Jordan Creek Watershed Recovery and Management Plan

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Juneau Field Office

In partnership with:
The Alaska Department of Environmental Conservation
and
The Mendenhall Watershed Partnership

Juneau, Alaska

Purpose and Need Statement

Although much of its watershed remains forested, Jordan Creek is located in an area that has rapidly urbanized late in the last century. The creek and its watershed are valued by local citizens as a wildlife corridor and natural area in the Mendenhall Valley, which has become the population center of Juneau. Ensuring that Jordan Creek continues to provide good fish and wildlife habitat and clean water may be challenging as the demand for a developable land-base in Juneau continues to grow.

Water quality monitoring and biological studies indicate that Jordan Creek water quality and fish populations are declining. Jordan Creek is currently on the Alaska Clean Water Action (ACWA) list due to a high frequency of debris, sediment loading, and low dissolved oxygen levels. Fish may be at least partly influenced by such water quality parameters, as well as more direct habitat impacts such as channel alteration and riparian disturbance. Assessing watersheds and identifying ways to improve stream conditions helps direct financial and organizational resources, as demonstrated by the Duck Creek Watershed Management Plan (Koski and Lorenz, 1999). The plan has and continues to guide water quality monitoring and habitat rehabilitation projects on Duck Creek, a nearby stream that is historically similar to Jordan Creek.

The purpose of this document is to summarize available information about Jordan Creek, describe the known and potential factors affecting water quality and fish habitat, and provide recommendations for further assessment and improving the overall condition of the stream while preventing further degradation. It is intended to address water quality recovery by outlining tasks for attaining State of Alaska water quality standards, and as a general watershed management plan for conserving and protecting habitat. This report is intended for use by agencies and citizens.

Acknowledgements

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1. Introduction

1.1 Watershed Description

Jordan Creek is a small, clear water stream located in the Mendenhall Valley (Figure 1), approximately 12 miles west of downtown Juneau, Alaska. Steep mountains border the valley to the west and east, and the Mendenhall Glacier is located at the north end. Prior to the Mendenhall Glacier's most recent retreat beginning in the mid-1700s, Duck and Jordan Creeks were the most significant waterbodies draining glacial meltwater from the valley (Neal and Host, 1999). While the Mendenhall River is a glacial river that flows from Mendenhall Lake at the terminus of the glacier, Duck and Jordan Creeks are clearwater streams originating in the glacial outwash or steep mountain slopes. Prior to the formation of the Mendenhall River, Duck and Jordan Creeks were the primary drainages in the Valley. While Duck Creek flows into the Mendenhall River in the intertidal wetlands area at the southern end of the Valley, the outlet of Jordan Creek is located approximately 1.6 miles to the east. The Jordan Creek watershed is effectively a small "sub-watershed" of the Mendenhall Valley. "Upper" and "lower" Jordan Creek in this report generally refer to the areas upstream and downstream of Alaska State Highway 7, known as Egan Drive.

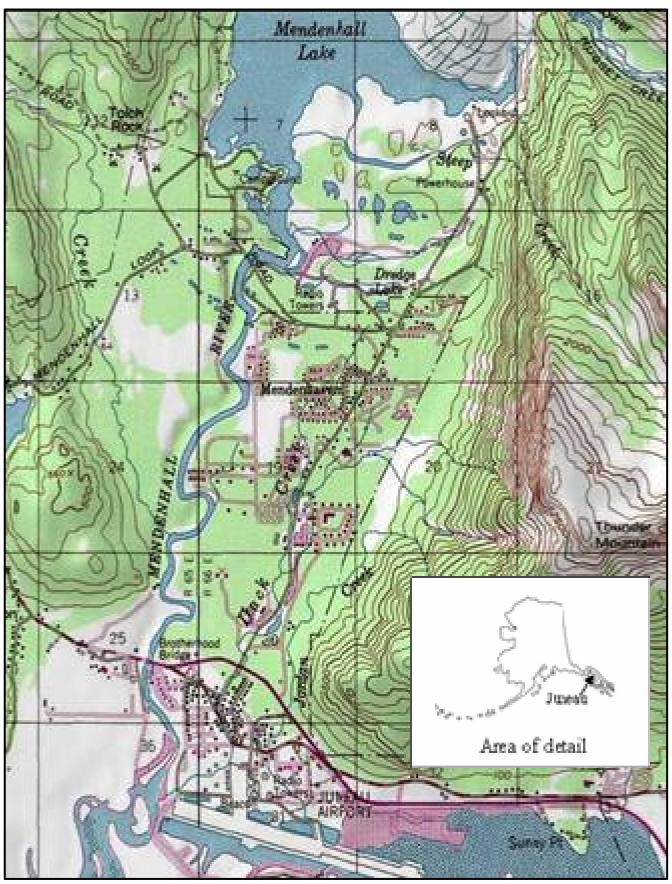

Figure 1. Map of the Mendenhall Valley. Jordan Creek is on the right.

Approximately 2,260 acres of land are contained within the Jordan Creek watershed (modified U.S. Forest Service 6th Level Hydrologic Unit Code). Several steep-gradient tributaries flow west to enter the main channel, which flows north-south near the base of Thunder Mountain. Elevation ranges from over 2,800 feet on the eastern slopes to sea level where the creek becomes part of a complex estuary system. Most of the east side of the watershed is undeveloped, forested uplands. However, the west side of the main channel and most of the watershed downstream of Egan Drive is developed as residential housing and industrial facilities. The creek flows through Juneau International Airport property before exiting a culvert into the Mendenhall Wetlands State Game Refuge.

Mean annual discharge recorded at the U.S. Geological Survey gaging station located downstream of Egan Drive was 7.76 cubic feet per second (cfs) for 1998-2002 water years (Host and Neal, 2004). Mean monthly discharge ranges from about 3 to 16 cfs (USGS station 15052475). Although a shallow water table helps maintain stream flows, discharge generally corresponds to precipitation patterns (Figure 2). Mean annual precipitation measured at the Juneau International Airport is approximately 57 inches, including 95 inches of snowfall (Western Regional Climate Center website). Portions of Jordan Creek downstream of Egan Drive go dry during periods of little or no precipitation (Host and Neal, 2004; Bethers et al., 1995; Alaska Department of Fish and Game, 1979 unpublished field notes).

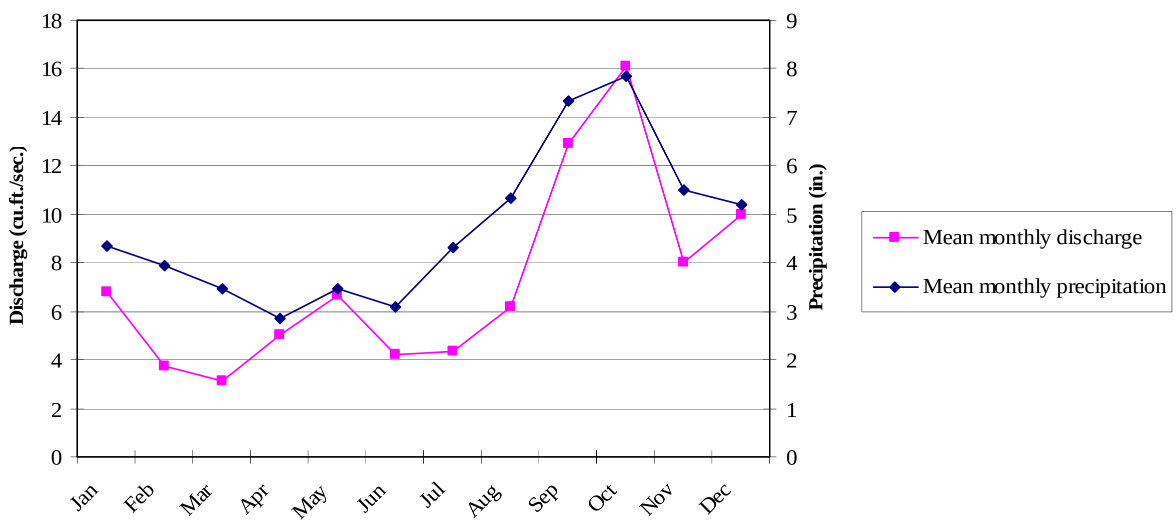

Figure 2. Mean monthly discharge values for Jordan Creek (U.S. Geological Survey station 15052475), and mean monthly precipitation at the Juneau International Airport (Western Regional Climate Center), Juneau, Alaska.

The watershed contains approximately 11 miles of streams, including the main channel and its tributaries. The main channel is about 3.5 miles long, and has been catalogued and confirmed as an anadromous fish stream by the Alaska Department of Fish and Game (ADF&G) (stream number 111-50-10620). A total of 6.5 miles of stream are included in the anadromous waters catalog, which includes portions of the tributaries contributing to the main channel of Jordan Creek. In terms of stream processes, much of the main channel is considered a narrow, low gradient floodplain channel. There is a beaver dam/pond complex in the channel reach near Jennifer Street, and most of the channel downstream of Egan Drive is a shallow groundwater-fed slough (ADF&G Division of Sport Fish, 2003).

1.2 Geology, Flora, and Fauna

Mendenhall Valley geology consists primarily of glacial, glaciomarine, and alluvial deposits overlying a northwest-trending belt of metamorphosed volcanic and sedimentary bedrock. Surficial geology in the Jordan Creek watershed ranges from exposed bedrock to soils more than 90 feet deep, depending on location and slope (Alcorn and Hogan, 1995; Brew and Ford, 1985; Schoephorster and Furbish, 1974). Much of Jordan Creek's main channel flows through stratified, well-drained, fine sandy loam. However, large areas of poorly drained soils with discontinuous layers of iron-containing materials exist in the upper main channel (Schoephorster and Furbish, 1974). A table summarizing identified soils information for the Jordan Creek watershed is included in Appendix A.

Regional uplift in the tidal flats area around the Juneau International Airport has been observed since 1936. The rate of uplift from 1936 to 1962 has been estimated at 0.05 ft/year, probably due to deglaciation. Uplift may result in lowering of the water table relative to the land surface, which will likely increase the frequency of dewatering in some stream reaches (Host and Neal, 2004).

Much of the watershed canopy cover is closed Sitka spruce-western hemlock forest (Viereck et al., 1992). The understory includes salmonberry, blueberry, devil's club, ferns, skunk cabbage, horsetail, and other herbaceous plants. Riparian areas may be populated by alder, willow, sedges, grasses, or the dominant tree species. As Jordan Creek approaches Gastineau Channel, the vegetation reflects the wetland and estuarine environments through which the creek flows. The presence of large trees diminishes as sedges and grasses become the dominant plant types, particularly near the Airport and the State Game Refuge.

Waterfowl, shorebirds, raptors, and songbirds frequent most of the watershed, but are particularly numerous in and around the State Game Refuge. Small mammals such as porcupine, red squirrel, voles, and mice are likely year-round residents. Large mammals such as black bear, Sitka black-tailed deer, and mountain goats live in portions of the watershed for at least part of the year. Beavers are active in reaches of the main channel above Egan Drive, and otters frequent the lower stream reaches.

Jordan Creek has been catalogued (stream number 111-50-10620) by ADF&G as an anadromous fish stream that supports coho, pink, and chum salmon, Dolly Varden char, and cutthroat trout (Johnson et al., 2004). Good spawning and rearing habitat can be found throughout most of the main stem and parts of the tributaries (Bethers et al., 1995). Other fish species such as capelin, sculpin, herring, eulachon, and flounder inhabit the estuarine areas in the State Game Refuge (K Koski, National Marine Fisheries Service, personal communication). Further discussion of fish and fish habitat is included in Section 4.

1.3 Land Use History

The Mendenhall Valley was sparsely populated in the early 1900s. Completion of the Nugget Creek powerhouse in 1914 (Alaska Electric Light and Power Company website) and the associated tramway facilitated travel and subsequent development of the Valley. Fox, mink, and dairy farms were operated by some early Valley residents. Salmon from Duck and Jordan Creeks were used to feed the fox and mink (Mielke, 2001).

