Tulsequah Chief Mine
Air Cushion Barge
Transportation System Volume 1: Project Description

Prepared for Redfern Resources Ltd.

Submitted by Gartner Lee

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Reference: **GLL 70-142**

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August 14, 2007

Tim Davies
Manager, Environmental and Regulatory Affairs
Redfern Resources Ltd.,
800 – 1281 West Georgia
Vancouver, BC V6E 3J7

Dear Mr. Davies:

Re: GLL 70-142 – Tulsequah Chief Mine – Air Cushion Barge Transportation System – Project Description

Gartner Lee is pleased to provide the final project description for the above noted project. This report constitutes Volume 1 of a two-volume Project Description and Environmental Assessment report that will be submitted to the regulatory agencies in British Columbia and Alaska for review and subsequent regulatory approvals. This project description has been modified from the initial draft dated March 12 2007, and has incorporated the salient changes to the proposed transportation system that have been proposed and carefully considered over the past four months. In addition, this project description incorporates several key mitigation measures (such as appropriate route selection; timing and sequencing of activities) that will avoid or minimize many of the potentially adverse effects of operating a year-round barge system on the Taku River.

Yours truly,
GARTNER LEE LIMITED

K. Wood

Kathleen Wood
Regulatory Specialist

KW:gc

Yo

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1. Introduction

The Tulsequah Chief mine project is located in a remote area of northwestern British Columbia, far from existing road, rail or marine transportation systems. The means of shipping ore concentrate off site and re-supplying the mine during operations has been a major consideration for this project. Although conventional barging was investigated in 1995, road access had, until recently, been viewed as the only viable transportation alternative for operation of the mine because it provided year-round transportation. Approval for construction, operation and maintenance of a 160-km road from the mine to Atlin, BC was granted under the British Columbia Project Approval Certificate issued in 1998 and subsequently re-issued in 2002. A Special Use Permit was conditionally issued jointly by the BC Ministry of Forests and Ministry of Mines in 1999 for the construction of the road. Redfern Resources Ltd. (Redfern) is now seeking an amendment to the Project Approval Certificate that will permit the use of a barging transportation system as described in this Project Description.

Volume 1 of this report describes the proposed barging alternative and its rationale, and outlines the steps necessary to approve an amendment to the Project Certificate Approval. An assessment of the environmental and socio-economic effects associated with the proposed barging alternative are included in Volume 2 as well proposed mitigative measures to minimize potentially adverse effects.

1.1 Rationale for the Proposed Amendment

The Taku River route from the mine site to Juneau and Skagway is a shorter route for transporting concentrate and mine supplies, requires little in the way of infrastructure development (existing marine shipping facilities will be used at the ports of Juneau and Skagway), and is predicted to have significantly lower unit costs of transporting concentrate as compared to trucking by road.

The Taku River was the transportation route when the mine was operated in the 1950s. Mine supplies and concentrate were transported by conventional river tug and barge; however, these conventional vessels could not operate during winter when the river remained frozen, nor could they operate during the spring and fall seasons when water levels in the Taku River provided insufficient depth to accommodate the draft of these vessels. Conventional barging was again considered in 1995, but rejected for many of the same reasons.

In late 2006, Redfern identified an alternative transportation option that would use air cushion barges (ACBs) and an amphibious tow vessel (amphitrac) operating year-round on the Taku River between the mine site and Juneau, Alaska. The ACB is sometimes referred to as a “hoverbarge”. Unlike a conventional barge system, the use of an ACB, towed by either a shallow draft tug (summer) or amphitrac (remainder of year) would be able to operate year-round over water, ice and land. This option offers several distinct and significant advantages over the road, including:

- reduced environmental impact;
- smaller overall project footprint;
- lower capital cost;
- reduced operating cost of shipping concentrate and mine re-supply;
- accelerated project construction schedule;
- reduced risk of cost overruns associated with road construction schedule;
- greater public acceptance;
- greater operational flexibility; and
- safer transportation alternative in winter months.

Redfern's commitment to continue to look for ways to minimize the environmental effects of its proposed operation is reflected in its decision to examine the concept of the ACB as a viable alternative to the 160 km access road that generated much of the concern about the project when it was initially proposed, assessed and permitted.

1.2 Regulatory Approvals

The proposed ACB transportation system will be subject to regulatory review within both British Columbia and Alaska. The following provides a summary of the regulatory approval process in both jurisdictions.

1.2.1 British Columbia Environmental Assessment

The British Columbia Environmental Assessment (BCEA) Office has clearly indicated that an amendment will be required to the Project Approval Certificate. The assessment will focus on those aspects of the transportation project in Canada that require amending.

1.2.1.1 Mines Act Permit

Concentrate will be trucked from the mine site to the barge landing site, a distance of about 12 km. The exploration road will require upgrading to accommodate year-round use during mine operations. A *Mines Act* permit will be required to authorize the proposed road upgrades and operations.

1.2.1.2 Fisheries Act Authorization

Disturbance of the riparian habitat along the river bank at the barge landing site and possible infilling of a seasonally flooded back channel may constitute a disturbance of fish habitat, requiring a federal *Fisheries Act* Authorization under S35(2) of the Act. The details of the impact and compensation commitments would likely be negotiated as part of the CEAA/BCEA process. Issuance of the Fisheries Act Authorization triggers a project screening under the *Canadian Environmental Assessment Act*. The CEAA screening would be harmonized with the BCEA process.

1.2.1.3 Navigable Waters Protection Act

This Act protects the public right of marine navigation on all navigable waters in Canada. Therefore, any proposed works built or placed in, over, through or across a navigable waterway must be authorized under the Act. The definition of a navigable waterway is very broad and both the Taku and Tulsequah Rivers would be classed as navigable. **As the proposed barging project does not involve the placement of any structures in or over navigable waterways, approval under this Act is likely. A field assessment by Transport Canada staff will make the final determination.**

1.2.1.4 Other Regulations

Several transportation regulations will apply to this project, including those listed below. None of these, however, require approvals or permits to be issued.

- Transportation of Dangerous Goods Regulations; and
- Dangerous Goods Shipping Regulation.

1.2.2 Alaska Regulatory Regime

The Department of Natural Resource's (DNR) Office of Project Management and Permitting will coordinate review of the proposal as to whether it is consistent with the *Alaska Coastal Management Plan*, the *Juneau State Land Management Plan* and the *Tongass Land Use Management Plan.* The DNR will circulate and solicit input from various State agencies and NGOs' with an interest in the project.

1.2.2.1 Title 41 Fish Habitat Permit

A *Title 41 Fish Habitat Permit* will be required if it is determined that there is potential for disturbance of the estuary bottom or lands below the ordinary high water mark. The amphitrac will cross shallow sections of the Taku River, depending on the season, tides, and river volume. The review and issuance of the Title 41 authorization can run concurrently with the DNR's review of the project with respect to the Coastal Management Zone Plan.

1.2.2.2 Coastal Zone Consistency Review

The review coordinated by DNR's Office of Project Management and Permitting with regard to the Coastal Zone Management Plan and the Fish Habitat Permit would all occur concurrently.

