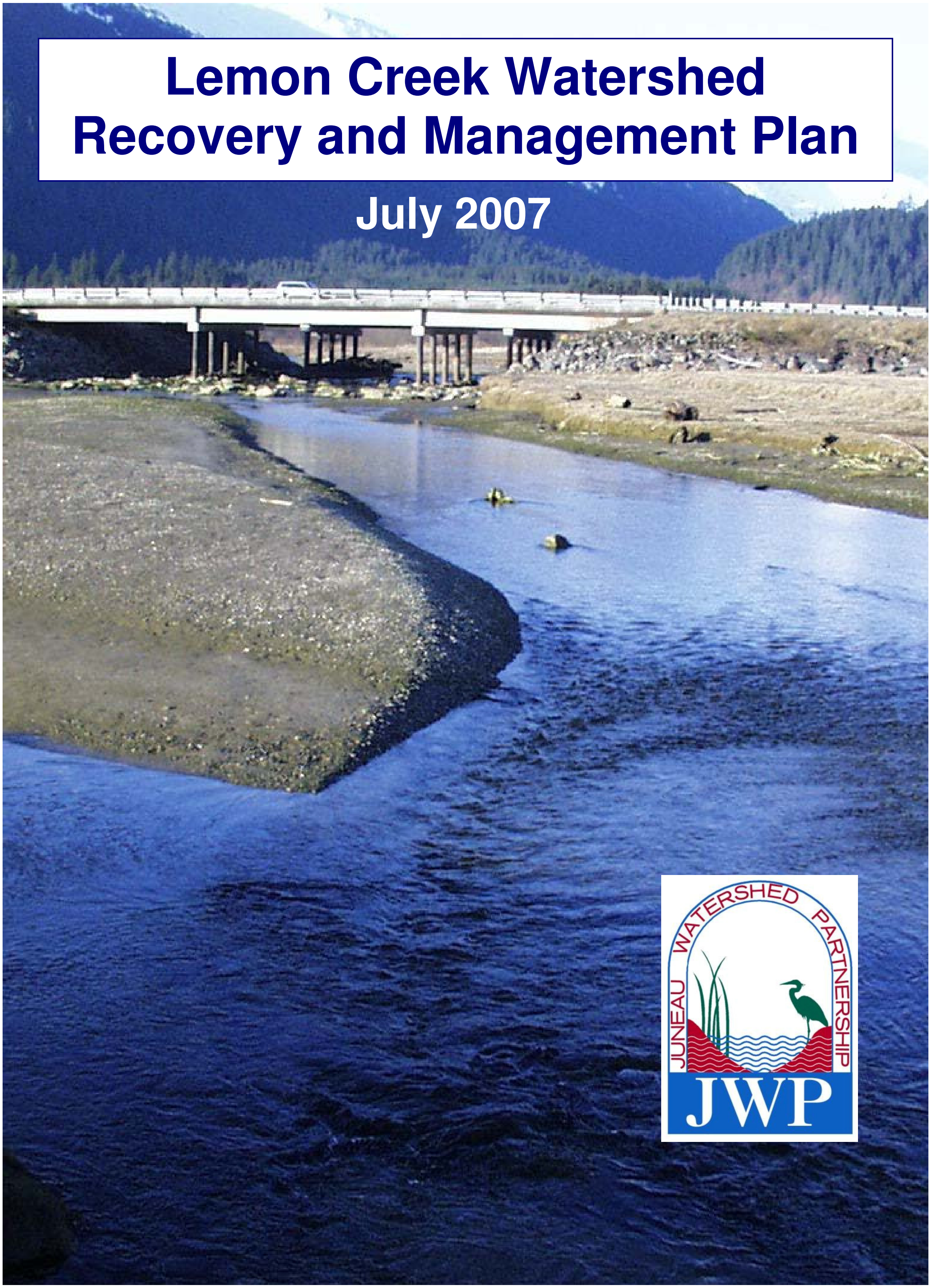
Lemon Creek Watershed Recovery and Management Plan

July 2007



Statement of Purpose and Need

As Juneau grows, the expansion of commercial and residential development requires careful planning and consideration to limit the impact of this growth on human and ecosystem health and safety. Current and proposed gravel extraction, construction of medium-density housing, and influx of commercial “box stores” in the Lemon Creek Valley create an urgent need to define an up-to-date management and recovery plan for Lemon Creek. The Lemon, Switzer, and Vanderbilt areas are a primary source of gravel in Juneau; as such, gravel extraction has driven the degradation of in-stream and riparian fish habitat in these areas over the last four decades. Rapid urban growth beginning in the early 1970’s resulted in a residential and commercial corridor along the lower reaches of Lemon Creek that constricts its naturally meandering flowpath. Extreme erosion upstream of the urban corridor has resulted in streambed aggradation and increased flood risk. Much of the Lemon Creek Watershed remains undeveloped; the creek and its watershed are appraised for recreational and educational public use and aquatic and terrestrial habitat. As Lemon and Ptarmigan Glaciers retreat, water quality impairment due to glacial activity is expected to improve significantly in the future. The challenge ahead is to minimize the impact of gravel extraction, necessary flood mitigation, and future development upon existing and potential uses dependent upon aquatic and riparian habitat.

Lemon Creek is currently listed as impaired for sediment, turbidity, and habitat modification on the Alaska Clean Water Action (ACWA) 4b list. Water quality monitoring and biological studies designed to determine the extent of these impairments are largely lacking, and no baseline water quality or biologic data collected prior to gravel extraction are known to exist. The Alaska Department of Environmental Conservation developed a Total Maximum Daily Load (TMDL) report for Lemon Creek, published in 1995, based on limited data. The TMDL report identified several sources or potential sources of sediment and turbidity in the Lemon Creek watershed, outlined a monitoring strategy for collecting water quality data, listed several recovery actions, and defined sediment allocations for key land users in the area.

The purpose of this report is to evaluate actions taken and information collected in the Lemon Creek area since the publication of the 1995 TMDL and apply this information to update the Lemon Creek recovery and management plan. An updated plan will assist local agencies, watershed groups, citizens, and land users to coordinate energy and resources as effectively as possible for the protection and improvement of water quality and fish habitat while providing relief from flood risk and supporting ongoing gravel extraction and development. The intended audience of this report includes citizens and agencies.

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Watershed Description

Lemon Creek is a medium-sized glacially-fed stream located in the Lemon Creek Valley, approximately five miles northwest of downtown Juneau, Alaska (Figure 1). Flowing east to west from the terminal lakes of the Thomas and Lemon Glaciers and emptying into Gastineau Channel, Lemon Creek courses through Tongass National Forest lands to a growing residential and industrial urban area. Elevations range from sea level to 5,600 feet (USGS); Lemon Creek is steeply bordered to the north by Heintzleman Ridge, to the south by Blackerby Ridge, and to the east by Lemon Creek Glacier and the Juneau Icefield.

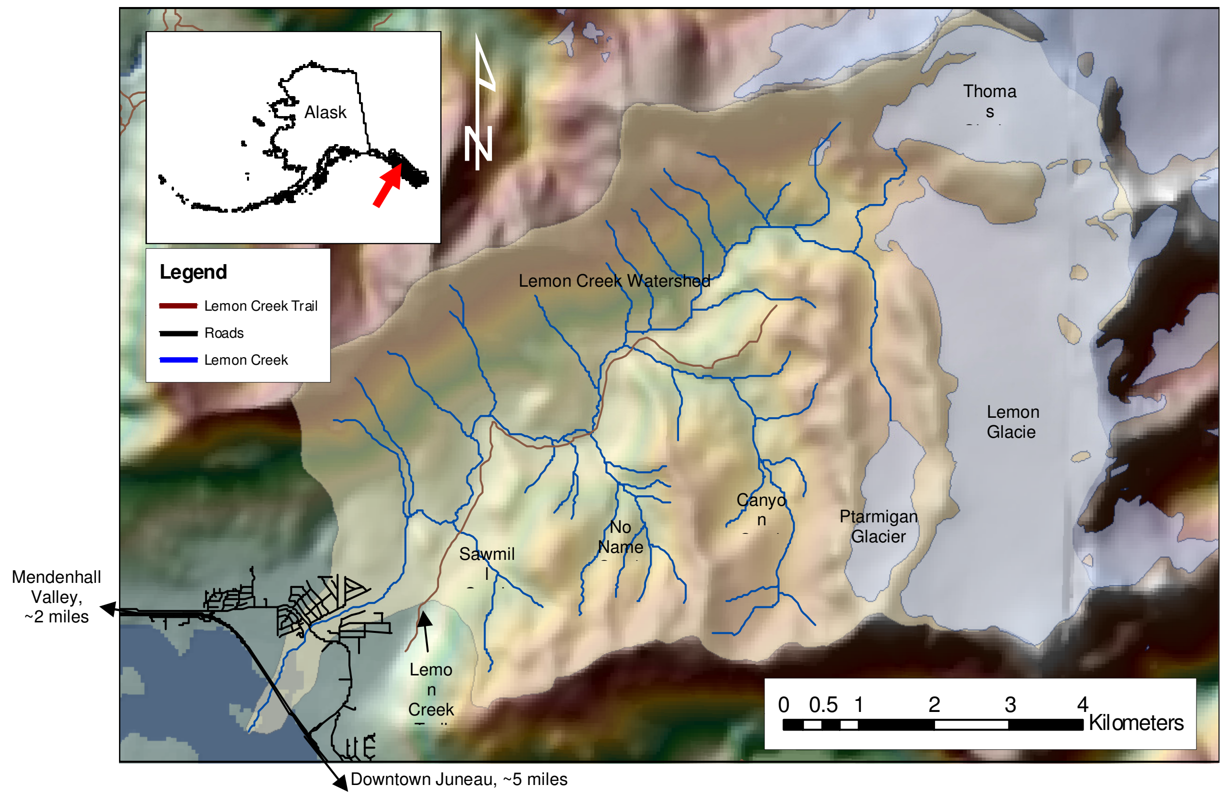


Figure 1: Lemon Creek Watershed, Juneau, Alaska

The maritime climate in Juneau, Alaska, delivers an average of 93 inches of precipitation annually from storms generated in the Gulf of Alaska (NOAA, 2003). Murphy (1963), reported on orographic precipitation studies in the Juneau area (Mountain Versus Sea Level Rainfall Measurements During Storms at Juneau, Alaska). This study attempted to approximate the lapse rate, or variation in rainfall intensity with altitude, in the Mt. Juneau area, and concluded that rainfall at 3400 feet atop Mt. Juneau average 2.4 to 3.3 times the rainfall measured locally at sea level. From this, the only published record of its type for this area, it may be approximated that rainfall in the alpine elevations of the Lemon Creek watershed are similarly 2.4 to 3.3 times greater than at the airport weather station.

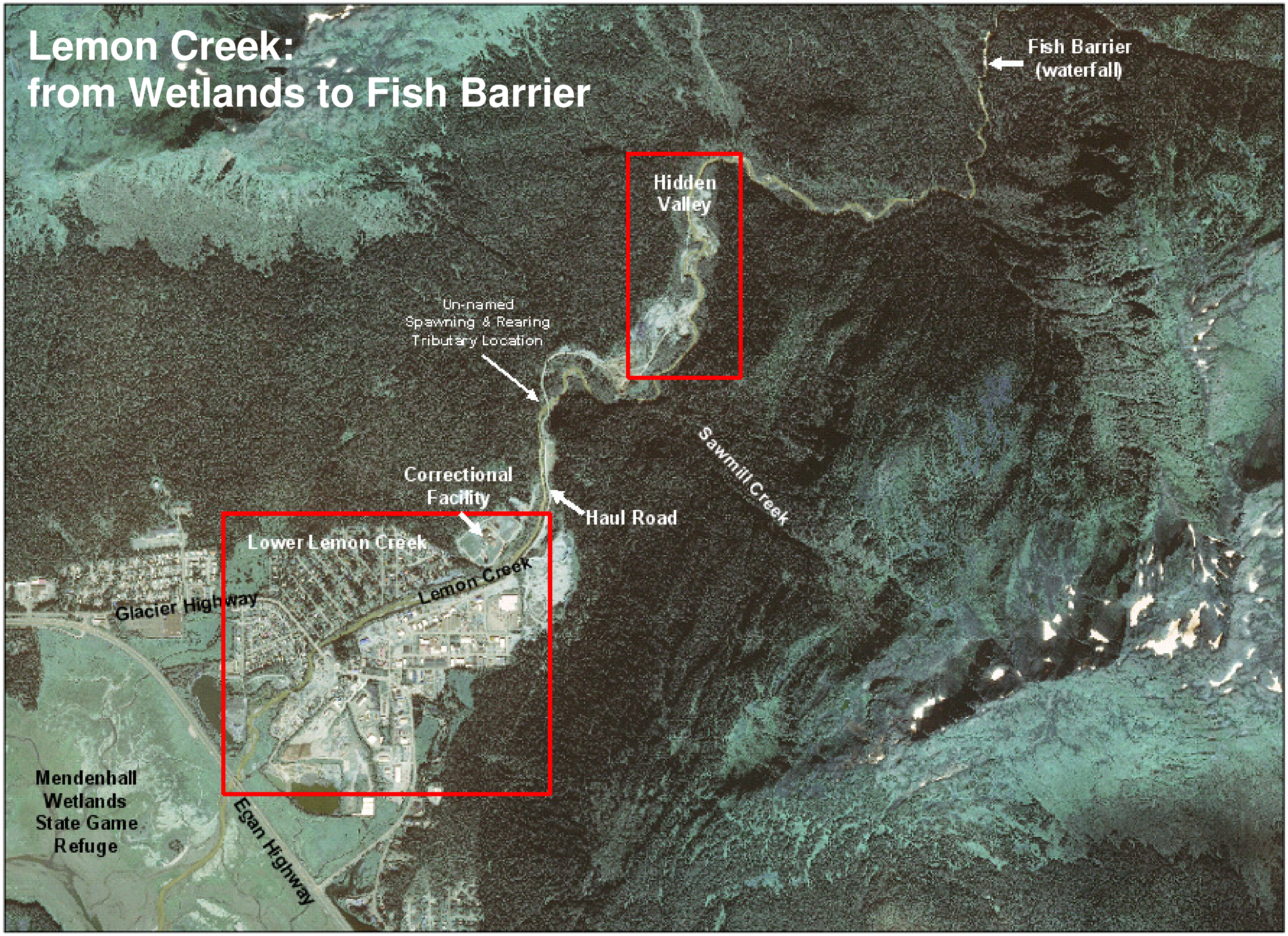


Figure 2: Lemon Creek from wetlands to fish barrier. Key locations and areas mentioned in this report are also identified. Background image courtesy USFWS. Taken: April 2005. Projection/Datum: UTM NAD27, zone 8

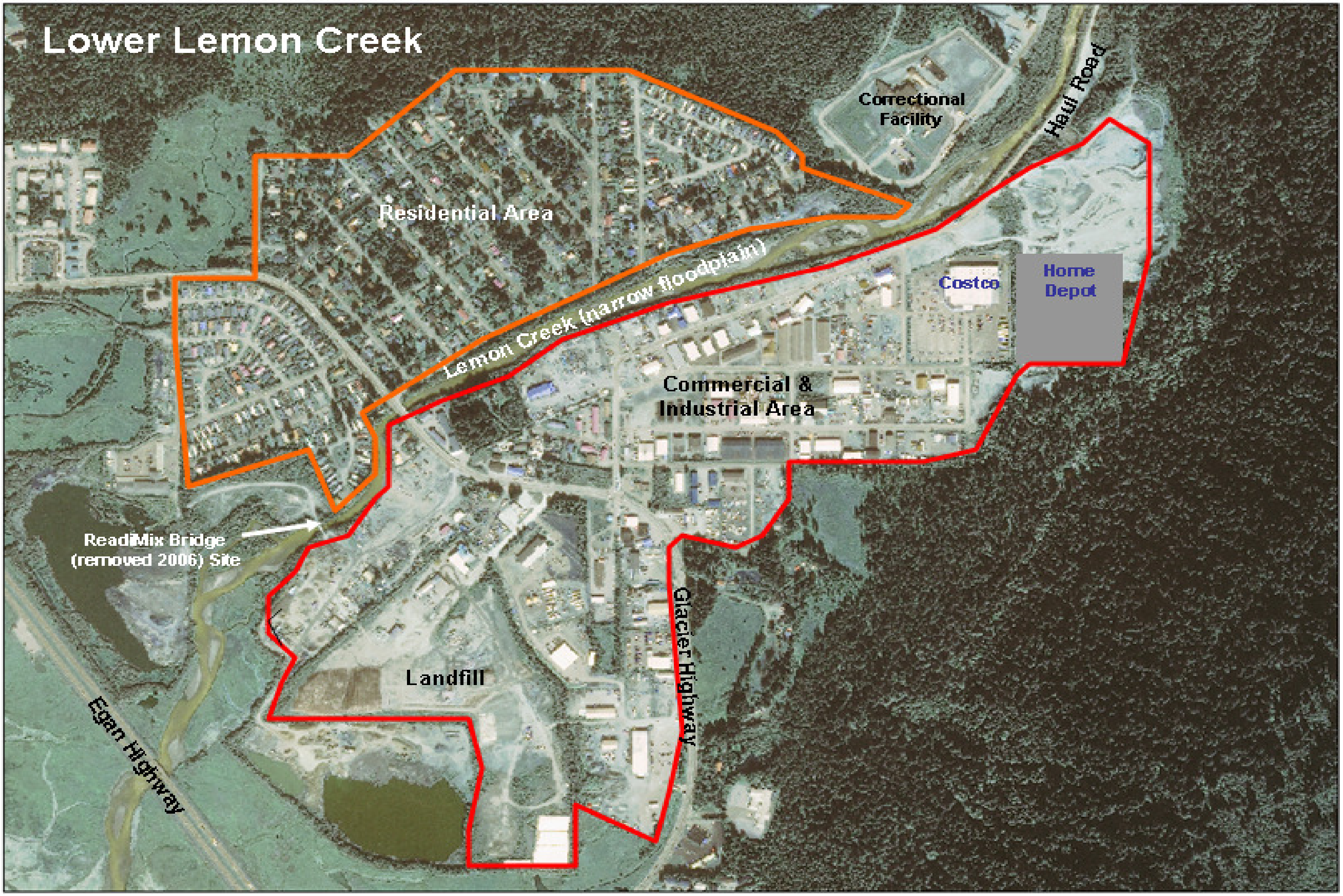


Figure 3: The Lower Lemon Creek Area. Background image courtesy USFWS, April 2005. Projection/Datum: UTM NAD27, zone 8

The Lemon Creek Watershed includes 24.3 mi^2 of alpine and forested uplands, wetlands, and urban areas. The Hidden Valley area (see Figure 2) is, in general, the divide between upper undeveloped reaches and lower developed reaches of Lemon Creek. Below Hidden Valley, the west side of the main channel is mostly medium and low density residential housing, while the east side of the main channel is populated by industrial and commercial facilities. The creek currently flows beneath four bridges, two haul road bridges above the correctional facility, one at Glacier Highway, and a fourth at Egan Drive. Between these bridges, the main channel passes concrete and gravel stockpiles, residential and urban runoff outfalls, and the local landfill. Lemon Creek empties into the Mendenhall Wetlands State Game Refuge and the Gastineau Channel (see Figure 3).

Discharge on Lemon Creek is monitored by the U.S. Geological Survey (USGS) at a gauging station located at the 650 foot elevation level, about 4.5 miles above the mouth of the creek (USGS station #15052000). Mean annual discharge recorded at this station located upstream of the Canyon Creek confluence for the period of 1951 to 2006 (no data 1974-2003) was 161 cubic feet per second (cfs). Mean monthly discharge for the same period of record ranges from 7 to 468 cfs. The highest recorded peak discharge at this station is 5900 cfs (10/20/1998). Peak flows between 1951-1973 average 1600 cfs, while peak flows between 2002-2006 average 2700 cfs.