Rapid development of the Valley occurred late in the last century (Figure 3). About 39% of Juneau's population resides on the east side of the Mendenhall River in the Valley. Most of the 12,122 Valley residents live in single family dwellings (City and Borough of Juneau, 2001). Land use zoning upstream of Egan Drive is a mixture of single-family to multi-family residential

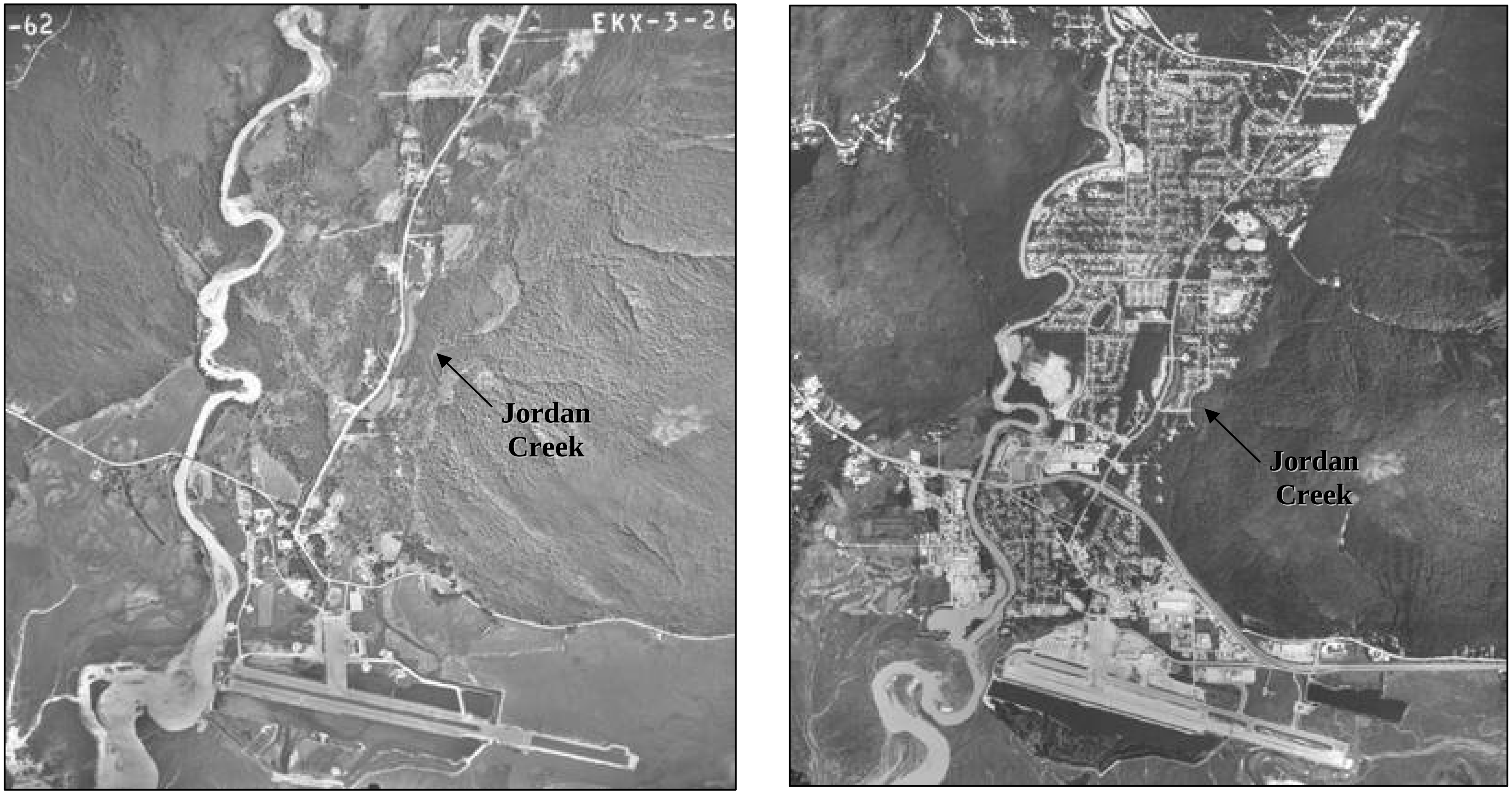

Figure 3. Aerial photographs of the Mendenhall Valley, 1962 (left) and 2001 (right).

designations, with some land set aside as “rural reserve” (Figure 4). The Tongass National Forest owns and manages much of the upland area on the east side of upper Jordan Creek. Downstream of Egan Drive, most of the land area drained by Jordan Creek has been developed for commercial and industrial uses. Land use zoning in this area is a mixture of general commercial, light commercial, industrial, and some residential districts. A higher density of stream crossings and riparian disturbance are found in lower Jordan Creek than in the stream corridor and its tributaries upstream of Egan Drive. There is also more paved land surface per unit area in the lower than in the upper watershed.

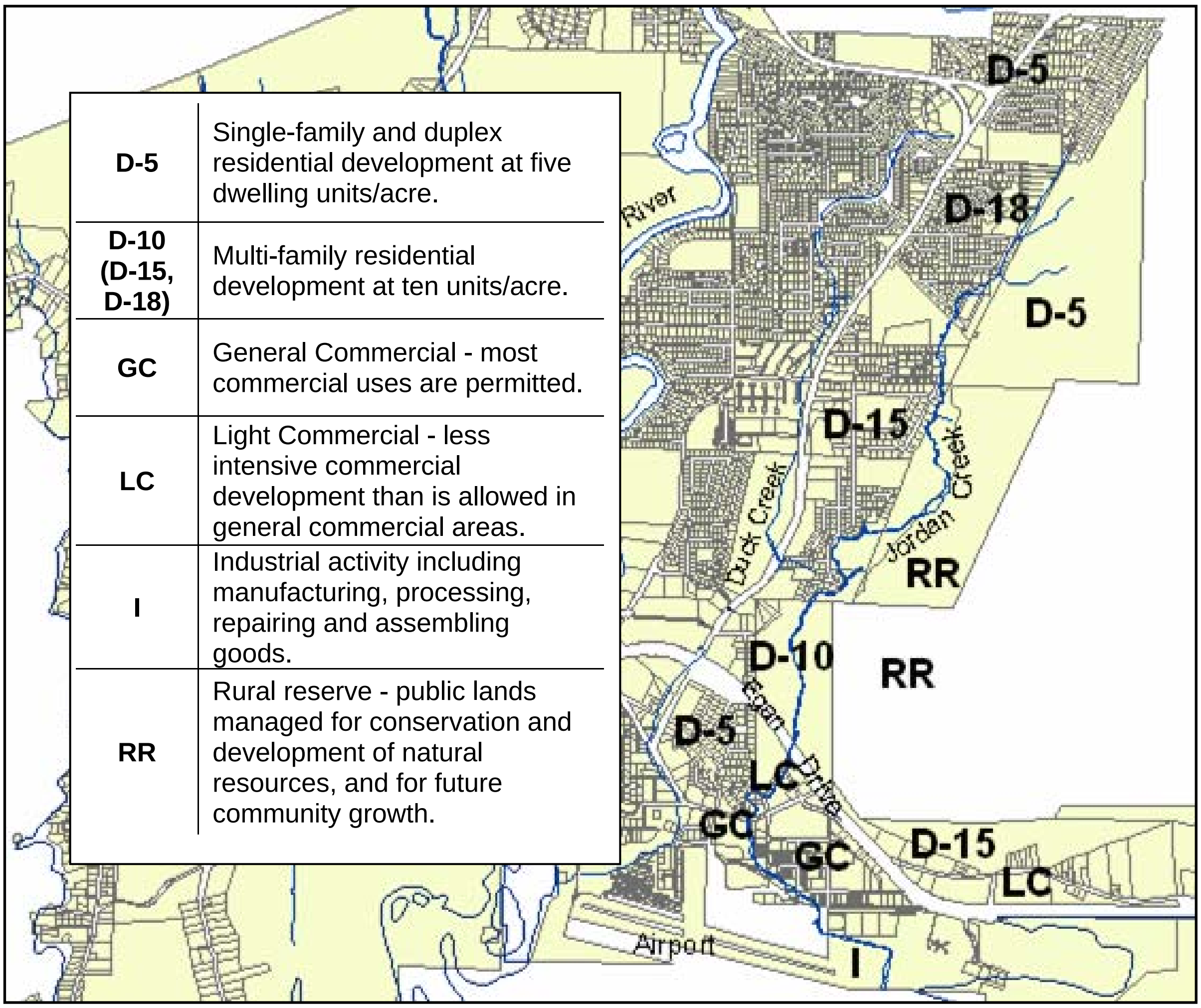

Figure 4. Zoning designations of lands in the Jordan Creek corridor (City and Borough of Juneau Zoning Maps, 1987).

The Juneau International Airport occupies the largest single piece of property in the lower watershed. The airport was established to support U.S. military operations during World War II. The runway was paved in 1942, and the City of Juneau gained control of the airport in 1953. Runway expansion to allow for jet aircraft use was completed in 1961, and a full-length taxiway was constructed in 1989 (City and Borough of Juneau, 1999). Jordan Creek flows through culverts beneath the taxiway and runway.

Resource use in the Jordan Creek watershed has included logging, gravel extraction, and water collection. Land on the east side of Jordan Creek was clearcut in the late 1960s. Also in the late 1960s, a gravel pit was excavated on the creek just downstream from where the Thunder Mountain Trailer Court is currently located. Known as Reid Pond, the pit was over 70 feet deep and was used as a dump for several years, though it has since been filled in (Bethers et al., 1995). A water collection system and storage tower was constructed in the mid-1980s on the largest single tributary to Jordan Creek, on the east side of the main channel.

2. Water Quality

2.1 Water Quality Regulations

Under section 305(b) of the Clean Water Act, states are required to evaluate all surface waterbodies and establish maximum allowable levels of pollutants, known as Total Maximum Daily Loads (TMDLs). State water quality standards designate the uses to be protected (e.g., water supply, recreation, aquatic life) and the criteria for their protection (e.g., how much of a pollutant can be present in a waterbody without impairing its designated uses). TMDLs are developed to meet applicable water quality standards, which may be expressed as numeric water quality criteria or narrative criteria for the support of designated uses. The TMDL target identifies the numeric goals or endpoints for the TMDL that will lead to attainment of the water quality standards. The target may be equivalent to a numeric water quality standard where one exists, or it may represent a quantitative interpretation of a narrative standard.

Waterbodies in need of TMDL establishment are placed on a list that is often referred to as the “303(d)” list, after the associated section of the Clean Water Act. In Alaska, the state Departments of Environmental Conservation, Fish and Game, and Natural Resources work collaboratively to characterize surface waters and identify stewardship actions. Waterbodies nominated for protection or restoration, including 303(d) waters, are included on the state’s Alaska Clean Water Actions (ACWA) list.

Title 18, Chapter 70 of the Alaska Administrative Code (AAC) establishes water quality standards for the waters of Alaska, including the designated uses to be protected and the water quality criteria necessary to protect the uses. Designated uses established in the State of Alaska Water Quality Standards (18 AAC 70.020) for fresh waters of the state include (1) water supply, (2) water recreation, and (3) growth and propagation of fish, shellfish, other aquatic life, and wildlife, and are applicable to all fresh waters, unless specifically exempted. The TMDLs for each water quality parameter for which a waterbody is listed must be developed to meet all applicable criteria.

2.2 Jordan Creek Water Quality

Water quality standards for each pollutant and use applicable to Jordan Creek are presented in Appendix B. In 1998, Jordan Creek was added to Alaska’s 303(d) list for water quality impairment due to high sediment loads, low dissolved oxygen, and debris, and remains on the

2003 303(d) list for non-attainment of the applicable water quality standards. Roads, recreation, urban development, and stormwater runoff were identified as nonpoint sources of pollution.

The TMDL for debris has been set at zero, meaning that the water quality target for Jordan Creek is absence of garbage or other foreign residue. TMDLs for dissolved oxygen and sediment have not been finalized. Nevertheless, this document outlines a recovery plan for all three pollutants and includes suggestions for reducing or preventing others from affecting the water quality of Jordan Creek.

Other potential pollutants include hydrocarbons from fuel storage tanks or spills, fertilizer or pesticide runoff from residential and industrial areas, and fecal coliforms from failing sewage lines, pet or wildlife waste, or camp sites primarily in the upper creek corridor. In addition, ADEC has listed several contaminated sites in the Jordan Creek area. A discussion of potential pollutants is included in this report to assist resource managers with preventing future water quality impacts.

2.3 Designated Use Impairments

2.3.1 Debris

Jordan Creek does not fully support its designated uses of water supply and water recreation due to elevated instream debris levels. Debris detracts from inherent aesthetic qualities and recreation, can introduce contaminants to the stream, and can impede fish passage or degrade habitat quality. Potentially hazardous debris, such as fuel containers, have been observed and documented within Jordan Creek. Debris from household garbage can attract undesirable wildlife such as nuisance bears, a chronic problem in the upper watershed.

The primary sources of debris in the creek are littering and improperly stored garbage near the creek. Most debris in Jordan Creek appears to be a product of direct input from residential, commercial, and industrial areas or indirect inputs brought into the creek by wind, snowmelt, runoff, or wildlife. In some areas, snow removal activities on streets, parking lots, and driveways result in debris deposition into or on the banks of the creek. Littering is a chronic problem where roads and buildings are close to the creek, but is especially pronounced near food and convenience store businesses in the lower portion of the creek.

Figure 5: Garbage in Jordan Creek. May, 2003.

Household garbage pulled into the creek or its banks by bears is a substantial source of debris in the upper Jordan Creek watershed (Figure 5). Bears frequent the forested east side of Jordan Creek along Thunder Mountain. Improperly stored garbage has been documented as a prime bear attractant and has been a source of concern both from a public safety and a litter problem. CBJ records show that many of the reported bear sightings in the Mendenhall Valley are in the more densely populated areas that lie at the edge of the forest, such as Thunder Mountain Trailer Park. Most trailer residents do not have garages or outbuildings, and find it difficult to keep trash indoors between collections.

2.3.2 Dissolved Oxygen

Jordan Creek was included on the ACWA list in 1998 for non-attainment of the dissolved gas standard due to low dissolved oxygen. State water quality standards stipulate that dissolved oxygen concentrations must be greater than 7 mg/L in the water column and not less than 5 mg/L to a depth of 20 cm in interstitial water in order to meet the designated uses of growth and propagation of fish, shellfish other aquatic life and wildlife. Limited monitoring conducted thus far on Jordan Creek indicates that low dissolved oxygen may occur at least periodically in both surface and interstitial water. Additional monitoring is necessary to adequately assess dissolved oxygen in the creek, and the possible causes for low dissolved oxygen where it occurs.

Dissolved oxygen in both the water column and interstitial gravels is critical for fish survival. Salmonids will seek areas that have adequate dissolved oxygen concentrations. Several studies have shown that low interstitial dissolved oxygen concentrations during egg incubation reduced coho survival rates, and resulted in smaller alevins than would have hatched in greater concentrations of dissolved oxygen (Bjornn and Reiser, 1991).

Low dissolved oxygen has been measured in both the surface and interstitial water of Jordan Creek, though most of the data was collected in surface water. Data comparison and evaluation is problematic due to lack of established sample sites, differences in analysis techniques, lack of supporting data, and sporadic sampling frequency. Amalga Street and Egan Drive locations have been used in the largest number of studies, and may offer the best available opportunities for comparing data over time and indicating upper and lower Jordan Creek water quality. Interstitial dissolved oxygen measurements were included only in the National Marine Fisheries Service study on egg survival. The following studies have included collection of dissolved oxygen data:

- 1996-1998 National Marine Fisheries Service, Egg to Fry Survival Studies: studies of egg-to-fry survival in Duck Creek, Jordan Creek and Steep Creek, along with dissolved oxygen measurements in the creeks.
- 1997 National Marine Fisheries Service, Duck Creek Water Quality Monitoring: water quality information for Duck Creek using Jordan Creek as a baseline for comparison.
- 2002 CBJ, Stormwater Sampling Project: water quality and flow velocity measurements from Mendenhall Valley and Vanderbilt Creek.
- 2002-2004 Discovery Southeast, Educational Monitoring at Amalga Bridge: water quality sampling at Amalga Street by middle school students under supervision of Discovery Southeast staff.
- 2003-2004 University of Alaska Southeast, Mendenhall Valley Water Quality Sampling: water quality sampling by university students at Jordan Creek, Montana Creek and Mendenhall River.

