City & Borough of Juneau
Alaska's Capital City

Engineering Department
155 South Seward Street
Juneau, Alaska 99801
Telephone: 586-0800 Facsimile: 463-2606

DATE: February 23, 2012

TO: Assembly

FROM: Rorie Watt, PE, Engineering Director
Engineering Department

RE: AJ Mine Related Water Study

Please review this **DRAFT** report on water issues related to the potential redevelopment of the AJ Mine. The report includes the following documents:

Water System

CBJ Water System Overview – This document gives a brief overview of the existing CBJ drinking water system, and includes a general discussion of both the Last Chance Basin (Gold Creek) and Salmon Creek drinking water supplies.

Watershed

Gold Creek Watershed Current Conditions and Vulnerability Assessment – Prepared by the Juneau Watershed Partnership, this document summarizes of the existing conditions in the Gold Creek watershed.

Water Resources

AJ Mine Related Water Resources Report – A summary of water quantity and quality data about Gold Creek watershed.

Permits and Authorizations Required for Mining in Alaska – A short memorandum listing permits and authorizations that could be required of a mine operator.

System Improvements – Four short memos on possible improvements to the CBJ drinking water system:

Gold Creek Drain Tunnel Bypass Piping
Alternate Drinking Water Sources
Salmon Creek Water Treatment Improvements
Last Chance Basin Water Storage Reservoir Evaluation

Scenarios

Drinking Water Supply & AJ Mine Development Scenarios – Conceptual scenarios that blend potential mining activity with water management approaches and drinking water supply improvements.

For those interested in more information, I have posted three additional documents on our web page: http://www.juneau.org/engineering/AJ_MINE/index.php

Condition #129 – Historic Documents regarding the drinking water conditions placed on Echo Bay's Large Mine Permit by the CBJ Planning Commission in 1994.

AJ Hydrology – Documents from the Alaska Department of Natural Resources from 1993 regarding impacts the CBJ drinking water system from the removal of drainage tunnel waters from Gold Creek.

Tri-Party Agreement – Agreement between CBJ, AEL&P and DIPAC regarding the use of waters from Salmon Creek.

Technical Memorandum

Carson Dorn, Inc.

712 West 12th Street
Juneau, AK 99801

Tel: 907-586-4447
Fax: 907-586-5917

Date: 12/2/2011

To: Rorie Watt

Reference:

From: Jim Dorn

Subject: CBJ Water System Overview

The following memo is a brief overview of the CBJ water system and important facilities within the system that have been constructed to support providing water to residents of Juneau.

CBJ Water Department

It is the purpose of the CBJ Water Utility to collect, provide proper treatment and distribute safe drinking water to the residents of Juneau in a reasonable and responsible manner.
Proper treatment and distribution is that which meets or exceeds the minimum requirements established by the United States Environmental Protection Agency (EPA) and the Alaska Department of Environmental Conservation (ADEC) and reflects the attention to safety and health expected by the residents of Juneau.

The Safe Drinking Water Act (SDWA) is the main federal law that ensures the quality of Americans' drinking water. Under the SDWA, EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards.
The SDWA was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and has established many requirements to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. EPA has given ADEC primary responsibility for implementing the SDWA in Alaska. In 1977, ADEC developed regulations for Alaska to address the quality and safety of drinking water in Alaska. These regulations, 18 AAC 80 Drinking Water, have been amended since they were first developed (most recently in May 2011) to remain current with the national standards for providing safe drinking water.

CBJ Area Wide Water System

In 1983 voters in the CBJ authorized an increase in the local sales tax to expand Juneau's water system to provide water for domestic use and fire protection to many areas of the borough that did not have municipal water service. This expansion took place over a 25 year period and resulted in the construction of over 130 miles of new water line, 7 new water storage reservoirs, 6 new water booster pump stations, and water source improvements for both the Last Chance Basin and Salmon Creek water sources. The area currently served by the CBJ water system along with significant water system facilities is shown on Figure 1.

As part of this Area Wide Water System expansion, minimum water service criteria were developed to identify needed capital improvements. The minimum service criteria used to develop the Juneau Area Wide Water System project were:

- The system shall be capable of providing a minimum fire flow of 3,500 gpm, sustained for 3 hours, to all commercial, industrial and high density multi-family residential areas.
- The system shall be capable of providing a minimum fire flow of 1,500 gpm, sustainable for a minimum of 2 hours to all residential areas.
- The minimum residual pressure anywhere in the system during a fire should be 20 psi.
- The static pressure within the system should not be less than 40 psi.
- The static pressure within the system should not be greater than 95 psi.
- Storage volume should be sufficient to provide emergency storage equal to an average day water demand, plus the commercial fire demand, plus operational storage. Operational storage is additional water available to the distribution system when demand exceeds the system supply during the peak demand hours of a day.

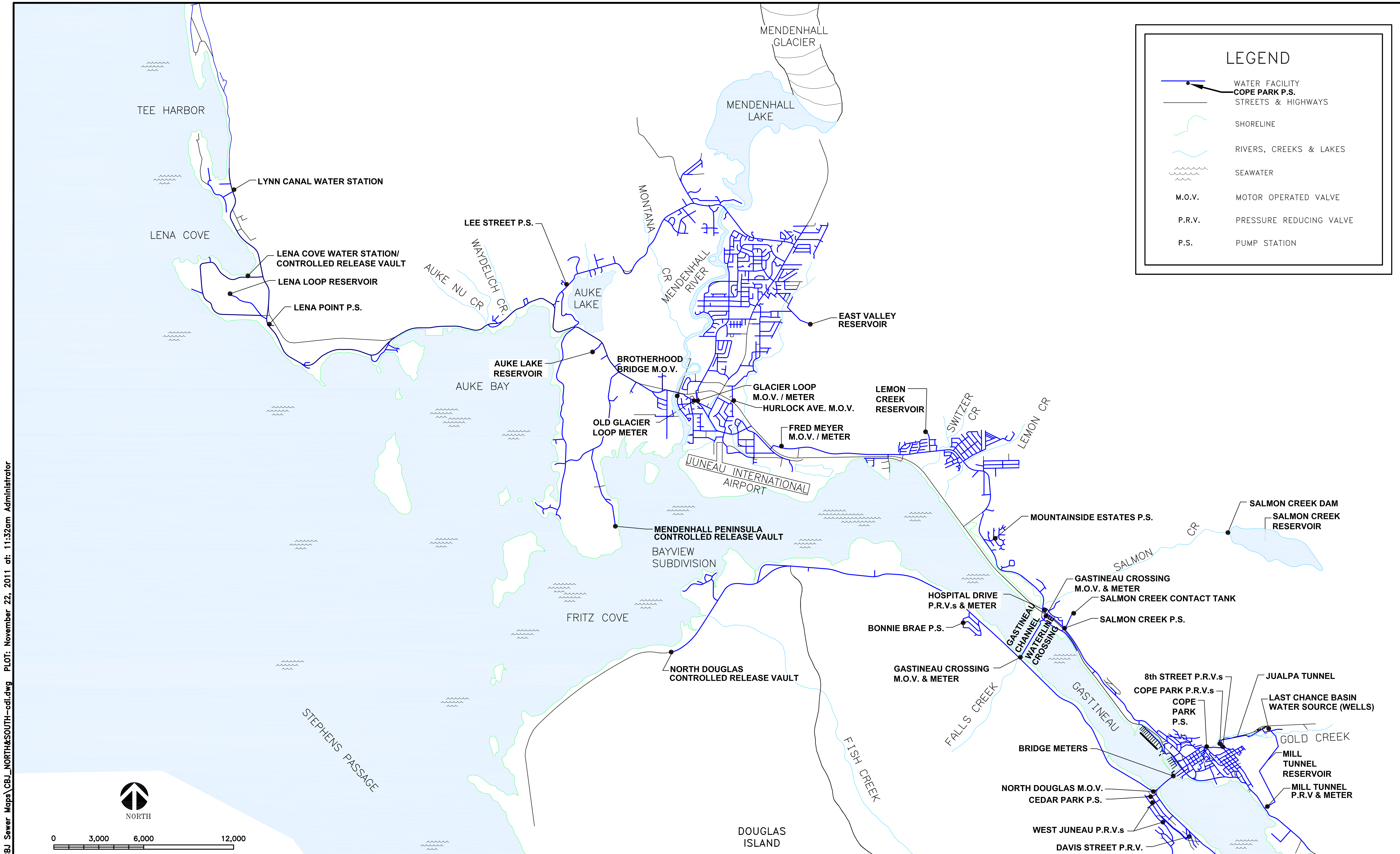
Water Distribution and Service

When completed the Juneau Area Wide Water System project resulted in a fourfold increase in the length of water distribution and water transmission lines in the systems. There was also a fourfold increase in the number of residents served by the water system. Table 1 is a summary of the current CBJ water distribution system and the customers served.

TABLE 1 – CBJ WATER DISTRIBUTION
180 Miles of Water Distribution and Transmission Mains
1,310 Fire Hydrants
8,155 Residential and Commercial Water Accounts
31,072 Customers Served

Water Storage Reservoirs

When water is transported long distances in water lines there is a frictional effect that results in a loss of water pressure. This pressure loss is more pronounced at higher flow rates and in smaller diameter water lines. As part of the Juneau Area Wide Water System project, a hydraulic model



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CITY AND BOROUGH OF JUNEAU
PUBLIC WORKS DEPARTMENT

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586-4447

CBJ
WATER SYSTEM
OVERVIEW

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of the water system was developed to analyze water system pressures under varying water demand conditions throughout the distribution system. The computer modeling focused on ensuring the water system could provide the desired fire flows, while maintaining water system pressures meeting the CBJ design criteria. The hydraulic analysis was used to identify strategic locations for water storage reservoirs. A water storage reservoir can provide a short term immediate source of water for firefighting purposes in the area it is needed. Water storage reservoirs can also be used to meet peak flow demands that occur throughout a day and typically fill during the night when water system demands are low.
The following reservoirs are part of the Juneau Area Wide Water System and are also shown on Figure 1.

TABLE 2 - WATER STORAGE RESERVOIRS (MG = MILLION GALLONS)		
1.0	MG	Crow Hill Reservoir
0.9	MG	West Juneau Reservoir
3.2	MG	Mill Tunnel Reservoir
2.2	MG	Salmon Creek Chlorine Contact Tank
1.6	MG	Lemon Creek Reservoir
2.1	MG	East Valley Reservoir
1.4	MG	Auke Lake Reservoir
1.0	MG	Lena Point Reservoir
13.4	MG	TOTAL

The Crow Hill, West Juneau, Lemon Creek, East Valley, Auke Lake and Lena Point Reservoirs are welded steel tanks whose purpose is to store water for use in the water distribution system and to provide water when the water supply is interrupted.

The Salmon Creek Chlorine Contact Tank is a welded steel tank with internal baffles. This tank is fed from the Salmon Creek surface water source and provides the required contact time established by EPA for chlorine added as a disinfectant, to inactivate giardia. Giardia is microscopic protozoan frequently found in surface water sources that can cause the gastrointestinal disease commonly known as "Beaver Fever". As such, the water in the Salmon Creek Chlorine Contact Tank is part of a water treatment process and is not available for meeting water system demands.

The Mill Tunnel Reservoir is an old hard rock mine tunnel primarily used to transport miners from Juneau to the Perseverance Mine in Last Chance Basin. This tunnel was modified in 1976 to be a water storage reservoir by adding concrete bulkheads at each end of the tunnel effectively creating a long water storage reservoir. This reservoir tunnel is at an elevation such that it can serve the higher elevations areas of Juneau, (i.e. Starr Hill and the Highlands area above the high school) and is connected to the high elevation water distribution system piping in those areas. There is also a connection to the water distribution system piping on South Franklin Street. The water pressure from the Mill Tunnel Reservoir passes through a pressure reducing valve before entering the South Franklin Street water distribution system piping. Stored water from the Mill Tunnel Reservoir is used to meet the peak water system demands that occur when cruise ships use the CBJ water system to fill their onboard water storage tanks.

Water Booster Pump Stations

Water system operating pressures decrease within a water distribution system as the service area elevation increases. There are a number of locations within the Juneau Area Wide Water System service area boundary that are at elevations too high to be served by the water system without booster pumps to increase operating pressures. CBJ currently operates 7 water booster pump stations to serve high elevation areas.

In some instances such as the Crow Hill Pump Station, Cedar Park Pump Station and the Lena Point Pump Station, reservoirs were constructed at the highest elevation to be served and the pump stations are used to keep the reservoir filled. Water in the reservoirs is used to meet domestic water demand and fire demands at desired water system pressures.

Other pump stations such as the Cope Park Pump Station, Mountainside Estates Pump Station, Bonnie Brae Pump Station and the Lee Street Pump Station maintain water system pressures within the high elevation zone they serve with constant pressure control faciltiies. Generally these pumps meet the domestic water system demand and a percentage of the desired fire flows, but not necessarily all of the 1,500 gpm fire flow for residential areas. Table 4 is a summary of the water booster pump stations operated and maintained by CBJ.

TABLE 3 - WATER BOOSTER PUMP STATIONS
Crow Hill Pump Station (2 pumps 60 hp 600 gpm each)
Cedar Park Pump Station (2 pumps 50 hp 275 gpm each)
Cope Park Pump Station (2 pumps 40 hp 600 gpm each)
Mountainside Estates Pump Station (3 pumps 10hp 200 gpm each)
Bonnie Brae Pump Station (2 pumps 6 1/2 hp 155 gpm each)
Lee Street Pump Station (2 pumps 7 1/2 hp 100 gpm each)
Lena Point Pump Station (2 pumps 10 hp 250 gpm each)

CBJ Water Sources

CBJ has two water sources for its water system. The primary water source is a well field in Last Chance Basin located above Juneau. The other source of water, Salmon Creek near the hospital, is a secondary interruptible water source that collects water from the tailrace of the Alaska Electric Light and Power hydroelectric plant at Salmon Creek.

Last Chance Basin Water Source

The Last Chance Basin water source consists of 5 wells located in the Last Chance Basin Basin. Wells 1, 2, and 3 have been in operation since the early 1960's and wells 4 and 5 were placed in operation in 1989.

As part of the nationwide program to provide safe drinking water, EPA developed criteria to determine if a ground water source was under the direct influence of surface water or not. Monitoring for water temperature, pH, conductivity and turbidity from wells is performed to determine if there are rapid changes in any of these water quality parameters in response to storm events or seasonal changes. Rapid changes in any of these parameters would tend to indicate the well water may be under the direct influence of surface water. A microscopic particulate analysis is also performed to determine if particulates common to surface water are present in the wells or not. For the Last Chance Basin wells it was determined that they are not under the direct influence of surface water. This is significant from a water treatment standpoint because groundwater sources only require the addition of a disinfectant such as chlorine whereas a surface water sources requires additional treatment. The Last Chance Basin wells provide low cost, high quality water to the Juneau water system.

With time, water production from wells can diminish as a result of fine material in a aquifer slowly moving towards wells and impacting the open pore spaces in the aquifer around wells. This restricts the amount of water that can enter the well and be made available for the drinking water system. In 2009 CBJ conducted a rehabilitation project of the wells in Last Chance Basin to improve water production from the wells. A nitrogen gas hydropulsing technique was used to create pressures pulses in the aquifer to loosen the aquifer material around each well and surging, bailing and pumping the wells was done to remove the loosened fine material from the aquifer around the wells. After the well rehabilitation project, measured production rates from the wells had increased on average about 78%.

Table 4 is a summary of the production rate for each of the wells in Last Chance Basin as well as the depth of each of the 5 wells and the depth to the top of the screen in each well. All the well screens all begin at least 50’ below the ground surface.

TABLE 4 - LAST CHANCE BASIN WELLS

WELL	Production Rate	Depth to Bottom of Well	Depth to Top of Screen	Length of Screen
1	625 gpm	92'	52'	40'
2	640 gpm	96'	54'	42'
3	1,240 gpm	96'	61.5'	34.5'
4	2,500 gpm	132'	86'	46'
5	1,230 gpm	133'	74'	59'
TOTAL	6,235 gpm (9.0mgd)			

Since water from the Last Chance Basin wells has been determined to be groundwater that is not under the influence of surface water, the only treatment required is chlorine disinfection for inactivation of viruses.

Wells 1, 4 and 5 pump directly into the Juneau water distribution system and are controlled so that water distribution system pressures do not exceed the CBJ water system design criteria for system pressures.

Well 3 pumps to the Mill Tunnel Reservoir. Water from the Mill Tunnel Reservoir is used primarily to serve the higher elevations of Juneau such as the Starr Hill area and the Highlands area above the high school. During the summer months, water in the Mill Tunnel is also used to meet peak demand conditions that occur when cruise ships use CBJ's water system to fill their onboard drinking water tanks.

Well 2 can either pump to the Mill Tunnel Reservoir or directly to the CBJ water distribution system.

Salmon Creek Water Source

Alaska Electric Light and Power operates a hydroelectric plant at Salmon Creek located across Egan Drive from DIPAC's Macauley Salmon Hatchery. Water from the Salmon Creek dam travels in a penstock to the hydroelectric plant and passes through the turbines that generate electricity. Water from the turbines then enters a tailrace that passes under Egan Drive and fills the pond located next to DIPAC. The tailrace water in the pond is used for DIPAC's operations. Before it crosses Egan Drive, some of the water in the tailrace enters a wet well located next to the hydroelectric plant that is pumped to the Salmon Creek Chlorine Contact Tank and used to provide water to the CBJ water system.

Water from Salmon Creek has been classified by EPA and ADEC as originating from a surface water source. EPA and ADEC regulations requires filtration of all surface water supplies unless stringent source water quality for bacteria and turbidity; disinfection criteria for chlorine concentration and contact times; and site specific conditions protecting the watershed are met. CBJ has met all the conditions for filtration avoidance and so the Salmon Creek water source is an unfiltered surface water source. Other communities with unfiltered surface water sources in Alaska include Ketchikan, Sitka, Kodiak, Cordova, and Unalaska.

The City and Borough of Juneau (CBJ) water system has established water rights to withdraw about 3.5 million gallons per day of water from Salmon Creek to provide drinking water to residents of Juneau. The Salmon Creek water system has been in operation for approximately 25 years.

One of the surface water filtration avoidance criteria requires that the source water turbidity not exceed 5 NTU. At times the water from Salmon Creek exceeds 5 NTU. During these times use of Salmon Creek as a water source must be discontinued. As a result, Salmon Creek is considered a secondary interruptible water source. Since 2005 the Salmon Creek water source has been taken off-line 4 times due to high turbidity and 3 times for maintenance.

For CBJ’s unfiltered Salmon Creek water source, inactivation of *Giardia* and viruses is currently being accomplished in accordance with the EPA and ADEC requirements. This is done by keeping the disinfectant residual (chlorine) and contact times at concentrations and durations that are specified in the regulation. The contact times are met as the water transits the baffled water storage tank located above Salmon Creek. Water flow rates are carefully controlled to ensure sufficient contact time is achieved prior to the water reaching the distribution system and the first customer.

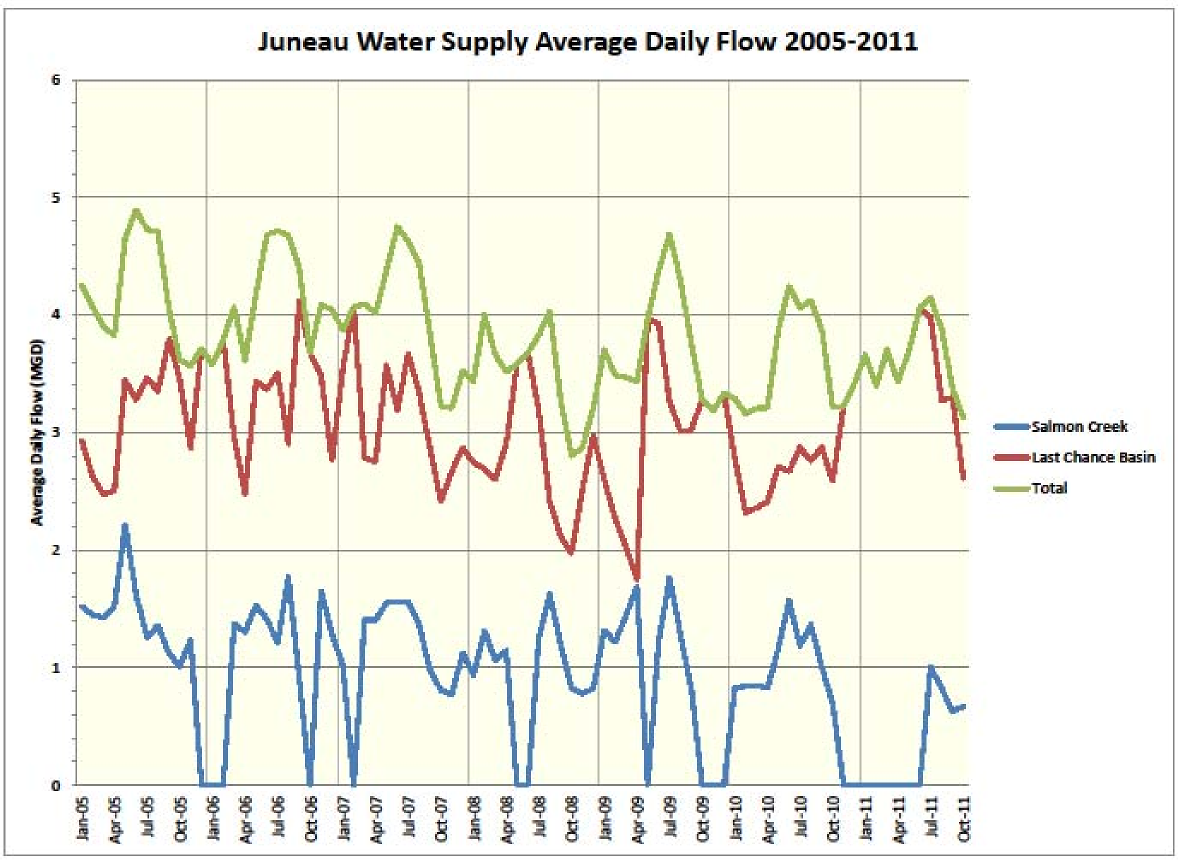
CBJ is also adding soda ash to the water at Salmon Creek to adjust the pH of the water to reduce leaching of lead and copper into the water system. This is to comply with EPA and ADEC requirements for lead and copper levels in water systems.

