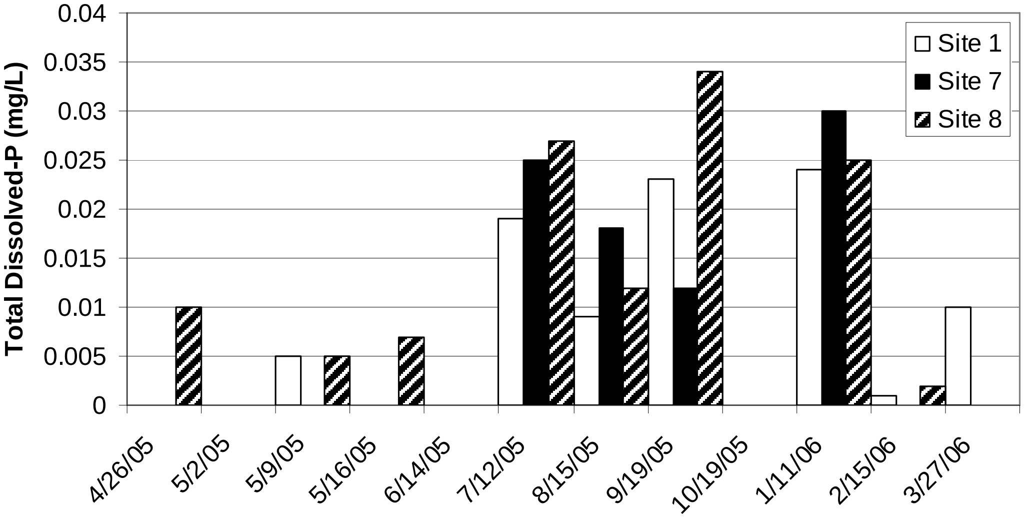


Figure 10. Total dissolved phosphorus increase during base flow conditions and in January at the 3 mainstem sites.

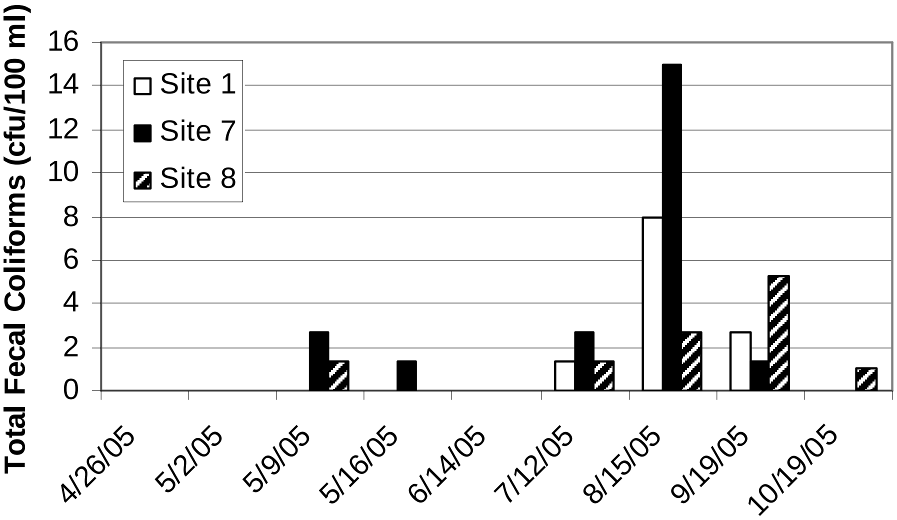


Figure 11. Total fecal coliform bacteria for the mainstem showing peaks in August.

Total fecal coliform bacteria counts were below detection limits on most sampling dates. Counts exceeded detection limits in the lower river (Sites 7 or 8) on two dates during snowmelt and at all sites during July, August and September (Figure 11). The highest recorded value was 15 colony forming units per 100 ml at Site 7 in August.

Physical and Biotic Characteristics

The riparian vegetation along the stream margins of upper Little Susitna River and Archangel Creek are low closed willow and alder scrub with patches of grasses and fireweed. There are some occasional poplar stands. There were some tall closed alder and willow scrub zones continuing downstream to Fishhook Road mile 12.5. At near mile 12.5 (just upstream from Fishhook Creek), the closed tall alder zones increase along with open poplar forests. These zones continue to where the stream becomes more confined. Open poplar forest increases continuing downstream to mile 10 where there are some mixed open poplar and spruce forests. Some birch appear at mile 9.5 just upstream from where the channel passes through a bedrock canyon. Within and below the canyon, the forest changes to a closed canopy of mixed spruce and birch forest with a riparian zone composed of closed tall alder scrub with some occasional poplars.

Large woody debris was not observed within the upper river site, or within the sampling reaches of the upper river tributaries. Large woody debris was present within the channel at Site 8 where the stream enters the birch and spruce forest. However, only 7 individual pieces and 1 debris dam were counted for an overall Large Woody Debris Index score of 138 for a 100-m reach.

The stream channel at all sites appeared stable and the substrate at all sites was dominated by large cobble or boulders (Figure 12). The substrate size in both tributaries, Archangel Creek and Fishhook Creek was similar with a D50 of 180 mm. The D50 within the upper Little Susitna River was slightly smaller at 128 mm. The percent fines (<2 mm) was low at all sites, with values of 4% for Fishhook Creek, 7% for the Upper Little Susitna, and 10% for Archangel Creek. Similarly, the embeddedness was lowest at Fishhook Creek with only 19% of the particles embedded greater than 20%. In comparison, 50% of the particles in Archangel Creek and 47% of the particles in the upper Little Susitna River were embedded greater than 20% (Figure 13). Measures of substrate size distribution and percent embeddedness below Site 8 were not possible due to channel size and the water depth made it impossible to lift stones or measure them accurately on the bottom. Estimates were made by wading along the stream margin. The substratum at Site 8, however, remained dominated by large cobble and boulder, with fines similar to the upper Little Susitna River (Site 1). It was estimated that there were approximately 5% fines, 10 to 20% 64 to 90 mm, and the remaining 75 to 85% boulders.

At the upper Little Susitna River Site 1, the stream channel was wide with intermittent small islands. Channel width was much greater than the adjacent Archangel Creek; however, cross-sectional area and average water depth were lower (Table 3). Stream channel slope was slightly higher at the upstream compared to lower Little Susitna Sites. The channel slope of the Little Susitna River between Site 1 and Site 8 appeared to be similar at approximately 2%, with the exception of the confined section from road Mile 9.5 to the U.S.G.S. site at road Mile 8.4 where slope increased. The stream channel of Fishhook Creek was considerably steeper at 7%. Fishhook Creek was the only location with any appreciable bank undercut. Bank undercut, however, was not due to bed movement but rather by vegetation encroaching over the spaces between large boulders.

ASCI rankings are broken into 5 categories: very poor, poor, fine, good, and excellent. Rankings are based upon the average of multiple metric scores which vary for low and high gradient, coarse substrate streams. Site 5 was evaluated as a high gradient site, whereas the remaining sites were considered low gradient, even though slopes were at, or just above 2%. Water quality based upon the macroinvertebrate community was ranked “Excellent” within the upper Little Susitna River at Site 1 but only “Good” for the adjacent Archangel Creek Site 2 (Table 4). Archangel Creek has a lower number of Ephemeroptera taxa, a very low percentage of Plecoptera, and only half of the families expected to be represented. Water quality at the lower river, Site 8, was also ranked “Good”. The average metric score at Site 8 was greater than that at Archangel Creek. Among the individual metrics, only the percent scrapers were lower at Site 8 compared to Site 2. Water quality within Fishhook Creek was ranked “Fair”, with low scores for most metrics; however, particularly low representation of the Diptera order when compared with most high gradient sites within south central Alaska (see Major et al. 2001).

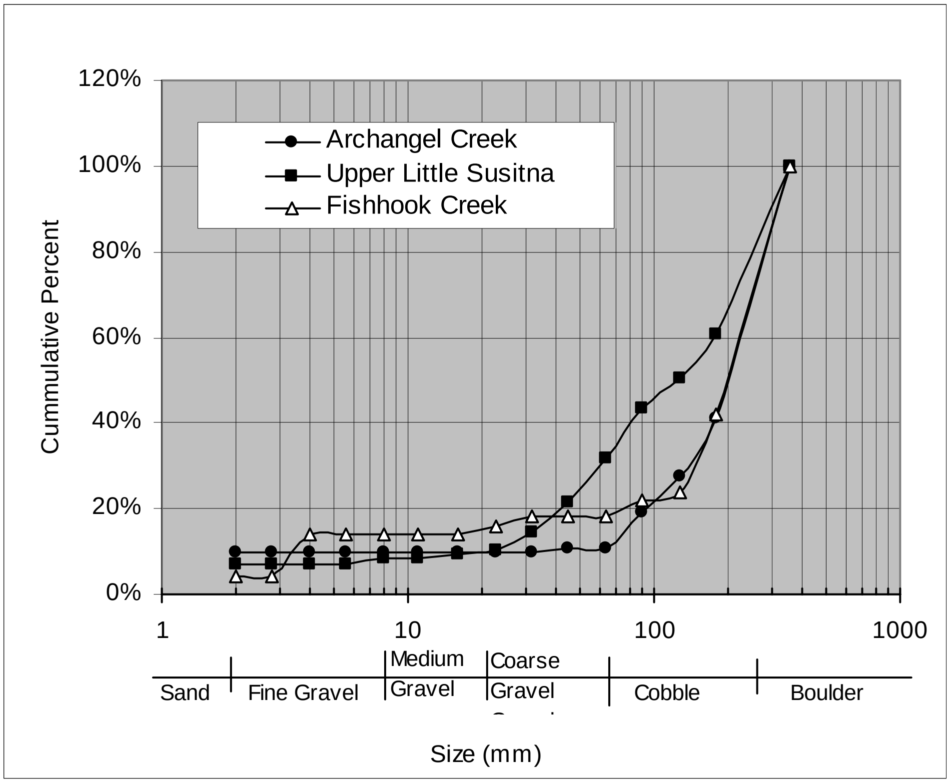


Figure 12. Sediment size distribution for the upper Little Susitna River and two major tributary streams.

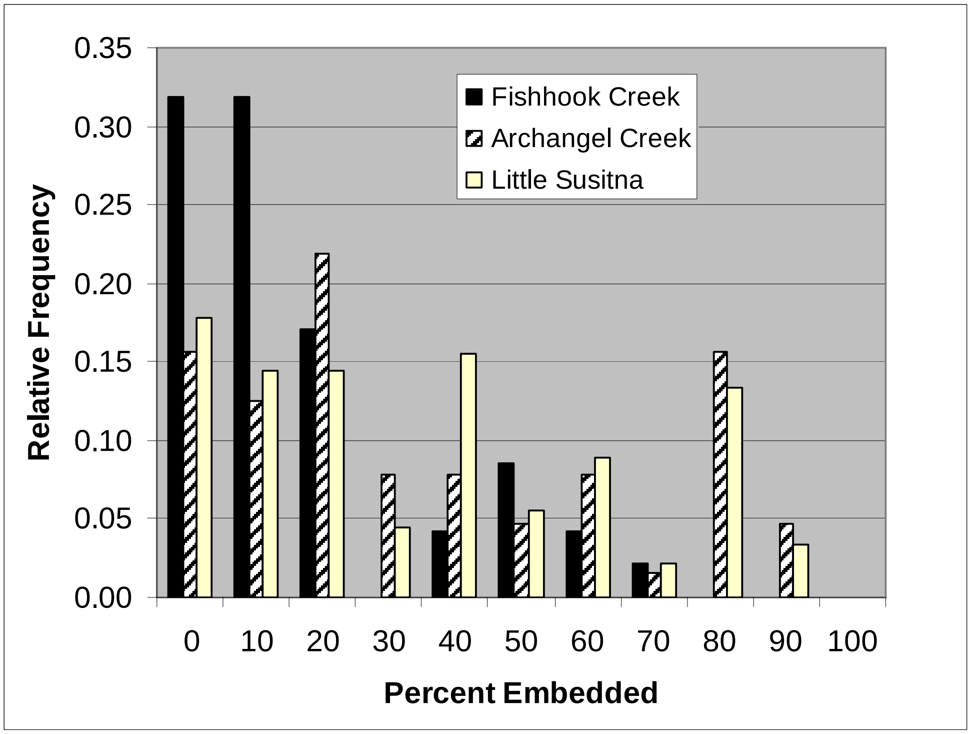


Figure 13. Frequency of which larger sediment particles are embedded within fine material.

