DEPARTMENT OF ENVIRONMENTAL CONSERVATION
NONPOINT SOURCE POLLUTION PROGRAM
ACWA NPS WATER QUALITY GRANT

FY 2005
FINAL REPORT

PROJECT #: ACWA 05-010

Duck and Jordan Creek Protection and Recovery

July 2005

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Executive Summary

A comprehensive water quality study was conducted from September 2004 through June 2005 in the Mendenhall Valley to assess the current state of water quality and the effectiveness of ongoing restoration projects in Jordan and Duck Creeks. In addition, a bioassessment of Duck Creek was conducted in April and June of 2005. Water quality on Duck Creek was heavily impaired for a variety of parameters, reflecting the extensive urban development within the watershed. Dissolved oxygen routinely dropped below the 7 mg/L criteria set by the state of Alaska for anadramous waters, particularly at sites lower in the watershed. Conductivity values in Duck Creek were quite high reflecting a high ionic load derived from anthropogenic inputs and an influx of iron-rich groundwater. Water temperature at downstream sites also exceeded Alaska standards for spawning water in June, 2005. Fecal coliform bacteria, which have previously been a problem on Duck Creek, were present at low levels suggesting that efforts to remedy this problem have been effective. The bioassessment of Duck Creek showed that the aquatic invertebrate community has not measurably improved since the last data collected in 1994-1996. Duck Creek continues to show signs of environmental stress, andlLow flows and high iron floc and sediment loadings continue to plague the stream between Taku Boulevard and Aspen Avenue. These problems appear to be hindering recovery of the invertebrate community. Taken together, the water quality and bioassessment data for Duck Creek suggest that future restoration efforts in Duck Creek should aim towards augmenting stream flow in combination with control and removal of sediment and dissolved iron. Jordan Creek showed consistently better water quality compared to Duck Creek. Levels of dissolved oxygen were consistently higher and the dissolved ionic load in Jordan was consistently lower compared to Duck Creek. However, Jordan Creek still shows water quality impairments when compared to more pristine streams such as Montana Creek. Dissolved oxygen levels dropped below the state criteria for anadramous waters in June, 2005 during a period of low discharge and high water temperature. Similarly, water temperature exceed the state standard for spawning and rearing waters in June, 2005. Both Duck and Jordan Creek are dependent on precipitation and shallow groundwater for streamflow and suffer from low discharge during dry periods. The lower reaches of both creeks ran dry during the periods in the late spring. This problem is likely being exacerbated by isostatic rebound of the land surface in the Juneau area. Thus, the issue of water quantity will likely increase in importance on these creeks in the future.

Data from this study were presented at two research conferences in 2005: the American Chemical Society meeting in Anchorage and the 26th Annual Meeting of the International Society of Wetland Scientists in Charleston, SC. The research posters from these presentations are being submitted in electronic form with this report and are also available through Dr. Lisa Hoferkamp at the University of Alaska Southeast.

Project Description and Purpose

The purpose of this project was to evaluate the effects of ongoing development on the water quality of streams within the Mendenhall Watershed. The stream corridor of Duck Creek has undergone extensive development but has also been the subject of broad restoration efforts. A suite of water quality parameters was collected at three representative sites on Duck Creek and Jordan Creek. The goal of data collection was to provide baseline water quality information as well as information that can be used to assess pre-established and ongoing restoration efforts on Duck and Jordan Creeks.

The specific goals of this project included:

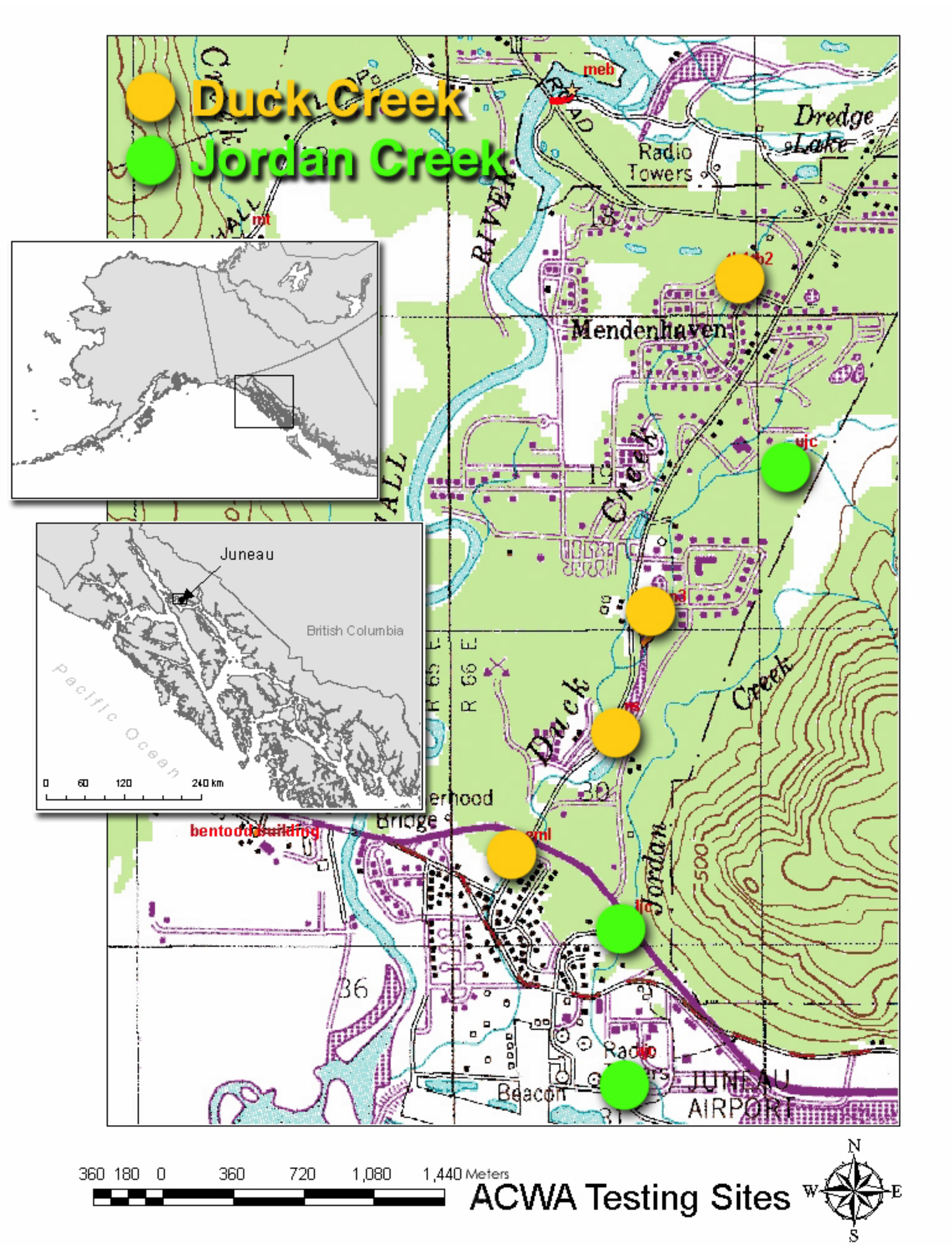
- To document existing water quality conditions in Duck and Jordan Creeks
- To provide water quality data for the Jordan Creek Watershed Assessment
- To use water quality data for Duck Creek and data from Jordan Creek to differentiate natural versus anthropogenic inputs
- To use water quality data for Duck Creek to aid in assessments of various restoration efforts both finished and underway on Duck Creek
- To conduct a bioassessment on Duck Creek in order to evaluate the effectiveness of ongoing restoration projects