1.3 Scope

For the purposes of the proposed amendment to the Project Certificate, the scope of the Project is defined to include the following components and activities:

1. Year-round barge operation between the proposed landing site on the Taku River and Juneau, Alaska.
2. Construction of a barge landing and loading facility located near the confluence of the Taku and Tulsequah Rivers.
3. Upgrading of the exploration access road to all-weather operational standard between the mine site and the barge landing site – a distance of approximately 12 km.

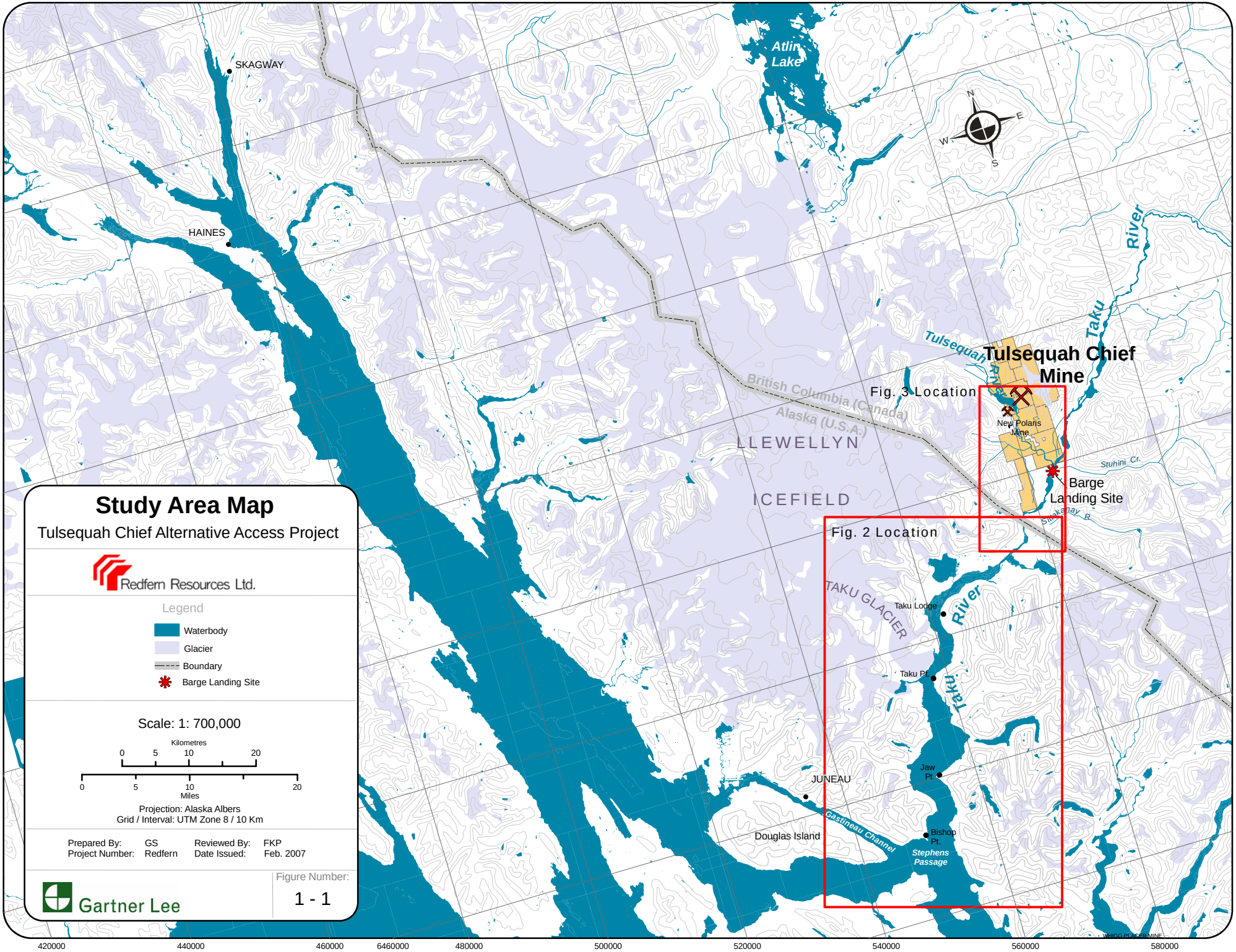
Figure 1-1 provides an overview of the Study Area. All concentrate will be containerized at the mine and the sealed containers will be transported to Skagway with no re-handling of the concentrate between the mine and the bulk loading facility in Skagway. The commercial barging operation between Juneau and Skagway and the bulk loading operations in Skagway are not included in the scope of this amendment. The port facility owned by the Alaska Industrial Development and Export Agency (AIDEA) indicated that it could handle the concentrate within its normal operating conditions and permits. Similarly, the barge loading facilities owned and operated by Alaska Marine Lines (AML) at Juneau are not included in the scope of this amendment as it is understood that AML is fully capable of handling the trans-shipment within its standard operating procedures and permits.

1.4 Timing

Overall, Redfern's schedule places mine construction starting in the fourth quarter of 2007. The barging system should be in place during the winter of 2007/08 to facilitate mobilization of mine construction equipment and supplies:

- construction of the amphitracs and ACBs is to begin in the late summer of 2007; and
- the ACB and amphitrac system is expected to be operational by winter of 2007/08, depending on completion of manufacture and certification of the vessels, and regulatory approvals.

The Tulsequah Chief project schedule is based on having an approved transportation route that is viable year-round, both for the construction of surface facilities and for operations. Conventional shallow-draft river barging, however, is constrained by water levels and does not provide continuous or predictable access. A year-round access route must be developed by the winter of 2007/08 to support construction activities at the Tulsequah Chief mine.


Study Area Map
Tulsequah Chief Alternative Access Project
Redfern Resources Ltd.
Legend
Waterbody
Glacier
Boundary
Barge Landing Site
Scale: 1: 700,000
Kilometres
0 5 10 20
0 5 10 20
Miles
Projection: Alaska Albers
Grid / Interval: UTM Zone 8 / 10 Km
Prepared By: GS
Project Number: Redfern
Reviewed By: FKP
Date Issued: Feb. 2007
Gartner Lee
Figure Number:
1 - 1
SKAGWAY
HAINES
Atlin Lake
Tulsequah Chief Mine
Fig. 3 Location
New Polaris Mine
Barge Landing Site
Tulsequah River
Taku River
Stuhini Cr.
Shakedar R.
British Columbia (Canada)
Alaska (U.S.A.)
LLEWELLYN
ICEFIELD
Fig. 2 Location
TAKU GLACIER
Taku Lodge
Taku Pt.
JUNEAU
Douglas Island
Jaw Pt.
Bishop Pt.
Gastineau Channel
Stephens Passage
N
S
E
W