Table 3. Channel physical characteristics at the upstream, Site 1 and downstream, Site 8, Little Susitna and major tributaries (Archangel Creek, Site 2, and Fishhook Creek, Site 5.

	Site 1	Site 2	Site 5	Site 8
Width (m)	25.75	14.98	7.25	43.20
Area (m2)	7.90	9.35	2.92	
Depth (m)	0.31	0.64	0.42	1.50
w/d ratio	85.74	24.63	18.60	28.80
Lt Bank ht. (m)	1.08	0.85	1.00	2.00
Rt Bank ht (m)	0.93	0.61	1.04	1.00
Lt upper bank slope (degrees)	45.00	12.53	21.32	71.57
Rt upper bank slope (degrees)	88.57	35.42	16.80	90.00
Left Undercut(m)	0.00	0.00	0.22	0.00
Rt Undercut(m)	0.15	0.09	0.22	0.00
Channel Slope	0.027	0.015	0.069	0.012

Table 4. ASCI metrics and score based upon macroinvertebrate community composition at upper and lower mainstem sites and within the two tributaries.

Low Gradient and Coarse Substrate Less than 2% Slope	**Site 1**	**Site 2**	**Site 8**	**Site 5**
Ephemeroptera taxa 100 * X / 5.5	57.14	42.86	57.14	
% Ephemeroptera (no Baetidae) 100 * X / 20	100.00	45.63	69.51	
% Plecoptera 100 * X / 14	72.39	8.15	41.64	
Baetidae / Ephemeroptera 100 * (100 - X) / 100	45.64	19.67	22.30	
% non-insects 100 * (30 - X) / 30	95.50	96.20	97.01	
O/E (family 75%) 2 100 * X	90.00	50.00	80.00	
% scrapers 100 * X / 15	85.59	50.70	29.90	
HBI 100 * (6.5 - X) / 2	100.00	100.00	100.00	
Average	80.78	51.65	62.19	
Ranking	**Excellent**	**Good**	**Good**	
High Gradient and Coarse Substrate Greater than 2% Slope				
EP taxa 100 * (12 - X) / 9				88.89
Trichoptera taxa 100 * X / 5				60.00
% Baetidae and Zapada 100 * (70 - X) / 70				44.70
% Diptera 100 * X / 90				26.88
O/E (family 75%) 3 100 * X				75.00
% collectors 100 * (100 - X) / 75				63.80
Average				59.88
Ranking				**Fair**

Discussion

In 2005, breakup began near the end of April. The lower river, near the USGS site was open by the first week of May; however, the upper river and Archangel Creek were not ice-free until May 15. Peak flows were during spring snowmelt in mid June and following September rain storms. Based upon stream flow, Archangel Creek is the dominant channel during snowmelt; however, during the remainder of the year approximately 60% of the flow is from the Little Susitna relative to Archangel Creek. Stream flow within the upper Little Susitna River near the Gold Mint Trailhead contained 30% of the flow relative to site 8 in early spring; however, as temperatures rose and the upper river began to clear of ice, flow increased to 60% to 75% of flow as measured at the USGS gauging station. Increased turbidity supported glacial influence on Little Susitna River flows; however, the upper river hydrograph was not distinct from the major clear water tributaries.

Stream water temperatures reached their maximum in mid August with daily values exceeding 13° C for 6 days at the lower sites 7 and 8. These values exceed the State Water Quality Standard (18 AAC 70) for fish spawning and incubation. The maximum water temperatures; however, do not coincide with the timing of fish spawning or egg development. Stream water temperatures increased with air temperatures reported for the Palmer Airport; however, correlations were weak. This suggests that other factors are acting to buffer water temperatures (Poole and Berman 2001). The surrounding mountains and riparian vegetation reduce the amount of solar radiation reaching the stream surface. The difference between upstream and downstream discharge indicates ground water input further buffering water temperature changes.

Stream water hydrogen ion concentrations remained near neutral pH values. There was a slight decrease at all sites during spring snowmelt that may have been an indication of flushed organic acids, which became diluted as breakup progressed (Boyer et al. 1997). The range of pH values were within State Water Quality Standards and did not approach those that would be likely to affect aquatic life. The low alkalinity, however, would allow for rapid changes in pH with the addition of acids or bases.

Specific conductance is a surrogate for total dissolved solids and is an indication of the concentration of dissolved chemicals. Specific conductance deceased as winter base flows began to be augmented from snowmelt waters. Similarly, concentrations of nitrate nitrogen decreased through the sampling period as snowmelt increased and stream flow became dominated by groundwater along with the onset of terrestrial primary production. Differences between total and dissolved phosphorus also support an increased groundwater influence. During June snowmelt, total phosphorus greatly exceeded dissolved phosphorus. Therefore, the phosphorus pool was dominated by organic and inorganic particulate forms. However, following snowmelt total and dissolved fractions were nearly equal. Both total and dissolved phosphorus concentrations were near detection limits, which make determining trends difficult; however, it appears that concentrations of this macronutrient increased with groundwater dominance. Nitrogen and possible phosphorus concentrations likely approached or exceeded concentrations limiting to primary production during base-flow conditions. Primary production has been shown to be saturated at nitrogen concentrations of 0.10 mg/L and phosphorus at 0.003 mg/L (Grimm and Fischer 1986, Lohman et al. 1991, Mulholland et al. 1990, Bothwell 1989); however, nutrient limitation or saturation concentrations have not been determined for this, or other, sub-arctic glacial streams. Ratios of nitrogen to phosphorus during the growing season shifted from above to below 16, indicating neither consistent phosphorus nor nitrogen limitation.

There appeared to be some differences between data collected through this study and historic USGS water chemistry data. The USGS recorded pH values less than observed in this study with a minimum value of 6.2 from data collected between 1948 and 1972 (Table 5). Specific conductance appears to have decreased since previous measures, while both alkalinity and nitrate concentrations are similar.

Table 5. Comparison of descriptive statistics for selected water chemistry parameters from historic USGS data and this study.

USGS Data from Gauging Station. 1948 to 1972				**ARRI 2005**		
	Average	**Maximum**	**Minimum**	**Average**	**Maximum**	**Minimum**
Alkalinity (mg/L CaCO3)	34	84	20	30.4	42	22
pH	7.2	8.1	6.2	7.43	7.73	7.04
Specific Cond. (μS/cm)	107	220	42	70.28	149.5	30.5
Nitrate-N (mg/L)	0.27	0.9	0.05	0.36	1.3	0.01

There was a definite increase in total fecal coliform bacteria during the growing season. However, there was no indication of pollution from animal wastes based upon counts of fecal coliform bacteria.

There was no clear indication of sediment pollution of the Little Susitna River or its tributaries. Turbidity increased only slightly during snowmelt even though there were numerous runoff channels flowing within the road ditches and through culverts. We did not record any increase in turbidity following storm events in September. Likewise, the portion of fine sediment within the channel and embeddedness, was low. Based upon qualitative observations, the fine sediment was composed of larger sand sized particles rather than silts or clays. The stream channel appeared stable with no signs of bank erosion that would contribute fine sediment. For the most part the riparian vegetation remained intact except for locations where Fishhook Road approached the stream channel. As fine sediment is likely to be transported out of this reach of the Little Susitna River, the size distribution of sediment within deposits along the stream margin could provide a tool to measure changing conditions following development.

Macroinvertebrates provided the only indication of potential water quality problems which were isolated within the tributaries. The ASCI scores showed a decrease in water quality in Archangel Creek and to a greater extent, Fishhook Creek. The apparent decrease in water quality could be due to both historic and current activity within these drainages. Both of these drainages supported mining historically and currently have road access. Macroinvertebrate sampling could be conducted below the confluence of Archangel Creek and the Little Susitna River to determine whether effects are transmitted to the mainstem.

This project has provided a baseline of information against which future data can be compared. We did not record any water quality parameters that exceeded State Standards. The macroinvertebrate community composition was the only indication of potential problems. The changes in invertebrate composition may be due to historic impacts associated with mining (i.e. cadmium, lead, zinc, or mercury) or current activities (heavy metals, hydrocarbons, or sediment from road runoff). Concentrations of metals, including zinc, above background levels have been documented in Alaska urban streams and streams draining previously mined sites (Frenzel 2002), although the Little Susitna River was not among those sampled. Macroinvertebrates have been shown to respond to increases in heavy metal due to mining activity (Maret et al. 2003). Maret et al. (2003) documented decreases in total abundance, species richness, EPT richness and metal sensitive Ephemeroptera taxa. Among the metal-sensitive Ephemeroptera include the species of the *Drunella* genus. Drunella species accounted for approximately 10% of the total sample at the mainstem Sites 1 and 8 but were absent from Fishhook Creek and were only 1% of the community at Archangel Creek.

Invertebrate sampling within the tributaries should be repeated in order to confirm the findings of this study. If invertebrate sampling is used in future water quality assessments, mainstem samples below suspected effected areas should be compared with upstream reference sites. An upstream mainstem sample below the confluence with Archangel Creek will be necessary to determine whether factors influencing the invertebrate community of Archangel Creek are transmitted to the Little Susitna River and the appropriate reference site.

Likely impacts from the development of recreational facilities: ski resort and lodging, include increases in fine sediment, increases in hydrocarbon runoff from parking areas, and groundwater loading nutrients and organics. Stream water turbidity during storm events collected at the USGS gauging station should be an effective monitoring tool as we did not measure any increases in turbidity during runoff events. Other options for sediment evaluation could include the size distribution of fine material within depositional zones. Current size distribution appears to be dominated by sands but would need to be quantified. Sediment runoff from construction and development could result in a relative increase in the smaller, silt and clay, size fractions. Continued water chemical sampling for ammonia nitrogen and fecal coliform bacteria should be used to evaluate potential groundwater loading from on-site wastewater treatment facilities. Petroleum hydrocarbons were not evaluated in this study, but should be considered for future monitoring as concentrations could increase with the development and use of residential and commercial parking facilities.

Literature Cited

Bothwell, M. L. 1989. Phosphorus-limited growth dynamics of lotic periphytic diatom communities: areal biomass and cellular growth rate responses. Canadian Journal of Fisheries and Aquatic Sciences 46:1293-1301.

Boyer, E.W., G.M. Hornberger, K.E. Bencala and D.M. McKnight. 1997. Response characteristics of DOC flushing in an alpine catchment. Hydrological Processes 11:1635-1647.

Grimm, N. B. and S. G. Fisher. 1986. Nitrogen limitation in a Sonoran Desert stream. Journal of the North American Benthological Society 5:2-15.

Lind, O.T. 1985. Handbook of common methods in Limnology. Kendall/Hunt Publishing Company. Dubuque, Iowa.