- 2004 U.S. Geological Survey, Baseline Characteristics of Jordan Creek: water quality and discharge data from nine sites along Jordan Creek, including in-depth characterization of the creek in three separate reaches.

Three of the four low dissolved oxygen readings for Jordan Creek that led to its placement on the state impaired waters list were taken in a small tributary at Valley Boulevard, which no longer flows into Jordan Creek. The water source for this tributary was a pair of gravel pits on Valley Boulevard that were mined in the 1960s and 1970s. When the pits reached a depth of about 60 feet, they intercepted an artesian aquifer high in iron and low in dissolved oxygen. Gravel mining was abandoned due to an inability to control the water, and the pits became ponds.

In 1981, a near-drowning incident occurred that resulted in a plan to fill in the ponds. However, large amounts of unsuitable material were backfilled in the ponds (ADF&G reported household garbage, junked automobiles, and discarded equipment in the pit in 1984). The pit was eventually completely filled, but the artesian flow has not stopped. Most of the flow was rerouted to Duck Creek in the 1980s, but a small seep continued to enter Jordan Creek until recently. Construction of a housing development on Valley Boulevard during the summers of 2003 and 2004 regraded the surface pit flow to Duck Creek, though groundwater flow direction has not been determined.

Additional low dissolved oxygen observations have been made at sites near Valley Boulevard, downstream of Thunder Mountain Trailer Park, and at Egan Drive. The low dissolved oxygen readings corresponded to low discharge rates recorded at the stream gage. However, the available discharge data may not accurately reflect stream flows at all study sites. The U.S. Geological Survey has continuously collected discharge data at the gaging station located downstream of Egan Drive since May, 1997. A review of the online gage data shows that discharge was estimated (rather than measured) during some of the study periods. Furthermore, Host and Neal (2004) found that channel dewatering downstream of Egan Drive may occur when flows at the gage are less than 0.6 ft^3/s. They also found that flow tends to increase between Thunder Mountain Trailer Park and Nancy Street, and that “Jordan Creek loses water in a downstream direction” from Nancy Street to Yandukin Drive.

Interstitial dissolved oxygen has been measured in channel substrate at fifteen locations downstream of Thunder Mountain Trailer Court (K Koski, 1997 unpublished data). Instrument readings were taken several times from April through June. Dissolved oxygen concentrations at two locations were below the state standards for the entire study period. Other sites had low dissolved oxygen on one or more sample dates. Only one of the fifteen sites met state standards for interstitial dissolved oxygen concentrations throughout the study period, though measurements were not taken at all sites consistently. Nearly all sites exhibited low interstitial dissolved oxygen concentrations on April 22, 1997, but discharge data for the gaging station is not available and flow measurements were not included in the study.

Low interstitial dissolved oxygen is at least partly due to natural groundwater quality in the Jordan Creek watershed. Groundwater contains little or no dissolved oxygen until it reaches the hyporheic zone, where oxygenated surface water infiltrates the stream substrate. This zone can range from a few centimeters to more than a meter in depth, depending on several factors including sediment composition, substrate particle size, elevation changes, and flow characteristics (Wetzel, 2001). Furthermore, surface flow velocity is positively correlated with dissolved oxygen concentrations in both interstitial and surface water (Wetzel, 2001; Bjornn and Reiser, 1991), and should be locally measured in conjunction with dissolved oxygen readings.

The presence of rust-colored precipitate (Figure 6) confirms that groundwater entering Jordan Creek in some stream reaches is low in oxygen and contains substantial concentrations of iron. Anoxic groundwater picks up dissolved iron as it flows through iron-containing soil layers. Upon reaching the hyporheic zone and subsequently the water column, the dissolved iron binds with oxygen to form a precipitate. The process results in consumption of dissolved oxygen as surface waters mix with the groundwater and iron oxides are formed.

Figure 6: Iron precipitate in the main channel near Jennifer Drive. April, 2005.

Further monitoring of dissolved oxygen in surface and interstitial waters is necessary to determine the extent impairment and potential causes of the problem, which may be partly due to natural conditions. Under normal conditions, the concentration of dissolved oxygen in small, turbulent streams is often at or above saturation. Variations in dissolved oxygen concentrations may occur spatially and seasonally within a given stream, and can be influenced by fluctuations in discharge rates, temperature variations, and organic matter input. Decreases in base flows, increasing water temperature, and decomposition of organic matter can cause dissolved oxygen declines. Such influences may be partly responsible for some of the low dissolved oxygen observations made in Jordan Creek, but do not account for the substantial declines in fish populations that have been observed in recent years.

2.3.3 Sediment

Preliminary data suggest that Jordan Creek may not support its designated uses of growth and propagation of fish, shellfish, other aquatic life, and wildlife due to sediment input. Excess sediment embeds spawning gravels, creating a physical impediment to fish reproduction and decreasing interstitial dissolved oxygen concentrations. Since newly emerged fry occupy the interstitial spaces in optimal stream substrates, large inputs of sediment may also reduce stream carrying capacity by reducing available refuge (Bjornn and Reiser, 1991). Over time, sediment inputs will change the hydrologic characteristics of a stream, potentially increasing the likelihood of flooding. Although some natural sediment input is expected in nearly all stream systems, land use activities can have a significant impact on upland erosion and subsequent deposition of sediment in streams.

Jordan Creek hydrology is characterized by a low gradient main channel that is fed by relatively high gradient tributaries. Stream channel process groups and types were identified and mapped by ADF&G Division of Sport Fish during the 2003 habitat survey of Jordan Creek, using the classification system developed by Paustian et al. (1992). According to the survey data, the main channel has a tendency to retain sediment transported from steeper reaches or tributaries (Appendix C). The tendency to store sediment in the main channel is exacerbated by soils in the watershed. The steep upland slopes through which the high gradient tributaries flow have shallow, unstable, and unconsolidated soils. Soils in the Valley and estuarine areas are deeper, but have high quantities of fine materials left behind as the glacier retreated. Streambed materials in the main channel are potentially mobilized only during high runoff events.

The low gradient of the main channel implies that Jordan Creek is extremely sensitive to sediment input; erosion is likely to occur on steep uplands and disturbed areas, and stream energy is not normally great enough to mobilize accumulated sediments. Although some sediment inputs can be expected under natural conditions, riparian and upland disturbance has occurred throughout the watershed as the area becomes more urbanized. Substantial erosion was reported during construction of the water tower east of Jordan Creek, an area that continues to contribute sediment to the stream (Figure 7). Illegal off-road vehicle use in the upper watershed has caused streambank, floodplain, and upland erosion. Riparian disturbance can frequently be observed in the lower stream corridor, where development is in close proximity to the stream.

Figure 7: Streambank erosion near the City water tower. The tower is located to the right of the stream. April, 2005.

Sand that is applied to roads and parking areas for traction during winter months also contributes to streambed sedimentation. The CBJ Streets Division cleans out sediment traps and oil-water separators in storm drains throughout the Borough at least once each year, which helps reduce the amount of sediment being delivered directly into surface waterways. However, sand used on local roadways accumulates in snow enters the creek during spring runoff or is deposited in the creek during snow removal and storage activities throughout the winter (Figure 8).

There may be a relationship between sediment loading and low dissolved oxygen levels in Jordan Creek. Studies have shown that sediment input can reduce interstitial water flow, which leads to low dissolved oxygen levels in the substrate and in turn reduces the likelihood of egg survival (Hicks et al., 1991). Because of this, the draft TMDLs developed for sediment and dissolved oxygen in 2004 have not been finalized. The Mendenhall Watershed Partnership

(MWP) and University of Alaska Southeast are working to examine the two parameters concurrently, focusing on interstitial dissolved oxygen levels.

2.4 Other Potential Pollutants

Jordan Creek is listed as impaired only for the parameters discussed above—debris, dissolved oxygen, and sediment. However, a comprehensive examination of factors that may affect water quality must also include potential pollutants. The number of homes and businesses in the watershed has increased rapidly since the mid-1950s, which changes the nature and characteristics of runoff entering surface waters.

Figure 8: Snow plowed from streets and driveways stored in the creek near Jordan Creek Center. Sediment and debris are deposited in the creek when the snow melts. February, 2005.

As urbanization occurs, floodplain vegetation is replaced with impervious surfaces such as rooftops and pavement. Runoff is transported more rapidly to stormwater systems and streams than it would be in an undeveloped area where precipitation is filtered through soils and vegetation before entering ground or surface water. Household and industrial runoff may contain pollutants such as hydrocarbons, fertilizers, pesticides, pet feces, and various chemicals including solvents and cleaning fluids. Hydrocarbon sheen has been observed on the surface of Jordan Creek during stream surveys (Figure 9).

Figure 9: Hydrocarbon sheen on the water surface near Jordan Creek Center. February, 2005.

Reid Pond, the former gravel pit located in the headwaters of Jordan Creek, was used as a dump site for household garbage, overburden, and other debris (Bethers et al., 1995; Host and Neal, 2004). A water sample collected in 1999 was analyzed for volatile organic compounds and found to contain 1.68 µg/L of dichlorofluoromethane. The compound is commonly known as Freon® 12 and is used as a refrigerant. No water quality standards have been set for the compound at either the state or federal levels. The Occupational Safety and Health Administration and the National Institute for

Occupational Safety and Health have established exposure standards for the gaseous phase only (1,000 ppm over an 8-hour period and 10 ppm for a 10-hour period, respectively). Although the site has been backfilled and the surface drainage has been routed to Duck Creek, groundwater flow may still lead to Jordan Creek.

The area near the former pond site continues to be used as an illegal dump site. Several similar illicit dumps exist in the upper creek corridor and may contain debris that includes toxic chemicals. Car batteries, fuel containers, appliances, paint cans, and even a vehicle (Figure 10) have been found in or near the creek.

Figure 10: A truck in upper Jordan Creek. Spring, 2003.

Most Valley homes have sewer lines that transport waste to the treatment plant located on the Mendenhall River near the Airport property. Fecal coliforms from human sewage are therefore unlikely to become a contaminant in Jordan Creek unless sewer lines fail. However, fecal coliforms concentrations in stormwater entering Jordan Creek exceeded state water quality standards for several sampling events in 2002. Samples collected at Amalga Street, upstream of Egan Drive, and near the Jordan Creek Center contained fecal coliforms at concentrations ranging from 2 to 170 cfu/100ml during the study period. The state standard of less than 3 cfu/100ml was exceeded at all three sites for 50% or more of the sampling events (Carson Dorn, 2002b). Pet waste, inputs from wildlife, and waste left by squatters living in the woods in the upper creek corridor are potential fecal coliforms sources.

Several contaminated sites near Jordan Creek are identified on the DEC website (http://www.dec.state.ak.us/spar/csp/search/lust_results.asp). Some of the listed sites remain in active status, and hydrocarbons have been detected in the groundwater in some areas. At the present time, the only known data related to organic compounds in Jordan Creek was the sample taken near the former Reid Pond site.

3. Fish and Fish Habitat

3.1 Jordan Creek Fish Species

Jordan Creek is an anadromous fish stream that has supported coho, pink, and chum salmon, Dolly Varden char, and cutthroat trout (Johnson et al., 2004). Steelhead have also been captured at the weir operated by ADF&G. Stocking occurred in 1953 with the addition of 3,000 brook trout, followed by 4,800 coho salmon in 1970. Good spawning and rearing habitat can be found throughout most of the main stem and parts of the tributaries (Bethers et al., 1995). Other fish species such as capelin, sculpin, herring, eulachon, and flatfish inhabit the estuarine areas in the State Game Refuge (K Koski, National Marine Fisheries Service, personal communication).

Adult coho salmon typically enter Jordan Creek during high water periods in August through October, with the peak returns occurring in mid-September through early October. Coho fry spend one to three winters in the creek, then migrate out to sea as smolts during May and June. Adult pink salmon occupy lower Jordan Creek between late June and mid-August. Pinks spawn primarily in the intertidal zone, with smolt outmigration occurring in late winter and early spring. Chum salmon also spawn in intertidal areas and further upstream, and tend to stay in estuarine environments longer than pink salmon. The Juneau area has a summer chum run that enters fresh water in July and August and spawn by the end of September, and a fall chum run that enters streams September through November and spawns from October through December. Resident cutthroat trout typically spawn in May through early June in tributary streams and headwaters, and adult Dolly Varden hatch in March and spawn in October and November (Bethers et al., 1995; Carson Dorn, 2002a).

3.2 Fisheries Research

3.2.1 Coho Egg and Smolt Studies

Coho salmon have been studied as an indicator for resident and anadromous fish habitat condition in Jordan Creek, since spawning, incubation, egg development, emergence and juvenile rearing all take place within the creek. Mean survival rate of 5.2% in 1996 and 44.7% in 1998 were reported during a study of egg-to-fry survival (Koski and Lorenz unpublished data, National Marine Fisheries Service, Auke Bay Fisheries Laboratory). Dissolved oxygen levels were measured concurrently at Steep Creek, Duck Creek, and Jordan Creek in the 1998 study. Greater survival rates correlated to locations with higher dissolved oxygen levels at all sites as well as within Jordan Creek itself.

Coho salmon escapement for 1996-2000 was below ADF&G management goals, and far below other nearby streams for the same time period. Reduced smolt production is the suspected cause. The 2002 high peak count does not appear to be related to an increase in spawning escapement. Outmigrating smolts in 2001 were most likely the offspring of spawners from 1998 and 1999. Peak brood year spawner counts were 63 in 1998 and 47 in 1999, which are relatively low compared to the corresponding 25,909 smolts counted in 2001. Data from Jordan Creek and other area streams suggest the unusually high smolt counts could be a result of greater smolt productivity than is normally observed, or that juveniles from other stream systems are moving into Jordan Creek to rear (Shaul et al., 2003).

