The Little Susitna River— An Ecological Assessment

ALASKA Department of Environmental Conservation

ARRI
Aquatic Restoration & Research Institute

Jeffrey C. Davis and Gay A. Davis
P.O. Box 923 Talkeetna, Alaska
(907) 733.5432. www.arrialaska.org

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Acknowledgements

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Table of Contents

Table of Figures

Summary

The Little Susitna River is an important recreational resource within south-central Alaska. The river supports five species of salmon and very popular Chinook and coho salmon fisheries. In 2004, 20,000 angler days were spent harvesting 45,000 coho, which is the second highest harvest level in south-central Alaska. Rapid increases in Matanuska-Susitna Borough populations and the river's popularity have resulted in increased residential development and recreational use along the river. There is a potential for residential development and recreational use to cause a decrease in water quality and fish habitat. This study is the first step in characterizing the Little Susitna River from the Edgerton Road Bridge to below the Public Use Site. Project objectives included, documenting the degree and cause of bank and riparian area modification, determining basic water chemistry including nutrient concentrations, fecal coliform bacteria, and petroleum hydrocarbons, obtaining measures of fish and macroinvertebrate community composition, and the physical channel characteristics from Edgerton Park Road to the Public Use Site.

Bank and riparian modification was measured from 2004 aerial photography. Approximately 1% of the bank and riparian habitat has been modified from the Edgerton Road Bridge to the Susitna Lodge at river mile 15. Between Edgerton Park Road and Schrock Road, bank and riparian modifications increase to approximately 3%. The dominant cause of bank and riparian modification is residential development, followed by land clearing for agriculture, and roads. Stream water turbidity, fecal coliform bacteria, and water temperatures exceeded State Standards from water samples collected below the Public Use Site. However, these evaluations are based upon limited measures and require further confirmation. The river segment between the Edgerton Park Bridge and Cook Inlet can be divided into three distinct reaches that vary in channel slope, sinuosity, substrate particle size, and riparian vegetation. The biotic community reflected good water quality and habitat, with juvenile salmon abundant throughout.

The bank and riparian areas along the Little Susitna River are largely unmodified. Most of the modifications have occurred due to residential development of the river between Schrock Road and Edgerton Park Road. This stream reach also contained the largest number of juvenile salmonids. None of the stream characteristics within this upper reach indicated any water quality or fish habitat problems; however, sampling was minimal. There was an increase in fine sediment and bed particle embeddedness below the Miller's Reach launch suggesting increased bank erosion. There also appeared to be an increase in point bar formation within this area. Turbidity increased below the public use boat launch in June, which coincided with increased boat traffic during the Chinook sport fishery. Stream temperatures and fecal coliform bacteria were higher below the public use site than other locations; however, there was no consistent indication of volatile organic carbons, and juvenile salmon were abundant. As this was the first phase of the characterization of the Little Susitna River, additional information is necessary to support these initial findings.

Introduction

The Little Susitna River is within the Cook Inlet Ecoregion (Gallant et al. 1995). Ecoregions were developed based upon similarities in environmental factors including climate, terrain, soils, and vegetation and provide a framework for the comparison of information within areas of similar overriding environmental factors. The Cook Inlet Ecoregion includes portions of the Kenai Peninsula, the Knik and Matanuska River drainages, and the Susitna River drainage up to 500 m elevation. The Cook Inlet Ecoregion extends north of Talkeetna, and east to the Talkeetna Mountains and West to the Alaska Range. Average annual precipitation ranges from 280 to 680 mm. Winter temperatures range from lows of -15°C to highs of -5°C and summer highs of about 5 to 8°C. May through September is generally frost free (Gallant et al. 1995). The Little Susitna River flows an estimated 113 miles from the Talkeetna Mountains to Cook Inlet, with an elevation change of over 4,000 feet.

The Little Susitna River is an important recreational area for south-central Alaska. The river supports popular Chinook and coho sport fisheries. The river is road accessible upstream from the Park’s Highway. Access downstream of the Park’s Highway and the Millers Reach subdivision is limited to the Public Use Site located at the end of Ayrshire Road. The Little Susitna River is one of the rivers managed under the Susitna Area Recreational Rivers Management Plan. The lower river is located within the Susitna Flats State Game Refuge, and a small portion of the river downstream from the Park’s Highway flows through the Nancy Lake State Recreation Area. The river is within the Hatcher Pass State Management Area upstream of the Edgerton Road Bridge. Residential and commercial development is restricted to the road accessible areas near the cities of Wasilla and Houston.

The population within the Matanuska-Susitna Borough has been increasing rapidly over the past few years. This has resulted in an increase in development and recreational use along the Little Susitna River. Residential development and recreational use have the potential to negatively affect the aquatic ecosystem. Residential development and associated road construction can result in the direct loss of fish habitat and indirect effects to water quality. Riparian vegetation often is removed for home construction or to provide unimpeded river views. The removal of bank vegetation can cause accelerated bank erosion rates. Increases in bank sediments in excess of the stream transport capacity can cause areas of sediment deposition. Fine sediment deposition can affect the transport of water and oxygen through the substrate reducing the quality of fish spawning habitat and the living space for aquatic insects. Road construction can be a source of sediment, concentrating surface flows along ditch lines, and delivering sediment to streams at road crossings. The delivery of toxic hydrocarbons can increase at road crossings. The construction and use or failure of residential septic systems can result in an increase in concentrations of fecal coliform bacteria in adjacent waters causing increased risk to human health through direct or indirect contact with contaminated waters. Increases in stream water nutrient concentrations resulting in blooms of nuisance algae also have been associated with residential development.

Recreational use can cause an increase in sediment delivery rates, fecal coliform bacteria, and toxic hydrocarbons. Fine sediment delivery rates can increase with increasing bank failures due to the removal of bank vegetation due to multiple factors including foot traffic. Boat waves also can increase bank failure rates and sediment delivery by eroding bank materials. Motor boats can deliver toxic hydrocarbons through fuel and oil leaks, spills or the inefficient combustion of engines. Fecal coliform bacteria can increase at remote camping sites adjacent to streams that do not have restroom facilities. All terrain vehicle stream fords and use within the riparian area can remove bank vegetation, and cause bank sloughing and erosion. Other potential impacts from residential development and recreation include compaction of spawning gravels, and increased temperature due to the loss of riparian vegetation.

The objectives of this project were developed to begin to address Alaska Clean Water Action Plan (ACWA) priorities by measuring baseline chemical and physical habitat conditions as well as evaluating previous qualitative observations of habitat degradation. Project objectives were to calculate the amount and types of bank and riparian modifications occurring along the river, develop an index to evaluate bank conditions, provide an initial characterization of water chemistry, channel physical characteristics, and biotic measures at multiple stream reach locations. The ACWA project grant agreement was completed on August 9, 2006, and on August 19 there were peak flood flows on the Little Susitna approaching a 100 year occurrence interval. The late start of the project and the interruption of fall data collection prevented completion of all of the objectives within the ACWA funding cycle.

Methods

The project sampling design and method details can be found within the project sampling plan and quality assurance project plan (QAPP). The project sampling plan and QAPP are provided in Appendix A.

Sampling Locations

Stream sampling locations were distributed from the Edgerton Park Road Bridge to the Public Use Site (Figure 1, Table 1). Sites were located to bracket areas of potential impacts and differences in stream physical characteristics. Areas of potential impact and differences in physical characteristics were determined through qualitative surveys and review of 2004 aerial photography. Qualitative surveys were conducted by foot from car-accessible locations from Edgerton Park Road to Schrock Road and by boat from Schrock Road to the Public Use Site. The river section from Edgerton Park to Schrock Road was selected to bracket most of the residential development. There is minor residential development between Schrock Road and the sampling site located upstream from Houston. Sites were located above and below Houston, bracketing the Park's Highway, the city of Houston, and areas of recreational access. The area between the downstream Houston sampling site and the upstream Public Use Site, bracket an area of moderate recreational use, with the greatest recreational use adjacent to the Public Use Sites.

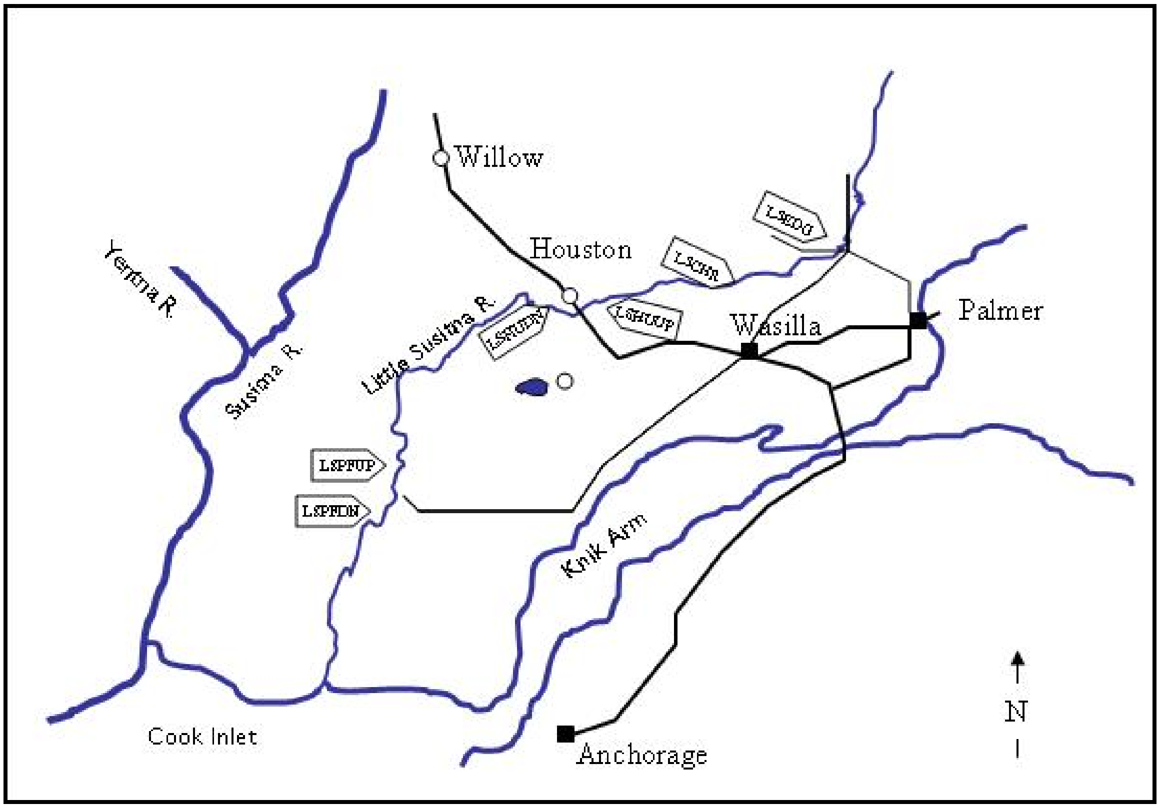

Figure 1. Map of Little Susitna River Sampling Locations.