Research Design

This project collected data on two streams in the Mendenhall Valley: Duck Creen and Jordan Creek (Figure 1). Samples were collected at three sites on each of the two creeks (Table 1). Duck Creek watershed is 1.3 square miles (above the former USGS gage site at Nancy Street) and includes areas of heavy suburban development as well as 2 acres of created wetland. Jordan Creek watershed is 2.6 square miles (above the Jordan 3 sample site), a large portion of which is suburban development in the Mendenhall Valley.

The sample sites on Duck Creek were chosen to evaluate differently impacted areas of the watershed as well as ongoing remediation projects. DC3 is located farthest upstream on a severely impacted stretch of Duck Creek that has been subject to very limited attempts at remediation and is heavily impacted by groundwater intrusion and iron floc. DC3 will reflect conditions common to the impaired portions of Duck Creek. DC2 is located at the outflow of one of three fill ponds remaining after excavation in the 1960s; the Nancy Street Pond. Nancy Street Pond is immediately downstream from the wetland created in 1998. DC2 will partially reflect changes in water quality resulting from the created wetland but these effects will be lessened due to groundwater intrusion at several locations on the fill pond. DC1 is located on a stretch of the stream that was subject to relocation during the construction of Egan Blvd and Mendenhall Loop Rd. Recent restoration efforts (2000) along the stretch of Duck Creek represented by DC1 include sediment removal (lowering the stream bottom) and streambed lining in an effort to minimize water loss during periods of low flow. However, water loss still occurs at this site as evidenced by the lack of data for this site during the summer months.

Figure 1. Map of the Mendenhall Valley and sample sites used in the study on Duck and Jordan Creeks. One extra sampling site from a concurrent study on constructed wetlands is shown for Duck creek.



Sample sites on Jordan Creek similarly represent differently impacted areas of the watershed. The JC1 site is upstream, closest to the headwaters of Jordan Creek on the western flank of Thunder Mountain. JC2 is located immediately downstream of where Jordan Creek flows under Egan Drive at the site of the US Geological Survey streamgage. JC3 is located at the edge of the Juneau airport property, just upstream from the fish weir operated by the Alaska Department of Fish and Game.

Water quality parameters at the six sample sites were measured bi-monthly throughout the project period. Water temperature, conductivity, dissolved oxygen, and pH were measured in the field using a YSI multi-probe unit. Grab samples were also collected and returned to the UAS lab for analysis of turbidity, and total suspended sediment (TSS). The three sites on Duck Creek were also tested for fecal coliform in the winter, spring and early summer. The fecal coliform determination was carried out by Analytica Alaska Inc, 5840 Shaune Dr., Juneau, AK. Holding times were met for all DC samples sent to Analytica Inc. for fecal coliform determination. Sample sites were chosen to identify source areas for aquatic pollution within the watershed and to monitor changes resulting from restoration efforts.

Aquatic invertebrates were also sampled at two sites on Duck Creek in the spring and early summer. These sites (Taku Boulevard and Aspen Avenue) were chosen because they were sampled in a baseline bioassessment survey conducted during the period 1994-1996 and can thus be compared to the results from that survey.

Table 1. Stream sample locations in the Mendenhall Valley.

Waterbody	Site Code	Site Description
Jordan C	JC1	Jord C @ Amalga Dr
Jordan C	JC3	Jord C @ Super 8 Motel
Jordan C	JC4	Jord C @ Yandukin Footbridge
Duck C	DC1	Duck C @ Egan/Mendenhall Loop
Duck C	DC2	Duck C @ Church of Nazarene
Duck C	DC3	Duck C @ Taku Blvd

Stream sampling was conducted from September 2004 to June 2005. No operating stream gauge was available on Duck Creek, however streamflow was measured continuously on Jordan Creek by the USGS.

Water quality data collected for Duck Creek during the project is shown in Appendix A of this report. Water Quality data for Jordan Creek are shown in Appendix B. A project database has been created at UAS and all data were geo-referenced using the UAS Environmental Science Program's (ENVS) mapping-grade GPS.

Water Quality on Duck Creek

The Duck Creek watershed has undergone extensive development. While small portions of the original upland forest and muskeg still remain, more than 90% of the watershed is developed with various structures and impermeable surfaces. Duck Creek is primarily groundwater fed and subject to iron floc formation originating from groundwater intrusion. The stream channel has been redirected multiple times. Four large ponds resulting from excavation for fill material in the 1960s and located upstream from sampling site DC1 have been and continue to be the focus of restoration efforts. One of these fill ponds (Church of the Nazarene) was converted into a wetland in 1998 and a second (Nancy Street Pond) is scheduled for wetland conversion in July 05. Sampling site DC2 is located at the outlet of the Nancy Street Pond. In general, water quality decreased moving in an upstream direction (toward site DC3). Dissolved oxygen decreased and conductivity and total suspended sediment both increased moving upstream between the three sites (Table 2). However, water quantity was often higher at the upstream sites with the DC1 site having no surface flow during portions of the late spring and summer.

Table 2: Average values (standard deviation in parentheses) for water quality parameters during the period July, 2004 to June, 2005 at 3 sites on Duck Creek.

site	DO (mg/L)	Cond (μS/cm)	pH	Turb (NTU)	TSS (mg/L)
DC1	9.6 (1.8)	177.0 (16.4)	6.7 (0.7)	7.8 (3.4)	3.4 (3.1)
DC2	6.3 (2.4)	168.6 (11.9)	6.4 (0.6)	22.8 (11.1)	8.2 (11.2)
DC3	5.4 (2.9)	240.3 (40.0)	6.5 (0.5)	7.0 (6.4)	7.7 (5.3)

Fecal coliform determinations on Duck Creek are shown in Table 3. Fecal coliform was one of the original impairments that earned Duck Creek a listing on the DEC listing of Alaska's impaired water bodies. The current DEC regulations on fecal coliforms for water used in aquaculture stipulate no more than 200 FC/100 mL. None of the sites sampled exceed the state limits suggesting efforts to remedy this problem have been effective.

