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

FY 2004
FINAL REPORT

PROJECT #: ACWA-04-R04

Mendenhall Watershed Protection and Recovery

June 2004

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Executive Summary

A comprehensive water quality study was conducted from December 2003 through June 2004 in the Mendenhall Valley to assess the current state of water quality in Jordan Creek, Montana Creek, and the Mendenhall River. Data collected during this study were also used in the development of TMDLs for Jordan Creek. This study highlighted the hydrologic differences between glacial watersheds, which see and increase in streamflow and a decrease in water temperature with the onset of summer, and non-glacial watersheds, which see greatly decreased streamflow and increased water temperatures in the late spring and early summer. Additionally, the glacial Mendenhall watershed had much higher levels of total suspended solids and turbidity than the non-glacial Montana and Jordan Creek watersheds. A parameter of particular concern on Jordan Creek was dissolved oxygen (D.O.). Levels of D.O. decreased to close to 9 mg/L in Jordan Creek during May and June during a period of low streamflow and high water temperatures. And, although this is above the 7 mg/L criteria mandated by the state of Alaska, it appears that D.O. levels in Jordan Creek have the potential to drop below 7mg/L during extended periods of warm, dry weather. Levels of D.O. in the Montana and Mendenhall systems, in contrast, never dropped below 11 mg/L during this study. At the time of this report, data is still being collected on Jordan Creek in order to characterize water quality through an entire annual hydrologic cycle. These data should provide further insight into the magnitude and spatial extent of possible D.O. depletion on Jordan Creek.

Project Description and Purpose

The purpose of this project was to evaluate water quality impacts of ongoing development within the Mendenhall Watershed. A suite of water quality parameters were collected at seven sites in the Mendenhall Valley. This project was designed provide baseline water quality information as well as to collect information that can be used to assess existing pollution controls in the Mendenhall Valley. This information is particularly critical in the case of Jordan and Montana Creeks. Past data collection on Jordan Cr. has been too irregular to meaningfully quantify TMDLs. Montana Cr., although not highly developed yet, is under growing development intensity and other activities that pose a potential threat to the basin's ecological sustainability.

The specific goals of this project included:

- Determining the spatial variability of water quality parameters in the Mendenhall Valley and how these parameters change seasonally with changes in stream discharge.
- Collecting water quality data necessary for establishing TMDLs on Jordan Creek which is on the Section 303(d) list for sediment, debris, and DO.

- Determining the relative contribution of human pollution sources by comparing areas of the Mendenhall Watershed that have been influenced differently by ongoing development in the valley.

Research Design

This project collected data on three streams in the Mendenhall Valley: Montana Creek, Jordan Creek, and the Mendenhall River (Figure 1). Samples were collected at one site on Montana Creek, four sites on Jordan Creek, and two sites on the Mendenhall River (Table 1). Mendenhall River watershed is 85.1 square miles (above the Mendenhall 1 sample site), the majority of which is glaciated. Montana Creek watershed is 14.1 square miles (above the Montana 2 sample site) and includes areas of alpine tundra and snow fields as well as low-lying spruce/fir forests and wetlands. 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.

Water quality parameters at the seven sample sites were measured bi-monthly during the winter and weekly during the spring when streamflow is traditionally at a minimum. Water temperature, conductivity, 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 dissolved oxygen (DO), turbidity, and total suspended sediment (TSS). The density of sample sites was highest on Jordan Creek because of the need to collect water quality information to aid in the development of TMDLs. Additionally, sample sites were chosen to identify source areas for aquatic pollution within the Jordan Creek watershed.

Waterbody	Site Code	Location
Mendenhall R	MR1	Mend R @ Back Loop Bridge
Mendenhall R	MR2	Mend R @ Brotherhood Footbridg
Montana C	MC1	Mont C @ Back Loop Bridge
Jordon C	JC1	Jord C @ Amalga Dr
Jordon C	JC2	Jord C @ Jennifer Dr
Jordon C	JC3	Jord C @ Super 8 Motel
Jordon C	JC4	Jord C @ Yandukin Footbridge

Table 1. Stream sample locations in the Mendenhall Valley.

Stream sampling was conducted from December to June, which spanned a wide range of streamflows. For example, on Jordan Creek streamflow ranged from <1cfs to >50 cfs during the study period. Streamflow data were obtained from the USGS Juneau office which maintains continuously recording stream gauges on the Jordan and Montana Creeks and the Mendenhall River (Figure 1).