Table 1. Little Susitna sampling locations and site names used throughout report.

Site Name	Site Description	Latitude	Longitude	River Mile
LSEDG	Edgerton Park Road Crossing	61° 41’ 37.7”	149° 14’ 41.2”	92
LSCHR	Schrock Road Crossing	61° 38’ 33.0”	149° 31’ 30.0”	79
LSHUUP	Upstream of Houston at the ADFG Weir Site	61° 37’ 30.3”	149° 46’ 57.5”	64
LSHUDN	Downstream of Houston at the Miller's Reach Boat Launch	61° 37’ 16.6”	149° 50’ 57.8”	59
LSPFUP	Upstream of the Public Use Site below My Creek	61° 26’ 29.8”	150° 09’ 35.5”	25.5
LSPFDN	Downstream of the Public Use Site	61° 26’ 07.4”	150° 10’ 21.8”	24.8

Aerial photographs (2004) were downloaded from the University of Alaska, Fairbanks, and combined by overlaying physical features to form a continuous aerial view of the Little Susitna River. Stream miles were measured and marked on the aerial photograph from the Susitna Lodge and runway at river mile 15 to Edgerton Park Road at river mile 92. Bank and riparian development were evaluated using the methods previously applied on Montana Creek (Davis et al. 2006a). The total amount of bank habitat was determined as twice stream length plus twice the length of major secondary channels (6 miles) located between Edgerton Park Road and Schrock Road. The riparian area was arbitrarily determined to extend 50 m lateral to the bank. Total riparian area was determined by multiplying the total bank habitat in meters by 50. Areas of modified banks or riparian area were identified on the aerial photographs. The length of bank modification and area of riparian modification were measured from the aerial photographs. The causes of bank or riparian modification were based upon the types of clearing or structures within modified areas. The sites were located on current Matanuska-Susitna Borough tax maps and identified by tax map, section, and lot.

Water samples were collected from all sites for chemical analyses in August of 2006 and May and June of 2007. Samples were analyzed for pH, specific conductance, turbidity, nitrate-nitrite nitrogen, ammonia nitrogen, total phosphorus, total dissolved phosphorus, and alkalinity. Dissolved oxygen and temperature were measured *in situ* on each sampling date. Water samples were collected from LSEDG, LSCHR, LSHUDN, and LSPFDN on four dates in May and June of 2007 for fecal coliform bacteria analyses. Water samples were analyzed for volatile organic carbon compounds from samples collected at LSPFDN on August 14, 2006, and from LSHUDN, LSPFUP, and LSPFDN on June 20, 2007. Water temperature was recorded every hour using Onset Stowaway temperature loggers located at LSEDG, LSCHR, LSHUDN, and LSPFDN. Discharge data were downloaded from the U.S.G.S web site for the weir site at Palmer Fishhook Road.

Stream physical characteristics and large woody debris were measured in May of 2007. Stream substrate size distribution was measured using Wolman pebble counts. Channel and bank characteristics were measured directly at 4 transects, two located on straight sections and two located on bends within each sampling segment. All woody debris was counted within a 100 m sampling reach.

Macroinvertebrates were sampled on May 10 and 11, 2007 and processed using the Alaska Stream Condition Index methods (Major et al. 2001). Juvenile fish were captured during the last week of June with 6-baited minnow traps fished for 12 to 24 hours. Captured fish were identified and measured for fork length and observed for any signs of lesions or other abnormalities.

Results

Riparian Development

The lengths and amounts of riparian development by property are located in Appendix B. We measured 91.7 stream miles from Cook Inlet to the Edgerton Park Road Bridge and an additional 6 miles of stream in secondary channels between Schrock Road and Edgerton Park Road. This is probably an under estimate, due to the large number of side channels and sloughs throughout this river segment. The amount of bank and riparian area modification also may be underestimated as we could not identify small trails on the aerial photographs, which we knew were present based upon ground surveys. We did not observe any extensive bank vegetation clearing or bank modification due to recreational camping from Schrock Road to below the Public Use boat launch. All of the camping occurred on point bars and may have resulted is some minor vegetative impacts.

Recreational impacts were primarily adjacent to Schrock Road, Miller's Reach boat launch and at the Public Use Site.

Vegetated, but cleared land was identified as agricultural, although this may not be the current use. Recreation and transportation modifications often occurred together such as at the Park's Highway. This area was categorized as transportation since that is the primary use; however, recreation use of the area is responsible for some portion of riparian and bank habitat losses.

The amount and percentage of total bank and riparian habitat modification is shown in Table 2. The amounts are broken out by the areas bracketed by sampling stations, which are not separated by equal lengths of the river. For the entire segment, approximately 1% of the bank and riparian area of the Little Susitna River has been modified by human land use. Most bank and riparian modifications were due to residential development and occurred in the river section between Schrock Road and Edgerton Road. Land clearing for apparent agricultural use was the second leading cause of bank and riparian modification and occurred exclusively within this same river section. Other areas of agricultural clearing were identified between Schrock Road and the Park's Highway but they were located greater than 50m from the river. Private, Borough, and State roads were the third leading cause of modification and occurred in the same section of river upstream from Schrock Road.

Table 2. Total amounts of bank and riparian habitat and lengths and areas of bank and riparian modification by land-use category.

Bank Length (m)	Total Amount	Agriculture	Commercial	Gravel Pads	Recreation	Residential	Transportation	Total Modified	Percent of Total
Edgerton to Schrock Road	60,350	704	0	0	0	538	204	1,445	2.40
Schrock Road to Park's Hwy	52,143	0	35	0	93	132	179	439	0.84
Park's Hwy to Millers Reach	12,875	0	54	0	18	97	35	203	1.57
Millers Reach to Susitna Lodge	140,979	0	33	0	83	0	0	117	0.08
Total Segment (m)	**266,346**	**704**	**122**	**0**	**193**	**767**	**418**	**2,203**	**0.83**
Riparian Area (m^2)									
Edgerton to Schrock Road	3,017,520	39,873	0	0	0	43,814	16,292	99,979	3.31
Schrock Road to Park's Hwy	2,607,137	0	0	385	4,287	13,828	17,349	35,850	1.38
Park's Hwy to Millers Reach	643,738	0	4,617	462	769	3,540	1,539	10,927	1.70
Millers Reach to Susitna Lodge	7,048,927	0	3,333	0	8,333	0	0	11,666	0.17
Total Segment (m^2)	**13,317,322**	**39,873**	**7,950**	**847**	**13,389**	**61,182**	**35,180**	**158,422**	**1.19**

Index of Bank Stability

The second project objective was to develop an index of bank stability which could be used to evaluate and quantify bank damage due to boat waves or foot trampling. We were unable to accomplish this objective because we were unable to identify areas of obvious boat-caused bank damage. That is, areas of bank instability were observed, however, at most sites there was not an obvious cause and we could not differentiate between natural and human induced causes. However, we made some qualitative and quantitative observations that could be incorporated into an index. There appeared to be an increase in the amount of point bars in the area downstream from Houston and downstream from the Public Use boat launch. Point bars could be forming from local sources of sediment due to bank erosion that exceed transport capacity. There are point bars at almost every bend from Millers Reach to Lake Creek and just downstream of the Lake Creek confluence. There are very few point bars between Lake Creek and the Public Use boat launch. Point bars also end a few miles below the Public Use boat launch. Bank undercutting also was highest below the Public Use boat launch and would be on the upper end of the distribution of bank undercutting on other regional streams, which rarely exceed 0.5 m (Davis and Davis 2007). However, a qualitative survey of streambanks from Millers Reach to below the Public Use boat launch did not reveal any obvious signs of bank erosion except where the bank vegetation was lost due to foot traffic. These areas were in the immediate vicinity of the boat launch. Downstream of the boat launch at areas of apparent bank erosion we observed fine sediment deposits on the outside of bends during low flow, which would not be expected to occur in these areas where tractive forces are relatively high. We recommend that the following characteristics be measured to develop a bank stability index: bank undercut, bank slope, nearshore substrate size, bank height, bank vegetation cover, and exposed bank soil. Bank soil exposure could be measured from photographs. Multiple measures of these characteristics should be taken at a number of locations (approximately 3 m intervals) and replicated at the outside bends of a number of potentially impacted and reference stream sections.

Chemical Characteristics and Turbidity

Data Collection and Discharge

Water samples were collected for chemical analyses on August 14, 2006, May 14, May 21, June 4, June 12, and June 20, 2007. May 2007 sampling occurred during the rising limb of the hydrograph and June sampling occurred during peak spring flows (Figure 2). August 14, 2006 sampling occurred during the rising limb of the hydrograph during fall storm events and just prior to flows of over 4000 cfs (Figure 3), which occurred on August 19, 2006 (a 50 to 100 year flood event (Conway and Meyer 2006)). Water samples were collected for fecal coliform bacteria analyses at Edgerton Parkway, Schrock Road, Below Houston, and below the Public Use Site on May 21, June 4, 12, and 18. Water samples were collected for VOC analyses on August 14, 2006 and June 20, 2007.