1.5 Barge System Overview

1.5.1 Historical Perspective

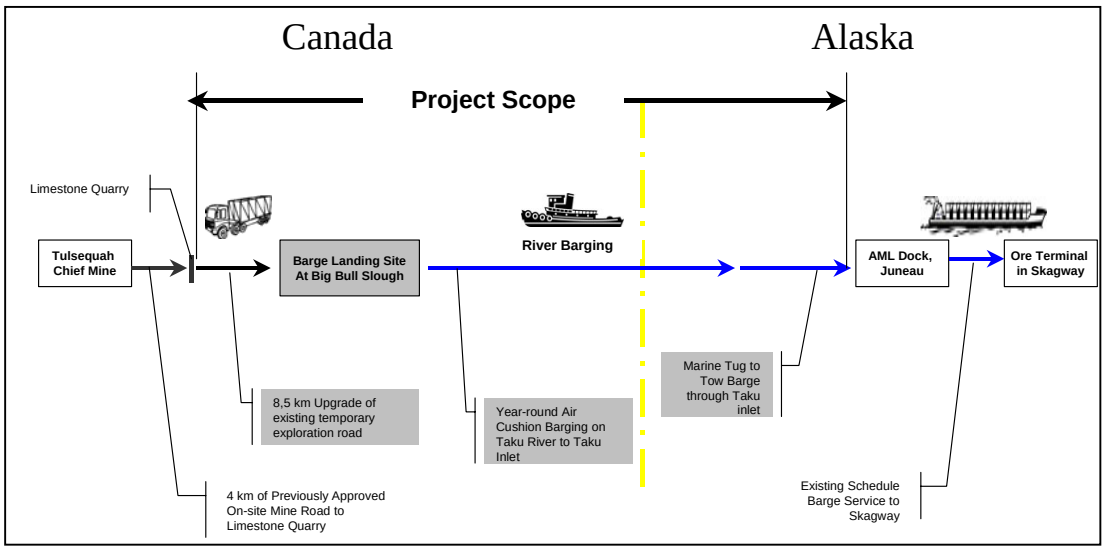
Following several decades of exploration in the area, Cominco brought the Tulsequah and Big Bull properties into production in 1951. The only means of transportation into Tulsequah were by air and water. Barging operations were possible from late May until late September, depending on the flow in the Taku River, during which time concentrate and supplies were transported in and out of the mine. Freight was hauled by ocean steamers to Taku Point, where it was transferred to river barges and towed up the Taku River by small tugboats. These tugboats were shallow draft, requiring less than two feet of water. A fleet of eight barges (100 ton capacity) and two tugboats operated continuously during this period, taking concentrate out and bringing in supplies. Cominco operated year-round, but given the seasonal transportation system, large facilities were needed at the mine site to store concentrate and supplies. Cominco's operations closed down in 1957.

1.5.2 System Overview

The primary means of accessing the site will be by ACB, towed by a conventional shallow draft tug operating during the open-water season, and by an amphibious vessel called an amphitrac when the river is frozen during the winter. This system will operate year-round on the Taku River from its confluence with the Tulsequah River to the Taku Inlet. From there, a conventional ocean going tug will transport the ACB to the port of Juneau. In Juneau, the concentrate will be transferred to the marine barge service operated by Alaska Marine Lines (AML) that runs regularly to Skagway, Alaska (see Figure 1-2). At Skagway, mineral concentrate will be loaded into bulk carriers for transport to Asian smelters.

All supplies, including fuel, cement, reagents, dry goods and other supplies needed during operations will, be backhauled to the mine site on the ACB.

Figure 1-2. Transportation System Schematic



2. Transportation Requirements

2.1 Annual Concentrate Shipping

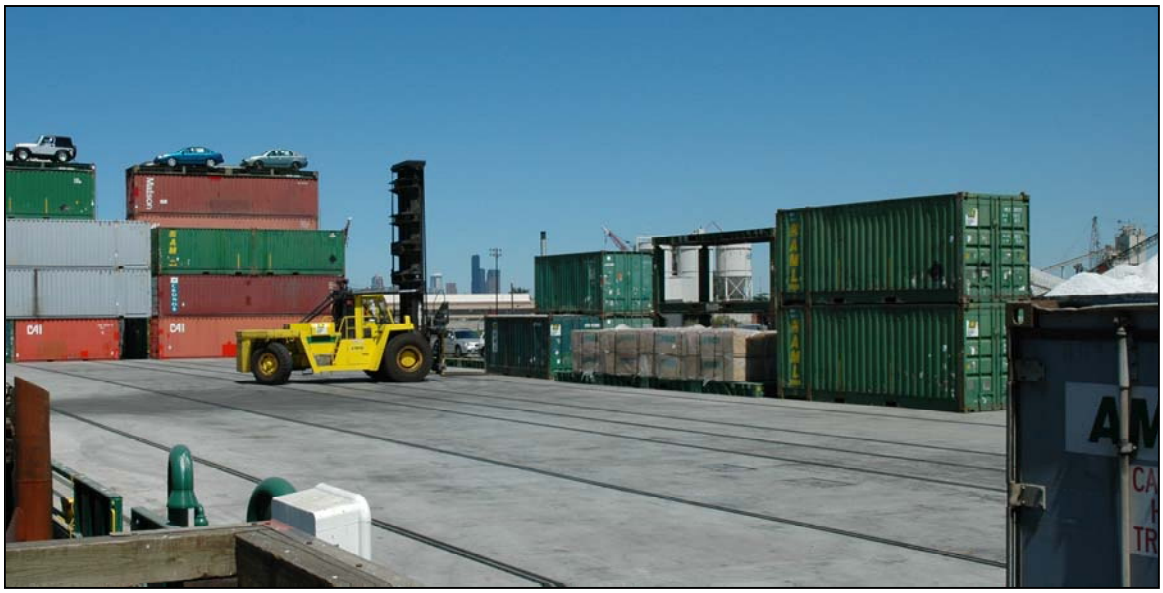
2.1.1 Concentrate Handling

Concentrate will be loaded directly into 20-foot half-height sea containers at the processing plant and trucked to the barge landing facility. Containers will be brought to the barge loading area by truck and loaded on the hoverbarge or ACB that is secured up onshore. This procedure is the same as any standard ferry service.

Standard heavylift forklifts will be used to load and unload the containers from the ACB in Juneau. It should be noted that the ample deck space on the ACBs eliminates the need for stacking of the containers, enhancing the stability of the barges and reducing wind-induced effects, and will also allow for the use of hook-lift trucks. All freight, containers and trailers on the ACBs will be secured to the deck during transit. AML will use its own equipment to load and unload containers for transhipment at Juneau.

In Skagway, containers will be hauled from the AML dock to the AIDEA facility by truck, where they will be unloaded by AIDEA. Containers will be dedicated to a specific mineral commodity to prevent cross-contamination of concentrates. Concentrate will then be loaded by AIDEA using an enclosed conveyor system onto bulk carriers for shipment to smelters in Asia.