Table 3: Fecal coliform counts in FC/100 mL, for three sites on Duck Creek.

	DC1	DC2	DC3
2/17/05	28.0	< 2	< 2
3/11/05	33.3	10.0	13.3
4/11/05	4.0	36.0	4.0

Comparison of water temperature at the three locations along Duck Creek show upstream DC3 to have generally lower and more stable temperatures (Figure 2). DC3 is most dominated by groundwater feed (upwelling occurs at sites all around DC3) and while residential dwellings surround site DC3, the stream cover has remained intact. Higher temperatures at DC2 and DC1 are consistent with the more urbanized surroundings at these sites. Temperatures observed at DC2 and DC1 are approaching the upper limits (20^{o}C) for habitation by salmonid species.

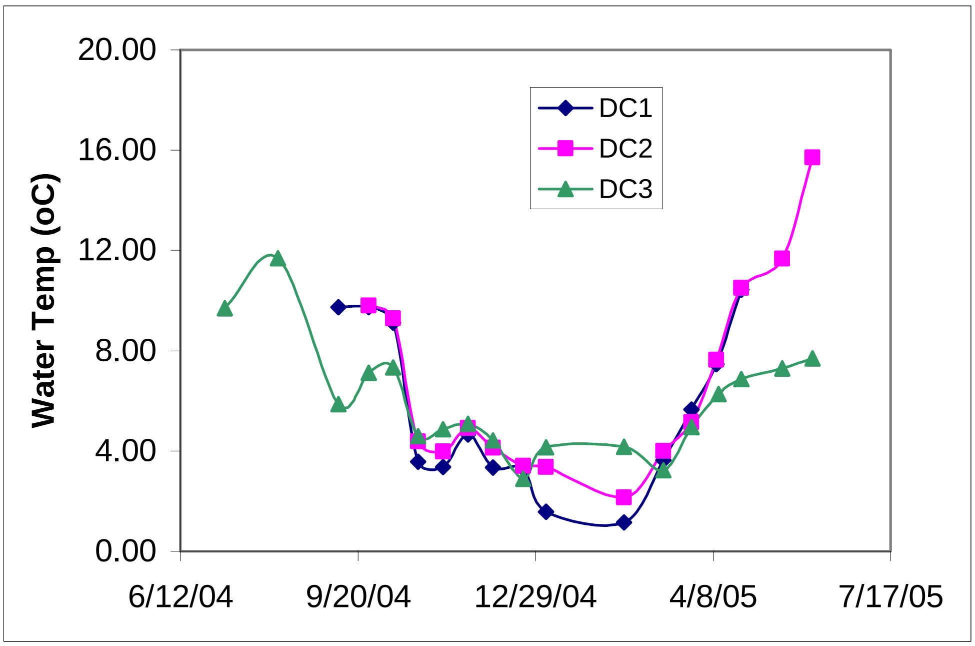


Figure 2: Water temperature at the three sampling locations on Duck Creek.

Values for pH showed significant scatter, ranging from 7.5 to 5.0. Lower pH extremes were consistent with iron-rich groundwater intrusion during dry periods. The oxidation of reduced species prevalent in anaerobic groundwater produces significant acidity as a side-product (see D.O. discussion below for further details).

The state of Alaska water quality standards for turbidity dictate that to protect fish and wildlife, turbidity may not exceed 25 nephelometric turbidity units (NTUs) above natural background conditions. Turbidity is not a direct measurement of solids, but is related to the amount of suspended material in the water column because it is a measure of light attenuation due to absorption and reflection by solids. Turbidity can be expected to closely parallel total suspended solids (TSS). Depending on sampling date and location, Duck Creek water clarity will vary significantly. Significant variation in turbidity and TSS values was observed within a single sampling location as well and this is most obvious at the site representing the unimproved section of Duck Creek, DC3. Turbidity and TSS measurements at DC3 show a large degree of error and thus correlations between these two parameters are not obvious. Turbidity and TSS measurements at all three sites indicate persistent water quality problems on Duck Creek.

Dissolved oxygen (D.O.) has been previously identified as a parameter of concern on Duck Creek. The state of Alaska water quality standards state that dissolved oxygen must be greater than 7 mg/L in waters used by anadramous and resident fish. For waters not used by anadramous or resident fish, D.O. must be greater than 5 mg/L. Among the objectives of restoration efforts on Duck Creek, reestablishment of a healthy salmonid habitat is primary and therefore the water column DO goal is 7 mg/L. While average D.O. levels in Duck Creek meet water quality criteria within error limits, closer inspection of the data indicates acute problems at all three sites (Figure 3).

Levels of D.O. at site DC1 are acceptable. Water loss at this site during drier months is the major concern with respect to anadroumous fish populations. Lower D.O. levels at DC3 can be explained by considering the groundwater source of this stretch of Duck Creek. Anaerobic groundwater from SE Alaska is typically high in dissolved ferrous iron and sulfide ion. These two species are unstable under surface conditions and quickly oxidize to ferric iron and sulfate ion, consuming significant amounts of oxygen in the process. Supporting this conclusion are the significantly higher conductivities measured at DC3 compared to the two other sites (Figure 4). Conductivity quantifies dissolved ions in the water column. The presence of the charged species, Fe^{2+} (ferrous iron), Fe^{3+} (ferric iron), S^{2-} (sulfide ion) and SO_4^{2-} (sulfate ion) is consistent with the higher conductivities measured at DC3. Furthermore, increased acidity is a side-product of oxidation and will further increase conductivity. Time-dependent D.O. and conductivity are presented in Figures 3 and 4 for comparison.

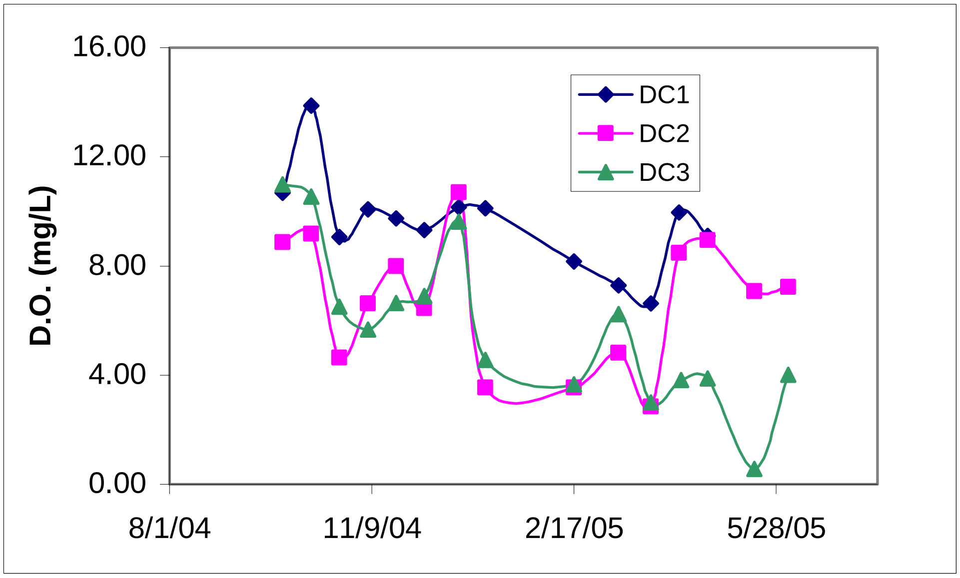


Figure 3: Dissolved oxygen (D.O.) concentrations for the three sites sampled on Duck Creek.