Lohman, D., J. R. Jones, and C. Baysinger-Daniel. 1991. Experimental evidence for nitrogen limitation in a northern Ozark stream. Journal of the North Americn Benthological Society 10:14-23.

Major, E.B., B.K. Jessup, A. Prussian, D. Rinella. 2001. Alaska stream condition index: biological index development for Cook Inlet 1997-2000 Summary. Universityof Alaska Anchorage, Environment and Natural Resources Insititute. Anchoarge, AK. 54pp.

Maret, T.R., D.J. Cain, D.E. MacCoy, and T.M. Short. 2003. Response of benthic invertebrate assemblages to metal exposure and bioaccumulation associated with hard-rock mining in northwestern streams, USA. J.N. Am. Benthol. Soc 22(4):598-620.

Frenzel, S.A. 2002. Priority-Pollutant trace elements in stream bed sediments of the Cook Inlet Basin, Alaska, 1998-2000. U.S. Geological Survey, Water-Resources Investigations Report 02-4163.

Mulholland P.J., A.D. Steinman, and J.W. Elwood. 1990. Measurement of phosphorus uptake length in streams: comparison of radiotracer and stable PO4 releases. Canadian Journal of Fisheries and Aquatic Sciences 47:2351-2357.

Poole and Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27(6):787-802.

Appendix A—QAPP

Quality Assurance Project Plan

Little Susitna Water Quality Monitoring

April 2005

(Revision Number 1.1)

AQUATIC RESTORATION AND RESEARCH INSTITUTE
P.O. Box 923, Talkeetna, AK.
(907) 733-5432 (phone/fax)

A1. Little Susitna Water Quality Monitoring

Aquatic Restoration and Research Institute

Project Manager: ________________________________ **Date:** ______________

Quality Assurance Officer: _________________________ **Date:** ______________

Alaska Department of Environmental Conservation

Project Manager: ________________________________ **Date:** ______________

Quality Assurance Officer: _________________________ **Date:** ______________

Effective Date:______________________________________

A2. Table of Contents

A3. Distribution List

Ms. Laura Eldred
Alaska Department of Environmental Conservation
555 Cordova St.
Anchorage, Alaska 99501
laura_eldred@dec.state.ak.us

Mr. Jim Gendron
ADEC Quality Assurance Officer
Juneau, AK
Ph: 907-465-5305
jim_gendron@dec.state.ak.us

A4. Project/Task Organization

The ARRI project manager listed below will be responsible for all project components including data collection, entry, analyses, and reports.

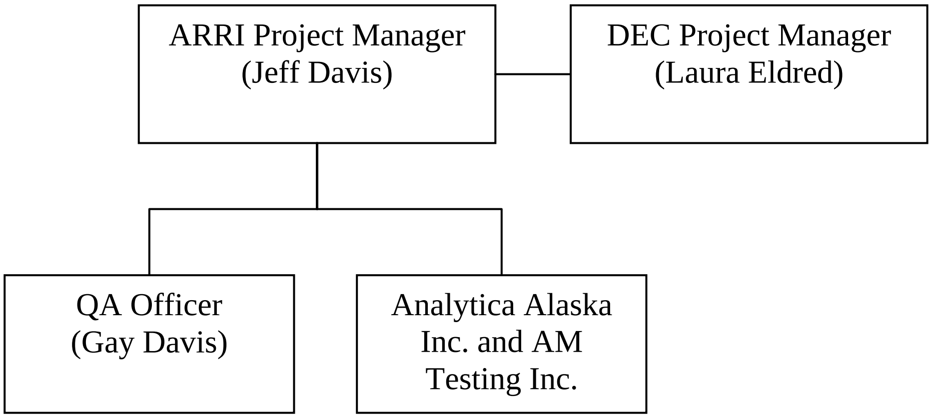
Laura Eldred (DEC). DEC Project Manager. Ms. Eldred will oversee the project for DEC, provide technical support, QAPP review and approval, review of any proposed sampling plan modifications, and the review of all reports.

Jeffrey C. Davis (ARRI): Project Manager. Mr. Davis will make sure that all field data are collected as specified in the QAPP. He will test and maintain all equipment prior to use and perform the review of data entry and analyses. He will be responsible for preparing all reports.

Gay A. Davis (ARRI) will act as Quality Assurance Officer. Ms. Davis will be responsible for making sure that all data are collected, replicate samples taken and analyzed, and all data entered and analyzed correctly.

Analytica Alaska Inc.—5761 International Way, Unit N, Anchorage, Alaska 99518. (907) 258-2155, (907) 258-6634 Fax. The testing laboratory will be responsible for analyzing all collected water samples for fecal coliforms.

AM Testing Inc.—AM Test, Inc. Laboratories,14603 NE 87th Street, Redmond, WA 98052. AM Testing will be responsible for analyzing all collected water samples for the macronutrients nitrogen and phosphorus and providing quality control and quality assurance reports relative to parameters tested.



A5. Problem Definition/Background

The Little Susitna is a high priority ACWA water for protection. It is a highly popular recreational salmon fishery; in 2004, 20,000 angler days were spent harvesting 45,000 silvers, which is the second highest harvest level in southcentral Alaska. The river is also used for canoeing, rafting, powerboating, camping, and hunting. The headwaters supported historical mining in an area that now provides substantial tourism opportunities and which is being developed as a major ski resort. Lower river stretches flow through residential areas which are also under development. The economic benefits from the Little Susitna's uses, particularly its fishery, are clearly substantial.

The Little Susitna River's headwaters begin at the Mint Glacier in the Talkeetna Mountains in Hatcher Pass outside of Palmer and Wasilla in the Matanuska-Susitna Borough. The Hatcher Pass area is a historic gold mining district and there are still active mines within the area. Most of the gold mining on the Little Susitna side of Hatcher Pass is historic with the most recent being in the 1970's. The area geology is mostly diorite and granite. Most of the gold in the area is associated with granite seams. There is some pyrite (which is associated with sulphides and acid mine or rock drainage) but it is not high. Most of the gold mining on the Little Susitna side of Hatcher Pass was done with tunnels. DNR Mining does not know if any of the old tunnels are leaking or if they connect to groundwater and/or tributaries to the Little Susitna River.

The Little Susitna River is a high gradient stream in the upper watershed and several tributaries flow into it. The Hatcher Pass area is experiencing increased development for increased tourism in the area, including plans for a new ski area, residential community and commercial village. The window of opportunity to collect background water quality information in the Little Susitna River's upper watershed is narrow. The ski resort development has applied for water rights (864,000 gallons/day) for the Little Susitna and some of its tributaries for making snow during the winter months. This is when the river is at base flow. The Department of Fish & Game (F&G) has concerns with how this may impact the fisheries and the DEC is concerned with how lower flow may concentrate possible pollutants. The F&G has applied for an instream flow reservation which is pending adjudication at this time.

Currently, the road into Hatcher Pass, which runs along the Little Susitna for several miles to the Gold Mint parking area by the Motherload Lodge, has been straightened and paved with several pullouts developed for parking, picnicking and camping. The 113 mile river then flows through suburban areas outside of Wasilla and Houston and the mouth empties into Cook Inlet. The Little Susitna River is anadromous supporting 5 native salmon species as well as Dolly Varden. Most of the spawning and rearing takes place north of the Parks Highway. The Chinook and Coho salmon spawn and rear up to the headwaters of the Little Susitna including tributaries and sloughs.

Water quality monitoring in the upper portion of the Little Susitna watershed is very sparse and consists of a few sampling points from a volunteer water quality monitoring program and a few sampling points with unknown QA/QC from a Mat-Su Borough (MSB) contractor over the past year. The sampling showed pH levels during their three sampling events in the 4.76 – 3.28 pH unit range. This is well below the Water Quality Standard of 6.5 pH units minimum (18 AAC 70.020(6)(C)). Follow-up monitoring over various flow scenarios with documented QA/QC is critical to determine if there is a pH problem. There is an active USGS gauging station (15290000) with 56 years of record downstream of the bridge on Palmer Fishhook road as the river exits the Hatcher Pass area. The gauging station measures discharge and gauge height.

A6. Project/Task Description

Objective 1: *Develop a sampling plan and QAPP to conduct water quality sampling on the upper section of the Little Susitna River. Submit to the Department for review and approval.*

Objective 2: *Conduct water quality sampling at approximately 8 sites in the upper Little Susitna River and its main tributaries in the Hatcher Pass area for various parameters. Present evaluated results to the Department with recommendations for next steps.*

The project scope of work consists of the following tasks (also see Figure 1 and Table 2):

1. **Develop Sampling Plan:** Develop water column sampling plan for the upper section of the Little Susitna River – Edgerton Parks Road upstream to above Gold Mint Trail parking area. The sampling plan will identify sample timing, frequency, location, methods, parameters and number of sample events. Requested parameters include: pH; flow, sediment/embeddedness, temperature, fecal coliform bacteria, nutrients, conductivity, dissolved oxygen, aquatic habitat and macroinvertebrates, and others suggested by the contractor and approved by ADEC. Habitat assessment should use the UAA Environment and Natural Resource Institute’s Alaska Stream Condition Index or other Department specified method. Alternative suggestions for sampling parameters are acceptable.
2. **Quality Assurance Project Plan:** Develop a Quality Assurance (QA) Project Plan which identifies QA/QC procedures, data quality objectives, equipment to be used, calibration procedures, methodologies, laboratory information, pollutants to be sampled, etc as described in the Department’s QAPP guidance documents at www.state.ak.us/dec/water/wnpspc/index.htm.
3. **Field Data Collection:** Collect water quality data according to the developed sampling plans and QAPP on approximately 8 sites in the upper Little Susitna River and its main tributaries. Include photo documentation of field sampling and GPS coordinates of sampling stations. Not all parameters will be collected during each sample event at every site (e.g. benthic invertebrates.)
4. **Weather Conditions:** Report weather conditions for the sample day and previous 24 hours, including precipitation and average temperature.
5. **Sampling Event Reports:** Following each sampling event and lab analysis, submit a brief description of the sampling event discussing any problems that occurred, recommendations for modifying the sample design, and/or any observations made while conducting the sampling that may require immediate ADEC attention. Submit preliminary lab and sampling results when available.
6. **Preliminary Results Report ending Fiscal Year 2005:** Submit a report with results of sampling and lab analysis to-date. Include any recommendations for modifying the sampling plans.
7. **Draft Final Report:** Analyze all project samples and prepare draft report of findings,

including tabular and graphical data results, conclusions and recommendations for ADEC review and comment.

8. **Final Report:** Following ADEC review, prepare final report.

A7. Quality Objectives and Criteria for Measurement of Data

The parameters in the Table 1 will be measured at the indicated performance level. All parameters are critical to meeting project objectives. Criteria for Measurements of Data are the performance criteria: accuracy, precision, comparability, representativeness and completeness of the tests. These criteria must be met to ensure that the data are verifiable and that project quality objectives are met.

Table 6. Accuracy, precision, and completeness objectives for measurement parameters.