Shaul et al. (2003) speculate that the Jordan Creek stock may be particularly sensitive to variable environmental conditions that affect freshwater survival. Murky, foamy runoff was observed by ADF&G crew members monitoring smolt traps on the creek in the spring of 2003, for about a day following the first rainfall after extended periods of dry weather. Trapped smolts experienced about a 50% mortality during the first event. Later events were monitored and the traps were emptied to allow the smolts to move out of the area (Carson Dorn, 2004).

3.2.2 Adult Coho Counts and Escapement Analysis

ADF&G conducts annual peak counts of coho salmon in Jordan Creek as an indication of escapement levels, though the counts are not equivalent to total spawning stock sizes. The stated "adult returns" on the 303(d) list for Jordan Creek refer to peak counts from those years rather than total spawning stock sizes. Escapement trends were assessed for Jordan Creek by analyzing peak adult coho counts for 1981 through 2003, using Geiger and Zhang's (2002) method (Carson Dorn, 2004). Escapement trends can be difficult to determine because salmon populations typically fluctuate over time. Data outliers and the data series length influence the outcome of statistical analyses. Geiger and Zhang's method is designed for analyzing trends in either escapement estimates or escapement peak counts, using 15 or 21 years of data in order to represent the current production regime of three to four generations for most salmon species. Peak adult coho counts and two possible escapement trends are shown in Figure 11. The solid line represents the estimated trend based on 21 years of data (1983-2003) and the dashed line represents the estimated trend based on 15 years of data (1989-2003). A population that declines at the rate of 3% over a 21-year period will have been reduced to 37% of its original size, which is a substantial change. Similarly, a 75% reduction in population occurs at a declination rate of 5% over a 15-year period. The estimated annual population decline for the 21-year data series is 3.1%, and 7% for the 15-year data series. Both series analyses lead to the same conclusion—the coho salmon stock in Jordan Creek has experienced what Geiger and Zhang term "a biologically meaningful decline." Analyzing the same data with a standard linear regression would indicate a population increase due to the influence of outlying values in 1992 and 2002.

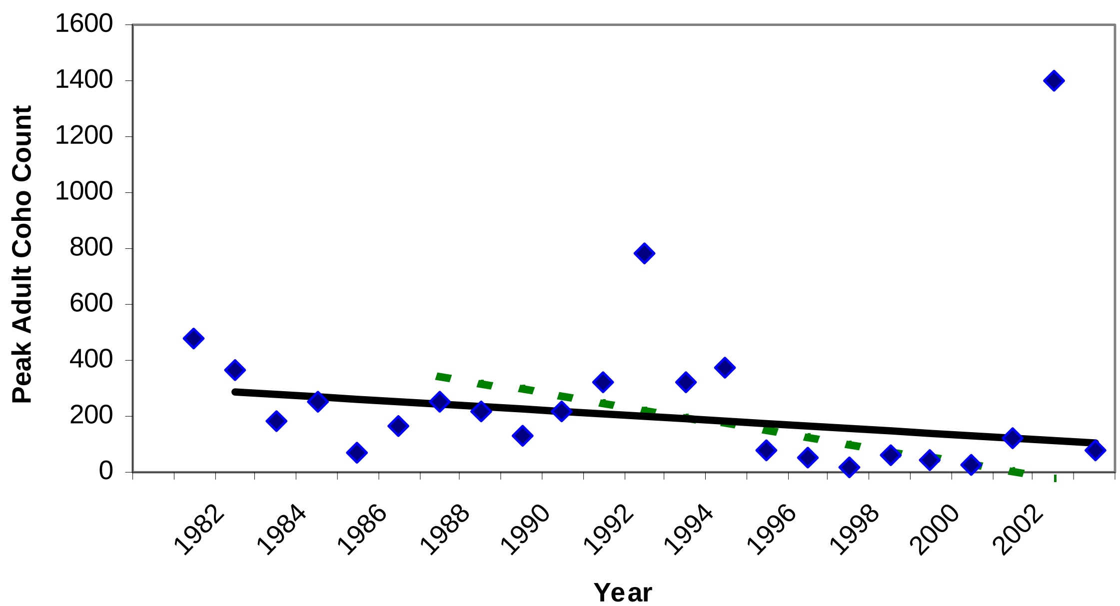

Figure 11. Adult peak coho counts and estimated population trends for Jordan Creek, 1981-2003. The diamonds represent yearly peak coho counts. The solid line represents the population trend estimated using a 21-year series. The dashed line represents the population trend estimated using a 15-year series (Carson Dorn, 2004).

3.3 Fish Habitat Impacts

Encroaching development has adversely impacted Jordan Creek fish habitat. Downstream of Egan Drive, the stream corridor has been developed and there is little remaining connectivity to the floodplain. Although much of the watershed upstream of Egan Drive remains largely undeveloped, most of the area is steep with small tributary channels that lack suitable fish habitat or are simply inaccessible due to high gradient. Fish and fish habitat in Jordan Creek have been affected by both physical habitat alteration and by water quality influences.

3.3.1 Channel Alterations

Direct impacts to fish habitat include channelization and relocation of the stream channel. Some stream reaches in the lower corridor have been moved or channelized to facilitate commercial development. The portion of Jordan Creek flowing through Airport property was moved to its current location during initial construction in the 1930s (Federal Aviation Administration, 2005). Upstream of the Airport, approximately 1,000 yards of Jordan Creek were channelized between Old Glacier Highway and Egan Drive (Bethers et al., 1995). Tributary flow into Jordan Creek was lost when the Egan Drive expressway was constructed (K Koski, personal communication). Although much of this section currently has overhanging banks and good vegetative cover, urbanization of the area continues to influence fish habitat quality.

3.3.2 Streambank and Riparian Disturbance

Riparian disturbance in several areas has resulted in loss of vegetative cover for fish. On Airport property, removal of riparian vegetation is one of the wildlife management practices used for aircraft safety (Figure 12). By reducing bird habitat, the Airport hopes to decrease the chances of aircraft accidents resulting from collisions with birds. Streambanks in the Airport reaches of Jordan Creek appear to be stable, however, and herbaceous plants provide some fish cover in mid- to late summer.

Figure 12: Damage to the streambed, banks, and adjacent wetlands in upper Jordan Creek due to illegal off-road vehicle use. May, 2004.

Elsewhere, riparian disturbance is less contrived. Clearing of riparian vegetation is sometimes conducted by streamside landowners. Riparian vegetation has been trampled in several locations in the lower creek corridor, particularly where parking lots and businesses are in close proximity to the stream. Damage caused by illegal off-road vehicle users is more common in upper Jordan Creek, where floodplain wetlands associated with the Jordan Creek drainage on the east side of the stream have also been affected (Figure 11). Several locations near

Nancy Street and Valley Boulevard have been damaged by vehicles driving through and sometimes in the creek. The loss of riparian vegetation decreases available cover for fish, but also tends to destabilize streambanks. Erosion—either natural or human-caused—will result in sediment deposition in the creek since most of the area's soils have high sand and silt content (Schoephorster and Furbish, 1974), and the main channel lacks sufficient energy to mobilize fine materials. The result is a loss of spawning habitat and a decrease in egg survival rates.

Development projects and other human activity have also contributed sediment to the stream. Notices of violation for illegal placement of fill in Jordan Creek have been issued on several occasions. Jordan Creek is listed as one of the streams "most seriously affected" by development activities in Juneau (City and Borough of Juneau, 1986). The presence of regulatory controls over each of these activities has not prevented damage to instream habitat from occurring. Water quality factors have also impacted fish reproduction and fish habitat quality. As previously discussed, sediment inputs may contribute to low interstitial dissolved oxygen. Excess sediment may also embed spawning gravels, decreasing the amount of available spawning habitat and burying existing eggs. Finally, debris can impede fish passage by accumulating in log jams or clogging culverts.

3.3.3 Fish Passage

Providing adequate passage allows fish at various life stages to migrate into areas that will benefit them most. A juvenile fish may move upstream or downstream to find food and cover until it is ready to go to saltwater, and adult fish need to migrate upstream in order to spawn. The map included in Appendix C shows 21 stream crossings on Jordan Creek (ADF&G habitat survey, 2003; NRCS staff observations, 2005). Most of the crossings are located from Egan Drive downstream to the outlet. A culvert is also located on the floodplain tributary channel north of the Airport taxiway (not shown on the map due to discrepancies between data layers.)

Most of the crossings appear to be functioning, with the exception of the old bridge at Sasha Street (Figure 13). Near the outlet in the State Game Refuge, the Airport maintains four stream crossings in close succession on Jordan Creek, with culverts ranging from 81 to 350 feet in length. Tidal fluctuations influence water levels and flow velocities in the Crest Street, taxiway, and runway culverts. According to the Alaska Department of Natural Resources, the runway and taxiway culverts are in poor condition. Fish passage through these culverts may be impeded during ebbing tides or when low tide is coupled with high stream discharge rates, when flow velocity through the culverts is greatest (Federal Aviation Administration, 2005). Current

Figure 13: Collapsed bridge near Sasha Street. April, 2005.

plans to expand the runway safety area includes replacing the runway and taxiway culverts with a single culvert that is approximately 770 feet in length, which may further impair fish passage near the mouth of the creek.

4. Recovery and Stewardship

Although much of the watershed is forest land, the density and close proximity of urban development have impacted Jordan Creek water quality and fish habitat. Physical alterations to the stream channel and associated floodplain have contributed to declining water and fish habitat quality. Nevertheless, Jordan Creek still provides good fish habitat throughout most the system and steps can be taken to improve water quality and prevent further degradation.
A discussion of general recovery and stewardship topics is included below, followed by an outline of specific goals, objectives, and action items. Improving water and fish habitat quality in Jordan Creek will require cooperation between multiple entities including resource agencies, local government, land owners, citizens, and natural resource nonprofits. The plan should be revisited approximately every five years to determine if goals, objectives, and action items should be adapted to new conditions.

4.1 Discussion

Impacts to water quality and fish habitat on Jordan Creek are often interrelated. There are also some impacts that are caused by natural processes. For instance, dissolved oxygen levels are affected by the presence of iron-rich groundwater entering Jordan Creek. Discontinuous strata of iron-containing soils are found throughout the Valley. Groundwater transports some of this iron in solution to the stream, where it mixes with dissolved oxygen to form iron oxides. This rust-colored precipitate is found in various stream reaches, and has been observed at least since the 1930s (Mielke, 2001). Control of this process would require maintaining streamflow and discharge velocities great enough to flush iron—something that is difficult given the low gradient of Jordan Creek's main channel.

Similarly, it would not be feasible to control geologic and other natural processes that may be affecting streamflow. The lower portion of the stream near the estuary has been subject to dewatering for many years (ADF&G unpublished field notes, 1965, 1970, 1977, and 1979). Whether this is a function of the channel's hydrology, a result of periodic drought, related to global warming, a product of glacial uplift, or a combination of these factors is subject to discussion and further monitoring.

Human influences are likely accelerating or exacerbating such natural processes, and adding additional pressures on water and habitat quality. Improvement the condition of Jordan Creek and protecting its future will depend on communication and coordination among agencies, local government, community groups, businesses, and residents. Several organizations and government agencies can provide technical and/or financial assistance for specific projects, including MWP, state and federal resource agencies, and CBJ. Organizations such as Trail Mix and Southeast Alaska Guidance Association (SAGA) do hands-on work and may be able to provide knowledge or services that can assist with completion of bank stabilization, revegetation, trail construction, or other resource improvements.

Communication between these entities is critical for identifying, prioritizing, and completing successful projects. The Duck Creek Advisory Group (DCAG) has functioned as a forum for stream management dialogue between agencies and community groups since the late 1990s, but has met with decreasing frequency in recent years. Initially the group focused solely on Duck Creek, but has expanded their scope to include Jordan Creek and other Juneau streams. Currently a technical advisory subcommittee of MWP, the DCAG needs to be revitalized. Involving neighborhood associations and local residents in protection and rehabilitation efforts will be essential to improving and protecting Jordan Creek.

4.1.1 Urbanization and Land Use

Regardless of the natural processes influencing Jordan Creek, human activities have had a substantial impact on water quality and fish habitat. Land use has perhaps been the single most influential factor affecting the creek. Southeast Alaska's rugged terrain precludes an abundance of developable land. This is apparent in Juneau, where the demand for residential land exceeds the available supply. Because of this, areas along the east side of Jordan Creek may eventually be considered for housing or commercial development. Much of the area is zoned as "rural reserve" and currently provides the only remaining open space on the east side of Mendenhall Valley. Even under the current zoning designation such land uses as residential development, resource extraction activities, and development of recreational facilities may be allowed (City and Borough of Juneau Land Use Ordinance 49.25.200, and Table 49.25.300).

Urbanization alters stream hydrology. As the amount of impervious surface area increases within a given watershed, infiltration decreases. The result is that peak stream discharges increase and occur soon after precipitation events or snowmelt occurs. Base flows may also decrease as groundwater infiltration is impeded (U.S. Environmental Protection Agency, 1993; Knighton, 1998; Dunne and Leopold, 1978). Loss of habitat, degraded water quality, and decreased biological diversity has also been correlated with increases in the percentage of developed watershed area (Schueler, 1994; Arnold and Gibbons, 1996). Maintaining the east side of Jordan Creek as open space, therefore, would help prevent further stream degradation. Reestablishing riparian buffers through purchasing land and/or easements where development has occurred within the setback should be pursued where possible. Finally, development should be minimized if preventing it altogether is not possible.

Should the area east of upper Jordan Creek be developed, land use planning can be an effective tool in preventing water quality and habitat degradation. Techniques such as watershed-based, overlay, and low density zoning; and establishing urban growth boundaries can all be used to direct land uses and ultimately protect the hydrologic function, water quality, and biologic diversity of surface water systems (Schueler and Holland, 2000). Erosion potential, vegetation type, hydrology, proposed land uses, fish and wildlife sensitive habitat areas, and flood frequency are among the parameters that should guide establishing development zones. Once established, zoning can only help prevent degradation if followed consistently.

