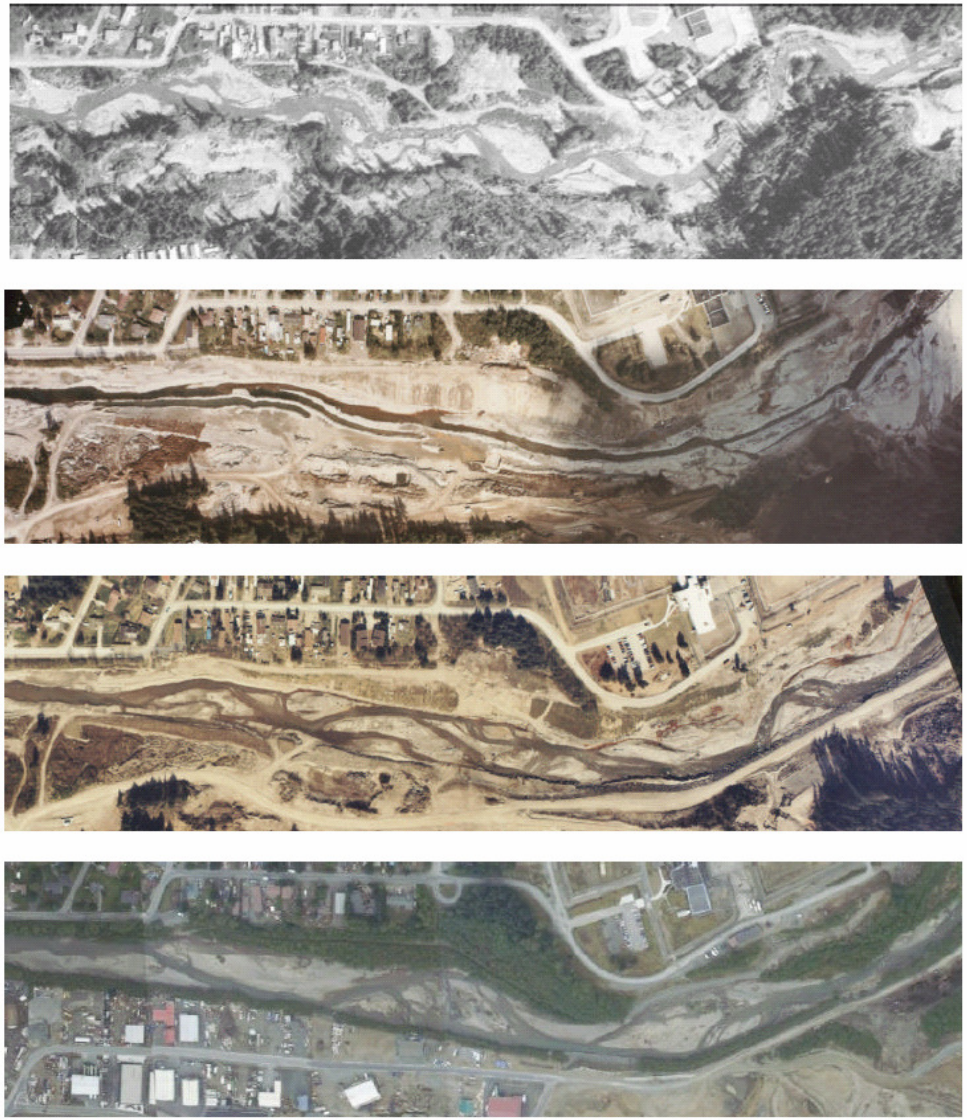


1974 AIR PHOTO

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.