Parameter	Method	Resolution/ Limit	Expected Range	Accuracy%	Precision	Completeness
pH	Meter	0.01	6.5 to 8.5	95 to 105 @ 7.0	5%	100%
Turbidity (NTU)	Meter	0.1	1 to 6	75 to 125	20%	100%
Conductivity (µS/cm)	Meter	0.1	100 to 200	95 to 105 @ 100µS/cm	5%	100%
DO (mg/L)	Meter	0.1	8 to 16	95 to 105 @ 10mg/L	5%	100%
Alkalinity ($CaCO_3$ mg/L)	SM 2320	0.1	50 to 150	75 to 125	10%	100%
Fecal Coliforms (cfu)	SM9222D	1	0 to 50	N/A	25%	100%
Nitrate-N (mg/L)	EPA 353.2	0.010	0.05 to 0.5	75 to 125	20%	100%
Ammonia-N (mg/L)	EPA 350.1	0.005	0.01 to 0.05	75 to 125	20%	100%
Total-P (mg/L)	EPA 365.2	0.005	0.001 to 0.005	75 to 125	20%	100%
Dissolved-P (mg/L)	EPA 365.2	0.001	0.001 to 0.005	75 to 125	20%	100%
Substratum (mm)	Counts	N/A	0.2 to 500	N/A	10%	100%
Macroinvertebrates	ASCI	N/A	N/A	N/A	20%	100%
Temperature (°C)	Stowaway	0.1	0 to 15	97 to 103 @ 15°C	5%	100%
Discharge(cfs)	Measure	1	15 to 40	N/A	10%	100%

Quality Assurance Definitions

Accuracy

Accuracy is a measure of confidence that describes how close a measurement is to its "true" value. Methods to ensure accuracy of field measurements include instrument calibration and maintenance procedures.

$$Accuracy = \frac{MeasuredValue}{TrueValue} \times 100$$

Precision

Precision is the degree of agreement among repeated measurements of the same characteristic, or parameter, and gives information about the consistency of methods. Precision is expressed in terms of the relative percent difference between two measurements (A and B).

$$\Pr ecision = \frac{(A - B)}{((A + B)/2)} \times 100$$

Representativeness

Representativeness is the extent to which measurements actually represent the true condition. Measurements that represent the environmental conditions are related to sample frequency and location relative to spatial and temporal variability of the condition one wishes to describe.

Comparability

Comparability is the degree to which data can be compared directly to similar studies. Standardized sampling and analytical methods and units of reporting with comparable sensitivity will be used to ensure comparability.

Completeness

Completeness is the comparison between the amounts of usable data collected versus the amounts of data called for.

Quality Assurance for Measurement Parameters

Accuracy

The percent accuracy for the acceptance of data is shown for each parameter in Table 2. Accuracy will be determined for those measurements where actual values are known. For pH, conductivity, turbidity, and dissolved oxygen, measurements of commercially purchased standards within the range of expected values will be used. For dissolved oxygen, 100% saturated air will be used as a standard. Measurement accuracy will be determined for each sampling event. Contract laboratories will provide the results of accuracy measures along with chemical analytical reports. Accuracy for Stowaway temperature loggers has been calculated to be 0.40°C by the manufacturer, which at 15°C is 97% to 103%. Accuracy will not be determined where true values are unknown: substratum, macroinvertebrates, and discharge. However for discharge, the velocity meter will be spin tested as per manufacturer's recommendation prior to each use. Accuracy of discharge rating curves will be determined by comparing measured value (as actual) with calculated value.

Precision

Table 2 shows the precision value for the acceptance of data. Precision will be determined for all chemical measure by processing a duplicate for every 8 samples. Discharge measure will be repeated at one site on one occasion to determine measurement precision. Precision of stowaway meters will be determined by placing all meters in one location for 24 hours. Precision for substratum size distribution will be determined by repeating the pebble count at one location and comparing the number of stones within each size class.

Representativeness

The monitoring design site locations, sampling frequency, and timing will ensure that the measurement parameters adequately describe and represent actual stream conditions for the sampling period. Chemical measures should represent two distinct periods within the single annual period, spring runoff and baseflow conditions. Single year data should not be interpreted to be representative of conditions over longer temporal scales. Repeated measures over multiple years are necessary to describe the variability among years. However this is beyond the scope of this project.

Comparability and Completeness

The use of standard collection and analytical methods will allow for data comparisons with previous or future studies and data from other locations. We expect to collect all of the samples, ensure proper handling, and ensure that they arrive at the laboratory and that analyses are conducted. Our objective is to achieve 100% completeness for all measures. Sample collection will be repeated if problems arise such as equipment malfunction or lost samples. For spring runoff samples, due to laboratory turnaround time, repeating sample collection may need to occur the following year.

A8. Special Training Requirements/Certification Listed

Jeffrey C. Davis (Project Manager) has a B.S. degree in Biology from University of Alaska Anchorage and a M.S. degree in Aquatic Ecology from Idaho State University. He has 12 years of experience in stream research. Mr. Davis has experience in all of the assessment techniques outlined in this document. He has experience in laboratory chemical analyses, macroinvertebrate collection pursuant to the USGS NAWQA program, the EPA Rapid bioassessment program, modification of these methodologies for Idaho and Alaska. Mr. Davis also has experience in aquatic invertebrate and vertebrate species identification.

Gay Davis (Quality Assurance Officer) has a B.S. degree In Wildlife Biology from the University of Maine. She has 13 years of experience in stream restoration and evaluation. Ms. Davis has over 5 year experience in stream ecological field assessment methods and water quality sampling.

Chemical analyses will be conducted through Analytical International, Inc. laboratory in Anchorage and AM Testing in Redmond Washington.

With the combined experience of these investigators, no additional training will be required to complete this project.

A9. Documentation and Records

Field data including replicates measures for quality assurance will be recorded in Rite-in-the-Rain field books. Upon returning to the laboratory, the field book will be photocopied (daily or weekly). The field data book will be kept and stored by the project manager and the Quality Assurance Officer will store the photocopies. ARRI will maintain records indefinitely. The final data report will include as appendices photocopies of the field data book, Excel data sheets, and results of QC checks. Any sampling problems will be recorded on the data sheets and included in the field sampling report. Laboratory reporting and requested laboratory turn around times of 6 to 10 days are discussed in section B4.

The project reporting requirements are as follows:

- Field Sampling Plan. **April 8, 2005.** The Sampling plan will outline sample parameters, location, frequency and timing of sample collection, and sample handling and processing.
- Quality Assurance Project Plan. **April 15, 2005.** Plan will be submitted and approved prior to collecting data subject to the plan.
- Field Sampling Reports: **Weekly/Monthly.** Brief reports following field work outlining data collected and any problems or suggested sampling modifications.
- First Annual Report: **July 30, 2005.** ARRI will submit a report to the ADEC project manager summarizing previous data collection. The report will provide a summary of collected data, evaluation of any data trends, any sampling problems, and any potential recommendations regarding sampling design or methods. Three unbound hard copies and 5 bound copies and electronic copies of the reports in Microsoft Word and as pdfs will be submitted to ADEC. Data will be provided in a STORET compatible format.
- Draft Final Report: **June 20, 2006.** ARRI will submit a draft final report to the ADEC project manager. The report will describe the objectives of the project and the methods used to meet project objectives. Monitoring data will be summarized and evaluated for any trends and differences among sites. Data will be compared to previously published data for other similar stream systems. Potential causes of variability in the data will be discussed relative to any potential historic or current causes.
- Final Report: **June 30, 2006.** ARRI will provide the ADEC project manager with the final report. The final report will be modified to incorporate any

editorial, content, or formatting comments to the draft report as requested by the ADEC project manager.

B1. Sampling Process Design

Water quality monitoring has multiple purposes: (1) to evaluate potential affects from historic mining, (2) to provide the baseline data necessary for the evaluation of proposed development plans (3) to measure the affects of increased development and human use of the area, and (4) to provide water quality reference data upstream of most urban development. The monitoring plan has been developed to provide information necessary to address these purposes.

Sampling locations have been selected to describe the variability throughout the sampling reach and within the major tributaries. A sampling site upstream of Archangel Creek will serve as a reference site. Additional mainstem sites will be distributed along the reach bracketing the tributaries (Figure 1); therefore, additional sites will be located below Archangel Creek but upstream of the Motherload Lodge, below the lodge but upstream of Fishhook Creek, below Fishhook Creek, mid-point between Fishhook Creek and Edgerton Park Road, and immediately upstream of Edgerton Park Road. Differences among mainstem sites will provide for the evaluation of changes in water chemistry over distance due to tributary inputs, groundwater discharge, and physical or biotic processes.

Tributary sampling sites will be located near the mouths of Archangel and Fishhook Creeks. Sampling sites at the major tributary mouths will provide for the evaluation of proposed development within the major sub-drainages and the distribution of sites along the mainstem will allow for the evaluation of proposed development within discrete sections of the river. The distribution of sites will provide a good description of water quality above, within, and below the location of proposed development as well as provide information on potential inputs from historic mine shafts hydrologically connected to the tributaries or mainstem. The latitude and longitude of all sampling locations will be determined using a hand-held GPS receiver.

Sampling frequency will document the temporal variability, and the times of rapid variability, in water quality parameters. Defining the natural variability is necessary to determine whether subsequent measures are within or outside the expected range of values. The portion of water derived from surface, relative to subsurface sources, varies throughout the year and usually has distinct differences in some water chemistry parameters. Ground water likely is the dominant source during base-flow conditions while surface flow will be greater and may dominate during spring snowmelt, or rainstorms. It is important to distinguish between these two events as some parameters may be affected greater during base-flow or runoff. Additional, subsequent monitoring or evaluations need to be compared with the range of base-flow or runoff values. For example, specific conductance may increase during spring runoff relative to base-flow conditions. Subsequent high specific conductance measures obtained during base-flow conditions may be abnormal even if they fall within the range observed during spring runoff.