In describing stream channel process types throughout Southeast Alaska, Paustian et al. (1992) suggested management considerations for hydrology, aquatic habitat, and riparian areas associated with each stream classification. ADF&G classified Jordan Creek channel process types during the 2003 habitat survey of Jordan Creek. A map of channel types and tables listing stream channel process types and management considerations are included in Appendix C. In general, the portions of Jordan Creek that provide good fish habitat also have a tendency to store sediment. Because of the high concentration of fine materials in most of the watershed's soils, activities that cause erosion should be avoided. If and when development does occur, efforts should be made to prevent offsite soil transport and ultimately its deposition in the creek.

Some resource development has occurred on the east side of Jordan Creek. The area near Sasha Street has been logged in the past, and the City constructed a water collection system adjacent to the primary tributary to Jordan Creek in the mid-1980s. The tank and associated service road was constructed on steep terrain with unconsolidated soils. A substantial amount of sediment was contributed to the stream during construction, and erosion continues to be apparent. Stabilizing exposed riparian and upland areas would greatly reduce the amount of erosion and therefore the sediment inputs into the stream. Streambanks near the water tower should be regraded to gentler slopes and revegetated. Reducing the pad and road footprints to the minimum necessary area would decrease the amount of exposed soil that is subject to erosion runoff. And finally, sealing or paving the road and tower pad would protect the soil and prevent future erosion.

4.1.2 Riparian Buffers

Part of good stream stewardship involves maintaining adequate setbacks and avoiding riparian disturbance. The City and Borough of Juneau Coastal Management Program (1986) includes a 50 foot setback for development adjacent to anadromous streams or lakes, and states that the setback area should be vegetated or revegetated to "maximize shade on the stream." The same statement is also made in Section 49.70.950 of the local Land Use Ordinances. In addition, no disturbance is allowed within 25 feet of anadromous waterbodies (CBJ Land Use Ordinance 49.70.310). Structures and parking areas do exist within the setback, either because they were constructed prior to enacting the ordinance or because variances are granted. Development close to the creek is particularly evident downstream of Egan Drive (Figure 14).

Figure 14: Buildings and parking areas in lower Jordan Creek that are situated within the 50-foot setback. February, 2004.

Maintaining the minimum setback will ensure riparian buffers exist, providing adequate instream fish cover and helping to filter potential pollutants from surface runoff before water enters the stream. Foregoing granting variances for building setbacks and enforcing the ordinance when violations occur are two important aspects of maintaining riparian buffers. Reestablishing a riparian buffer where development within the setback has occurred should be pursued where feasible.

Recreational activities in the upper watershed have disturbed riparian areas, wetlands, and the floodplain. Off-road vehicle use is illegal in the areas of Jordan Creek currently being damaged by such recreation is subject to local ordinances governing riparian disturbance as well as state regulations that protect anadromous fish habitat (AS 41.18.870). While rehabilitation of the disturbed sites is under way, it is likely that the area will continue to be used unless education, enforcement, and access control occur, and an off-road recreation area is established.

The need for providing an approved off-road recreation area in Juneau is apparent. There currently are no City lands set aside for off-road vehicle use, and Forest Service lands such as the Dredge Lakes area used to be open to motorized recreation but have since been closed. Raising public awareness of appropriate public land uses may help reduce the frequency of impacts to the creek either by appealing to riders themselves or to local residents and other recreationists interested in protecting the area. Enforcing City ordinances governing off-road vehicle use would also help, but requires additional patrols and is therefore difficult. Ideally, a combination of these tactics should be used in combination with rehabilitation of damaged habitat in order to improve the condition of upper Jordan Creek.

Riparian vegetation has been removed on Airport property in order to minimize the amount of bird habitat, thereby reducing the likelihood of aircraft accidents due to bird strikes. Eliminating vegetation by paving or gravel surfacing adjacent to the aircraft operations areas is recommended in the Airport's Wildlife Hazard Assessment (Wilmoth et al., 2001). The report also recommends reducing the number of trees near the float plane pond, and removing any vegetation that provides food sources for wildlife (such as woody, berry-producing shrubs and trees). Although such a recommendation is not specifically stated for the Jordan Creek corridor, much of the woody riparian vegetation has been removed.

Although such practices impact salmonid habitat, maintaining or restoring woody riparian vegetation is counter to Airport wildlife management procedures. However, maintaining a building setback of at least 50 feet and retaining the herbaceous cover that currently exists will at least provide some protection to water quality while allowing fish to migrate through the property. Following the Wildlife Hazard Assessment recommendation to avoid mowing grassy areas in mid- to late summer will not only reduce the likelihood of birds using such areas, but will help provide some instream fish cover and filter runoff entering the stream. Where Airport stormwater runoff is routed to the stream, settling basins should be used to reduce the amount of fines entering the system. And finally, any additional development of the Jordan Creek corridor on Airport property should be avoided to prevent further degradation of fish habitat and water quality in both the creek and the estuary.

4.1.3 Snow Removal and Storage

With almost eight feet of average annual snowfall in the Juneau area, ice control and snow storage can be problematic. Sand is often used to improve traction on icy streets, later depositing in local streams during runoff periods. Streams are convenient areas to dump excess snow when people clear driveways or parking areas. Businesses and residential homeowners need to be educated about the potential impacts of improper snow storage on water quality and fish habitat, and provided with some guidance on proper snow management. Alternative storage locations should be established through collaboration between resource agencies, CBJ, local businesses, and snow plow contractors.

Snow management practices should be planned to maintain vehicle and foot traffic access while taking natural areas into consideration. Snow should be stored away from streams, preferably in areas where good vegetative cover will trap excess sediment before entering stormwater systems or waterways. This is particularly important where large areas are cleared, such as on Airport property or business centers like the Nugget Mall or Jordan Creek Center parking lots. Government road maintenance crews and individual snow removal service operators should be encouraged to reduce plowing speed over stream crossings in order reduce the amount of snow that is sidecast into surface waterways. Providing a community snow storage area with a settling basin would help reduce the amount of sediment entering Jordan Creek and other local waterbodies as a result of snow removal and storage activities.

4.1.4 Other Potential Pollutants

Residential, commercial, and industrial development will likely continue to grow and change in the Jordan Creek watershed. Demand for residential property remains high in Juneau, and the Airport plans to expand facilities in the near future. As previously discussed, runoff from developed areas may contain a variety of potential pollutants. Controlling nonpoint source pollution will be more critical to protecting water quality as development continues to occur in the Jordan Creek watershed.

Sediment, chemicals used for road de-icing, petroleum products, household and industrial cleaners, and pet waste can all be at least partially filtered by riparian vegetation. Upholding the required 50 foot building setback will help prevent pollution from entering streams via surface runoff. Rehabilitation of disturbed riparian areas and damaged streambanks should also be a priority. Offering tax breaks or other incentives for developers who leave more than a 50 foot setback intact, or who enhance an existing setback, would provide additional motivation for protecting stream buffers. And finally, installation and regular maintenance of oil-water separators and sediment traps in stormwater collection systems will reduce direct inputs of sediment and hydrocarbons into the stream.

In addition to maintaining riparian buffers to assist with runoff filtration, reducing the source of potential pollutants is also important. The U.S. Environmental Protection Agency estimates that nearly one million tons of chemical fertilizers and 70 million pounds of active pesticide ingredients are applied to the nation’s lawns each year (Schueler and Holland, 2000). Should residential development continue in the Jordan Creek watershed, public education about the affects of such chemicals and alternative lawn maintenance techniques would help prevent potential impacts to water quality.

Assessment of contaminated sites within the Jordan Creek watershed needs to be completed in order to determine the potential of hydrocarbons or other organic compounds entering the creek.

At the present time, the only water quality data related to organic compounds in Jordan Creek was a sample taken near the former Reid Pond site in the upper creek corridor that was analyzed for volatile organic compounds (Host and Neal, 2004).

4.1.5 Fish Habitat

Bethers et al. (1995) state that "much of the productive capability of Jordan Creek has been lost," though the report also notes that good spawning and rearing habitat can be found throughout the system. Improving water quality will likely improve fish survival and reproduction in Jordan Creek. Direct, physical implications of management alternatives on fish survival, productivity, or habitat quality are stated in the following sections, but may touch on water quality parameters previously discussed.

Maintaining stable, well-vegetated riparian corridors is important for both water quality and fish habitat. Streambank erosion adds sediment to the stream, which can physically clog spawning gravels. Embedded substrate impedes creation of redds (gravel "nests" in which fish lay their eggs), decreases the chances of egg survival, occupies interstitial space that might be used by fry, and potentially reduces interstitial dissolved oxygen. Excess sediment may also reduce the abundance or type of invertebrates available for food (Bjornn and Reiser, 1991). Removing riparian vegetation also directly impacts fish habitat—lack of vegetative cover makes fish vulnerable to predation and leads to increased stream temperatures.

The connectivity of streams to their associated floodplains is ecologically important, and helps attenuate flood flows that may threaten human infrastructure (Dunne and Leopold, 1978). Juvenile fish will sometimes use side channels and wetlands associated with a stream as rearing habitat. Such areas contribute nutrients to the stream, and provide aquatic and terrestrial habitat for macroinvertebrates that are a source of food for fish. Reduction of floodplain habitat often results in a decline in stream biodiversity (Wetzel, 2001). Additional development of the floodplain may therefore impact fish productivity in Jordan Creek, and increase flood frequency and severity. Impacts to wetlands and floodplains that are outside of the recommended setback should be avoided in order to protect biologic and hydrologic stream functions.

4.1.6 Fish Passage

An assessment of all culverts on Jordan Creek would provide information about the overall quality of fish passage on Jordan Creek, and help determine which structures should be replaced or removed to ensure all life stages of fish are able to migrate up and downstream at various flows. Unnecessary stream crossings should be removed when possible, particularly when the structure has failed. The abandoned bridge near Sasha Street is one such example, though it does not appear to block fish passage. Should new stream crossings be constructed, bridges should be installed if possible as they are preferable to culverts for providing good fish passage.

Most of the existing stream crossings are located on lower Jordan Creek. In order to access upstream spawning areas, anadromous fish must migrate from saltwater through a series of culverts on the Airport property. Proposed expansion of the runway safety area includes plans to replace the existing runway and taxiway culverts with a single culvert that is 770 feet in length.

The proposal includes daylight wells at 100-foot intervals, a "more natural channel bottom than the current culverts," and a shallower channel slope with correspondingly lower stream velocities (Federal Aviation Administration, 2005). Although culvert extension is generally counter to fish passage goals, upgrading this culvert is expected to improve conditions and should be a priority.

4.2 Goals and Action Items

Several factors affecting Jordan Creek have been discussed in this and other reports. These factors are often interrelated, and are both caused by human activity and can be mitigated by future actions. Timing is critical however, as increasing pressure on Jordan Creek threatens to degrade the system to a point where recovery is difficult and costly, as has occurred with Duck Creek. Although the TMDLs for sediment and dissolved oxygen have not been finalized, water quality recovery can still proceed.

Goals for improving Jordan Creek are stated below. Because this report was initiated to address waterbody recovery in relation to the TMDLs, water quality goals are listed first and have been prioritized according to the degree to which they threaten the creek. The listing of the fish habitat protection goal last does not imply that it is less important than the water quality goals. Rather, many of the associated objectives and action items are similar to or reinforce those stated for water quality goals. Objectives and action items listed for each of the goals are intentionally not prioritized because they are often interrelated. Furthermore, projects addressing specific resource concerns are most often initiated opportunistically, when funding, time, agency and/or local government policies, and community initiative are favorable. The information is outlined for reference in Appendix D, which includes a list of potential leaders or participants in working toward stewardship of Jordan Creek.

Goal 1: Jordan Creek meets state sediment water quality standards.

Objective 1.1: Prevent and reduce erosion.

Action 1.1.1 ⇒ *Discourage motorized recreation in the upper Jordan Creek corridor by eliminating/blocking access points, posting signs, regular public outreach, and establishing an acceptable riding area.*

Motorized vehicle use in the upper Jordan Creek corridor is damaging streambanks, spawning areas, floodplains, and wetlands. Efforts have been made to deter use of the area, with varying degrees of success. Posted signs have been removed or destroyed, and attempts to block access have been bypassed or have led to development of additional access points. These efforts will only be successful if combined with a public outreach campaign and enforcing regulations governing such activities.

Wetland areas and floodplains near Montana Creek have been similarly impacted by illegal motorized recreation. Discouraging off-road vehicle use will remain ineffective if riders have no options. Providing established off-road vehicle use areas would help prevent degradation of Jordan Creek and other streams within the City and Borough of Juneau.

Action 1.1.2 ⇒ *Enforce regulations that address riparian and stream disturbance.*

Regulations governing riparian and stream disturbance are in place at the city, state, and federal levels. Enforcement of setback ordinances, state regulations regarding protection of anadromous fish habitat, and federal laws governing wetlands and waterways will protect Jordan Creek and prevent future violations from occurring. Requiring habitat rehabilitation actions should be part of the enforcement, but will only be effective if oversight and subsequent monitoring is done.

Action 1.1.3 ⇒ *Require and encourage best management practices that control off-site migration of sediment during land-disturbing activities.*

Best management practices (BMPs) are often included in federal, state, and city permits issued for development projects. It is critical that BMPs are included with such permits, and that they address erosion control measures. Ensuring that the permitee follows the BMPs requires monitoring by the issuing authority. However, limited staff resources often preclude project oversight and developer interaction. In such cases, it is helpful to have community groups such as the MWP or neighborhood associations who are willing to encourage land owners and developers to use BMPs, and check to see that practices are being maintained throughout the duration of a given project.