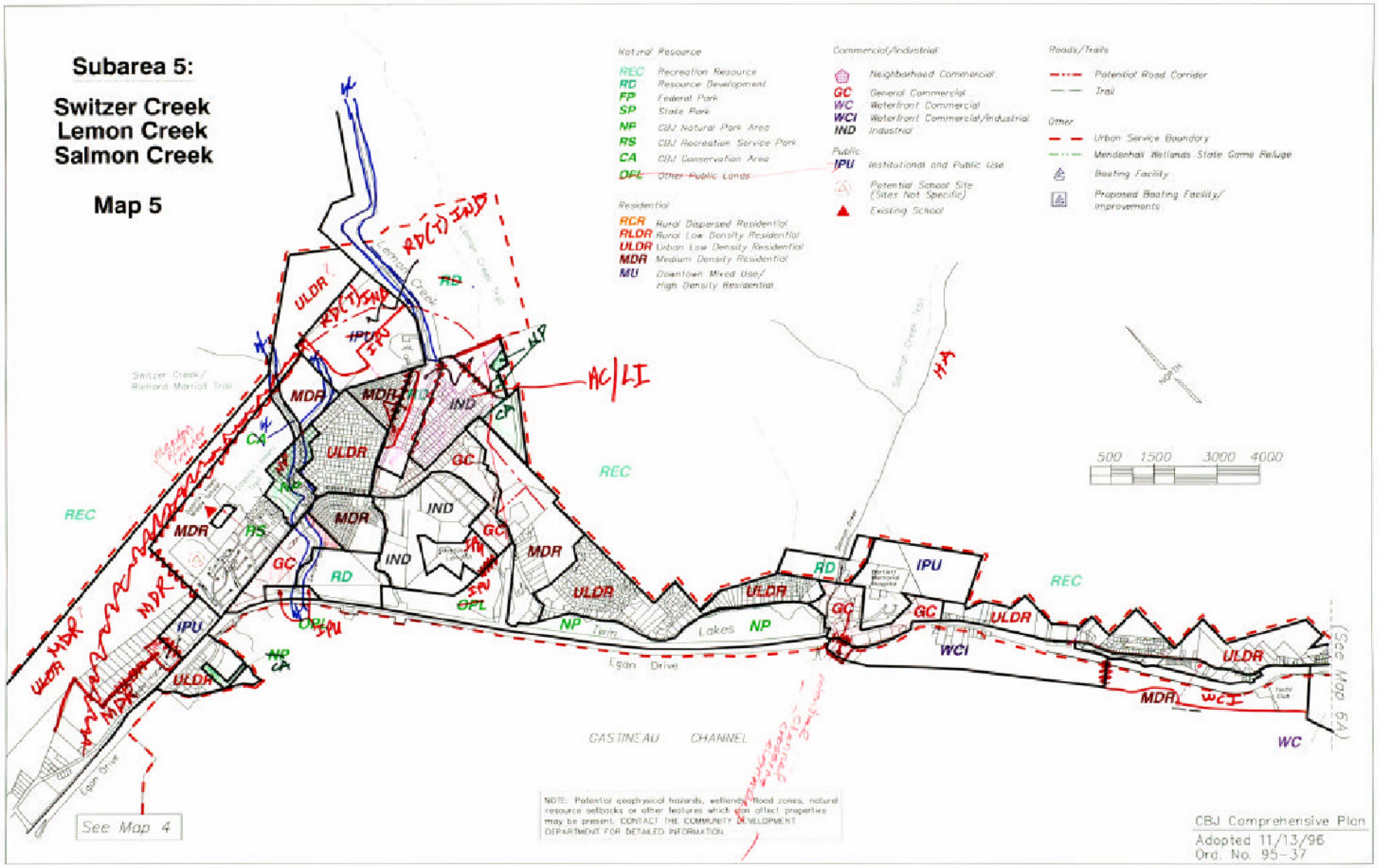


Figure 16: Subarea 5 zoning map from the draft CBJ Comprehensive Plan Update, 2007. Changes proposed in Lemon Creek include expansion of Medium Density Residential (MDR) areas west of Lemon Creek and changes from Resource Development (RD) areas to Industrial (IND), creation of CBJ park and conservation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