Water quality data collected during the project are shown in Appendix A of this report. 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. Project research papers for publication in refereed journals are in preparation.

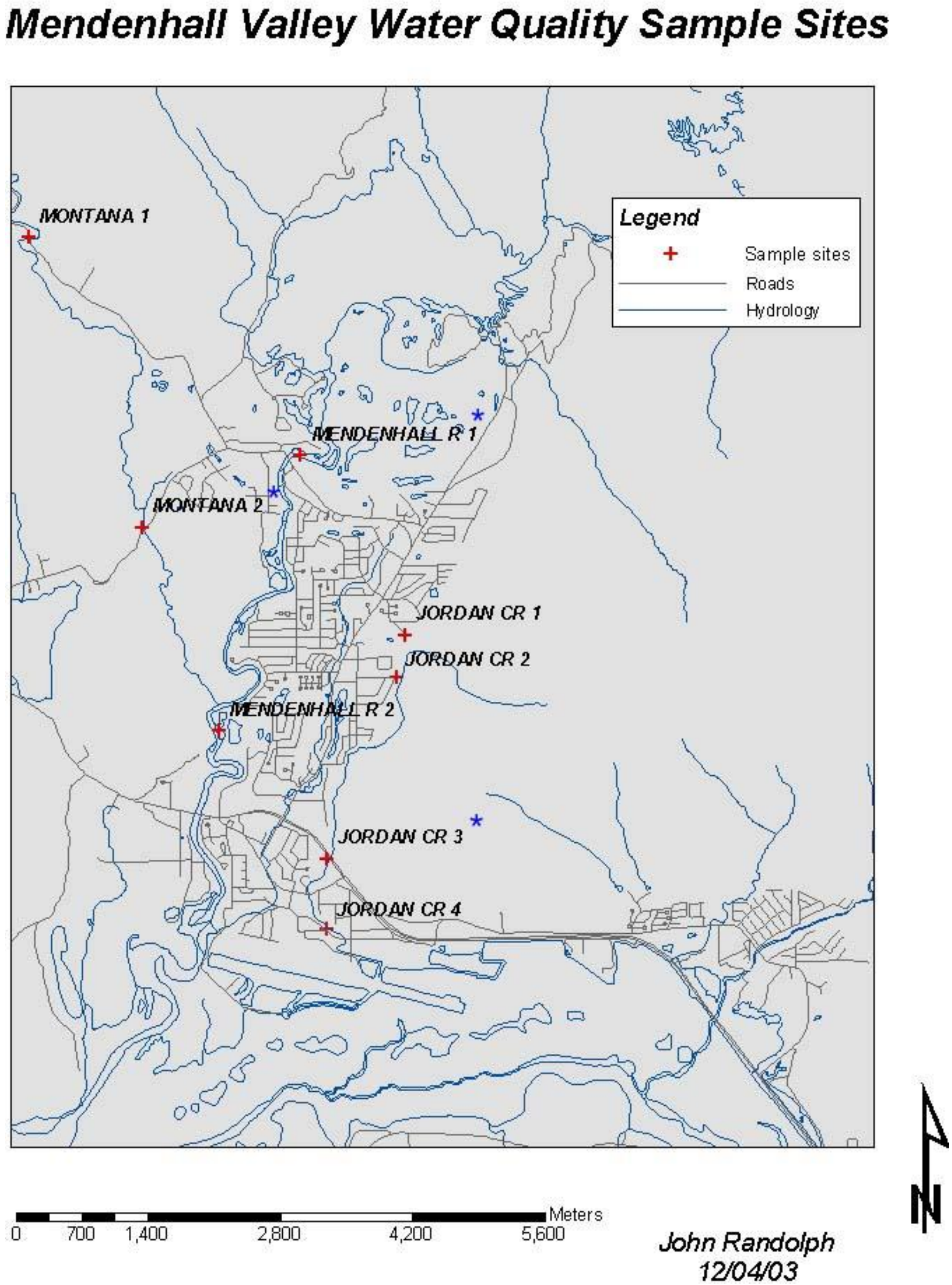

Figure 1. Map of the Mendenhall Valley and sample sites used in the study on the Mendenhall River and Montana and Jordan Creeks. Sampling was discontinued at Montana 1, the upstream Montana Creek site, because of difficult winter access. Sites with continuously recording stream gages are denoted with blue stars.