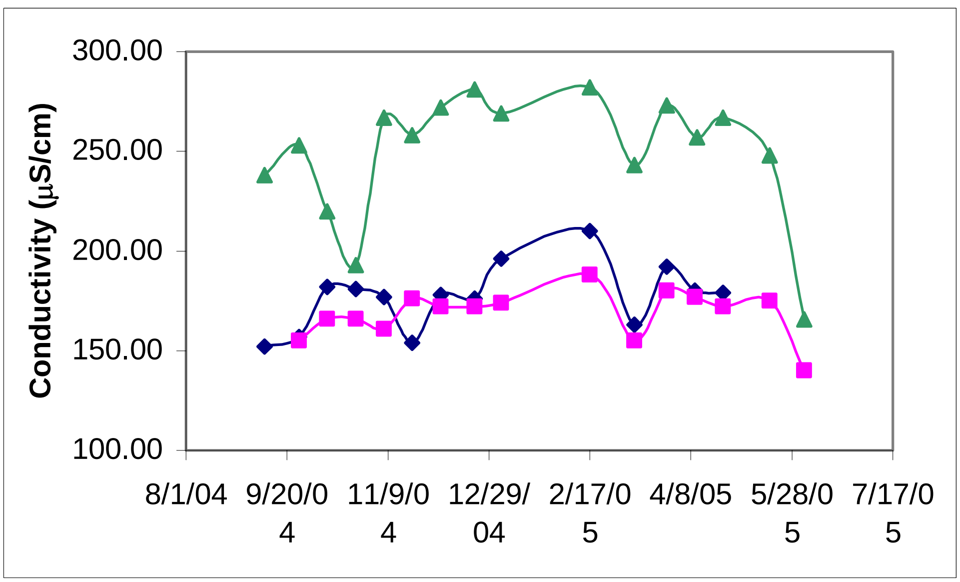


Figure 4: Conductivity values for the three sites sampled on Duck Creek.

Bioassessment on Duck Creek

Bioassessment Background

Duck Creek is listed as an impaired water body by the state of Alaska. Four decades of urbanization in the watershed have contributed to poor water quality and loss of aquatic habitat, diminishing the creek's ability to support fish and wildlife (Koski and Lorenz 1999). In recent years, restoration efforts have included sediment removal, channel and riparian restoration, wetland creation, and improved fish passage.

Since 1996, the stream channel between Taku Boulevard and Mendenhall Boulevard has been restored. The aquatic invertebrate community was surveyed in this reach in 1994-1996, providing baseline information on stream health to gage the success of restoration efforts (Milner, 1996). Invertebrate communities are unique indicators of water and habitat quality because they integrate impacts from multiple stressors over time (Rinella et al. 2003). Invertebrates are also important components of aquatic food webs as they transfer energy from primary producers to secondary consumers such as fishes, waterfowl, and other birds.

The following information is a summary of the results of an invertebrate bioassessment on Duck Creek at Taku Boulevard and Aspen Avenue in the spring and summer of 2005. Results are compared to the baseline survey of 1994/1996.

Methods

Aquatic invertebrates were sampled at Taku Boulevard and Aspen Avenue on 23 and 24 April and 11 June of 2005. Invertebrate sampling, processing, and data analysis procedures were similar to those outlined by the Environmental and Natural Resources Institute (ENRI) at the University of Alaska Anchorage for conducting biological assessments in streams (AK SOP Methods 1-4).

Invertebrate samples downstream of Taku Boulevard were collected in a 100 m long reach restored in 1996/1997. Restoration included replacing fine sediments with cobbles and gravels, narrowing the channel, and increasing the channel depth and sinuosity. Sampling at Aspen Avenue took place in a pond 5 m upstream of the road. The pond has a maximum depth of approximately 1 m, the bottom consists of a thick layer of fine sediment, and thick stands of emergent horsetail (*Equisetum*) cover most of the surface. No restoration has occurred at the Aspen Avenue site.

Aquatic invertebrate data were summarized using five bioassessment metrics that reflect species diversity and tolerance for degraded water quality. Two of the metrics rely on the number of taxa in the insect orders Ephemeroptera (mayflies, E), Plecoptera (stoneflies, P), and Trichoptera (caddisflies, T). EPT taxa are generally most sensitive to water quality degradation. The bioassessment metrics used were:

Percent EPT Taxa – The number EPT individuals divided by the total number of individuals in a sample. In southeastern Alaska, percent EPT Taxa ranges from 65 to 75% in unimpaired streams and from 5 to 40% in urban streams (Rinella et al. 2003).

EPT Richness – The number of EPT genera in a sample. In southeastern Alaska, EPT Richness ranges from 13 to 18 in unimpaired streams and from 4 to 10 in urban streams (Rinella et al. 2003).

Percent Dominant Taxa – The most abundant taxon as a percentage of the total number of organisms in a sample. Numerical dominance by one or two taxa in a community can indicate environmental stress. In southeastern Alaska, Percent Dominant Taxa ranges from 25 to 40% in unimpaired streams and from 45 to 60% in urban streams (Rinella et al. 2003).

Taxa Richness – The number of taxa in a sample. Taxa richness in southeastern Alaska streams ranges from 19 to 23 in unimpaired streams and from 14 to16 in urban streams (Rinella et al. 2003). Taxa richness is sensitive to the taxonomic level of identification. For example, members of the dipteran family Chironomidae (midges) are generally not identified beyond the family level (as in this study). Because the midges in a sample usually belong to several genera, identifying them to genus can greatly increase taxa richness. Taxa richness values given above include midge genera.

FBI (Family Biotic Index) – This index ranges from 0 (most sensitive to water quality degredation) to 10 (very tolerant of degradation). FBI is calculated by multiplying the total number of individuals in a family by the family FBI score and then dividing by the total number of individuals in the sample. In this assessment, several invertebrate orders were treated as families because family level identification was not practical.

Results

The aquatic invertebrate community at the sites examined showed no improvement since baseline data were collected 10 years ago (Table 4). All bioassessment metrics were below or within the range exhibited by other urbanized streams in southeastern Alaska.

Percent EPT taxa values were zero or nearly zero at both sites in both months. Caddisflies were the only EPT taxa collected and they were rare - only 4 individuals were found in the subsamples processed for calculating metrics. Consequently, EPT richness was very low (0-3).