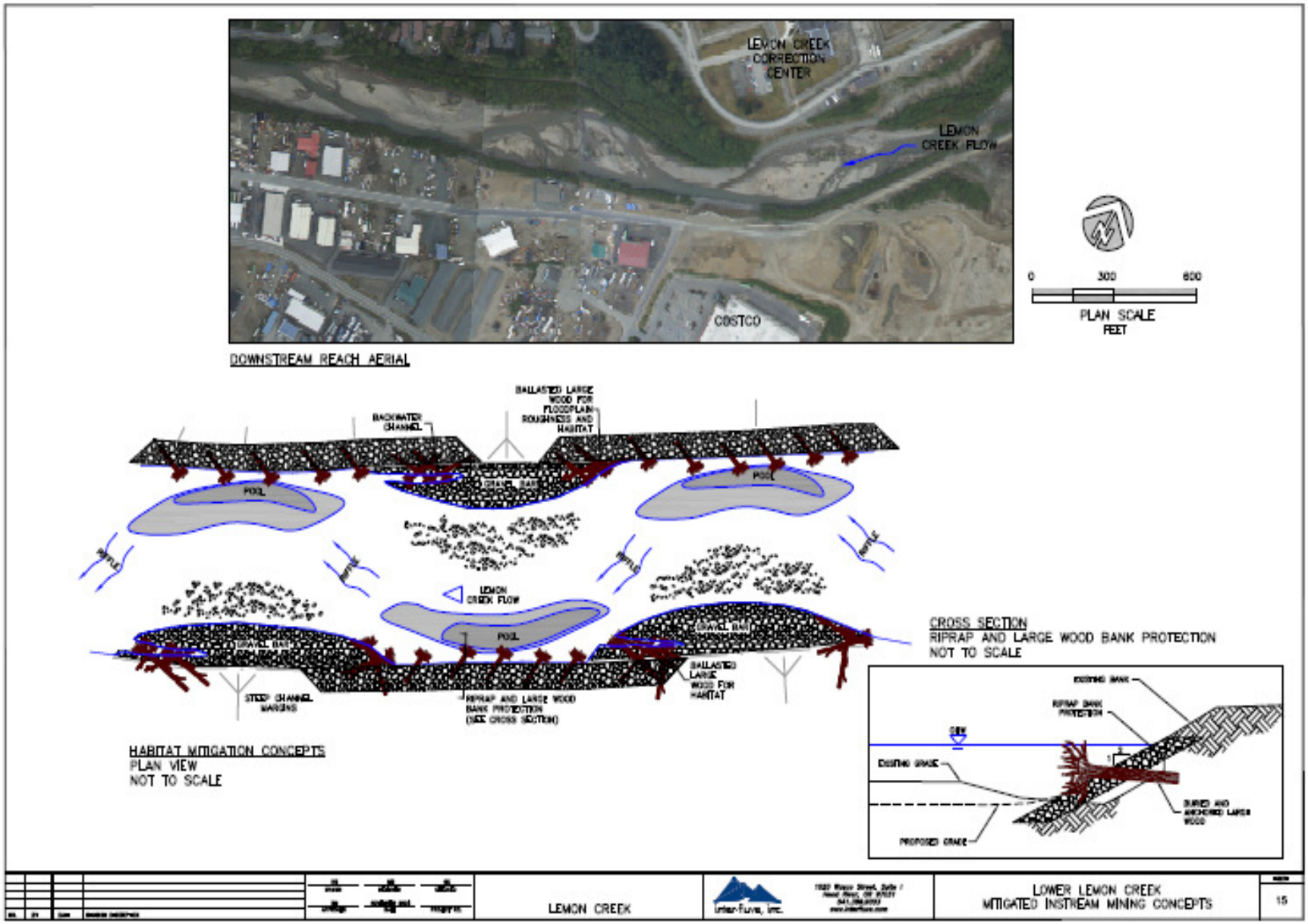


Figure 17: Lower Lemon Creek Mitigated Mining Concepts, from CBJ, 2004.

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

A hearty thanks to the reviewers who helped refine report content and recommendations. This report was made possible with assistance from individuals at:

- City and Borough of Juneau
- US Fish and Wildlife Service
- Juneau Watershed Partnership
- Alaska Department of Fish and Game
- Alaska Department of Natural Resources
- 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.

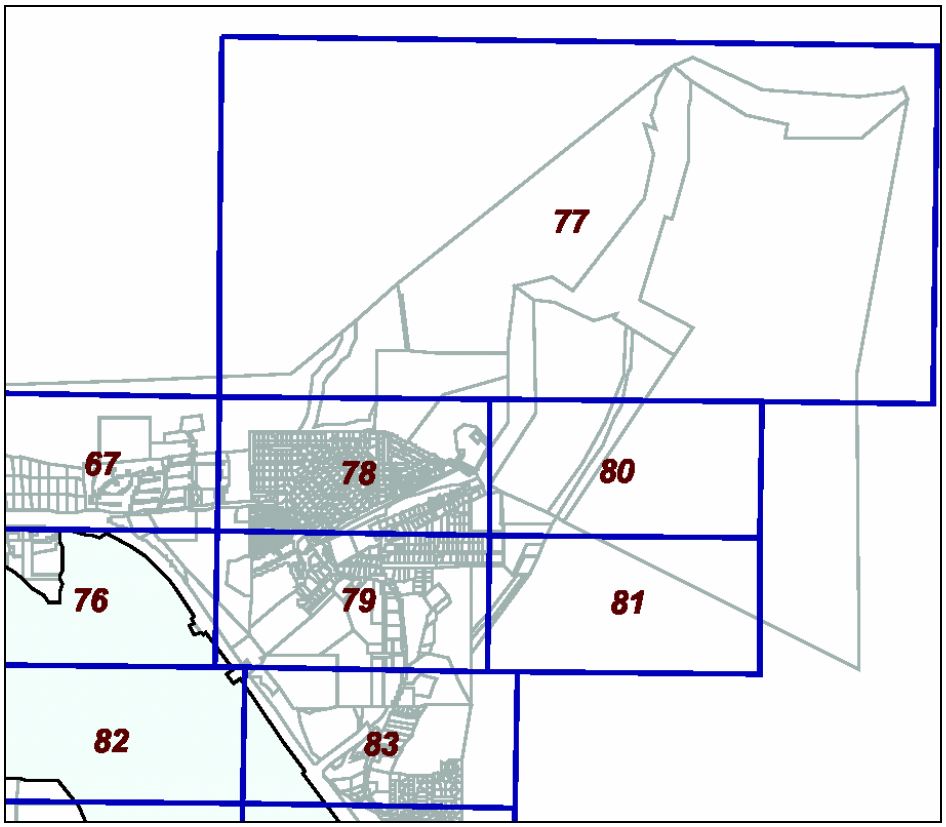
Large wood accumulations have limited influence on LC2 channel morphology. Relatively high stream energy in LC2 channel types tends to displace in channel debris bank areas. Total woody debris loading is moderate and is comprised of large diameter (45.7-76.2 cm) pieces longer than 15.2 meters in length. 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