Data Precision

Laboratory measures of accuracy met quality assurance objectives for all sampling dates. Precision measures are shown in Appendix B. Precision did not meet quality assurance objectives of some measures as follows. Ammonia values were on one occasion differed by an order of magnitude from values at the other sites. This has occurred during previous studies, and is believed to be due to diffusion of atmospheric nitrogen from air trapped in the sample bottle. Care was taken during this project to ensure that no air was left within the sample bottles. Water super-saturation with air also may be occurring as water is discharged from the syringe into the sample container. Values that differed by an order of magnitude from other sites, or from replicates, were not reported. Total dissolved phosphorus did not meet the precision objective on one sampling date; however, replicate values differed only by 0.012 mg/L. For total dissolved phosphorus the lower of replicate values is reported. Maximum difference between replicates for total phosphorus was 0.026 mg/L. Phosphorus adsorbs to sediment particles, so differences in sediment could result in differences in total phosphorus. In this case, both values of total phosphorus would be correct. However, we report the lower of the two measures. Turbidity also did not meet precision objectives; however, we believe this was due to variability in turbidity within the water column. The maximum difference in turbidity was 5 NTU. We reported the lower of two replicate values.

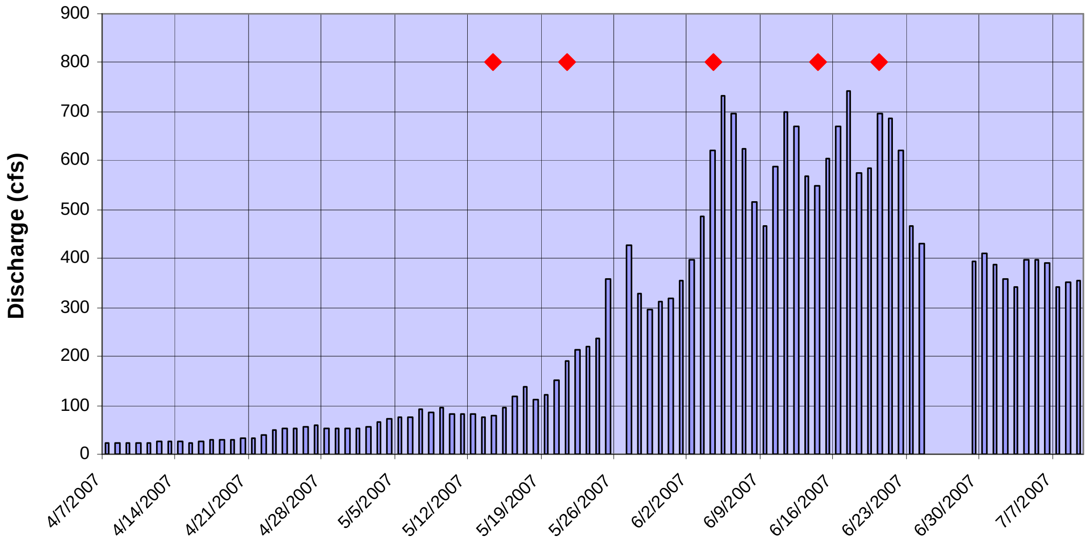

Figure 2. Little Susitna discharge from the U.S.G.S. gauging station on Fishhook Road during spring 2007. The red triangles mark water sampling dates.

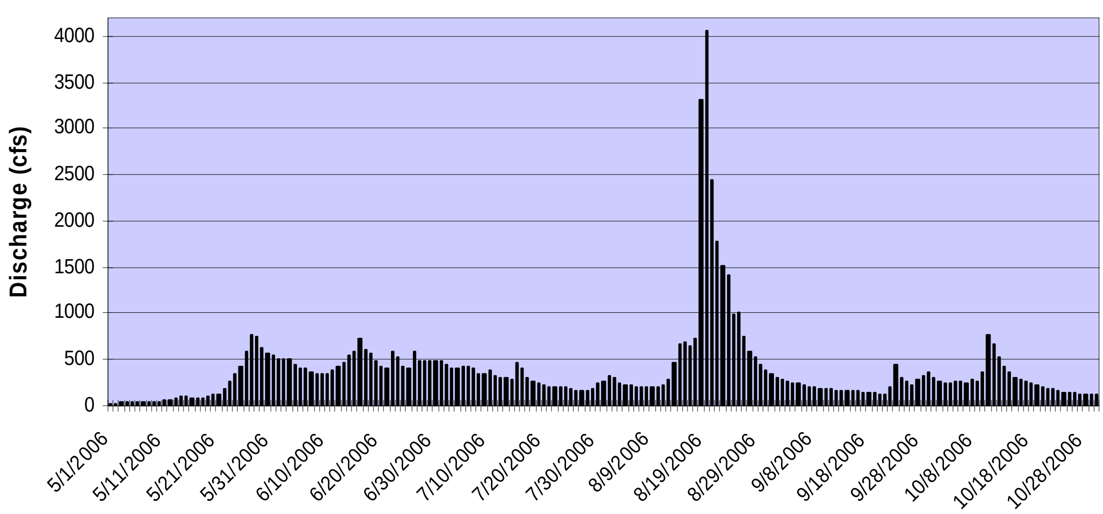

Figure 3. Little Susitna discharge from the U.S.G.S. gauging station on Fishhook Road during 2006 showing high August peak flows.

Specific Conductivity and pH

Water chemical analytical results are shown in Figure 4 through Figure 12. Specific conductivity ranged from 46 to150 µS/cm. Specific conductivity tended to be high at the lower river sites and highest during low spring flows prior to increasing discharge. Trends in alkalinity were similar to specific conductance. Alkalinity ranged from 18 to 68 mg/L $CaCO_3$. Stream water pH was near neutral on all sampling dates. The upper river was more acidic and pH values were lowest on the June sampling dates coinciding with high spring flows (Figure 5).

Turbidity

Stream water turbidity throughout the Little Susitna River increased during high flows following fall storms to 6 to 8 NTU (Figure 6). This is compared to values below 2 NTU during low spring flows, and values of 5 NTU during high spring flows in mid to late June. Boat use occurs upstream and downstream from the Public Use boat launch. Early in the Chinook run all of the boat traffic is downstream from the launch, with use increasing upstream as the fish move up river. There was a marked increase in turbidity below the Public Use boat launch on June 12 and both above and below the Public Use boat launch on June 20, 2007. There was very little variability among the four upstream sampling locations and the average of these four sites was used to define natural conditions. On June 14, turbidity upstream from the Public Use Site was 2 NTU above natural conditions, and 9 NTU above natural conditions below the Public Use Site. On June 20, turbidity was 4 NTU above natural conditions upstream from the Public Use boat launch and 9 NTU above natural conditions below the Public Use boat launch. By comparison, turbidity below the Public Use Site was 2 NTU greater than natural conditions on August 14, during fall storms. Turbidity below the Public Use Site exceeded State Water Quality Standards for drinking water (5 NTU above natural conditions) but not for the growth and propagation of fish (25 NTU above natural conditions).

Nitrogen and Phosphorus

Ammonia nitrogen concentrations were high during fall storms, and early spring, but were below detection limits on May 21 and June 4. However, concentrations began to increase on the June 12 and June 20 sampling dates. Nitrate plus nitrite nitrogen trends were opposite, with high values in early May that decreased in June coinciding with peak flows and increasing terrestrial production.

Ratios of total to total dissolved phosphorus show that dissolved phosphorus dominates the phosphorus pool during high storm flows and spring runoff. Particulate phosphorus was present during high spring flows in mid to late June, while total dissolved phosphorus decreased below detection limits (<0.001 mg/L) (Table 3). Average total and total dissolved phosphorus concentrations were highest on during fall storms and early spring runoff.

Molar ratios of nitrate plus ammonia nitrogen to total phosphorus suggest phosphorus limitation on most sampling dates, with ratios generally below 16 (Table 4). Nitrogen is limiting during periods of phosphorus pulses during storm flows and during early spring runoff. This is particularly apparent for ratios of inorganic nitrogen to total dissolved phosphorus. These ratios show phosphorus limitation except on during the rising hydrograph on August 14, 2006, and the rising spring hydrograph on June 4, 2007.

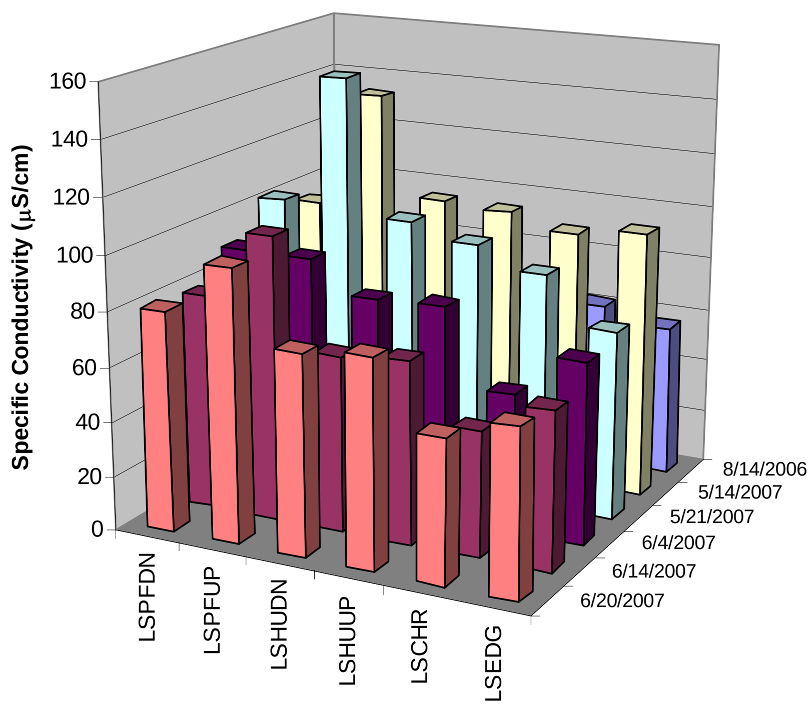

Figure 4. Specific conductivity (µS/cm) for all sampling locations and dates, with highest values occurring during low flows prior to increasing spring discharge. LSEDG=Edgerton Road Bridge, LSCHR=Schrock Road Bridge, LSHUUP= upstream from Houston and the ADFG fish weir, LSHUDN=downstream from Houston at the Millers Reach Launch, LSPFUP=upstream of the Public Use Site boat launch, and LSPFDN=downstream from the Public Use Site boat launch.