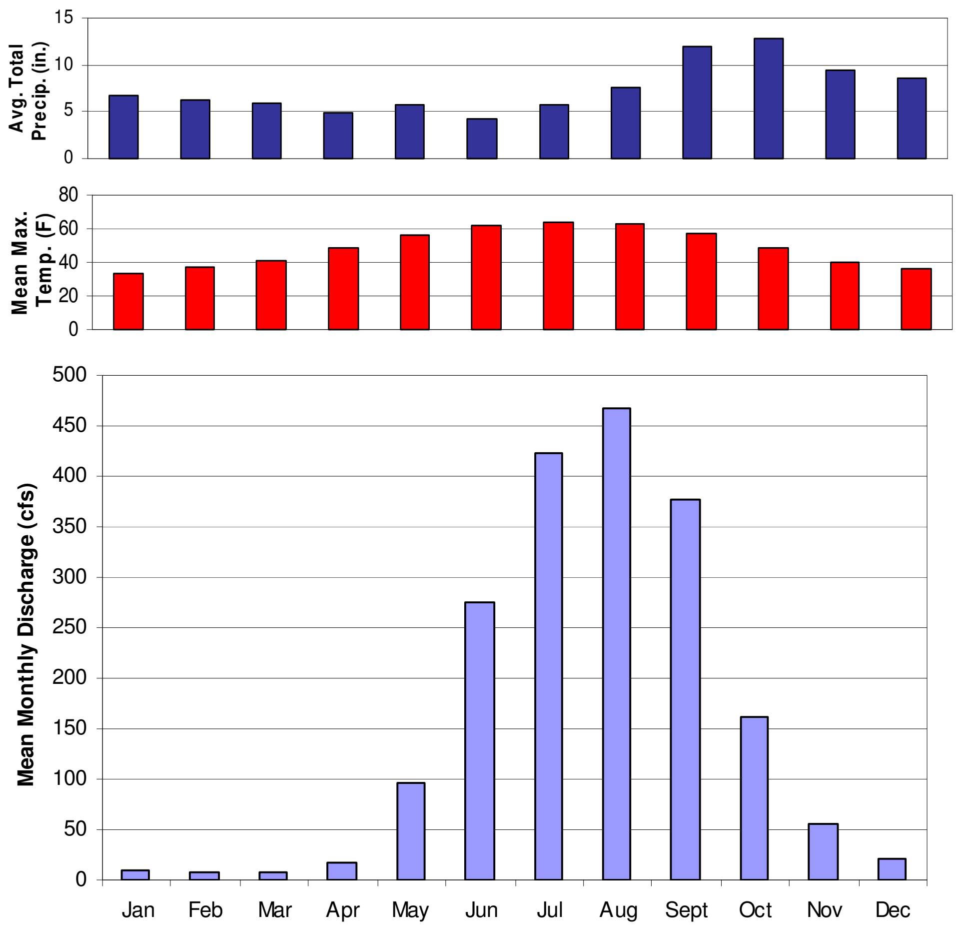


Figure 4: USGS Monthly Mean Discharge 1951-2006 (http://waterdata.usgs.gov/ak/nwis) and WRCC Average Monthly Total Precipitation and Mean Monthly Maximum Temperature 1965-2006 (http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak4094).

Mean annual discharge recorded at a USGS gauging station located near the Lemon Creek Correctional Facility, above the Glacier Highway Bridge at 50 feet above sea level for the period of 1982 to 1986 was 214 cubic feet per second (cfs). Mean monthly discharge for the same period of record ranges from 45 to 584 cfs. Peak discharge for the period of record was 4,510 cfs on Aug. 23, 1983. This gauge was in operation for two years before and two years after in-stream gravel extraction ceased.

Streamflow in Lemon Creek is representative of a glacier-fed waterbody, exhibiting more consistent discharge volumes year-round than a typical non-glaciated watershed, as well as demonstrating high summer and fall turbidity and suspended sediment levels associated with periods of glacial melt. The Lemon and Ptarmigan Glaciers present in Lemon Watershed (comprising roughly 30% percent watershed area) store water from rain and snowfall in fall and winter and later contribute that stored water to Lemon Creek during low-flow periods in summer after snowmelt. Peak flows on Lemon Creek are most often associated with warm summer temperatures and subsequent glacial melting and occasionally with sustained precipitation in the fall, while peak flows in non-glacier fed streams are associated with spring snowmelt and fall rainstorms. Supraglacial lake drainage occurring high up in the watershed is linked to high suspended sediment and turbidity levels in Lemon Creek (Walter, 2003). These glacial lakes, which are artifacts of glacier retreat and downwasting, typically fill with snowmelt and rain water from May to July and drain in late July or early August every year; however, lake level data from 2003 exhibit lake filling and drainage during an atypically warm December storm cycle as well (Walter, unpublished data).

The watershed network is extensive, including the 7.3 mile-long main channel and its tributaries. Major tributaries joining the main channel of the Lemon are Ptarmigan Creek, Canyon Creek, No Name Creek, and Sawmill Creek. These creeks and their sub-watersheds are all located on the east side of the main channel, due to regional geomorphology. Lemon Creek and its lower tributaries (stream number 111-40-10100) are listed as anadromous fish streams by the Alaska Department of Fish and Game (Johnson, 2006).

Lemon Creek stream process types were identified and mapped by the Alaska Dept. of Fish and Game, Sportfish Division, in 2004 as part of the Lemon Creek Watershed Geomorphic Assessment and Sediment Management Alternatives Analysis (CBJ, 2004). Appendix A lists the process types identified on Lemon Creek and their descriptions. Eight lower reaches of Lemon Creek were detailed in this study for fish use and existing habitat condition. Refer to Section 3: Fish and Fish Habitat for more information.

Figure 5. Supra-glacial lakes on Lemon Glacier fill and drain intermittently throughout the summer and into fall. *Photo: S. Seifert.*

The USGS surveyed Lemon Creek channel cross sections to determine rates of channel aggradation or degradation between 2002 and 2004. No clear trend of aggradation or degradation was defined for this two-year period of study. Subsequent U.S. Army Corps of Engineers HEC-RAS streamflow modeling resulted in estimates generated profiles of water elevations for 2-, 10-, 25-, 50-, and 100-year floods (assuming the Juneau ReadiMix bridge was removed). Figure 6, reproduced from the USGS report, shows these flood profiles. Channel cross-section 8.5, just upstream of the Glacier Highway Bridge, is the only cross-section showing over-bank flow (flooding). Since the removal of the ReadiMix Bridge in 2006, this model is potentially representative of existing conditions (Host, 2005), however the impact of Ready-Mix Bridge removal has not yet been assessed.

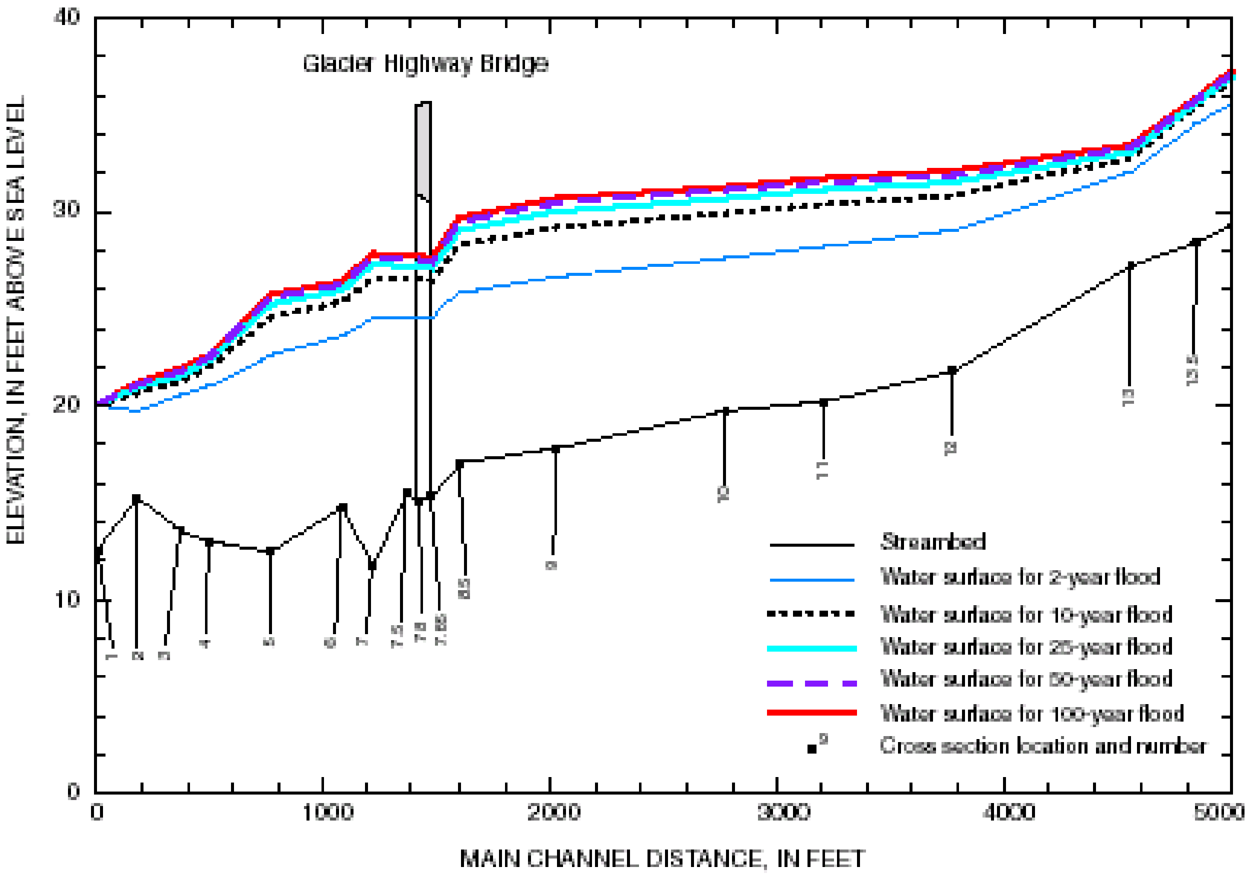


Figure 6: Profile of computer water-surface elevations, streambed elevations, and locations of cross sections on lower Lemon Creek for 2-, 10-, 25-, 50-, and 100-year floods, with the lower ReadiMix Bridge removed. Reproduced from U.S. Geological Survey results of HEC-RAS streamflow simulation on Lemon Creek (Host, 2005).

1.2 Geology, Flora and Fauna

Geology

Lemon Creek Valley geology consists primarily of glacial, glaciomarine, and alluvial deposits overlaying metamorphosed siltstones and mudstones punctuated by intrusive granitic sills (Schoephorster and Furbish, 1974; Miller, 1975; Connor and O'Hare, 1988). Soils in the steep upland areas are well-draining glacial gravels and loamy till. Shallower upland topography exhibits poor-draining deep peat soils and muck. Lowland soils are primarily well-draining, sandy to gravelly alluvium (Schoephorster and Furbish, 1974; Miller, 1975).

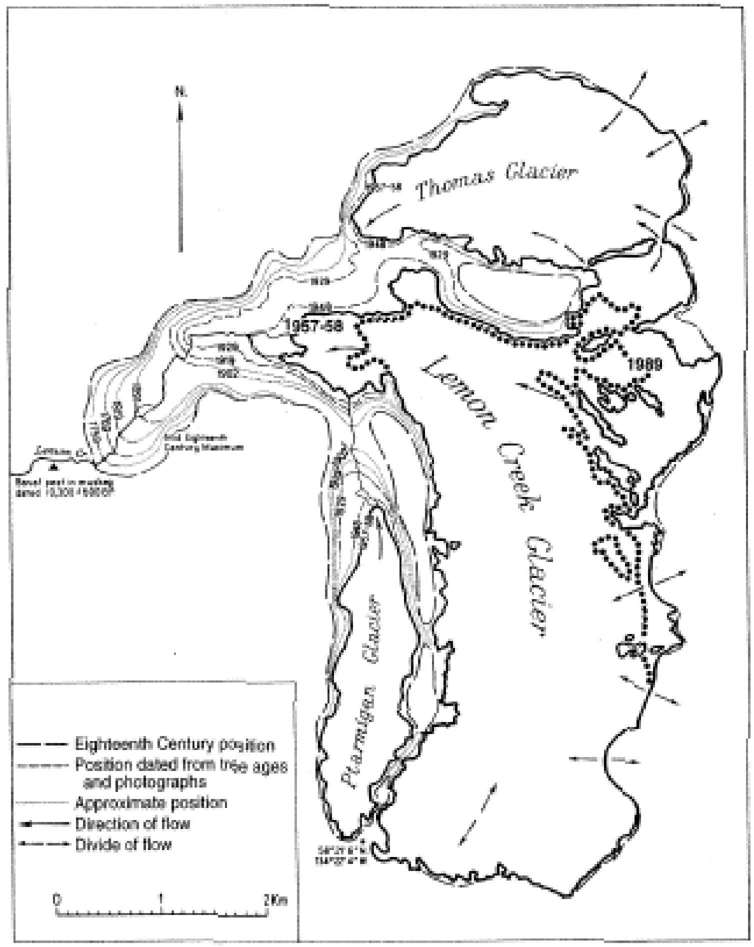
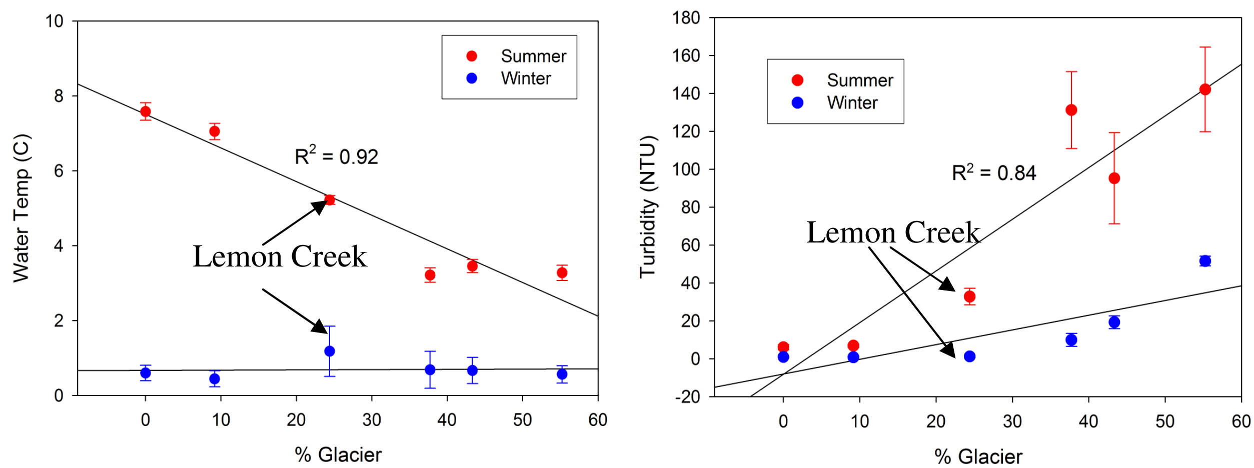


Figure 7: Lemon Glacier and Ptarmigan Glacier retreat map. Reproduced from Marcus, 1995.

Isostatic rebound, or post-glacial rebound, is the rise of land masses that were once depressed by the weight of ice sheets or glaciers. In the Juneau area, isostatic rebound due to deglaciation may lower water table depths throughout the region. Uplifting at a rate of roughly 1.9 cm/yr, local shorelines and low-lying areas are accreting land despite global sea level rise (Hicks and Shofnos, 1965). Locally, small, low-discharge streams (such as Duck Creek and Jordan Creek) appear to be evolving into subsurface, groundwater flowpaths as uplift is occurring at a faster rate than stream flows are able to downcut. The impact of isostatic rebound on Lemon Creek is not known, though uplift has changed the character of wetland areas near the mouth of Lemon Creek. Glacier retreat results in hydrologic changes throughout the watershed. Glaciated watersheds exhibit a hydrologic regime distinct from non-glaciated watersheds: peak flows are associated with warmer, summer temperatures which result in large volumes of glacial meltwater surging downstream. Peak flows in non-glaciated watersheds are more generally associated with spring snowmelt and rainfall. Glacier retreat in the Lemon Creek Watershed is well documented by the Juneau Icefield Research Program (see figure 7: Lemon and Ptarmigan Glacier retreat map), and recent research demonstrates that Lemon Creek is in an advanced state of retreat. Lemon Creek Glacial ice thickness is ablating, or surficially melting downward, at an estimated rate of 1 meter per year (Larsen, et. al., 2007).

As Lemon Creek Watershed transitions from a glaciated to a non-glaciated catchment, the hydrology regime will change, exhibiting lower sustained summer flows during dry periods and more "flashy" peak flows associated with rainfall and a lack of precipitation storage as snow. In addition to this change in discharge regime, widespread sediment and turbidity changes will also occur. For example, in comparison to other watersheds in the Borough of Juneau, Lemon Creek's summer turbidity levels more closely resemble those of Cowee and Montana Creeks (highly productive salmon streams, little to no glaciated area in the watershed) than Mendenhall, Herbert, and Eagle Rivers (less productive, glaciated watersheds). Winter turbidity levels are the same across the board since glacier activity is minimal in winter (Eran Hood, UAS, personal communication). Figures 8 & 9 demonstrate water temperature and turbidity as a function of watershed area for six watersheds on the Juneau road system: from left to right, Montana Creek, Cowee Creek, Lemon Creek, Herbert River, Eagle River, and Mendenhall River. Notice that Lemon Creek falls in the middle of this group and exhibits lower turbidity and higher water temperatures relative to other local glaciated watersheds.



Figures 8 and 9: Water temperature and turbidity as a function of percent glaciated area for five southeastern Alaska watersheds. Lemon Creek is highlighted in the middle of the data set. Figures provided by Dr. Eran Hood, UAS.

Vegetation

Upland vegetation is primarily spruce forest and muskeg, while lowlands are dominated by spruce forest, wetland, muskeg, and intertidal plant communities. Sitka spruce and western hemlock canopy shades a diverse understory of devil's club, blueberry, skunk cabbage, fern, horsetail, and salmonberry. Disturbed areas are commonly populated by alder, willow, grasses, and horsetail. Riparian habitat is similar, with the addition of mosses and fungi. Sedges and grasses dominate intertidal areas near the State Game Refuge.

Fish and Wildlife

In the high alpine, mountain goat, ptarmigan, black bear, and voles are common wildlife. Sitka black-tailed deer, black bear, and porcupine sign are prolific along the Lemon Creek trail, which follows the creek from behind the Home Depot parking area to the USGS stream gage station located roughly 6 miles upstream from the mouth of the creek in Gastineau Channel. Dippers, kingfishers, eagles, crows, ravens, gulls and grouse are all common birds in the Lemon Creek watershed. Shorebirds, raptors, and waterfowl are very common in and around the State Game Refuge at the mouth of Lemon Creek. Many of these animals rely on the creek for some form of support, be it drinking water, shelter, or food supply (invertebrates, fish, other birds). The tidal wetland near the mouth of Lemon Creek has some of the highest late-summer concentrations of Bald Eagle in the Juneau Wetland study area, as well as Green-winged Teal and Trumpeter Swan. Red-winged Blackbirds breed in the same area, and the wetland is used by shorebirds, Canada Geese, Arctic Terns, and others (Adamus, 1987).

Lemon Creek is listed by ADF&G as an anadromous fish stream (#111-40-10100) supporting stocks of coho, chum, and pink salmon, and Dolly Varden char (Johnson, 2006). The main channel currently provides only marginal spawning habitat and limited rearing habitat and is perhaps predominantly used as a migratory channel to access clearwater tributaries and side channels for spawning and rearing. Capelin, eulachon, pink and chum salmon, and stickleback are thought to use intertidal areas and the mouth of the creek near the State Game Refuge (ADF&G, 2004).

1.3 History

Lemon Creek owes its name to John Lemon, a prospector and placer miner who first worked the area in the 1870s. Placer claims in the Lemon Creek area were recorded as early as 1884 and continued in to the early 1900s, though production was only fair. The Vanderbilt Gold Mine, located in the Lemon Creek Watershed, employed approximately 50 people prior to 1900 (Host, 2005) Historical Library photographs depict a dairy farm located on the flats of lower Lemon Creek (Alder House students, 2003).

Logging was also common in Lemon Creek watershed, evidenced by spring board notches in large stumps above the Hidden Valley area, though no concrete record of dates and areas logged was found. From historical photographs, logging of the Switzer Creek headwaters and lot-clearing activities significantly reduced tree cover during rapid development in the 1970s (CBJ, 2004).Trees were most recently logged from the Hidden Valley area in the 1980s (Host, 2005). Throughout much of the Lower Lemon Creek floodplain, vegetation and topsoil has been removed for mining or construction activities and disposed of as overburden at fill local sites. A permit history of the East Creek, Switzer Creek, Lemon Creek and Vanderbilt Creek Wetland Complex reveals a record of chronic unauthroized fill and construction activities in the Lemon Creek Valley stretching back to the 1970s.