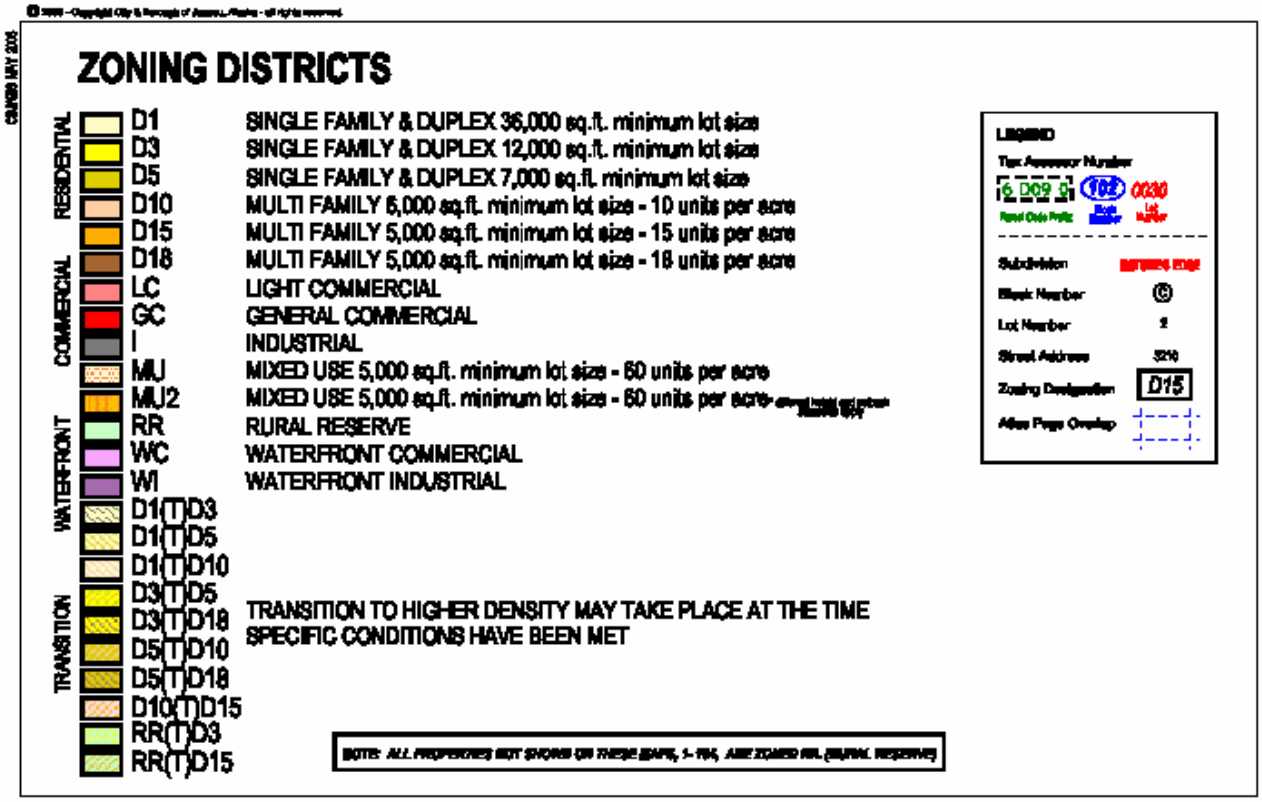
erosion if disturbed by road cuts, blowdown, or timber yarding. Riparian management should emphasize protection of unstable side slopes.

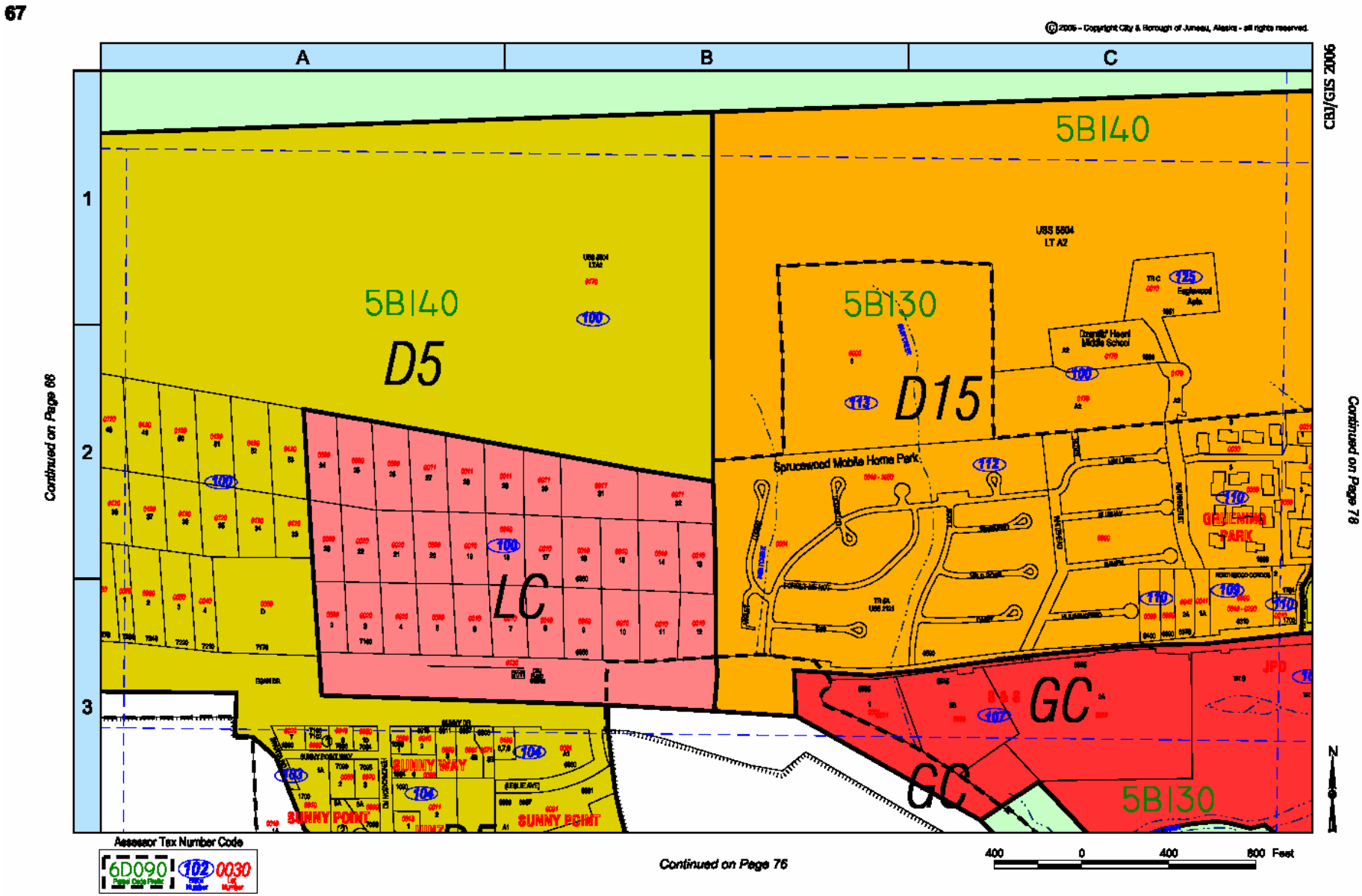
Due to long, steep side slopes adjacent to the channel, road crossings are generally not practical along LC2 channels types. Suitable crossing sites generally require multi-span bridges. Special road location and design, and slope stabilization measures should be considered for these streams.