In 2006 EPA adopted new rules which specifically addresses inactivation of cryptosporidium. in surface water sources. Cryptosporidium is a parasitic protozoan that forms a protective cyst which makes it resistant to chlorine levels normally found in public water systems. Cryptosporidium and the disease it causes, cryptosporidiosis, was brought to the public's attention by an outbreak in 1993 in Milwaukee, Wisconsin. Up to 300,000 residents became ill during the outbreak. Cryptosporidium are affected by UV light and so the unfiltered surface water sources in Alaska have been adding UV light disinfection to their surface water treatment systems specifically for treatment of cryptosporidium. Juneau currently plans to add a UV light disinfection system to the Salmon Creek water treatment plant in 2012.

Water Supply Needs

Over the last 6 years Juneau's water demand has been averaging about 4.5 MGD during the summer months and about 3.5 MGD during the winter month. Much of this seasonal difference can be attributed to cruise ships using Juneau's water system to fill their on-board water storage tanks and to the increase in tourists during the summer months. Roughly 2/3rds of Juneau water supply comes from the Last Chance Basin with the other 1/3rd coming from Salmon Creek.

The following chart tracks average daily water flows for each month during 2005-2011.



Gold Creek Watershed
Current Conditions and Vulnerability Assessment

Prepared by:

Juneau Watershed Partnership

In Partnership with the
The City and Borough of Juneau

Juneau, Alaska
February 2012

TABLE OF CONTENTS

List of Figures

Acknowledgements

We would like to thank Dave Evans for providing his technical expertise and for generating the GIS maps and figures for this report. Thanks to Richard Carstensen and Discovery Southeast for generously allowing us to use the maps and figures they created for the City and Borough of Juneau's Juneau Trails Project. Many thanks to Lee Benda from Earth Systems Institute in Mt Shasta, CA for their help generating the landslide/avalanche susceptibility model and data. We would also like to thank Rorie Watt and the CBJ Engineering Department for partnering with us on this assessment. Technical support for this project was also provided by the JWP Board and Technical Advisory Committee.

The Juneau Watershed Partnership (JWP) is a 501 (c) 3 non-profit organization whose mission is to promote community stewardship and sustainable use of Juneau's watersheds.
For information on our projects and programs, please go to our website at www.juneauwatersheds.org

1. INTRODUCTION

In February 2011, Mayor Bruce Botelho of the City and Borough of Juneau (CBJ) convened a citizen's task force to analyze under what circumstances, if any, should the CBJ consider pursuing the redevelopment of the AJ Mine, located in the Gold Creek Watershed near downtown Juneau, Alaska. The AJ Mine Advisory Committee (AJMAC) recommended that further research on the Gold Creek Watershed be conducted and decimated into information that was easily accessible to the public.

The Juneau Watershed Partnership (JWP) proposed to partner the CBJ Engineering Department to gather existing information and research about the Gold Creek system in order to summarize the existing hydrological conditions and the historic and current use of the watershed.

JWP was also tasked with updating information found in the CBJ's "Watershed Control and Wellhead Protection Program- Gold Creek Source" report (1995), which contained a vulnerability assessment that identified potential threats to water quality and quantity in the Gold Creek Watershed.

2. GOLD CREEK WATERSHED CURRENT CONDITIONS

2.1 Watershed Description

The Gold Creek Watershed originates from the western edge of the Juneau Ice field and extends approximately 5 miles before terminating in Gastineau Channel (Bethers, 1995). The watershed drains approximately 8.5 square miles of land and includes drainage from Lurvey and Granite Creeks and seasonal snowmelt from Mounts Juneau and Roberts, and Olds and Sheep Mountains. Extensive glaciation has modified the watershed leaving behind multiple glacial-carved basins and bowls including Granite Basin, Silverbow Basin, Last Chance Basin and the Evergreen Bowl (Easton, 1995).

In the headwater reaches of the watershed, water flows downslope through the Silverbow Basin where some of the water seeps into holes and crevices created from past mining activities (Noll, 1996). The largest of these openings are two large "Glory Holes". Waters that enter the mine workings are channeled and directed into and underground drainage tunnel called the Gold Creek Drainage Tunnel.

The Gold Creek Drain Tunnel discharges above the CBJ's Last Chance Basin well field, which is the main source of CBJ's municipal drinking water. Currently there are 5 wells operating in the well field that supplies approximately 3.0 to 4.0 million gallons per day to the Municipal Water system. This system was built in 1959, with additional wells drilled and other improvements made in 1976 and 1990 (CBJ, 2011a).

Downstream of the aquifer and well field, Gold Creek is confined into a 250 foot concrete flume for the Alaska Electric Light and Power (AELP) water intake system. The water then runs feely through Cope Park until it is re-confined to another concrete flume approximately 0.42 miles in length at Cope Park and Irwin Street, before Gold Creek terminates into Gastineau Channel.

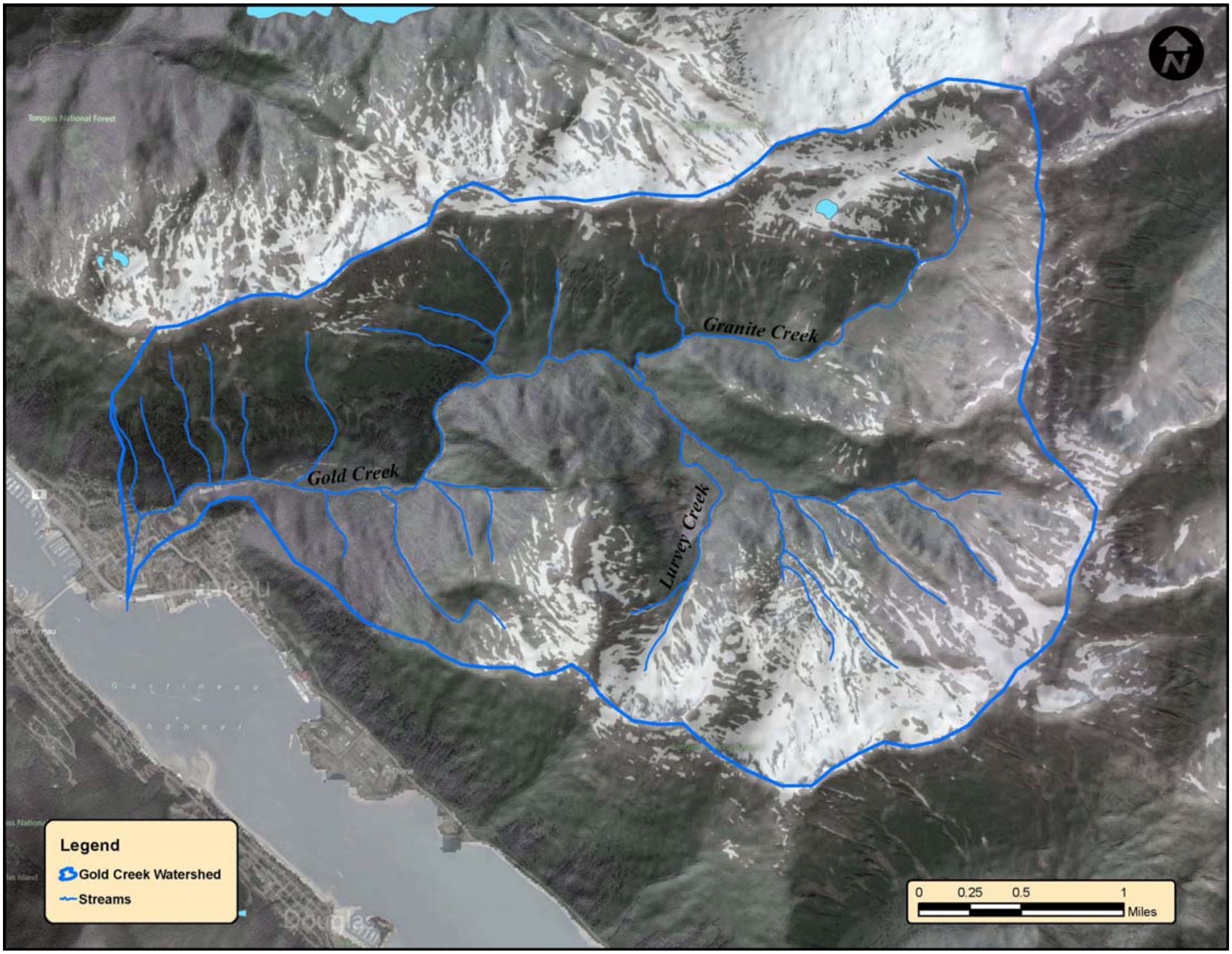


Figure 1: Gold Creek Watershed and Contributing Waterbodies **JWP, 2012**

2.2 Watershed Features

Geology

The geology of the watershed is mostly metamorphic bedrock and glacial, marine, alluvium and colluvial deposits (CBJ, 1995). There are two intersecting tectonic plates in the watershed; the Sumdum Thrust, which runs Northwest to Southeast, and the Silverbow Fault, which runs East to West. In the Eocene times (about 55 million years ago) plate movement caused hot water to percolate up from the deep earth into these fault zones. When this water cooled in the upper crust of the earth, slowly over millions of years, gold and other minerals were developed in the resulting veins (CBJ, 2011b).

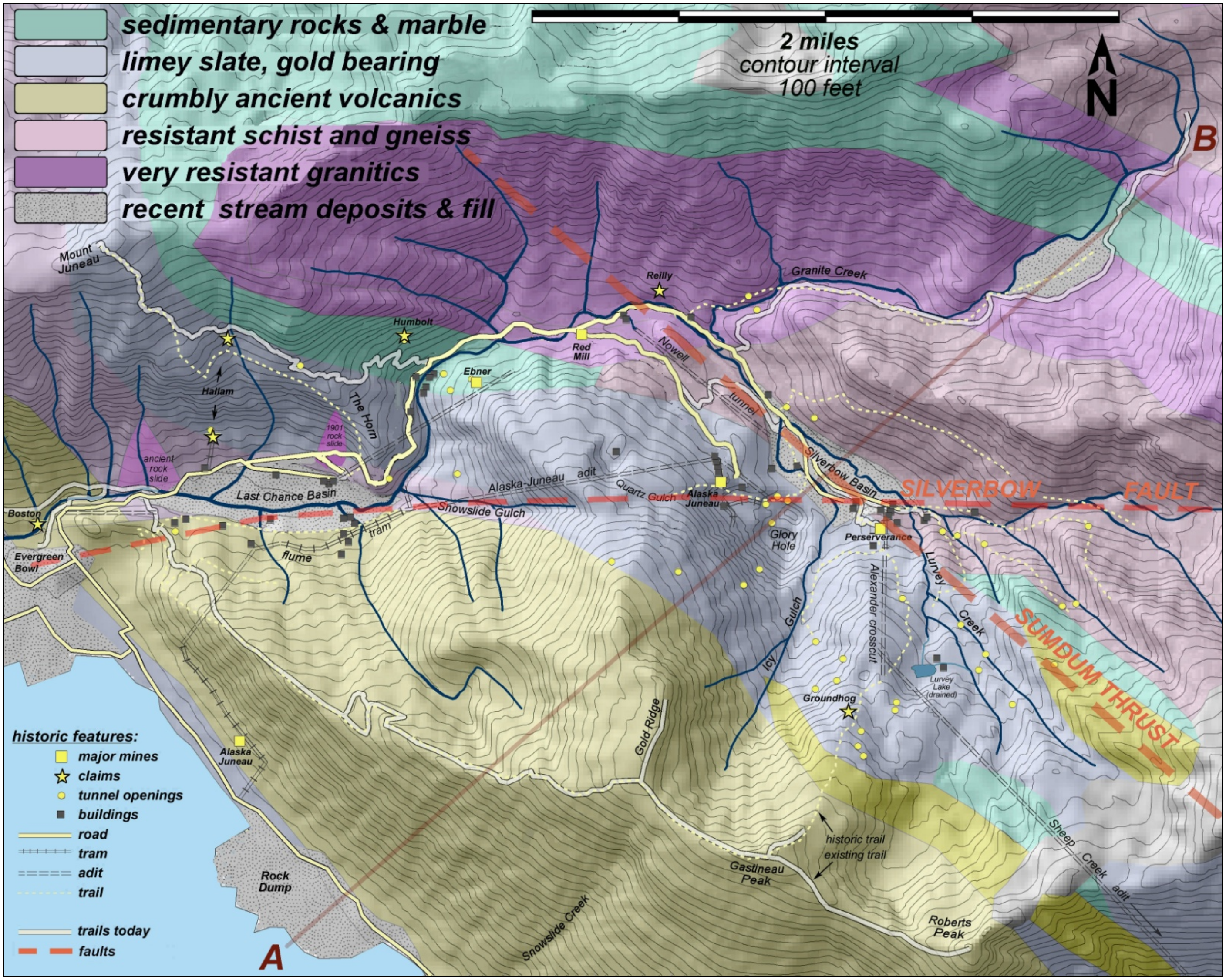


Figure 2: Gold Creek Geology **Figure courtesy of Richard Carstensen and Discovery Southeast**

Hydrology

Streamflow data have been collected by the USGS on Gold Creek at a few locations, including a stream gauge point located 245 feet above the mouth of the creek and another site 50 feet up from that elevation (USGS, 2005).

The gauging station at Gold Creek (USGS station #1505000) was operated from July 1916 to December 1920 (monthly discharge only), October 1946 to September 1948, October 1949 to September 1982, and October 1997 to 2005. Mean annual flow at the station in 2005 was 122 cubic feet per second (ft^3/s) and mean monthly flows range from a minimum of 9.0 ft^3/s in February 2005 to 910 ft^3/s in September of that year. During the total period of record, the lowest daily mean discharge in Gold Creek was zero flow/discharge recorded at the gauging station March 4, 1951 and the highest daily mean discharge was 1830 ft^3/s measured on August 12, 1961 (USGS, 2005).

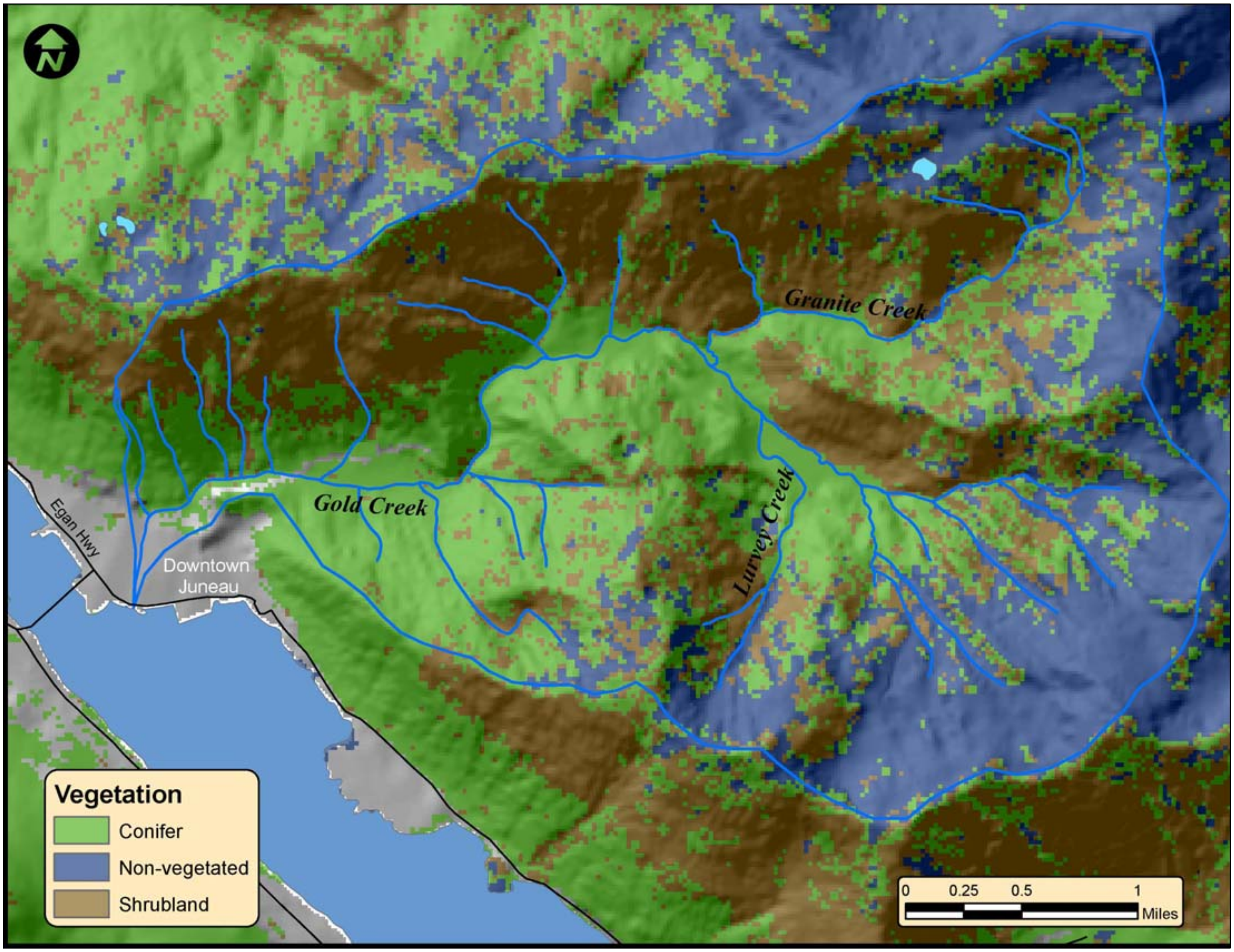


Figure 3: Vegetation Types **JWP, 2012**

Vegetation and Invasive Weeds

The watershed contains extensive high elevation reaches of alpine tundra with many successional attributes typical of recently deglaciated terrain such as exposed bedrock, with thin and poorly developed soils (Identified in Figure 3 as 'Non-vegetated').

In the lower reaches of the watershed, the landscape is older consisting of a mixture of conifers including spruce, hemlock, Sitka and red alder, willow, and cottonwood trees. The majority of the trees in the lower elevations of the watershed are even age, spruce dominated, second-growth timber. Understory vegetation includes shrubs like salmonberry, ferns, horsetail, devil's club, Columbine and native grasses (CBJ, 2011b).

Invasive plants and weeds that have been documented on the Alaska Exotic Plant information Clearinghouse's (AK EPIC) Early Detection and Distribution Mapping System (EDD Maps) in the Gold Creek Watershed include Bluegrass and Chickweed varieties, Broadleaf Plantain, Common Tansy, Common Toadflax, Creeping Buttercup, Damesrocket, Dandelion, Pineapple Weed, Tall Buttercup, Timothy Grass and White Clover. Out of these species Toadflax, Tansy and Clover are ranked highest for “invasiness” of Alaska invasive plants, by the Alaska Association of Conservation Districts.

Fish and Wildlife Habitat

The area at the mouth of Gold Creek from the end of the concrete flume to the intertidal area of the creek is listed in the State of Alaska’s Anadromous Waters Catalog (AWC) for chum and pink salmon holding and spawning habitat.

Although little record can be found about historic fish populations in the creek, according to the Juneau Fish Habitat Assessment (1995) Gold Creek is reported to have been “one of the great salmon creeks” in Gastineau Channel. The upstream habitat is typical of a high-gradient mountain stream and Ebner Falls is a natural fish barrier 2 miles upstream from the mouth of Gold Creek (Bethers, 1995). The concrete flume installed in the late 1960’s in the lower watershed to reduce erosion and flooding, displaced spawning and rearing habitat and is a fish passage barrier to the upper reaches of the creek due to the high velocity of the water.

Between December of 1952 and December 1953, 110,000 eyed King Salmon eggs and 4,000 Brook Trout were introduced to the system, although both of those stocking efforts were considered failures by ADF&G in 1970 (Reed, 1997).

There have been a few documented ‘fish kill’ events in Gold Creek. According to the ADF&G, between 500 and 1,000 Dolly Varden char between two and eight inches in length were found dead one mile upstream from the mouth of Gastineau Channel in 1967 (Reed, 1997). In March of 1994, between two and three hundred dead Dolly Varden char were found in a pool near the bottom of the Last Chance Basin and in January 1995 there was another fish kill event in the lower pool (CBJ, 2011a.

A 2007 macroinvertebrate study conducted by the US Department of Fish and Wildlife Service (FWS) found healthy and diverse levels of aquatic biota in Gold Creek. The study concluded that although intensive mining took place in historically in the watershed, the macroinvertebrate populations in Gold Creek were comparable to other, non-developed watersheds in the region (Rudis, 2007).

Birds and Wildlife

The Gold Creek watershed provides bird and wildlife habitat for waterfowl, raptors, songbirds, and small and large mammals. Sitka black-tailed deer, mountain goats, and black bears are the large mammals present in the watershed. Other mammals likely to inhabit the watershed include porcupine, marmot, shrews, martens, red squirrel, and voles (CBJ, 1995).