Mendenhall Valley Hydrology

The three waterbodies monitored are diverse in their hydrology. The Montana Creek watershed is predominantly upland forest and muskeg with areas of high-elevation alpine tundra and permanent snowfield. As a result streamflow is fed primarily by snowmelt and rainfall. In contrast, the Mendenhall River watershed is dominated by the Mendenhall Glacier and streamflow is derived predominantly from the melting of snow and ice in this system. Streamflow on the Mendenhall is relatively low during the winter months and increases dramatically in the early summer when melt begins on the glacier (Figure 2). The Jordan Creek watershed is largely 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 groundwater in the Mendenhall valley. As a result, streamflow is relatively flashy, responding quickly to the large frontal rainstorms typical of fall in winter in the Juneau area (Figure 2). In addition, streamflow in Jordan decreases dramatically during the late spring and early summer during periods of low rainfall. This was particularly true in 2004 when total rainfall in May and June was only 2.15 inches.

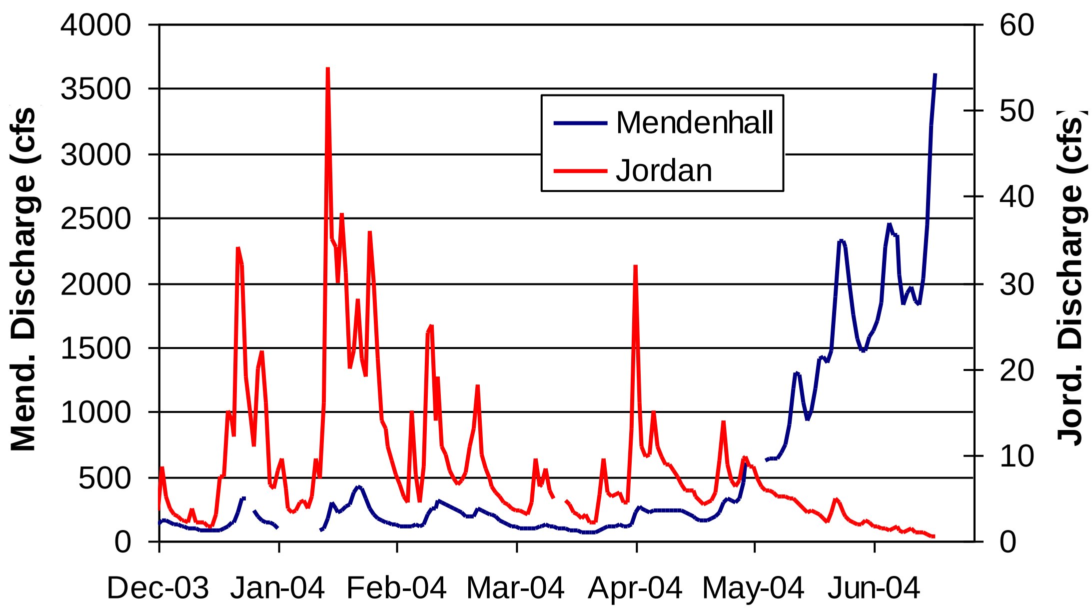

Figure 2. Streamflow on the Mendenhall River and Jordan Creek during the study.

The difference in hydrology between these three waterbodies is also reflected in water temperatures (Figure 3). The glacier-fed Mendenhall River was typically the coldest of the three waterbodies and was never above 6°C during the study period. Interestingly, the temperature of the river dropped in early summer with increased contribution of glacial meltwater. Streamflow in Jordan Creek derived from rainfall and groundwater was consistently warmer than the other waterbodies, and water temperatures in Jordan warmed rapidly in the late spring and summer to >10°C in June. The higher temperatures on Jordan Creek were associated with lower streamflows in the spring, with water temperatures of >8°C in May and June occurring during a period when discharge was consistently <10 cfs.