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

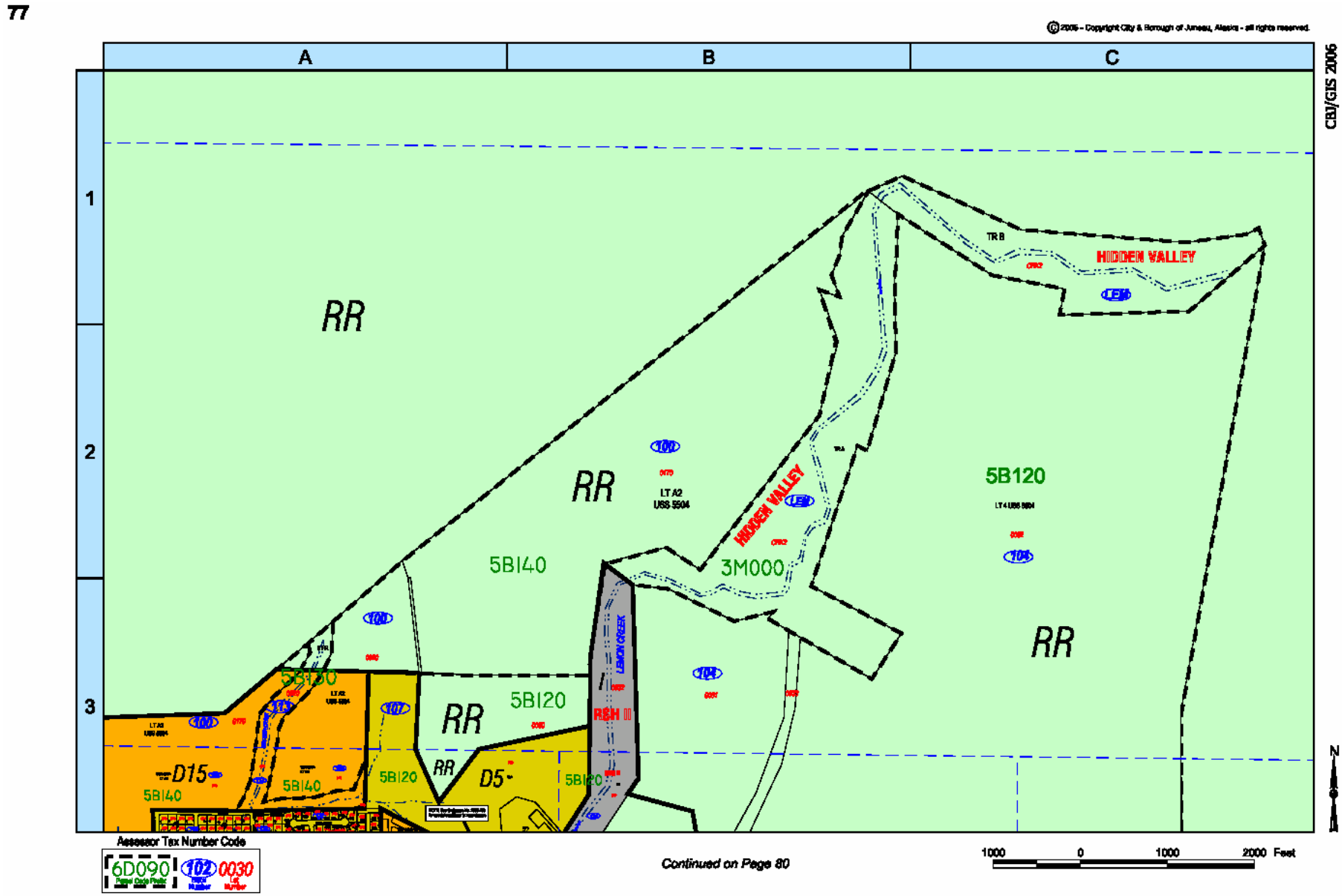


Subset of 2006 CBJ Zoning Maps Index. The Lemon Creek Area is represented by map numbers: 67, 76, 77, 78, 79, 80, 81, 82, & 83. These maps are included in this appendix. The Zoning Districts map key is also provided, below.