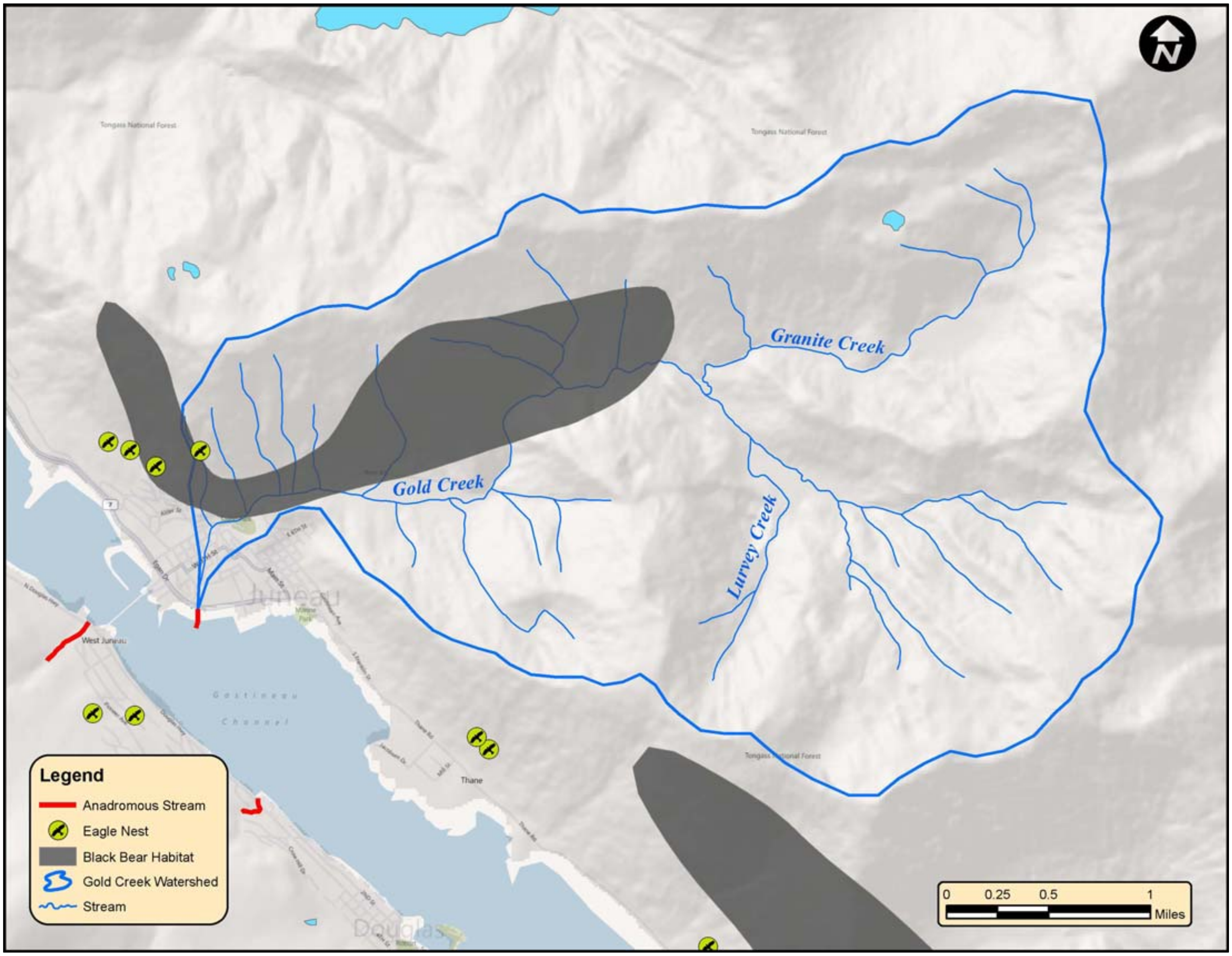


Figure 4: Fish and Wildlife Habitat **JWP, 2012**
(Data Source: Eagle data from US Fish and Wildlife Service- Juneau Ranger District. Bear Habitat data from The Nature Conservancy- Juneau Office)

2.4 Historic Land Uses

Tribal Uses

The Auk Tribe of the Tlingit had a main village located in Auk Bay, but many relocated to Juneau after gold was discovered there. Gold Creek was called Dzantik'i Heeni by the Auk people, and was an important source of fish prior to the discovery of gold. It was noted to support pink, chum, coho salmon and steelhead, and was the site of a fish camp (Goldschmidt and Haas, 1998).

Mining

Chief Kowee of the Auk Tribe led Sitka prospectors Richard Harris and Joe Juneau to the Gold Creek watershed during the summer of 1880, which then launched the Juneau Gold Rush. The large, low-grade gold quartz ore deposit in the basin spurned rapid development of both commercial mining operations in the watershed and the formation of the City of Juneau (DeArmond, 1967).

From October 1880 through December 1881, a total of 293 placer claims were filed in the Gold Creek Watershed (DeArmond, 1967). A number of small companies and individual operators mined the area beginning in the 1880's, and these operations eventually were conglomerated into the Alaska Juneau Mining

Company (AJ Mine). The larger mining operations in the watershed included the Perseverance, Ebner, Alaska Gastineau and Alaska Juneau. Mines operated continually in the watershed from 1893 to 1944.

In 1972, the CBJ and AELP acquired most of the historic mining properties, pooled mineral rights, and negotiated a lease of the mining properties. The lease was eventually conveyed to Echo Bay Alaska Inc. (CBJ, 2011a). Exploration work started in 1989, and Echo Bay conducted activities in the old mine including drilling and widening tunnels, washing rock, and drilling core samples (EPA, 1995). The company submitted proposals and permits to begin the development of a 22,000 ton per day operation at the AJ, and after a lengthy and controversial public process they withdrew their permit applications in 1997. Echo Bay cited low gold market pricing as the reason for permit withdrawal. Echo Bay then contracted with Kvaerner Environmental to perform required clean-up and closure tasks, those efforts were completed in 2002.

Much is written about the history of mining in the watershed, a brief summary of infrastructure developed for the historic placer and hard rock mining includes approx. 100 miles of underground tunnels, mills, a wooden flume, tramway, railway, numerous buildings, dams and hydro electrical power (Gillette, 1990). Mining infrastructure that remains in the watershed includes remnant buildings and structures, tailing disposal site, Glory Holes, tunnels and adits (Easton, 1995).

Hydropower

In 1893 a local businessmen installed a water wheel and electric generator on the banks of Gold Creek and by the summer of 1894 Alaska Electric Light and Power Company (AELP) was formed and provided power to some of downtown Juneau (AELP, 2011). Gold Creek was dammed in 1900 for hydraulic placer mining operations and in 1916 the Alaska Juneau Gold Mining Company built the AJ Steam Plant on Gold Creek, along the shore of Gastineau Channel (AELP, 2011a and Easton, 1995). Currently AELP maintains the active Gold Creek Hydro Plant, which generates a seasonal production of 4.5 GWH of energy annually (AELP, 2011).

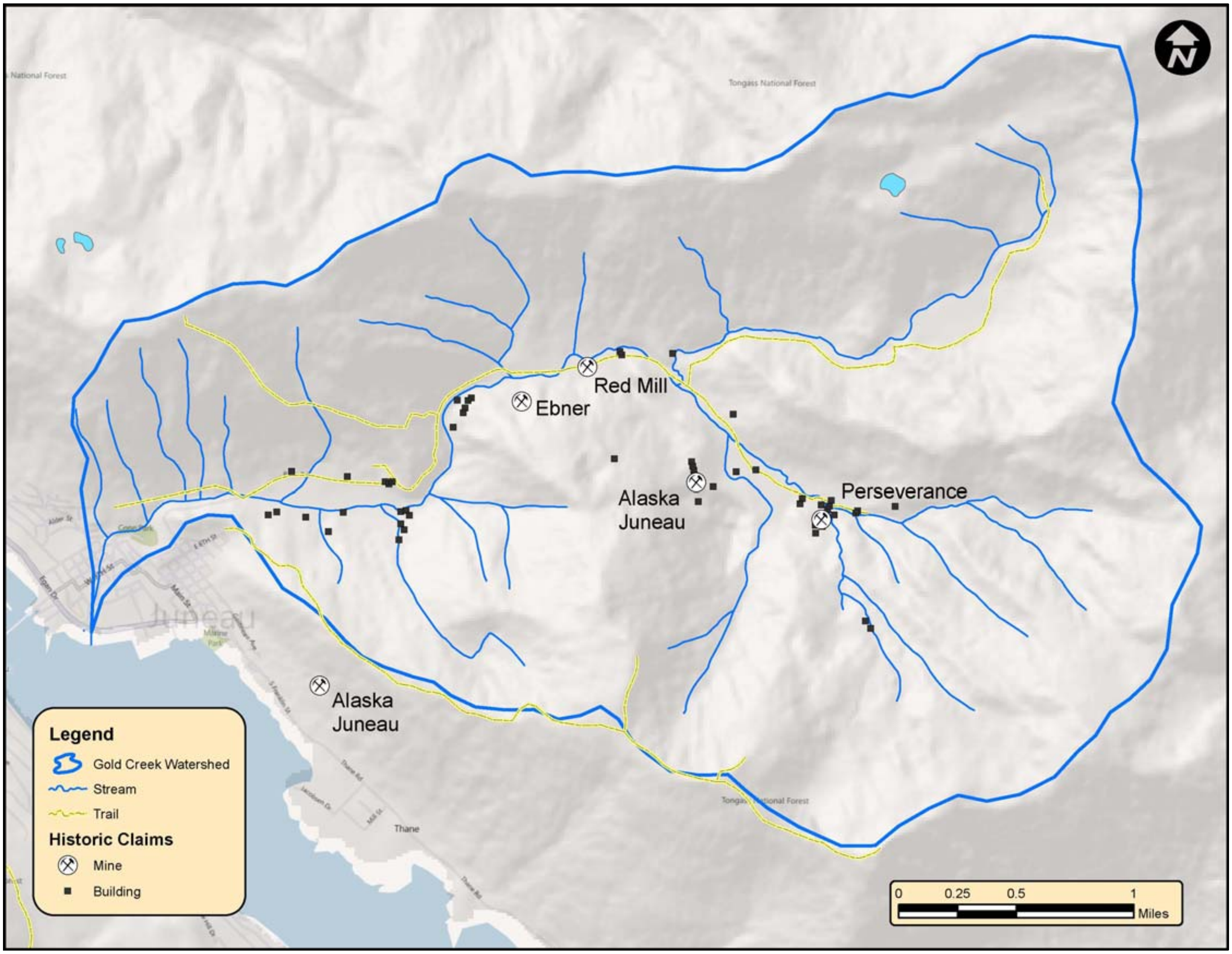


Figure 5: Historic Mining Structures **JWP, 2012**

Data courtesy of Richard Carstensen and Discovery Southeast

2.5 Current Land Uses

Landownership

Landownership in the watershed includes a mix of Federal, State, Municipal and private ownership. Currently, property owners or leases in the Gold Creek Watershed include:

- City and Borough of Juneau- CBJ
- US Forest Service- USFS
- Alaska Department of Natural Resources- DNR
- AEL&P

The Land Use Designation for the upper watershed is identified as "Rural Reserve" by the CBJ and the lower watershed is a mix of residential and light commercial zoning (CBJ, 2011c). Currently land use in the watershed includes residential uses, light commercial, hydropower generation, recreation and tourism use.

Municipal Drinking Water
The Gold Creek and Salmon Creek Watershed are the existing domestic water sources for the CBJ. There are two natural aquifers in the Last Chance Basin, and these are the primary water source for the CBJ, typically supplying 3.0 million gallons per day.

According to the USGS, an aquifer is an underground body of porous materials that is filled with water which has enough supply to be able to contribute to a well or spring. In the case of Gold Creek, the CBJ aquifers are made up of sandy/silty deposits that are thought to be from a prehistoric rockslide/avalanche (CBJ, 1995).

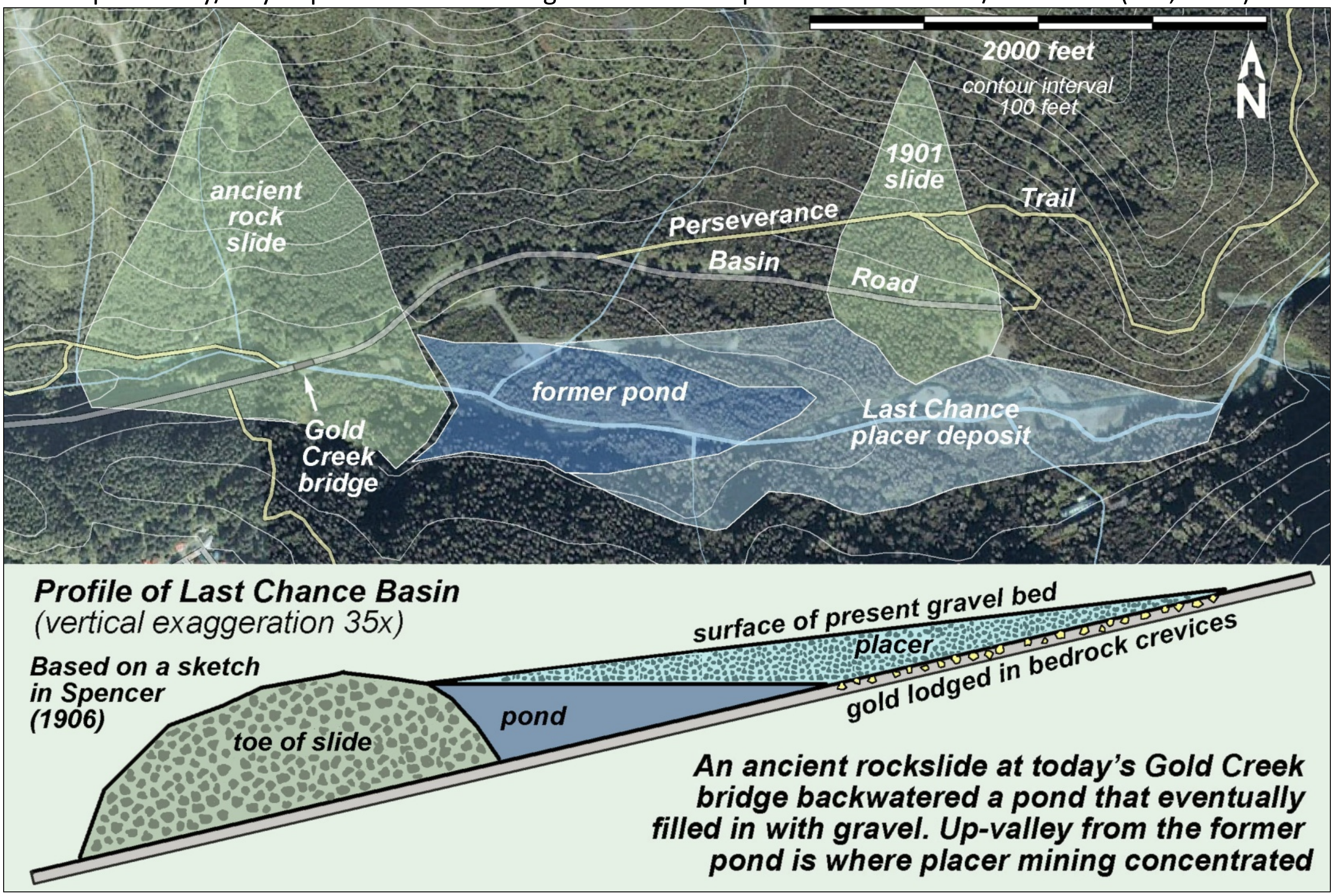


Figure 6: Geological Profile of Last Chance Basin
Figure courtesy of Richard Carstensen and Discovery Southeast

The well field has an unconfined aquifer and a semi-confined production aquifer. (Noll, 1996) An unconfined aquifer means that the water is not confined under pressure of heavy rock or clay. A semi-confined aquifer, or a 'leaky' aquifer, means that the aquifer is partially confined by an impermeable rock layer underneath the aquifer and a semi-permeable soil layer above. According to the Alaska Department of Natural Resources, "A ten to twenty foot silty semi-confining layer exists between the two aquifers. The aquifers are predominantly recharged by Gold Creek in the upper part of Last Chance Basin" (Noll, 1996).

The source was first developed in 1959, with additional wells and improvements made in 1976 and 1990 (CBJ 2011d). The Watershed Control and Wellhead Protection Program—Gold Creek Source (1994) was adopted as part of the CBJ Comprehensive Plan to guide protection of the domestic water supply. The 1994 Update –Last Chance Basin Land Management Plan also provides guidance on land use activities in the watershed to protect Gold Creek as a water supply.

The entire Gold Creek Watershed is designated as the well-head protection area, since the entire area recharges the aquifer and contaminants are reasonably likely to reach the well field from almost anywhere within the recharge area. According to information by Alaska Department of Environmental Conservation (ADEC) , the time of travel in which contaminants could reach the Last Chance Basin well field ranges from several months to two years (ADEC, 2011c).

Recreation and Tourism

Hiking, snowshoeing, skiing, recreational gold panning, bird watching, and biking are some of the recreational uses of the Gold Creek Watershed. Trails in the watershed include the Perseverance, Mount Juneau, Granite Creek, and Mount Roberts Trails. The Perseverance Trail is easily accessible from Basin Road. It has an easier gradient than the other nearby trails and includes access to historic mining sites. The Perseverance Trail is approximately 3.5 miles, though it also provides access to two other recreational trails: the Mount Juneau and the Granite Creek trails.

Cope Park, located adjacent to Gold Creek, is a city-owned park that includes facilities such as picnic shelters, playground equipment, a baseball field, and a tennis court. Several small footpaths connect Cope Park to the Flume Trail and Basin Road, which leads to the larger trails in the area.

Tourism activities in the watershed include the Last Chance Mining Museum, run by the Gastineau Channel Historic Society (GCHS) and Gold Panning tours with Alaska Travel Adventures (ATA). According to GCHS, approximately 2000 people visited the museum in 2011 and the majority of those visitors were local families.

Residential/ Other Commercial Uses

Below Cope Park and along Basin Road, there are residential and mixed-use light commercial areas in the Gold Creek Watershed, and neighborhoods include the "Federal Flats" area and the Willoughby District. Currently a "Willoughby District Land Use Plan" is in draft form at the CBJ and it includes plans to triple the number of residential units in the area, increase commercial use, and to expand civic, cultural and art facilities in the district. The plan also suggests that the CBJ partner with local organizations to remove Gold Creek from the concrete flume from the mouth of the channel up to the Federal Building and try to restore rearing habitat in the lower reach of the creek (Sheinberg, 2011).

2.6 Summary of Current Conditions

Although extensive development has fundamentally changed the natural hydrography of the watershed, Gold Creek has excellent water quality, healthy macroinvertebrate populations, offers good habitat for birds and wildlife, and supports rearing and overwintering of juvenile salmon populations at the mouth of the creek.

3. WATERSHED VUNERABILITY ASSESSMENT

As part of the CBJ report, "Watershed Control and Wellhead Protection Program- Gold Creek Source," (1995), a vulnerability assessment was conducted to identify potential threats to water quality and quantity in the Gold Creek Watershed. The major threats to watershed health identified in the assessment were landslides/avalanches, the diversion of water through the mines drainage tunnels, mineralized sediments from historic mining activity, and the presence of two underground fuel tanks at the well field and commercial facilities and activities.

JWP was tasked to review the 1995 assessment and compare the findings to current conditions in the watershed. In the last 16 years some of these threats have changed or conditions have improved, while some have remained the same. Below is a list of the current status of these potential threats.

3.1 Gold Creek Drainage Tunnel

In 1911, the Alaska Juneau (AJ) mining company planned a new mill above South Franklin Street and began construction of a new access to tunnel reach the ore body. The new access tunnel was called the “Bradley Adit” (aka “Gold Creek Adit”) and extended from the Jualpa Camp (site of the present day Mining Museum in Last Chance Basin) to a location in the mountain near the Perseverance Mill (at the end of Perseverance Trail). The Bradley Adit was used by the developers of the AJ mine to access the mineral deposits in the back of the Gold Creek Valley and to transport ore to the new mill that they constructed above South Franklin Street.

Subsequent mining operations caused surface collapses and introduced significant amounts of water into the mine (Juneau Empire, 2003). A second tunnel was driven in the 1930’s and was designed to drain the water that had begun to enter the mine. This drainage tunnel was parallel to and below the Bradley Adit. This drainage tunnel, called “The Gold Creek Drain Tunnel,“ is nine feet high by seven feet wide and travels 6538 feet through historic mine workings and discharges above the Last Chance Basin well field (Redmen, 1986, CBJ, 2011a).

It is estimated that the tunnel receives as much as 15 percent of the surface run-off flow from the Gold Creek Watershed. However, the percentage of Gold Creek that flows through the drain tunnel varies throughout the year. In the winter, during low flow periods, the greatest percentage of over watershed drainage routes through the tunnel. In the summer the creek and tunnel flow increases significantly, but the overall percentage of water that flows through the tunnel is reduced to as little of as 5 percent of total creek flow (CBJ, 2011a).

During the exploration work of the AJ Mine in the late 1980’s to mid-90’s, Echo Bay Alaska Inc. received several water quality violations in relation to illegal discharges into the Gold Creek Tunnel. In 1989, the DEC issued a ‘Notice of Violation” to Echo Bay for violating water quality standards for turbidity, oil and discharging wastewater without a permit (EPA, 1995).

After the 1994 fish kill event in Gold Creek, EPA investigated a complaint filed by the DEC that alleged that Echo Bay did not properly treat or dispose of their wastewater, failed to report illegal discharges of petroleum, and violated State water quality standards for turbidity (EPA, 1995). EPA found that Echo Bay was in violation of the CWA and fined the company $250,000 for the violations.

In previous reports and in the 2011 AJMAC committee notes, it has been recommended that the Gold Creek tunnel should be completely blocked off, or that the water should be diverted for drainage past the CBJ wellfield, if new mining is to be developed in the watershed. Other recommendations have been to prohibit any discharge into the tunnel or into the underground mining tunnels in the watershed.

The AJMAC also made several recommendations for the protection of water quality and water quantity from the Gold Creek tunnel, including frequent, possibly third party, monitoring of water quality from the outfall of the tunnel if new mining were to occur. They recommended that the CBJ and the future mining developer should have a well designed emergency plan in place in the event that there was a contamination problem in the mine.