Action 1.1.4 ⇒ *Stabilize the road, tank pad, and streambanks associated with the CBJ water storage facility on the main Jordan Creek tributary.*

Substantial erosion occurred during construction of the CBJ water tower, and the area continues to contribute sediment to Jordan Creek. The road and tank pad are unpaved and are subject to sloughing and rill erosion during precipitation and runoff events. Nearby streambanks are unvegetated, steeply sloped, and composed of unconsolidated material that is vulnerable to erosion. Sediment transport to Jordan Creek is facilitated by a combination of steep upland slopes and high gradient stream channel. Stabilizing the storage tank area will help reduce the amount of sediment being deposited in the main stem of Jordan Creek.

Action 1.1.5 ⇒ *Rehabilitate disturbed streambanks, riparian areas, floodplains, and uplands.*

Rehabilitation of disturbed areas is much less effective than preventing damage from occurring in the first place. Resource agencies, local government, and community groups must continue to work proactively to prevent impacts to streambanks, riparian areas, floodplains, and uplands. Once damage occurs, issuing violations and requiring mitigation for damages to aquatic resources will help prevent future problems.

Streambanks damaged by off-road vehicle use in upper Jordan Creek were recently stabilized through a cooperative effort by U.S. Fish and Wildlife Service, CBJ, and SAGA. Similar bank rehabilitation projects may need to be completed at other locations in upper Jordan Creek, and at several locations in the lower stream corridor. Bank trampling in the lower creek reaches has occurred primarily where businesses and parking lots are within the setback.

Objective 1.2: Maintain and improve riparian areas.

Action 1.2.1 ⇒ *Educate the public about stream stewardship and the importance of maintaining riparian buffers for fish streams.*

The MWP distributed flyers about streamside stewardship to residents in the Mendenhall Valley several years ago, in cooperation with CBJ. Such public outreach should be repeated, perhaps including other media. For example, watershed councils in the upper Lynn Canal communities of Haines and Skagway are initiating a "Watershed Weekly" radio show to help educate listeners about watershed resources and conservation. Incorporating internet, radio, and printed material into an education campaign about stream stewardship would reach a wider audience than using a sole media source.

Discovery Southeast continues to provide outdoor education to students. Their programs have fostered an appreciation of stream resources in the Mendenhall Valley and elsewhere. Support for theirs and similar programs will promote awareness about resource stewardship.

Action 1.2.2 ⇒ *Maintain riparian buffers by not granting streamside setback variances.*

The fact that CBJ has a setback ordinance can be considered progressive. Many local governments in Alaska and the Pacific Northwest do not have such ordinances, which are critical for ensuring good water quality and fish habitat. However, variances are often granted and development within the setback has occurred. Ensuring a 50-foot riparian buffer along Jordan Creek and other streams will help protect water quality and fish habitat, and will only occur if variance requests are forgone in favor of maintaining the setback.

Action 1.2.3 ⇒ *Enforce regulations where disturbance has occurred.*

Where working cooperatively with landowners has proven ineffective, issuing citations may be necessary to prevent future violations. As in the past, organizations such as MWP, DCAG, and neighborhood associations can assist in bringing violations to the attention of the appropriate authorities.

Action 1.2.4 ⇒ *Reestablish riparian corridors where possible.*

The area downstream of Egan Drive has several parking lots and some structures that are in close proximity to the creek. Some may have been constructed prior to enactment of the setback ordinance. Reestablishment of adequate riparian buffers may require purchasing property or easements, followed by rehabilitation efforts. This would be particularly beneficial for areas such as the corridor behind Jordan Creek Center and Lyle's Hardware.

Objective 1.3: Improve snow removal and storage practices.

Action 1.3.1 ⇒ *Develop a city-wide snow management plan that includes best management practices for snow plowing and storage, and an* *education and outreach component for contractors, residents, business owners, and both state and local government crews involved in snow management.*

Streams and riparian areas are often used as snow dumps because they are usually outside of heavy traffic areas. However, plowed snow often contains debris, hydrocarbons, deicing chemicals, and sand used for traction on roads and driveways. When stored in or directly adjacent to streams, pollutants enter the system as the snow melts. A city-wide plan should be developed to help improve snow management practices. The plan should include recommendations for storage, use of sand and de-icing chemicals, and an outreach campaign oriented toward those involved in snow management. Plowing speeds should be reduced when waterways are crossed in order to reduce the distance and amount that snow is sidecast. In some cases, it may be best to install snow or silt fences to prevent debris and other nonpoint source pollutants from entering streams when snow melts.

Action 1.3.2 ⇒ *Establish snow storage areas that includes measures to prevent offsite transport of sediment (e.g., sediment traps, silt fencing).*

Ideally, snow storage areas should be established. The City of Anchorage maintains several snow storage areas that include sediment traps and flow barriers to contain pollutants. Establishing similar storage facilities in Juneau is a long-term project that will involve planning for future land uses.

Goal 2: Dissolved oxygen concentration in Jordan Creek meets water quality standards for designated uses.

Objective 2.1: Determine if dissolved oxygen concentrations in the water column and substrate are adequate to support designated uses.

Action 2.1.1 ⇒ *Establish monitoring sites and analysis techniques, and monitor regularly.*

Several studies have collected data on dissolved oxygen in the water column of Jordan Creek, and one study included interstitial dissolved oxygen. The available data indicate that dissolved oxygen concentrations fall below state water quality standards at some locations at least periodically. Establishing regular monitoring sites, including locations that have been sampled in the past, would help with comparison and statistical analysis of existing data. If sites cannot be staked or marked, documenting their locations will assist future monitoring efforts.

Water quality analyses techniques for dissolved oxygen can yield different results. For instance, results obtained by using a Hach kit can give significantly different readings from an instrument with a dissolved oxygen probe. Conducting a study that includes different analysis techniques may also help identify gaps in existing data, and determine a degree of confidence for drawing conclusions about water quality data obtained in different studies.

Objective 2.2: Assess the influences on dissolved oxygen levels in the water column and substrate

Action 2.2.1: *Monitor dissolved oxygen throughout the year.*

Both interstitial and water column dissolved oxygen monitoring should occur throughout the year. Studies thus far indicate that oxygen levels fall below state standards seasonally or periodically. In order to gain a better understanding of the variations in dissolved oxygen concentrations, monitoring needs to occur on a regular basis throughout the year. Conducting dissolved oxygen studies in relation to rearing and spawning times may also provide additional information about its relationship to fish in Jordan Creek.

Action 2.2.2: *Monitor potentially influential factors in conjunction with dissolved oxygen studies.*

Several factors influence the concentration of dissolved oxygen in surface waters. Therefore, in order to allow for more accurate data interpretation, such factors should be measured concurrently. Water temperature, at-site discharge and/or flow velocities, current and recent weather, and contributing groundwater hydrology would provide additional information that may help in analyzing Jordan Creek water quality. Corresponding collection of iron concentrations may also help determine the relationship between iron and dissolved oxygen at specific sites and throughout the stream system. Sampling methods should be recorded, and sampling sites should be standardized so that repetition is possible.

Interstitial dissolved oxygen should be monitored in spawning areas. A full habitat assessment of the stream that includes identification of spawning areas would be necessary to establish optimal monitoring sites that would not disturb fish. The habitat assessment should be coordinated with ADF&G, and establishing interstitial monitoring sites would require a permit.

There may be some correlation between sediment loading and interstitial dissolved oxygen concentrations. For this reason, sedimentation should be monitored in conjunction with dissolved oxygen studies. Established sampling sites could be periodically surveyed to illustrate changes in the channel cross-section over time. Coupled with sieve analyses of substrate samples, the data could be analyzed with interstitial dissolved oxygen readings to determine the relationship between sediment and dissolved oxygen levels exists.

Goal 3: Keep Jordan Creek free of anthropogenic debris.

Solving the debris problem in Jordan Creek is twofold – prevention of nonpoint sources of debris, and cleanup activities. A number of actions including increased public awareness of the importance of Jordan Creek as a resource, increased abundance and use of appropriate garbage receptacles, and increased enforcement of public ordinances, can significantly reduce the amount of debris input into the stream. However, as it is not practical to expect that all debris will be controlled even with the best preventative measures, cleanup activities will likely be an integral, ongoing part of the solution to the debris problem in Jordan Creek.

Objective 3.1: Remove existing debris from Jordan Creek and its tributaries.

Action 3.1.1 ⇒ *Continue to support and expand volunteer cleanup events.*

Litter-Free, a non-profit organization committed to keeping Juneau clean and encouraging recycling, organizes a community-wide cleanup each Spring where residents and volunteers pick up garbage throughout the city. The MWP organizes an adopt-a-stream program to help keep defined reaches of streams in the Mendenhall Valley (including Jordan Creek) free of garbage and litter. Groups dedicated to a specific reach should also be encouraged to conduct trash pickups during the summer and fall.

In order to foster education and to get school groups involved, a program could be started at Glacier Valley Elementary and Floyd Dryden Middle School to have each class pick up trash at least once a year, and track the amount and type of trash they remove. Promoting additional cleanup events by involving local businesses and community groups would help ensure debris removal continues on a regular basis.

Action 3.1.2 ⇒ *Remove the failed bridge at Sasha Street.*

The failed bridge on Jordan Creek near the end of Sasha Street is more of a debris source than a block to fish passage. The bridge was probably constructed to facilitate logging on the east side of Jordan Creek many years ago, and is no longer in use. Removal of the bridge may require permits if working in the stream is necessary to complete the project, but most likely could be done by hand or with small equipment during low water periods.

Objective 3.2: Prevent debris from entering Jordan Creek and its tributaries.

Action 3.2.1 ⇒ *Educate the public about the need to control litter for health and sanitation, animal control, protecting fish and wildlife habitat, and ensuring good water quality.*

A change in public attitude and perception toward the importance of small stream systems such as these is critical in implementing the debris TMDL. Educational and outreach programs targeted at the two nearby schools (Glacier Valley Elementary School and Floyd Dryden Middle School) are recommended to foster a sense of ownership among the residents of the area. Information plaques about specific habitat features and water quality could be added to the nature trail area near Jennifer Drive in order to educate the public about the need for stream stewardship. Additionally, neighborhoods could be encouraged to organize junk-hauling days, where residents could group together to make efficient and cost-effective trips to the landfill.

Action 3.2.2 ⇒ *Promote the use of bear-proof containers or centrally located trash receptacles in high-density housing areas.*

A pilot program was instituted by the local refuse collection company to test bear-resistant trash bins for residential use. The bins hold the same volume as three standard trash cans (96 gallons per bin) and have a latching lid mechanism. The bins have been used at two trailer parks near downtown Juneau, and have successfully deterred bears. Containers can be rented for a monthly fee. An incentive program for residents or for the local refuse company could be initiated to reduce the expense of providing containers and would encourage more widespread use.

An alternative to individual bear-proof trash receptacles would be centrally located bearproof garbage storage buildings for high-density residential areas. Central garbage containment systems for high density housing areas would be more cost-efficient than renting individual containers, and would save valuable space. If used effectively, a central container may help de-habituate bears that have become accustomed to roaming through housing developments in search of garbage. Outreach to residents and property managers in such areas would likely need to be coupled with incentives or grants to construct facilities and encourage their use.

Action 3.2.3 ⇒ *Provide bear-proof garbage and recycling receptacles in source areas such as store parking lots.*

The amount and frequency of debris in Jordan Creek increases substantially where “source” businesses are nearby. In lower Jordan Creek, there is an abundance of litter from businesses such as McDonald’s and the Breeze In. Placing bear-proof garbage receptacles that are easily visible within the commercially developed portion of Jordan Creek would help reduce the amount of litter on streets as well as the creek. Centralized recycling containers placed in convenient locations such as outside of convenience and grocery stores would help encourage recycling and reduce the amount of garbage that accumulates between weekly pickups.

Action 3.2.4 ⇒ *Enforce local ordinances that address garbage storage, littering, polluting water, and illegal camping.*

In March 2002, the City and Borough of Juneau adopted an Urban Bear Ordinance designed to reduce the attractiveness of garbage to bears. Relevant provisions specify that garbage must be kept in a bear-resistant container or enclosure, and put out for collection no sooner than 4 a.m. on pickup day. If garbage has attracted bears and the resident or business fails to take steps to legally store the garbage, they may be cited for maintaining a bear attraction nuisance. The citation carries a $50 fine for the first offense.

Similar ordinances exist for littering, polluting water, and illegal camping. Several illegal dumping sites are located in upper Jordan Creek, some of them in drainages that periodically go dry but contribute seasonal flow to Jordan Creek. Garbage associated with illegal camps or squatters is common in upper Jordan Creek. The mere presence of ordinances does not appear to deter people from littering. Enforcement is needed in order to stop such activities from occurring, and may provide funds to help in future control efforts.

Action 3.2.5 ⇒ *Establish a bottle deposit system for the Borough.*

In conjunction with garbage containment strategies, more stringent enforcement of littering and garbage-related ordinances can help reduce the input of debris to the creek. However, enforcement is difficult. A long term incentive program such as establishing a bottle deposit system for the Borough could help encourage recycling and defray some of the costs associated with garbage control efforts, or fund similar programs.

Goal 4: Jordan Creek water quality is not degraded by point and nonpoint source pollution.

Objective 4.1: Assess Jordan Creek water quality.

Action 4.1.1⇒ *Continue monitoring basic water quality parameters.*

Jordan Creek is included on the ACWA list in part because there had been some preliminary data suggesting impaired water quality. Parameters such as temperature, dissolved oxygen, pH, turbidity, and conductivity are standard for most monitoring efforts. Continuing to collect such data will provide basic water quality information over time. However, the comparability and analysis of such data will only be possible if sampling sites are well documented and preferably established to allow for replication, and adequate quality control measures are utilized in data collection.

Action 4.1.2 ⇒ *Maintain stream gaging on Jordan Creek.*

The USGS has a gaging station on Jordan Creek. Discharge data collected at the station has been useful for a variety of different studies conducted on the creek and in the Mendenhall Valley. Maintaining the gaging station would provide continuity in discharge information, an important factor for being able to assess changes over time. The station is currently not operating due to lack of funding.