Percent Dominant Taxa in April samples decreased at both sites from 1996 to 2005. This finding should be interpreted with caution because three small and nondescript taxa found in this assessment may have been overlooked or ignored in the baseline survey of 1994/1996. These taxa included the orders Ostracoda (seed or mussel shrimps), Gastropoda (snails), and Bivalvia (clams). Furthermore, although Percent Dominant Taxa decreased at Taku Boulevard over the period, the two most abundant taxa present in 2005 – oligochaets and chironomids, both indicators of poor water quality – made up 97% of the invertebrate community.

Table 4. Aquatic invertebrate taxa and standard bioassessment metrics from two sites in Duck Creek in spring and summer of 1994/1996 and 2005. Biotic Index values for invertebrate families and orders are given in parentheses.

	Taku Boulevard				Aspen Avenue			
Sampling Date	4/23/05	4/12/96	6/11/05	6/13/94	4/24/05	4/12/96	6/11/05	6/13/94
Taxon								
TRICHOPTERA								
Limnephilidae (4)							X	
Onocosmoecus				X				
Lenarchus			X[1]					
Ecclisomyia			X[1]					
Grammotaulius[2]					X		X[1]	
Halesochila[2]							X	
DIPTERA								
Ceratopogonidae (10)								X
Chironomidae (6)	X	X	X	X	X	X	X	X
Empididae (6)								X
Similiidae (6)								
Tipulidae (3)		X		X		X		X
Dicranota			X				X	
Culicidae			X					
COLEOPTERA								
Dytiscidae (5)	X[TR]		X				X[TR]	
OLIGOCHAETA (8)	X	X	X	X	X	X	X	X
OSTROCODA (8)			X		X		X	
GASTROPODA			X		X		X	
BIVALVIA (8)	X		X[TR]		X		X	
HIRUDINEA (8)							X	
% EPT TAXA	**0**	**0**	**0**	**NA**	**<0.01**	**0**	**.01**	**0**
EPT RICHNESS	**0**	**0**	**0**	**1**	**1**	**0**	**3**	**0**
% DOM TAXA	**54**	**88**	**51**	**NA**	**47**	**97**	**77**	**67**
TAXA RICHNESS	**4**	**3**	**11**	**4**	**6**	**3**	**11**	**5**
FBI	**6.1**	**6.0**	**5.9**	**NA**	**6.3**	**6**	**6.2**	**6.2**

[1]Taxa used for Taxa Richness and FBI calculations only; [2]Confirmation of identification pending

Taxa richness also improved over the 10-year period. Apparent gains in Taxa Richness may be real, but could also be explained by the inclusion of overlooked (e.g. seed shrimp) or rare taxa (e.g. various limnephilid caddisfly genera) in calculating the metrics as described above. Even if these gains are real, Duck Creed Taxa Richness values continue to be far below those found in unimpaired water bodies.

FBI values were similar among sites, did not change over the 10-year period, and suggest an invertebrate community dominated by taxa that are tolerant of poor water quality.

Discussion

This bioassessment was conducted at two sites in the upper portion of the Duck Creek watershed where baseline invertebrate community data were collected 10 years ago. Care should be taken in applying these findings to other parts of the watershed.

Duck Creek continues to show signs of environmental stress. Low flows and high iron floc and sediment loadings continue to plague the stream between Taku Boulevard and Aspen Avenue, hindering recovery of the invertebrate community.

Increased stream flows and improved invertebrate habitat (gravels and cobbles) below Taku Boulevard following restoration were short-lived. Groundwater seepage high in dissolved iron has coated these new substrates and many of the invertebrates with iron deposits. Interstitial spaces within the streambed – critical habitat for invertebrates – have filled with silt and sand. In some places, iron floc is so abundant that accumulations where water is slow and shallow have dammed the stream, creating pools up to 8 m long; sediment in these small impoundments exhibit evidence of anoxia. Stream productivity Between Taku and Mendenhall boulevards is probably further suppressed by a lack of sunlight penetrating the thick riparian canopy.

Hydrology and Water Quality on Jordan Creek

Hydrology

The Jordan Creek watershed is comprised largely of suburban development in the Mendenhall Valley, although the creek also receives water from the northwest side of Thunder mountain. Streamflow in Jordan is derived primarily from rainfall and shallow groundwater, as a result, streamflow is relatively flashy, responding quickly to the large frontal rainstorms typical of fall and winter in the Juneau (Figure 2). Large winter storms, particularly rain on snow events, can also cause streamflow to rise dramatically as eveidenced by the discharge record in early March, 2005. Streamflow in Jordan decreases dramatically during the late spring and early summer during periods of low rainfall. The USGS streamflow record on Jordan Creek during the study in 2004 and 2005 is discontinuous because of issues related to funding of the gage and icing during winter months.

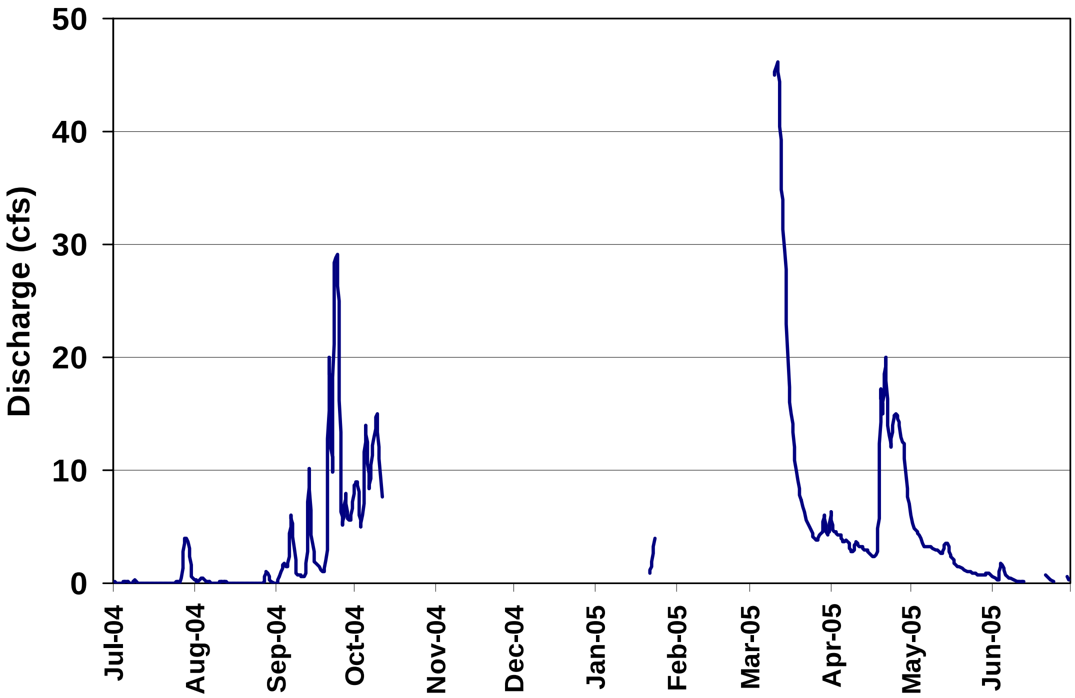


Figure 5. Streamflow on Jordan Creek during the period July 2004 – June 2005.