Lemon Creek has been dredged intermittently for gravel acquisition since 1945. Changes to the creekbed and streambanks over the last 40 years have resulted in changes to channel flood water conveyance, degraded creek habitat, and bank instability. Major dredging operations in the 1970s and 1980s straightened and deepened the lower reaches of Lemon Creek by roughly 15 to 20 feet (Bethers, 1995), changing the nature of the creek from a shallow, braided, and meandering stream to a relatively straight man-made channel (Host, 2005). While a straight, deep channel affords improved flood water conveyance, it increases stream velocity and lacks essential fish habitat including pools, riffles, spawning gravel beds or riparian vegetation. This artificial increase in conveyance enabled development within the historic floodplain. Since the suspension of in-stream gravel extraction activities in the 1980s due to poor operational practices, the channel has slowly returned its natural state, including shallowing (aggradation of sediments), braiding, and some minimal formation of meanders, gravel bars, shallow pools and riffles in the area between the correctional facility and the Glacier Highway Bridge (CBJ, 2004).

The lower Lemon Creek area has been extensively developed since the 1950s and grew rapidly in the 1970s. Currently, about 15% of Juneau's population resides in the Lemon Creek Valley and nearby Switzer Creek and Twin Lakes communities. About 35% of the 4,805 residents live in mobile homes located in medium density residential areas, while the bulk of the remainder of residents live in single and multifamily homes located in urban low density residential areas (CBJ, 2006). Zoning in the urban valley area is fairly consistent, with primarily residential and rural reserve areas west of Lemon Creek and commercial, industrial, and resource development to the east. Most of the watershed remains undeveloped forest land, though the extent of the lower reaches of Lemon Creek from Hidden Valley south is privately owned and zoned to permit resource extraction. The Lemon Creek urban area is currently an industrial center in Juneau, including large box stores, a power generation plant, a brewery, small business and retail facilities, concrete, gravel mining and stockpiling operations, and the local landfill.

Public recreational use of Lemon Creek watershed includes hiking, trail-running, birding, wildlife viewing, and skiing. The Lemon Creek Trail follows the creek roughly 3.5 miles upstream from the Home Depot parking lot to the USGS stream gauging station located at an elevation of 650 feet, roughly 4.5 miles upstream from the mouth of the creek. Access to the Ptarmigan and Lemon Glaciers, and the Juneau Icefield, is also provided via the Lemon Creek Trail Corridor, which includes 13.75 acres of land owned by the City and Borough of Juneau. In addition to general public use, the educational Juneau Icefield Research Program (JIRP) has used the Lemon Creek Trail as the start of their yearly scientific trek across the Juneau Icefield into Atlin, B.C. since 1950. JIRP maintains two permanent camps (C-17 and C-17A) of small wood and corrugated metal buildings, including outhouses and machine shop, in the high alpine region of the Lemon Watershed. These camps are in use roughly 2-3 weeks in June every summer, and are occasionally accessed by backcountry skiers in the winter. Contact use of Lemon Creek includes whitewater kayaking in the gorge area.

2. WATER QUALITY

2.1 Water Quality Regulations

Under section Section 305 (b) of the Clean Water Act, states are required to assess if all surface waterbodies meet state water quality standards. Water quality standards for the state of Alaska (18 AAC 70.020) define water quality criteria for protecting designated water uses. Criteria are often allowable limits on the amount of a pollutant present in a waterbody in regard to its designated uses. Defined uses of waterbodies in the state of Alaska include water supply, recreation, and growth and propagation of fish, shellfish, other aquatic life and wildlife.

Waterbodies failing to meet state criteria for any designated use are added to the state 303(d) Clean Water Act list and often a Total Maximum Daily Load (TMDL) is established by Alaska Department of Environmental Conservation (ADEC), Alaska Department of Fish and Game (ADFG), and Alaska Department of Natural Resources (ADNR) together to characterize surface waters and identify stewardship actions. TMDL determination is required to establish maximum allowable loadings of pollutants an impaired stream or lake and sets targets for meeting water quality criteria for all designated uses. When met, TMDL targets signal attainment of water quality standards. The primary goals of TMDL processes are meeting and maintaining water quality standards and restoring beneficial stream uses. Waterbodies nominated for protection or restoration are included on the Alaska Clean Water Actions (ACWA) list.

2.2 Lemon Creek Water Quality

Lemon Creek first appeared on Alaska's "303(d)" list in 1990. Upon adoption of the 1995 TMDL, Lemon Creek was assigned "4b" status and remains on the state impaired waterbody list. The three major stressors responsible for impaired status are **sediment** and **turbidity** with consideration of **habitat modification**. Alaska water quality standards (18 AAC 70) for sediment and turbidity are listed below. Alaska water quality standards regulations do not include standards or criteria for habitat modification; identifying waterbody uses as impaired due to habitat modification therefore requires professional judgment in absence of specific water quality standards. Habitat modification was identified in this fashion as a stressor in Lemon Creek. Material stockpiling, gravel operations, roads and embankments, residential urban stormwater runoff, industrial urban stormwater runoff, and natural point and non-point sources were listed as sources of stressors in the 1995 TMDL.

Alaska Water Quality Standards for Sediment and Turbidity (ADEC, 1995)

> ***Turbidity:*** *May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU.*
>
> ***Sediment:*** *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 water no sediment loads (suspended or deposited) that can cause adverse effects on aquatic animal or plant life, their reproduction or habitat may be present.
Habitat Modification: *Alaska water quality standards regulations do not include standards or criteria for habitat modification.*

Other potential pollutants include debris, hydrocarbons from fuel storage tanks or spills, pet waste, landfill leachate, and residential or commercial runoff including pesticides, fertilizers, petroleum, and other substances.

Quantifiable End-Points
The loading capacities provided in the TMDL are based on the following quantifiable end-points. The end points are provided here as standards against which the effectiveness of controls can be measured.

Turbidity: *Increase from upstream to downstream not to exceed 5 NTUs.*
Sediment (Total Suspended): *Annual average overall increase from upstream to downstream not to exceed a load and concentration corresponding to a 5 NTU increase in turbidity.*
Sediment (Settleable): *No increase from upstream to downstream in settleable solids load and concentration (Imhoff cone method).*
Sediment (Spawning Gravels): *Percent accumulation of fine sediment in the range of 0.1mm to 4.0mm in spawning gravels less than 30% by weight. This goal may be limited by natural gravel composition and sediment levels.*
Debris: *Essentially no debris present and no debris that would interfere with aquatic life uses.*
Habitat Modification: *No further degradation of aquatic habitat. Restoration of habitat values to the extent practicable.*

2.2.1 TMDL Loading Capacity Estimates

The loading capacity is the amount of a pollutant that can be carried by a waterbody while still meeting water quality standards. In Lemon Creek, loading capacity is estimated for each month of the year due to lack of monitoring and natural source loads that vary seasonally. For detailed information regarding how these estimates were derived, refer to Appendix F of the 1995 TMDL document. The Lemon Creek TMDL Determination does not address turbidity directly, but uses suspended and settleable solids metrics instead. Daily loading capacities by month for Total Suspended Solids and Settleable Solids (indicators of sediment and turbidity) range from 0.2 to 61.8 tons Total Suspended Solids per day and 0.0 to 45.6 tons Settleable Solids per day. Daily loading capacities by month are listed in tables 1 and 2 below. It is important to note that, although the natural sediment loads are by far the greatest contributor in the summer, it is essential to reduce anthropogenic inputs throughout the year to improve water quality while glacial activity is low (fall, winter, and early spring) This pattern of high natural sediment loading corresponds with fish use in the watershed.

Table 1: Daily **Total Suspended Solids** Loading Capacity by month, Lemon Creek, reproduced from the ADEC 1995 Lemon Creek TMDL report.

Month	Mean Monthly Flow (cfs)	Natural Sus. Sediment Load (Tons/Day)	Sus Sediment Load Capacity (Tons/Day)
Oct	147	7.9	11.5
Nov	49.2	1.3	2.5
Dec	17.6	0.2	0.7
Jan	8	0.1	0.3
Feb	5.4	0	0.2
Mar	5.8	0	0.2
Apr	12.9	0.1	0.5
May	85.4	3.2	5.3
Jun	261	20.2	26.6
Jul	418	43.8	54
Aug	457	50.7	61.8
Sep	358	34	42.7

Table 2: Daily **Settleable Solids** Loading Capacity by month, Lemon Creek, reproduced from the ADEC 1995 Lemon Creek TMDL report.

Month	Mean Monthly Flow (cfs)	Natural Sus. Sediment Load (Tons/Day)	Sus. Sediment Load Capacity (Tons/Day)
Oct	147	7.1	7.1
Nov	49.2	1.2	1.2
Dec	17.6	0.2	0.2
Jan	8	0.1	0.1
Feb	5.4	0	0
Mar	5.8	0	0
Apr	12.9	0.1	0.1
May	85.4	2.9	2.9
Jun	261	18.2	18.2
Jul	418	39.4	39.4
Aug	457	45.6	45.6
Sep	358	30.6	30.6

2.2.2 Total Load Allocations

Total load allocations are amounts of pollutant allowed for input by each identified source. Load allocations are reductions of the current loading that was estimated in this case. Total load allocations were originally published for specific sources in the area, but these sources may not be current (development and recent restoration may have impacted source loads). Also, Lemon Creek was one of the first TMDL determinations made for almost exclusively non-point source pollution in a glaciated watershed, and, as such, the TMDL terminology and methods presented in this report are not necessarily current with currently established norms. For example, the total load allocations listed here are for locations treated as point sources; non-point source discharges are now known as wasteload allocations. Monthly load allocations presented in the TMDL required an overall reduction in total suspended solids of roughly 60 percent to bring the sediment load into compliance with Lemon Creek's least loading capacity. Target reductions were then specified at 70 percent (except for stormwater runoff from residential areas, set at 50 percent). These tables are available in the original TMDL document and are no longer representative of existing ground conditions.

Existing Pollutant Controls
Refer to Appendix E of the 1995 TMDL document for a comprehensive list of existing controls.

Control Actions Update
Control actions for this target reduction level were listed as a part of the original TMDL recovery plan (See Appendix D: 1995 TMDL Control Actions). Of the site-specific control actions listed, the following table summarizes the status of specified activities.

Major Findings:

- The Juneau ReadiMix (JRM) stockpile land is now the Concrete Way commercial subdivision and the stockpiles are no longer present.
- Blasting activity and hauling in the active gravel mining areas impeded the inspection of Goldbelt and RSH areas, now SECON and CBJ property, respectively. It is not known if specified actions there were completed and these should be assessed.
- Haul road surface and embankment control actions appear partially met, as CBJ has somewhat realigned and chip-sealed the haul road near Anka St., and SECON has surfaced the remainder of the haul road with 2 to 3 inch gravel. The lower portion of the haul road is graded to route runoff from the road into a series of detention ponds, however, no berm exists to physically prevent sediment from entering the creek.

Watershed controls listed in the 1995 TMDL are long-term, ongoing, goals and are also included in this recovery plan. ADEC is responsible for monitoring, review, and TMDL revision activities, and these are also carried over from the TMDL controls to the recovery plan. An updated monitoring plan, developed by JWP and the University of Alaska Southeast, will provide guidance, determine current sources of pollutants, and will aid an advisory committee in re-assessing TMDL capacities, targets, and allocations. Items are review briefly in Table 3, below, Review of 1995 TMDL Proposed Actions.

Table 3: Review of 1995 TMDL Proposed Actions

Site/Action	Accomplished?	Notes and 2007 Status
Phase 1: Site-Specific Control Installation		
Juneau ReadiMix Stockpile		New ownership. Stockpile removed. Now "Concrete Way" commercial subdivision.
Establish terrace with reverse slope.	n/a	Not applicable.
Stabilize stream bank below terrace.	n/a	Not applicable.
RSH Retention Basin		Now CBJ property. Basin appears unused. Determine if in use.
Maintain storage and retention capacity.	No	Either re-commission or decommission and fill if not in use.
Goldbelt Upper Sediment Pond		Now SECON property.
Re-direct flow to lower infiltration basin.	unknown	Determine if in use. Define actions accordingly.
Increase pond volume.	unknown	
Establish silt dikes in ditch.	unknown	
Goldbelt Sidecast Area		Now SECON property.
Establish surface cover in grass and alder.	unknown	Determine if this goal was met with site visit.
Phase 2: Site-Specific Control Installation		
Additional Juneau ReadiMix stockpile measures if required.	n/a	Remove from control actions list.
Additional Goldbelt Upper Sediment Pond measures if required.	n/a	Follow up with control measures if pond is still in use.
Additional Goldbelt Sidecast Area measures if required.	n/a	Follow up and vegetate surface if not already accomplished.
Haul Road Surface/Embankments		Ongoing.
Shift alignment below gorge away from creek.	Yes (partial)	Now SECON and CBJ properties. Alignment shifted along section nearest Anka St.
Surface road.	Yes	CBJ chip-sealed realigned portion of road, SECON resurfaced remainder of road with 2-3" gravel in 2007.
Watershed Control Installation		
Establish stable, vegetated, 50-foot buffer.	No	ADEC, CBJ Responsibility. Ongoing.
Install sediment control devices on conveyances.	Yes, Ongoing	ADEC, CBJ Responsibility. CBJ is currently developing a comprehensive stormwater management program with enforceable regulations in the building and land use code.
Develop and implement construction BMPs	Yes, Ongoing	Current EPA NPDES permitting requires a Stormwater Pollution Prevention Plan (SWPPP) including BMPs.
Monitor and improve habitat.	Partially, Ongoing	ADFG conducted a reconnaissance mainstem stream habitat survey in 2004. Anadromous tributaries were not surveyed. No habitat improvements are recorded as of 2007.
Improve agency and public awareness.	No	Ongoing. No known program in place.
Establish implementation and oversight committee.	No	ADEC Responsibility. Not completed. Action is re-listed in this report.
Monitoring		
Initiate monitoring per monitoring plan.	No	Monitoring Plan completed in 2007 by JWP and UAS. No scheduled monitoring
Annual Progress Assessments		
First annual progress assessment. (1996+)	No	ADEC.
TMDL Updates		
First TMDL Update. (Anticipated 1998-2000)	No	ADEC. Overdue due to lack of sufficient monitoring.

2.3 Relevant Water Quality Data

Discharge and Solids Data

U.S. Geological Survey discharge data are available online for the historic and current gauging stations located on Lemon Creek. Station #15052000, located about 0.3 miles upstream from the confluence of Canyon Creek, was operated from 1951 to 1973, and 2001 to present. The USGS also collected 23 sets of water quality data between 1948 and 1972. Fifteen of those data sets include suspended sediment concentration (SSC) and loads. The USGS also operated a second discharge gauging station located roughly 1 mile upstream from the mouth of Lemon Creek between 1982 and 1986.

University of Alaska Southeast discharge data for 2002-2004 are also available online at http://www.uas.alaska.edu/spatialdata. Clean Water Act funds provided support for two years (2003-2004) of student-led monitoring in Lemon Creek by the University of Alaska Southeast, Juneau, Environmental Sciences program. Parameters monitored include 15-minute discharge, daily SSC, and 15-minute water and air temperature at approximately the same locations as previous USGS gages. Supraglacial lake level was also monitored for a portion of the study.

The UAS South East Alaska Monitoring Network for Science, Telecommunications, Education, and Research (SEAMONSTER) is a smart sensor web project designed to support collaborative environmental science with near-real-time recovery of large volumes of environmental data. The Year One (2007) geographic focus is the Lemon Creek Watershed. Researchers plan to collect discharge and meteorologic data primarily in the high alpine area of the watershed.

ADEC collected half-hourly turbidity and TSS data near the Glacier Highway bridge during in-stream gravel extraction activity on March 17, 1982. Weekly turbidity and TSS data for the reach from Glacier Highway Bridge upstream to the Correctional Facility were collected in summer 1982. TSS and turbidity data were also collected in July 1995 at the end of the access road and below the Juneau ReadiMix operation. Settleable solids were measured twice during the same period at both stations. These data are available in the Appendix of the 1995 TMDL report.

Inter-fluve, Inc. collected streambed gravel samples from 13 sites spread throughout the lower reaches of the creek and analyzed them for grain size distribution (GSD). These data were used for spawning habitat suitability and sediment transport analysis and are presented in the Lemon Creek Watershed Geomorphic Assessment and Sediment Management Alternatives Analysis prepared for CBJ.

Other Data

Adamus' 1987 Juneau Wetlands Functions and Values collected nutrient data from creek mouths throughout the Mendenhall/Lemon Creek wetland area. This report was updated as of June 1995.

Eran Hood, UAS Assistant Professor, is finishing one year of weekly nutrient sampling in several creeks along the Juneau road system with different glaciated areas in each watershed. Lemon Creek is included in this study.

Lisa Hoferkamp, UAS Assistant Professor, conducted another UAS study looking for pollutants in sediments and organisms around the landfill area collected soil and biologic samples in and around the mouth of Lemon Creek and analyzed them for polybrominated diphenyl ether (PBDE) levels (Hoferkamp, 2006).

2.4 Designated Use Impairments

As identified in Alaska's Water Quality Standard Regulations (18 AAC 70), protected, designated uses for Lemon Creek waters include use as a source of drinking water, industrial and aquacultural purposes; contact and non-contact recreation uses; and growth and propagation of aquatic life and wildlife. State regulations protect both existing and potential uses. The primary use affected by sediment and turbidity pollution and habitat modification is aquatic life.

Fish spawning and rearing habitat is the primary beneficial use of Lemon Creek waters. The riparian and in-stream fish habitat has been impacted by human activities such as channelization, flow modification, removal of riparian vegetation, stream bank modification and alteration of the streambed. The most significant changes to creek morphology have occurred in the mid and lower reaches, where gravel extraction, fills, surface topography changes, and removal of vegetative mats may have influenced groundwater flow direction and rates. The mouth and lowest reach of Lemon Creek is influenced by tidal action. In these lower areas, both surface and ground water are mixed with saltwater.

Adamus (1987) lists fish habitat quality as poor due to the absence of undercut banks and overhead cover, high seasonal turbidity, fluctuation in water levels, and paucity of rearing pools. Bethers (1993) later reports that spawning habitat for chum, coho, and pink salmon in the main stem is good, though better rearing habitat exists in non-impacted tributaries upstream. Reconnaisance-level fish habitat surveys of Lemon Creek conducted in May 2004 by Alaska Department of Fish and Game reveal that bank disturbance, sediment inputs from roadbed and cut/fill activities, and encroachment upon riparian areas continue in lower reaches due to commercial and industrial development (ADFG, 2004).

Alaska Water Quality Standards (18 AAC 70) for sediment and turbidity are listed under section 2.2, above. These standards must be met before Lemon Creek will be removed from the state 4b impaired waterbody list.

2.4.1 Sediment

Lemon Creek is impaired in its designated uses of growth and propagation of fish, shellfish, other aquatic life, and wildlife by sediment.

Effects of suspended and deposited sediment on benthic habitat and freshwater aquatic organism survival and reproduction are well documented. Sediment load changes can impact fundamental stream morphology, such as channel shape, bed elevation, sinuosity, and pool and riffle balance, as seen in Lemon Creek (ADEC, 1995). Fish egg mortality in lower Lemon Creek is probably high due to egg burial in the main channel by excess sediment.

Over time, excess sediment builds up, or aggrades, in the stream bed. Since the urban reaches of Lemon Creek are confined to an abbreviated floodplain by development within the 50 foot riparian buffer zone, the creek cannot meander in response to bed aggradation which results in lower conveyance capacity at bank-full stages, increasing the likelihood of flooding.

Although high summer sediment loads are typical of active glacial streams such as Lemon Creek, land use and human activities, such as logging, road cuts, construction, and bank destabilization, significantly impact upstream erosion and downstream deposition of sediment in Lemon Creek. Glacial sediment loads are expected to decrease as Lemon and Ptarmigan Glaciers continue to retreat.

Highly erodable stream banks in the Hidden Valley area supply excessive sediment to lower-gradient, confined urban reaches downstream (Figure 10: Hidden Valley Area of Lemon Creek). In November 2005, high streamflow undermined two large cut banks, transporting tons of sediment, vegetation, and debris into Lemon Creek. This event carried away two large containers and some other equipment stored at the end of the access road and lodged them downstream.