Photo 2-1. Typical ISO Shipping Container



2.1.2 Shipping Requirements

Redfern anticipates being in full production in late 2008, and plans to ship concentrate year-round except during temporary shutdowns due to severe weather conditions. Based on the annual production rate at the mine, approximately 342 tonnes of concentrate (including moisture) will be produced from the operation each day on average. The average daily requirement for outbound (mine to Juneau) shipping is approximately 407 tonnes. This is made up of:

- Concentrate 342 tonnes
- Container weight 35 tonnes
- Other outbound supplies 30 tonnes

Mineral concentrate will be loaded into standard-dimension, weather-sealed shipping containers. The containers will be filled at the mine and sealed during barge transportation. Each container will be loaded with approximately 37 tonnes of mineral concentrate. Given an average concentrate production rate of 342 tonnes per day, nine to ten containers of concentrate would be shipped on each barge load. Containers will be dedicated to a specific mineral concentrate (zinc, copper or lead). This will prevent mixing of concentrates and allow containers to be re-used without having to be cleaned between loads.

The total annual average weight shipped from the mine (concentrate plus containers plus outbound supplies) is calculated to be 148,555 tonnes. The capacity of the ACB is 450 tonnes. Using a single ACB making round trips, this would require an average of 330 barge trips each year between the mine site and Juneau to keep pace with the rate of production at the mine. In order to provide a more realistic estimate of the number of trips required over the year, the following assumptions have been made:

- 365 concentrate production days per year;
- 20% downtime due to bad weather, freeze-up and break-up periods, maintenance etc, resulting in potentially 292 effective operating days/year; and
- one round trip each operating day for a single barge.

An extra barge would be required for make up trips for up to 38 days over the year, or an average of two trips/month. These additional barge trips could be done using an additional ACB periodically throughout the year, or using a conventional shallow barge during the summer, or both. Any additional barge trips would be run in tandem with the regularly scheduled barge trip on the river to avoid multiple disruptions to other river traffic that may be present. The tandem barge trips will provide the additional capacity that is needed over the year, while making reasonable allowances for weather and other delays.

2.2 Mine Re-Supply

Supplies required during mine construction and operation will be transported from Juneau to the mine site via the ACB. These supplies include fuel, cement, reagents used in processing, dry goods, etc. Table 2-1 lists the supplies that will be transported daily to the mine on a typical average barge load. The bulk of the re-supply load will consist of fuel and cement, the latter used as paste backfill for underground mining. Fuel will be transported in standard fuel trucks (average capacity of 40,000 litres), so there would be between one and two trucks per day.

Table 2-1. Average Mine Re-Supply Load / Trip

Item	Daily Average Tonnes	% of Total Weight
Diesel	70.4	45.6
Cement	40.4	26.2
Process Consumables	23.1	15.0
Misc. Equipment and Supplies	6.8	4.4
Food and Camp Supplies	6.0	4.0
Propane	2.7	1.7
Explosives	2.3	1.5
Process Plant Maintenance Supplies	1.7	1.1
Rock Bolts	0.6	0.4
Misc. Underground Supplies	0.3	0.2
Total	**154.3**	**100.0**

Photo 2-2. Typical Cement Container

2.3 Manpower Requirements

The total manpower required for the transportation system is estimated to be 20 persons, and is distributed more or less evenly between those based at the mine and those based in Juneau. Table 2.2 provides the estimated breakdown of manpower by position and location.

Table 2-2. Manpower Estimate for Transportation System

Position	# Persons per Shift	Total # Persons
River Crew:		
Captain	2	4
First Mate	2	4
Pilot Boat	1	2
Marine Crew		
Marine Tug Captain	1	2
First Mate	1	2
Mechanics	2	4
Supervisor	1	1
Clerk	1	1
Total	**11**	**20**

3. The Equipment

The fleet of equipment proposed for the barging system consists of a combination of vessels that are designed specifically for operations in the marine environment, or in a riverine environment, or both. Conventional vessels such as the marine and shallow-draft tugs are a familiar and accepted means of transportation for the purposes for which they are designed. ACBs have operated in a variety of challenging environments around the world and offer a year-round transportation solution in the range of conditions that will be encountered on the Taku River and in the Gastineau Channel. The amphitrac – an amphibious vessel – will be able to operate during the winter over the frozen river ice on tundra tires, and during the periods of break-up and freeze-up on the river when its amphibious capability will be needed.

The primary fleet includes two air cushion barges, one marine tug, one shallow draft tug, and two amphitracs. Secondary vessels that will accompany the fleet include a small power boat or jet boat that will operate during the open-water season on the river, and snow machines that will be employed during the winter season. These ancillary vessels will assist in navigation and to provide support in the event of emergencies. In addition to these vessels, an additional barge and shallow draft tug will be available to provide extra transport capacity at times when additional trips are

required to make up for delays due to bad weather, maintenance, etc. The following paragraphs describe the key features and capabilities of the fleet.

3.1 The Air Cushion Barge – Year Round Operations

Air cushion barges are slow moving (5 to 10 knots), shallow-draft barges that can be towed by aquatic vessels such as tugs, or winched along a fixed cable attached to shore or another fixed anchor point. They are built to meet marine specifications to accommodate the specific sea conditions on or off hover. The air cushion makes the barge amphibious, able to operate in open water or on land, and through extreme weather conditions. The barge travels at low speed with the bottom of the flexible skirt in the water. Air cushion barges have several distinct and important advantages over conventional barges (see Table 3-1):

- can travel over shoals, sand, gravel, ice, and not ground out;
- approximately 1 psi on hover – less than human footprint on land;
- very low ground pressure allows these craft to operate in sensitive environments; and
- very stable in rough water as skirts dampen effect of waves.

Numerous ACBs have been operated around the world over the past 30 years. The most widely known Alaskan experience was the ACBs that were used year-round to cross the Yukon River during the construction of the Trans-Alaska pipeline in 1976 (see Photo 3-1) and during this period there were no reported environmental issues.

Table 3-1. Comparison of ACB and Hovercraft

Feature	ACB	Hovercraft
Speed of travel	5-10 knots- sits in water at depth of about 0.7 m (2 ft)	35-60 knots – skims the water
Cargo Capacity	Depending on size, but has large capacity (300 to 600 tonnes is standard)	Limited cargo capacity as compared to ACB
Skirt construction	Individual segments. If one tears, the adjacent segments fill in and seal the cushion.	Loop skirt segments (see comment below on reliability
Noise	Diesel engines to fill skirt; amphitrac and ACB engines similar noise level as a tug	Loud - hovercraft is self-propelled with turbine engines and travels at higher speed
Wake	Low speed generates minimal wake	Higher speed generates more wake
Ability to travel in adverse conditions	Can operate safely in rough sea conditions; less prone to wave impacts than hovercraft	More prone to effects of wave impact, cushion wash out, wind and wave action causing vibration.
Reliability	Very reliable in wide range of weather and sea conditions.	Reliable within the range of conditions for which it is designed.