Water Quality

Conductivity is a measure of ionic strength and, as such, reflects the load of total dissolved solids in the water column. Conductivity values measured on Jordan Creek (Table 5) were generally about 50% of the values measured in Duck Creek but are substantially higher than conductivity on more pristine local streams like Montana Creek (Hood, unpublished data). Conductivity tended to decrease moving downstream in Jordan Creek, which suggests that either inflows to the Creek below the JC1 site have a lower ionic strength or that that dissolved solids are removed by precipitation or biological uptake. The relatively high conductivity in upper Jordan Creek is a likely a result of inputs of ions such as nitrate and sulfate from anthpogenic sources as well as inputs of iron from groundwater.

Table 5: Average values (standard deviation in parentheses) for water quality parameters during the period September, 2004 to June, 2005 at 3 sites on Jordan Creek.

site	DO (mg/L)	Cond (μS/cm)	pH	Turb (NTU)	TSS (mg/L)
JC1	9.8 (1.3)	110.0 (20)	6.3 (0.6)	0.5 (0.4)	1.8 (1.6)
JC2	11.1 (1.7)	80 (10)	6.7 (0.7)	2.0 (1.1)	3.6 (3.0)
JC3	11.0 (2.1)	90 (20)	6.8 (0.5)	2.6 (2.0)	3.0 (2.7)

On Jordan Creek, water clarity is generally quite high and well within water quality standards for the state of Alaska. Average turbidity at the four sample sites ranged from 0.5 to 1.6 (Table 5). Turbidity generally increased moving downstream on Jordan Creek however turbidity at the lowest site on the Creek (JC3) only exceeded 4 NTU twice during the study and never exceeded 9 NTU. It is important to note that weekly sampling is not always adequate for characterizing problems with high turbidity because turbidity impairments can be highly time-specific and are often associated with periods of intense rainfall and high discharge. These results do however show that Jordan Creek does not have chronic problems with high turbidity.

Total suspended solids (TSS) refers to solids that are not dissolved in solution and can be removed by filtration. Suspended solids include both organic particles and inorganic, mineral particles, both of which can contribute to turbidity. Similar to the trends in turbidity, values for TSS were relatively low (typically <4.0 mg/L) on Jordan Creek (Table 5) and consistently about 50% of TSS values measured on Duck Creek.

Average values for pH were predominantly clustered ranged from 6.3 to 6.8 on Jordan Creek (Table 5) and showed relatively little seasonal variation. Values for pH were lowest at the JC1 site and tended to increase moving in the downstream direction.

Water temperature was most stable at the upstream JC1 site (ranging from 2.5 to 7.6 ºC) suggesting that streamflow at this site is dominated by groundwater inputs, which are buffered from large fluctuations in temperature. At the downstream JC2 and JC3 sites, water temperatures had a much larger range (0 to 13.6 ºC) being colder during winter and warmer during the late spring and summer. It is important to note that the JC3 site near the airport exceed the Alaska water quality standard for spawning and incubation areas (13 ºC) in June, 2005.

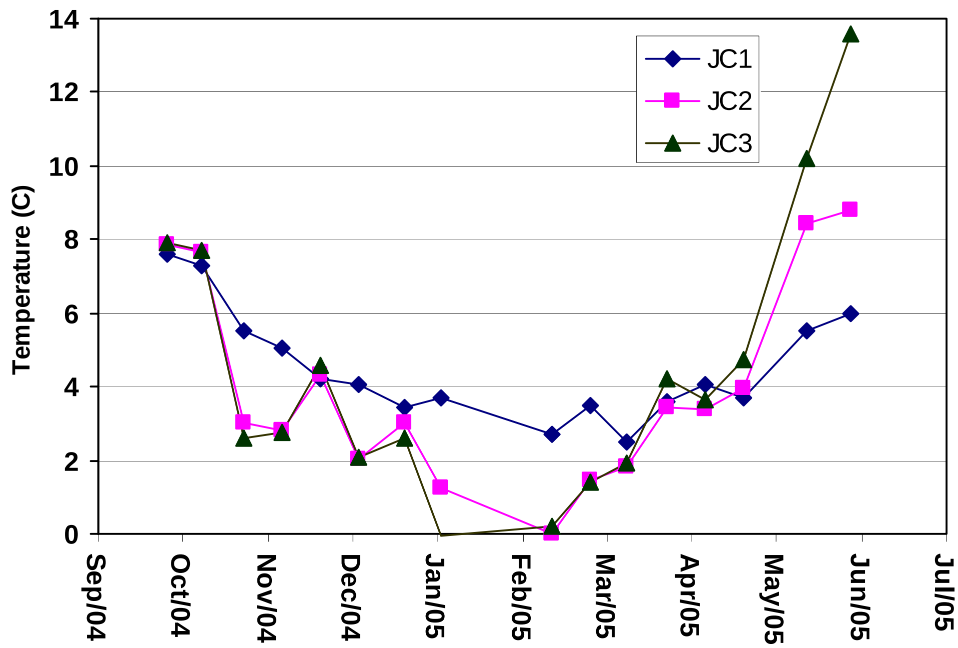


Figure 6. Water temperature at three sites on Jordan Creek during the period September 2004 – June 2005.

Dissolved oxygen (D.O.) has been previously identified as a parameter of concern on Jordan Creek. The state of Alaska water quality standards state that dissolved oxygen must be greater than 7 mg/L in waters used by anadramous and resident fish. For waters not used by anadramous or resident fish, D.O. must be greater than 5 mg/L. Because Jordan Creek has historically supported salmon runs, the water column DO criterion is 7 mg/L. Average D.O. levels on Jordan Creek varied from 9.8 to 11.1 mg/L, well above the 7 mg/L criteria (table 2). However, a D.O level of 6.6 mg/L was measured at the JC3 site near the Juneau Airport in June, 2005. During the fall and winter months, D.O. levels were generally lowest at the upstream JC1 site and increased downstream at JC2 and JC3 (Figure 7). In the spring and summer, when water temperatures increased, particularly downstream, D.O. levels were lower and comparable between the three sites. In general, the lower D.O. concentrations occurred at low streamflows with warmer water temperatures in the late spring and summer.