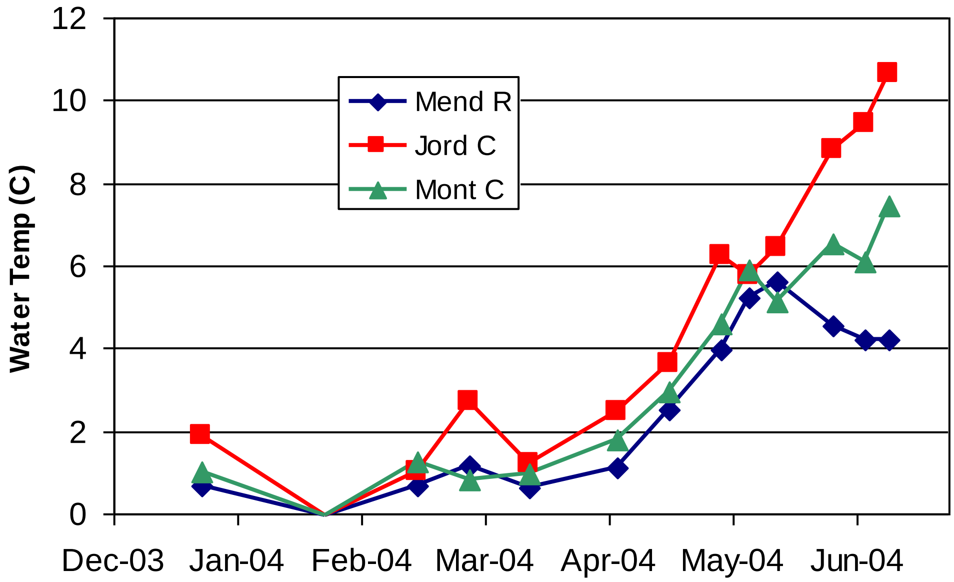

Figure 3. Water temperatures in Mendenhall Valley waterbodies. Temperatures shown were measured at the MR1, MC2, and JC3 sites.

Analysis of Mendenhall Valley Water Quality Data

Conductivity is a measure of ionic strength and, as such, reflects the load of total dissolved solids in the water column. In the Mendenhall Valley streams sampled in this study, conductivity was consistently highest in Jordan Creek (Table 2). In particular, the upper Jordan Creek sites (JC1 and JC2) typically had conductivities of >100 μS/cm, which was approximately twice the conductivity measured in Montana Creek. The high conductivity at the upper Jordan Creek sites is a likely a reflection of the urbanized nature of the upper reach of the Jordan Creek where nutrients such as nitrate and ammonium can be washed into the stream during storms. For example, total dissolved nitrogen levels in upper Jordan Creek are typically >0.75 mg/L (Hood, unpublished data). In contrast, Montana Creek, which is far less impacted by suburban development, typically has total dissolved nitrogen levels of <0.25 mg/L and a correspondingly lower conductivity. The downstream decrease in conductivity on Jordan Creek suggests that either inflows to the Creek below the JC2 site have a lower ionic strength or that that dissolved solids are removed by precipitation or biological uptake. Conductivity in the Mendenhall River was typically low at the upstream MR1 site reflecting the low ionic strength of ice and snow on the Mendenhall Glacier. The increase in conductivity at the downstream MR2 site is due to tidal influence at this downstream sample site. The episodic nature of the tidal influence at this site is reflected in the high standard deviation for conductivity measurements at this site.

Site	Cond μS/cm	pH	Turb NTU	DO mg/L	TSS (mg/L)
JC1	104.6 (6.6)	6.5 (0.2)	0.4 (0.3)	10.2 (0.3)	1.1 (0.9)
JC2	104.4 (6.2)	6.6 (0.3)	0.9 (0.7)	10.4 (0.7)	2.0 (2.3)
JC3	80.4 (16.5)	7.0 (0.4)	1.8 (0.5)	12.0 (0.9)	1.8 (1.6)
JC4	80.5 (13.7)	7.1 (0.5)	1.9 (0.5)	11.9 (0.8)	1.4 (0.7)
MC2	48.9 (8.7)	6.8 (0.4)	1.2 (0.6)	12.3 (0.7)	2.2 (2.9)
MR1	49.9 (9.4)	6.8 (0.5)	75.2 (12.4)	12.7 (0.4)	39.0 (11.3)
MR2	74.9 (30.7)	7.0 (0.5)	61.1 (13.3)	12.5 (0.5)	32.2 (11.5)

Table 2. Average values (standard deviation in parentheses) for water quality parameters during the period December, 2003 to June, 2004 at 4 sites on Jordan Creek, and one site on Montana Creek and the Mendenhall River.