Figure 10: Hidden Valley. Land use, highly erodable banks, and Lemon Creek collide, sending sediment downstream. *Photo: CBJ*

Sediment from eroding banks is transported downstream; since the creek width is constrained and therefore cannot meander, as it did historically, the creek bed is aggrading. The un-abated aggradation of sediments in lower Lemon Creek is impacting fish habitat by filling in pools and burying spawning gravels and contributing to increased flood risk.

In addition to sediments transported from erosion in the Hidden Valley area, stormwater runoff throughout urban lengths of the stream transports sediment via culverts, ditches, and overland flow into creek waters. The lack of riparian buffer or insufficient buffer or vegetation also overland flows to carry sediments into the creek unfiltered.

2.4.2 Turbidity

Lemon Creek is impaired in its designated uses of growth and propagation of fish, shellfish, other aquatic life, and wildlife by high turbidity levels.

Turbidity, or a lack or water clarity, is caused by suspended fine sediments. Excessive turbidity levels reduce the amount of light available to aquatic plants for photosynthesis. Cloudy, turbid water decreases underwater visibility, inhibiting fish migration and the ability of predators to see prey. Invertebrate populations are impacted by turbidity; populations are reduced and can drift downstream. As fine sediments that cause turbidity settle, they can bury plants, invertebrates, eggs, and alevin. Suspended solids can irritate fish gills (ADEC, 1995).

Levels of turbidity in Lemon Creek are seasonally elevated in late summer due to glacial activity, but often contributions of fine sediments from road surfaces, bank erosion, and runoff lead to high turbidity during rainstorms throughout the year. Known turbidity sources are the same as the sediment sources listed above.

2.4.3 Habitat Modification

Lemon Creek is impaired in its designated uses of growth and propagation of fish, shellfish, other aquatic life, and wildlife by habitat modification. ***A discussion of habitat modification and fish use of in-stream habitat follows in Section 3: Fish and Fish Habitat. Below is a brief introduction to habitat issues in Lemon Creek.***

Erosion
Extreme bank erosion in the Hidden Valley area contributes to high suspended fine sediment and turbidity levels downstream, which have altered stream morphology, reducing pool and riffle formation, blanketing spawning gravels and cloaking invertebrate prey.

Channelization
The lower reaches of the stream are confined to an abbreviated floodplain, reducing available rearing habitat for juveniles, including side channels. Clear water tributaries continue to provide the best spawning and rearing habitat in Lemon Creek. Historic straightening and deepening of the main channel by in-stream gravel extraction severely impacted habitat and is still evident in current channel morphology. Filling of adjacent wetlands and estuarine areas has reduced available fish and wildlife habitat.

Riparian Areas
Riparian and streambank disturbance have led to a paucity of undercut banks, large woody debris, and shade-producing vegetation that provide habitat for birds, insects, small mammals, fungi, and amphibians and cover for fish throughout the main channel.

2.4.4 Other Pollutants of Concern

Runoff from human activities may contain a variety of other potential pollutants, such as litter and debris, household and industrial cleaners, pet waste, petroleum products, fertilizers, and de-icing salts and gravels. Fecal coliforms may be present due to pet and wildlife waste or leaking sewage treatment or transport systems. Illegal dumping or improper storage of paint, vehicles, car batteries, fuels, or chemicals may be common in the urban corridor and presents a potential source of contaminants. Leaking fuel underground storage tanks or vehicles may contribute hydrocarbons. Many of these pollutants are successfully intercepted by riparian buffers and comprehensive stormwater management controls.

3. FISH AND FISH HABITAT

3.1 Lemon Creek Fish Species

As designated by the Alaska Department of Fish and Game (ADF&G), Lemon Creek (ADF&G #111-40-10100) is an anadromous fish stream supporting stocks of coho, chum, and pink salmon, and Dolly Varden char. Eulachon or capelin are present in the mouth of Lemon Creek in early spring (CBJ, 2004). An unnamed tributary (#111-40-10100-2029) and Sawmill Creek tributary (#111-40-10100-2036) are also included in the AWC listing chum (spawning) and coho (spawning and rearing), and coho and Dolly Varden (rearing) use, respectively. See Figure 11: ADF&G Lemon Creek Anadromous Waters map. Fish Periodicity was estimated by ADFG for purposes of recommending an in-stream flow reservation for fish use on Lemon Creek to ADNR. This table is included, below, to demonstrate approximate timing of fish use by species at each life stage. Fish periodicity should guide timing of activities in and around the creek. This table is an estimate only, and should be confirmed or updated with fish data collected as a portion of the monitoring recommended in this recovery plan.

Table 4: Fish Periodicity Estimates by Species (Estes, 1996)

Coho Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage				XX	XXXX	XX						
Adult Passage									XXXX	XXXX	X	
Spawning										XXXX	XXXX	X
Incubation	XXXX	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

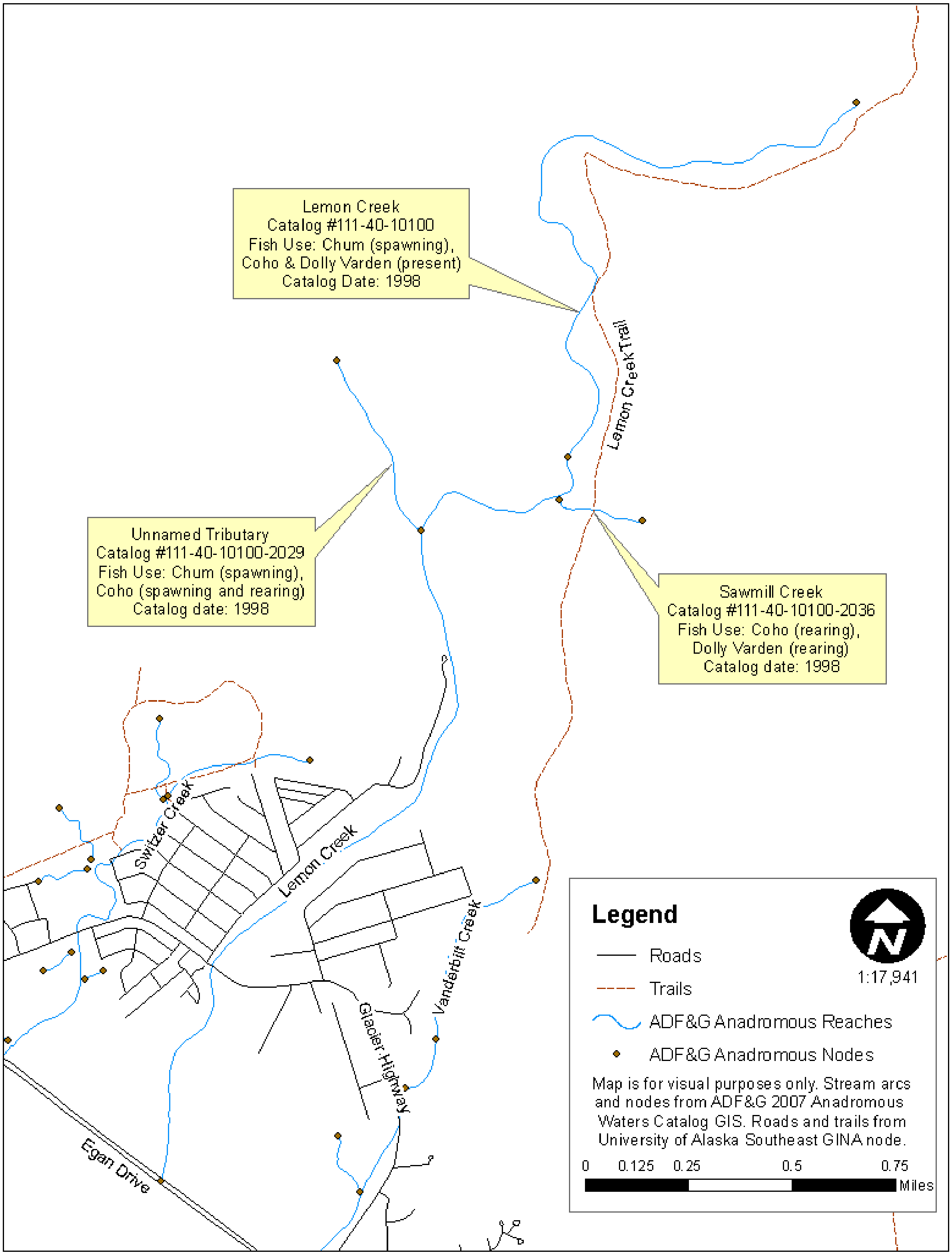
Chum Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			XX	XXXX	XX							
Adult Passage								X	XXXX	XX		
Spawning									XXXX	XXXX	XX	
Incubation	XXXX	XXXX	XXXX						XXXX	XXXX	XXXX	XXXX
Rearing			XX	XX								

Pink Salmon	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			XX	XXXX	X							
Adult Passage							XXX	XXX				
Spawning							XX	XXXX	X			
Incubation	XXXX	XXXX	XXXX				XX	XXXX	XXXX	XXXX	XXXX	XXXX
Rearing			X	X								

Dolly Varden	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Smolt Passage			XX	XXXX	XXXX	XX						
Adult Passage							XXX	XXXX	XXXX	XXXX	XX	
Spawning									XX	XXXX	XX	
Incubation	XXXX	XXXX	XXXX	XXXX	XX				XX	XXXX	XXXX	XXXX
Rearing	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX

Available online: http://www.sf.adfg.state.ak.us/FedAidPDFs/FDS96-45.pdf

Figure 11: ADFG Anadromous Waterbody Catalog streams in the Lemon Creek Watershed.



3.2 Fisheries Research

The Alaska Department of Fish and Game, Sport Fish Division, generated a baseline aquatic habitat characterization report for Lemon Creek in response to community consideration of resuming in-stream gravel extraction for increasing flood water conveyance (ADFG, 2004). Data from this report are presented in Table 5: ADFG Habitat Feature Data Summary, and Figure 12: ADFG Reach Map, and are summarized below.

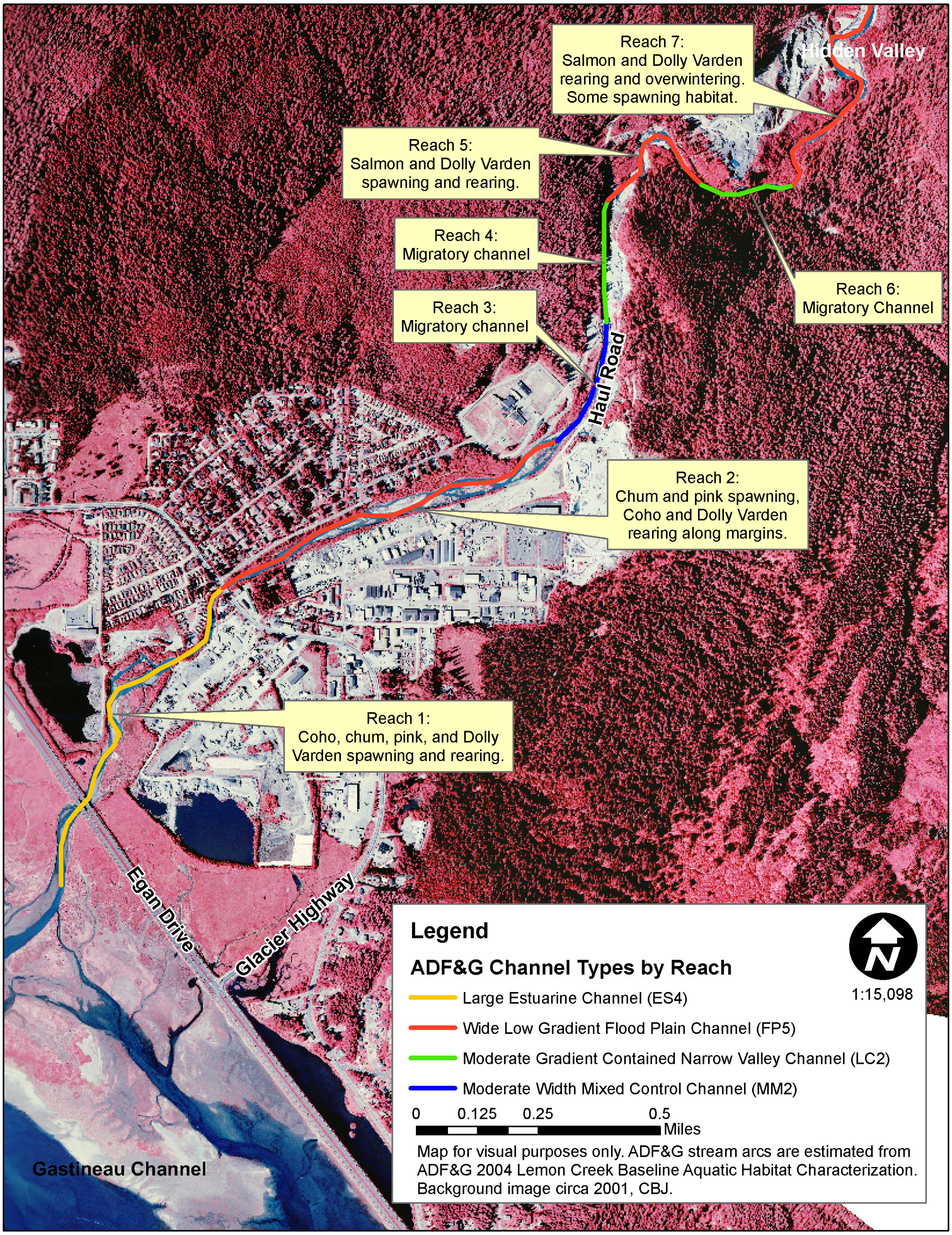
The fishery resources of Lemon Creek have not been assessed thoroughly, primarily because fish habitat is so heavily impacted by human activity and disturbance (Bethers, 1995; ADF&G, 2004). The main stem of Lemon Creek provides fair rearing habitat for Dolly Varden char and coho salmon and clear water tributaries upstream provide good rearing habitat (Bethers, 1995). A 2004 ADF&G habitat assessment from tidewater to a fish passage barrier located 4.5 miles upstream described habitat value and potential.

- Lower Lemon Creek, below the canyon area, provides pink and chum spawning habitat, but fine sediment accumulation in the area likely impacts egg viability. Clear water side channels, though limited, provide rearing habitat for juvenile coho salmon and Dolly Varden char. Margins of vegetated banks provide limited rearing habitat for out-migrating chum, coho, and pink salmon juveniles.
- The canyon gorge area functions simply as a migratory corridor due to high water velocity and the paucity of bank vegetation.
- Hidden Valley and upper Lemon Creek contain variable fish habitat. Areas upstream of human activity provide good spawning and rearing habitat. Reaches within the Hidden Valley area and downstream to the gorge area are heavily impacted by active erosion and human activities. Despite sufficient woody debris, channel slope, gravel, and clear-water tributary contributions, mass wasting and absence of riparian vegetation severely limits spawning and rearing habitat throughout the area (ADFG, 2004).

Table 5: ADFG Habitat Feature Data Summary. Modified from ADFG *Lemon Creek Baseline Aquatic Habitat Characterization, May 2004.*

	Reach 1	**Reach 2**	**Reach 3**	**Reach 4**	**Reach 5**	**Reach 6**	**Reach 7**	**Reach 8**
Channel Type	ES4	FP5	MM2	LC2	FP5	LC2	FP5	LC2
Surveyed Distance (km)	1.6	1.35	0.356	0.365	0.654	0.189	3.4	0.676
Average Gradient (%)	1.1	1.1	2.9	4.2	1.2	2	1.5	2.6
Bankfull Width (m)	38	60	20	20	25	12	45	17
Incision Depth (m)	2	1.5	2.5	50	3	50	2.8	8
Pools (count)	0	10	4	18	8	6	23	5
Pool Density (pools/m)	0	0.007	0.011	0.049	0.012	0.032	0.007	0.007
Large Wood (count)	0	560	20	71	237	2	980	31
LW Density (pieces/m2)	0	4.15	0.056	0.195	0.362	0.011	0.288	0.046
Key Piece (count)	0	3	0	2	7	0	52	2
Key Piece Density (pieces/m2)	0	0.022	0	0.005	0.011	0	0.015	0.003
Riparian Disturbance (m, both banks)	980	791	585	437	196	0	2146	0

Figure 12: ADFG 2004 Habitat Characterization Map, Reaches 1-7.



3.3 Fish Habitat Impacts

3.3.1 Erosion

In addition to increasing sediment and turbidity loads, excessive erosion upstream of critical fish habitat such as spawning beds and rearing areas may increase egg mortality and fry survival. Downstream deposition of materials derived from erosive processes, such as bank sediment and gravel, can reduce the depth and number of available pools for overwintering juveniles and make spawning gravels unsuitable for spawning adults.

3.3.2 Channel Alterations

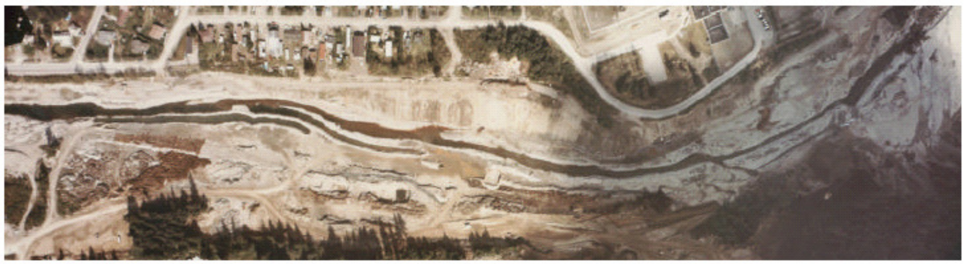
Channelization of Lemon Creek directly impacts fish habitat by removing diversity of habitat features such as pools, side channels, and marginal vegetation on bars and flooplains. In-stream gravel extraction activities throughout the urban reach of Lemon Creek have historically lowered the streambed and straightened the channel (see Figure 13). In-stream gravel mining was halted in the 1980s; subsequently, stream morphology has slowly returned to its natural state, where the creek meanders throughout the remaining floodplain. Resumption of in-stream gravel extraction may impact fish habitat if channel straightening, removal of side channels and meanders and loss of pool and riffle structure are not mitigated by pre-extraction planning and post-extraction habitat reconstruction and enhancement actions. Bank stabilization activities have altered stream morphology as well by confining the creek and removing riparian habitat.

3.3.3 Streambank and Riparian Disturbance

Riparian buffers provide essential shade, nutrients, natural debris, and organisms to anadromous streams. Buffers filter particulates from runoff before it enters the creek, and provide moderate bank armoring and stabilization to reduce erosion. The reduction of riparian area in the urban Lemon Creek corridor is evident in repeat aerial photography in the area between the 1950's to present. Structures, roads, and private stockpiles or property exist within the proscribed 25-foot setback and much of the creek riparian area is disturbed and/or lacks vegetation, and cannot provide shade. Development adjacent to the creek edge can be seen throughout the urban corridor. The haul/access road along the corridor is perched atop what would naturally be a riparian buffer area, and potentially contributes sediment and turbidity in the creek. Refer to the ADFG Habitat Survey data (Table 5) for quantitative riparian disturbance data.

1974 AIR PHOTO

PARTIALLY INTACT RIPARIAN MARGIN AND CHANNEL COMPLEXITY PROVIDES HABITAT. CHANNEL IS DISTURBED BUT SIMILAR TO WHAT MAY HAVE EXISTED BEFORE DEVELOPMENT. AVULSION CHANNELS AND SIDE CHANNELS MAY HAVE OCCURRED ALONG HISTORIC FLOOD TERRACES WHERE ROADS AND BUILDINGS EXIST IN THIS PHOTO. THIS CANNOT BE CONFIRMED DUE TO THE LACK OF HISTORICAL RECORDS.



1984 AIR PHOTO

PHOTO SHOWS MINING OPERATIONS HAVE STRAIGHTENED AND DEEPENED THE STREAM CAUSING MULTIPLE STREAM MEANDER CUTOFFS. THE LOSS IN GRADE DUE TO CUTOFFS AND EXCAVATION RESULTED IN HEADWARD EROSION UPSTREAM OF THE WORK AREA AND A FLATTER DEPOSITIONAL REACH WITHIN THE EXCAVATED AREA.

1988 AIR PHOTO

PHOTO SHOWS PREVIOUSLY EXCAVATED CHANNEL TRANSFORMING BACK TO THE BED FORM THAT EXISTED BEFORE EXCAVATION OBSERVED IN 1984 PHOTO. FORMATION OF GRAVEL BARS AND MEANDERING PLANFORM ARE CHANNEL RESPONSE TO RESTORE GEOMORPHIC FORM AND COMPLEXITY.