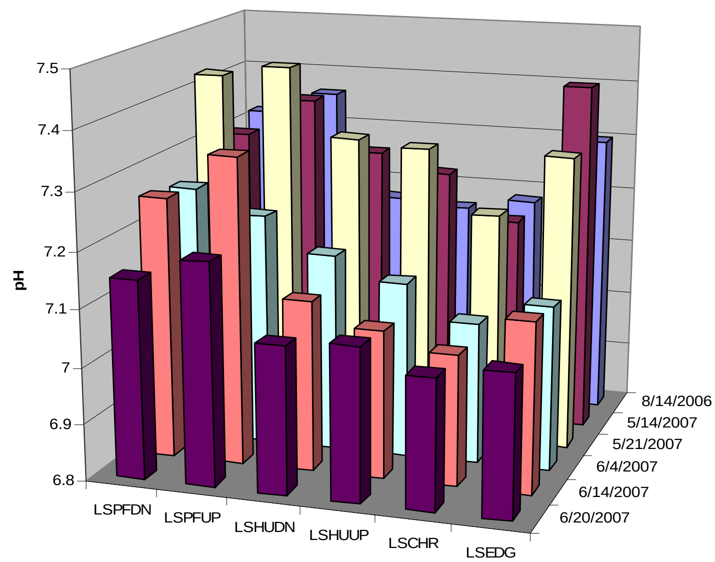

Figure 5. Stream water pH for all sites and all dates. pH was above 7.0 on all dates. Values were lowest during high spring flows and tended to increase downstream.

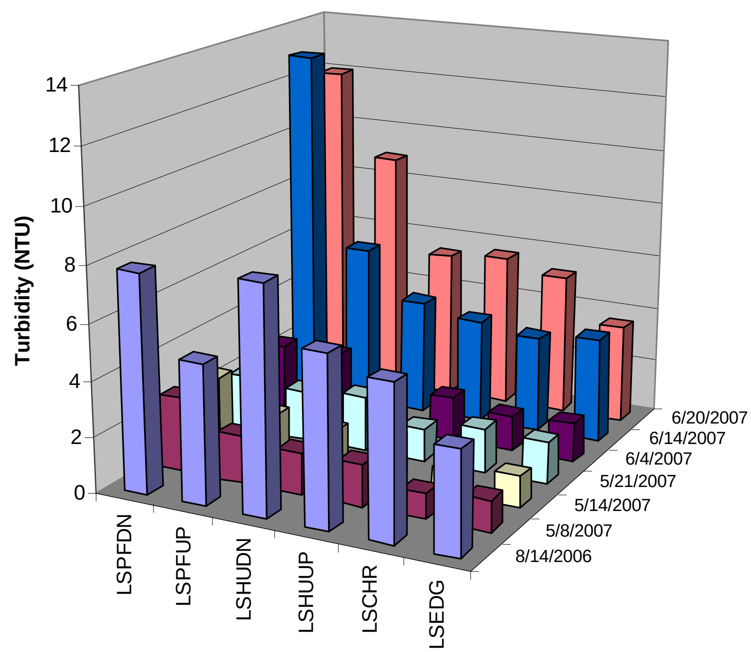

Figure 6. Turbidity was highest during fall rain events. Turbidity increased with increasing flows. There was a marked increase in turbidity below the Public Use Site that coincided with increased use.

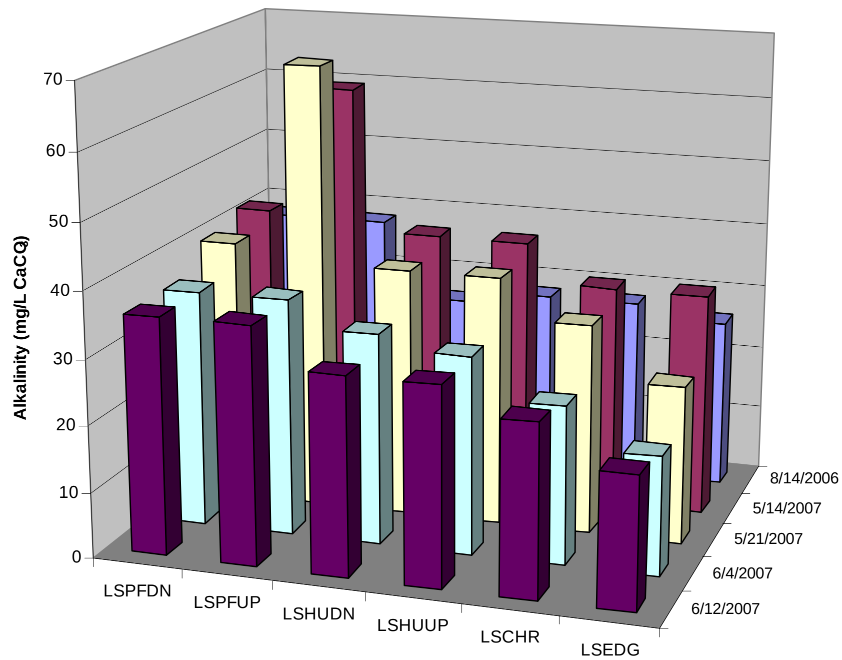

Figure 7. Alkalinity values responded similar to specific conductivity with the highest values during low flows and in the lower river. The high values at LSPFUP reflect the greater influence of My Creek on Little Susitna water chemistry during low spring flows, which enters the Little Susitna upstream of the sampling location.

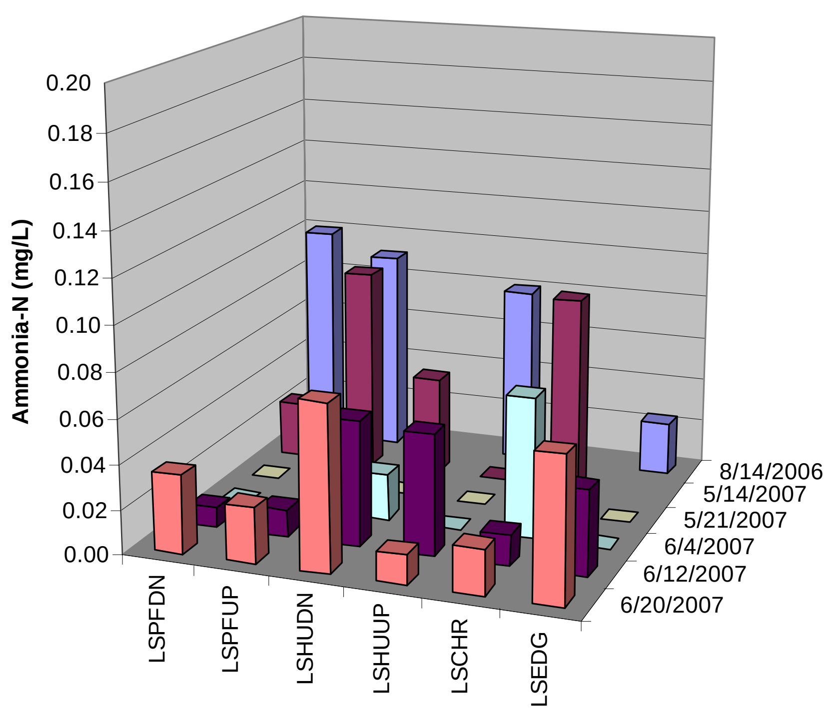

Figure 8. Ammonia nitrogen concentrations were high in August of 2006 and early spring and began to increase again in mid June.

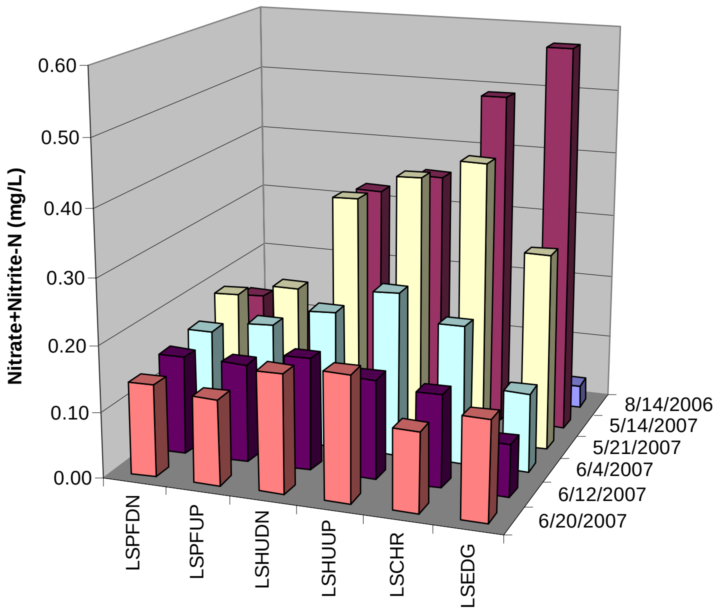

Figure 9. Nitrate nitrogen concentrations were high during low flows in early spring and decreased with increasing flows and increasing terrestrial production.

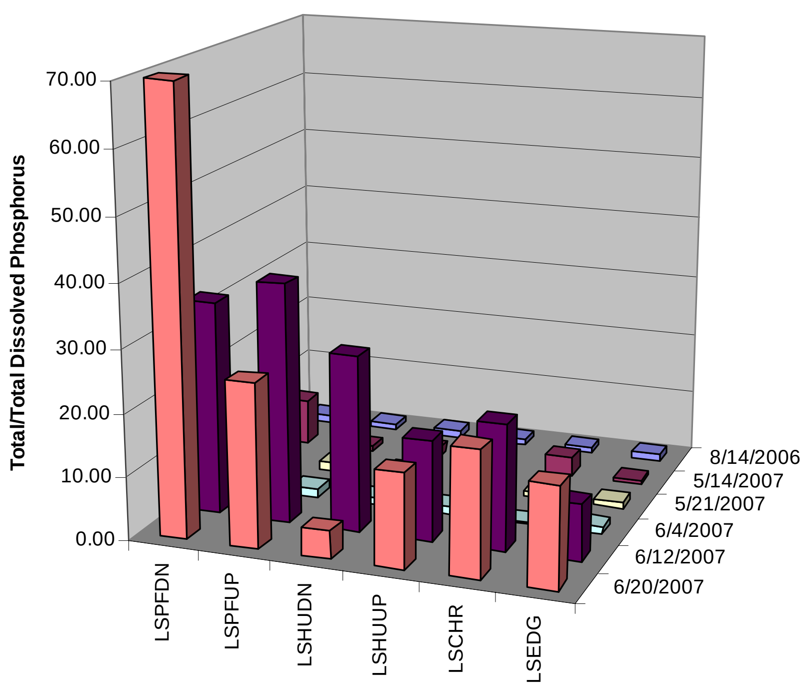

Figure 10. Ratio of total to total dissolved phosphorus showing the dominance of the dissolved fraction during high fall storm flows and early spring runoff and particulate phosphorus during peak spring flows.