3.2 Mineralized Sediments

The Perseverance Mill Waste site is a historic mining tailings (i.e. ore processing milling residuals) disposal site located at the headwaters of Gold Creek. The site was added to the ADEC Contaminated Sites database in 1993 for elevated levels of arsenic, lead, zinc, and mercury present in the tailings piles. The potential impacts from these tailings and associated buried mining equipment include contamination from sediment, metal and metalloid contamination from exposed or leaching materials. Another tailings pile from the AJ stamp mill is located downstream from the Glory Hole at the end of Basin Road. However, ADEC found that surface water and groundwater from that site was above drinking water standards for heavy metals (ADEC, 2011b).

The specific threat to watershed health identified in 1995 was that future construction or surface mining on, or around, the tailings could accelerate leaching of and exposure to these metals. As the landscape ages, hydrological flowpaths can change, landscape erosion occurs and leaching will potentially change over time. This area will need ongoing monitoring if there is the potential for metals contamination, as identified by the ADEC in 1993.

According to the CBJ Engineering Department, there are no future plans for addition clean-up of historic mining remnants or tailings. Water quality sampling has not indicated that the historic tailings present a hazard to the drinking water system and to remove the tailings road improvements into the Silverbow Basin would need to be constructed .

3.3 Landslides/ Avalanches

Both landslides and avalanches are a continuing threat to water quality and quantity in the Gold Creek watershed, with the primary concern being increased sedimentation and erosion in Gold Creek and the Last Chance Basin wellfield. Snowslide Gulch coming off of Mount Roberts and multiple avalanche paths on Mount Juneau could impact Gold Creek (CBJ, 2009). One concern with avalanches and landslides is increased turbidity in Gold Creek and the Last Chance Basin wellfield. While in some instances the turbidity levels in the well water correlates with Gold Creek turbidity levels, the layers of sand, silt and gravel overlying the aquifer serves as a natural filter to some extent (Easton 1995).

However, if present in the water, sediment from avalanches or landslides can reduce the effectiveness of disinfection process (Easton 1995). Chlorination is the only treatment drinking water derived from the Last Chance Basin wellfield receives (CBJ 2011d). There is no filtration process to treat the water for sediment and other particles.

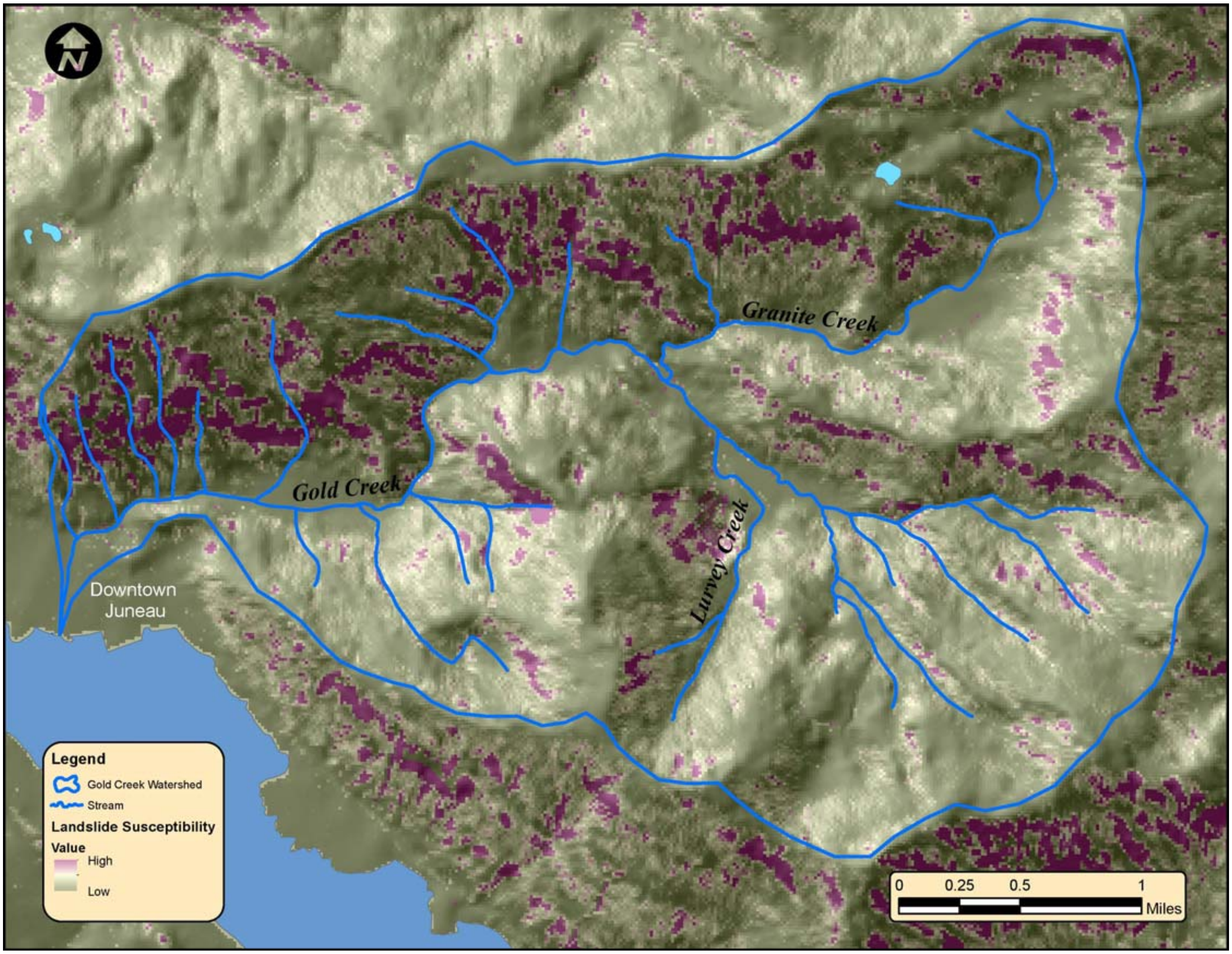


Figure 7: Landslide Susceptibility in the Gold Creek Watershed **JWP, 2012**
Data courtesy of Earth Systems Institute

Staff from Earth Systems Institute in Mt. Shasta, CA, used NetMap software to predict landslide susceptibility for the Gold Creek watershed. Landslide susceptibility is based on calculation of a topographic index (TI) where two well-recognized topographic drivers of hillslope stability, namely gradient and convergence, were used (Miller and Burnett 2007 and 2008). Figure 7 shows a gradient of highest landslide susceptibility to lowest, with the northern part of the watershed showing the greatest risk of landslide potential.

3.4 Underground Storage Tanks

There were two underground storage tanks (UST) in the Last Chance Basin in 1995, and both were owned by the CBJ and were used to store diesel fuel for emergency fuel power. The concern was that the first UST was installed in 1974 and there was a threat of volatile organic compounds leaking into the well field, but up to that point there was no evidence of leaks, spills or contamination at the site.

In June of 1996, a small petroleum leak was detected from the older UST in Last Chance Basin. ADEC inspected the site and found a leak but noted that the contamination volume was extremely small as shown by samples immediately downgradient. Although the leak was small, the ADEC added this site to their Contaminate Site Database. In August of 1996, the ADEC gave their approval to close the site from the database after the CBJ completely removed the tank from the ground that summer. (ADEC, 2011a)

According to the CBJ, the remaining fuel tank has corrosion protection, spill and overfill basins, and has double wall fuel piping. If there were leaks in the fuel piping, fuel would drain back in the secondary containment piping to a basin on the fuel tank.

3.5 Other Vulnerabilities

Several other threats to water quality and quantity were identified in the 1995 report and they are summarized below identifying the factor of concern, what the management recommendations were in the past to address these concerns, and what the current conditions of these factors are today.

Current Use	**1995 Factor of Concern**	**1995 Management Recommendation**	**Current Conditions**
Recreation	Microbial contamination from humans and dogs.	Prohibit camping in the Last Chance Basin.	In March 1998, adopted a local CBJ ordinance No. 98-07 which prohibits camping in Last Chance Basin or camping for more than two nights in the Gold Creek Watershed outside the Last Chance Basin.
Recreation	Microbial contamination from humans and dogs.	Require that dog owners remove feces from Last Chance Basin	CBJ Code 08.40.020, Leash Law prohibits dogs off leash in the Gold Creek Watershed (Re: The area bounded on the north by Basin Road, on the east by Snowslide Gulch, on the south by an imaginary line 500 feet south of Gold Creek, and on the west by the gate to the Last Chance Basin wellfield) CBJ Code 08.40.040 requires that dog owners in the Last Chance Basin leash area, must carry an instrument and container to properly remove dog waste from the area.
Recreation	Microbial contamination from humans and dogs.	Require that dog owners remove feces from Last Chance Basin	CBJ and Grateful Dog groups provide dog waste bags and garbage disposal at the Mt. Roberts trailhead and at the Perseverance Trail head.
Commercial Operations	Gold Creek Salmon Bake operations and increased or new commercial activity in the watershed.	Ensure current commercial activities pose no threat to water quality. Prohibit the development of future commercial activities and restrict commercial activities to minor uses that will not cause discharges of pollutants in the watershed. Remove existing Salmon Bake facilities if another use is not finalized by May 1995.	Gold Creek Salmon Bake has moved to the Fish Creek Watershed. Alaska Travel Adventures brings in cruise ship passengers for the gold panning tour, although they use existing infrastructure for their operations.

Wildlife	Microbiological contamination	Monitor for changes and the presence of aquatic mammals.	According to the EPA, decreasing the risk of containment in municipal water supplies can be managed by removing wildlife attractants or harassing nuisance species, but that does not seem feasible or practical in Juneau due to our abundance and distribution of wildlife in our city.
Sub-Normal Temperatures and Precipitation	Water quantity concern	Control measures cannot be identified, manage for emergencies.	Potential Limitation of existing drinking water system.
Basin Road	Volatile organic compounds, sediments, runoff and other road maintenance chemicals	Continue to maintain Basin Road to minimize erosion, illegal dumping and runoff. Maintain Basin Road in an unimproved state.	No change.

3.6 Summary of Vulnerability Assessment

While there are still threats to watershed health in Gold Creek, the CBJ has addressed and mitigated some of the concerns in the 1995 assessment. However, other factors of concern have not changed or cannot be changed through management controls.

Continued monitoring of the underground storage tanks and mineralized sediment areas is needed to reduce the threat of toxins and pollutants entering the Gold Creek system. The CBJ and AELP should continue to update emergency management plans in the watershed to be able to respond quickly to natural threats, such as landslides and avalanches.

The CBJ should also continue to explore alternate sources of municipal drinking water and work to promote water conservation efforts in the community. These are proactive measures to address the potential threat of water shortages or contamination due to landslides and avalanches, as well as planning ahead for potential mining developments in the area.

4. CONCLUSIONS AND RECOMENDATIONS

The Gold Creek Watershed is a valuable recreational and historical area for the City and Borough of Juneau. It serves as the main source of CBJ municipal drinking water and a secondary source of municipal hydropower. Gold Creek remains a relatively pristine watershed supporting populations of birds, mammals, fish and other aquatic life, despite the previous mining activities and current recreation and municipal water use.

Recommendations for further study or action in the watershed include:

- Further study on the Gold Creek tunnel drainage system is needed to better understand how future mining developments might affect water quality and quantity in the Gold Creek system.
- Based on historic USGS flow measurement and previous ‘fish kill’ events, Gold Creek can have dramatic fluctuations of flow. A permanent stream-gaging station should be reestablished on Gold Creek to obtain a continuous record of flow, periodic discharge, and other information in order for CBJ and AELP land managers to understand the relationship between seasonal flow and discharge in Gold Creek.

- Invasive and noxious weed survey and a long term management plan for invasive weeds in the watershed should be conducted to help protect native plant populations.
- Restoring the tidally-influenced, confined reach of the watershed could improve rearing and overwintering habitat for juvenile salmon and a large scale restoration project could also improve the aesthetic values of the creek in the lower watershed.
- Additional development in the watershed must be planned and developed to protect and maintain water quality in Gold Creek for the municipal water system and for fish and other habitat values.

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AJ Mine Related Water Resources Report

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The City and Borough of Juneau (CBJ) is evaluating the potential opportunities and challenges/constraints associated with the redevelopment of the AJ Mine. Some of the challenges/constraints arise from the location of CBJ's existing water supply infrastructure and its proximity to historic mine workings.

CBJ derives its water from two water sources for the area wide water system. The Last Chance Basin well field on Gold Creek is the primary source; Salmon Creek provides CBJ's secondary water source. The Last Chance Basin well field consists of five wells drilled into aquifer in direct communication with Gold Creek. Because Gold Creek is CBJ's only dependable year-round water supply, any reduction in flow or proposed industrial development near or within the Gold Creek watershed needs to be evaluated for potential effects on ground and surface water supply within the Gold Creek drainage system. This report considers the existing AJ Mine drainage tunnel which discharges above CBJ's existing well fields.

Salmon Creek Dam is located in the upper reaches of the Salmon Creek watershed and the water stored behind the dam feeds the Alaska Electric Light & Power (AEL&P) hydro powerhouse which is located near sea level below the Dam. CBJ obtains water from Salmon Creek after it passes through the generator facility. Salmon Creek is only an intermittent water source for CBJ because of seasonally high turbidity. Salmon Creek Dam is the sole source water provider for the Douglas Island Pink and Chum Hatchery located on lower Salmon Creek (AEL&P, 2011). This water source is also unavailable to CBJ during annual AEL&P maintenance of the power plant.

The AJ Mine operated from 1891 to 1944 and processed; approximately 100,000,000 tons of ore during that time. Between 1936 and 1939, the AJ Mine drainage tunnel was driven through the ore body to drain water that entered the mine from seepage and overhead subsidence areas (glory holes) (AJ Mine NPDES Permit, 1997).

This water resource report describes existing conditions within the CBJ's water supply system. Section 2 summarizes water rights for Gold Creek. Section 3 summarizes existing information regarding water quantities and water quality for Gold Creek and for the AJ mine drainage tunnel.

2.0 EXISTING WATER RIGHTS FOR GOLD CREEK

Water rights in Alaska are legal rights to use ground or surface water under the Alaska Water Use Act (AS 46.15). Water rights certify a specific amount of water from a specific source to be withdrawn, diverted or impounded for a specific use. Preferential appropriation goes to applicants who intend to use the water for public water supply (AS 46.15.090). When there are competing applications for water from the same source, and the source is insufficient to supply all applicants, preference is given first to public water supply and then to the use that alone or in combination with other foreseeable uses will constitute the most beneficial use (AS 46.15.090). Once water rights have been appropriated the water right certificate are transferred with the sale or transfer of the land. With permission from the commissioner, all or part of the appropriation of water may be sold, leased or transferred (AS 46.15.160).

Three certificates of appropriation have been issued for Gold Creek water rights by the Alaska Department of Natural Resources (DNR) and one application by CBJ for additional water rights is pending from 1990, these water rights are profiled in Table 1. The three certified water rights appropriate a total use of 144.8 cubic feet per second (cfs) of flow from Gold Creek; however this amount is not used or required at all times throughout a given year. The average annual flow in Gold Creek is 116 cfs, and during the winter, low flow events can decrease to less than 10 cfs (DNR, 1993).

Table 1. Gold Creek Water Rights.

File	Name	Status	Priority/Date	Point of Diversion	Type of Use	Cubic feet per second (CFS)	Gallons per minute (GPM)	Million gallons per day (MGD)
ADL-43152	AEL&P	Certificate	5/16/1896	Intake weir at Basin Road	Powerhouse capitol Ave	137	61,485	88.5
ADL-44439	CBJ	Certificate	12/31/1962	Last Chance Basin Wells 1 and 2	Juneau Public Water Source	5.5	2,468	3.55
ADL-100066	CBJ	Certificate	4/12/1977	Last Chance Basin Well 3	Juneau Public Water Source	2.3	1,032	1.49
LAS-13044	CBJ	Application	8/16/1990	Last Chance Basin Wells 1 through 5	Juneau Public Water Source	10.8	4,860	7
Total Certified						144.8	64,985	93.5
Total Certified and Applications						155.6	69,845	100.5

CBJ is currently appropriated 7.8 cfs from Gold Creek, with an additional 10.8 cfs application pending since 1990. CBJ pumps its appropriated share of the water through the Last Chance Basin ground water well system. The five ground-water supply wells are, capable of producing up to 18 cfs. The wells are screened in a deep-semi confined aquifer. On average CBJ currently uses 3.9-7 cfs from the Last Chance Basin well field (CBJ, 2011).

AEL&P installed the initial hydroelectric plant in downtown Juneau at the base of Gold Creek, in 1893 and rebuilt it in 1914, with upgrades completed in the 1950s. In the late 1990's AEL&P replaced sections of the penstock and installed a fore bay to remove sediment and debris. AEL&P is appropriated 137 cfs from Gold Creek to power the hydroelectric powerhouse. Energy production from the Gold Creek hydroelectric powerhouse peaks during higher demand periods (May-November) and drops off significantly during Gold Creek's low-flow periods in the winter months. Currently the Gold Creek plant produces approximately 4.5 gigawatt hours (GWh) of energy annually. Monthly averages of AEL&P's estimated annual usage of Gold Creek is shown in Table 2.

Table 2. Monthly averages of AEL&P's annual usage of Gold Creek.

Gold Creek Flume	
Estimated Water Usage	
Month	**Average CFS**
JAN	18
FEB	11
MAR	8
APR	27
MAY	86
JUN	97
JUL	94
AUG	76
SEP	65
OCT	67
NOV	37
DEC	24

The Salmon Creek Dam and powerhouses were constructed in 1914. A series of upgrades have been made since then, including a new powerhouse built in 1984, which generates 29.5 GWh annually. This supplies approximately 10 percent of Juneau's power. The majority of Juneau's power is supplied by the Snettisham Hydroelectric Plant producing 78,000 GWh annually (AEL&P, 2011).

No instream flow requirements have been established for Gold Creek. The state, an agency, or a person may apply to the commissioner to reserve sufficient water to maintain a specified instream flow or water level at a specific point on a stream or body of water throughout a year or at specific times in order to protect fish and wildlife migration, habitat and propagation. Additionally instream flow can be reserved for recreational, navigational, sanitary and water quality purposes. The commissioner shall issue a certificate reserving instream flow if it is found the rights of prior appropriations will not be affected and the applicant has demonstrated a need for the reservation or the proposed reservation is in the public interest. Once a certificate reserving instream flow is issued, any new applications to appropriate reserved instream flow water will be rejected. A reservation of in stream flow cannot affect certified water rights in existence (AS 46.15.145).

In the 1990's Echo Bay proposed to use and divert water from the Gold Creek watershed for use in their mill. It is not known how much water a future mine operator could use for the mine concept that CBJ is currently considering. Operations at the AJ mine would require fresh water (makeup water) for the milling process, domestic uses, and mining operations, including dust suppression. Specific water supply demands for the AJ project would depend on the amount of ore being processed per day, the number of on-site workers, and variables associated with the mining methods employed. However, a comparison of water usage at the Kensington mine can be used as an example of approximate potential demands.

Goals for the Kensington Project were to mine and process 2,000 tons of ore per day (tpd). Approximately 200 on-site workers would be hosed at the site at any given time (USFS, 2004). Mine operations continue 24 hours a day and 7 days per week. Total fresh water demands average approximately 234 gallons per minute (gpm) which is 0.52 cfs. Specific requirements are 84 gpm (0.19 cfs) for the milling circuit which is a froth floatation process, however most of this requirement is recycled. There is a small loss of water in the produced concentrate and tailings which must be made up from a water source. Kensington requires 50 gpm (0.11 cfs) for domestic water with is approximately 0.25 gpm per on-site worker. Power supply and mining operations require 100 gpm (0.22 cfs) which is approximately 0.05 gpm per ton of ore produced per day.

3.0 WATER QUANTITY/QUALITY FOR GOLD CREEK AND AJ DRAINAGE TUNNEL

3.1 Flow Characterization of Gold Creek

Gold Creek drains an area of 8.4 square miles above the Last Chance Basin, and is a major recharge source for the aquifers in Last Chance Basin (Figure 1). The United States Geological Survey (USGS) maintained a stream flow gage in Gold Creek from 1916 to 2006. Mean monthly and annual discharge rates were calculated from daily discharge rates and are presented in Table 3 and Table 4, respectively. The USGS reports that the annual mean discharge from Gold Creek is 116 cfs. The average annual discharge ranges between 155 cfs and 77.5 cfs. The maximum recorded peak flow is 2,950 cfs and the lowest recorded instantaneous flow is 0 cfs (USGS, 2011). Periods of no flow in Gold Creek were recorded by the USGS gage located near AEL&P's diversion in 1951, 1956, 1974, and 1982 (USGS, 1990). In January 1991, Gold Creek was recorded at approximately 7 cfs at the USGS gage, however the creek was reported to be completely dry approximately 1,000 feet below the Salmon Bake Bridge (Figure 1) (DNR, 1993).

Historic Fish Kills. In March 1994 an estimated 200-300 dead Dolly Varden char *(Salvelinus malma)* were found dead in a pool in Gold Creek at the bottom of Last Chance Basin. A second fish kill event occurred the following year during a low flow event in Gold Creek (Figure 2). The 1995 fish kill event coincided with a hydrologic evaluation of Last Chance Basin being conducted by the DNR. Flow conditions in Gold Creek were checked and found to be dry between the CBJ well field and the metal car bridge.