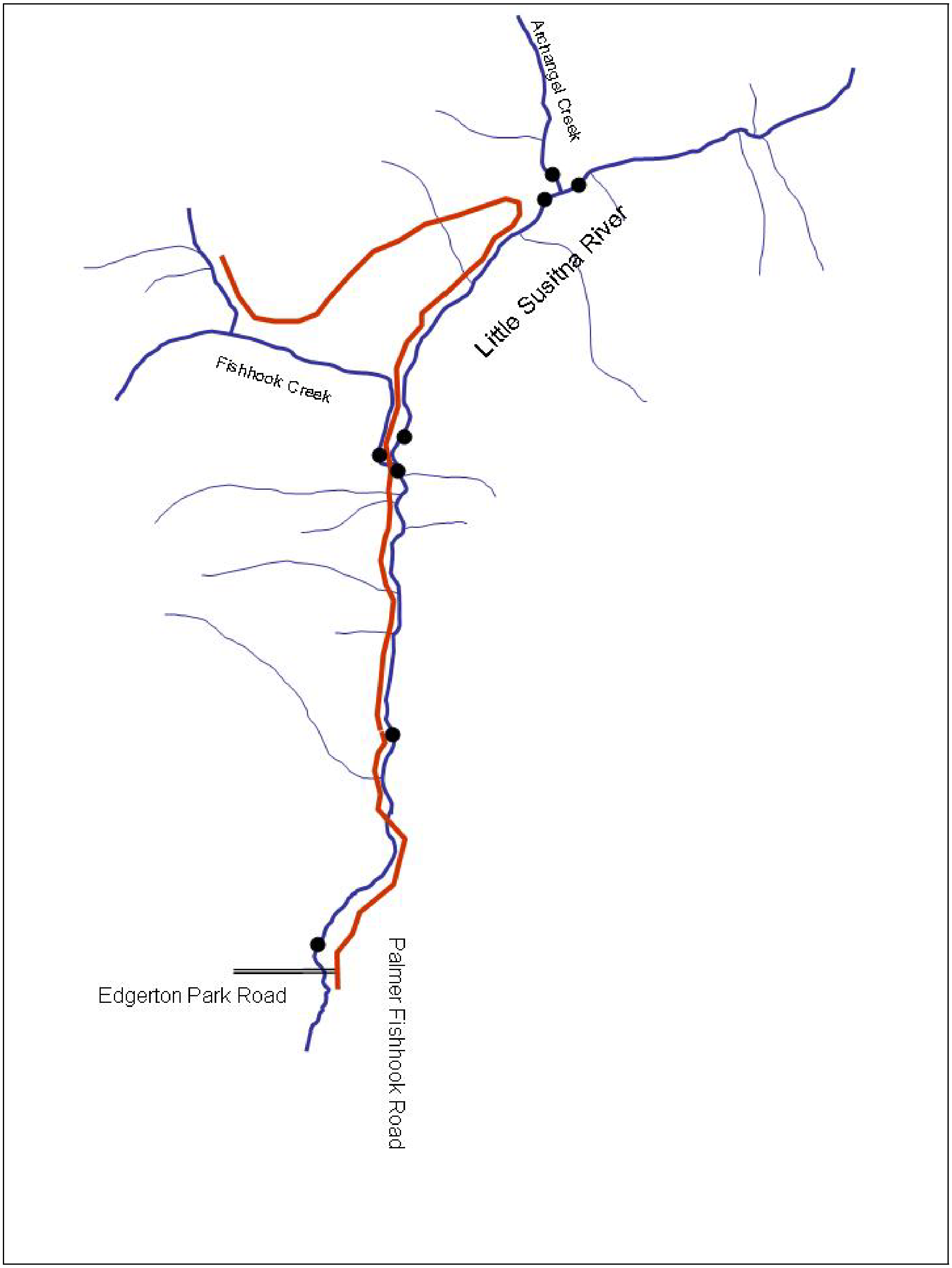


Figure 14. Drawing of project location with black dots showing sampling locations.

Surface runoff during storm events can vary considerably and be difficult to predict. Variability in water chemistry can result from the time of year storms occur due to the relative biotic activity, time between storm events, and the duration and intensity of the storm event. Due to the potential for high and unpredictable variability during storms we will focus water chemistry sampling to adequately describe conditions during spring snowmelt and base-flow conditions. Specific sampling frequency and total number of samples for water chemistry measures are shown in Table 1.

Sample Parameters consist of chemical, physical, and biological measures. Recommended parameters as well as proposed methods are as follows (Table 1).

During spring snowmelt water samples will be collected and analyzed for the following parameters at all 8 sites at weekly intervals for 4 weeks. Sampling is estimated to begin in late April or early May based upon changes in the hydrograph as measured by the USGS gauging station. Monthly sampling will continue at all 8 sites through the ice-free period (June through October). Winter samples will be collected from 3 sites on the Little Susitna every other month (December, February, and March) if there are open leads or we are able to bore through the ice to open water.

- pH. This is a measure of hydrogen ion activity. pH is controlled by the rock weathering, buffering capacity of the water, and influenced by biotic respiration. pH will be measured using a calibrated portable meter in the field (Hanna HI 9023 or equivalent).
- Alkalinity (mg/L $CaCO_3$). This is a measure of the buffering capacity of water. Alkalinity will be measured by titration at the ARRI Laboratory (APHA 2320).
- Turbidity (NTU). This measures of the reflective properties of the water sample relative to the amount of organic and inorganic particles. Turbidity will be measured using a Turbidimeter (Hach Chemical Co. 16800, or equivalent).
- Specific Conductance (µS/cm). Specific conductance is the inverse of electrical resistance and is relative to the concentration of ions in water. Specific conductance is used as a surrogate for Total Dissolved Solids. Specific conductance will be measured in the field using a conductivity probe and meter (Sper Scientific 840039 or equivalent).
- Dissolved Oxygen (mg/L). Oxygen concentration and percent saturation will be measured using membrane electrode.

Sampling sites and frequency will vary for the following parameters as described below.

- Temperature (°C). Water temperature will be measured at 1 to 3 hour intervals using Stowaway data loggers (Onset Corporation). Temperature loggers will be placed at the farthest upstream and downstream sites and at a mid-point location in early April. Hand held thermometers will be used to measure water temperature when collecting other samples or measuring conductivity and dissolved oxygen at all sites.
- Fecal Coliform Bacteria (cfu/100 ml). Fecal coliform bacteria will be sampled during spring snowmelt and summer baseflow at upstream, mid-point, and downstream sites. Water samples will be submitted to a commercial laboratory

for analyses using SM 9222-D. Analytica International Inc. will be the proposed subcontractor.

- Discharge. Stream discharge will be measured or estimated from discharge rating curves at the upstream sampling location and within the two tributaries on all sampling dates within the ice free period.
- Substratum. The substratum particle size distribution and percent embeddedness will be estimated at 3 mainstem sites and within the two tributaries using pebble counts of 100 stones. Stream surveys to determine cross-section morphometry and energy slope will be conducted at substratum collection points.
- Macroinvertebrates/Habitat. Macroinvertebrates will be collected, processed, and analyzed following the Alaska Stream Condition Index (ASCI) methods. Samples will be collected from 4 locations: the upstream end of the reach, the downstream end and within the two major tributaries. Stream habitat conditions will be evaluated using the ASCI qualitative assessment.

Water samples will be collected for macro-nutrient analyses at 3 mainstem sites on all sampling dates.

- Nutrients—Nitrogen (mg/L-N). Water samples will be collected for Nitrate and Nitrite ($NO_3 + NO_2$) and ammonium (NH_4) analyses. Samples will be submitted to commercial laboratory for analyses using SM 4500-NO_3-E and 4500-NH_3-H. Currently AM testing is the proposed subcontractor.
- Nutrients—Phosphorus (mg/L-P). Water samples will be collected and analyzed for total and dissolved phosphorus (SM 4500-P E). Currently AM testing is the proposed subcontractor.

External Data

Discharge and weather data will be obtained from U.S. government agency web sites. Data includes U.S. Geological Survey real time streamflow data from site 1529000 (http://nwis.waterdata.usgs.gov/ak/nwis/). Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html).

Sample Timing

To minimize diel variability, water sample collection will be standardized to the time between 8:00 to 12:00. In addition, to characterize diel variability, July water samples will be collected at two-hour intervals from 06:00 to 10:00 at the reference site and analyzed for pH, conductivity, and dissolved oxygen.

Table 7. Sampling frequency, location, and timing for storm flow and base flow conditions for each measurement parameter.

Parameter	Locations	Frequency/samples: Breakup	Frequency/samples: Base flow	Timing	Total Samples Breakup 05	Total Samples Baseflow 06
pH	8	Weekly/4	Monthly and bi-monthly/8	Mid-Day	32	64
Alkalinity	8	Weekly/4	Monthly and bi-monthly/8	Mid-Day	32	64
Sp. Conductance	8	Weekly/4	Monthly and bi-monthly/8	Mid-Day	32	64
Turbidity	8	Weekly/4	Monthly and bi-monthly/8	Mid-Day	32	64
Dissolved Oxygen	8	Weekly/4	Monthly and bi-monthly/8	Mid-Day	32	64
Nutrients	3	Weekly/4	Monthly and bi-monthly/8	Mid-Day	12	24
Fecal Coliforms	3	Weekly/4	Monthy/6	Mid-Day	12	18
Substratum/Embeddedness	3		Once	N/A		4
Macroinvertebrates/Habitat	4		Once	N/A		4
Water Temperature	3	Continuous		N/A		
Discharge	3	Weekly/4	Monthly/6	N/A	12	36

B2. Sampling Methods Requirements

Field Data Collection

Field data collection will be conducted by ARRI staff. The latitude and longitude of sampling locations will be recorded and photographs taken. Sampling will occur on Monday or Tuesday of each week. Measures of dissolved oxygen, pH, specific conductance and temperature will be conducted in the field. Samples for turbidity and alkalinity will be collected in clean sample bottles and returned to the ARRI Laboratory for analyses. Samples will be collected from a well-mixed area at each sampling site. Water-column integrated samples will be collected by drawing water into a 60 ml sterile syringe while drawing the syringe up from near the stream bottom to near the water surface. The water within the syringes will be discharged into pre-labeled sample bottles. A new sterile syringe will be used for each sample.

pH, Specific Conductance, Turbidity, Alkalinity, and Dissolved Oxygen

Depth integrated water samples will be collected in 500 ml sample bottles. The sample bottles will be filled and emptied 3 times before a sample is retained. Water characteristics will be measured using appropriate meters. Meters, pH, Hanna HI 9023, conductivity, SPER Scientific model 840039, and turbidity, HACH Chemical Co. Model 16800. Support equipment will include extra batteries and sample bottles. Clean sample bottles will be used. All meters will be tested and calibrated prior to use.

Materials Required: Data book, pencils, sharpie, 500-ml sample bottles (16 minimum), 60-ml syringe, cooler, gel-paks, pH meter with standards, dissolved oxygen meter, thermometer, extra batteries, and camera.

Weather Conditions

Weather conditions for the 24 hours previous to sampling will be obtained through direct observations and from on-line National Weather Service Website for Wasilla.

Nitrogen and Phosphorus

Water samples will be collected in sample containers provided by AM Testing Inc. Sample bottles will contain preservative where required (H_2SO_4 for nitrogen and total phosphorus, 4°C for dissolved phosphorus). Samples will be collected using the "clean hands" method described below. Samples will be sealed within a cooler with frozen gel-paks and shipped by Federal Express to the laboratory for analyses. Maximum holding time for preserved samples is 28 days; however, sample turn-around is 14 to 21 days.. Chain of custody forms will be used by ARRI staff and the receiving laboratory to track sample handling.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-paks (6), 60-cc syringe (9), thermometer, and sterile gloves.

Fecal Coliform Bacteria

Water samples will be collected in containers provided Analytica Alaska Inc. The sample bottles will be sterile. Samples for fecal coliforms will be collected from mid channel-mixed sites. Samples will be depth integrated as described above using only new packaged sterile syringes for each sample. The "clean hands" method will be used to avoid contamination. Sterile or near sterile procedures are used to collect the sample. Sterile gloves are used and contact only the collection bottle and the source water until the sample bottle is sealed. Once the sample is collected, the sample is labeled, and placed in a cooler and gel-packs are used to bring the sample temperature down to and maintained at 4-degrees Celsius. The sample will be labeled with the site ID, sample time and date and any additional information needed by the laboratory. The sample must be returned to the laboratory within 6 hours of collection.

Materials Required: sample bottles, labels, markers, chain-of-custody forms, cooler, frozen gel-paks (6), 60-cc syringe (9), thermometer, and sterile gloves.

Substratum/Embeddedness

Substratum size distribution will be determined through Wolman pebble counts of 100 stones as modified by Bevenger and King (1995). Beginning at the downstream end of the sampling reach, the intermediate axis of rocks is measured at roughly one-meter intervals as the investigator moves upstream, continually moving at an angle from bank to bank. The rock axis will be determined using an aluminum measuring template. The portion of each rock submerged below the substrate will be estimated from differences in algae or other markings on the rock and recorded as percent embedded (Davis et al. 2001).

Materials Required: Rite-in-the-Rain data book, pencils, aluminum template, meter stick.

Macroinvertebrates/Habitat Assessment

Macroinvertebrates will be collected, processed, and analyzed using the Standard operating procedures for the Alaska Stream Condition Index (ASCI) (Major and Barbour 2001). Composite invertebrate samples will be placed within pre-labeled whir-pak bags. Paper labels will be placed into the bags with the sample and the sample preserved with formalin. Labels will include date, time, location, and investigators. Stream invertebrate collections will be returned to the ARRI laboratory, sorted, and identified to genus (except for Chironomidae, Simuliidae, and Oligochaeta). Stream habitat will be evaluated using the habitat assessment methods of ASCI, or EMAP habitat assessment methods.