2002 AIR PHOTO

PHOTO SHOWS A CONTINUATION OF DEPOSITION AND REBUILDING OF GRADIENT AND CHANNEL GEOMETRY THAT EXISTED BEFORE EXCAVATION. THE PHOTO SEQUENCE IN THIS DRAWING IS A GOOD EXAMPLE OF CHANNEL PROCESSES REBUILDING STREAM GRADE AND GEOMETRY THAT ARE CONSISTENT WITH PHYSIOGRAPHIC LOCATION WITHIN THE WATERSHED. MATURATION OF GRAVEL BARS AND MEANDERING PLANFORM LEADS TO BANK EROSION AS THE CHANNEL ATTEMPTS TO REESTABLISH MEANDER WIDTH.

Figure 13: Modified from CBJ, 2004 (figure 8 in the Lemon Creek Watershed Geomorphic Assessment and Sediment Management Alternatives Analysis.

4. RECOVERY AND STEWARDSHIP

Despite much of the upland watershed of Lemon Creek remaining undeveloped glaciated or forested land, urban development and resource extraction activities along the lower reaches of the creek have impacted water quality and fish habitat. Physical alterations to the creek channel, floodplain, and riparian areas have contributed to decline in water quality and fish habitat which has resulted in listing on Lemon Creek on the State's 303(d) and 4b listings of impaired waterbodies for sediment, turbidity, and habitat modification. Remaining fish habitat supports runs of salmon and Dolly Varden char, and steps should be taken to protect and improve water quality and fish habitat. A discussion of general recovery and stewardship topics is included below, followed by an outline of specific goals, objectives, and action items.

The job of improving water quality and fish habitat in Lemon Creek requires stakeholder, agency, non-profit, and government cooperation. Oversight of management and restoration should be conducted by a committee of interested parties. This committee should revisit the watershed recovery and management plan every three to five years to review accomplishments, monitor conditions, and keep goals, objectives, and action items current.

4.1 Discussion

This report focuses on providing information geared at addressing water quality issues for the purposes of preserving and improving fish habitat in Lemon Creek. Some impacts are caused by natural processes, and it is not feasible to mitigate high sediment and turbidity inputs of Lemon and Ptarmigan Glaciers. However, it is possible to develop and implement: construction BMPs, Comprehensive stormwater controls, bank stabilization projects, clear water side channel conservation or enhancement, and other sediment and turbidity controls that will improve fish habitat for the long term on Lemon Creek.

Since human activities throughout the developed length of Lemon Creek exacerbate natural erosion and deposition processes, improving water quality and habitat in Lemon Creek will require public cooperation of stakeholders including agencies, local government, community groups, businesses, and residents. The Juneau Watershed Partnership, state and federal resource agencies, and CBJ can coordinate to provide or seek necessary technical and financial assistance. Similar mitigation work, such as trail construction, maintenance, revegetation, and bank stabilization has been conducted by local organizations such as Trail Mix and Southeast Alaska Guidance Association (SAGA), and these parties may provide assistance for those actions. Refer to (external) Figures 11-14 in the CBJ *Lemon Creek Watershed Geomorphic Assessment and Sediment Management Alternatives Analysis* for general Hidden-Valley sediment control prescriptions.

Coordination and communication should be facilitated by an advisory group or oversight committee. A joint agency-landowner committee to oversee and assist in the implementation of restoration actions, monitoring, and other activities was recommended in the 1995 TMDL, but did not materialize. The Duck Creek Advisory Group (DCAG) has served this purpose for other Juneau watersheds in the past; forming a branch of this group for Lemon Creek, or forming a working group similar to the DCAG in Lemon Creek is essential to keeping restoration and protection momentum going indefinitely.

4.1.1 Urbanization and Land Use

Human activities in the Lemon Creek area have degraded water quality and fish habitat, regardless of natural processes occurring upstream of the Hidden Valley area, and this is reflected in the 1995 TMDL based on increases in sediment and turbidity relative to background levels. Land use throughout the lower portion of the watershed is the primary driver of creek impairment; human activities are likely responsible for water quality and habitat impacts from the Hidden Valley area, where logging, mining, and road construction exacerbated a highly erodable landscape, through the urban corridor, where in-stream gravel extraction, bank stabilization, development within riparian areas, removal of large woody debris, and urban runoff all compound naturally high sediment and turbidity levels.

Community Planning & Zoning
Land use planning and zoning in Lemon Creek Valley can aid in preventing further water quality and habitat degradation as described in Chapter 7 of the 2007 CBJ Comprehensive Plan draft. Subarea 5 of CBJ Comprehensive Plan (CBJ, 2007), including Switzer Creek, Lemon Creek, and Salmon Creek, provides zoning for resource development use of the Lemon Creek streambed and floodplain corridor below Hidden Valley, flanked to the west by medium density residential, urban low density residential, institutional and public use, CBJ natural park area, CBJ conservation area, and general commercial land use areas. To the east of the resource development corridor, additional resource development, industrial, general commercial, and medium density residential use areas are planned (see Figure 16: Draft CBJ Zoning map). The Mendota Park area below the Lemon Creek Correctional Facility adjacent to the western bank of Lemon Creek was re-zoned from rural to residential area (CBJ Ord. No. 2005-15b) under conditions that a park, playground, and bicycle/pedestrian path are constructed in the area. The River's Edge condominium development now stands in this area and a bicycle/pedestrian path was constructed in spring of 2007.

Stormwater Management
As impervious area increases and infiltration of rainfall and snowmelt decreases due to urban development, groundwater levels may potentially be lowered. Lowering groundwater elevations may reduce essential baseflow contributions to nearby streams. In addition to potential baseflow reduction, impervious areas generate overland flow, or runoff, where surfaces quickly shed stormwater, often polluted by surface oils and chemicals from parking lots and/or streets, resulting in higher peak stream discharge volumes closely linked to rainfall intensity and duration. Aside from preventing or minimizing development in an area, it is possible to mitigate these negative impacts with construction of artificial stormwater runoff-catchment and treatment structures proportionate to the added impervious surface area and local soil infiltration rates. Examples of these engineered structures include infiltration basins, constructed wetlands, vegetated channels, swales, and detention ponds.

As evidenced in the planning and design of the Home Depot facility (east of Costco), developers, CBJ, and ADEC coordinated efforts to accommodate water quality and quantity concerns in

Lemon Creek Valley. This project demonstrates how stakeholders and the municipality can work in concert to mitigate impacts of development, as pre-construction studies directed appropriate routing of runoff. Clean hillside and rooftop water was diverted into Vanderbilt Creek, which was historically cut off from its headwaters in the area by CBJ gravel pit development. Runoff from the parking lot travels through oil and water separators and a vegetated open channel before entering Lemon Creek (Ron King, CBJ, personal communication). Monitoring runoff from this design (at both outfalls into Lemon Creek and Vanderbilt Creek) will help determine if the controls in place are sufficient to meet water quality standards and will aid in the TMDL revision. Future design and construction in the area should continue to incorporate and improve upon this example.

Figure 14: Turbid stormwater discharge into Lemon Creek from a failing oil-water separator at the (removed) Juneau ReadiMix Bridge site, May 2007. *Photo: S. Seifert.*

The commercial and industrial community in the Lemon Creek area is developing rapidly into a a retail/industrial business park; stormwater management should account for the increase in impervious area, including sediment and turbidity controls in addition to the oil-water separators currently installed. Sediment ponds and vegetated swales are just two examples of structures that can be engineered to reduce sediment content of stormwater runoff as well as add beneficial "green" areas in business parks.

CBJ and US Fish and Wildlife have partnered to develop a *Stormwater Control Design Toolbox for Southeast Alaska* to address a lack of stormwater design criteria guiding permitting and design in the City and Borough of Juneau and protect water quality. Comprehensive stormwater treatment throughout the Lemon Creek Valley will improve seasonal, non-glacially active, flow water quality.

Figure 15: Construction of the CBJ Upper Lemon Creek Bridge (completed July 2007). *Photo: Bob Millard, CBJ project manager, June 14, 2007.*

Transportation Enhancements

The CBJ Area-Wide Transportation Plan (1991) recommended construction of a third Lemon Creek crossing near the Correctional Facility to provide additional transportation between the residential and commercial zones of the valley. A fourth bridge crossing upstream from the correctional facility was constructed in June 2007 for CBJ resource development access as per the CBJ comprehensive plan update recommendation. This bridge joins the existing haul road along the south bank to the north bank, where it joins the existing correctional facility and gun range road and a planned haul road spur. Further transportation improvements, including a second bridge crossing to Douglas and the Lemon Flats Second Access projects are in the design phase and have potential to impact Lemon Creek. More information about these projects can be found online at the CBJ Engineering Department website: http://www.juneau.lib.ak.us/engineering_ftp.

Flood Control

Flood control is a concern in Lemon Creek due to deposition of sediment in lower reaches leading to higher streambed elevations and lower flood water conveyance. The Lemon Creek Watershed Geomorphic Assessment and Sediment Alternatives Analysis (CBJ, 2004) proposed three recommendations:

1. *The highest priority is for CBJ to pursue removal of the RediMix Bridge. Removal of the bridge will provide immediate and significant reductions in flood water surface elevations. HEC-RAS model results indicate that the 100-year water surface elevation will be below the Glacier Highway Bridge deck and will only exceed the top of bank in one location by less than 1 foot.*
2. *The second priority should be to reduce excessive erosion in the Hidden Valley area. This will provide benefits of reduced rates of deposition, decrease turbidity, decrease the volume of fines deposited in the Gastineau Channel and result in fewer fines in spawning gravels. Reducing excessive erosion along the Hidden Valley supply reach will increase the interval between in stream maintenance operation along the lower Lemon Creek. In addition, methods to increase flow roughness along gravel bars to store sediment and encourage establishment of vegetation have been presented to restore natural stream-forested terrace processes.*
3. *Over the long term, deposition of gravel will continue for all Alternatives in response to flood events. Therefore, in order to maintain flood conveyance capacity, maintenance mining will be required at some point in time. Methods to construct aquatic habitat following removal of in stream gravels have been presented.*

While bed elevations have increased noticeably in the last 20 years, aggradation is a slow process. Demonstrated by the USGS 2-year survey of creek cross sections, streambed elevation change was not measurably occurring at a short-time scale (Host, 2005). There is time to adequately plan and initiate a well-designed and thorough methodology for planning a flood control program in Lemon Creek. It is important to assess the impact of RediMix Bridge removal completed in 2006 on water surface and streambed elevations upstream. Removal of the RediMix Bridge was expected to lower water surface elevations upstream and increase sediment transport throughout lower reaches Lemon Creek (CBJ, 2004).

Since the goal of flood control in this case is to lower flood-stage water surface elevations in Lemon Creek relative to bank elevations, the length of lower Lemon Creek would have to be re-graded (by in stream mining) and Glacier Highway Bridge would have to be improved to increase hydraulic conveyance, otherwise mining will result in excavation of artificial pools retaining original water surface elevations. The benefit of mining at a single location on the creek would be to create a basin capable of collecting bed materials that would otherwise collect downstream, thereby slowing aggradation. This would maintain water surface elevations at current heights.

Any mining activity must be designed to minimize impacts to water quality, aquatic life, and fish habitat. Mitigation of mining activities with appropriate stream restoration and soft bank stabilization/re-vegetation activities will be necessary to restore fish habitat and protect water quality once mining activity concludes. An outline and plan form for maintenance mining above the Glacier Highway Bridge is shown in Figure 17, excerpted from CBJ, 2004.

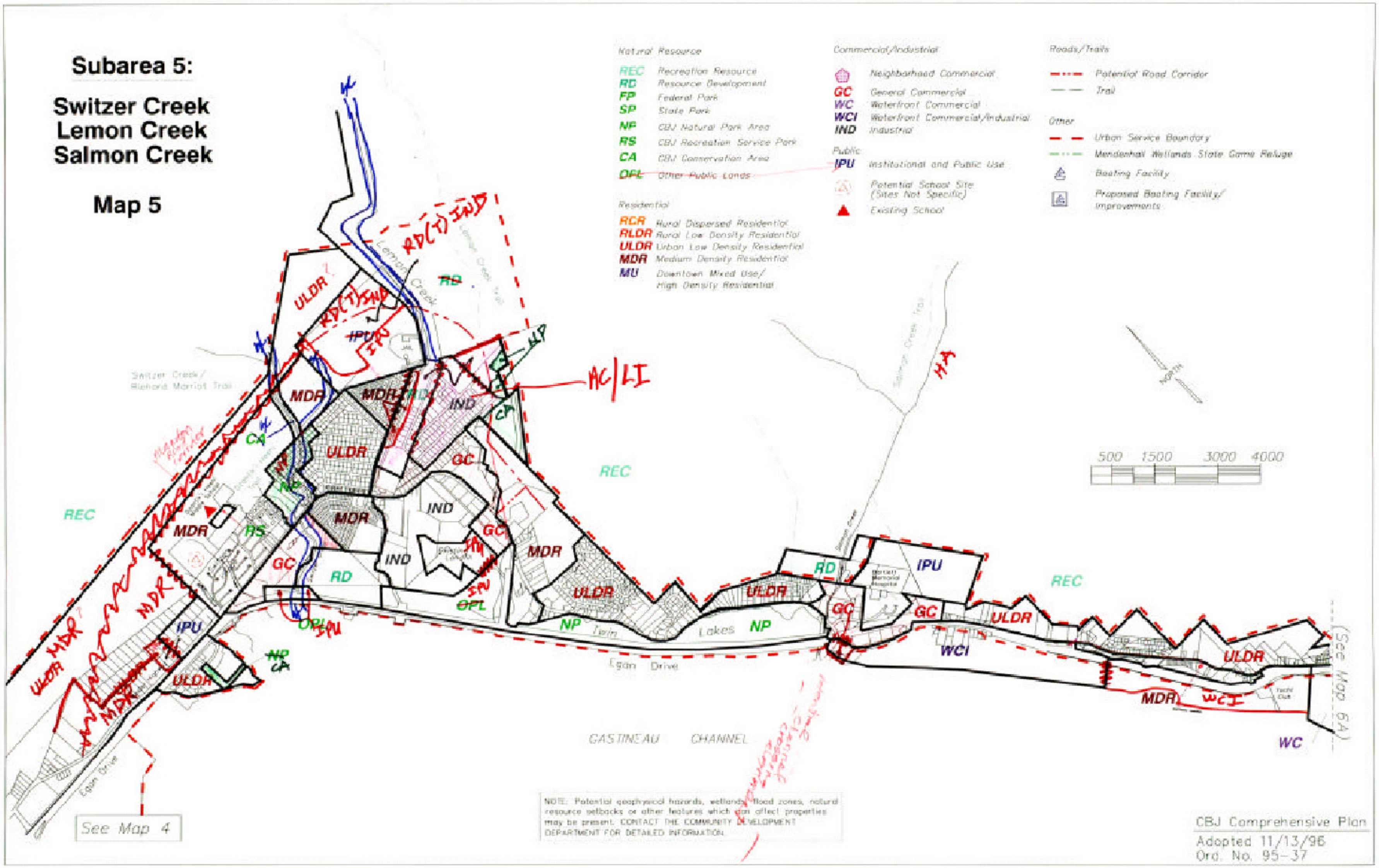


Figure 16: Subarea 5 zoning map from the draft CBJ Comprehensive Plan Update, 2007. Changes proposed in Lemon Creek include expansion of Medium Density Residential (MDR) areas west of Lemon Creek and changes from Resource Development (RD) areas to Industrial (IND), creation of CBJ park and conservation areas (near Vanderbilt Creek headwaters), and a potential road corridor to the east of Lemon Creek

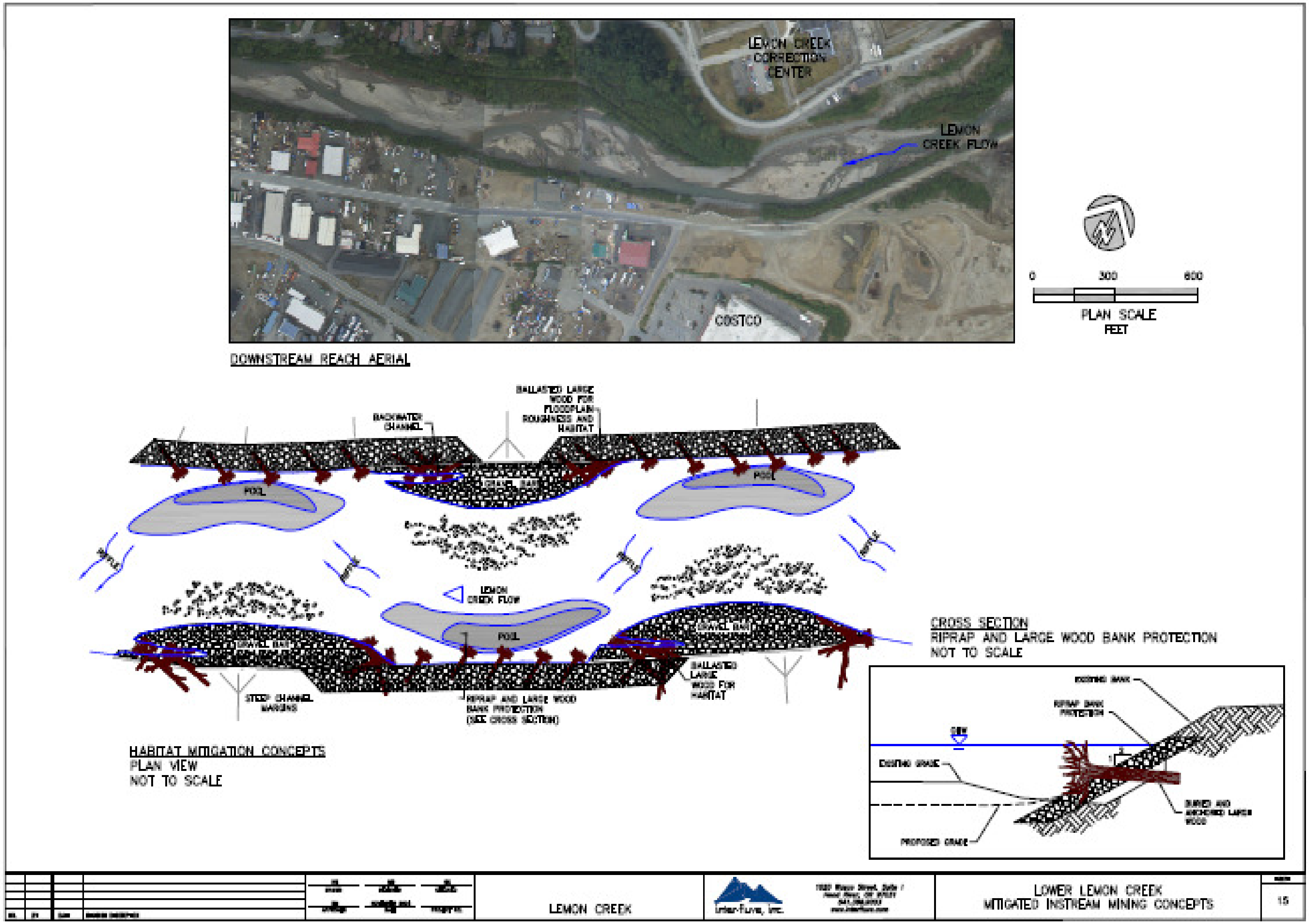


Figure 17: Lower Lemon Creek Mitigated Mining Concepts, from CBJ, 2004.

4.1.2 Riparian Buffers

Riparian buffers provide essential shade, nutrients, natural debris, and organisms to anadromous streams; maintaining adequate setbacks and prohibiting riparian disturbance is crucial to providing good fish habitat in urban creeks. Disturbance along the riparian corridor also opens the door for invasive species such as Japanese knotweed to thrive without native competition. Riparian buffers aid in treating surface runoff before it enters the creek as well. The City and Borough of Juneau Coastal Management Program (1986) calls for a 50-foot setback adjacent to anadromous streams or lakes and recommends that these areas be established with vegetation to extensively shade the waterbody. Local Land Use Ordinances (section 49.70.950) call for this setback and vegetated buffer as well. CBJ Land Use Ordinance 49.70.310 bars disturbance within 25 feet of anadromous waterbodies. Despite these guiding principles, many structures, roads, and stockpiles of private property exist within the proscribed setback and much of the creek riparian area is disturbed and/or lacking any vegetation, let alone providing shade. Some structures were constructed before the ordinance was enacted while others were granted variances. Development adjacent to the creek edge can be seen throughout the urban corridor.