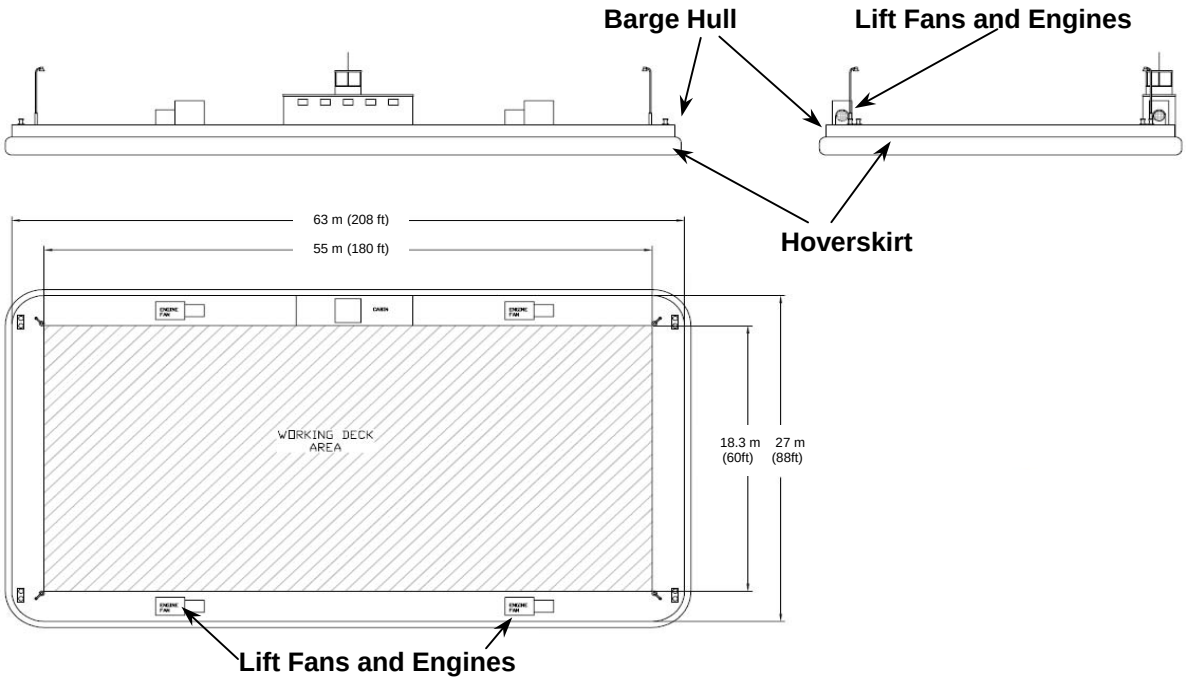
Photo 3-1. ACBs Operating Year-round Crossing the Yukon River during the Construction of Trans-Alaska Pipeline (1976)

As the ACB has been confused with a hovercraft, it is useful to summarize the key differences between these two vessels:

3.1.1.1 Barge Components

The main components of the barge are shown on Figure 3-1, and include the marine steel hull, the skirts, and the fans and engines that provide the lift when on hover. The overall dimension of the barge will be approximately 63 m x 27 m (208 ft x 88 ft). Unloaded, its weight will be 300 tonnes. Fully loaded, the gross weight will be 750 tonnes.

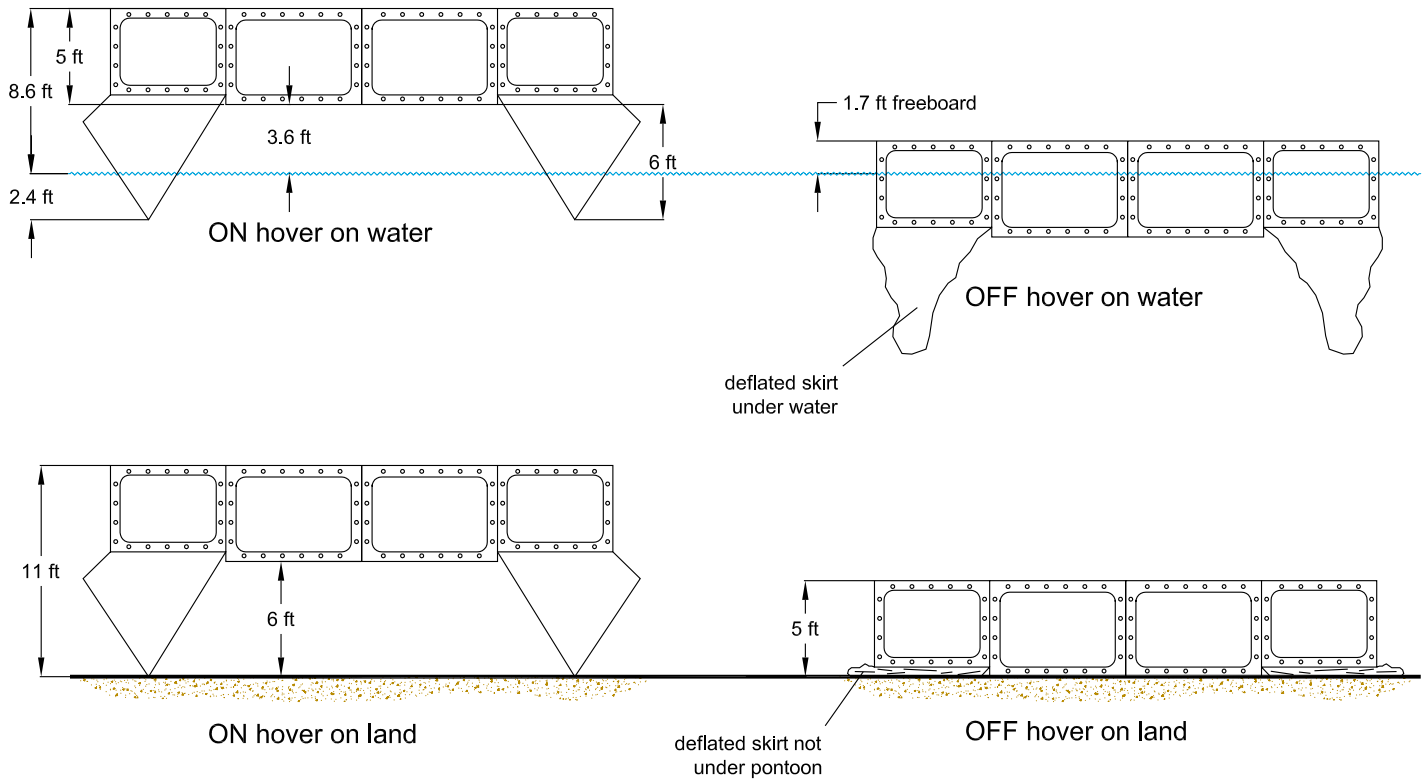
Figure 3-1. Air Cushion Barge Components



The dimension of the pontoon is 18.3 m x 54.9 m (60 x 180 ft), representing the usable deck area. The pontoon is 1.5 m thick (5 ft). Over water, the barge will hover at a height of approximately 1.8 m (6 ft) above the water's surface. When fully loaded, the draught will be approximately 0.7 m (2.4 ft) on hover. When not hovering, the barge will float with the pontoon in the water and the deck about 0.5 m (1.7 ft) above water. Figure 3-2 illustrates the hoverbarge on and off hover over water.