Materials Required: ASCI Habitat Assessment Data Sheets, whirl-pak bags, 5-gallon bucket, formalin, D-Nets, gauntlets, labels, pencils, sieve, and sharpies.

Temperature

Stream water temperature data loggers (Stowaway by Onset corp.) will be placed within the stream at three locations on April 1. Loggers will be secured to the bank using plastic coated wire rope. Loggers will be downloaded at least monthly.

Materials Required: 4-m sections of wire rope (3), clamps (6), stowaway temperature data loggers with backup (4), software, base station, coupler, and shuttle.

Discharge

Discharge will be measured using the methods of Rantz et al. (1982). A meter tape will be suspended across the stream. Water velocity will be measured at multiple intervals across the stream using a Price AA velocity meter. The meter will be spin tested prior to use. A top-setting wading rod will be used to ensure velocity is measured at 0.6 depth. Staff gauges will be secured at each discharge sampling points and a rating curve developed to calculate discharge when direct measurements are not possible. Discharge will be measured or estimated from the rating curve on each sampling date.

Materials Required: Rite-in-the-Rain data book, pencils, 100-meter tape, top-setting wading rod, velocity meter, and staff gauges.

Corrective Actions

The QA officer will ensure that all equipment is prepared and ready for sampling and that all samples are collected as described. The QA officer will inform the project manager of any problems with equipment or any missing data due to collection or laboratory errors. The project manager will be responsible for repairing or replacing equipment, taking additional samples, or replicating measurements as needed.

B3. Sample Handling and Custody Requirements

Water samples will be labeled in the field. Sample labels will record the date, time, location, preservation, and initials of collector. Chain of custody forms will be initiated in the field and completed each time samples are transferred to a laboratory, or other carrier. Field samples that are to be transferred to either of the contract laboratories will be placed within a cooler and the cooler sealed closed using plastic packing tape. Samples will be transported to the laboratory where they will be placed in a secure location until analyses are completed.

B4. Analytical Methods Requirements

Sample analytical methods are shown in Table 3. Field samples will be collected by ARRI staff and either delivered to the commercial laboratory for subsequent analyses by the identified standard method. Meter measures will be conducted in the field except for turbidity and alkalinity, which will be measure in the ARRI laboratory.

Table 8. List of Analytical methods and detection limits for study parameters.

Measurement	**Collection/ Analyses**	**Method**	**Limits**	**Turnaround Time (days)**
Fecal Coliforms	ARRI/AI Inc.	SM 9222-D	n/a	6 to 10
Total Phosphorus	ARRI/AM Testing	EPA 365.2	0.005 mg/L	14
Dissolved Phosphorus	ARRI/AM Testing	EPA 365.2	0.005 mg/L	14
Ammonia-N	ARRI/AM Testing	EPA 350.1	0.005 mg/L	30
Nitrate + Nitrite-N	ARRI/AM Testing	EPA 353.2	0.01 mg/L	30
pH	ARRI/ARRI	Meter (Hanna HI 9023)	0.01 pH units	1
Alkalinity	ARRI/ARRI	SM 2320	0.1 mg/L $CaCO_4$	1
Conductivity	ARRI/ARRI	Meter (SPER 840039)	0.1 mhos (0 to 200) 1.0 mhos (>200)	1
Turbidity	ARRI/ARRI	Meter (HACH Model 16800)	0.1 NTU (0 to 10) 1.0 NTU (10 to 100)	1
Dissolved Oxygen	ARRI/ARRI	Meter (YSI Model 55)	0.01 mg/L (0 to 20)	1
Temperature	ARRI	HOBO Stowaway	0.1 Degree C	Monthly Download

Corrective Action
ARRI will be responsible for ensuring that all samples are collected and delivered to the laboratory. The QA officer will make sure all samples are labeled and stored correctly and that all equipment has been calibrated and accuracy tests completed as needed. The project manager will be informed of any errors and will be responsible for corrective action including repeating sample collection or analyses (for metered measures). If any samples are lost or are determined to be contaminated by the laboratory or if there are any laboratory problems, the project manager will be responsible for collecting new samples and delivering them to the laboratory.

B5. Quality Control Requirements

The following table (Table 4) lists the percent of field and laboratory replicates to be used for quality control (See section A7 for discussion on calculation of precision and accuracy). If accuracy and precision are not met for analyses ARRI is conducting the meters will be recalibrated and measures will be repeated or meters or probes will be replaced. Data measurements that do not meet the limits described in A7 may or may not be used in the final report depending on degree to which limits are not met. However, the report will clearly state if there are any questions regarding used data.

Table 9. Field and laboratory replicates for quality control.

Parameter	Field Replicates	Laboratory Replicates	Comments
pH, Cond, Turb, DO, alkalinity.	10 Percent	None	Replicate measurements one of every 8 samples.
Fecal Coliform and Total Dissolved Solids, phosphorus, nitrogen,	10 Percent	None	Duplicate sample collected at one of the sites every sampling event.
Substrate	25%	None	Pebble counts will be repeated at one site.
Temperature	1%	None	Water temperature will be measured on each sampling event with meters and compared with stowaway readings. Stowaways will be placed in the same location for 24 hours and reading compared.

B6. Instrument/Equipment Testing, Inspection, and Maintenance Requirements

Instruments and meters will be tested for proper operation as outlined in respective operating manuals. Inspections and calibration will occur prior to use at each site. Equipment that does not calibrate or is not operating correctly will not be used. For most parameters (temperature, conductivity, and pH), duplicate instruments and meters are available. In the case of complete equipment failure, new equipment will be purchased. The Project Manager will be responsible for calibrating and testing and storing equipment and completing log sheets. All calibrating, testing and storage will follow the manufacturer’s recommendations. The QA Officer will inspect the log sheets. Spare batteries and repair equipment will be taken during field sampling events.

B7. Instrument Calibration and Frequency

The pH meter, conductivity meter, dissolved oxygen, and turbidity meter will be calibrated in accordance to instructions in the manufacturer’s operations manual by the project manager prior to each use and a log will be maintained documenting calibration. Standards are required for pH, and turbidity and will be used for conductivity.

B8. Inspection/Acceptance Requirements for Supplies and Consumables

Sample containers will be obtained from Analytical International Incorporated. Any needed standards for equipment calibration will be purchased directly from the equipment manufacturer if possible or from a well established chemical company. The QA officer will be responsible for ensuring that standards are not outdated and for the purchase of replacements. The date and source of all purchased materials will be recorded within a separate file for each piece of equipment and kept on file by ARRI along with equipment calibration records.

B9. Data Acquisition Requirements for Non-Direct Measurements

U.S. Geological Survey (USGS) stream flow data will be used. Data will be downloaded from the USGS web site (http://nwis.waterdata.usgs.gov/ak/nwis/). Real time and historic data from site number 15290000 will be assumed accurate. Weather data downloaded or purchased through the National Oceanic and Atmospheric Administration (NOAA) web site (http://www.ncdc.noaa.gov/oa/ncdc.html) also will be used and assumed accurate. Some supplemental data such as maps, outfall locations, water quality samples, may be obtained from other currently unknown sources for comparisons.

B10. Data Management

Field data will be entered onto rite-in-the-rain books. The Quality Assurance Officer will copy the field books and review the data to ensure that it is complete and check for any errors. Field and laboratory data sheets will be given to the project manager. The project manager will enter data into Excel spreadsheets. The Quality Assurance Officer will compare approximately 10% of the field and laboratory data sheets with the Excel files. If any errors are found they will be corrected and the Project Manager will check all of the field and laboratory data sheets with the Excel files. The Quality Assurance Officer will then verify correct entry by comparing another 10% of the sheets. This process will be repeated until all errors are eliminated. The Project Manager will then summarize and compare the data. The Quality Assurance officer will review any statistical or other comparisons made. Any errors will be corrected. The Project Manager will write the final report, which will be proofed by the Quality Assurance officer and submitted to the DEC project manager.

Water quality data will be provided to DEC in a modernized STORET compatible format. Data will be formatted into STORET compatible files as described at the following DEC web site (https://www.state.ak.us/dec/water/wqsar/storetdocumentation.htm).

C1. Assessments and Response Actions

Project assessment will primarily be conducted through the preparation of field sampling event reports for DEC by the project manager. Section A6 contains more information on the type and date of each required report. At that time the project manager will review all of the tasks accomplished against the approved workplan to ensure that all tasks are being completed. The project manager will review all data sheets and entered data to make sure that data collection is complete. If necessary, data collection processes or data entry will be modified as necessary. Any modifications of the data collection methods will be reviewed against the processes described within the QAPP to determine whether the document needs to be updated.

The Project Manager will check on contractor's laboratory practices to ensure that samples are handled correctly and consistently. The final report will contain an appendix that will detail all of the QA procedures showing precision and accuracy. Representativeness, completeness, and comparability will be discussed in the body of the report. Any QA problems will be outlined and discussed relative to the validity of the conclusions in the report. Any corrective actions will be discussed as well as any actions that were not correctable, if any.

The QA officer will report to ARRI management any consistent problems in data collection, analyses, or entry identified either internally or through a 3rd party audit. ARRI management will be responsible for developing and implementing a course of action to correct these problems. Where consistent problems may have affected project validity, these will be identified and reported to the DEC project manager directly and included in project reports as directed. Field sampling problems will also be included in the sampling event report submitted to the DEC project manager following each sampling event.

C2. Reports to Management

Reports will be prepared by the ARRI Project Manager and distributed to the Department of Environmental Conservation Project Manager. Reports will update the status of the project relative to the schedule and tasks of the work plan. Reports include Sampling Event Reports, First Annual Report (FY 05), Draft Final Report, and Final Report. Any field QA problems will be identified and reported in the sampling event reports. The Project Manager will prepare the draft and final reports. The final report also will be submitted in electronic format. Any potential problems with data due to QA will be identified and reported all submitted reports.

D1. Data Review, Validation, and Verification

The Project Manager and the Quality Assurance Officer will conduct data review and validation. This process for data review is described under section B10 and A7. Data that are obtained using equipment that has been stored and calibrated correctly and that meets the accuracy and precision limits will be used. Data that does not meet the accuracy and precision limits may be used; however, we will clearly identify these data and indicate the limitations.

D2. Validation and Verification Methods

The Project Manager and the Quality Assurance Officer will conduct data validation and verification. The Project Manager will enter all data from laboratory and field data sheets into Excel worksheets. The Project Manager will double-check all entries to ensure that they are correct. The Quality Assurance Officer will compare 10% of the laboratory and field data sheets with the Excel worksheets. The Project Manager will enter all formulas for calculation of parameters and basic statistics. All of these formulas will be checked by the Quality Assurance Officer. If any errors are found, the Project Manager will correct the errors and then check all entries. The Quality Assurance Officer will then repeat a check of 10% of the data entry and all of the formulas and statistics. This process will be repeated until any errors are eliminated. The Project Manager will organize and write the final report. The Quality Assurance Officer will check the results in the report and associated statistical error (i.e. standard deviation and confidence interval) against those calculated with computer programs. Any errors found will be corrected by the Project Manger.

D3. Reconciliation with User Requirements

The project results and associated variability, accuracy, precision, and completeness will be compared with project objectives. If results do not meet criteria established at the beginning of the project, this will be explicitly stated in the final report. Based upon data accuracy some data may be discarded. If so the problems associated with data collection and analysis, or completeness, reasons data were discarded, and potential ways to correct sampling problems will be reported. In some cases accuracy project criteria may be modified. In this case the justification for modification, problems associated with collecting and analyzing data, as well as potential solutions will be reported.