"*During January 1995 another fish kill occurred concurrently with this study. On January 12th living, dying, and dead fish were observed in the lower pool on dewatered stream bed under an insulating layer of ice. The State Department of Fish and Game fish pathologist examined the fish and found them to be in a similar state to those found in the 1994 fish kill event, including sediment imbedded in the gills. DEC personnel observed Gold Creek going dry between CBJ well field and the metal car bridge early in the morning. This dewatering occurred when water demand increased and the CBJ pumps cycled on.*

After observing the 1995 fish kill and the well logs for MW-C, Gold Creek dewatering was reevaluated as the sole or primary cause of the 1994 fish kill. The fish in Gold Creek appear to have adapted to sudden dewatering by burrowing into the sediment. Fish that die from dewatered conditions do so at varying times, and do not show a uniform time of death, evidence of drying, or evidence of freezing" –Attorney General Report, 1995, pg. 13

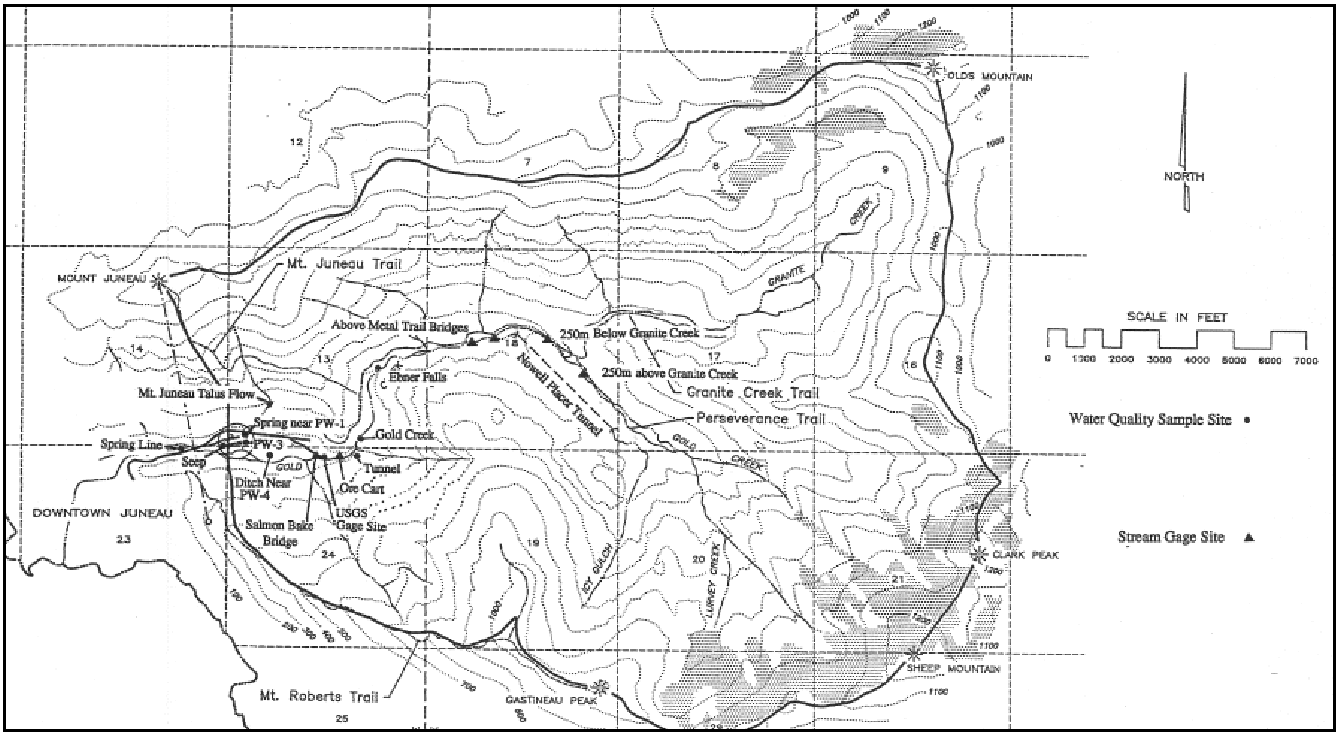

Figure 1. Overview of Last Chance Basin (DNR, 1993).

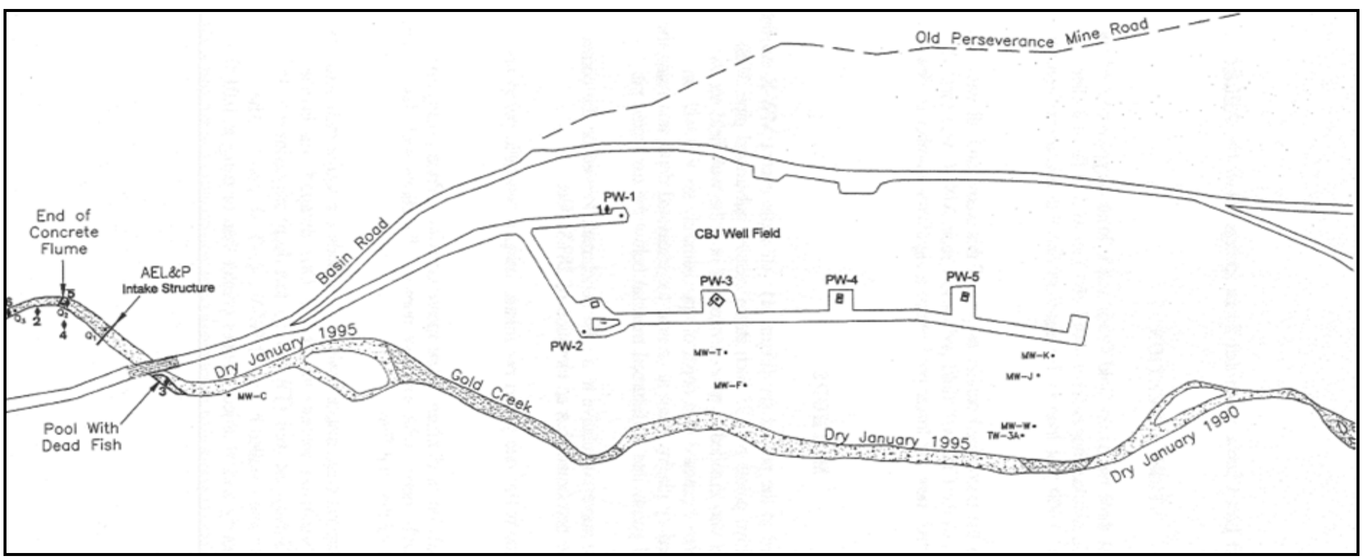

Figure 2. Map of CBJ well fields and areas of Gold Creek that were pumped dry in 1994 and 1995 resulting in the fish kills observed downstream (Noll, 1996).

Table 3. USGS Gage Data for average monthly discharge of Gold Creek 1916-2006 (below CBJ well field).

YEAR	Average Monthly Discharge in Gold Creek in cfs (1916-08-01 - 2006-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1916	-	-	-	-	-	-	-	208.7	225.5	177.4	45.8	13.2
1917	7.85	27	8.42	17.4	118.3	215.9	250.5	219.6	156.6	138.9	158.1	18.7
1918	11.1	4	1	7.77	105.4	212.1	208.8	259.5	195.2	112.7	117.7	34.3
1919	26.6	9.54	5	35	79.8	158.9	237.1	175.9	192	114.8	39	27
1920	47.6	14.4	3.91	10.3	64.5	248.5	255.7	251.6	161.3	89.7	106.3	11
1946	-	-	-	-	-	-	-	-	-	170.7	205.8	16.4
1947	15.7	6.36	137.5	91.7	173.2	220.9	179.7	173.8	278.1	140.2	139.8	53.6
1948	41.2	11.9	3.03	4.3	220	195.1	211	113.8	238.4	-	-	-
1949	-	-	-	-	-	-	-	-	-	193.2	192.5	20.1
1950	4.37	1.29	0.755	3.9	97.2	197.2	191.4	118	150.9	69.9	30.4	6.43
1951	5.06	1.52	2.38	22.1	170	246.4	177.2	103.6	89.7	62.6	41	18.7
1952	4.36	2.23	3.96	23.1	116.7	207.2	237.4	200.6	261.1	202.8	129.4	32.2
1953	11.2	8.53	2.69	26.2	169.6	218.4	175.9	166.1	166.6	210	35.3	33.7
1954	11.2	50	4.67	3.78	104.5	201.1	177.5	98.3	115	109.3	121.9	102.6
1955	20.9	9.64	5.66	8.98	86.2	226.9	270.6	270	167.8	87	50.5	6.22
1956	2	0.6	0.335	6.16	185.9	181.5	200.7	251	112.3	99.9	165.3	95
1957	25.3	5.76	2.75	16.8	151.8	261.8	192.2	109.9	154.5	92.4	147.8	21.1
1958	44.2	8.29	6.23	36.7	166.8	206.8	166.5	146.5	101.1	178.7	56.1	49
1959	10.6	5.68	9.09	17.9	141.9	280.9	290.6	218.3	124.6	136.5	82.2	38.1
1960	16	9.68	8.28	31.9	159.4	219.9	269.1	179	199.3	208.8	98.2	86.6
1961	33.3	25.6	14.5	42	172.1	265.7	305.3	374.2	157.1	200.6	46.5	9.84
1962	25.7	11.4	2.63	20.2	92.8	269.5	227	169.2	270.9	147.7	99.2	90
1963	37.5	69.2	25.1	24.6	153.3	204.7	192.1	106	161.3	185.2	37.3	52.3
1964	19.7	24.8	10.4	33.1	108.3	306.5	354.2	182.2	105.3	124.8	67.8	38.8
1965	57.9	10.2	18.6	33.8	80.3	223.2	220.5	150.3	105.1	183	38.6	22.8
1966	3.72	3.04	15.5	21.9	77.7	227	193.4	244.7	176.3	149.8	49.3	14.4
1967	13	2.61	1.62	5.04	122.8	274.6	192.4	206.5	297.3	111.9	153.8	24.5
1968	11.4	24.2	63.6	20.3	104.3	153.1	151.7	85.4	237.6	90.5	47	14.9
1969	3.04	0.747	1.63	19.6	142.9	250.1	252.1	178.1	98.5	88.6	117.4	63.1
1970	9.46	28.2	26.5	30.2	96.1	231.5	266.8	277.6	285	145.8	61.1	10.7
1971	24.3	9.05	4.3	21.9	74.6	189.1	236	213.7	153.6	80.6	31	13.6
1972	2.14	0.478	11.8	7.78	130.8	207.3	231	342.8	228	167.8	42.3	12.6
1973	6.73	9.3	8.49	49.5	137.4	207.2	223.6	297.3	135.3	126.7	18.8	6.58
1974	1.71	2.28	0.055	14.8	100.5	216.7	198.6	202.4	162.3	255.3	134.9	39.2
1975	14.6	3.72	1.69	15.5	129.9	212.4	363.8	186.1	223.7	119.2	18.1	18.6
1976	18.2	20.3	5.47	19.9	121.2	197.3	235.7	169.1	232.5	123	112.5	30.9
1977	25.6	81.4	15.3	67.2	109.5	284.7	216.5	143.2	167	168.6	26.2	6.62

YEAR	Average Monthly Discharge in Gold Creek in cfs (1916-08-01 - 2006-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1978	8.05	19.1	11	31.5	103.9	228.9	210.3	123.5	73.7	334.5	84.6	37.2
1979	6.55	2.27	13	29.3	145.7	248.3	299.7	116.4	165.6	238.9	108.8	40.2
1980	13.8	20.2	15.6	46.4	128.7	262.6	256.5	227.7	177.1	273.3	107	22.4
1981	170.3	26.4	29.5	18.8	137.3	133.9	154.4	159.4	275.4	149.5	101.6	20.4
1982	5.32	0.874	0.107	7.27	92.5	215.2	130.4	100.4	130.5	-	-	-
1997	-	-	-	-	-	-	-	-	-	144.6	58.2	94.8
1998	14.5	16.1	11.1	33.7	173.9	196.1	192.2	219.6	271.1	227.5	19.3	17.7
1999	16.8	2.12	2.32	31.3	120.7	244	177.7	185.3	302.3	349.2	50.2	202.2
2000	43.3	6.89	15	41.3	142.8	277.5	310.3	221.8	193.5	154.2	69.9	28.8
2001	44.2	26.5	11.4	9.39	68.8	228.6	269.5	138	210.9	158.2	33.1	25.6
2002	34.4	15.1	8.02	7.9	167.4	326.1	306.5	367.2	157.4	243.9	94.5	73.6
2003	49.1	10.1	5.58	36.6	77.2	121.3	110.6	117.3	267.6	109	51.3	43.5
2004	52.1	50.4	17.1	57.9	199.8	227.5	139.9	51.7	183.9	132.7	89	135.9
2005	18.1	14.9	50.5	108	179.2	136.7	162.7	148	282.5	140.8	299.1	74
2006	13.5	6.27	2.09	17.9	138.7	281	173.1	248	333.1	-	-	-
Mean of monthly Discharge	23	15	13	27	128	224	222	188	190	158	86	40
** No Incomplete data have been used for statistical calculation												

Table 4. USGS Gage Data for annual mean discharge of Gold Creek 1916-2006 (below CBJ well field).

Water Year	00060, Discharge, cubic feet per second
1948	114.6
1950	97.9
1951	77.5
1952	98.4
1953	109.7
1954	87.4
1955	117.4
1956	90.9
1957	107.1
1958	95.8
1959	116.1
1960	112.8
1961	149.7
1962	112.6

Water Year	00060, Discharge, cubic feet per second
1963	109.4
1964	118.8
1965	94.8
1966	101.3
1967	111.2
1968	95.0
1969	92.2
1970	127.1
1971	95.9
1972	107.7
1973	108.9
1974	88.1
1975	132.6
1976	98.2
1977	114.5
1978	84.8
1979	124.5
1980	128.4
1981	126.4
1982	79.8
1998	119.4
1999	112.8
2000	155.5
2001	105.4
2002	134.9
2003	101.0
2004	98.6
2005	122.0
2006	144.1

3.2 Flow Characterization of AJ Mine Drainage Tunnel

Historic mining activities produced glory holes (sink holes created by the collapse of underground workings) at the upper end of the Gold Creek watershed in the Silverbow Basin. The glory holes currently capture a small portion of water from Gold Creek (Figure 3). The captured water is routed through the mine and is redirected back to Gold Creek through the AJ Mine drainage tunnel. This tunnel discharges into Gold Creek near the head of Last Chance Basin, upstream of the USGS gage and, immediately west of Snowslide Gulch. Glory holes capture an estimated average of 5 to 6.5 percent of summer and 11 to 14 percent of winter stream flow from upstream portions of Gold Creek, the flows are then, intercepted by the AJ Mine drainage tunnel and returned to Gold Creek downstream (OTT, 1989). In the late 1980s and early 1990s Echo Bay Mines actively pursued re-opening the AJ Mine and submitted a series of baseline studies. Bureau of Land Management (BLM) prepared an environmental impact statement (EIS). Echo Bay proposed plugging the old AJ Mine drainage tunnel to prevent water contamination in Gold Creek during mining operations.

Discharge rates for the AJ Mine drainage tunnel are a function of Gold Creek discharge. IT Corporation developed a regression analysis of the AJ Mine drainage tunnel discharge by comparing Gold Creek stream flow during low flow winter months to discharges from the AJ Mine drainage tunnel (R^2=.84) This relationship is presented in Table 5.

Table 5. Regression of AJ Mine drainage tunnel discharge on Gold Creek flow.

Gold Creek Flow (cfs)	Calculated AJ Mine Tunnel Flow (cfs)	Date
4.91	1.01	March 1989
7.57	1.23	February 1989
11.5	2.00	February 1990
12.5	1.60	January 1989
13.0 est.	1.45	December 1990
13.3	1.59	January 1988
16.0 est.	1.79	January 1997
20.2	1.98	March 1988
21.9	1.39	February 1988
26.6	3.48	March 1990
29.6	3.48	January 1990
30.5	2.00	April 1988
31.5	2.50	April 1989
47.5	3.60	December 1987
55.9	4.83	December 1988
61.8	4.71	April 1990

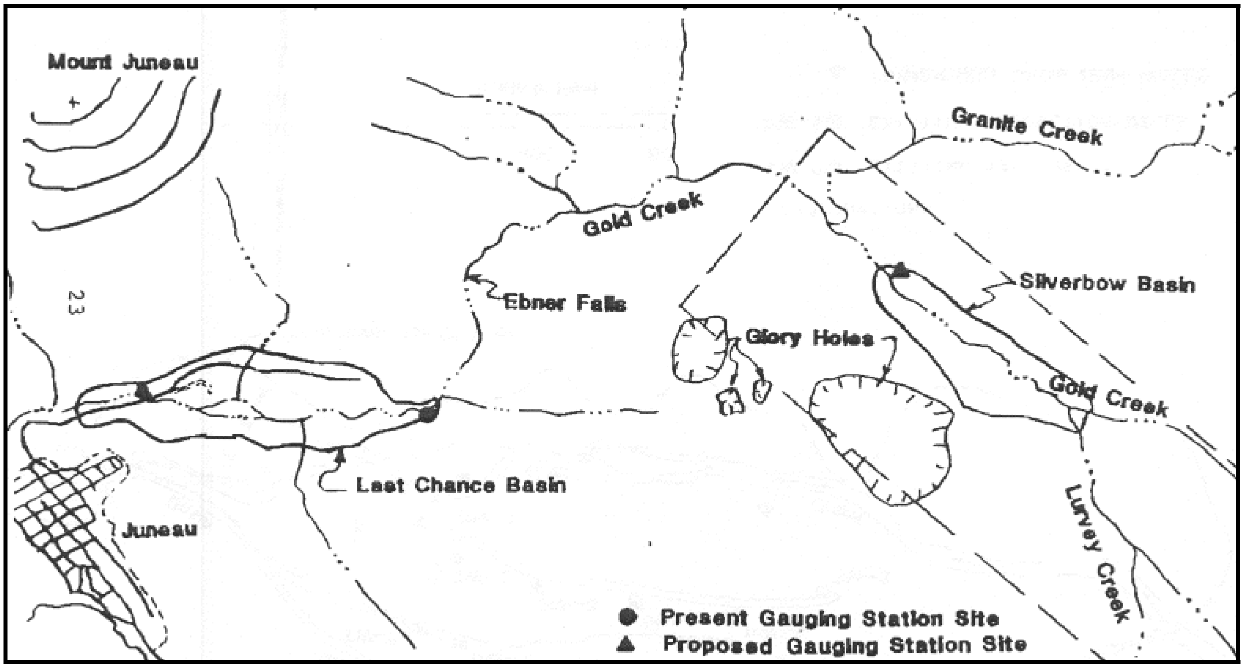

Figure 3. Sketch of glory hole locations and USGS gage location in the Last Chance Basin (Motyka, 1990).

3.3 Last Chance Basin Well Field Yield

The Last Chance Basin hydrogeologic system is composed of two gravel and sand aquifers. The upper aquifer is shallow and unconfined while the deeper aquifer is semi-confined by a clayey, silty sand bed. Below the deep aquifer is an extensive clay layer, more than >236 feet thick (Waller, 1959). The shallow upper aquifer is in direct connection with Gold Creek along the entire reach of Gold Creek. Ground water levels in the deep aquifer are highest near the head of Last Chance Basin and gradually decrease towards the lower portion of the basin, indicating ground water flows westward across Last Chance Basin (Waller, 1959). CBJ's five production wells draw from the deeper semi-confined aquifer. Pump tests of the production wells indicate that the shallow aquifer is in direct hydraulic communication with Gold Creek, supporting base flows, but also acts as a storage reservoir for the deeper aquifer. The transmissivity of the aquifer ranges from 18,000 to 188,000 gallons per day per foot. The hydraulic conductivity spans from 360 to 2,300 gpd/ft^2 (Waller, 1959). The Last Chance Basin aquifers are recharged by infiltration of snow melt and runoff from the talus slopes on the north side of the basin as well as leakage from Gold Creek (IT Corporation, 1992). The total aquifer storage in the Last Chance Basin is estimated to be 117 million gallons in the shallow aquifer and 263 million gallons in the deep semi-confined aquifer (Montgomery, 1985).

Gold Creek typically has low flows during winter months, when frozen conditions restrict the volume of surface runoff or infiltration from the talus slopes. During periods of freezing, Gold Creek and the water that does manage to flow from the talus slopes become the only recharge sources for the Last Chance Basin aquifers. When Gold Creek flow decreases below CBJ's well field pumping rates, water stored in the aquifer is drawn down to supply the remaining water needed by CBJ's well field. On average CBJ water consumption from the well field ranges from

3.9 to 7 cfs (CBJ Water Usage Statistics, 2011). Historically CBJ's water consumption during winter months has averaged 4.5 cfs (CBJ Water Usage Statistics, 2011). USGS gage data reported Gold Creek flow below 4.5 cfs for more than 30 consecutive days during winter months in 14 years since 1950, and less than 6.4 cfs for more than 45 consecutive days during winter months in 12 years since 1950 (USGS, 1990). In addition to CBJ's average consumption of 4.5 cfs, CBJ's fire-flow requirements can exceed 10.4 cfs for a three hour period in the event of a fire event (equates to approximately 850,000 gallons) (Motyka, 1993). CBJ has approximately 13.4 million gallons of water storage capacity within its existing steel and tunnel reservoir.

The IT Corporation conducted an analysis for Echo Bay of Gold Creek flow rates in correlation with the Last Chance Basin's well field yield. IT Corporation's analysis was based on average discharge rates from the AJ Mine drainage tunnel and Gold Creek, as well as Last Chance Basin aquifer recharge and CBJ pumping rates (IT Corporation, 1992; DNR, 1993). DNR did not fully agree with regression models compiled by IT Corporation and conducted its own analysis using a different data set (DNR, 1993).

Based on the rate and duration of time the aquifer is pumped, water yield from Last Chance Basin can be temporarily supported by water stored in the aquifer (DNR, 1993). DNR analyzed the impact of Gold Creek's low flow events on CBJ's well field by assuming zero flow in the creek and calculating sustainable pumping rates, based on 7, 14, and 30 day periods of zero cfs flow in Gold Creek. DNR's estimates the aquifer could support a pumping rate of 7.1 cfs for seven days, 3.5 cfs for 14 days, and 1.0 cfs for 30 days during periods of zero flow (DNR, 1993). Assuming zero flow is a conservative number, from 1915 to 2006 the USGS gage recorded periods of zero flow ranging from 7 to 20 days in the months of March and April in the years, 1951, 1956, 1974, 1982, 1999 (USGS, 2012). It should be noted the USGS gage measures Gold Creek flow below the CBJ well field, after CBJ drinking water has been removed, therefore the flow analyses are conservative.