Figure 18: Riparian vegetation creates habitat and slows water velocities at water’s edge. *Photo: S. Seifert, July 2007.*

It is important that CBJ not grant additional variances and address violations of the ordinance to maintain riparian buffers. Where possible, buffers in previously developed areas should be re-established. Roads constructed within the setback should be surfaced and graded to direct runoff to settling ponds rather than into the creek; an effort to provide shade along these areas should be made. Introducing large woody debris and establishing native vegetation along these banks may provide habitat improvements.

4.1.3 Other Potential Pollutants

Gravel extraction, roads, construction, and industrial and residential runoff all contribute to the sediment and turbidity impacts discussed earlier. However, runoff from these activities and ongoing development may contain a variety of other potential pollutants, such as litter and debris, household and industrial cleaners, pet waste, petroleum products, fertilizers, and de-icing salts and gravels. Though difficult, it is possible to minimize the transport of most of these non-point source pollutants into the creek using the same measures as sediment and turbidity controls.

Riparian buffers can partially filter potential pollutants though they are primarily efficient at trapping particulate matter such as debris and sediment. The 50 foot development setback and associated vegetation will prevent surface runoff from delivering pollutants directly into the creek. For these reasons, priority actions should include protection of existing setbacks and rehabilitation of disturbed and developed streambank and riparian areas. Incentives to stakeholders for maintaining, re-implementing or enhancing setbacks should be considered to encourage and make riparian stewardship feasible. Incorporating a variety of runoff capture and treatment structures designed to remove or reduce pollutant loads into all new construction will also aid in keeping pollutants from impairing Lemon Creek water and habitat.

Reducing pollutant sources is also key to preventing surface water pollution. Sponsored clean-up events, such as those organized by Litter-Free Juneau, can remove debris, litter, and pet waste for proper disposal. Education of the public and local landscape organizations about the negative impacts of excess fertilizer and pesticide runoff from lawns and gardens can prevent potential water quality compromise from development as well. Other source-limiting activities that are currently improving water quality include household and commercial hazardous waste collection services, electronics recycling, scrap metal, and other recycling programs, and scrap vehicle donation or collection drives. Public education on the availability and benefits of these programs can aid in protecting water quality and habitat.

Commercial and residential storage of vehicles, construction materials, chemicals, stockpiles or other moveable property within the 50-foot setback area should be removed to areas beyond the setback where possible. In the event of flooding or bank erosion this property can enter the creek and cause unnecessary pollution or even create or contribute to a dangerous, artificial dam at a construction in the stream channel.

The city commercial sanitary landfill is located adjacent to the south bank of Lemon Creek near its mouth at Gastineau Channel. A large berm surrounds the perimeter of refuse pile; the effectiveness of this barrier in preventing pollutants from entering the creek is not known. A few surface water and groundwater samples from around the lower Lemon Creek area and were collected and tested for metals and organic compounds between 1982 and 1993 (ADEC, 1995). Limited sampling during the 1991 Juneau Streams Project and a City and Borough of Juneau groundwater monitoring program has also occurred and is discussed in the ADEC water quality assessment (1995). Groundwater is currently sampled with ADEC oversight at the landfill. Recently, soil and biologic samples from the wetland and creek areas beyond the berm were collected, analyzed, and found to contain low levels of the flame-retardant chemical polybrominated diphenyl ether (PBDE). Levels were elevated in biologic samples when compared to soil samples, suggesting bioaccumulation of PBDE occurring in the tidal wetland at the mouth of Lemon Creek (Hoferkamp2006).

4.1.4 Fish Habitat

The fishery resources of Lemon Creek have not been assessed thoroughly, primarily because fish habitat is so heavily impacted by human activity and disturbance (Bethers, 1995; ADF&G, 2004). However, it is known that salmon and char use the creek for spawning and rearing. Protecting and improving this fishery resource can aid growth of these fish populations and overall biodiversity within the watershed as long-term watershed evolution continues. Glacial

Figure 19: Juvenile salmon and Dolly Varden enjoy relative safety in overhanging grasses within a small estuarine side channel.
Photo: S. Seifert, July 2007.

retreat and plant succession will alter Lemon Creek discharge and aquatic chemistry, as will continued urban growth within the lower watershed area.

In general, improving water quality with respect to sediment and turbidity will benefit fish habitat. Eliminating or minimizing the artificial alteration of the stream channel, floodplain, and riparian areas and restoring natural vegetation and improving bank stability can improve fish habitat as well (CBJ, 2004).

While the main channel and tributaries provide poor to good spawning habitat which can be improved, a lack of side channels available for juvenile fish rearing should be addressed (ADF&G, 2004).

Again, maintaining and re-establishing a 50-foot setback and vegetated riparian buffers will improve fish habitat by protecting water quality, improving shade and fish cover, reducing water temperature in shallow areas, and contributing natural woody debris, nutrients, and organisms upon which fish can feed. Re-vegetating disturbed areas will provide additional shade, habitat, and will reduce sediment loading by stabilizing banks and floodplain features.

4.1.5 Wetlands

The mouth of Lemon Creek in Gastineau Channel is a popular location for dog walking, bird watching, nature study, plant collecting, sport fishing, boating, and duck hunting (Adamus, 1987). The wetland and intertidal areas are thought to support a variety of fish and other marine organisms, including eulachon, capelin, and three-spine stickleback (ADFG, 2004). Coho salmon rear in the marsh of this area, feeding on the invertebrates supported by drifting algae. Large numbers of migrating birds and marine mammals are observed in this area seasonally.

Hydrologic values of Lemon Creek wetlands are listed in Adamus (1987) as “flood/water storage, erosion control, water quality maintenance and flood control.” The wetlands are habitat for fish, eagles, seabirds, ducks and Canada geese. Negative aspects listed include “little erosion control, floods, poor drainage of developed areas, loss of fishery and pollution from industrial activities and toxic wastes.”

Discovery Southeast, a local non-profit, produced a report on mapping wetlands and local wetland evolution in light of isostatic rebound in the Mendenhall Wetland State Game Refuge area which includes the lower portion of Lemon Creek. The importance of low sedge marsh in this area and the habitat it provides for rearing fish is emphasized, as well as the stress upon this type of marsh from human activity and isostatic rebound. Areas of low sedge marsh, and uplifting areas which have potential to become low sedge marsh should be protected (Carstensen, 2004).

4.2 Goals and Action Items

Lemon Creek has growing fish habitat potential as the Lemon and Ptarmigan Glaciers retreat. However, impacts of development as Juneau develops this area for further residential and commercial use must be mitigated for any lasting restoration plan to succeed in maintaining viable fish habitat and populations. A long-term management plan in this area must accommodate inherent climate and watershed changes, such as uplifting tidewater areas and the eventual absence of glacial water and sediment inputs in the next century. The original TMDL for Lemon Creek outlined a handful of goals and specific objectives for restoring habitat and improving water quality. Other more recent reports are designed to inform flood control decision making; recommendations from the CBJ Geomorphic Assessment and Sediment Alternatives Analysis are incorporated with respect to minimizing impacts of flood control activities on habitat and water quality. This report brings together these ideas into a single plan.

Goals and action items for improving Lemon Creek water quality and habitat are outlined below.

GOAL 1: Lemon Creek meets state sediment and turbidity water quality standards.

Objective 1.1: Establish an oversight and implementation committee consistent with a watershed management approach to problem solving.

Objective 1.2: Assess Lemon Creek water quality including seasonal parameter fluctuations at background and downstream locations.

> Action 1.2.1: Develop a monitoring plan to sample basic water quality parameters throughout the lower 2 miles of creek seasonally determine if Lemon Creek meets state water quality standards at this time and initiate monitoring.
>
> Action 1.2.3: Install and maintain a stream gage at or near the CBJ Haul Road bridge. The current gage is located 6 miles upstream and captures only discharge from glaciated sub-basins.

Objective 1.3: Document and assess known and potential contaminant sources.

> Action 1.3.1: Identify and map, where possible, potential contaminants, point and non-point pollution sources, including stormwater discharge sites.
>
> Action 1.3.2: Use data collected in Actions 1.2.1 and 1.2.3 to reevaluate the existing TMDL background and downstream sediment and turbidity levels and (re)allocate source and waste loads.

Objective 1.4: Assess and improve stormwater and runoff water quality.

> Action 1.4.1: Sample sediment and turbidity seasonally at sites identified in Action 1.2.1, above. Identify inadequate or failing systems for maintenance or improvements.

Action 1.4.2: Work with land owners, CBJ, and appropriate agencies to reduce pollution from areas identified in Action 1.2.1.

Action 1.4.3: Control off-site migration of sediment during land development and mining activities.

- Continue to require Stormwater Pollution Prevention Plans (SWPPPs) for land development sites and ensure BMPs are followed.
- Research and publish a *Construction BMP Manual for Southeast Alaska* for use by contractors writing and implementing Stormwater Pollution Prevention Plans (SWPPPs) required by EPA for NPDES stormwater permitting.
- Create regulations requiring use of local stormwater protocols at construction and mining sites once manual is distributed.
- Identify, map, and control historic and recent gravel mining sidecast areas and overburden storage sites.
- Do not allow operators to store sidecast or overburden within 25 feet of Lemon Creek.

Action 1.4.4: Control sediment and turbidity from urban stormwater systems.

- Repair or improve existing stormwater treatment systems identified as failing in Action 1.2.1 to treat sediment and turbidity.
- Incorporate sediment and turbidity controls into all future stormwater systems.
- Research and publish a *Stormwater and Runoff Treatment BMP Manual for Southeast Alaska* for use in parking lots, residential, and commercial development design and permitting.
- Create regulations requiring use of local stormwater BMPs for new development once manual is distributed.
- Research and publish a public-oriented guide to benefits of capturing and treating stormwater runoff locally on a small-scale, i.e. rain gardens, to reduce stormwater peak flows.

Action 1.4.5: Improve the Haul Road surface and embankments to reduce sediment transport.

- Create a small vegetated berm along the creekside edge of the haul road to ensure that stormwater runs off into catchment basins and that sediment is not transported into the stream from the road.
- Continue to pursue a road maintenance agreement between CBJ and SECON to better address road issues and improvements between users.

Action 1.4.6: Reduce gravel, debris, and hydrocarbon inputs from snow plowing and storage sites.

Objective 1.5: Assess and Reduce Erosion.

Action 1.5.1: Assess and map locations and extents of actively eroding banks throughout the creek. Identify areas where stabilization or other controls are warranted to improve water quality or fish habitat.

Action 1.5.2: Reduce Erosion.

- Identify areas in the lower reaches where vegetative methods can be used to restore erosion resistance.
- Review and implement strategies to stabilize actively eroding banks and existing floodplain features in the Hidden Valley area as per CBJ 2004 Sediment Alternatives Analysis recommendations.
- Stabilize disturbed hillslopes and historic sidecast areas adjacent to the access road in and below the gorge area.
- Rehabilitate disturbed streambanks, riparian areas, floodplains, and uplands where feasible to increase erosion resistance.
- Conduct outreach to landowners regarding bank stabilization methods and permitting process.

Action 1.5.3: Prevent future erosion.

- Continue to enforce current regulations that pertain to riparian and stream disturbance.
- Maintain and improve riparian areas to maintain and increase erosion resistance in areas adjacent to actively eroding banks.

Objective 1.6: Maintain and improve riparian buffers.

Action 1.6.1: Evaluate and map existing riparian buffers and riparian degradation.

Action 1.6.2: Maintain existing riparian buffers by continuing to regulate setback variances and incorporate water quality and habitat based criteria into CBJ variance criteria.

Action 1.6.3: Enforce regulations and require mitigation where riparian disturbance has occurred within the 50 foot setback.

Action 1.6.4: Create an outreach program to re-vegetate degraded riparian areas and control invasive weeds identified in Action 3.3.1.

Objective 1.7: Prevent future pollution.

Action 1.7.1: Include Lemon Creek in a yearly Litter-Free or JWP trash pick-up effort. If possible, find a group to adopt the section of creek between the correctional facility and Glacier Highway Bridge for monthly observation and clean up.

Action 1.7.2: Inform stream-adjacent landowners of local ordinances regarding 25-foot setback and 50-foot setback ordinances and criteria for appropriate use of riparian areas. Follow-up with a survey or 25-foot setbacks and approach landowners to resolve any inappropriate use observed.

Action 1.7.3: Incorporate bear-proof trash receptacles along the new bike/pedestrian path on the northern bank of Lemon Creek.

Action 1.7.4: Educate the public regarding negative impacts of using chemical fertilizers and pesticides, dumping pollutants into storm drains, and improperly storing fuels, chemicals, and garbage on water quality.

Action 1.7.5: Continue to fund and support electronics and scrap metal recycling as well as hazardous waste collection events in the Lemon Creek Valley to prevent pollutants from entering the creek and/or landfill.

Objective 1.8 Minimize impact of flood control projects on sediment, turbidity, and habitat.

Action 1.8.1: Re-evaluate flood risk on Lemon Creek.

- Follow-up hydrologic impact of Ready-Mix Bridge removal.
- Use existing USGS cross-section survey data to track changes in stream bed elevations and ascribe a quantitative bed “trigger” elevation for commencing in-stream mining activities to minimize and coordinate mining events.
- Resurvey USGS cross-sections every two years to assess bed elevation changes over time.

Action 1.8.2: Coordinate maintenance mining as appropriate to reduce flood risk while protecting critical habitat areas and minimizing sediment and turbidity inputs.

- Identify a working group to oversee and coordinate pre-& post- mining and restoration activities on Lemon Creek.
- Develop a mining plan for the entire lower length of the creek to coordinate mining as a single disturbance and most effectively increase flood conveyance.
- Initiate mining aimed at increasing overall flood conveyance capacity based on quantitative bed elevation “trigger” heights.
- Enforce regulatory process for in-stream gravel extraction permitting.
- Create and follow-through with monitoring activities ascribed to each extraction permit to assess if BMPs are followed and effective.
- Require mitigated mining into the plan, including subsequent post-mining habitat restoration activities.

GOAL 2: Maintain and improve Lemon Creek anadromous and resident fish habitat. Growth and propagation of aquatic life is the primary designated use affected by sediment, turbidity, and habitat modification. Protecting and restoring fish habitat is therefore the primary benefit of attaining water quality standards in Lemon Creek.

Objective 2.1: Document current in-stream and riparian habitat conditions.

Action 1.1.1: Using geomorphic and fish habitat feature data collected by stream reach in the Baseline Aquatic Habitat Characterization (ADF&G, 2004), map habitat and stream channel characteristics, identifying areas critical for protection or with restoration potential.

Objective 2.2: Assess fish distribution and critical fish habitats (spawning and rearing) in the mainstem and tributaries.

Action 2.2.1: Determine fish species presence and seasonal distribution throughout the creek and tributaries located below the fish barrier.

Action 2.2.2: Using GIS, merge habitat characterization and fish distribution data to identify and catalog spawning and rearing areas. These areas will be defined as "critical habitat" for purposes of protection and restoration.

Action 2.2.3: Monitor the location, condition, and fish use of habitat features identified in Actions 2.1.1 & 2.2.2 over time to guide future development and enhancement opportunities.

Objective 2.3: Maintain and enhance in-stream fish habitat.

Action 2.3.1. Create maps of critical habitat areas and distribute them online to inform development, permitting, planning and restoration activities.

Action 2.3.1: Maintain or re-establish riparian buffers of sufficient size to provide fish habitat and protect water quality. Encourage greater than 50-foot setback distances near critical habitat areas.

Action 2.3.2: Conserve estuarine, wetland, and floodplain areas upstream from and adjacent to critical habitat areas identified in Action 2.2.2 where possible.

Action 2.3.3: Identify habitat enhancement opportunities and prioritize them according to habitat type. Conduct outreach to stakeholders and landowners regarding particular habitat restoration and enhancement opportunities and benefits. Aid interested parties in identifying funding sources.

Action 2.3.4: Restore riparian buffers adjacent to critical habitat areas identified in Action 2.2.2.

Objective 2.4: Update local regulations to address habitat degradation.

Action 1.4.1: Incorporate restoration as mitigation for enforcement actions in cases where in-stream or riparian habitat is compromised.

Action 1.4.2: Incorporate habitat conservation and restoration plans as mitigation into in-stream gravel extraction plans and permits.

The above goals and actions are not all immediately achievable; in fact many of the objectives require monitoring to assess the state of the watershed or other long-term steering. These goals cannot be met without input and cooperation from adjacent land owners and municipal, federal, and state agency support and guidance. In light of these realities, it follows that a joint agency-landowner committee should be established to oversee and assist in the implementation of TMDL controls, recovery actions, and other activities in Lemon Creek. This committee will fulfill a long overdue role to oversee a watershed management approach to solving chronic water quality and habitat issues.

The committee's responsibilities, as outlined in the original TMDL document, include:

- Overseeing the installation and implementation of the other control measures set out in the TMDL and this Recovery Plan in a timely schedule.
- Identifying information needs and overseeing the design and conduct of monitoring, other data collection, and modeling efforts.
- Developing specific objectives for improving habitat values and addressing habitat modification that allow for development and industrial use.
- Working with landowners to develop opportunities for improving habitat, implementing other control measures, and accommodating development through land trades and other agreements.
- Serving as a forum for review of permit applications.
- Identifying and pursuing appropriate funding sources for ongoing monitoring, application of control measures, and restoration.
- In light of monitoring data, providing input on revising loading capacities, when appropriate, source load allocations, and load reductions.
- Helping agencies assess attainment of water quality standards and habitat improvements, and developing modification to the source-specific, watershed and habitat controls for subsequent phases of the TMDL process.

While JWP can aid in forming the committee, CBJ and ADEC should provide leadership in organizing and managing the committee's activities.

This plan should be consistently revisited and revised as the state of the watershed progresses. It is possible to meet state water quality standards in Lemon Creek with cooperation from a wide variety of stakeholders in the Lemon Creek Valley. By working toward development of a better information base and understanding of current fish use, urban impacts, hydrology and geomorphic processes at work in this particular watershed, those managing Lemon Creek activities can improve water quality and habitat in Lemon Creek for the long-term.

REFERENCES

Adamus, Paul, et al. 1987. Juneau Wetlands Functions and Values. Adamus Resource Asessment, Inc.

Alaska Department of Environmental Conservation. 1995. Total Maximum Daily Load for Sediment and Turbidity with consideration of Habitat Modification in the waters of Lemon Creek. Juneau, Alaska.

Alaska Department of Fish & Game, 2004. Lemon Creek Report: Baseline Aquatic Habitat Characterization.

Alder House students, 2003. Tides, toads, and topography; the natural and human history of the Lemon Creek watershed. Discovery Southeast student publication, 24pp.

Bethers, M., K. Munk, and C. Seifert. 1995. Juneau Fish Habitat Assessment. Alaska Department of Fish and Game, Division of Sportfish. Juneau, Alaska.

Carstensen, Richard. 2004. GIS Mapping for Mendenhall Wetland State Game Refuge. Discovery Southeast, Juneau, Alaska.

City and Borough of Juneau, 2007. Comprehensive Plan Update, draft. Juneau, Alaska. http://www.juneau.org/cddftp/CompPlanUpdate.php

City and Borough of Juneau, 1986. Juneau Coastal Management Program. Juneau, Alaska.

City and Borough of Juneau, 2004. Lemon Creek Watershed Geomorphic Assessment and Sediment Management Alternatives Analysis. Prepared by Inter-Fluve, Inc., Hood River, Oregon.

City and Borough of Juneau, 2006, Population by Geographical Region. Juneau, Alaska. http://www.juneau.org/cddftp/documents/2006Population.pdf

Connor, Cathy, and Daniel O'Haire. 1988. Roadside Geology of Alaska. Mountain Press Publishing Company. Missoula, Montana.

Estes, Christopher C. 1996. Annual summary of instream flow reservations and protection in Alaska. Alaska Department of Fish and Game, Fishery Data Series No. 96-45, Anchorage.

FEMA, 1990, Flood Insurance Study City and Borough of Juneau, Alaska

Hoferkamp, L. H. and S. L. Tamone. (2006). Polybrominated Diphenyl Ethers (PBDEs) In Sediments And Biota In A Pristine Southeast Alaska Watershed And Near A Municipal Waste Landfill, Juneau, Alaska. North Pacific Research Board Final Report.

Hood, Eran. 2007. UAS Assistant Professor. Personal Communication.