Objective 4.2: Assess known and potential contaminant sources.

Action 4.2.1 ⇒ *Assess and map potential contaminants, point and nonpoint sources of pollution in the watershed.*

The common water quality monitoring parameters discussed above do not serve as indicators for chemical or biological water quality impairments such as hydrocarbons or microbial pollutants. A full assessment and mapping of potential contaminants and potential sources of pollution in the watershed would assist with further water quality recovery and protection planning. Updating the 1996 Mendenhall Valley Drainage Study that was conducted by R&M Engineering, Inc. may be necessary to accurately identify flow pathways and stormwater inputs for Jordan Creek and other Valley waterbodies. Additional stormwater monitoring efforts, contaminated site assessment, evaluation of existing and planned wastewater systems, and identification of hydrocarbon and chemical storage sites would help identify potential threats to Jordan Creek water quality.

Action 4.2.2 ⇒ *Assess active contaminated sites and groundwater flow into Jordan Creek and associated wetlands.*

Determination of local groundwater flow direction should occur in areas where active contaminated sites exist in the lower creek corridor, and in the former Reid Pond area. Such an assessment would help determine potential contaminant sources for Jordan Creek and adjacent wetland areas.

Objective 4.3: Reduce current and prevent future nonpoint source pollution.

Action 4.3.1 ⇒ *Work with appropriate land owners and responsible agencies to eliminate or reduce potential pollutants.*

Once the assessments of Objective 4.1 are completed, land owners and responsible agencies need to work cooperatively to eliminate or reduce potential pollutants. Efforts may include relatively simple tasks like public outreach and education, and more complicated projects such as contaminated soil removal. Opportunities for improving stormwater management, such as installation or improved maintenance of oil-water separators and sediment traps, should be identified.

Action 4.3.2 ⇒ *Educate the public about potential impacts of residential chemical use on water quality.*

Stream stewardship outreach campaigns should include information on how individual residential homeowners can reduce potential impacts to surface water quality. Efforts such as the storm drain stenciling project implemented by MWP several years ago should be revitalized. The project involved painting streets to remind people that gutters and drains lead to fish streams. Community hazardous waste collection days are periodically hosted at the local landfill, and should be supported by public education about potential impacts of chemicals on stream resources. A volunteer pick up service could be initiated to facilitate collection.

Goal 5: Jordan Creek is a productive anadromous and resident fish stream.

Objective 5.1: Maintain and improve instream fish habitat quality.

Action 5.1.1 ⇒ *Maintain building setbacks to protect riparian buffers, and revegetate disturbed areas.*

As previously discussed, riparian buffers are critical for protecting water quality and providing instream fish cover. The setback should be maintained, and may need to be extended in areas where wetland or floodplain habitat connectivity to the creek is necessary to ensure fish habitat quality. The primary oversight for maintaining riparian buffers is provided through project development and local permits, but community groups can work proactively to encourage protection of riparian areas. Organizations such as the MWP can promote good stream stewardship as well as initiating rehabilitation projects where needed.

Action 5.1.2 ⇒ *Address issues related to motorized recreation in the upper Jordan Creek corridor.*

As previously discussed, controlling off-road vehicle use will be a long-term effort involving a variety of different stakeholders and approaches. Access to the upper Jordan Creek corridor needs to be blocked, damaged areas need to be stabilized and revegetated, and pertinent regulations need to be enforced. Outreach and education of adjacent residents and user groups is also necessary to control the problem. Without providing approved riding areas however, upper Jordan Creek and other stream and wetland areas will remain vulnerable to off-road vehicle use. A combination of these approaches will be most effective at achieving the intended goal.

Action 5.1.3 ⇒ *Enforce regulations governing anadromous waters.*

Enforcement of regulations governing anadromous waters is twofold—it involves working with developers and resource users to obtain necessary permits when projects include working in streams, and issuing citations for those violating relevant laws. While most developers obtain necessary permits, a review of Jordan Creek project history reveals several citations that have been issued for permit violations or code violations without a permit. With regard to illegal vehicle crossings of anadromous fish streams, enforcing regulations is complicated by lack of staff and difficulty in accessing vulnerable areas. Still, enforcement is necessary in order to prevent future impacts to stream resources.

Objective 5.2: Protect hydrologic and ecologic stream functions.

Action 5.2.1 ⇒ *Maintain connectivity with the floodplain by preserving open space along stream corridors.*

Further development of the floodplains associated with Jordan Creek should be avoided in order to protect fish habitat and attenuate potential flooding. Purchasing easements to protect the remaining floodplain should be pursued where possible. Reestablishing floodplain corridors that have been developed is more expensive and difficult, as it involves purchasing land and/or easements and may involve extensive rehabilitation work to restore floodplain functions. However, it may be a long-term option for restoring Jordan Creek.

Objective 5.3: Ensure adequate passage for resident and anadromous fish at all life stages.

Action 5.3.1 ⇒ *Assess and map fish passage structures at all stream crossings on the mainstem and tributaries, and prioritize those needing replacement or removal.*

Most of the stream crossings on Jordan Creek were mapped by ADF&G during the 2003 stream habitat survey. Assessment of fish passage on Jordan Creek should include mapping the stream crossing locations on the main stem and tributary channels, a description of the structure, dimensions, and age or date of installation. Much of the information exists, but should be compiled and prioritized for replacement or removal.

Action 5.3.2 ⇒ *Replace or remove inadequate or unnecessary stream crossings.*

Information gathered from a fish passage assessment and prioritization could be used to work with landowners and resource agencies to remove or replace stream crossings to improve fish passage. Since most of Jordan Creek's stream crossings are downstream of Egan Drive, ensuring fish passage is critical for returning adult salmon as well as juveniles seeking rearing habitat.

Current Airport expansion plans include replacing the aging taxiway and runway culverts with a single, 770-foot long culvert. Although the existing culverts are in poor condition and create a partial barrier to fish passage, extending the culverted stream section will likely exacerbate the problem. The proposed design provisions include a bottomless arch or box culvert that is 12 feet in diameter, with daylight wells at approximately 100-foot intervals. Ensuring that the provisions are included in the culvert replacement will help alleviate some aspects of extending the culvert, but do not improve the overall condition of lower Jordan Creek.

Action 5.3.3 ⇒ *Avoid installing additional stream crossings if possible. Where new crossings are necessary, minimize their number and ensure that new structures are constructed to provide fish passage at all life stages.*

Installation of bridges or culverts inevitably contributes sediment to streams, even when best management practices are employed to control erosion during construction. Because the main channel of Jordan Creek lacks sufficient stream energy to mobilize sediment regularly, projects that are likely to contribute sediment to the stream should be avoided. Minimizing the number of stream crossings necessary to provide safe access should be pursued wherever possible, and can be accomplished through development planning and design. And finally, should stream crossings be necessary, they should be designed and installed to provide adequate passage for fish at all life stages.

Action 5.3.4 ⇒ *Clear debris from existing structures on a regular basis.*

Culverts on Jordan Creek appear to pass debris, seldom accumulating enough debris to prohibit stream flow or fish passage. City maintenance crews periodically check stream crossings and clear debris where obstructions may cause backwatering.

Objective 5.4: Conduct biological monitoring of Jordan Creek and its tributaries.

Action 5.4.1 ⇒ *Continue to monitor fish populations.*

Weir data gathered by ADF&G has helped with analyzing population trends in Jordan Creek. Such data becomes more valuable over time, allowing for meaningful statistical analyses. Continuing operation of the weir will help assess the creek's biological condition.

Action 5.4.2 ⇒ *Identify and monitor spawning areas in conjunction with water quality studies and land use activities.*

An assessment of spawning areas in Jordan Creek and subsequent monitoring of the sites would help determine if a correlation exists between sediment loading, low dissolved oxygen, and the presence and quality of spawning areas in the creek. Monitoring the areas over time would provide additional information about fish populations and productivity.

Action 5.4.3 ⇒ *Include invertebrate sampling in biological studies.*

Aquatic invertebrates have been used as indicators of water quality and stream condition. Since they spend much of their lives in the stream, near or in the substrate, invertebrates are influenced by water quality and changes in the physical environment. Including invertebrate sampling with stream monitoring events may provide additional information about the overall condition of Jordan Creek.

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Appendix A
Jordan Creek Soils Information

Soils in the Jordan Creek watershed (Schoephorster and Furbish, 1974). Series names may not reflect current taxonomic naming conventions.

Series	Series Description	Soil Depth	Vegetation Type*	Mapping Unit	Mapping Unit Description	Depth to Groundwater
Am	Somewhat poorly and poorly drained soils occurring on broad, nearly level valley bottoms and gently sloping alluvial fans. Generally consisting of gray silty and sandy waterlaid sediments over gravel and coarse sand. Iron-containing materials and strata of very coarse sand may occur in discontinuous layers at any depth.	40 inches to many feet	Two main types: tall willows, and a forest of stunted western hemlock with Sitka spruce.	AmA AmB	Am fine sandy loam, 0-3% slopes. Am fine sandy loam, 3-7% slopes.	Fluctuates between 0 to 4 feet, but usually less than 2 feet
Be	Excessively drained, very gravelly sandy soils occurring on nearly level alluvial plans and terraces or undulating to hilly moraines. Soil composition below 10 inches is generally 50-75% gravel and cobblestones.	Generally 5 feet or more	Slow growing Sitka spruce, willows, and scattered patches of cottonwood, low shrubs and herbaceous plants.	BeA	Be very gravelly sand, 0-3% slopes. May include areas of wet sandy soils, steeper Be soils, and Mh soils.	Usually greater than 4 feet, but may be less in low-lying areas.
Co	Poorly drained soils on nearly level alluvial plains, consisting of deep gray silty waterlaid sediments that often contain strata of sandy materials and peat. May contain thin strata of fine sand and seams of buried organic matter at various depths.	Generally 5 feet or more	Predominantly sedges and grasses, but may support stands of Sitka spruce and western hemlock.	CoA	Co silt loam, 0-3% slopes in low-lying, alluvial plains near the coast. Includes areas of very poorly drained shallow peat and pockets of Am and Le soils.	Usually 2 feet or less
He	Well-drained soils on nearly level alluvial plains in broad stream valleys. Stratified sediments consist of olive gray silty and sandy waterlaid sediments overlying coarse sand and gravel.	40 inches to 6 feet	Sitka spruce and western hemlock forest	HeA	He fine sandy loam, 0-3% slopes on nearly level, slightly elevated areas on alluvial plains.	Usually more than 4 feet but may be less during runoff periods
Kupreanof	Well drained soils on moraines, formed in very gravelly loamy till. Coarse fragments comprise 40-60% of the soil volume, and large stones or boulders are common.	Generally 5 feet or more	Forest dominated by Sitka spruce and western hemlock.	KuF	Kupreanof gravelly silt loam, 35-75% slopes. Includes small areas of Tolstoi and Karta soils.	n/a

Soils in the Jordan Creek watershed (Schoephorster and Furbish, 1974). Series names may not reflect current taxonomic naming conventions.

Series	Series Description	Soil Depth	Vegetation Type*	Mapping Unit	Mapping Unit Description	Depth to Groundwater
Le	Very poorly drained soils on nearly level flood plains. Composed of a thick mat of partially decomposed organic material overlying predominantly silty sediments that may contain thin strata of fine sand.	40 inches to several feet	Sedges, grasses, patches of willow and alder brush.	LeA	Le silt loam, 0-3% slopes. Occurs in slight depressions in stream valleys and occasionally floods. Includes small streams and patches of Fu and Am soils.	Usually less than 1 foot
Mh	Well drained soils on low undulating or hilly moraines near large glaciers. Consists of variable quantities of gravel, cobble, and boulders in dark gray loamy materials.	Generally 5 feet or more	Primarily Sitka spruce and western hemlock forest.	MhC	Mh gravelly sandy loam, 3-7% slopes. Includes areas with irregular, short slopes and small, ponded depressions.	Varies
Salt Chuck	Well drained very gravelly soils on alluvial fans and uplifted beach areas. Coarse, flat or subangular fragments make up 40-75% of the soil volume.	4 feet or more	Forest dominated by Sitka spruce and western hemlock.	SaB	Salt Chuck very gravelly silt loam, 3-7% slopes. Occurs in gently sloping alluvial fans formed by small streams.	Usually >4 feet, unless inundated by runoff.
				SaC	Salt Chuck very gravelly silt loam, 7-12% slopes. Occurs in moderately sloping alluvial fans formed by small streams.	
Tolstoy-McGilvery Complex	Well-drained, shallow soils over bedrock occurring hilly to steep ridges and mountainsides. May consist of forest litter overlying thin, gray to brown soil layers over bedrock, or forest litter resting directly on bedrock. Commonly associated with steep, irregular slopes with rock outcrops.	5 to 20 inches	Forest dominated by Sitka spruce and western hemlock.	ToF	Tolstoy-McGilvery Complex, 35-75% slopes	n/a
Wadleigh	Somewhat poorly drained soils that occur on lower slopes of hills and mountains. A mat of forest litter overlies thin, very gravelly loamy materials on top of a firm substratum of glacial till that impedes internal drainage.	Generally 5 feet or more	Western hemlock forest with scattered Sitka spruce.	WaD	Wadleigh gravelly silt loam, 12-20% slopes.	Seepage perched on slowly permeable, compact substratum

Appendix B
Alaska Water Quality Standards
for Debris, Dissolved Oxygen, and Sediment

Alaska water quality standards for debris

Water Use	Description of Standard
(A) Water Supply	
(i) drinking, culinary and food processing	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines.
(ii) agriculture, including irrigation and stock watering	May not be present in quantities to cause soil plugging or reduced crop yield, or to make the water unfit or unsafe for the use.
(iii) aquaculture	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use.
(iii) industrial	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use.
(B) Water Recreation	
(i) contact recreation	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines
(ii) secondary contact	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use; cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. May not, alone or in combination with other substances, cause a film, sheen, or discoloration on the surface of the water or adjoining shorelines; cause leaching of toxic or deleterious substances; or cause a sludge, solid or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines

Alaska water quality standards for dissolved oxygen

Water Use	Description of Standard
(A) Water Supply	
(i) drinking, culinary and food processing	Dissolved oxygen (DO) must be greater than or equal to 4 mg/l (this does not apply to lakes or reservoirs in which supplies are taken from below the thermocline, or to groundwater).
(ii) agriculture, including irrigation and stock watering	DO must be greater than 3 mg/l in surface waters.
(iii) aquaculture	DO must be greater than 7 mg/l in surface waters. The concentration of total dissolved gas may not exceed 110% of the saturation at any point of sample collection.
(iii) industrial	May not cause detrimental effects on established water supply treatment levels.
(B) Water Recreation	
(i) contact recreation	DO must be greater than or equal to 4 mg/l.
(ii) secondary contact	DO must be greater than or equal to 4 mg/l.
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	DO must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may DO be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning. For waters not used by anadromous or resident fish, DO must be greater than or equal to 5 mg/l. In no case may the DO be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of the saturation at any point of sample collection.