Tetra Tech conducted a flow duration analysis for Gold Creek for this report, to evaluate the percentage of time that high and low flows occur. A flow duration curve is a probabilistic description of stream flow, and plots the percentage of time a stream is likely to equal or exceed a specific value or limit of interest. Flow duration curves can be used in conjunction with other information to gain a greater understanding of that stream. For example, a sediment load rating curve can be used in conjunction with a flow duration curve to estimate the mean annual sediment load of a stream; or a chart showing a flow duration curve with an overlay of parameter concentrations plotted against the discharge level can provide a visual graph of the chemical behavior of a given stream section.

IT Corporation, DNR and Tetra Tech flow analyses assume that the Gold Creek Drainage Tunnel continues to discharge into Gold Creek. Calculations are based on USGS gage data; the USGS gage measures creek flow below the CBJ well field, after CBJ drinking water has been removed, therefore the flow analyses are conservative.

Figure 4 shows the flow duration analysis based on the entire record. The curve defines the percent of time that a specific flow is exceeded. As can be seen by observing the plot, extremely low flows are exceeded a high percentage of the time. As flow volumes increase, the percent of time that the given flow is exceeded becomes lower and lower. Tetra Tech used the flow duration analysis to evaluate the percentage of time Gold Creek flow is less than the 144 cfs allocated, the percentage of time flow is less than the average discharge of Gold Creek of 116 cfs, and the percentage of time flow is lower than 10 cfs. Figure 5 shows this analysis focusing on flows occurring below 200 cfs. As can be seen from this plot, the flow is less than the total allocation of 144 cfs 70 percent of the time. Conversely, flows are higher 30 percent of the time. It is also less than the average annual flow of 16 cfs 63 percent of the time (i.e., flows are higher 37 percent of the time); and flows are less than 7 cfs 10 percent of the time.

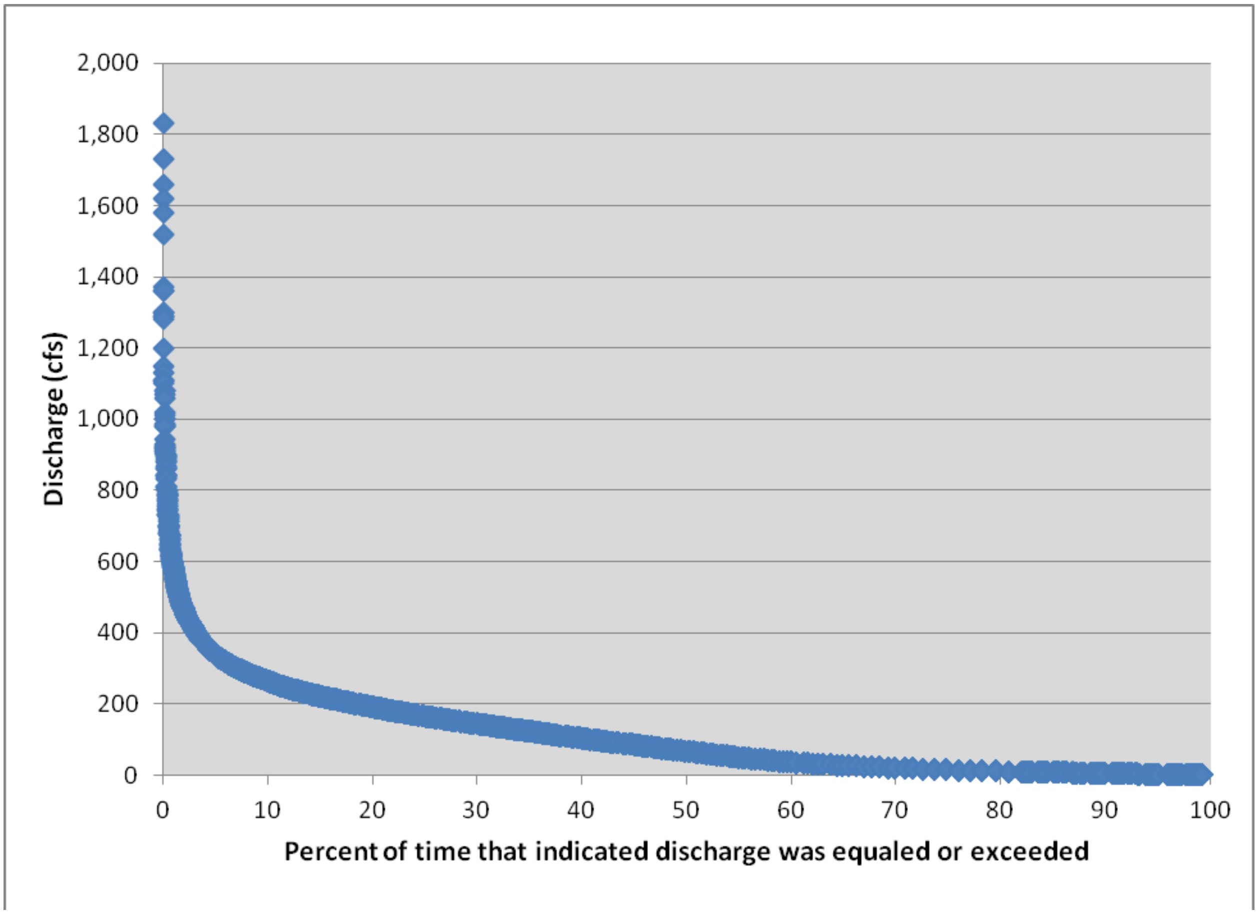

Figure 4. Flow duration curve for Gold Creek based on USGS gage discharge measurements from 1916-2006.

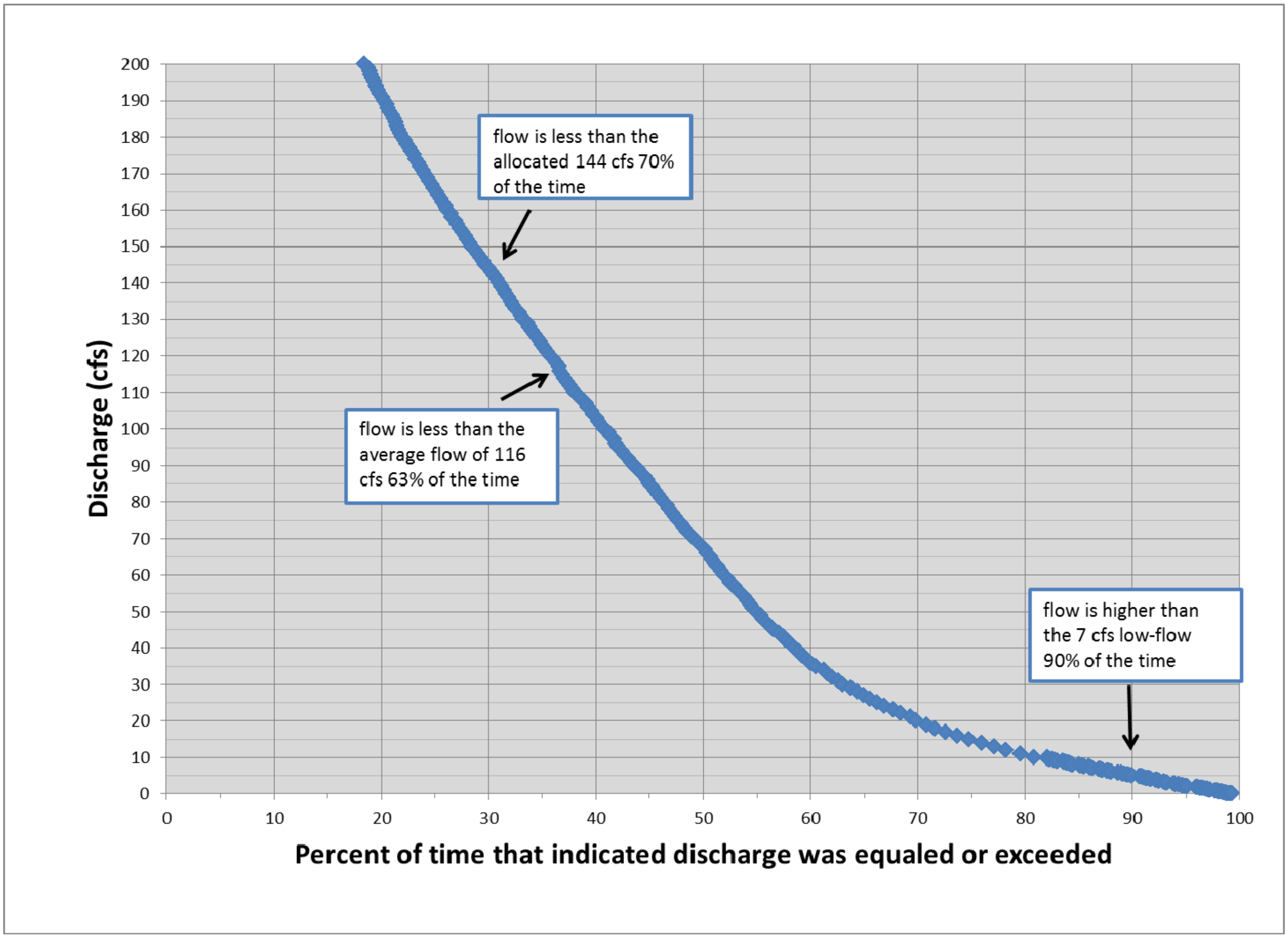

Figure 5. Flow duration curve for Gold Creek based on USGS gage discharge measurements from 1916-2006 showing flows below 200 cfs.

3.4 Existing Threats to the System

3.4.1 Subsidence Report

Glory holes, as noted previously, occur in Last Chance Basin and capture a portion of surface water flow. SRK Consulting estimated based on Echo Bay's mining plan, subsidence would increase the size of the existing glory holes over time (SRK, 1990). Based on Echo Bay's mine plan, the existing glory holes could potentially double in area, and in turn increase the capture rate from Gold Creek's total basin area. SRK conducted preliminary modeling for the worst case scenario of the amount of water that could be captured as a result of additional subsidence of the historic workings. This study focused on an unnamed stream's base flow that is supported by Icy Gulch springs and Silver Bow Basin aquifers. This unnamed stream exits Silverbow Basin through a tunnel, and reenters Gold Creek approximately 2,000 feet downstream of Granite Creek (Spencer, 1906). The objective of the investigation was to determine the importance of springs and aquifer discharges in upgradient basins to the stream flow in Gold Creek during low flow periods.

Stream flow measurements taken on November 4, 1991 on this unnamed stream were 8.31 cfs, with concurrent measurements on Gold Creek out of Silverbow Basin of 1.08 cfs, and 9.8 cfs on Granite Creek during a low flow event. These flows were used to estimate the percentage of Gold Creek flow that can be contributed to the unnamed stream (Noll, 1992). Gold Creek flow measured by the USGS gage downstream was 31 cfs on the same day. Based on these one-time concurrent flow measurements, the unnamed stream supplied 27 percent of the flow for Gold Creek. The unnamed creek is approximately 380 feet from the collar of the glory hole. Based on the surrounding geologic conditions and geologic conditions of the glory hole, SRK estimated that there was a low probability that this unnamed creek would be captured by the glory hole. However, if the collar of the glory hole were to slough further, the flow in the unnamed stream could be lost, resulting in an estimated 27 percent reduction in flows to Gold Creek (DNR, 1993). The AJ Mine glory holes were created in the 1930's. There is no evidence that the glory holes have expanded since that time; barring new mining activity, the glory holes appear to be stable.

3.4.2 Mine Water Levels

Water levels in the Deep North ore body have been monitored most recently by CBJ. Currently, mine levels 6 through 13 are completely inundated with groundwater that drains through the mine. This water is transported vertically and to the lower levels of the mine that occur below sea-level. The AJ drainage tunnel is estimated to be 395 feet above sea level. The potentiometric surface (water level) in the Deep North ore body is approximately 110 feet above sea level and is roughly estimated to be increasing at an average rate of two to five feet a year. The rising water level in the Deep North ore body may be long-term risk for the water quality in Gold Creek. If the water levels in the Deep North ore body rise up to the elevation of the Ebner Adit (374 feet above sea level) or higher to the AJ Mine drainage tunnel (395 feet above sea level) water will drain out and discharge into Gold Creek.

The Gold Creek Drainage Tunnel has not had significant maintenance since AJ Industries closed down the mine in 1944. Approximately 1300 feet in from the portal, the tunnel passes through a section of weaker rock; this section of the tunnel has partially collapsed as seen in Figure 6.

Figure 6. AJ Mine drainage tunnel blockage (Alan Steffert, CBJ Engineering 4/15/09).

Citizen concern has been raised about the possibility of future contamination to the well field from the water reservoir in the Deep North and from pasted tailings placed in the mine.

The possibility of underground workings, paste tailings piles, and drill cuttings leaching contaminants into the drinking water supply is very low. Paste tailings are made by mixing tailings with concrete which neutralizes any potential acid generation and dissolution of metals. Very small quantities of paste tailings and drill cuttings are located in areas subject to high flow events and the rising of the Deep North water levels. In the event the mine is filled with water to the 4 Level estimated concentrations of metals and constituents associated with paste tailings piles and drill cuttings would be insignificant (Kvaerner Environmental, 1998). Additionally the water captured in the Deep North ore body is not hydrologically connected to the CBJ well field. The water surface of the Deep North water reservoir is 165 feet below CBJ the well field in a confined basin.

Approximate elevations of relevant AJ Mine and Last Chance Basin features:

AJ 4 Level (Main Haulage):	450
Gold Creek Drain Tunnel:	395
Ebner Adit:	374
LCB Well Field:	275
Bottom of Deepest Well:	145
Proposed Sea Level Access	30
Bottom of North Orebody:	-1000

3.5 Water Quality

The water chemistry for the surface and ground water in Last Chance Basin are similar. The similarity in surface and ground water chemistry supports the direct interaction and hydraulic connectivity of surface and ground water sources within the basin. Beneficial uses for waters within the Gold Creek area are fresh water industrial water supply use, contact recreation, secondary recreation, water supply for drinking, culinary and food processing, and for the growth and propagation of fish, shellfish, other aquatic life, and wildlife. The most stringent water quality criteria across these designated uses apply to area streams. For most parameters and metals, the most stringent criteria are for the propagation of fish and aquatic life. However since the primary use of Gold Creek is for drinking water, drinking water quality standards are considered for this analysis of the Gold Creek watershed.

Available water chemistry from the AJ Mine drainage tunnel shows elevated concentrations of sulfate, total dissolved solids (TDS), hardness and some trace metals, and arsenic in comparison to Gold Creek (Motyka, 1993). Weekly water quality samples were collected from Gold Creek above the AJ Mine drainage tunnel, at the AJ Mine drainage tunnel outfall, and from Gold Creek below the AJ Mine drainage tunnel, from December 1994 through December 1996. The averaged results of the water quality samples collected over two years are in Table 6.

Table 6. Averaged water quality results for Gold Creek above the AJ Mine drain tunnel, from the drain tunnel and Gold Creek below the drain tunnel

(AJ Mine NPDES application, 1997).

Parameter	GCR (Gold Creek above drain tunnel)	GCT (Gold Creek Drainage Tunnel)	GCB (Gold Creek Below Tunnel)	2011 Alaska Drinking Water Quality Standards	CBJ Drinking Water System Test Results (CBJ, 2010)
pH	7.43	7.87	7.48	6.5-8.5	n/a
Conductivity(µmhos/cm)	80.6	808.3	148.4	n/a	n/a
TDS (mg/l)	41.5	**561.3**	85.3	500 [a]	n/a
TSS (mg/l)	1.3	0.8	2.0	n/a	n/a
Turbidity (NTU)	0.768	0.873	0.902	5[b]	n/a
Hardness (mg$CaCO_3$/l)	36.5[c]	**431.7**[c]	**68.8**[c]	46[c]	n/a
Nitrate (mg/l)	0.364	0.328	0.243	10	.2130
Sulfate (mg/l)	6.1	**324**	36.6	250	n/a
Ammonia (mg/l)	0.050	0.050	0.050	n/a	n/a
Chloride (mg/l)	1.548	2.992	1.421	250	n/a
Oil & Grease (mg/l)	1.0	1.0	1.0	n/a	n/a
TPH (mg/l)	0.20	0.21	0.20	n/a	n/a
Arsenic (mg/l)	0.00088	0.00179	0.00068	10	.000247
Barium (mg/l)	0.50	0.50	0.50	2	n/a
Cadmium (mg/l)	0.00020	0.00023	0.0021	0.005	n/a
Chromium (mg/l)	0.0200	0.0200	0.0200	0.1	n/a
Copper (mg/l)	0.00200	0.00244	0.00200	1.3	.335
Iron (mg/l)	0.0870	0.0810	0.1059	0.3	n/a
Lead (mg/l)	0.00003	0.00221	0.00031	1.1	0.00071
Manganese (mg/l)	0.0137	0.0140	0.0135	1.6	n/a
Nickel (mg/l)	-	0.0100	0.0003	0.7	n/a
Selenium	0.0000	0.0026	0.0000	0.05	n/a
Silver (mg/l)	-	0.00050	0.00000	0.2	n/a
Zinc (mg/l)	0.011	0.043	0.014	10	n/a
Mercury (mg/l)	0.0000	0.0002	0.0000	0.002	n/a

[a] Site specific criteria for Gold Creek TDS limits is 300 mg/L

[b] May not exceed 5 NTU above natural conditions when natural turbidity is 50 NTU or less

[c] Secondary water quality standards are based on taste, smell, or aesthetics related to general public acceptance of drinking water, elevated concentrations in secondary water quality standards are not a human health concern

The elevated sulfate concentrations in water from the AJ Mine drainage tunnel may be attributed to oxidation of sulfide minerals to sulfate from exposed areas in the mine. Similarly high TDS concentrations are likely a result of water flowing through highly mineralized abandoned ore stockpiles in the mine (IT Corporation, 1992). As the water discharged from the drainage tunnel enters Gold Creek and mixes, the high concentrations of TDS and sulfates are diluted.

Elevated turbidity has been recorded during naturally occurring high flows in Gold Creek. However, the high turbidity has not created significant effects to the CBJ water supply. Suspended solids associated with turbidity events are effectively filtered by the gravel layers in the well field and upper aquifer (AJ Mine NPDES Application, 1997). The elevated concentrations of sulfates and TDS are not detected in CBJ's drinking water at the tap.

In the summer and fall of 2011, significant turbidity events were observed in Gold Creek, caused by landslides and heavy rainfall events. Gold Creek turbidity levels did not have a discernable affect on the turbidity of the drinking water that was pumped from the Last Chance Basin well field. Below is turbidity measurements taken by the CBJ Water Utility (Table 7).

Table 7. Last Chance Basin water turbidity measured at point of entry to drinking water system (Cope Park Pump Station, CBJ Water Utility, 2011).

Date	Turbidity (NTU)
1/7/2011	0.27
1/14/2011	
1/21/2011	0.17
1/28/2011	0.24
2/4/2011	0.18
2/11/2011	0.25
2/18/2011	0.31
2/25/2011	0.21
3/4/2011	0.21
3/11/2011	0.21
3/18/2011	
3/25/2011	0.41
4/1/2011	0.31
4/8/2011	
4/15/2011	0.18
4/22/2011	0.32
4/29/2011	0.36
5/6/2011	0.28
5/13/2011	
5/20/2011	0.21
5/27/2011	0.29
6/3/2011	0.22
6/10/2011	0.26
6/17/2011	0.21
6/24/2011	0.42
7/1/2011	0.13
7/8/2011	0.28
7/15/2011	0.48
7/22/2011	0.30
7/29/2011	0.25
8/5/2011	0.14
8/12/2011	0.23
8/19/2011	0.15
8/26/2011	0.30
9/2/2011	0.25
9/9/2011	0.86
9/16/2011	0.32
9/23/2011	0.29
9/30/2011	0.27
10/7/2011	0.22
10/14/2011	0.26
10/21/2011	0.22

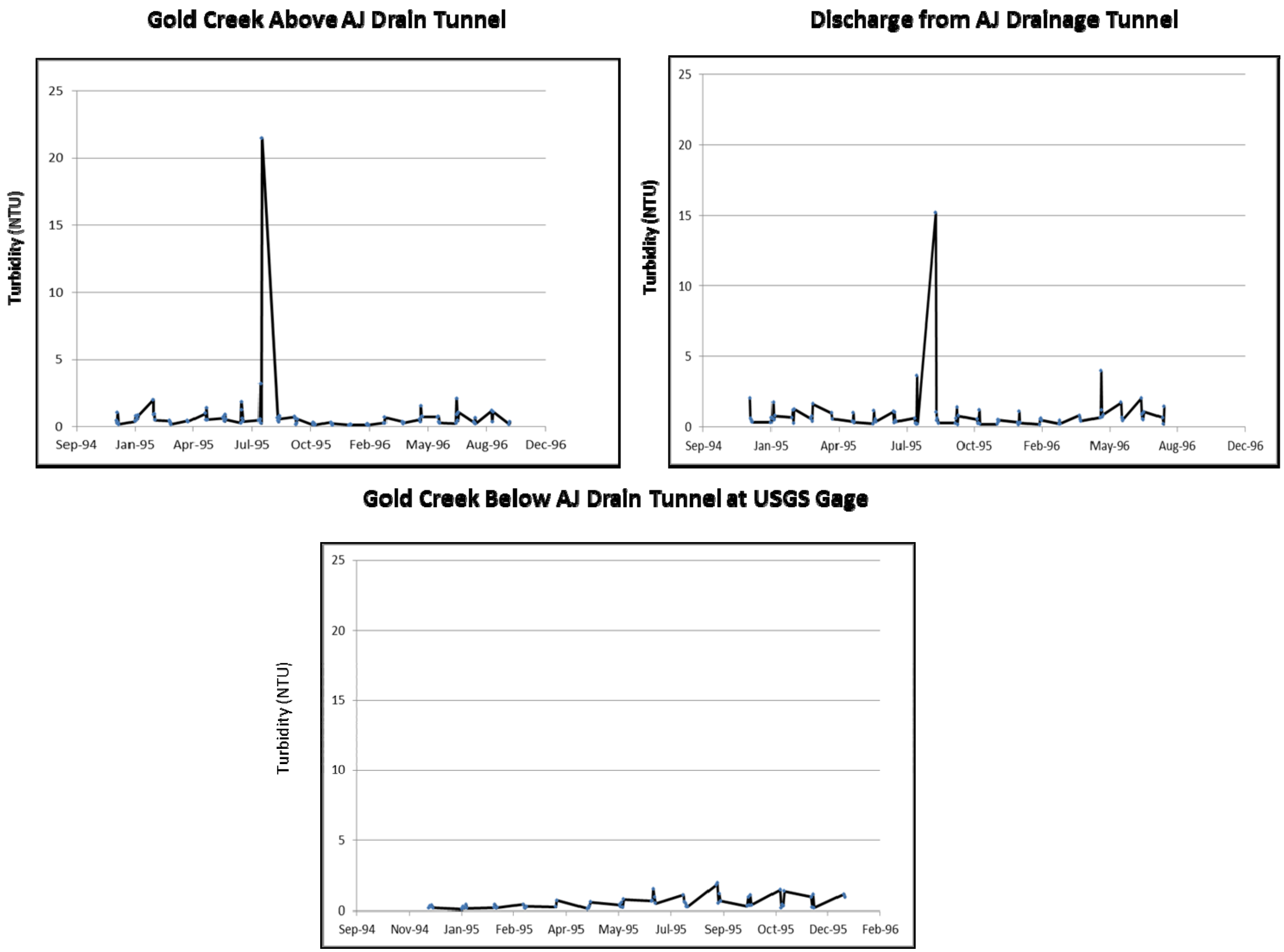

Figure 7. Turbidity measurements for Gold Creek above the AJ Mine drainage tunnel, at the Gold Creek AJ Mine drainage tunnel, and below the AJ Mine drainage tunnel (AJ Mine NPDES Application, 1997).