Air Cushion Barge Section

showing critical dimensions; barge width NTS



Vertical Scale: 1" = 10'

File:70142_By2_Fig3-2_BargeSchematic.dwg
Reviewed by: FP
Date Issued: July, 2007
Prepared by: MP
Project Number: 70-142

Redfern Resources Ltd.

Project: Tulsequah Chief Mine, Air Cushion Barge Access Alternative
Project Description
Location: Northwest British Columbia

Air Cushion Barge Operating Heights

Gartner Lee

Figure 3-2
Version 1

On land, the barge will be able to move across obstacles less than the hover height. When not on hover, the barge will gently settle on the ground surface. The skirts fold under themselves when the barge comes off hover and do not become trapped beneath the pontoon.

The skirt, comprised of many individual segments, surrounds the perimeter of the ACB. When inflated with air, the skirt creates a flexible seal with the water/ground surface. On uneven ground, the skirt segments will conform to the uneven surface, and at sea, this dampens the wave action as the barge travels through the water. When operating on water, about 0.7 m (2.4 ft) of the skirt will drag through the surface of the water. As the skirt system is comprised of many individual segments, damage to one or several adjacent segments does not affect its performance. Adjacent skirt segments simply over inflate and fill the gap created by the damaged segments, thereby reducing loss of air and maintaining hover pressure. The barge can tolerate considerable damage to adjacent segments before there is any noticeable loss of air pressure.

Photo 3-2. ACB Outer Spray Skirt – this ACB Operating in Surinam

Some of the pressurized air will escape from beneath the skirt, or between the skirt segments. A spray skirt lining the perimeter of the barge will contain spray and minimize ice formation on the skirts in winter.

Four 500 HP diesel engines will drive the fans pressurizing the skirts and provide power for lighting, heat, and cable winching. There is adequate resilience in the lift system for complete failure of one engine with no affect on performance. The fans are positioned on each corner of the barge deck. The pressurized air will be forced through the skirt segments into the space underneath the pontoon, and it is this air pressure that lifts the barge. The average pressure exerted on the surface (ground or water) is 1 psi (pounds per square inch). By comparison, a human footprint exerts 5 to 10 psi of ground pressure.

3.1.1.2 Noise

The ACB engines will be muffled and enclosed to minimize noise. The noise generated by the ACB and the Amphitrac will be approximately 70 dB at 100 ft, roughly equivalent to a tug passing by. The following table shows the noise rating for the ACB and amphitrac, as compared to various other vessels and craft. It should be noted that the dB rating is a logarithmic scale: a ten point change in the scale indicates double the noise (Table 3-2).

Table 3-2. Noise Comparison

Sound Source	dB
Pain threshold	140
Ship siren at 100 ft distance	130
Jet boat at 30 mph	88
Sport hovercraft at 85 ft	87
Float plane on take off	85
Jet ski at 20 ft.	80
Jet boat idling	70
Amphitrac at 100 ft	70
ACB at 100 ft	70

The ACB will be operated such that when it is operating in open water, the engines will be throttled back, as the skirt need not be fully inflated. When it is operating along the Taku River during the summer, for example, the noise generated will be less than when it operates over land as it will be moving more slowly.

The ACB will generate very little underwater noise. Noise, which is a vibration, will not be transmitted directly from the steel pontoon to the water as there is no contact between the pontoon and the water when on hover. The only contact between the ACB and the water would be the skirts that do not transmit sound well. All other sound will be muffled by the 6 ft air gap between the pontoon and the water's surface. Noise transmitted to the water will also be muffled by the 5 ft internal air gap between the upper and lower planes of the pontoon.

Two studies monitored noise effects of hovercraft, and concluded that underwater noise impacts from hovercraft were considerably less than from similar sized conventional vessels, and had little effect on fish and wildlife resources in the area of operation.

One of these studies was completed for the US Postal Service, and was carried out by Volpe National Transportation Systems Center. The conclusion of a three-year monitoring project was "*the winter underwater noise monitoring and visual observations showed that the hovercraft had little impact on blackfish subsistence gathering by local Eskimos. It also showed that, after careful observation and repeated testing performed by Volpe staff over the past three years, the hovercraft had little impact on waterfowl.*"

A second study was conducted by Susanna B. Blackwell and Charles R. Greene, Jr. of Greeneridge Sciences Inc. of Goleta CA in Prudhoe Bay to assess the underwater and in-air sounds created by a Griffon 2000TD hovercraft driven at full power. This work was published in the 1 Dec. 2005 Journal of the Acoustical Society of America. Their conclusion was "The hovercraft was considerably quieter underwater than similar-sized conventional vessels and may be an attractive alternative when there is concern over underwater sounds."

As hovercraft are in the order of four times louder than ACBs, it is reasonable to conclude that underwater noise from the ACBs would have even less effect on fish an wildlife operating under similar conditions.

3.1.1.3 Wake

During the aquatic season, the ACB will be pushed by the shallow draft tug, assisted by the amphitrac towing the barge. It is difficult to precisely describe the wake that will be generated by the combined vessels as they shuttle back and forth on the Taku River; however, each vessel can be independently analyzed and some preliminary conclusions drawn. The size of the wake is a function of the draft of the vessel (deeper draft generates more wake), and the speed of the vessel (faster speed generates more wake).

A Rolligon (similar to the proposed amphitrac) makes essentially no wake when traveling in water. It is uncertain as to what the Archimedes screws will contribute to wave generation, but any wake produced by the amphitrac would be dampened by the much larger ACB following close behind it.

The ACB itself will make a minimal wake, as demonstrated in Photo 3-1, showing the Yukon Princess being ferried across the Yukon River at 5 mph. This photo was taken when the Yukon River was flowing at ten knots. The wake generated by a craft is affected primarily by its speed, draft and length. The ample length of the ACB generates little or no wake.

The main contributor to wake, therefore, will be the shallow draft tug pushing the ACB. The tug will produce less wake than a marine tug due to the shallower draft.

Wake is of concern primarily in areas of development along the river banks, where increased bank erosion and potential damage to docks and/or moored craft is a concern. In areas such as Martini Row where cabins are concentrated over a very short stretch of the river, speed will be reduced through this area to minimize wake. The operation of the barge system will contribute minimally to ongoing bank erosion that results from the annual freshet that modifies the river morphology annually, such as occurred in June 2007. This is well demonstrated in the photographs below. No wake issues were identified during conventional barging in summer 2007.

Photo 3-3. Low and High Water in Taku River: Photos Taken May (left) and June (right) 2007, just upstream of Cranberry Island

3.1.1.4 On-board Fuel Containment

Approximately 2,500 litres (660 gallons) of diesel fuel will accompany the barge to provide sufficient fuel to the engines during a round trip as well as emergency fuel supply. The fuel will be contained in a double-walled tank with surrounding containment. Refuelling of the ACB will be done in Juneau at the existing marine fuelling facilities.

3.1.1.5 Controls and Operating Constraints

The ACB will not be manned, but will be operated remotely from the towing vessel (tug or amphitrac). In addition to the usual controls to run the engines and fans, the deck will be heat-traced to prevent the build up of ice during winter operations. All maintenance on the ACBs will be done in Juneau. As the lift is provided by standard diesel engines, no specialized maintenance personnel or facilities are required.