Alaska water quality standards for sediment

Water Use	Description of Standard
(A) Water Supply	
(i) drinking, culinary and food processing	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method.
(ii) agriculture, including irrigation and stock watering	For sprinkler irrigation, water must be free of particles of 0.074 mm or coarser. For irrigation or water spreading, may not exceed 200 mg/l for an extended period of time.
(iii) aquaculture	No imposed loads that will interfere with established water supply treatment levels.
(iii) industrial	No imposed loads that will interfere with established water supply treatment levels.
(B) Water Recreation	
(i) contact recreation	No measurable increase in concentration of settleable solids above natural conditions, as measured by the volumetric Imhoff cone method.
(ii) secondary contact	May not pose hazards to incidental human contact or cause interference with the use.
(C) Growth and Propagation of Fish, Shellfish, other Aquatic Life and Wildlife	The percent accumulation of fine sediment in the range of 0.1 mm to 4.0 mm in the gravel bed of waters used by anadromous or resident fish for spawning may not be increased more than 5% by weight above natural conditions (as shown from grain size accumulation graph). In no case may the 0.1 mm to 4.0 mm fine sediment range in those gravel beds exceed a maximum of 30% by weight (as shown from grain size accumulation graph). In all other surface waters no sediment loads (suspended or deposited) that can cause adverse effects on aquatic animal or plant life, their reproduction or habitat may be present.

Appendix C
Jordan Creek Channel Types and Process Groups

Map of Jordan Creek channel process types and stream crossings

Jordan Creek main channel process groups and management considerations (ADF&G Division of Sportfish stream habitat survey data, 2003; Paustian et al., 1992).

			Management Considerations		
Symbol	**Process Group**	**Channel Type**	**Hydrology**	**Aquatic Habitat**	**Riparian Management**
PA3	Palustrine	Shallow groundwater fed slough	Tends to store fine sediment due to low stream energy and peak flows. Often associated with wetland or floodplain complexes, which help buffer flooding and store sediment and nutrients.	Seasonally low flows may isolate portions of the stream. Habitat is generally favorable for coho rearing.	Soils are generally unconsolidated, fine textured alluvium that is easily displaced by riparian disturbance.
PA5	Palustrine	Beaver dam/pond channel	Sediment is retained due to low stream energy. Flooding is buffered by large pools and wetlands created by beaver dams, but substantial water and sediment discharge may occur if dams are breached.	Deep pools and abundance of woody debris provide good salmonid overwintering and rearing habitat.	Sediment retention is high, so upstream riparian disturbances may accelerate pond filling.
FP3	Flood Plain	Narrow low gradient floodplain channel	Sediment deposition occurs due to low stream energy, but high runoff events may mobilize streambed materials.	Used by most salmonids for spawning, rearing, and overwintering. Sediment deposition and retention adversely impacts spawning habitat quality.	Coarse to fine textured alluvial soils are moderately sensitive to disturbance. However, sediment contributed by bank erosion will likely be deposited and retained.

Jordan Creek tributary channel process groups and management considerations (ADF&G Division of Sportfish stream habitat survey data, 2003; Paustian et al., 1992).

			Management Considerations		
Symbol	**Process Group**	**Channel Type**	**Hydrology**	**Aquatic Habitat**	**Riparian Management**
AF1	Alluvial Fan	Moderate gradient alluvial fan channel	Sediment erosion, transport, and deposition may occur as the channel transitions from high to low gradient.	Rearing and spawning habitat is good in the lower gradient reaches. Pools and low gradient areas with groundwater upwelling provide good overwintering habitat.	Streambanks are unstable due to slope and fine textured alluvial bank materials. Stream crossings are susceptible to clogging or damage by bedload and woody debris.
AF2	Alluvial Fan	High gradient alluvial cone channel	Streambed materials are transported to lower gradient channels downstream. Snow avalanches, debris flows, and large woody debris influence channel form and stability.	Spawning, rearing, and overwintering habitat value is generally low due to high flow velocity.	Steep slopes and unconsolidated, coarse soils contribute to streambank instability. Disturbances such as removal of riparian vegetation, mass wasting, or avalanches may cause abrupt channel shifts. Stream crossings are at high risk of being clogged or damaged by bedload and woody debris.
ES2	Estuarine	Narrow small substrate estuarine channel	Channel is influenced by ocean tides. Sediment deposition occurs due to low stream energy.	Coho, pink, and chum salmon frequently use ES2 channels as rearing areas prior to outmigration. Spawning habitat is of low value due to sediment retention.	Streambanks often consist of fine materials and are susceptible to riparian disturbance.
ES4	Estuarine	Large estuarine channel	Wide, low gradient stream channels are influenced by ocean tides. Accumulation of sediment and debris helps form moderately stable bars and pools.	Provides important spawning habitat for pink and chum salmon, and rearing habitat for pink, chum, and coho salmon.	Banks are easily disturbed. Upstream and localized erosion can be a significant source of fine sediment, which decreases the value of spawning habitat.
HC2	High Gradient Contained	Shallowly to moderately incised footslope channel	Sediment is rapidly transported from steep mountain headwaters to lower gradient streams.	Not typically used by fish due to high flow velocities, but some use of confluence areas may occur. Channel and upland condition influences downstream habitat.	Banks are moderately stable due to shallow channel incision.

Jordan Creek tributary channel process groups and management considerations (ADF&G Division of Sportfish stream habitat survey data, 2003; Paustian et al., 1992).

			Management Considerations		
Symbol	**Process Group**	**Channel Type**	**Hydrology**	**Aquatic Habitat**	**Riparian Management**
HC6	High Gradient Contained	Deeply incised mountainslope channel	Rapid response to runoff events facilitates transport of sediment from steep, unstable sideslopes.	Virtually no spawning or rearing habitat is available due to high stream gradient, presence of migration barriers, and seasonally low water.	Slopes are steep and unstable. Riparian and upland vegetation disturbance can result in mass wasting.
PA1v	Palustrine	Narrow placid flow channel, scrub forest phase	Low stream energy. Channel stores fine sediments. Stream flow is somewhat influenced by runoff from extensive muskeg bogs.	Channels tend to be accessible to anadromous fish, but fine substrate reduces spawning habitat availability. High quality rearing habitat exists where mean pool depth is >2.3 feet and bank vegetation is in good condition.	Banks are generally composed of dense organic root mats that resist erosion. Trampling can degrade streambanks.

Appendix D
Jordan Creek Water Quality Recovery and Fish Habitat Improvement Action Items

Goals, Objectives, and Action Items		Participants
GOAL 1: Jordan Creek water quality meets state sediment water quality standards.		
Objective 1.1: Prevent and reduce erosion.		
Action 1.1.1	Discourage motorized recreation in the upper Jordan Creek corridor by eliminating/blocking access points, posting signs, regular public outreach, and establishing an acceptable riding area.	CBJ, resource agencies, MWP
Action 1.1.2	Enforce regulations that address riparian and stream disturbance.	CBJ, DNR, USACE, State Troopers
Action 1.1.3	Require and encourage best management practices that control off-site migration of sediment during land-disturbing activities.	CBJ, DNR, USACE
Action 1.1.4	Stabilize the road, tank pad, and streambanks associated with the CBJ water storage facility on the main Jordan Creek tributary.	CBJ, resource agencies, MWP
Action 1.1.5	Rehabilitate disturbed streambanks, riparian areas, floodplains, and uplands.	resource agencies, MWP, landowners
Objective 1.2: Maintain and improve riparian areas.		
Action 1.2.1	Educate the public about stream stewardship and the importance of maintaining riparian buffers for fish streams.	MWP, local schools, resource agencies
Action 1.2.2	Maintain riparian buffers by not granting streamside setback variances.	CBJ
Action 1.2.3	Enforce regulations where disturbance has occurred.	CBJ
Action 1.2.4	Reestablish riparian corridors where possible.	landowners, resource agencies, MWP
Objective 1.3: Improve snow removal and storage practices.		
Action 1.3.1	Develop a city-wide snow management plan that includes best management practices for snow plowing and storage, and an education and outreach component for contractors, residents, business owners, and both state and local government crews involved in snow management.	snow removal services, CBJ, residents and business owners
Action 1.3.2	Establish snow storage areas that include measures to prevent offsite transport of sediment (e.g., sediment traps, silt fencing).	CBJ, state and federal resource agencies
GOAL 2: Dissolved oxygen levels in Jordan Creek meet water quality standards for designated uses.		
Objective 2.1: Determine if dissolved oxygen concentrations in the water column and substrate are adequate to support designated uses.		

Goals, Objectives, and Action Items		Participants
Action 2.1.1	Establish monitoring sites and analysis techniques, and monitor regularly.	ADEC, MWP, UAS, USGS
Objective 2.2: Assess the influences on dissolved oxygen levels in the water column and substrate.		
Action 2.2.1	Monitor dissolved oxygen throughout the year.	ADEC, MWP, UAS, USGS
Action 2.2.2	Monitor potentially influential factors in conjunction with dissolved oxygen studies.	ADEC, MWP, UAS, USGS
GOAL 3: Keep Jordan Creek free of anthropogenic debris.		
Objective 1.1: Remove existing debris from Jordan Creek and its tributaries.		
Action 3.1.1	Continue to support and expand volunteer cleanup events.	MWP, CBJ, Litter Free, local citizens
Action 3.1.2	Remove the failed bridge at Sasha Street.	MWP, SAGA, resource agencies
Objective 3.2: Prevent debris from entering Jordan Creek and its tributaries.		
Action 3.2.1	Educate the public about the need to control litter for health and sanitation reasons, animal control, fish and wildlife habitat, and ensuring good water quality.	CBJ, Litter Free, MWP, ADF&G, ADEC, local schools, local citizens
Action 3.2.2	Promote the use of bear-proof containers or centrally located trash receptacles in high-density housing areas.	CBJ, Litter Free, MWP, neighborhood associations
Action 3.2.3	Provide bear-proof garbage and recycling receptacles in source areas such as store parking lots.	CBJ, local businesses, refuse company
Action 3.2.4	Enforce local ordinances that address garbage storage, littering, polluting water, and illegal camping.	CBJ
Action 3.2.5	Establish a bottle deposit system for the Borough.	CBJ, Litter Free
GOAL 4: Jordan Creek water quality is not degraded by point and nonpoint source pollution.		
Objective 4.1: Assess Jordan Creek water quality.		
Action 4.1.1	Continue monitoring basic water quality parameters.	ADEC, MWP, resource agencies
Action 4.1.2	Maintain stream gaging on Jordan Creek.	USGS, resource agencies
Objective 4.2: Assess known and potential contaminant sources.		

Goals, Objectives, and Action Items		Participants
Action 4.2.1	Assess and map potential contaminants and nonpoint sources of pollution in the watershed.	ADEC
Action 4.2.2	Assess active contaminated sites and groundwater flow into Jordan Creek and associated wetlands.	ADEC, MWP
Objective 4.3: Reduce current and prevent future nonpoint source pollution.		
Action 4.3.1	Work with appropriate landowners and responsible agencies to eliminate or reduce potential pollutants.	ADEC, MWP, resource agencies, landowners
Action 4.3.2	Educate the public about potential impacts of residential chemical use on water quality.	MWP, resource agencies, CBJ
GOAL 5: Jordan Creek is a productive anadromous and resident fish stream.		
Objective 5.1: Maintain and improve instream fish habitat quality.		
Action 5.1.1	Maintain building setbacks to protect riparian buffers, and revegetate disturbed areas.	CBJ, MWP, resource agencies, landowners
Action 5.1.2	Address issues related to motorized recreation in the upper Jordan Creek corridor.	CBJ, resource agencies, MWP, user groups
Action 5.1.3	Enforce regulations governing anadromous waters.	USACE, DNR, CBJ, NOAA, USFWS, ADF&G
Objective 5.2: Protect hydrologic and ecologic stream functions.		
Action 5.2.1	Maintain connectivity with the floodplain by preserving open space along stream corridors.	CBJ, landowners, Southeast Alaska Land Trust
Objective 5.3: Ensure adequate passage for resident and anadromous fish at all life stages.		
Action 5.3.1	Assess and map fish passage structures at all stream crossings on the mainstem and tributaries, and prioritize those needing replacement or removal.	ADF&G, MWP, resource agencies
Action 5.3.2	Replace or remove inadequate or unnecessary stream crossings.	resource agencies, MWP
Action 5.3.3	Avoid installing additional stream crossings if possible. Where new crossings are necessary, minimize their number and ensure that new structures are constructed to provide fish passage at all life stages.	resource agencies, CBJ, landowners, developers
Action 5.3.4	Clear debris from existing structures on a regular basis.	CBJ
Objective 5.4: Conduct biological monitoring of Jordan Creek and its tributaries.		
Action 5.4.1	Continue to monitor fish populations.	ADF&G

Goals, Objectives, and Action Items		Participants
Action 5.4.2	Identify and monitor spawning areas in conjunction with water quality studies and land use activities.	ADF&G, MWP, resource agencies
Action 5.4.3	Include invertebrate sampling in biological studies.	MWP