Values for pH were predominantly clustered between 6.0 and 7.5 at all seven sites (Table 2) and showed relatively little seasonal variation. On average, the pH at the upper Jordan Creek sites was slightly lower than at the other sample sites. However, values for pH were never below 6 on Jordan Creek. In both Jordan Creek and the Mendenhall River, pH values showed slight increases moving in the downstream direction. In addition, pH tended to increase slightly as water temperatures warmed toward the end of the sampling season.

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. 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 0.4 to 1.9. Turbidity generally increased moving downstream on Jordan Creek (Figure 4), however turbidity at the lowest site on the Creek (JC 4) did not exceed 3 NTU during this study. Water quality on Montana Creek was very high. Turbidity never exceeded 2.2 and had an average of average of 1.2 NTU during this study. 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 neither of these waterbodies has chronic problems with high turbidity.

Background levels of turbidity on the Mendenhall are quite high because of large inputs of glacial flour and silt from the Mendenhall Glacier. Turbidity at the two sites on the Mendenhall ranged from 44-101 NTUs but was generally in the range of 60-75 NTUs. The occasionally high turbidity values at the upstream site are likely a result of episodic increases in sediment discharge from the glacier. There was a consistent downstream decrease in turbidity during low flow periods in the winter due to the input of low turbidity water from Montana Creek between MR1 and MR2. However, during higher streamflows in June the two sites showed very similar values for turbidity indicating that water from Montana Creek was not substantially diluting the sediment load in the Mendenhall during this time period.

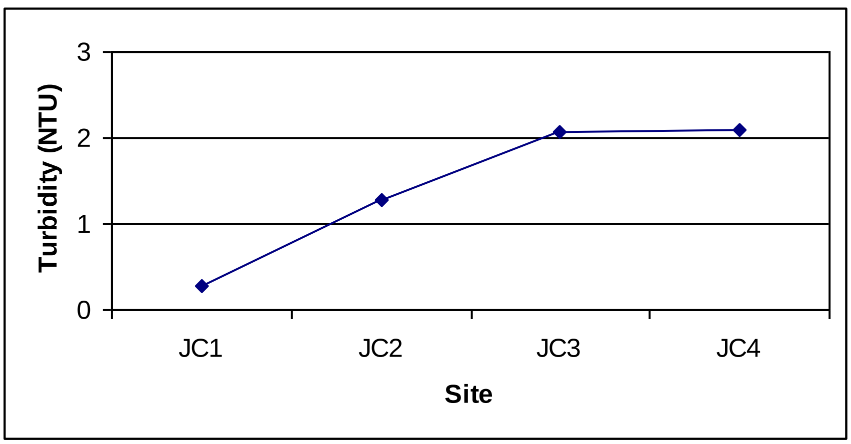

Figure 4. Example of a longitudinal turbidity profile for Jordan Creek on June 6, 2004.

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 low (typically <2.0 mg/L) on both Jordan Creek and Montana Creek (Table 2). Values for TSS were substantially higher on the Mendenhall River due to sediment inputs from the glacier and regularly exceeded 30 mg/L.

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 10.2 – 12.0 mg/L, well above the 7 mg/L criteria (table 2). D.O. levels were generally lower at the upstream JC1 and JC2 sites and increased downstream at JC3 and JC4. This trend is interesting because D.O. saturation is dependent on temperature, which generally increased in the downstream direction, particularly in the late spring and early summer. In general, low D.O. concentrations occur at low streamflows with warmer water temperatures. However, despite the strong increase in temperature moving downstream, D.O. levels actually increased moving downstream from JC1 to JC4.

Seasonally, D.O. levels did follow the expected pattern in Jordan Creek. As streamflow decreased and water temperatures increased, D.O. levels went down at all four Jordan sites. This seasonal decrease in D.O. was particularly pronounced at the JC2 site where D.O. levels approached 9 mg/L during late May and early June (Figure 5). These results suggest that the upper reaches of Jordan Creek may be at risk of dropping below the 7 mg/L criteria for D.O. during periods of very low streamflow and elevated water temperatures.