Host, R. and E. Neal. 2005. Hydrology Geomorphology and Flood Profiles of Lemon Creek of Lemon Creek, Juneau, Alaska. USGS, Scientific Investigations Report 2005-5186. http://pubs.usgs.gov/sir/2005/5186/pdf/LemonCreek.SIR.2005.5186.pdf

Johnson, J. and E. Weiss. 2006. Catalog of waters important for spawning, rearing, or migration of anadromous fishes – Southeastern Region, Effective September 15, 2006. Alaska Department of Fish and Game, Special Publication No. 06-17, Anchorage.

Marcus, M.G., F.B. Chambers, M.M. Miller, and M. Lang. 1995. Recent Trends in the Lemon Creek Glacier, Alaska. *Physical Geography* 16(2):150-161.

Miller, Robert D. 1975. Surficial Geologic Map of the Juneau Urban Area and Vicinity, Alaska. Dept. of the Interior, U.S. Geological Survey, Reston, VA. Misc. Investigations Series #I-885.

Murphy, Thomas D., and S. Seymour Schmach. 1963(?). Mountain Versus Sea Level Rainfall Observations During Storms at Juneau, Alaska: U.S. Bureau of Reclamation, Denver, Colorado.

Paustian, Steve J. 1992. *A Channel type user's guide for the Tongass National Forest, Southeast Alaska*. [Juneau, Alaska]: U.S. Dept. of Agriculture, Forest Service, Alaska Region.

Schoephorster, D.B. and C.E. Furbish. 1974. Soils of the Juneau area, Alaska. U.S. Department of Agriculture, Soil Conservation Service. Palmer, Alaska.

US Army Corps of Engineers, 1970, Floodplain Information Lemon Creek, Juneau, Alaska

USGS Gauge 15052000 (Lemon Creek near Juneau, AK). http://waterdata.usgs.gov/ak/nwis/inventory/?site_no=15052000

USGS Gauge 15052009 (Lemon Creek near Mouth near Juneau, AK). http://waterdata.usgs.gov/ak/nwis/inventory/?site_no=15052009

Viereck, L.A.; Dyrness, C.T.; Batten, A.R.; Wenzlick, K.J. 1992. The Alaska vegetation classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 278 p.

Walter, Jeanne and Dean Hughes. 2005. Streambank Revegetation and Protection: A Guide for Alaska. Alaska Department of Fish and Game, Division of Sportfish. http://www.sf.adfg.state.ak.us/sarr/restoration/techniques/images/reveg%20manual%20lo.pdf

Walter, M.T., S. L. Seifert, T.C. Schwarz, and C.L. Connor. 2003. Lemon Creek Natural Sediment Assessment. University of Alaska Southeast, Juneau, Alaska.

Western Regional Climate Center. Meteorological data and statistics for Alaska weather stations available at: http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ak4094)

APPENDIX A: Acknowledgements

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- Alaska Department of Environmental Conservation
- University of Alaska Southeast, Juneau

APPENDIX B: Lemon Creek Channel Types and Process Groups

The following Channel Type Definitions and Management Consideration are excerpted from the USFS Channel Type User Guide.

ES4 Channel Type Definition and Management Considerations (USFS 1992):

The ES4 streams are depositional channels subject to tidal influences. Stream energy is low, due to wide, low gradient channels. Gravel and sand bars tend to be stable bed features, except during extreme flow events. Large woody debris can significantly influence channel structure. Debris accumulations are important in forming pool habitat in ES4 channels.

These channels are always accessible to anadromous species. Generally, high quality substrate provides high available spawning area (Available spawning area, ASA 22%). Spawning pink and chum salmon will frequent ES4 channels in high densities. Although pool development is minimal (3% off water surface area), rearing coho salmon will move downstream from the mainstem in the summer to rear here (Available Rearing Areas, ARA 7%). Pink and chum salmon fry may temporarily remain in the ES4 system prior to moving seaward.

Sediment deposition is a dominant process in estuarine deltas; therefore, sediment retention in ES4 channels is high. These channels are very sensitive to intrusion of find sediments into spawning beds. The effect of cumulative sediment impacts from upstream watershed disturbance is a major management concern. Erosion control of road drainage, and road maintenance are mitigation measures that should be emphasized in areas near these streams.

Stream bank sensitivity is high due to high amounts of fine unconsolidated alluvium in ES4 stream banks. Bank erosion can be a significant source of fine sediment in these channels. Channel protection and bridge design and implementation should be emphasized.

FP5 Channel Type Definition and Management Consideration (USFS 1992):

The FP5 channels function as sediment deposition systems. Low gradient, poor flow containment, and fine sized substrate are indicative of low stream power. Substrate consists mainly of sand to small cobble size particles. Short-term storage of fine sediment is characteristic of FP5 channels. These fine sediment deposits are typically mobilized during high flow events. Small side channels dissecting the FP5 flood plain are a common feature.

FP5 channels are heavily used by spawning Chinook, chum, and pink salmon, and steelhead trout because of the abundance of high quality spawning gravels. These channels get only moderate use by spawning coho salmon, which prefer smaller channels. All freshwater rearing species make frequent use of these channels because rearing habitat is readily available, primarily in association with side channels, off-channel pools, and stream segments having large woody debris accumulations. Overwintering habitat in these channels is provided in off-channel slough areas and pools associated with large woody debris.

Maintaining future sources of woody debris is an important consideration in FP5 channels. Natural large woody debris volumes are moderately high, but generally, in channel wood accumulations are less stable than in smaller FP4 channels due to higher flood flows in P5 channel types.

Retention of fine sediment (sand, gravel) is often high in FP5 channels; therefore, these channels may be sensitive to cumulative sediment inputs from headwater sources. Excessive sediment loads can degrade spawning gravel quality and, in extreme cases, can disrupt sediment transport equilibrium and channel stability. Removal or disturbance of stream bank vegetation can accelerate bank erosion and the subsequent loss of undercut bank rearing habitat. Riparian management should emphasize stream bank protection and erosion control measures to minimize potential sediment sources.

Flood plain protection is a very important management consideration for FP5 channels because of off-channel features that contribute to juvenile fish rearing habitat. These off-channel floodplain features include small spring fed tributaries, sloughs, beaver pond complexes, and side channels.

The location and design of stream crossing structures is an important consideration due to the large size and natural instability of the channels and associate flood plains. Large multi-span bridges are often required to cross these channels. Roadways traversing flood plain tributaries must provide for juvenile fish migration through culverts.

MM2 Channel Type Definition and Management Considerations (USFS 1992):

MM2 channels are generally accessible to anadromous species, with several species of spawners using the moderate amounts of available spawning area (ASA). These channels have moderate amounts of rearing area that are used by coho salmon, Dolly Varden char, and steelhead trout juveniles. Pools are relatively deep (mean pool depth = 0.41 meters), and are highly dependent on large woody debris (LWD). Over-wintering habitat is primarily associated with these pools. When located next to accessible lakes, these channels provide good quality spawning for sockeye salmon and steelhead trout.

Large woody debris significantly influences channel morphology and fish habitat quality. Large wood volume is generally high. Large wood accumulations form pool and stream bank rearing habitat, as well as stabilize spawning substrate behind log steps. Maintenance of large woody debris sources is an important management concern.

Banks are composed primarily of unconsolidated cobble and gravel size materials, therefore, stream bank sensitivity is rated high. The volume and energy of flood discharge in MM2 channels are the major forces affecting bank erosion. Disturbance of streamside vegetation root mats may contribute to accelerated channel scour and lateral channel migration.

Flood plains associated with MM2 channel types are generally narrow, however, side channels and flood overflow channels are commonly found along MM2 reaches. Flood plain stability can be a concern in these uncontained channel segments.

This is a high level of concern for providing fish passage through road crossing structures. Bridges are generally the appropriate stream crossing structures for MM2 channels. Culvert installations on these streams will not generally meet anadromous fish passage requirements. In addition, heavy woody debris leading and bedload sediment transport in MM2 channels pose a serious risk to culvert and bridge maintenance.

LC2 Channel Type Definition and Management Considerations (USFS 1992):

LC2 channels are sediment transport systems. Moderate gradients, well-contained stream flow, and large class substrate are indicative of high stream energy. Sediment inputs from upstream mountain slope channels are rapidly transported through these channels. Mass wasting along channel side slopes is a major on-site contributor of sediment. Sediment contributions from stream banks are of minor significance because they are largely composed of bedrock or large rock fragments. Cobble and coarse gravel deposits are common substrate component around boulder cluster or large woody debris. Fine sediments are readily flushed through these streams.

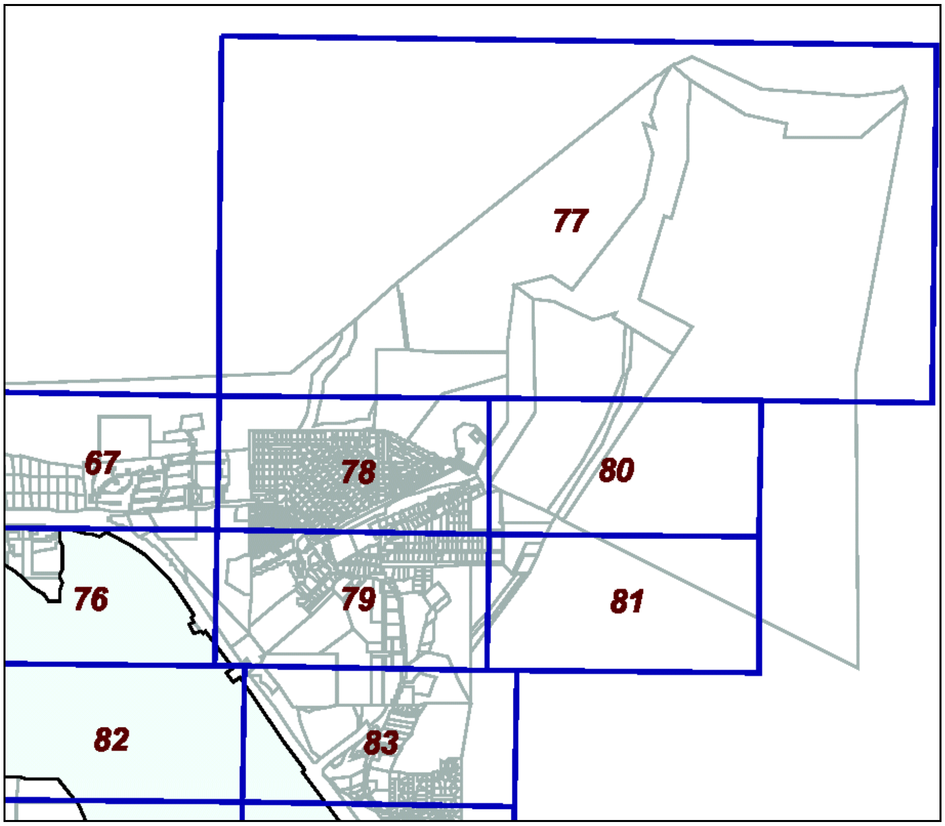
LC2 channels are frequently accessible to anadromous species, but often contain barriers that block upstream fish movement. Typically these streams get occasional use by spawning salmonoids, however, Dolly Varden and steelhead show the most frequent use by spawning areas. These channels do have some good rearing areas, especially in reaches with stable large woody debris. Chinook salmon, Dolly Varden, and steelhead tend to favor rearing in LC2 channels more than coho due to availability of boulder-pool habitats.

Large wood accumulations have limited influence on LC2 channel morphology. Relatively high stream energy in LC2 channel types tends to displace in channel debris bank areas. Total woody debris loading is moderate and is comprised of large diameter (45.7-76.2 cm) pieces longer than 15.2 meters in length. Large wood incorporated into the stream bed can have an important function trapping gravel and cobble substrate used for spawning habitat.

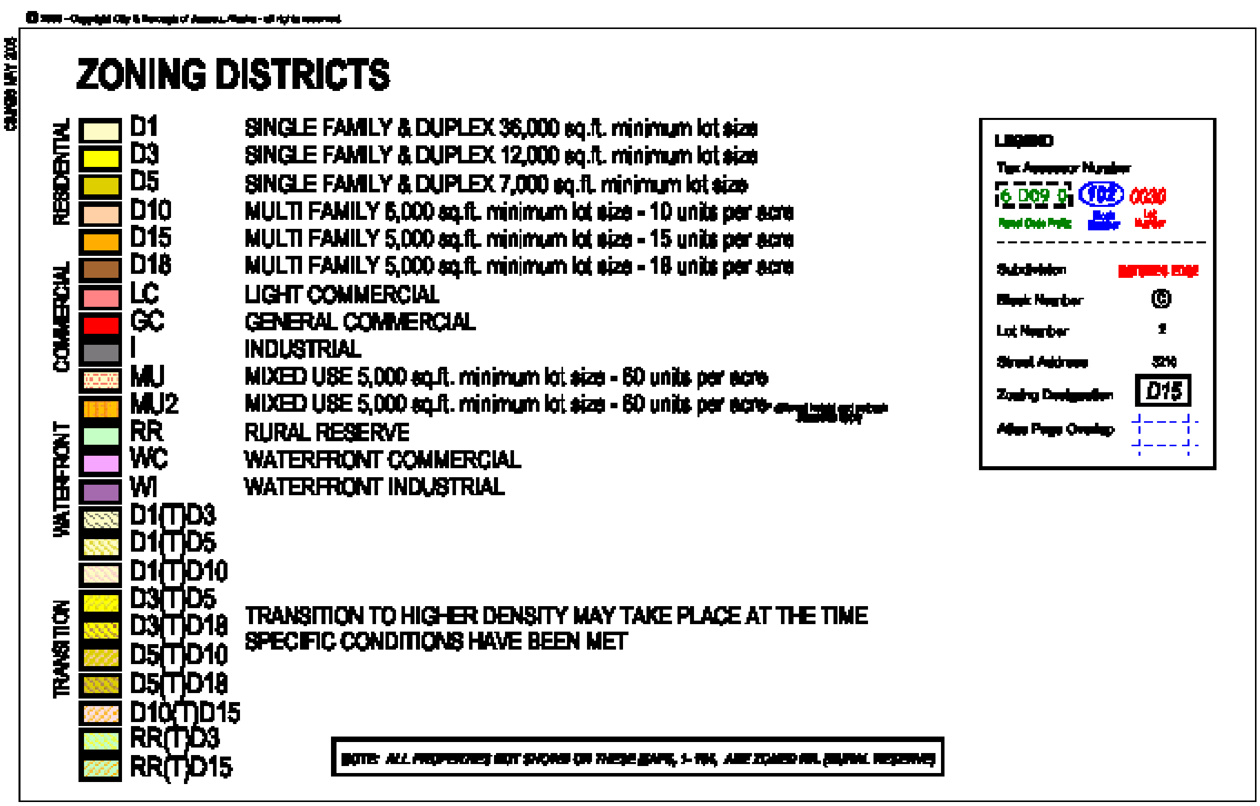
Stream banks in LC2 channels are relatively stable due to high amounts off bedrock and boulders incorporated into them. However, channel side slopes are steep (75%) and susceptible to mass erosion if disturbed by road cuts, blowdown, or timber yarding. Riparian management should emphasize protection of unstable side slopes.

Due to long, steep side slopes adjacent to the channel, road crossings are generally not practical along LC2 channels types. Suitable crossing sites generally require multi-span bridges. Special road location and design, and slope stabilization measures should be considered for these streams.

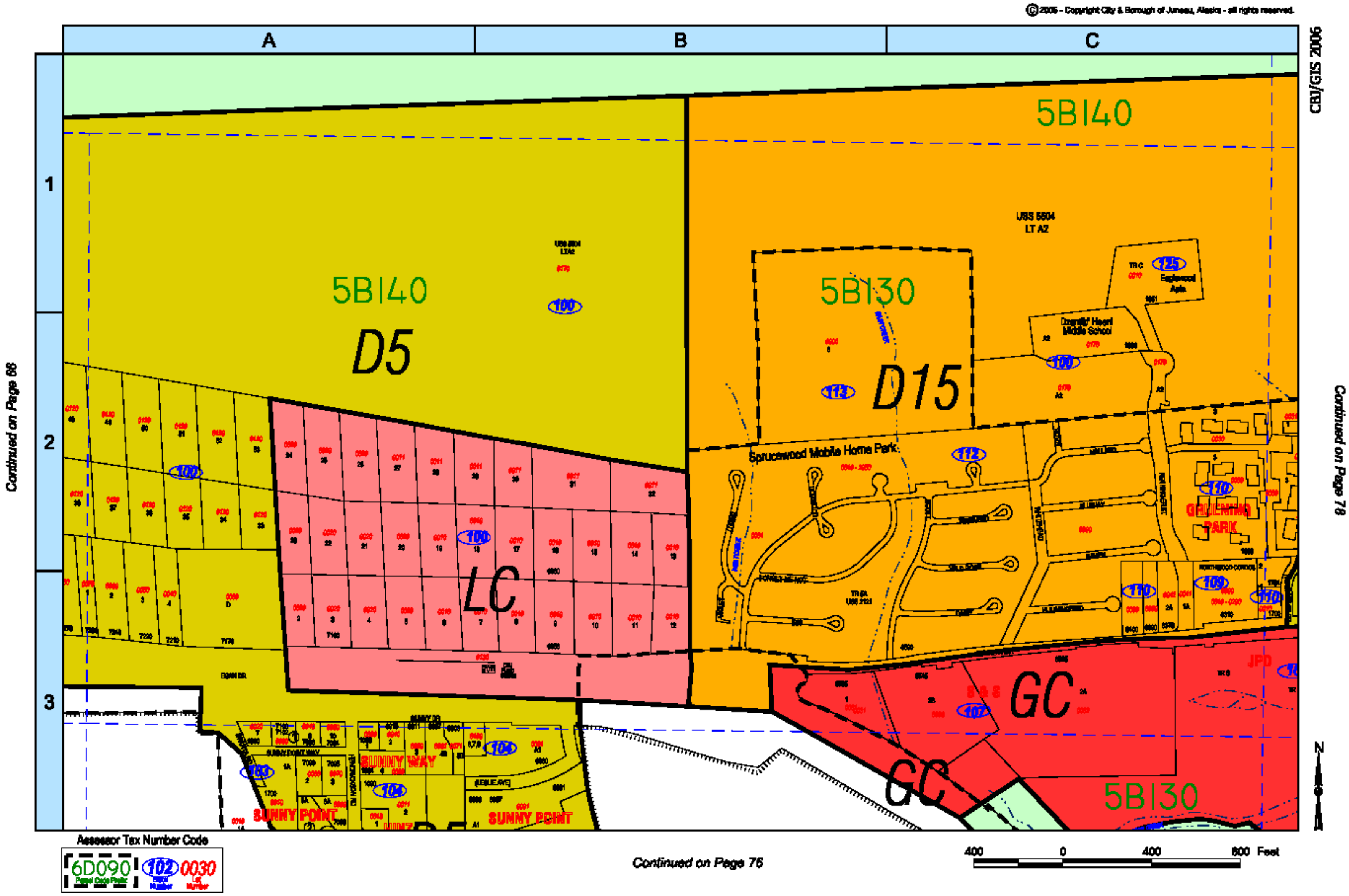
Appendix C: Lemon Creek Area Zoning Maps (CBJ, 2006)



Subset of 2006 CBJ Zoning Maps Index. The Lemon Creek Area is represented by map numbers: 67, 76, 77, 78, 79, 80, 81, 82, & 83. These maps are included in this appendix. The Zoning Districts map key is also provided, below.