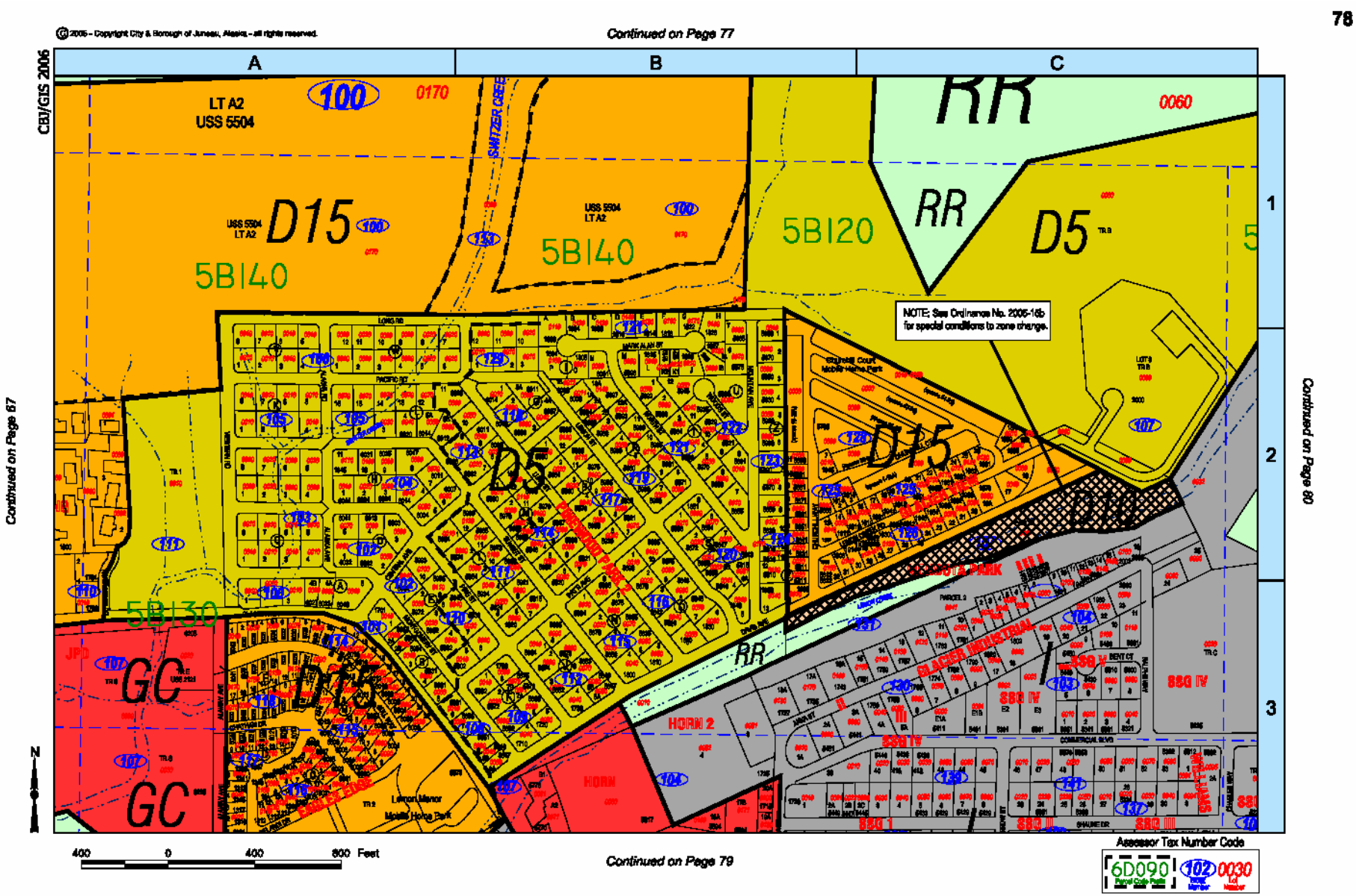




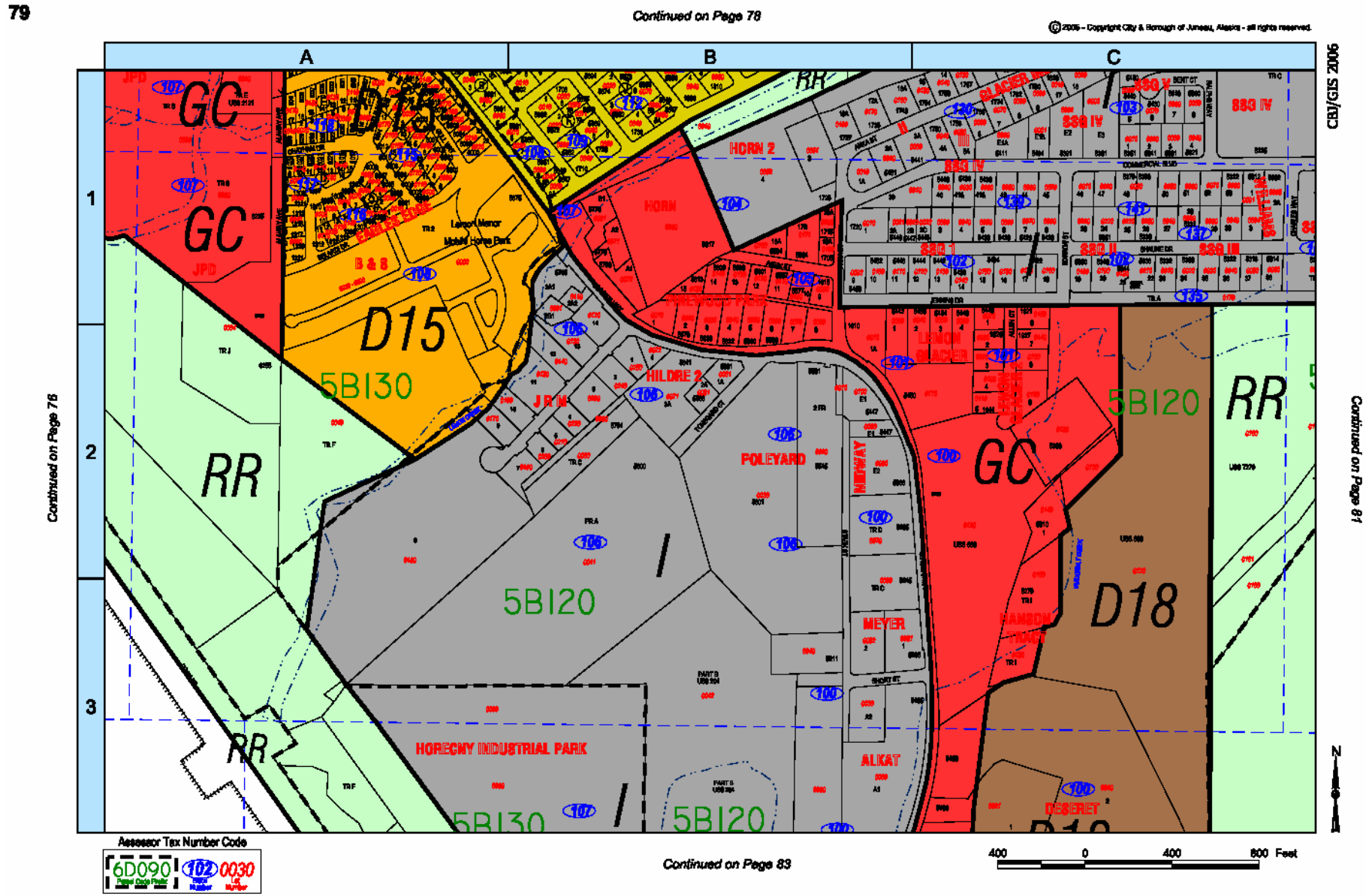
Map 67: CBJ 2006 Zoning Maps



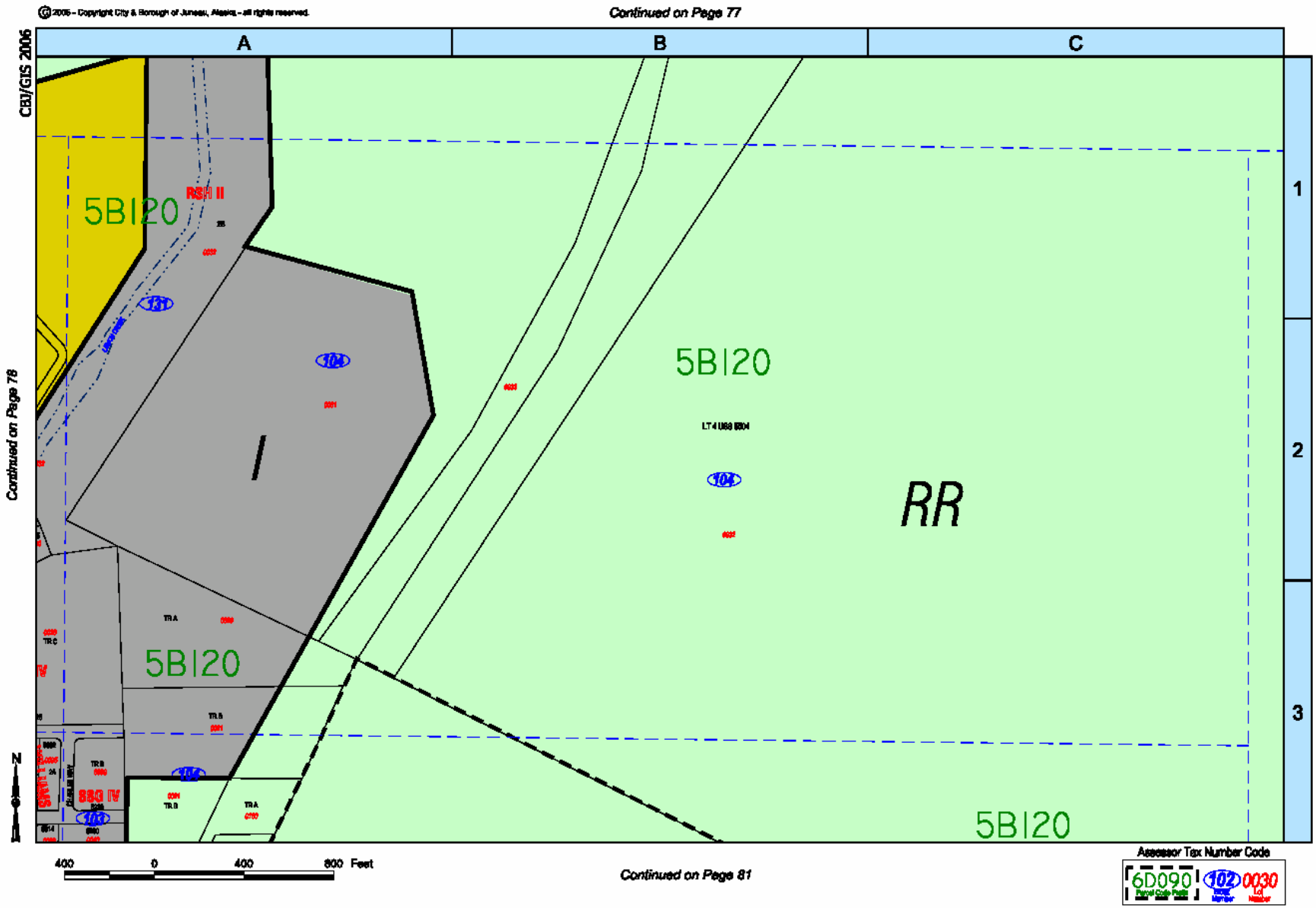