4.0 SUMMARY

This resource report summarizes hydrological and water quality aspects of CBJ's water supply as a basis for understanding the potential implications to that supply in conjunction with the potential redevelopment of the AJ Mine. CBJ derives its water from two water sources for the area wide water system. The Last Chance Basin well field on Gold Creek is the primary source; Salmon Creek provides CBJ's secondary water source.

DNR has issued three certificates of appropriation for water rights in Gold Creek; 137 cfs for AEL&P and 7.8 for CBJ totaling 144 cfs. CBJ pumps its allocated share of the water through the Last Chance Basin ground water well system. On average CBJ uses 3.9 to7 cfs from the Last Chance Basin well field (CBJ, 2011).

The USGS collected daily discharge data from 1916-2006, based on this data the average annual flow in Gold Creek is 116 cfs, and during the winter low flow events, discharge can be less than 10 cfs. During two independent events in 1994 and 1995 dead fish were found in a pool at the base of Gold Creek. It was determined the fish kill events in 1994 and 1995 were due to the sudden dewatering of Gold Creek caused by CBJ wells draining the underlying aquifer. The DNR analyzed the impacts of low flow events on the CBJ's well field. Sustainable pumping rates were calculated based on 7, 14, and 30 day periods of zero cfs flow in Gold Creek. Estimates indicate the aquifer could support a pumping rate of 7.1 cfs for seven days, 3.5 cfs for 14 days, and 1.0 cfs for 30 days under current flow conditions (DNR, 1993).

Tetra Tech a conducted flow duration analysis for Gold Creek, to evaluate the percentage of time high and low flows occur. This flow duration analysis shows that Gold Creek discharge equals or exceeds the total water rights allocated to CBJ and AEL&P 30 percent of the time, and low flow events (<10 cfs) occur 20 percent of the time.

The redevelopment of the AJ Mine could require plugging the AJ Mine drainage tunnel to prevent the discharge of contaminated waters to Gold Creek during operations. The AJ Mine drainage tunnel captures an estimated 5 to 14 percent of Gold Creek flow depending on the season. The reduction of flow in Gold Creek could impact CBJ's well field during sustained low-flow events. Additionally there is concern that a new mining operation could increase subsidence of the existing glory holes which in turn could capture additional flow from Gold Creek in the upper watershed.

Currently the water quality in Gold Creek meets Alaska drinking water standards. The water discharged from the AJ drainage tunnel has elevated levels of TDS, sulfate, and other trace metals, however as the tunnel water enters Gold Creek and mixes the dilution lowers the elevated levels back below WQS.

Currently there is more water appropriated from Gold Creek than is annually available. An additional decrease in Gold Creek flow due to plugging the AJ Mine drainage tunnel could cause shortages in the CBJ primary drinking water source during prolonged low flow events in Gold Creek.

5.0 CONCLUSIONS

The allocation of water to CBJ and AEL&P is greater than the annual average stream flow of Gold Creek and is there-fore over-allocated. The 144 cfs total allocation is only available 30 percent of the time based on the flow duration analysis. However AEL&P only uses its appropriated 137 cfs seasonally when flows have been sufficient to merit running the powerhouse. The AJ Mine drainage tunnel discharge provides an estimated 5-14 percent of Gold Creek flow depending on the season.

CBJ water consumption ranges from 3.9 to 7 cfs. Based on the analysis conducted by the DNR the Last Chance Basin aquifers can support CBJ's water needs with 0 cfs flow in Gold Creek for approximately one week. If this 0 cfs flow were to continue for two or more weeks CBJ would be able to pump less than half of the water needed to meet demand.

Potential water demand for future mining operations, based on CBJ's proposal to mine 3,500 tons of ore per day would require less water than estimated by Echo Bay; which proposed to mine 15,000 tons of ore per day. However, it should be noted that a feasibility-type study would be required to evaluate a specific proposed mine plan, water needs, a mine water balance, and the economics of processing ore at this lower mining rate.

Specific water supply demands for the AJ project would depend on the amount of ore being processed per day, the number of on-site workers, and variables associated with the mining methods employed. However, a comparison of water usage at the Kensington Mine (2,000 tons per day) can be used as an example of approximate potential demands. Total fresh water demands for the Kensington Mine average approximately 468 gpm or 1 cfs for all site operations and on-site workers.

Three separate concerns exist related to the long-term supply of water in Gold Creek. The first is a reduction in Gold Creek flow if the AJ Mine drainage tunnel is plugged for future mining activities. The second is the potential for continued subsidence of existing glory holes in the upper water shed. A modeling study done by SRK (1990) showed that in a worst case scenario (assuming Echo Bay's mining plan), the glory holes could double in size, and in turn captures a large percentage of Gold Creek and route it through the old mine workings. If subsidence were to occur and the AJ Mine drainage tunnel were blocked it is estimated an additional 27 percent of Gold Creeks flow could be rerouted into the AJ Mine. The third is the rising water level in the Deep North ore body. If the Deep North ore body is allowed to continue filling with water, ultimately it will rise to the elevation of the AJ Mine drainage tunnel and begin discharging into Gold Creek.

6.0 REFERENCES

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Memorandum

To: Rorie Watt **From:** Katie Goodwin

CC: **Date:** February 1, 2012

Re: Permits and authorizations required for mining operations in Alaska

Federal and state agencies, as well as the City Borough of Juneau (CBJ) all have regulatory authority in the process of permitting the AJ Mine. The principal federal agency is the Army Corp of Engineers (ACOE), but the US Environmental Protection Agency (EPA) also plays an important role in reviewing federal permits and the environmental impact statement. The principal state agencies include the Department of Natural Resources (ADNR), Department of Environmental Conservation (ADEC) and the Department of Fish and Game (ADF&G). Other state and federal agencies may issue minor permits as well, depending on the particulars of the AJ project when it is proposed. The following permits and authorizations will likely be required for the AJ mine:

Army Corp of Engineers

- Clean Water Act Section 404 permit

Environmental Protection Agency

- Hazardous Waste Generator (Resource Conservation and Recovery Act [RCRA]) Identification Number

Alaska Department of Natural Resources

- Reclamation Bond
- Certificate to Construct/Operate a Dam
- Reclamation and closure plan approval
- Plan of Operations Approval
- Temporary Water Use Permit
- Permit to Appropriate Water
- Cultural Resources Authorization (Section 106 National Historic Preservation Act) delegated to ADNR by EPA)

Alaska Department of Environmental Conservation

- Integrated Waste Management Permit
- Non-Domestic Wastewater Disposal Section of Waste Management Permit
- Clean Water Act Section 401 Certificate of Reasonable Assurance
- Clean Water Act Section 402 Alaska Pollutant Discharge Elimination System (APDES) Water Discharge Permit
- Plan Review and Construction Approval for Domestic Sewage System
- Storm Water Multi-Sector General Permit (Storm Water Discharge Pollution Prevention Plan)
- Air Quality Control Permit to Construct: Either a Minor Permit or Prevention of Significant Deterioration (PSD)
- Spill Prevention, Control, and Countermeasure Plan
- Oil Discharge Prevention and Contingency Plan
- Facility Response Plan
- Reclamation Bond
- Approval to Construct and Operate a Public Water Supply System

City and Borough of Juneau

- Large Mine Permit
- Reclamation Bond

Alaska Department of Fish and Game

- Fish Habitat Permit

Mine Safety and Health Administration

- Mine Training and Retraining Plan Approval
- Mine Identification Number

The following federal laws, statutes and ordinances may require the permits and authorizations listed above and would most likely apply to the operation of the AJ Mine. Additionally CBJ's mining ordinance would apply to the operation of the AJ Mine:

- Clean Water Act
- Clean Air Act
- Safe Drinking Water Act
- General Mining Law of 1872
- National Historic Preservation Act
- Magnuson-Stevens Fishery Conservation and Management Act
- National Environmental Policy Act
- Bald and Golden Eagle Protection Act
- Migratory Bird Treaty Act
- Fish and Wildlife Coordination Act
- Marine Mammal Protection Act
- Endangered Species Act
- Rivers and Harbors Act
- City and Borough of Juneau Exploration and Mining Ordinance (CBJ Title 49, Chapter 49.65, Article I)

Technical Memorandum

Carson Dorn, Inc.

712 West 12th Street
Juneau, AK 99801

Tel: 907-586-4447
Fax: 907-586-5917

Date: 2/19/2012

To: Rorie Watt

From: Jim Dorn **Reference:**

Subject Gold Creek Drain Tunnel Bypass Piping

It has been reported that when the AJ Mine first began operation the workings were relatively dry. However as mining proceeded a number of openings were created that allowed rain and snow melt to enter the mine. The largest openings (Glory Holes) contribute the majority of this flow.

To deal with the water, the AJ Mine constructed a drainage tunnel called the Gold Creek Drain Tunnel. Within the mine there are a series of small ditches and drop tunnels (bean holes) that direct water to the Gold Creek Drain Tunnel. The drainage system has functioned with little maintenance since the AJ Mine shut down over 65 years ago.

The Gold Creek Drain Tunnel discharges from the mine to Gold Creek, upstream of the mining museum. The discharge can be seen from the lookout at the “Horn” on Perseverance Trail.

Parts of the Last Chance Basin aquifer being used as a water source for CBJ’s water system are characterized as a “leaky artesian” aquifer. Water flows out of some wells onto the ground surface when the pumps are not operating. Consequently it can be assumed that recharge of the aquifer is most likely taking place at the upper end (higher elevation) section of the basin. Some recharge of the aquifer is undoubtedly occurring in the area of the Gold Creek Drain Tunnel discharge to Last Chance Basin.

If CBJ is wishes to prevent water being discharged from the Gold Creek Drain Tunnel from entering the Last Chance Basin wells, a bypass pipe from the tunnel mouth to Gold Creek below Well No. 2 would ensure the water does not enter the aquifer where it would be pumped by the wells.

It is estimated that about 3,000’ of pipe would be necessary have the drainage from the Gold Creek Drain Tunnel discharge to Gold Creek below the lowest of the Last Chance Basin wells. At estimated peak flow rates of about 100 cfs from the drainage tunnel (about 45,000 gpm) a pipe with an inside diameter of 42” would lose about 19.1’ of head at that flow rate.

It is recommended that a thermally fused high density polyethylene pipe be considered for this application. Since there will be water flowing in the pipe at all times freezing of the line is not an issue. While it would be acceptable from a freezing standpoint to lay the pipe on the ground, it should be buried a couple of feet to prevent vandalism.

The estimated cost of furnishing and installing this bypass pipe is as follows:

ESTIMATED COST

ITEM	**ESTIMATED COST**
Modify Tunnel to Collect Drainage in Pipe	$30,000
3,000’ 42” HDPE Pipe SDR 17 @ $200/ft	$600,000
Estimated Construction Cost	$630,000
Design, Inspections, CBJ Administration and Contingency at 50% of estimated construction cost	$315,000
Estimated Total Project Cost	$945,000

Technical Memorandum

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712 West 12th Street
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Tel: 907-586-4447
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Date: 2/19/2012

To: Rorie Watt

From: Jim Dorn **Reference:**

Subject: AJ Mine Water Study Alternate Drinking Water Sources

---

Peak monthly water system demand in Juneau is currently a little less than 5.0 million gallons per day (MGD) with peak day water system demands of about 6.0 MGD.

Juneau has two sources of drinking water:

1) The Last Chance Basin well field above Juneau which has 5 wells. The maximum output of the wells was measured at a rate of 9.0 MGD following rehabilitation of the wells.

2) The Salmon Creek unfiltered surface water source which currently has developed capacity to produce about 3.8 MGD. With improvements to the Salmon Creek water source, CBJ could take up to 10.0 MGD at Salmon Creek.

Salmon Creek is considered a secondary interruptible water source. Since it is an unfiltered surface water source it must meet stringent source water quality for bacteria and turbidity; disinfection criteria for chlorine concentration and contact times; and site specific conditions protecting the watershed. One of the water quality criteria unfiltered surface water systems must meet is that the turbidity in the raw water cannot exceed 5 NTU. A glass of water with turbidity of 5 NTU would appear clear. When raw water turbidity exceeds 5 NTU the Salmon Creek water source is turned off. This is a seasonal event that appears to be related to water levels behind the Salmon Creek dam or to avalanches that reach the water in the reservoir. For it to provide water year round uninterrupted, a filtration plant would need to be constructed.

GENERAL WATER SOURCE REQUIREMENTS

Before a water source can even be considered for development it is important to focus on two main factors, 1) quality of the water and 2) quantity of the water.

Quality of water means its physical and chemical characteristics. For water to be high quality it should be relatively free of the harmful bacteria, protozoans such as giardia and cryptosporidium, and viruses that might enter the drinking water system. In addition it must be free of high concentrations of harmful inorganic and organic chemical contaminants that are regulated by the Alaska Department of Environmental Conservation and the U.S. Environmental Protection Agency. It should also have low concentrations of troublesome minerals such as iron, manganese, sulfides, and calcium which will make the water unpalatable or will discolor water fixtures. Extensive laboratory testing of the water for at least one year is usually needed in order to identify possible seasonal variations in water quality.

The quantity of water available must be such that the maximum daily demands of the community are satisfied at all times, even during extended periods of low flow due the extreme weather conditions such would occur during long periods of freezing temperatures or drought.

WATER SOURCE ALTERNATIVES

There have been reasonably detailed studies of possible sources of drinking water for Juneau dating as far back as 1960. These studies evaluated a variety of surface water sources and groundwater sources and generally resulted in the conclusion that the Salmon Creek surface water source and the Last Chance Basin groundwater source provided the greatest benefit to Juneau.

Surface Waters

For most surface waters in Juneau, seasonally high turbidity levels are common during the heavy periods of snow melt and high stream flows in the fall. This would require treatment for removal of the turbidity.

Additionally, most surface water sources have low flows during the winter since most of their drainage basins are frozen. A large water storage impoundment is usually necessary to ensure adequate quantities of water are available during long periods of freezing temperature. For example, AEL&P monitors water levels behind the Salmon Creek dam and the snow pack above the dam that occurs each winter. It then carefully regulates the release of water from the dam and through its turbines to ensure adequate quantities of water are available year-round for power generation, the CBJ water system and DIPAC. During the spring melt and heavy rains that typically occur in the fall, the reservoir is allowed to fill to its maximum levels. Then during the winter, water levels behind the dam are slowly allowed to drop as water demand is met with water in the reservoir. No other surface water source on the Juneau road system currently has these water storage capabilities.

Evaluations have been done on:

- Nugget Creek,
- Montana Creek,
- Fish Creek,
- Sheep Creek and
- Lawson Creek.

These evaluations all led to the Salmon Creek being developed as a source of water for the Juneau water system.

Groundwater

For groundwater sources in the Juneau, water quality is usually the major issue. Iron and manganese, both of which stain plumbing fixtures and have an objectionable taste, and hydrosulfide, which has objectionable odors, are common in groundwater in the Mendenhall Valley and Lemon Creek areas. Well drillers in Juneau also report they have run into lenses of brackish water perched throughout the Mendenhall Valley and some of the deeper wells in the Valley have reportedly run into brackish water, possibly as a saltwater intrusion under the fresh water.

Small areas of relatively acceptable groundwater have been reported in the northeastern part of the Mendenhall Valley along Thunder Mountain and towards the glacier. Wells in these areas have proven acceptable for small single family residences or small multi-family developments, but there have been concerns that if major municipal wells capable of producing several million gallons per day were constructed in these areas, that they would draw poor quality water towards them from other areas of the valley. As a result, no municipal wells have been constructed in locations other than Last Chance Basin.

There has been some speculation that groundwater with acceptable quality and quantity might be found in the Upper Montana Creek Valley area above the Community Garden, but no work has been done to confirm this.

Areas that have been considered as possible a possible groundwater source for Juneau include:

- Dredge Lake area
- Lower Montana Creek/Back Loop Road
- Lower Thunder Mountain/East Mendenhall Valley
- Hidden Lakes area
- Mendenhaven area

None of these areas have been identified as being a better source of water than either Salmon Creek or the Last Chance Basin.

Technical Memorandum

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Date: 2/16/2012

To: Rorie Watt

From: Jim Dorn

Reference:

Subject: Salmon Creek Water Treatment Improvements

SALMON CREEK WATER SOURCE

Alaska Electric Light and Power operates a hydroelectric plant at Salmon Creek located across Egan Drive from DIPAC's Macauley Salmon Hatchery. Water from the Salmon Creek dam travels in a penstock to the hydroelectric plant and passes through the turbines that generate electricity. Water from the turbines then enters a tailrace that passes under Egan Drive and fills the pond located next to DIPAC. The tailrace water in the pond is used for DIPAC's operations. Before it crosses Egan Drive, some of the water in the tailrace enters a wet well located next to the hydroelectric plant that CBJ uses to provide water to the CBJ water system.

Water from Salmon Creek has been classified by EPA and ADEC as originating from a surface water source. EPA and ADEC regulations require filtration of all surface water supplies unless stringent source water quality for bacteria and turbidity; disinfection criteria for chlorine concentration and contact times; and site specific conditions protecting the watershed are met. CBJ has met all the conditions for filtration avoidance and so the Salmon Creek water source is an unfiltered surface water source. Other communities with unfiltered surface water sources in Alaska include Ketchikan, Sitka, Kodiak, Cordova, and Unalaska. With filtration avoidance and with the existing operating agreement where AEL&P provides electricity for pumping, the Salmon Creek source provides low cost water. There are however seasonal water quality issues that prevent use of the Salmon Creek source as a year-round source without additional treatment facilities.

One of the surface water filtration avoidance criteria requires that the source water turbidity not exceed 5 NTU. NTU is a measure of turbidity in water. At times the water from Salmon Creek exceeds 5 NTU. During these times use of Salmon Creek as a water source must be discontinued. As a result, Salmon Creek is considered a secondary interruptible water source. Since 2005 the Salmon Creek water source has been taken off-line 4 times due to high turbidity and 3 times for maintenance.

Direct filtration of surface water sources has been widely used in water treatment for removal of the particulates that cause turbidity. Filtration plants are also effective at removal of microorganisms such as bacteria, viruses, giardia and cryptosporidium. There are water treatment options other than direct filtration that should be considered in more detail as CBJ makes decisions about water treatment at Salmon Creek. These other options include membrane filtration, diatomaceous earth filters, and in-line pressure filters. However, for the purposes of this evaluation, direct filtration serves as a good benchmark against which other treatment alternatives can be evaluated. Direct filtration generally requires the largest footprint of any of the filtration options and a correspondingly higher capital cost.

On-site pilot plant studies for filtration systems are frequently used to determine design parameters for full scale water treatment systems. Bench-scale testing to determine coagulant doses is also done in association with pilot plant testing. Should CBJ wish to conduct a more detailed review of water treatment plant options at Salmon Creek, pilot plant testing and bench-scale testing of coagulants should be considered as part of that more detailed review of options.

DIRECT FILTRATION

The direct filtration alternative is a unit process widely used in water treatment for removal of particulate materials commonly found in water with literally thousands of direct filtration plants in operation throughout the United States and Alaska. In this process a coagulant such as ferric chloride or alum is added to the raw water and floc particles are encouraged to form. The floc particles capture the smaller materials in the water such as silts, clays, organic materials and microorganisms. After flocculation the water frequently enters a settling tank or clarifier that allows most of the floc particles to be removed. After settling, the water passes through a filter media and the remaining particulate materials are removed by accumulating on the surface of the media or are collected throughout its depth. As particulate material accumulates in or on the filter media, the pressure drop across the media increases until it uses its available pressure. At this time the filter media is cleaned hydraulically during a short regeneration/backwash cycle and then placed back into operation.

The City and Borough of Juneau (CBJ) water system has water rights for 10 MGD (6,950 gpm) at Salmon Creek but has only developed beneficial use of 3.8 MGD (2,650 gpm) of water from Salmon Creek to provide drinking water to residents of Juneau. CBJ rarely draws more than 1.8 MGD (1,250 gpm) from this source.