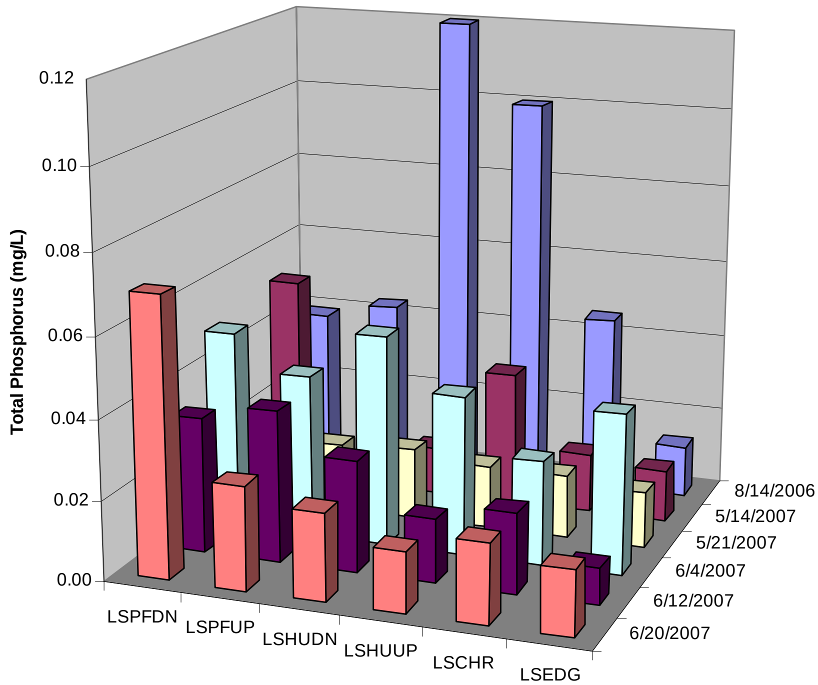

Figure 11. Total phosphorus concentrations for all sites and all sampling dates.

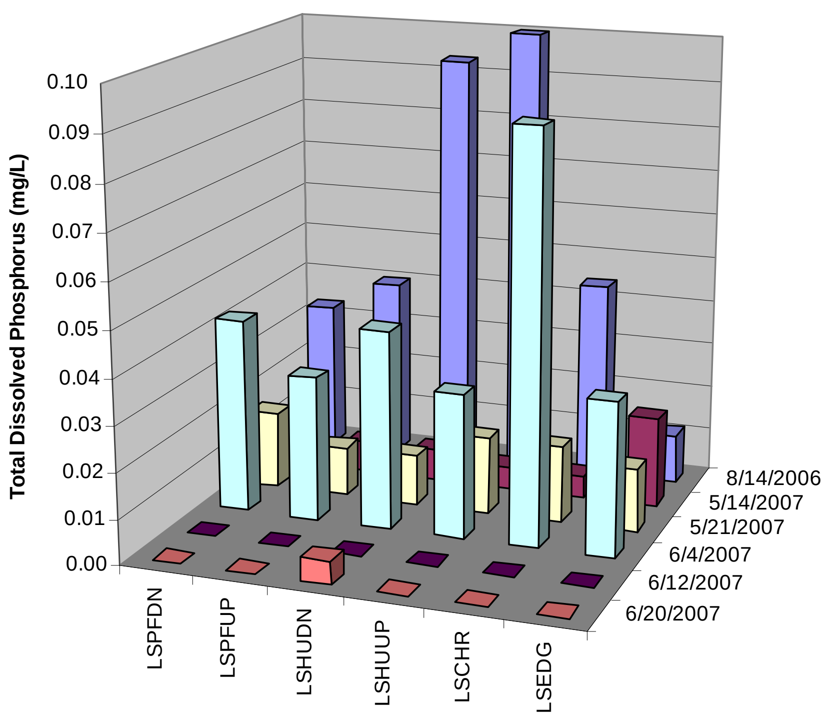

Figure 12. Total dissolved phosphorus concentrations showing higher values during high fall flows and early spring runoff.

Table 3. Total phosphorus (mg/L) above, and total dissolved phosphorus (mg/L) below.

	LSEDG	LSCHR	LSHUUP	LSHUDN	LSPFUP	LSPFDN	Average
8/14/2006	0.013	0.045	0.1	0.12	0.043	0.039	0.060
5/14/2007	0.013	0.015	0.034	0.012	0.006	0.053	0.022
5/21/2007	0.014	0.016	0.016	0.018	0.017	0.017	0.016
6/4/2007	0.040	0.026	0.040	0.053	0.041	0.050	0.042
6/12/2007	0.009	0.020	0.016	0.028	0.038	0.034	0.024
6/20/2007	0.050	0.016	0.020	0.015	0.022	0.026	0.025
Average	0.023	0.023	0.038	0.041	0.028	0.037	
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	LSEDG	LSCHR	LSHUUP	LSHUDN	LSPFUP	LSPFDN	Average
8/14/2006	0.011	0.044	0.1	0.093	0.04	0.033	0.054
5/14/2007	0.02	0.005	0.005	0.007	0.007	0.007	0.009
5/21/2007	0.014	0.017	0.017	0.011	0.011	0.017	0.015
6/4/2007	0.034	0.09	0.032	0.044	0.032	0.043	0.046
6/12/2007	0.001	0.001	0.001	0.001	0.001	0.001	0.001
6/20/2007	0.001	0.001	0.001	0.005	0.001	0.001	0.002
Average	0.014	0.026	0.026	0.027	0.015	0.017	

Table 4. Molar ratios of total inorganic nitrogen to total phosphorus (above) and total inorganic nitrogen to total dissolved phosphorus (below).

	LSEDG	LSCHR	LSHUUP	LSHUDN	LSPFUP	LSPFDN
8/14/2006	10.37	0.56	2.06	0.48	6.96	7.09
5/14/2007	103.74	91.12	25.88	75.05	84.19	7.98
5/21/2007	49.80	62.86	57.86	46.35	29.18	26.22
6/4/2007	7.14	24.00	14.57	9.96	10.31	7.54
6/12/2007	29.71	17.60	29.14	18.45	9.74	10.69
6/20/2007	26.29	24.00	29.41	21.19	14.51	1.14

	LSEDG	LSCHR	LSHUUP	LSHUDN	LSPFUP	LSPFDN
8/14/2006	12.26	0.57	2.06	0.61	7.49	8.38
5/14/2007	67.43	273.37	176.00	128.65	72.16	60.41
5/21/2007	49.80	59.16	54.45	75.84	45.09	26.22
6/4/2007	8.40	6.93	18.21	12.00	13.21	8.77
6/12/2007	267.43	352.00	466.29	516.57	370.29	363.43
6/20/2007	420.57	480.00	441.14	93.26	377.14	80.00

Fecal Coliform Bacteria

Fecal coliform precision was above the 25% limit designated within the QAPP on 3 of the 4 sampling dates. We believe that this is likely due to variability in fecal coliform distribution throughout the water column. Replicate samples were obtained below the Public Use Site where values were highest. The lower of the two replicates is reported. Fecal coliform bacteria concentrations exceeded State Water Quality Standards below the Public Use Site during spring runoff 2007 (Table 5). The most stringent water quality criteria applies to all Alaskan waters, and for fecal coliforms is the criteria for Water Supply, drinking and culinary use. This criteria states that, “In a 30-day period, the geometric mean may not exceed 20 FC/100 ml, and not more than 10% of the samples may exceed 40 FC/100 ml." Geometric mean fecal coliform counts exceeded 20 cfu/100 ml and 25% of the samples (1 of 4 were greater than 40).

Table 5. Fecal coliform bacteria (cfu/100 ml) on each sampling date, 30 day geometric means, and precision from replicate measures. The value of 0.5 is used to calculate geometric mean when fecal coliforms were not detected.

	Edgerton Road Bridge	Schrock Road Bridge	Below Houston	Below Public Use Site	Public Use Replicate	Precision
05/21/07	5	0.5	2	0.5	5	163.64
06/04/07	2	39	12	12	18	40.00
06/12/07	0.5	2	10	58	58	0.00
06/18/07	0.5	2	11	34	61	56.84
Geometric Mean	1.257433	2.971828	7.168049	10.42953	23.75473	

Petroleum Hydrocarbons

Toluene was the only analyte to measure above the detection limit. On August 14, 2006, toluene concentration was 4.1 µg/L below the Public Use Site. The detection limit for toluene is 1.0 µg/L. This is below the TAH water quality standard of 10 µg/L. Toluene was below detection limits in the trip blank. Samples collected on July 20, 2007 downstream from Houston, and above and below the Public Use Site were all below detection limits.

Physical Characteristics

The elevation of the Little Susitna River at its headwaters near Mint Glacier is approximately 1400 m (4500 ft) and flows to sea level (Figure 14). The river from Edgerton Park Road flows primarily from east to west to below Schrock Road, and then flows from northeast to the southwest. Changes in slope occur below Schrock Road and below the Public Use Site boat launch. The Little Susitna River can be divided into three distinct reaches (Frissell et al. 1986) based upon differences in slope, valley form, bed material, and riparian vegetation. From Edgerton Park Road (stream mile 91.75) to approximately river mile 74, below Schrock Road, stream slope is near 0.6%, sinuosity is low, and substrate larger (D50 45mm) than downstream. The stream channel is braided with areas of multiple side channels. There are a number of tributary streams flowing off of the Talkeetna Mountains into the Little Susitna River. Riparian vegetation contains poplars within the birch spruce forest, or is composed of open poplar forests. The river within this reach is confined by high bluffs or mountains, particularly along the right bank. From river mile 74 to the Public Use boat launch at river mile 25, sinuosity increases, substrate size decreases and the river is contained within a single channel. The riparian vegetation changes to an approximate 5 to 10 m margin of tall closed alder and willow scrub followed by the closed birch and spruce forest. Within this reach; however, there are areas where larger substrate occurs. Below the Public Use boat launch (river mile 25), water surface slopes decrease, sinuosity increases, substrate size decreases, and the birch and spruce forest is no longer present.