Literature Cited

Bevenger, G. S., and R. M. King. 1995. A pebble count procedure for assessing watershed cumulative effects. USDA Forest Service. Rockey Mountain Forest and Range Experiment Station. Fort Collins, CO. Research Paper RM-RP-319.

Davis, J.C., G.W. Minshall, C.T. Robinson, and P. Landres. 2001. Monitoring wilderness stream ecosystems. Gen. Tech. Rep. RMRS-GTR-70. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 137p.

Major, E.B., and M.T. Barbour. 2001. Standard operating procedures for the Alaska Stream Condition Index: A modification of the U.S. EPA rapid bioassessment protocols, 5th edition. Prepared for the Alaska Department of Environmental Conservation, Anchorage, Alaska.

Rantz, S. E., and others. 1982. Measurement and computation of streamflow--Volume 1. Measurement of stage and discharge. U.S. Geological Survey Water-Supply Paper 2175, 284p.

Appendix B—Water Chemistry

pH																	
Site	**4/21/05**	**4/26/05**	**4/28/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/13/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**	**Max**	**Min**	**Average**
1		7.44		7.04	7.44	7.11	7.39	7.54	7.54	7.26	7.68	7.2	7.46	7.49	7.68	7.04	7.38
2		7.51		7.12	7.49	7.16	7.48	7.58	7.55	7.37	7.7	7.15	7.34	7.44	7.70	7.12	7.41
3	7.36	7.45	7.53	7.10	7.43	7.19	7.43	7.55	7.52	7.37	7.73	7.17	7.41	7.41	7.73	7.1	7.40
4		7.51	7.53	7.14	7.38	7.22	7.2	7.56	7.53	7.45	7.71		7.39	7.4	7.71	7.14	7.42
5		7.49	7.51	7.13	7.35	7.27	7.45	7.56	7.63	7.52	7.61	7.35	7.54	7.52	7.63	7.13	7.46
6		7.5	7.53	7.18	7.34	7.35	7.45	7.63	7.66	7.57	7.55	7.38	7.45	7.54	7.66	7.18	7.47
7	7.33	7.34	7.53	7.20	7.35	7.35	7.46	7.61	7.62	7.47	7.5	7.12	7.43	7.53	7.62	7.12	7.42
8	7.35	7.5		7.23	7.35	7.40	7.51	7.62	7.61	7.55	7.66	7.38	7.41	7.49	7.66	7.23	7.47
x		7.59		7.23	7.35	7.43	7.52		7.6	7.57	7.62	7.4	7.42	7.46	7.62	7.23	7.47
Max	7.36	7.51	7.53	7.23	7.49	7.40	7.51	7.63	7.66	7.57	7.73	7.38	7.54	7.54	7.73	7.23	7.51
Min	7.33	7.34	7.51	7.04	7.34	7.11	7.20	7.54	7.52	7.26	7.50	7.12	7.34	7.40	7.54	7.04	7.33
Ave	7.35	7.47	7.53	7.14	7.39	7.26	7.42	7.58	7.58	7.45	7.64	7.25	7.43	7.48	7.64	7.14	7.43

Sp. Conductance (μS/cm)																	
Site	**4/21/05**	**4/26/05**	**4/28/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/13/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**	**Max**	**Min**	**Ave**
1		78.5		65.2	62.6	67.6	54.2	54.9	48.5	68.1	80.6	87.3	93.5	99.2	99.20	48.5	71.68
2		44.9		38.1	35	42.4	30.5	35.9	39.0	42.9	44	54	56.2	60.9	60.90	30.5	43.65
3	84.1	64.1		51.9	45.7	54	39.2	46.1	44.4	57.3	62.5	76	78.5	84.8	84.80	39.2	60.66
4		73.7	51.6	58	52.8	61.8	57.8	50.6	49.1	61.6	66.5		83.5	93.8	93.80	49.1	63.40
5		72.2	59.4	67.2	64.6	75	46.8	76.5	83.6	81.4	84.3	95	96.7	103.2	103.20	46.8	77.38
6		67.4	50.0	58.6	54.1	64.1	50.5	53.3	52.7	65.3	69.5	84	88.4	98.3	98.30	50	65.86
7	111.7	111.5	59.4	63.3	56.8	65.2	51.7	55.9	55.3	69.5	76.2	132	106.6	123.6	132.00	51.7	81.34
8	119.4	91.2		66.3	58.4	67.3	48.9	56.8	58.0	70.5	79.3	110.9	123.6	149.5	149.50	48.9	84.62
x		91.2		66.3	58.6	66.9	49.6		58	70.6	79.1	114.4	125	149.3	149.30	49.6	84.45
Max	119.4	111.5	59.4	67.2	64.6	75	57.8	76.5	83.6	81.4	84.3	132	125	149.5	149.50	57.8	91.94
Min	84.1	44.9	50	38.1	35	42.4	30.5	35.9	39	42.9	44	54	56.2	60.9	84.10	30.5	46.99
Ave	105.1	75.4	55.1	58.6	53.8	62.2	47.5	53.8	53.8	64.6	70.4	91.3	90.9	101.7	105.07	47.45	70.28

Turbidity (NTU)																	
Site	**4/21/05**	**4/26/05**	**4/28/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/13/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/05**	**2/15/06**	**3/27/06**	**Max**	**Min**	**Average**
1		0.5		0.7	0.9	0.9	2.8	8.5	9.8	1.1	1.2	1	0.5	0.8	9.80	0.5	2.39
2		0.6		0.7	1.4	1.3	1.8	1.1	1.6	0.9	0.8	1	0.9	0.4	1.80	0.4	1.04
3	0.48	0.5	0.8	1.0	0.8	1.1	3.5	3.1	6.8	1.1	0.9	1	0.9	0.5	6.80	0.48	1.61
4		0.6	2.2	0.7	0.9	1.1	2	3.5	6.9	1.0	1.1	1	1.4	0.5	6.90	0.5	1.76
5		0.6	3.8	0.9	0.65	0.7	3.1	0.8	0.8	0.8	1.2	1	0.9	0.5	3.80	0.5	1.21
6		0.9	11.5	1.0	0.9	1.2	2.2	3.1	5.8	0.9	1	1	0.6	0.5	11.50	0.5	2.35
7	0.55	1.1	5.1	2.3	0.9	1.2	2.6	3.1	5.8	0.9	1	1	0.8	0.4	5.80	0.4	1.91
8	0.75	1.0		3.1	0.9	1.4	3.1	3.2	5.3	1.1	1.2	1	0.6	1	5.30	0.6	1.82
x		1.2		3.5	0.85	1.2	3.3		5.2	1.0	0.9	1	0.9	1.5	5.20	0.85	1.87
Max	0.75	1.20	11.50	3.50	1.40	1.40	3.50	8.50	9.80	1.10	1.20	1.00	1.40	1.50	11.50	0.75	3.41
Min	0.48	0.50	0.80	0.70	0.65	0.70	1.80	0.80	0.80	0.80	0.80	1.00	0.50	0.40	1.80	0.4	0.77
Ave	0.59	0.78	4.68	1.54	0.91	1.12	2.71	3.30	5.33	0.98	1.03	1.00	0.83	0.68	5.33	0.59	1.82

DO % Sat																
Site	**4/21/05**	**4/26/05**	**4/28/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/13/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**	**Max**	**Min**	**Ave**
1		104.2	108.8	101.7	106.8	104.4	105	98.0	104.8	107.0	105.9	101.7	106.1	106.7	108.8	98.0	104.7
2		105.5	110.6	103.0	108.2	105.5	116	98.0	103.3	102.3	105.1	100.0	107.6	106.7	116.0	98.0	105.5
3		105.5		101.9	104.8	106.6	115	110.0	103.0	101.3	105.7	101.3	106.8	106.1	115.0	101.3	105.7
4		102.4	112.2	103.1	108.5	109.0	116	112.0	105.7	101.9	106.2		108.5	109.2	116.0	101.9	107.9
5		101.6	109.5	103.2	108.4	105.3	117	98.0	101.9	101.3	107.6		108.0	108.4	117.0	98.0	105.9
6		107.1	112.9	106.4	106.6	107.4	117	99.0	105.0	102.9	105.7	101.9	109.4	109.5	117.0	99.0	107.0
7		103.5	113.5	97.0	107.8	105.8	117	98.0	104.0	101.2	104.4	87.1	108.2	108.5	117.0	87.1	104.3
8		108.0		105.9	110	109.2	119	101.0	106.7	103.4	109.1	103.8	110.8	111.4	119.0	101.0	108.2
x		107.6									106.2				107.6	106.2	106.9
Max		108.0	113.5	106.4	110.0	109.2	119.0	112.0	106.7	107.0	109.1	103.8	110.8	111.4	119.0	103.8	109.8
Min		101.6	108.8	97.0	104.8	104.4	105.0	98.0	101.9	101.2	104.4	87.1	106.1	106.1	108.8	87.1	102.0
Ave		105.0	111.3	102.8	107.6	106.7	115.3	101.8	104.3	102.7	106.2	99.3	108.2	108.3	115.3	99.3	106.1

Alkalinity (mg/L CaCO3)												
Site	**4/26/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**
1	36	34	28	26	26	24	22	28	32	34	34	36
7	34	30	26	30	22	28	24	26	30	42	36	38
8	32	30	26	26	24	26	26	30	32	36	34	38
x	30	28	24	24				30		40	36	38

Ammonia-N (mg/L)												
Site	**4/26/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**
1	0.024	0.48	<0.005	<0.005	0.037	0.19	0.059	0.045	0.097	1.3	0.011	0.04
7	0.01	<0.005	<0.005	<0.005	0.022	0.19	0.029	0.061	<0.005	1.1	0.022	0.052
8	0.019	0.2	<0.005	0.009	0.005	0.19	0.18	0.033	0.52	0.019	0.02	0.005
x	0.033	0.38	<0.005	<0.005				0.039		0.093	0.14	0.005

Nitrate-N (mg/L)												
Site	**4/26/05**	**5/2/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**
1	0.42	0.66	0.32	0.26	0.12	<0.01	<0.01	0.025	0.18	<0.01	0.084	0.022
7	0.74	0.73	0.55	0.18	0.12	<0.01	<0.01	<.01	0.28	<0.01	0.062	0.063
8	1.3	0.92	0.64	0.16	0.019	<0.01	<0.01	<.01	0.02	<0.01	0.11	0.042
x	1.3	0.89	0.63	0.33				0.01		<0.01	0.03	<0.01

Total Phosphorus (mg/L)												
Site	**4/26/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**
1	0.007	<0.005	<0.005	<0.005	0.03	0.02	0.011	0.029	0.008	0.027	<0.005	0.015
7	0.009	<0.005	0.011	<0.005	0.037	0.033	0.018	0.011	<0.001	0.033	<0.005	0.01
8	0.01	<0.005	<0.005	0.010	0.017	0.025	0.013	0.023	0.003	0.039	<0.005	0.011
x	0.009	<0.005	0.005	0.013				<0.001		0.035	0.012	0.014

Total Dissolved Phosphorus (mg/L)												
Site	**4/26/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**	**1/11/06**	**2/15/06**	**3/27/06**
1	<0.005	<0.005	0.005	<0.001	<0.001	0.019	0.009	0.023	<0.005	0.024	0.001	0.01
7	<0.005	<0.005	<0.005	<0.001	<0.001	0.025	0.018	0.012	<0.005	0.03	<0.001	<0.001
8	0.01	<0.005	0.005	0.007	<0.001	0.027	0.012	0.034	<0.005	0.025	0.002	<0.001
x	<0.005	<0.005	<0.005	0.009				<0.005		0.029	0.012	<0.001