There are manufacturers that make package direct filtration water treatment plants such as the Siemens Water Technologies Trident Water System. Siemens manufactures a 4.0 MGD plant that consists of two parallel treatment process units. Each treatment process unit is about 12' wide, 40' long and about 10' tall. A building that is about 60'x60' and about 16' tall will provide sufficient operating room around the treatment units and provide for an electrical room, mechanical room and an office.

The following photo shows a typical direct filtration water treatment plant.

DIRECT FILTRATION PACKAGE PLANT

OTHER NEEDED SALMON CREEK SOURCE IMPROVEMENTS

Hydroelectric Plant Bypass Piping

AEL&P has included in the tri-party water use agreement the opportunity to conduct annual maintenance on its hydroelectric plant that requires the water flow in the hydroelectric plant and its tailrace to be interrupted. They do have some flexibility for scheduling this maintenance and so typically contact DIPAC and CBJ to ensure it does not significantly impact either of their operations. During these hydroelectric plant maintenance periods, CBJ typcially shuts down their Salmon Creek water source and maintains water service either from stored water in the Lemon Creek, Auke Lake, East Valley and Lena Point Reservoirs (total storage = 6.1 MG) or by allowing water from Last Chance Basin to directly serve the Lemon Creek, Mendenhall Valley and out-the-road area.

DIPAC, on the other hand, has installed a “bypass” pipe that connects to the penstock piping upstream of the hydroelectric plant and discharges water to their pond through a pressure reducing valve so that they can remain in operation while AEL&P performs maintenance on the hydroelectric plant.

A similar piping arrangement was provided for CBJ’s Salmon Creek water source but is was flanged off due to safety concerns. CBJ’s bypass piping and valves should be upgraded so that it can be safely operated. New pressure reducing valves, pressure relief/blow-off valves and additional pressure sensors with emergency alarms should be installed. This would allow CBJ to continue using the Salmon Creek water source while AEL&P conducts maintenance on the hydroelectric plant.

Salmon Creek Penstock Inspections and Maintenance

AEL&P also conducts periodic inspections of the penstock between their hydroelectric plant and the Salmon Creek dam. When they conduct thickness testing of the penstock pipe walls they do not need to drain the penstock. However, about every five years they drain the penstock so that they can do a visual inspection inside the penstock. This internal inspection can be scheduled so that it does not interfere with either CBJ or DIPAC operations. If Salmon Creek was CBJ's only water source, AEL&P would need to be approached about postponing interior inspections of the penstock until the Last Chance Basin source was available.

The upper section of the penstock is nearly 100 years old and so AEL&P is starting to consider replacing that section. In the event of a catastrophic failure of the penstock, CBJ would need to use its portable pumps and discharge piping to pump water directly from Salmon Creek to the treatment plant. DIPAC would be in the same situation in order to continue its fish rearing.

ESTIMATED COSTS

Following are the estimated project costs for a 4.0 MGD water treatment plant and associated improvements at the Salmon Creek water source.

4.0 MGD Salmon Creek Water Treatment Plant

4.0 MGD Package Water Treatment Plant	$2,000,000
60' x 60' Building @ $175/sf	$630,000
Site Preparation and Site Piping	$200,000
Treatment Plant Piping	$250,000
Electrical	$250,000
Instrumentation and Controls	$150,000
Pumps	$200,000
Freight and Shipping	$150,000
Estimated Construction Cost	$3,830,000
Design, Inspection, CBJ Administration and Contingency @ 50% of estimated construction cost	$1,915,000
Estimated Total Project Cost	**$5,745,000**

If CBJ wishes to increase treatment plant capacity to 8.0 MGD, which would be adequate to provide the water needs for the entire Borough, the estimated cost would double to $11,490,000.

Salmon Creek Bypass Piping and Valves

2-Pressure Reducing Valves @ $30,000 each	$60,000
1-Pressure Relief Valve @ $30,000 each	$30,000
Misc. Piping and Valves	$50,000
Estimated Construction Cost	$140,000
Design, Inspection, CBJ Administration and Contingency @ 50% of estimated construction cost	$70,000
Estimated Total Project Cost	**$210,000**

Technical Memorandum

Carson Dorn, Inc.

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Date: 2/14/2012

To: Rorie Watt

From: Jim Dorn **Reference:**

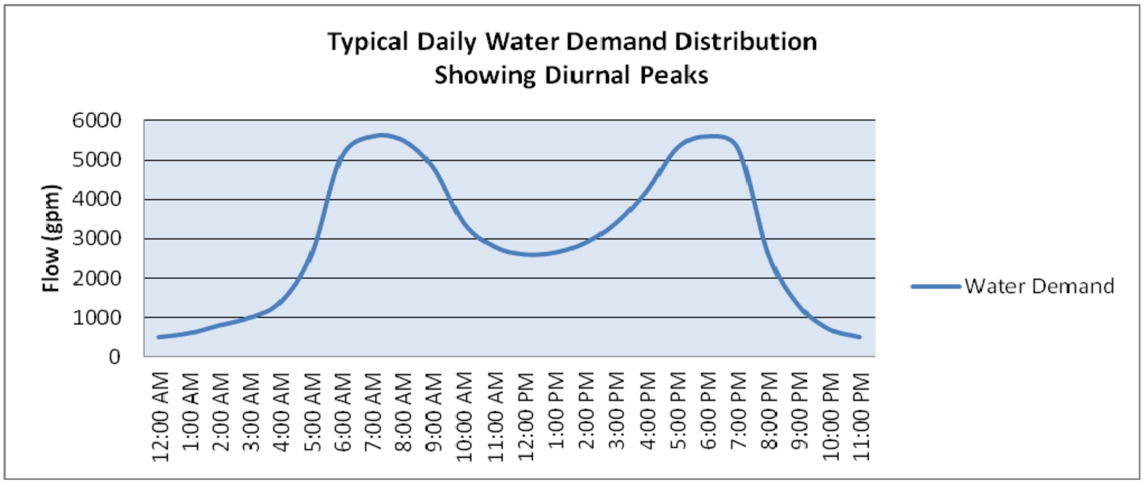
Subject: Last Chance Basin
Water Storage Reservoir Evaluation

The need for a new water storage reservoir in Last Chance Basin has been discussed for many years. Currently Wells 1, 4 and 5 pump directly into the downtown Juneau and Douglas water distribution system with Well 2 having the option of either pumping directly to the downtown and Douglas water system or to the high elevation water system serving the Highlands and Starr Hill areas. Well 3 can only pump to the Mill Tunnel Water Storage Tunnel which serves the Highlands and Starr Hill areas, and has a pressure reducing valve that allows water to enter the Juneau distribution system on South Franklin Street.

Water demand in a municipal water system varies throughout the day. Generally there are two peak demand periods, one in the morning and another in the evening, where water system demand is generally between 150 to 200% of the average daily demand.

For the Last Chance Basin water source where average daily flows of about 4.0 million gallons per day (2,800 gpm) have been recorded, the flows during the peak demand periods would be on the order of 5,600 gpm. The total production rate of all 5 wells in Last Chance Basin is about 6,235 gpm when the wells are operating at their extreme maximum pumping rate. There are days, primarily during the summer tourist season, when all the well pumps are operating at their maximum capacity and water is being withdrawn from the Mill Tunnel Water Storage Tunnel to meet system demand.

The following chart shows a typical daily water demand distribution with peak demand periods in the morning and again in the evening.



During the summer months, cruise ships will use Juneau's water system to fill their on-board potable water tanks. Each cruise ship can take on as much as 250,000 gallons per visit which typically occurs over about a 10 to 12 hour period. With 4 docks operating this results in total water demand of about 1,000,000 gallons from the cruise ships in a 12 hour period or about 1,400 gpm.

The flow rate from well pumps 1, 4, and 5 serving the downtown area is continually adjusted with automatic control valves to match the water demand in the downtown and Douglas area. During the day the pumps operate near their peak capacity to meet system demand. During periods of low water demand, such as would occur at night, the pumps are throttled back to run at much less than their optimal pumping rate since water demand is so low.

The water yield from water wells where the pumps are continuously operated will generally degrade with time. The pore spaces in the aquifer around wells can become plugged with small amounts of silt and sands which reduces water movement around the wells. As part of a 2009 project to increase well yields in Last Chance Basin by removing the silts and sands around the wells, it was recommended that the five wells in Last Chance Basin should not be run continuously. Instead, each pump should be stopped and started regularly to allow the well and surrounding aquifer to "relax". Relaxing of the wells on a routine basis can decrease the rate of mechanical plugging of the well screen and the surrounding aquifer pore spaces and extend the useful life of the wells.

Providing a new water storage reservoir in the Last Chance Basin will allow for the following:

1) During periods of low water demand (at night) the wells can be kept at their optimal pumping rate to fill a water storage tank instead of being throttled back to meet only the lower nighttime water demand. Once the water storage tank is filled it will be possible to turn the wells pumps off since they will no longer need to run continuously to provide water to the downtown area. Turning the pumps off at night after the water storage tank is filled will allow the aquifer to "relax" and will result in a reduction in power costs.

2) A water storage tank will allow the well pumps, when they are operating, to operate at their peak efficiency instead of being forced to operate at low flow rates where the

pumps are not as efficient. This will result in reduced power costs since the pumps will be run at a rate that more closely matches their peak efficiency.

3) Filling the water storage tank at night during periods of low demand will allow the Last Chance Basin to be able to better meet the peak demands from the public and cruise ships during the day. Water from the storage tank will be used to supplement the output of the wells, thereby increasing the amount of which water can be made available to system users during the day.

A water storage reservoir with a 2.0 million gallon capacity will allow at least half of the 4.0 million gallon daily demand to be provided from the water storage reservoir. This will require the Last Chance Basin well field to produce water at an average rate of 2,800 gpm instead of having to produce water at a rate of 5,600 gpm during peak demand periods. This average rate can be met by running a couple of wells at a time and turning the other 3 off.

There are two locations that appear suitable for a reservoir in Last Chance Basin. One is located near the existing water treatment building and the other is located near the vertical mine shaft which enters the Jualpa Tunnel.

Estimated construction costs for a reservoir are as follows:

ITEM	**ESTIMATED COST**
2.0 Million Gallon Reservoir	$3,000,000
Site Development	$50,000
Foundation	$50,000
Site Piping	$50,000
Instrumentation and Controls	$100,000
TOTAL ESTIMATED CONSTRUCTION COST	$3,250,000
Design, Inspection, CBJ Administration, Contingency (estimated at 50% of construction cost)	$1,625,000
ESTIMATED TOTAL PROJECT COST	$4,875,000

Drinking Water Supply & AJ Mine Development Scenarios

In its report of May 2, 2011, the AJ Mine Advisory Committee (AJMAC) made a number of recommendations to the City & Borough of Juneau Assembly. With regard to drinking water issues, the AJMAC report states:

> ***"Recommendation:*** *CBJ should develop a strong relationship between the Water Utility and the Mine Operator. Even if the mine is not developed, The drainage tunnel should be renovated to reduce the risk of future tunnel failures or drainage upsets that would adversely impact the existing discharge to Gold Creek.*
>
> *The City should make diligent efforts to increase common knowledge about the drinking water and AJ mine drainage systems, at a minimum to include information on the CBJ web page provided by the Water Utility and periodic consumer confidence reports.*
>
> *Prior to proceeding with mine development, the City should comprehensively analyze a variety of water supply and mine development scenarios. This analysis should study the current risks to the drinking water system, possible improvements or expansions to the water supply, analysis of capital and O&M costs, the availability of State, federal, or other public and private funds, the benefits to the community for future growth, and the effects of these various scenarios on mine development."*

In accordance with the AJMAC recommendation, the following narrative suggests a number of ***water supply and mine development scenarios*** that have been posed so that the Assembly and public may continue their consideration of the idea of re-development of the AJ Mine. Imbedded in all of these conceptual scenarios are some **key assumptions** which follow the logic of the AJMAC report and recommendations. Also presented are a number of **water management concepts** which suggest a variety of approaches which could be used to address the potential conflict between mining in the AJ and the provision of drinking water from Gold Creek.

Key Assumptions:

A. *Sea level Access* – A new access to the mine is developed, at an elevation near sea level, entering from the vicinity of the rock dump. Such access would be constructed so that it slopes (and therefore drains) towards the channel.

B. *Underground mill* – A mill is constructed underground, off of the sea level access. Milling occurs below the elevation of the Gold Creek Drainage Tunnel.

C. *Mine Discharge* – All mill discharge and any impacted waters (those affected by mine activity) are prohibited from discharge to Gold Creek locations above the drinking water well field; all mill discharge and other impacted waters are either discharged to Gastineau Channel or routed to a location below the CBJ Gold Creek drinking water well field. Any diversion of drainage tunnel waters (or other waters that originate in the Gold Creek watershed) to the channel would reduce the quantity of water in Gold Creek that recharges the drinking water aquifer. Reduction in flows to Gold Creek could result in a shortage in the supply available to the drinking water system during periods of low flow in Gold Creek.

D. *No Surface Tailings Facility* – All post-mill tailings are disposed of below ground.

E. *No Surface Caving* – Other than air vents and access points, no additional surface areas are opened to the environment, glory holes are not increased in size. Additional surface waters are not introduced into the mine.

Water Management Concepts:

1. *Upgrade Salmon Creek to a Year Round Supply* – The existing Salmon Creek drinking water supply could be upgraded with a new filtration system to allow year round provision of drinking water. Under this concept, Salmon Creek would remain as a secondary water supply. Some piping modifications would be required to allow CBJ use of Salmon Creek water during maintenance of the AEL&P power system. These upgrades would allow provision of sufficient drinking water in the event that Gold Creek was unable to supply all of the entire municipal demand due to diversions of drain tunnel waters, low flow creek flow, or diminished well field production.

2. *Upgrade Salmon Creek to a Year Round Primary Supply* – Similar to Concept 1 above, except the filtration upgrades would be expanded to allow provision of sufficient water for the entire municipal need. In order to distribute Salmon Creek water to all served properties, some improvements to the existing distribution infrastructure would also be required.

3. *Abandon and Replace Gold Creek Drinking Water Supply* – The Gold Creek drinking water supply can currently supply the entire municipal need. Under this

concept, CBJ would cease to use Gold Creek as a drinking water supply. A new water supply source would be located and developed and modifications would be made to the existing drinking water distribution system so that the new source could independently supply the entire municipal need. The existing Salmon Creek drinking water supply system would remain as a secondary supply, available on a seasonal basis.

4. *Relocation of Drain Tunnel Discharge Point* – The discharge location of the Gold Creek Drain Tunnel is just upstream from the Gold Creek drinking water well field. Through the construction of a pipe system, concrete flume or a tunnel extension, the discharge point of the Drain Tunnel could be relocated to a point downstream of the well field. This change would reduce water quantity in the well field recharge area, but could be implemented in a manner that would not reduce quantity at the AEL&P flume intake.

- ***a.*** *Permanent Diversion downstream of Well Field* – The drain tunnel waters could be diverted around the well field and discharged into Gold Creek. This concept would reduce flows to the well field, but not reduce flows to AEL&P's power generation system.
- ***b.*** *Permanent Diversion to Channel Through new Sea Level Access* – The entire quantity of Drain Tunnel waters could be routed out a new sea level access and discharged to Gastineau Channel. This concept would reduce flows to both the well field and to AEL&P's power generation system.
- **c.** *Diversion to Deep North During Exploration* – Drain tunnel waters were diverted into the Deep North Ore Body by Echo Bay during exploration activities in the 1990's. The Deep North workings descend to an elevation of about one thousand feet below sea level, the drainage tunnel is at about an elevation of about 375 feet above sea level. The water was diverted to remove the possibility of having a pollutant discharge into Gold Creek during exploration activities. Subsequently Echo Bay pumped out much of the water that had been diverted into the Deep North. This water was treated and piped to a discharge location under the basin road bridge (downstream of the LCB well field, just upstream of the AEL&P flume intake). Drain tunnel waters could again be temporarily diverted to the Deep North.
- **d.** *Dewatering of Deep North* – Much of the available gold in the AJ is in the Deep North Ore Body. To mine this ore, an operator would have to pump the water out (through a treatment plant) either to Gastineau Channel or to Gold Creek at a location downstream of the well field.

5. *Mine Drainage System Improvements*

- **a.** *Gold Creek Drain Tunnel Rehabilitation* – The existing Gold Creek Drain Tunnel is partially collapsed, and could pose long term problems to the mine drainage system. A mine operator would be able to rehabilitate the tunnel by supporting or lining sections of the tunnel. If the tunnel collapses and plugs, water flowing through the mine would fill the historic Deep North section of the mine and could ultimately discharge from the Ebner Adit near the Perseverance Trail Head. These drainage changes would likely cause significant turbidity events in Gold Creek, and would require improvements to the first section of the Perseverance Trail and possibly parking lot. Turbidity events are not considered a threat to the drinking water system.

   b. *Divert Surface Waters From Entering the Drain Tunnel* – There are opportunities to reduce the amount of water that enters the AJ mine, opportunities to reduce the amount of water that flows through the Gold Creek Drainage Tunnel.

      i. *Surface Ditching* – Some of the water that enters the mine comes from small streams that flow directly into the Glory Hole. Surface ditching could route some of these streams away from the Glory Hole and into Gold Creek. These types of diversions would require periodic maintenance.

      ii. *Discharge at Higher Elevation* – In the historic Perseverance Mine area, there is an adit at about an elevation of 1380' called the Alexander Cross-Cut. This adit daylights at the Perseverance mill site in Silverbow Basin (near the end of Perseverance Trail). Waters that enter the Perseverance section of the mine could be routed out the Alexander and into Gold Creek. This diversion change could be constructed as a permanent change. Historic mining activity at the Perseverance mill site would have to be further investigated to ensure that this conceptual drainage change could be designed and constructed in a manner that would not cause the remobilization of deposits of historic mineralized sediments and milling reagents.

6. *Pipe Surface Water through the Mine* – Some of the water that enters the mine could be intercepted prior to coming in contact with active working areas and piped through the mine to the Gold Creek Drainage Tunnel. The Tunnel could continue to discharge at its present location. Waters impacted by mining operations could be routed through a new sea level access to Gastineau Channel.

Water Supply and Mine Development Scenarios:

Base Scenario - No Action
Existing Conditions. No mine operator, no improvements to water or drainage systems

> *Pro's* – No additional risk from new mining activities.
> *Con's* – No economic benefits from mine, no improvement to mine drainage system, no improvement to drinking water system.

Scenario 1 – Re-Route Drain Tunnel Water, No Improvements to Water System
The mine property would be leased to a mining company and the water from the Gold Creek Drain Tunnel would be re-routed through a new sea level access to Gastineau Channel or to a location downstream of the well field. No improvements would be made to the drinking water system.

Note, this is similar to the approach taken in the 1990's with the Echo Bay proposal (See historic documents from Echo Bay's permitting regarding "Condition 129" from 1994 Conditional Use Permit). To resolve the problems caused by the proposed diversion of drain tunnel waters, Echo Bay paid the CBJ approximately $750,000 to increase the size of the Salmon Creek Chlorine Contact Tank - then under construction. This expansion of the Chlorine Contact Tank allows for the Water Utility to provide a sufficient quantity of water to serve the entire municipal need Salmon Creek. However, no changes were made to the Salmon Creek water supply to allow it to serve water during higher turbidity periods, and therefore while it may be able to serve our quantity needs for much of the year, Salmon Creek is not a year round supply. Additionally, the existing infrastructure does not allow Salmon Creek water to be distributed to all parts of the municipality. Since Gold Creek continues to function as our primary supply, the water utility operates Salmon Creek as a secondary supply, using less than the maximum available water quantities.

> *Pro's* – Improvements to mine drainage systems. Sufficient drinking water quantity and quality except when Gold Creek is very low flow **and** Salmon Creek is turbid. Eliminates possibility of contamination to drinking water system.
> *Con's* – No additional improvements to drinking water system. Potential loss of AEL&P power generation. Potential shortfall of available water for drinking water system.

Scenario 2 – Abandon Gold Creek Water Supply, Construct New Water System

The mine property would be leased to a mining company and the CBJ would abandon the Gold Creek water supply. A new primary water supply would be constructed.

Pro's – Improvements to mine drainage systems. Eliminates possibility of contamination to drinking water system. Maintains redundancy in water system.

Con's – Likely highest capital cost concept. Difficulties and uncertainty in locating, permitting and funding new water source. New water supply likely to be poorer quality than Gold or Salmon Creek (taste, odor) and likely to require higher pumping and treatment costs.

Scenario 3 - Abandon Gold Creek Water Supply, Upgrade Salmon Creek Supply

The mine property would be leased to a mining company and the CBJ would abandon the Gold Creek water supply. The Salmon Creek water supply would be upgraded to primary status.

Pro's – Improvements to mine drainage systems. Eliminates possibility of contamination to drinking water system.

Con's – Cost. Lack of redundancy in water supply system.

Scenario 4 – Re-Route Drain Tunnel Water, Add Filtration to Salmon Creek

The mine property would be leased to a mining company, the Drain Tunnel would be routed away from the well field, and the Salmon Creek water supply would be upgraded with filtration. Gold Creek and Salmon Creek would combined serve the municipal need.

Pro's – Improvements to mine drainage systems. Eliminates possibility of contamination to drinking water system. More stable year round water supply. Less costly than other water system improvements. Maintains redundancy in water system.

Con's – Cost.

Scenario 5 – Oversight of Mine Operations, Managed Drainage System

The mine property would be leased to a mining company. The Drain Tunnel waters would **not** be relocated and improvements would **not** be made to drinking water supply. Independent inspectors would oversee mine operations to ensure that mine impacted waters were directed to sea level access and discharged to Gastineau Channel. This scenario would include provisions to reduce waters flowing into the mine, and would pipe waters uncontaminated by mining operations through the mine to the Drainage Tunnel.

Pro's – Lowest capital approach.
Con's – Cost of oversight program. Human failure could lead to discharge of mine impacted waters to Gold Creek above the drinking water well field.

Rorie Watt **February 23, 2012**
Engineering Director
City & Borough of Juneau