The ACBs are very stable and will be designed to accommodate *sea state five* (wave heights up to four metres or 13 feet). The hoverskirt attenuates wave action and makes the ACB more stable than a conventional barge in waves.

The barge remains very stable even during high winds due to its size and configuration. Given the ample deck area, the nine or ten concentrate containers will not need to be stacked thereby giving the loaded vessel a low profile. Wind deflectors will be installed on the front and back of the ACB to provide some protection and shelter to the deck area. When wind speeds reach gale force (above 50 mph), the ACB will be taken off hover to wait out the adverse weather. In all cases, the operators will have contingency plans for these situations.

3.2 Shallow Draft Tug – River Operations in Summer

A shallow draft tug will be used as the primary means of propelling the ACB during the open water season on the Taku River. The shallow draft tug will operate on the mainstem of the Taku River, between the barge landing site and the Taku Inlet where the barge(s) will be transferred between the shallow draft tug and marine tug.

Shallow draft tugs are commonly used on large, shallow rivers such as the Tanana in Alaska, the McKenzie River in Northwest Territories, and the Mississippi and Ohio Rivers in the United States. Numerous designs have been developed over the years that are appropriate for this purpose. The closest parallel to Redfern's requirements is found on the McKenzie River, where powerful boats with shallow drafts are used. As a result, numerous vessel designs have been developed over the years that are appropriate to the application of towing an ACB on the Taku River. Some of the best designs for shallow draft tugs are produced in British Columbia by Robert Allen Ltd. and A.G. McIlwain Ltd. An example of an A.G. McIlwain design, the *Streeper*, is shown in Photo 3-4.

Photo 3-4. W R Streeper Shallow Draft Tug

The specifications of the shallow draft tug proposed for this operation would be similar to those of the W.R. Streeper, as follows:

- Length 20.42m
- Beam 7.92 m
- Full Load Draft 0.79 m
- 4 Main Engines 6 Rudders
- MHP 1,500
- Fuel Oil Capacity 6,400 L
- Crew Accommodation for 5
- Steel Hull, Aluminium House Work

The tugboat will have a draft of 0.7 m (2.4 ft). This is accomplished by embedding the propellers in tunnels inside the hull. This allows the use of large propellers to increase the bollard pull of the vessel, while protecting them from the damage that would be caused by touching the bottom or submerged logs.

The shallow draft tug will carry sufficient fuel onboard for at least one round trip on the river, and will be refuelled at the barge landing site in Canada. Refuelling will be done using a hose and hand pumps. Refuelling will be carried out in a designated area only, and spill contingency equipment will be in place at all times at the barge landing site.

3.3 Marine Tug – Marine Operations Year-round

A conventional marine tug will be used to tow the ACB between the Taku Inlet and Juneau (see Photo 3-5). The tug may be contracted through Alaska Marine Lines (AML), or contracted through another operator. Use of a conventional marine tug in the marine portion of the route ensures that:

- the tug is designed for the marine conditions that will be encountered;
- will reduce the operating time for the specialized equipment (amphitrac), thereby reducing maintenance costs and delays; and
- operated by experienced and qualified crew familiar with marine conditions and operations; and
- will be familiar technology to other marine operators in the area.

Photo 3-5. Example of Marine Tug

3.4 Amphitrac – Winter; Spring/Fall Aquatic Operations

The amphitracs will be used as the primary source of propulsion during the winter months when the river is frozen. The amphitrac is essentially a Rolligon that has been converted to an amphibious vessel, so that it can operate on land, using soft tires, or in water, using archimedes screws. Rolligons are low ground-pressure tractors with large soft tires that have been used routinely on the Alaskan North Slope for the past 35 years.

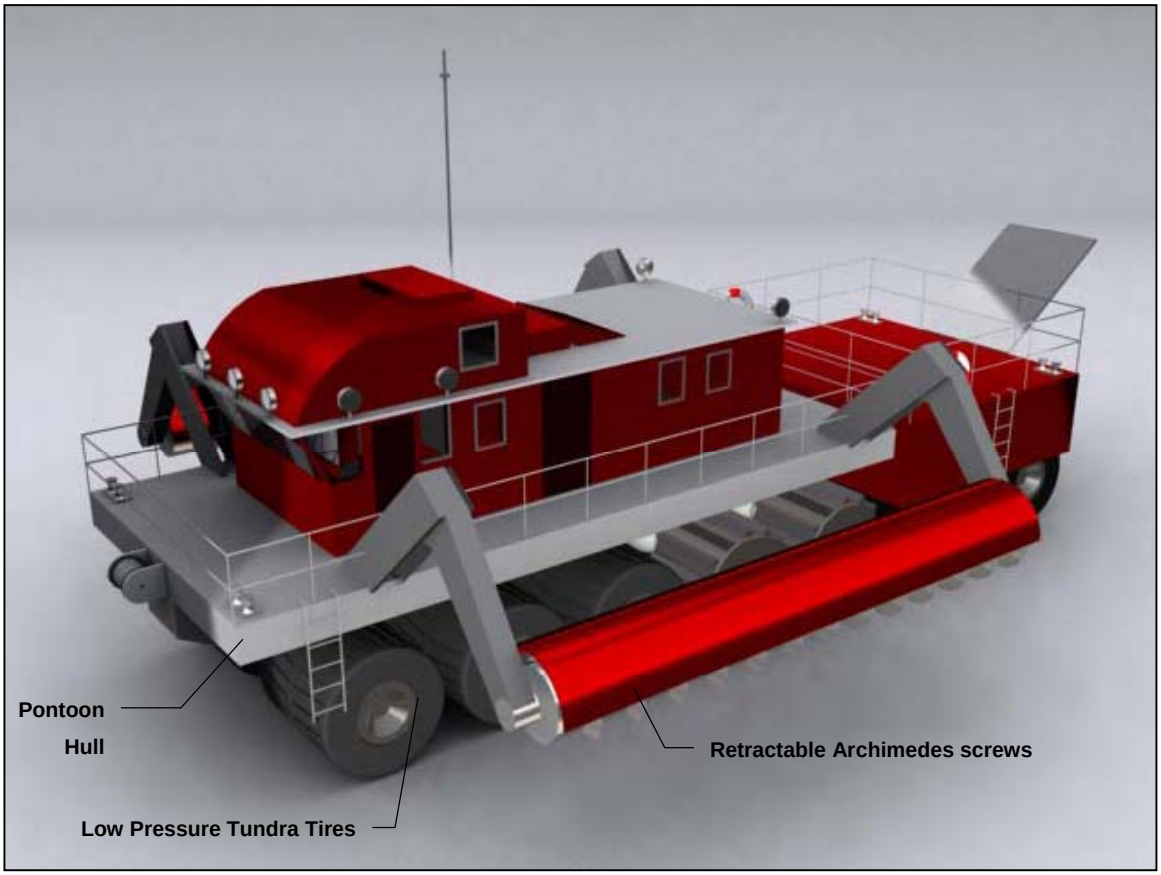
Vehicles of this type are the only vehicle permitted to operate on the tundra year-round due to the low ground pressure exerted by the soft tires (Photo 3-6).