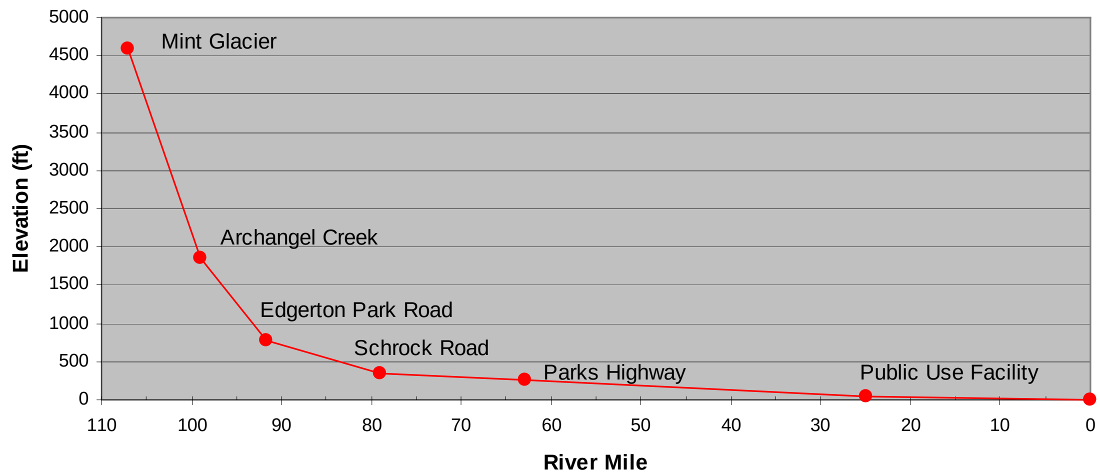

Figure 13. Elevation of points along the Little Susitna River by river mile showing changes in channel slope from the headwaters to Cook Inlet.

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Table 6. Stream channel physical characteristics at sampling stations within the different stream reaches. LWD = large woody debris, LWDI = large woody debris index.

	LSPFDN	LSPFUP	LSHUDN	LSHUUP	LSCHR
Slope from USGS Maps	0.0001	0.0014	0.0007	0.0010	0.0041
Water Surface Slope	0	0.0015	0.0017		0.006
Sinuosity (stream length/valley length)	2.34	1.59	1.75	1.67	1.10
D50 (mm)	2	16	16	16	45
Average Channel Width (m)	38.5	39.2	21.8	29.6	22.8
Average Channel Area (m^2)	63.1	43.6	48.7	57.1	24.8
Average Channel Depth (m)	1.6	1.1	2.2	1.93	1.1
Width:Depth Ratio	23.5	35.3	9.8	15.35	20.8
Maximum Bank Height (m)	0.77	0.68	2.25	2.25	1.23
Minimum Bank Height (m)	0.52	0.44	0.92	1.27	0.47
Maximum Undercut (m)	0.83	0.42	0.30	0.52	0.58
Minimum Undercut (m)	0	0.11	0.10	0.46	0.32
Maximum Upper Bank Slope (degrees)	66	53	54	58	59
Minimum Upper Bank Slope (degrees)	5	19	26	46	46
Maximum Lower Bank Slope (°)	18	24	11	26	27
Minimum Lower Bank Slope (°)	4	1	6	25	5
LWDI/100 m)	267	232	188	437	97
LWD Pieces/100m	18	9	7	3	5
LWD Dams/100m	0	2	2	4	1

Stream channel physical characteristics are shown in Table 6, and particle size distribution in Figure 15. Stream channel slope and water surface slope decreased from 0.6% at Schrock Road to 0.01% below the Public Use Site. Channel width increased from 23 to 39 m. Ratios of channel width to depth were similar among sites with the channel wider and shallower above the Public Use Site, and narrower and deeper at Millers Reach. Bank heights were generally near 1 meter but closer to 2 meters above and below the City of Houston. Large woody debris was considerably higher below the Public Use Site and was composed primarily of alders. We counted very little large woody debris upstream of Schrock Road. This does not coincide with qualitative observations, and we believe that the methodology, designed for small steams, underestimated woody debris within this reach where large wood can be transported.

Substrate size distribution reflected changes in channel and water surface slope with larger particles within the upper steeper reach and smaller particles downstream. Below the Public Use Site the substrate was dominated by fine particles less than 2 mm (sand and silt). Particle embeddedness was greatest below the Public Use Site and upstream and downstream from Houston (Figure 16). The substrate upstream from Houston was unconsolidated and appeared to be recently deposited. Based upon the unconsolidated substrate and signs of water flow over the 2-m high banks, we hypothesize that flood flows in August of 2006 backed up behind the Park's Highway Bridge causing a decrease in water surface slope upstream allowing sediment deposition.

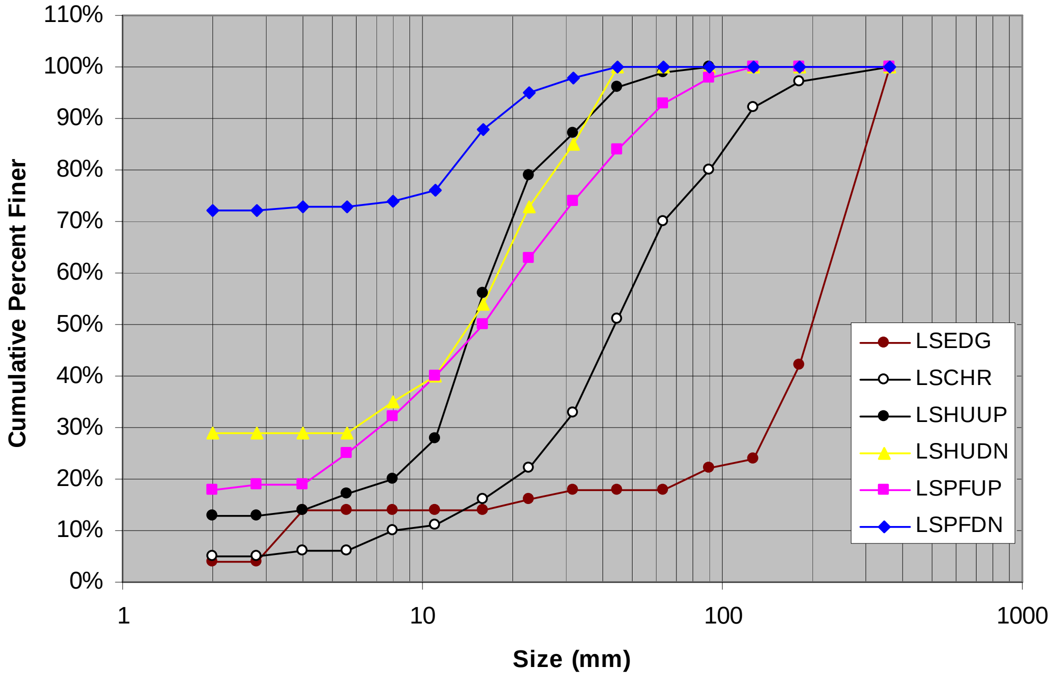

Figure 14. Stream bed particle size distribution.

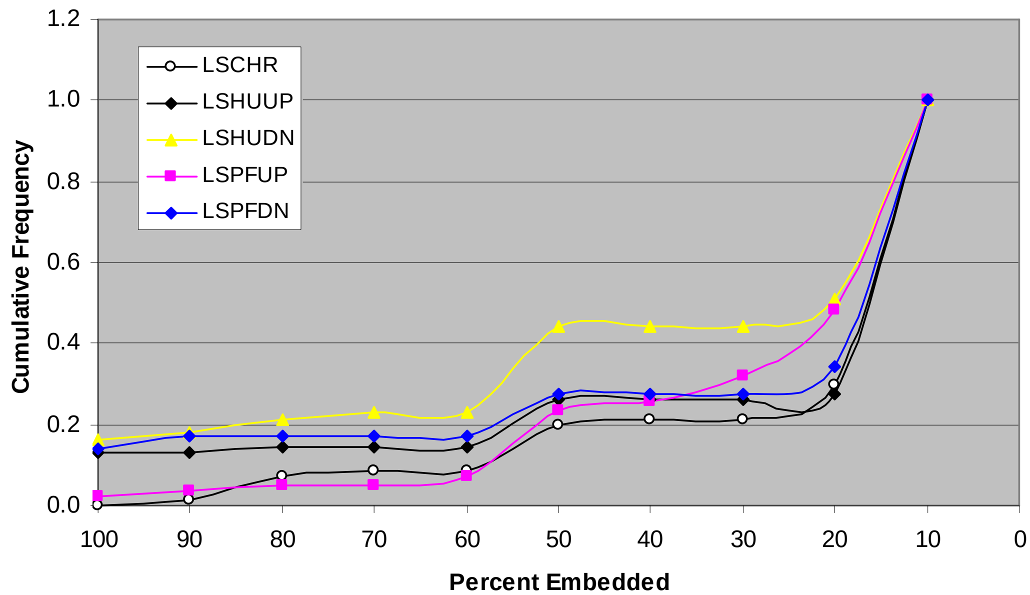

Figure 15. Cumulative frequency of percent particles embedded by fine material.

Water Temperature

Stream water temperature data are shown in Figures 17 through 20. Average and maximum daily temperatures were lowest upstream and highest downstream and increased from May through June. Daily changes in water temperature did not exceed 6°C.

State Water Quality Standards for the growth and propagation of fish, states that water temperatures, "may not exceed 20° C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15°C, Spawning areas 13°C, Rearing areas 15°C, egg & fry incubation 13°C. For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms." Three of these criteria are based on areas, and the fourth (egg and fry incubation) is based upon a time. Migration routes occur throughout the entire project area as adult Chinook salmon were observed upstream of the Edgerton Park Bridge. Rearing salmon were captured at all sampling stations. Young-of-the year fish less than 50 mm were captured at all sites on June 25. This suggests that spawning also occurs throughout the river; however, downstream migration of juveniles could have occurred. Salmon spawning below the public use site is probably limited due to substrate size distribution; however, it is probable that some spawning occurs within this region. The temperature criteria of 13°C for spawning areas, does not appear to be further restricted by potential spawning timing. Egg and fry incubation appears to distinguish a specific time rather than a location as incubation areas would be the same as spawning areas. As spawning areas occur throughout the study segment, the temperature criteria of 13°C, applies.