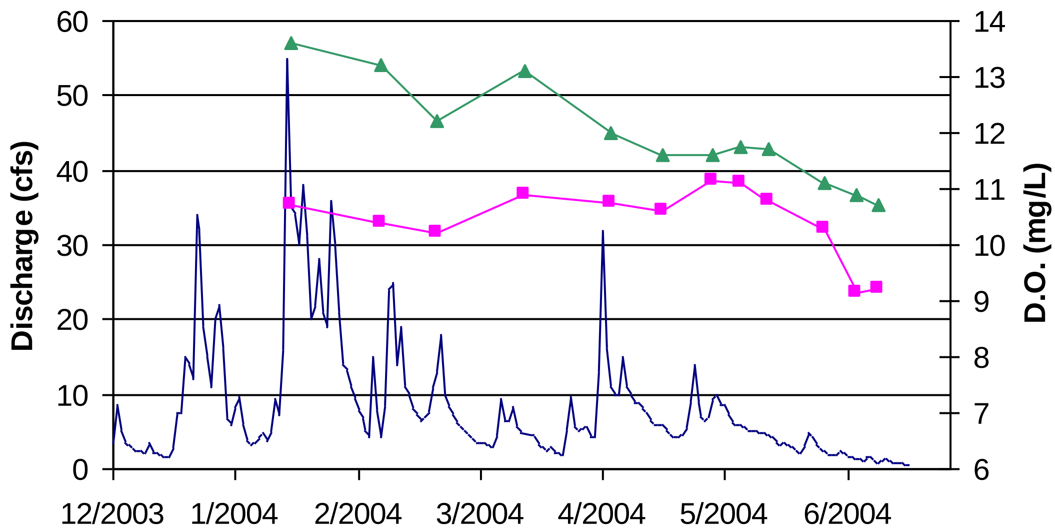

Figure 5. Seasonal trends in dissolved oxygen and discharge at the JC2 (denoted by squares) and JC3 (triangles) sample sites. Discharge was recorded at the JC3 site.

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 2004 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.

Dissolved oxygen levels were generally quite high in Montana Creek and the Mendenhall River. Levels of D.O. in Montana Creek did decrease with increased water temperatures and lower streamflows in the spring, however D.O. never dropped below 11 mg/L in Montana Creek (Figure 6), well above the 7 mg/L criteria established by the state of Alaska. Dissolved oxygen levels were typically even higher on the Mendenhall River, rarely dropping below 12 mg/L. Interestingly, D.O. levels in the Mendenhall reached a low point in April and increased in May and June as streamflow increased and water temperature decreased with increased melting of the Mendenhall Glacier.

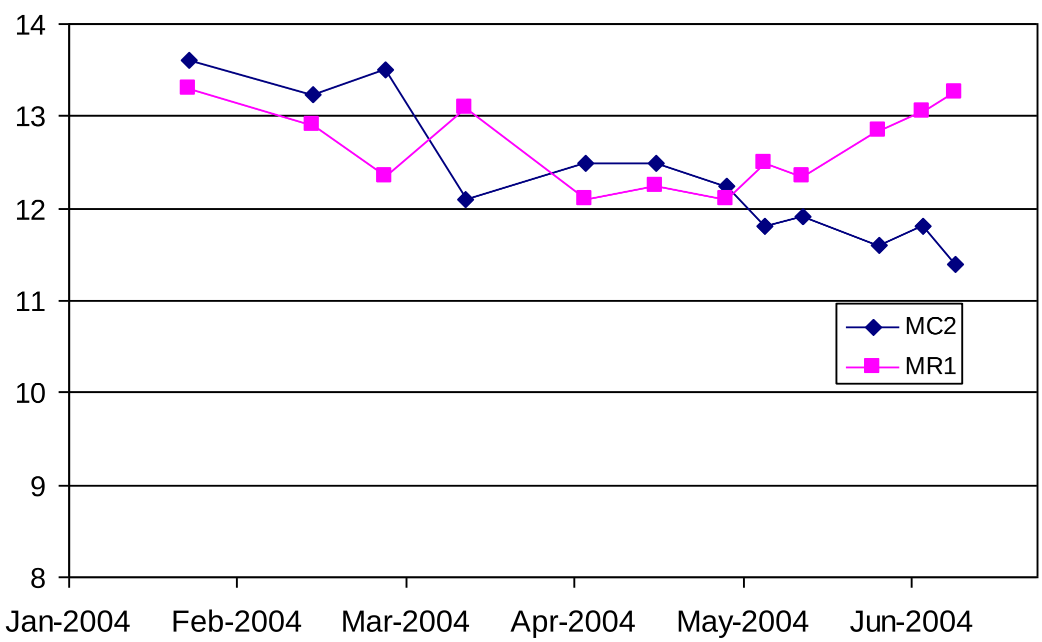

Figure 6. Time series of dissolved oxygen levels in Montana Creek (site MC 2) and the Mendenhall River (site MR 1).