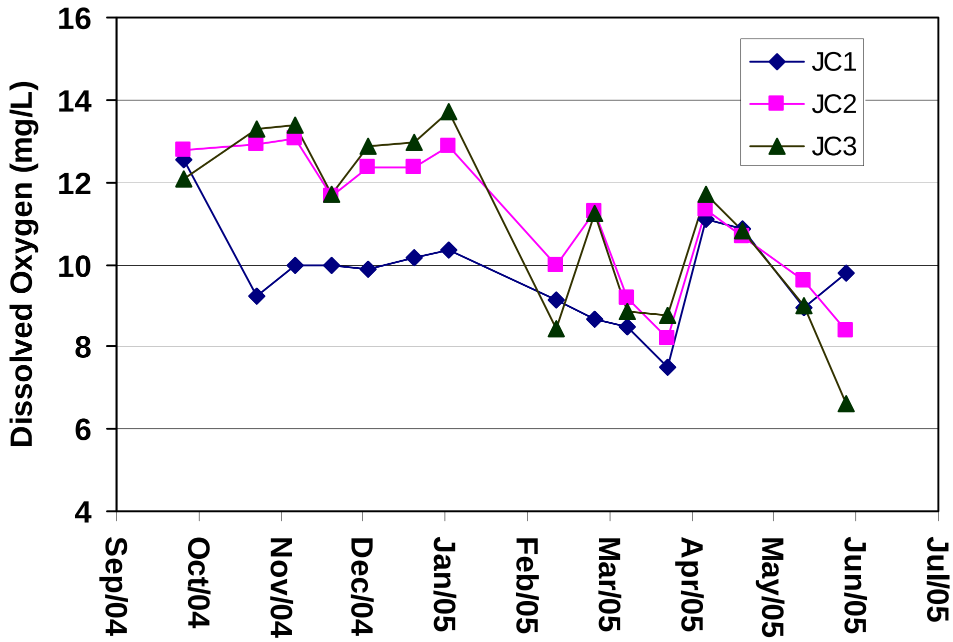


Figure 7. Dissolved oxygen levels at three sites on Jordan Creek during the period September 2004 – June 2005.

There are a number of potential sources of oxygen demand in Jordan Creek. The decay of organic material and the chemical conversion of ammonia to nitrite and nitrate both consume oxygen. However, it is unlikely that the D.O. depressions documented in the spring of 2005 are a result of nutrient conversion because of the relatively low concentrations of ammonium (Hood, unpublished data). Levels of biological oxygen demand (BOD) were not measured in this study however BOD has been shown to be relatively low in nearby Duck Creek (USEPA, TMDLs for Dissolved Oxygen and Iron in Duck Creek). Although Iron was not sampled as part of this study, it is likely that the decrease in D.O. concentrations during low flow periods is, at least in part, a result of an increase in the relative proportion of streamflow derived from groundwater. Groundwater entering Jordan Creek can have high levels of iron from the glaciomarine sediments that underlie parts of the Jordan Creek watershed. Iron rich groundwater consumes oxygen in the water column where the reduced ferrous iron is oxidized to insoluble ferric oxides or hydroxides. These forms of iron precipitate out of the water column as iron floc which coats the stream bed in several reaches of Jordan Creek. Groundwater itself is also depleted in D.O. so that an increase in the proportion of streamflow derived from groundwater results in lower instream levels of D.O. A more complete characterization of iron concentrations on Jordan Creek is necessary for evaluating the extent to which iron oxidation is responsible for instream oxygen demand in Jordan Creek.

References

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Appendix A – Water quality data collected on Duck Creek during the period, July 2004 – June, 2005.

Date	site	DO(ppm)	T(°C)	Cond[a]	pH	Turb(NTU)	TSS(ppm)	Fecal col[b]
7/7/04	DC1	DRY	DRY	DRY	DRY	DRY	DRY	DRY
8/6/04	DC1	DRY	DRY	DRY	DRY	DRY	DRY	DRY
9/9/04	DC1	*c*	9.73	152.00	7.33	2.85	n/a	n/a
9/26/04	DC1	10.67	9.73	157.00	7.33	9.24	bd	n/a
10/10/04	DC1	13.87	9.12	182.00	6.94	7.36	4.00	n/a
10/24/04	DC1	9.06	3.58	181.00	6.84	7.87	5.91	n/a
11/7/04	DC1	10.08	3.36	177.00	6.84	8.11	5.18	n/a
11/21/04	DC1	9.75	4.65	154.00	5.26	12.90	6.79	n/a
12/5/04	DC1	9.32	3.33	178.00	5.51	11.00	6.79	n/a
12/22/04	DC1	10.16	3.30	176.00	5.95	13.60	8.76	n/a
1/4/05	DC1	10.12	1.57	196.00	6.95	6.16	1.79	n/a
2/17/05	DC1	8.16	1.14	210.00	6.21	4.68	bd	28
3/11/05	DC1	7.28	3.63	163.00	6.67	11.10	2.87	33.3
3/27/05	DC1	6.63	5.66	192.00	6.92	5.29	bd	n/a
4/10/05	DC1	9.95	7.46	180.00	7.22	3.89	bd	4
4/24/05	DC1	9.10	10.44	179.00	7.52	5.34	1.70	n/a
5/17/05	DC1	DRY	DRY	DRY	DRY	DRY	DRY	DRY
6/3/05	DC1	DRY	DRY	DRY	DRY	DRY	DRY	DRY
9/26/04	DC2	8.86	9.79	155	6.6	23.3	0	n/a
10/10/04	DC2	9.18	9.28	166	6.63	22.3	7.19	n/a
10/24/04	DC2	4.64	4.38	166	6.5	21.3	7.25	n/a
11/7/04	DC2	6.63	3.97	161	6.55	22.7	8.04	n/a
11/21/04	DC2	8	4.91	176	5.11	26.9	8.39	n/a
12/5/04	DC2	6.46	4.12	172	5.55	23.3	8.73	n/a
12/22/04	DC2	10.7	3.4	172	5.82	47.4	47.6	n/a
1/4/05	DC2	3.54	3.35	174	6.4	21.3	5.45	n/a
2/17/05	DC2	3.54	2.14	188	6.21	8.2	5.31	< 2
3/11/05	DC2	4.81	3.99	155	6.46	36.5	6.42	10
3/27/05	DC2	2.84	5.14	180	6.22	32.8	5.96	n/a
4/10/05	DC2	8.47	7.64	177	6.9	15	5.29	36
4/24/05	DC2	8.94	10.49	172	7.14	12.1	2.26	n/a
5/17/05	DC2	7.07	11.66	175	6.64	5.79	2.32	
6/3/05	DC2	7.23	15.7	140	7.24	n/a	2.35	
7/7/04	DC3	2.53	9.70	166.70	6.96	12.30	n/a	n/a
8/6/04	DC3	3.38	11.70	172.90	6.90	24.20	n/a	n/a
9/9/04	DC3	*c*	5.86	238.00	6.61	11.00	n/a	n/a
9/26/04	DC3	10.99	7.12	253.00	6.64	2.92	5.29	n/a
10/10/04	DC3	10.54	7.34	220.00	6.64	2.18	10.25	n/a
10/24/04	DC3	6.51	4.59	193.00	6.67	16.10	20.31	n/a
11/7/04	DC3	5.68	4.86	267.00	6.74	1.31	15.16	n/a
11/21/04	DC3	6.64	5.08	258.00	5.00	1.31	8.52	n/a
12/5/04	DC3	6.89	4.43	272.00	5.76	1.03	5.54	n/a
12/22/04	DC3	9.63	2.88	281.00	5.91	10.10	5.80	n/a
1/4/05	DC3	4.56	4.14	269.00	6.90	11.30	6.80	n/a
2/17/05	DC3	3.67	4.16	282.00	6.22	2.03	0.84	< 2
3/11/05	DC3	6.24	3.23	243.00	6.59	2.70	1.08	13.3