All of the loggers deployed in July of 2006 were lost during the August flood with the exception of the temperature logger at the Edgerton Park Bridge. The temperature logger at the Edgerton Park Bridge did not download at the end of June and was sent to the manufacturer for data retrieval; however, the retrieved data did not appear accurate and was discarded. Average daily water temperatures exceeded 13°C at the Public Use Site on 13 days prior to July 2, 2007. Similar water temperatures probably extend some distance upstream but do not continue up to the temperature logger placed at the Millers Reach launch.

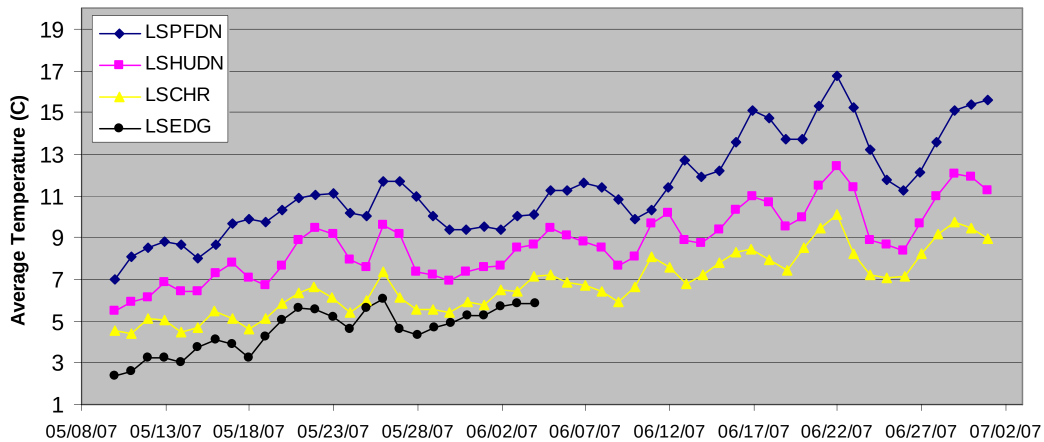

Figure 16. Average daily water temperature by date for the four locations along the Little Susitna River.

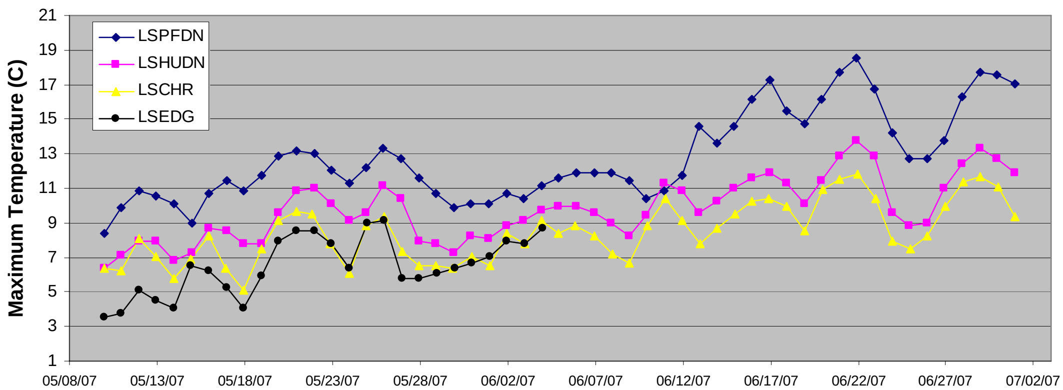

Figure 17. Maximum daily water temperatures. Maximum temperatures exceeded 13°C at the Public Use Site on 17 days and on 1 day below Houston.

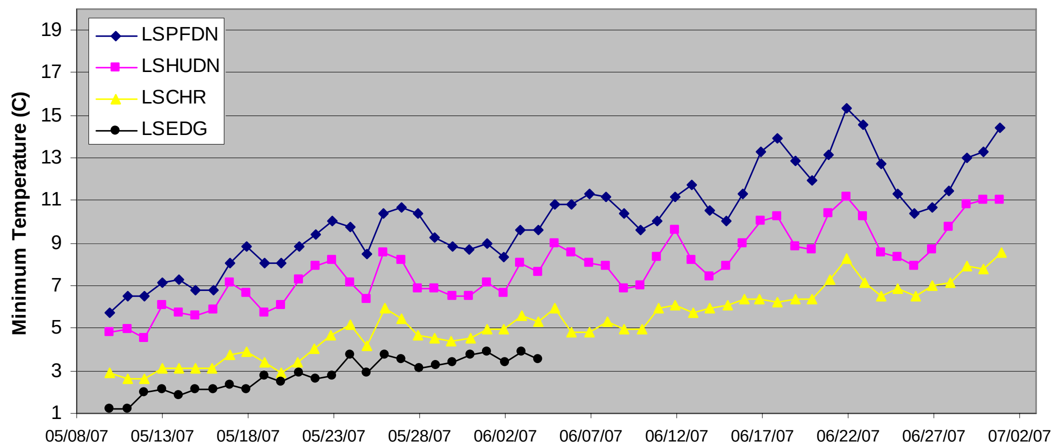

Figure 18. Minimum daily water temperatures. Minimum temperatures exceeded 13°C on 7 days at the Public Use Site.

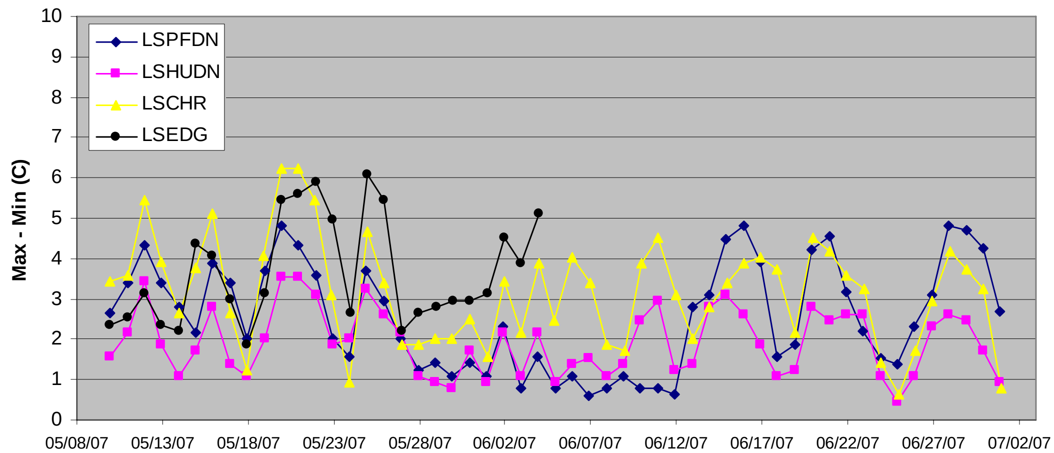

Figure 19. Daily change in temperatures at each sampling site. Temperatures changes were largest within the upper river.

Biotic Characteristics

Results from the macroinvertebrate community sampling are provided in Table 7. ASCI methods are based upon metrics developed from 300 individuals. At the site located downstream from Houston (LSHUDN) and the site downstream from the Public Use Site (LSPFDN), the entire composite sample was picked but 300 individual organisms were not obtained. Downstream from Houston, 216 individuals were found and only 88 in the sample collected below the Public Use Site. ASCI metrics do not document low invertebrate densities. Macroinvertebrate metrics from these sites reflect relative abundances from incomplete samples.

Water Quality based upon ASCI scores was “GOOD” to “Excellent” for all sites. Differences in ASCI metrics scores were similar among all sites. Differences among site were due to the relative abundance of Plecoptera taxa and the portion of non-Baetied Ephemeroptera. Macroinvertebrates were collected previously in 1998 and 2000 from two locations: below the Park's Highway and near Sushana Road (Major et al. 2001). ASCI metric scores from these studies ranged from 53 to 75 below the Park's Highway and from 65 to 91 within the upper reach (Major et al. 2001 Appendix B).

Table 7. Macroinvertebrate community metrics and resulting ASCI scores.

	LSEDG	LSCHR	LSHUDN	LSPFUP	LSPFDN
Total Organisms	320	301	216	251	88
Ephemeroptera	279	231	75	91	32
Plecoptera	11	4	12	25	22
Trichoptera	3	12	28	42	32
Diptera	24	52	98	39	1
Richness	13	12	12	14	11
Ephemeroptera Taxa	4	3	3	2	3
Trichoptera Taxa	1	3	2	3	2
% Plectopera	3.44	1.33	5.56	9.96	25.00
% Ephemptera (no Baetidae)	11.88	20.27	2.78	8.76	6.82
% Diptera	7.50	17.28	45.37	15.54	1.14
Baetidae/Ephemeroptera	0.86	0.74	0.92	0.76	0.81
% Non-insects	0.31	0.00	0.00	1.59	0.00
HBI	3.86	3.60	4.42	3.76	2.53
%Scrapers	10.31	0.00	0.93	0.00	1.14
% Collectors	79.69	81.73	62.50	44.62	35.23
% EPT no Baetids or Zapada	15.00	24.92	19.44	27.89	50.00
Low Gradient with Coarse Substrate ASCI Scores					
Ephemeroptera taxa 100 * X / 5.5	72.73	54.55	54.55	36.36	54.55
% Ephemeroptera (no Baetidae) 100 * X / 20	59.38	101.33	13.89	43.82	34.09
% Plecoptera 100 * X / 14	24.55	9.49	39.68	71.14	100.00
Baetidae / Ephemeroptera 100 * (100 - X) / 100	13.62	26.41	8.00	24.18	18.75
% non-insects 100 * (30 - X) / 30	98.96	100.00	100.00	94.69	100.00
O/E (family 75%) 2 100 * X	80	80	90	90	90
% scrapers 100 * X / 15	68.75	0.00	6.17	0.00	7.58
HBI 100 * (6.5 - X) / 2	100.00	100.00	100.00	100.00	100.00
Average	**64.75**	**58.97**	**51.54**	**57.52**	**63.12**
Ranking	**Good**	**Good**	**Good**	**Good**	**Good**
Low Gradient with Fine Substrate					
Trichoptera taxa 100 * X / 7					28.57
% EPT (no Baetidae or Zapada) 100 * X / 15)					100.00
% Diptera 100 * (100 - X) / 70					100.00
O/E (family 75%) 1 100 * X					50.00
% collectors 100 * (100 - X) / 70					92.53
HBI 100 * (6.5 - HBI) / 2					100.00
Average					**78.52**
Ranking					**Excellent**

Six different fish species were collected within baited minnow traps (Table 8). Dolly Varden (*Salvelinus malma Walbaum*) were the only fish captured at the Edgerton Park Bridge. Coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) were included in the catch at Schrock Road. Sculpin (*Cotttus* sp.) and sticklebacks (*Gasterosteus aculeatus*) were added at the site above Houston but not below Houston. Dolly Varden were not captured above or below the Public Use Site; however, burbot (*Lota lota*) were captured below the launch. We were surprised by the lack of rainbow trout at any site.