Conclusions

This study provided a comprehensive characterization of the water quality of three water bodies in the Mendenhall Valley near Juneau. The Jordan Creek, Montana Creek, and Mendenhall River watersheds are all subject to future increases in development within watershed boundaries, which could impact water quality. In this context, the data contained in this report are valuable for understanding the water quality impacts of current activities in the watersheds in the Mendenhall Valley. In addition, this information should prove valuable for assessing the extent to which future development affects water quality in these waterbodies and by extension be useful for helping to develop approaches for sustainable development in the valley. The data from this study are being provided to the DEC in both hard copy and electronic form. In addition, the data have been provided to the Spatial Data Center at the University of Alaska Southeast (http://www.uas.alaska.edu/spatialdata/) and are in the process of being made available via and interactive GIS map of the watersheds in the Mendenhall Valley being funded by the Mendenhall Watershed Partnership.

Appendix A – Water quality data collected in Montana Creek, Mendenhall River, and Jordan Creek during the period December, 2003 – June, 2004.

Date	Site	Temp *C	Cond μS/cm	pH	Turb NTU	DO mg/L	TSS (mg/L)
12/23/2003	JC1	3.66	105		0.92		3.1
1/15/2004	JC1	3.77	117	6.2	0.23	9.4	0.7
2/7/2004	JC1	3.66	108	6.4	0.29	10.3	bd
2/21/2004	JC1	4.04	97	6.1	1.27	10.1	0.9
3/14/2004	JC1	3.63	105	6.8	0.18	10.7	bd
4/5/2004	JC1	3.54	106	6.3	0.47	10.2	1.4
4/18/2004	JC1	4.15	108	6.6	0.21	10.4	bd
5/1/2004	JC1	5.05	106	6.7	0.19	10.3	0.2
5/8/2004	JC1	5.3	111	6.7	0.33	10.4	0.4
5/15/2004	JC1	4.99	109	6.6	0.17	10.4	0.2
5/29/2004	JC1	6	96	6.7	0.37	10.3	1.3
6/6/2004	JC1	6.01	96	6.6	0.29	10.2	1.4
6/12/2004	JC1	7.1	96	6.6	0.21	10.3	bd
12/23/2003	JC2	2.94	96		1.93		3.0
1/15/2004	JC2	3.02	114	6.0	0.48	10.7	0.4
2/7/2004	JC2	3.36	109	6.6	0.63	10.4	1.4
2/21/2004	JC2	4.15	96	6.3	0.64	10.2	0.9
3/14/2004	JC2	3.27	109	6.8	0.64	10.9	0.2
4/5/2004	JC2	3.47	107	6.4	0.7	10.8	1.4
4/18/2004	JC2	4.24	109	6.7	0.62	10.6	0.2
5/1/2004	JC2	5.61	94	6.9	2.8	11.2	7.9
5/8/2004	JC2	5.95	103	6.8	0.62	11.1	1.0
5/15/2004	JC2	5.81	99	6.8	0.53	10.8	0.9
5/29/2004	JC2	6.55	107	6.9	0.67	10.3	1.2
6/6/2004	JC2	6.6	108	6.7	1.28	9.2	6.3
6/12/2004	JC2	7.33	106	6.7	0.7	9.2	1.8
12/23/2003	JC3	1.91	49		2.58		6.3
1/15/2004	JC3	-0.06	64	6.3	1.38	13.6	1.2
2/7/2004	JC3	1.00	103	6.9	2.66	13.2	0.7
2/21/2004	JC3	2.69	59	6.6	1.77	12.2	1.8
3/14/2004	JC3	1.19	78	7.1	1.81	13.1	0.2
4/5/2004	JC3	2.45	63	6.4	1.58	12.0	3.5
4/18/2004	JC3	3.64	89	7.2	1.53	11.6	0.7
5/1/2004	JC3	6.22	83	7.2	1.84	11.6	1.7
5/8/2004	JC3	5.78	90	7.0	1.18	11.8	1.9
5/15/2004	JC3	6.44	86	7.1	1.05	11.7	0.9
5/29/2004	JC3	8.82	95	7.5	1.51	11.1	1.7
6/6/2004	JC3	9.43	92	7.4	2.08	10.9	0.9
6/12/2004	JC3	10.64	94	7.5	2.59	10.7	1.2