Map 77: CBJ 2006 Zoning Maps



Map 78: CBJ 2006 Zoning Maps



Map 79: CBJ 2006 Zoning Maps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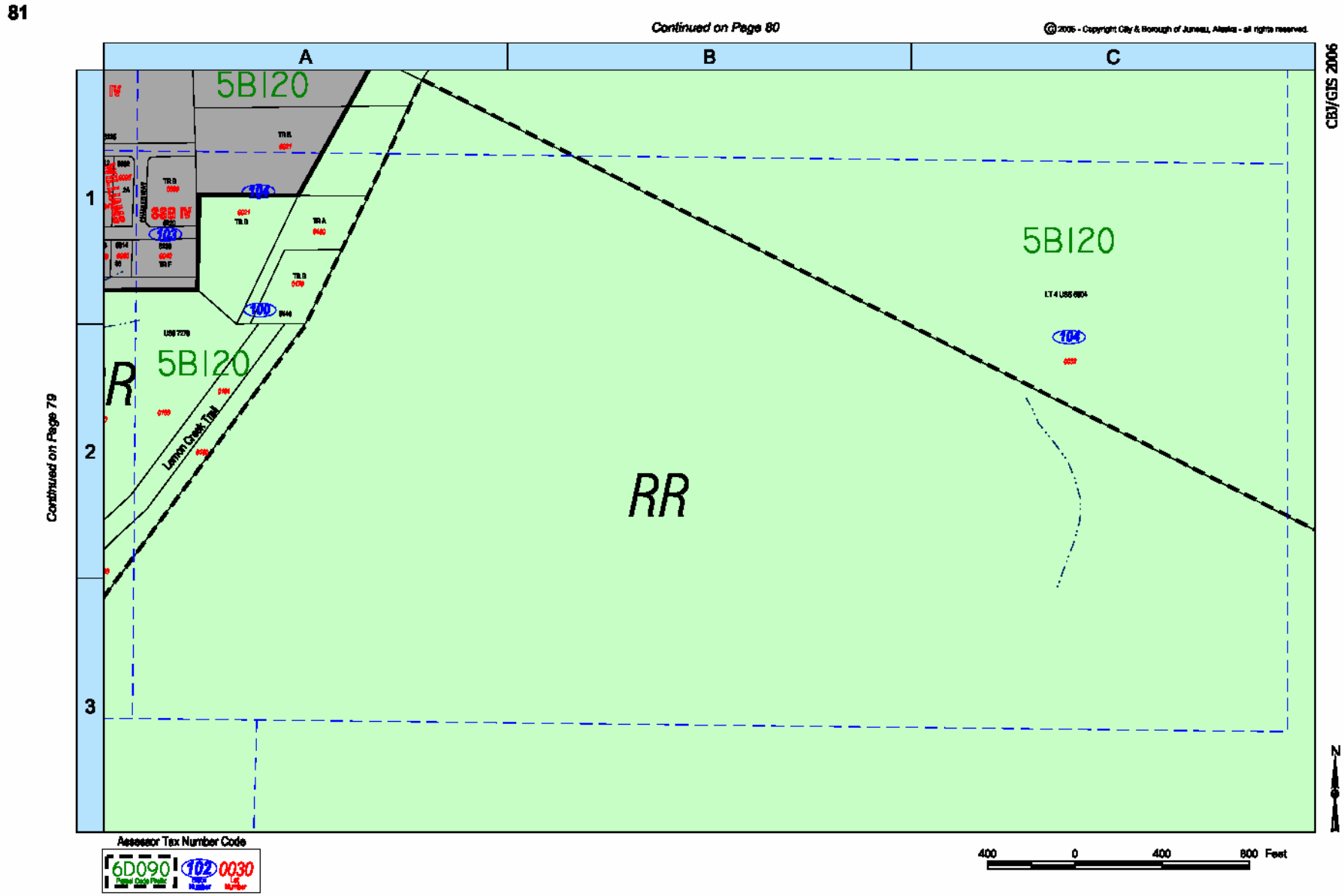
Map 80: CBJ 2006 Zoning Maps



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