Table 8. Total catch and average catch per trap by species and for total salmonids.

	DV	Co	K	SB	SC	Salmonids
LSEDG						
Total	27	0	0	0	0	27
Ave/trap	4.5	0	0	0	0	4.5
SD	4.6	0	0	0	0	4.6
LSCHR						
Total	143	97	1	0	0	241
Ave/trap	23.83	16.17	0.17	0	0	40.17
SD	11.75	13.99	0.41	0	0	24.95
LSHUUP						
Total	10	50	2	3	3	62
Ave/trap	1.67	8.33	0.33	0.50	0.50	10.33
SD	2.25	4.59	0.52	0.55	0.55	5.20
LSHUDN						
Total	8	30	10	0	0	48
Ave/trap	1.33	5.00	1.67	0	0	8.00
SD	2.34	5.51	2.66	0	0	4.94
LSPFUP						
Total	0	58	6	36	3	64
Ave/trap	0	9.67	1.00	6.00	0.50	10.67
SD	0	8.02	1.26	4.86	0.55	8.62
LSPFDN						
Total	0	84	48	18	2	132
Ave/trap	0	14.00	8.00	3.00	0.33	22.00
SD	0	6.26	9.42	2.97	0.52	15.28

Average catch per trap for salmonids was greatest at the Schrock Road site followed by catch rates downstream from the Public Use Site boat launch. Salmonid catch per trap was significantly higher at the Schrock Road site than all other sites except for downstream from the boat launch (ANOVA and Tukey Multiple comparison alpha < 0.05). Catches were dominated by young-of-the year coho and Chinook salmon (Figure 20). Of the 319 juvenile coho salmon captured, 20% were greater than 55 mm and considered 1 year old, although there was not a definite bimodal distribution of coho sizes demonstrating more than one age class. There appeared to be two age classes of Chinook salmon and three age classes of Dolly Varden. We did not observe any signs of lesions, tumors or abrasions. There were some eroded or damaged caudal fins, but this may have been due to trapping.

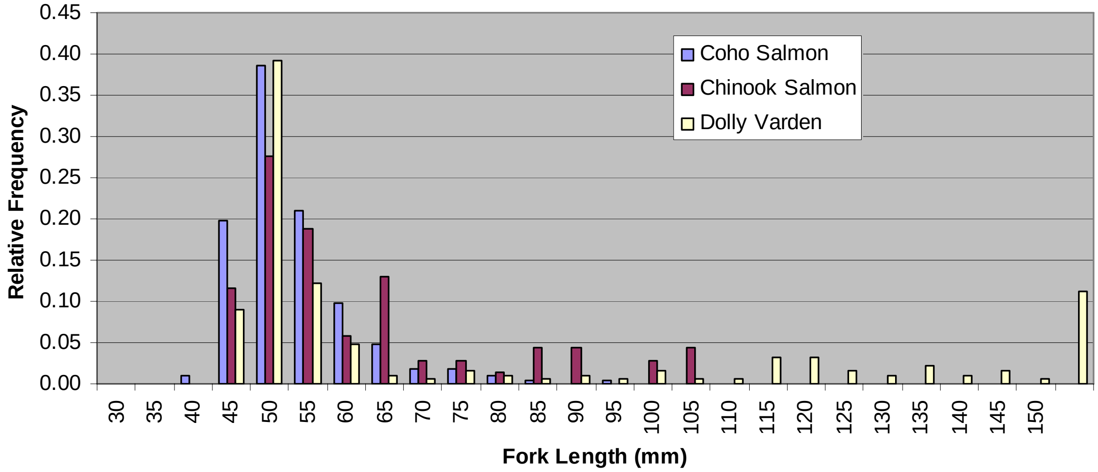

Figure 20. Relative frequency for species by fork length.

Discussion

Measurement of bank and riparian development from aerial photography appears to be an effective way to evaluate differences in streamside development among streams and over time. The method is limited by the ability to view small scale effects like trails or small access points on private property. Similar surveys should be conducted on other streams within the Matanuska-Susitna Borough using the 2004 aerial photography. Riparian and bank development along the Little Susitna River based upon the 2004 aerial photography is due to residential development, agricultural clearing, and roads and transportation corridors. Streamside modifications occur most often in the river reach between Schrock Road and Edgerton Park Road. The 3% bank and habitat modification within this 13 mile reach is similar to development along Montana Creek, where 7% of the bank and 4% of the riparian habitat was modified (Davis et al. 2006). Residential development within the riparian area led to bank modification at 30% of the 43 developed lots upstream of Schrock Road. This is twice as much as the 16% measured on Montana Creek. Recreational use was the major cause of riparian modification on Montana Creek, as opposed to residential development along the Little Susitna. The differences between the two streams likely are due to differences in road access and proximity to major population centers. Recreational bank damage along Montana Creek was mostly the result of foot accessible sport fishing within the Lower River. We observed similar bank damage along the Little Susitna due to foot traffic upstream of the Public Use Site boat launch and downstream from the boat launch below the walkways.

Stream turbidity increased from near 1 NTU to near 4 NTU in mid June during peak spring flows. Increases in turbidity in June also were measured in Hatcher Pass, above all development due to increased glacial runoff (Davis et al 2006b). There was clearly an observable increase in turbidity as boat traffic increased during the sport fishery. Increases in turbidity can result in reduced light penetration and a reduction in primary production as well as direct and indirect affects to stream invertebrates and fish (Loyd et al. 1987). It is not clear whether the changes were caused by the suspension of bed materials or eroded from the banks. The substrate within the lower river reach below the boat launch is composed of a large quantity of sands and silts, but we do not know if this reflects a change in conditions following increased boat use. Small substrate particle size is to be expected in a stream reach with such a low water surface slope. Bank undercutting over 1 m downstream of the Public Use Site boat launch supports the hypothesis that boat waves were causing some bank erosion. It appeared however, that steambank sloughing was not occurring as long as bank vegetation was in place. Bank sloughing was occurring where foot traffic caused the removal of bank vegetation below the walkway downstream from the boat launch. Bank vegetation has also been measured to prevent bank sloughing at a number of restored sites within the Susitna drainage (Davis and Davis 2007).

Regardless to changes in turbidity and potential increased bank erosion rates, juvenile fish were abundant within this lower river reach with average catch rates second only to those at Schrock Road. In addition to the amount of large woody debris measured during surveys within each sampling section, we snorkeled along the outside of a bend below the Public Use Site and observed a large amount of woody debris and complex bank habitat as a result of alders that had entered the stream from eroded banks. A large amount of woody debris was observed in Wasilla Creek as a result of bank sloughing due to grazing (Davis and Muhlberg 2002). Woody debris can redirect flow, causing additional bank scouring (Thorne 1990). This process of erosion, followed by deposition leading to more erosion has been observed by others (Beeson and Doyle 1995).

Primary production appears to be limited by phosphorus concentration. Molar ratios of inorganic nitrogen to total phosphorus were generally above 16 to 18 suggesting phosphorus limitation (Redfield 1958, Kahlert 1998), except following precipitation events and spring runoff when rising phosphorus concentrations reduced ratios. The general trend in nutrient concentrations appears to be similar to other streams within the Cook Inlet Ecoregion. Phosphorus, in particular total dissolved phosphorus, is in low concentrations during low flow conditions, but increases during spring runoff and storm flow and is likely due to the flushing of dissolved phosphorus, which is water soluble when reduced, from upland wetland and terrestrial soils. Nitrogen concentrations appear to be related more to terrestrial productivity than to the hydrograph. Nitrate concentrations tend to be higher in the spring and fall when terrestrial production is lowest and decrease with increasing upland production. Ammonia nitrogen concentrations tend to increase with terrestrial production and may be related to nitrogen fixation by cyanobacteria, symbionic with alder, which are ubiquitous along streams within the Cook Inlet Ecoregion.

There were increases in fecal coliform bacteria in the lower river that coincided with increased human use. We documented similar increases in fecal coliform bacteria within

Montana Creek that also coincided with the human use during the sport fishery (Davis et al. 2006). If the increases in bacteria were related to salmon migration or increase in other mammals such as bears, we would expect the changes to be noted throughout the drainage or at concentrated spawning areas and reduced where humans are present. However, we are seeing the opposite, with bacteria concentrations increasing at areas of concentrated human use and not salmon spawning areas. This leads to the hypotheses that there is either leakage from the restroom tanks or they are not being used 100% of the time. Sampling should be conducted at multiple sites (Montana Creek, Willow Creek, Little Susitna, Sheep Creek, Deshka River) where fecal coliform contamination during the sport fisheries could be evaluated.

Residential development is concentrated within the upper river reach from Schrock Road to Edgerton Park Road. This is an important area for salmon spawning and rearing. This study only provides a cursory look at stream conditions within this complex reach, and we recommend that additional work be focused on this area further documenting bank condition, physical characteristics, and the biotic community. Further studies should be conducted to evaluate the relationship between boat use, turbidity, stream productivity and bank erosion. The one high value for toluene suggests that further water testing should be conducted to evaluate potential hydrocarbon contamination. Hydrocarbon contamination has been documented within the adjacent Big Lake at areas with high motor boat use (Oasis 2006).

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