Date	Site	Temp *C	Cond μS/cm	pH	Turb NTU	DO mg/L	TSS (mg/L)
1/15/2004	JC4	-0.06	62	6.4	1.65	12.3	2.1
2/7/2004	JC4	n/a--frozen					
2/21/2004	JC4	2.92	58	6.8	1.98	12.3	1.1
3/14/2004	JC4	1.17	77	7.1	2.23	13.4	0.6
4/5/2004	JC4	2.48	62	6.3	1.54	12.4	2.6
4/18/2004	JC4	4.38	89	7.5	1.38	12.5	0.2
5/1/2004	JC4	6.28	83	7.3	2.24	11.9	1.5
5/8/2004	JC4	6.99	90	6.9	1.61	12.0	2.0
5/15/2004	JC4	8.17	86	7.0	1.2	11.4	0.9
5/29/2004	JC4	10.09	94	7.6	1.48	11.3	0.9
6/6/2004	JC4	10.66	94	7.4	2.09	10.6	1.1
6/12/2004	JC4	12.48	91	7.6	2.97	10.9	1.9
12/23/2003	MC2	1.02	30		1.93		10.4
1/23/2004	MC2	-0.06	54	7.2	2.21	13.6	3.5
2/15/2004	MC2	1.26	50	6.3	0.74	13.2	0.7
2/28/2004	MC2	0.84	63	5.9	0.66	13.5	0.2
3/14/2004	MC2	0.97	58	7.2	0.95	12.1	
4/5/2004	MC2	1.78	36	6.5	2.05	12.5	4.8
4/18/2004	MC2	2.93	54	6.8	0.78	12.5	1.2
5/1/2004	MC2	4.61	45	6.8	1.17	12.3	1.4
5/8/2004	MC2	5.88	53	7.2	0.62	11.8	0.8
5/15/2004	MC2	5.14	50	6.9	0.57	11.9	1.1
5/29/2004	MC2	6.52	51	7.0	1.29	11.6	0.6
6/6/2004	MC2	6.1	45	6.8	1.6	11.8	1.5
6/12/2004	MC2	7.47	47	6.9	1.62	11.4	0.2
12/23/2003	MR1	0.67	46		90.3		55.0
1/23/2004	MR1	-0.04	58	6.7	101.00	13.3	51.9
2/15/2004	MR1	0.67	53	6.5	75.10	12.9	34.5
2/28/2004	MR1	1.16	54	6.0	79.3	12.4	43.0
3/14/2004	MR1	0.62	57	7.5	74.6	13.1	17.6
4/5/2004	MR1	1.11	58	6.9	61.6	12.1	20.5
4/18/2004	MR1	2.52	59	7.2	66.8	12.3	37.1
5/1/2004	MR1	3.97	57	7.3	69.3	12.1	31.0
5/8/2004	MR1	5.22	52	7.6	70.9	12.5	40.0
5/15/2004	MR1	5.62	50	7.4	59.1	12.4	39.7
5/29/2004	MR1	4.57	39	7.0	61.2	12.9	39.3
6/6/2004	MR1	4.23	35	7.1	85.3	13.1	46.3
6/12/2004	MR1	4.22	31	6.9	83.1	13.3	51.7

Date	Site	Temp *C	Cond μS/cm	pH	Turb NTU	DO mg/L	TSS (mg/L)
12/23/2003	MR2	0.94	56		46.4		32.0
1/23/2004	MR2	-0.05	85	6.9	84.80	13.4	45.8
2/15/2004	MR2	0.86	85	6.5	60.90	12.9	27.7
2/28/2004	MR2	0.87	116	5.5	61.4	12.6	26.5
3/14/2004	MR2	1.01	138	7.2	50.1	13.0	20.0
4/5/2004	MR2	1.46	77	6.6	44	12.7	14.8
4/18/2004	MR2	2.83	103	6.8	49.4	12.0	19.0
5/1/2004	MR2	4.24	74	7.0	52.8	12.1	26.8
5/8/2004	MR2	5.64	67	7.4	65.6	12.0	33.0
5/15/2004	MR2	5.85	56	7.1	58.2	12.0	41.3
5/29/2004	MR2	4.87	43	7.0	61.6	12.7	32.3
6/6/2004	MR2	4.42	39	6.9	79.4	12.6	47.0
6/12/2004	MR2	4.59	35	7.1	79.8	12.8	52.1