3/27/05	DC3	3.01	4.95	273.00	6.50	6.90	bd	n/a
4/11/05	DC3	3.82	6.26	257.00	6.38	4.89	9.11	4
4/24/05	DC3	3.88	6.87	267.00	7.13	4.26	8.43	n/a
5/17/05	DC3	0.57	7.30	248.00	6.39	4.31	9.32	
6/3/05	DC3	4.02	7.70	165.60	7.22		8.91	

[a] Conductivity is temperature corrected and reported in μS/cm. [b] Fecal coliform is reported as fecal coliforms/100 mL. [c] DO data unavailable. n/a: data not available. bd: below detection limits.

Appendix B – Water quality data collected on Jordan Creek during the period, September, 2004 – June, 2005.

Date	Site name	DO %	DO mg/L	Temp ˚C	Cond [a]	pH	Turb (ntu)	TSS
9/26/2004	JC1	105.0	12.6	7.6	115	6.5	0.3	n/a
10/9/2004	JC1	n/a	n/a	7.3	124	6.5	0.3	3.2
10/24/2004	JC1	73.5	9.2	5.5	105	5.5	0.7	3.6
11/7/2004	JC1	78.3	10.0	5.0	131	6.5	0.3	3.9
11/21/2004	JC1	78.4	10.0	4.2	116	4.9	1.0	4.1
12/5/2004	JC1	75.7	9.9	4.1	130	5.5	0.2	4.0
12/22/2004	JC1	77.8	10.2	3.4	172	5.8	1.3	0.7
1/4/2005	JC1	79.4	10.3	3.7	113	6.5	0.5	0.6
2/14/2005	JC1	67.2	9.1	2.7	n/a	6.0	0.3	0.0
2/28/2005	JC1	64.3	8.7	3.5	101	6.6	0.2	0.7
3/13/2005	JC1	61.1	8.5	2.5	103	6.6	0.4	0.9
3/28/2005	JC1	56.7	7.5	3.6	102	6.5	1.6	0.9
4/11/2005	JC1	85.2	11.1	4.1	98	6.6	0.3	2.1
4/25/2005	JC1	82.2	10.9	3.7	109	7.2	0.3	0.8
5/18/2005	JC1	71.7	9.0	5.5	95	6.4	0.3	bd
6/3/2005	JC1	78.4	9.8	6.0	57	7.3	n/a	4.8
9/26/2004	JC2	107.6	12.8	7.9	90	7.0	1.3	na
10/9/2004	JC2	n/a	n/a	7.7	88	7.0	1.8	4.3
10/24/2004	JC2	96.7	12.9	3.0	100	7.0	2.3	4.9
11/7/2004	JC2	97.2	13.1	2.8	101	6.9	1.5	4.1
11/21/2004	JC2	90.3	11.6	4.3	68	5.3	4.8	7.1
12/5/2004	JC2	90.4	12.4	2.0	107	5.2	1.1	4.5
12/22/2004	JC2	92.3	12.4	3.0	92	5.9	2.5	1.7
1/4/2005	JC2	91.5	12.9	1.2	101	7.0	1.2	1.6
2/14/2005	JC2	67.1	10.0	0.0	n/a	6.0	1.7	n/a
2/28/2005	JC2	80.7	11.3	1.5	61	7.1	1.7	11.7
3/13/2005	JC2	66.1	9.2	1.8	71	6.9	0.8	2.1
3/28/2005	JC2	61.9	8.2	3.5	89	7.1	2.7	2.0
4/11/2005	JC2	86.0	11.4	3.4	74	7.1	3.5	3.6
4/25/2005	JC2	81.8	10.7	3.9	77	7.3	1.8	2.1
5/18/2005	JC2	81.4	9.6	8.4	90	7.3	0.9	0.6
6/3/2005	JC2	72.5	8.4	8.8	65	7.2	n/a	0.2
9/26/2004	JC3	101.7	12.1	7.9	88	7.3	1.5	n/a
10/9/2004	JC3	n/a	n/a	7.7	86	7.3	1.4	2.8
10/24/2004	JC3	99.0	13.3	2.6	103	7.1	3.1	4.3
11/7/2004	JC3	99.6	13.4	2.8	101	6.9	1.4	4.3
11/21/2004	JC3	91.8	11.7	4.6	63	6.2	5.7	8.2
12/5/2004	JC3	94.3	12.9	2.1	106	5.5	1.1	4.0
12/22/2004	JC3	97.0	13.0	2.6	102	6.4	8.2	6.1
1/4/2005	JC3	94.5	13.7	-0.1	101	7.0	1.1	2.3
2/14/2005	JC3	57.6	8.5	0.2	n/a	6.2	2.2	0.2
2/28/2005	JC3	80.3	11.3	1.4	61	6.9	2.0	0.5
3/13/2005	JC3	64.0	8.9	1.9	72	6.8	1.8	1.5
3/28/2005	JC3	67.4	8.8	4.2	97	7.3	2.6	bd

4/11/2005	JC3	89.4	11.7	3.7	73	7.2	3.8	6.7
4/25/2005	JC3	84.1	10.8	4.7	75	7.3	2.3	1.1
5/18/2005	JC3	81.2	9.0	10.2	90	7.2	0.9	bd
6/3/2005	JC3	63.7	6.6	13.6	70	7.2	n/a	4.8

[a] Conductivity is temperature corrected and reported in μS/cm. n/a: data not available. bd: below detection limits

Appendix C – List of professional meeting presentations related to this research project:

1) Nelson, N., J. Bower, L. Hoferkamp, and E. Hood. Dissolved oxygen levels in urban streams. American Chemical Society Meeting. Anchorage, AK. 2005.

2) Hoferkamp, L., J. Parks, K. Koski. Observed effects of a constructed wetland on streamwater quality, Duck Creek, Alaska. Meeting of the International Society of Wetland Scientists. Charleston, SC. 2005.

Research posters for these presentations are being submitted in electronic form to ADEC with this report.