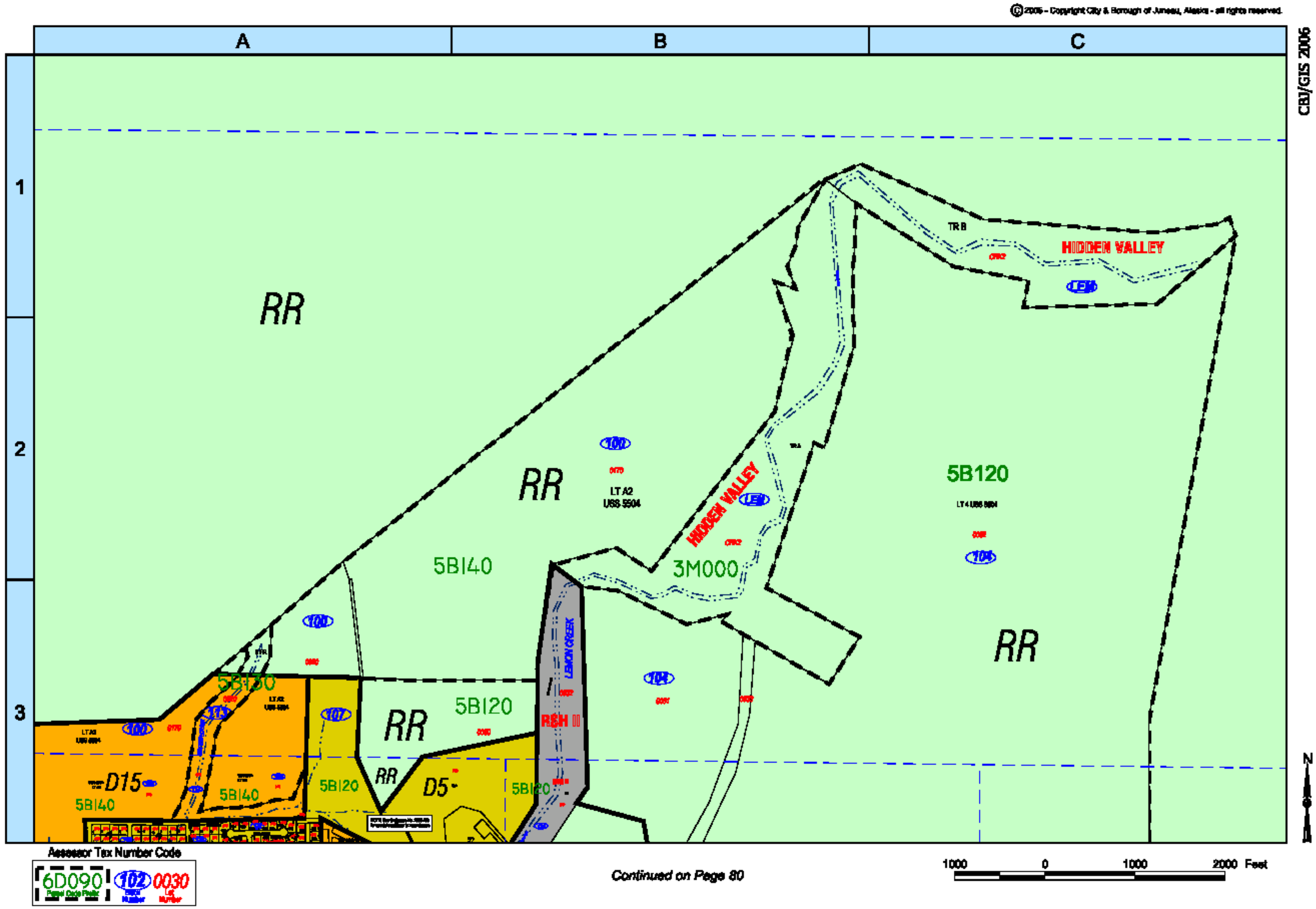


67

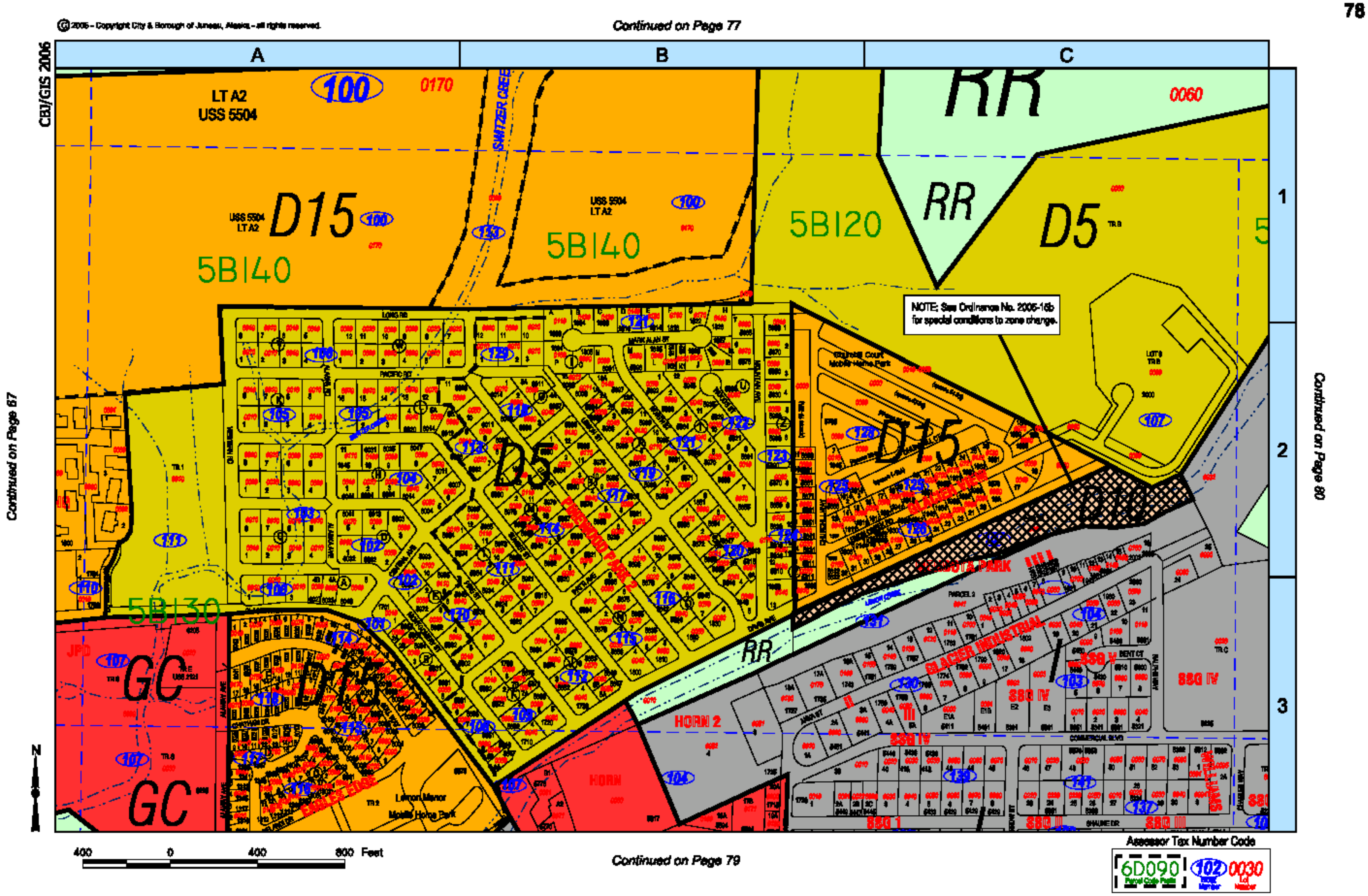


Map 67: CBJ 2006 Zoning Maps

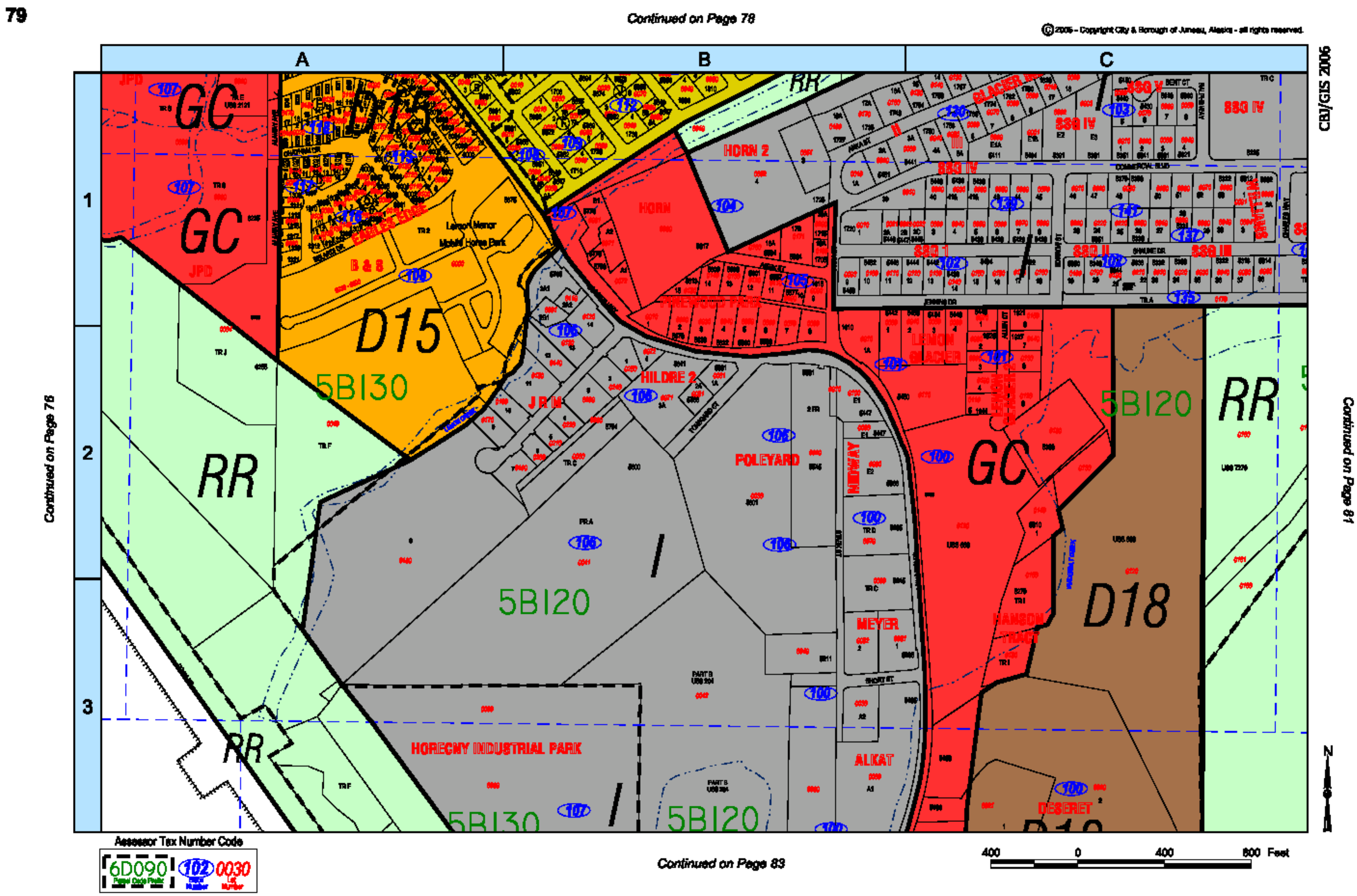
77



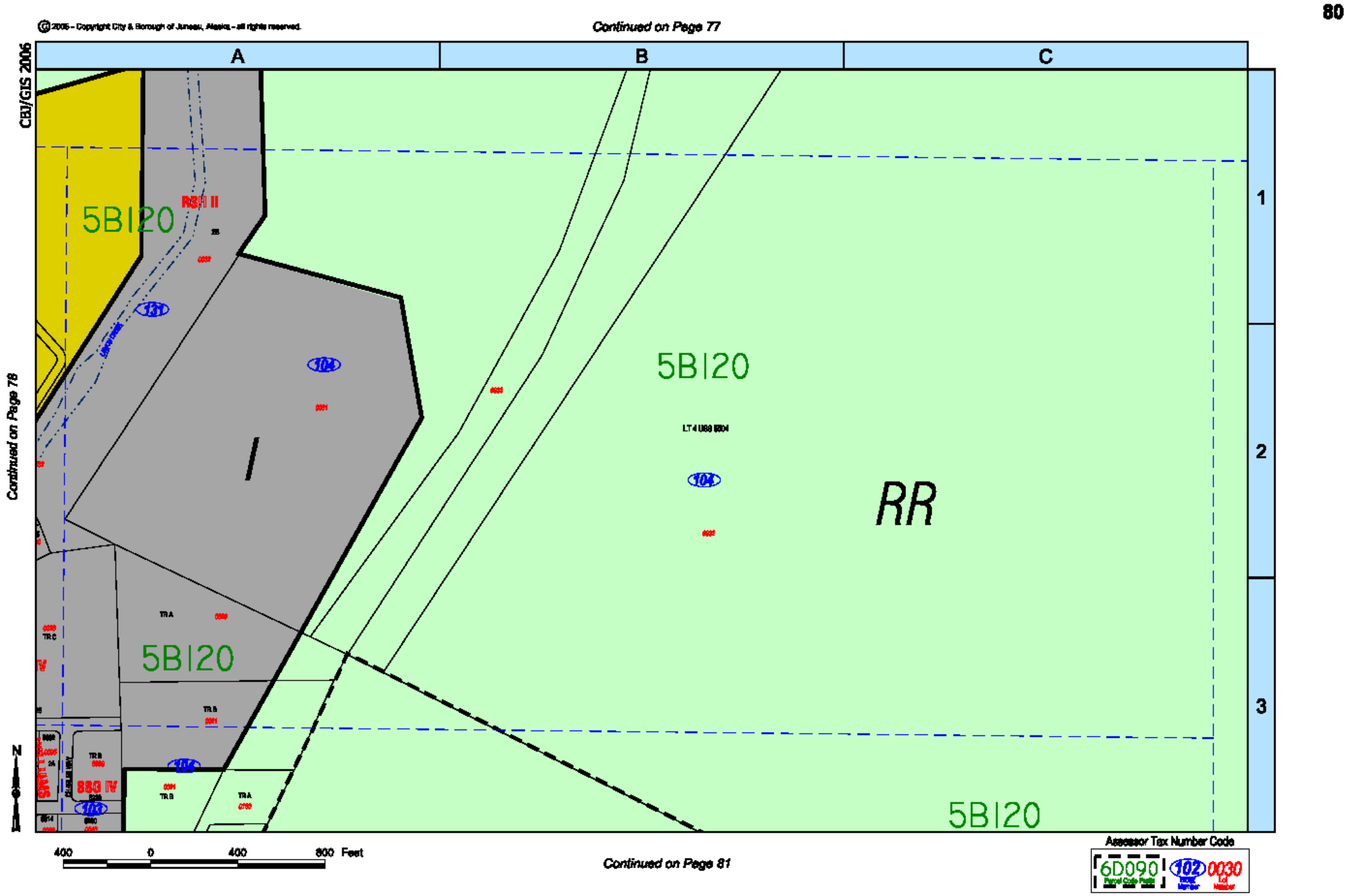
Map 77: CBJ 2006 Zoning Maps



Map 78: CBJ 2006 Zoning Maps



Map 79: CBJ 2006 Zoning Maps


80
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Continued on Page 77
CBJ/GIS 2006
Continued on Page 78
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Assessor Tax Number Code
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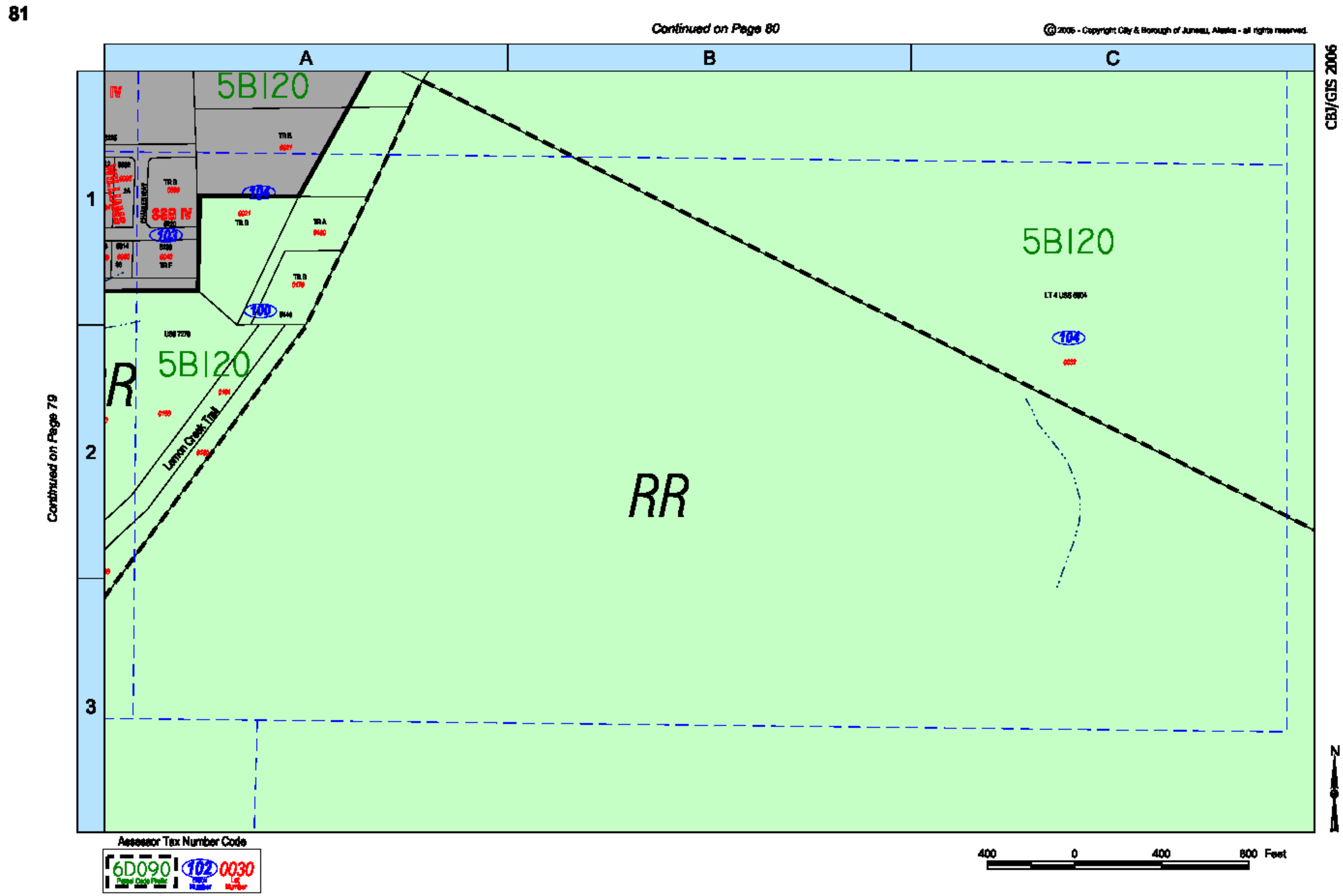
Map 80: CBJ 2006 Zoning Maps



Map 81: CBJ 2006 Zoning Maps

Appendix D: Lemon Creek Implementation Plan (from 1995 Lemon Creek TMDL Report)

Site/Action	Responsibility	Completion Date
Phase 1: Site-Specific Control Installation		
Juneau ReadiMix Stockpile	Juneau ReadiMix	11/1/1995
Establish terrace with reverse slope.	Juneau ReadiMix	7/15/1996
Stabilize stream bank below terrace.		
RSH Retention Basin		
Maintain storage and retention capacity.	RSH Company	Ongoing as needed
Goldbelt Upper Sediment Pond		
Re-direct flow to lower infiltration basin.	Goldbelt, Inc.	11/1/1995
Increase pond volume.	Goldbelt, Inc.	11/1/1995
Establish silt dikes in ditch.	Goldbelt, Inc.	11/1/1995
Goldbelt Sidecast Area		
Establish surface cover in grass and alder.	Goldbelt, Inc.	7/15/1996
Phase 2: Site-Specific Control Installation		
Additional Juneau ReadiMix stockpile measures if required.	Juneau ReadiMix	7/15/1997
Additional Goldbelt Upper Sediment Pond measures if required.	Goldbelt, Inc.	7/15/1996
Additional Goldbelt Sidecast Area measures if required.	Goldbelt, Inc.	7/15/1997
Haul Road Surface/Embankments		
Shift alignment below gorge away from creek.	RSH, CBJ	10/1/2000
Surface road.	RSH, CBJ	10/1/2000
Watershed Control Installation		
Establish stable, vegetated, 50-foot buffer.	DEC, CBJ	10/1/2000
Install sediment control devices on conveyances.	DEC, CBJ	10/1/2000
Develop and implement construction BMPs		10/1/2000
Monitor and improve habitat.		10/1/2000
Improve agency and public awareness.		10/1/2000
Establish implementation and oversight committee.	DEC	1/1/1996
Monitoring		
Initiate monitoring per monitoring plan.	DEC	10/1/1995
Annual Progress Assessments		
First annual progress assessment.	DEC	10/1/1996
TMDL Updates		
First TMDL Update.	DEC	within 3-5 years