Fecal Coliform Bacteria (cfu)									
Site	**4/26/05**	**5/3/05**	**5/9/05**	**5/16/05**	**6/14/05**	**7/12/05**	**8/15/05**	**9/19/05**	**10/19/05**
1	<MRL	<MRL	<MRL	<MRL	<MRL	1.3	8	2.7	<MRL
7	<MRL	<MRL	2.7	1.3	<MRL	2.7	15	1.3	<MRL
8	<MRL	<MRL	1.3	<MRL	<MRL	1.3	2.7	5.3	1.0
x	<MRL		5.3		<MRL		5.3		

pH				**Specific Conductance (uS/cm)**			**Turbidity (NTU)**		
Date	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**
4/21/05	7.35			119.4			0.75		
4/26/05	7.5	7.59	1.19	91.2	91.2	0.00	1	1.2	18.18
4/28/05									
5/3/05	7.23	7.23	0.00	66.3	66.3	0.00	3.1	3.5	12.12
5/9/05	7.35	7.35	0.00	58.4	58.6	0.34	0.9	0.85	5.71
5/16/05	7.4	7.43	0.40	67.3	66.9	0.60	1.4	1.2	15.38
6/14/05	7.51	7.52	0.13	48.9	49.6	1.42	3.1	3.3	6.25
7/13/05	7.62			56.8			3.2		
8/15/05	7.61	7.6	0.13	58	58	0.00	5.3	5.2	1.90
9/19/05	7.55	7.57	0.26	70.5	70.6	0.14	1.1	1	9.52
10/19/05	7.66	7.62	0.52	79.3	79.1	0.25	1.2	0.9	28.57
1/11/06	7.38	7.4	0.27	110.9	114.4	3.11	1	1	0.00
2/15/06	7.41	7.42	0.13	123.6	125	1.13	0.6	0.9	40.00
3/27/06	7.49	7.46	0.40	149.5	149.3	0.13	1	1.5	40.00

Maximum			**1.19**			**3.11**			**40**

Alkalinity (mg/L CaCO3)				**Ammonia-N (mg/L)**			**Nitrate-N (mg/L)**		
Date	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**
4/26/05	32	30	6.45	0.019	0.033	53.85	1.3	1.3	0.00
5/3/05	30	28	6.90	0.2	0.38	62.07	0.92	0.89	3.31
5/9/05	26	24	8.00	<0.005	<0.005		0.64	0.63	1.57
5/16/05	26	24	8.00	0.009	<0.005		0.16	0.33	69.39
6/14/05	24			0.005			0.019		
7/12/05	26			0.19			<0.01		
8/15/05	26			0.18			<0.01		
9/19/05	30	30	0.00	0.033	0.039	16.67	<.01	0.01	
10/19/05	32			0.52			0.02		
1/11/06	36	40	10.53	0.019	0.093	132.14	<0.01	<0.01	
2/15/06	34	36	5.71	0.02	0.14	150.00	0.11	0.03	114.29
3/27/06	38	38	0.00	0.005	0.005	0.00	0.042	<0.01	
Maximum			**10.52**			**150**			**114.29**

Total Phosphorus (mg/L)				**Total Diss Phosphorus (mg/L)**			**Fecal Coliform Bacteria (cfu)**		
Date	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**	**Site 8**	**Site X**	**Precision (%)**
4/26/05	0.01	0.009	10.53	0.01	<0.005		<MRL	<MRL	0.00
5/3/05	<0.005	<0.005	0.00	<0.005	<0.005	0.00	<MRL		
5/9/05	<0.005	0.005		0.005	<0.005		1.3	5.3	121.21
5/16/05	0.01	0.013	26.09	0.007	0.009	25.00	<MRL		
6/14/05	0.017			<0.001			<MRL	<MRL	0.00
7/12/05	0.025			0.027			1.3		
8/15/05	0.013			0.012			2.7	5.3	65.00
9/19/05	0.023	<0.001		0.034	<0.005		5.3		
10/19/05	0.003			<0.005			1		
1/11/06	0.039	0.035	10.81	0.025	0.029	14.81			
2/15/06	<0.005	0.012		0.002	0.012	142.86			
3/27/06	0.011	0.014	24.00	<0.001	<0.001	0.00			
Maximum			**26.09**			**142.86**			**121.21**

Appendix C—Invertebrate Samples

					Site 1	**Site 5**	**Site 8**	**Site 2**
Little Susitna River	**Oct. 4, 2005**		**Tol Val**	**FFG**				
Ephemeroptera								
Ephemeroptera	Baetidae							
Ephemeroptera	Baetidae	Baetis	4	Collector	81	54	108	98
Ephemeroptera	Baetidae	Acerpenna	4	Shredder				
Ephemeroptera	Ephemerellidae							
Ephemeroptera	Ephemerellidae	Ephemerella	2	Collector	1		1	
Ephemeroptera	Heptageniidae							
Ephemeroptera	Heptageniidae	Drunella	1	Predator	29		23	4
Ephemeroptera	Heptageniidae	Cinygmula	4	Scrapper				
Ephemeroptera	Heptageniidae	Acanthemola		Predator				
Ephemeroptera	Heptageniidae	Epeorus	0	Scrapper	38	46	7	20
Plecoptera								
Plecoptera	Chloroperlidae-UNID	Paraperla	1	Predator	4	3	5	
Plecoptera	Chloroperlidae-UNID	Katholperla	1	Predator				
Plecoptera	Chloroperlidae-UNID	Neaviperla	1	Predator	1			
Plecoptera	Chloroperlidae-UNID	Alloperla	1	Predator				
Plecoptera	Perlodidae							
Plecoptera	Perlodidae	Isoperla	2	Predator	25		8	
Plecoptera	Nemouridae							
Plecoptera	Nemouridae	Zapada	2	Shredder		18		3
Plecoptera	Pteronarcydae	Pteronarcella	0	Shredder				
Trichoptera								
Trichoptera	Rhyacophilidae							
Trichoptera	Rhyacophilidae	Rhyacophila	0	Predator	10	3	6	13
Trichoptera	Glossosomatidae							
Trichoptera	Glossosomatidae	Glossosoma	0	Scrapper			3	
Trichoptera	Brachycentridae							
Trichoptera	Brachycentridae	Brachycentrus	1	Filterer				
Trichoptera	Limnephilidae		4	Shredder	1			
Trichoptera	Limnephilidae	Ecclisomyia	4	Collector		7	8	
Trichoptera	Limnephilidae	Onocosmoecus	1	Shredder				
Trichoptera	Limnephilidae	Hesperophylax	5	Shredder				
Trichoptera	Limnephilidae	Psychoglypha	1	Collector		2		
Trichoptera	Hydropsychidae							
Trichoptera	Hydropsychidae	Hydropsyche	6	Filterer				1
Trichoptera	Apataniidae							
Trichoptera	Apataniidae	Apatania	4	Scrapper				
Trichoptera								
Diptera								
Diptera	Chironomidae-UNID		6	Collector	89	28	50	120
Diptera	Ceratopogonidae							
Diptera	Ceratopogonidae	Probezzia	6	Predator				
Diptera	Simuliidae-UNID		6	Filterer	12	17	2	
Diptera	Empididae							
Diptera	Empididae	Chelifera						
Diptera	Empididae	Clinocera						
Diptera	Empididae	Oreogoeton						
Diptera	Dolichopodiidae							
Diptera	Phoridae							
Diptera	Tipulidae		3	Shredder				
Diptera	Tipulidae	Dicranota						
Diptera	Tipulidae	Hexatoma						
Diptera	Tipulidae	Tipula	4	Shredder	1			1
Diptera	Psychodidae							
Diptera	Psychodidae	Pericoma	4	Collector				
Coleoptera								
Coleoptera	Hydrophilidae							

					Site 1	**Site 5**	**Site 8**	**Site 2**
Arachnoidea	Hydrachnidia							
Arachnoidea	Hydrachnidia	Hydracarina	6	Predator	4	1	2	2
Mulusca	Pelycypoda							
Mulusca	Sphaeriidae	Anadonta		Filterer				
Mulusca	Gastropoda							
Mulusca	Gastropoda	Lymnaeidae	7	Scrapper				
Mulusca	Gastropoda	Planorbidae	8	Scrapper				
Mulusca	Gastropoda	Physidae	8	Scrapper				
Mulusca	Gastropoda	Valvatiidae						
	Chrysomeliidae-UNID							
Analida	Oligochaeta		8	Collector		6		
Analida	Nematoda							
Hemiptera	Corixidae		5	Predator				1
Amphipoda	Gameroidea	Eogammerus	6	Omnivore				
Arachnoidia	Terrestrial							
Analid	Hiruindi		9	Predator		1		
Lepidop[tera	Terrestrial							
Total Organisms					296	186	223	263
Ephemeroptera					149	100	139	122
Plecoptera					30	21	13	3
Trichoptera					11	12	17	14
Diptera					102	45	52	121
Richness					13	12	12	10
Ephemeroptera Taxa					4	2	4	3
Plecoptera Taxa					3	2	2	1
Trichoptera Taxa					2	3	3	2
% Plectopera					10.13	11.290	5.830	1.141
% Ephemptera (no Baetidae)					22.97	24.73	13.90	9.12
% Diptera					34.45	24.19	23.31	46.00
Baetidae/Ephemeroptera					0.54	0.54	0.77	0.80
% Non-insects					1.351	4.301	0.897	1.141
HBI					3.54	2.09	2.82	3.88
%Scrapers					12.84	24.73	4.48	7.60
% Collectors					57.77	52.15	74.89	82.89
% EPT no Baetids or Zapada					36.82	32.80	27.35	14.45
% Baetidae and Zapada					27.36	38.71	48.43	38.40
Low Coarse	**Less than 2% Slope**	**ASCI Scores**			**Low Grad Coarse**	**Low Gradient Coarse**	**Low Grad Coarse**	**Low Grad Coarse**
Ephemeroptera taxa 100 * X / 5.5					57.14	28.57	57.14	42.85
% Ephemeroptera (no Baetidae) 100 * X / 20					114.86	123.65	69.50	45.62
% Plecoptera 100 * X / 14					72.39	80.64	41.63	8.14
Baetidae / Ephemeroptera 100 * (100 - X) / 100					45.63	46	22.30	19.67
% non-insects 100 * (30 - X) / 30					95.49	85.66	97.01	96.19
O/E (family 75%) 2 100 * X					90	80	80	50
% scrapers 100 * X / 15					85.58	100	29.89	50.69
HBI 100 * (6.5 - X) / 2		325			100	100	100	100
Average					**82.64**	**80.56**	**62.18**	**51.64**
Ranking					**Exc**	**Exc**	**Good**	**Good**
High Gradient	**>2% Slope**					**High Gradient Coarse**		**High Gradient Coarse**
EP taxa 100 * (12 - X) / 9						88.88		88.88
Trichoptera taxa 100 * X / 5						60		40
% Baetidae and Zapada 100						44.70		45.13

					Site 1	**Site 5**	**Site 8**	**Site 2**
* (70 - X) / 70								
% Diptera 100 * X / 90						26.88		51.11
O/E (family 75%) 3 100 * X						75		37.5
% collectors 100 * (100 - X) / 75						63.79		22.81
Average						**59.87**		**47.57**
Ranking						**Fair**		**Fair**