Photo 3-6. Rolligons on Alaska's North Slope

The Rolligon will be converted to an Amphitrac by the addition of the following:

- marine pontoons that will make it amphibious;
- retractable rear wheels will be metal to add greater traction for snow and ice;
- two retractable archimedes screws will be added to each side to provide propulsion in water, and to assist the vehicle as it transitions from water to ice. The screws will also increase the stability of the amphitrac;
- rubber tires will be retractable during aquatic operations;
- winches fore and aft to provide additional pull when required;
- standard marine safety equipment will be on board as well as a zodiac-style life raft; and
- there will be small but comfortable crew quarters on the amphitrac.

Photo 3-7. Illustration of Amphitrac



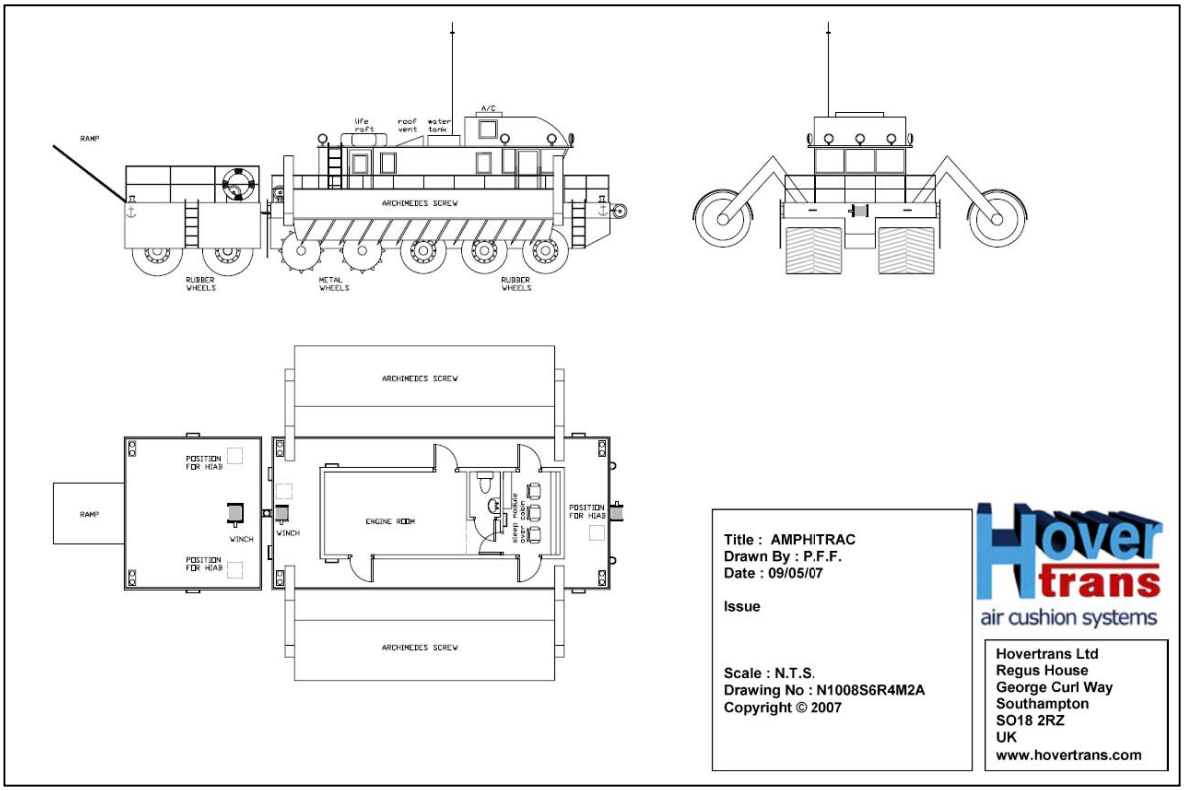
The low-pressure tires on the amphitrac are operated between 2 and 5 psi, but are typically set at 3 psi. Tire pressure can be adjusted within this range to suit the ground conditions, with lower pressure used for softer ground surfaces. A schematic diagram of the amphitrac is shown on Figure 3-3, and illustrated in Photo 3-7.

Amphitrac Specifications:

- overall dimensions are 18 m long x 8.5 m wide (59 ft x 28 ft);
- two 660 Hp diesel engines will provide all the necessary drive power (hydraulic).

The engines will be sized for maximum power needed (1,200 hp), such as transitioning from water to ice, and moving upstream against the river currents.

Figure 3-3. Amphitrac Components



During summer, one amphitrac will assist the shallow draft tug to provide additional upstream propulsion and downstream control over the barge. The archimedes screws allow the amphitrac to move through water as well as the ability to climb out of water onto land or ice. The archimedes screws are on retractable hydraulic arms that allow the operator to adjust both the depth and pitch of the screws to suit conditions. The screws also provide additional lateral stability by acting as outriggers. The anticipated speeds that the amphitrac is estimated to travel under various conditions are summarized in Table 3-3.

Table 3-3. Amphitrac Operating Speeds

Operating Mode – Towing Loaded ACB	Speed (kph)	Speed (mph)
Maximum speed over wet sand and gravel (tires)	32	20
Compact Snow and Ice (tires)	30	20
Average ground speed towing fully loaded ACB	15	9.3
Calm water (minimal current using screws)	12.8	8

The amphitrac will carry adequate fuel onboard for at least one roundtrip between the barge landing site and the Taku Inlet. Refuelling will be done at the barge landing site where fuel will be stored for this purpose.

When operating independently of the shallow draft tug, such as during the winter season over frozen ground, or during the shoulder season when there is insufficient depth for the shallow draft tug in the channels through the sand flats, two amphitracs will be needed to manoeuvre the ACB along the route. The amphitracs can either pull or push the ACB, providing the barge master flexibility in handling and manoeuvring the ACB depending on route conditions. When pushing, the amphitrac will be connected to a yoke located on the back of each ACB. In difficult sections of the route, for example when making the transition from water up onto the ice, one amphitrac can precede the barge and establish an ice anchor, then winch the barge across the difficult terrain before resuming normal travel.

The skills required for the operation of the amphitrac should be readily available in Juneau. These include diesel mechanics, barge masters, and operators. It is anticipated that some barge masters and crew may be Taku River residents and/or users as local river knowledge will be an asset to optimizing operations.

3.5 Ancillary Vessels

Several smaller vehicles and vessels will be used in conjunction with the primary vessels:

- A small powerboat will accompany the barge during the open water season to act as a pilot vessel ahead of the barge. This vessel will assist the barge master in determining the best route to follow up and down river, and provide advance warning to other river users of the barge's progress.
- Snow machine(s) will accompany the barge during winter, in the event of emergency evacuation of personnel, or to scout obstacles along the route.
- All tugboats and the amphitracs will be equipped with zodiacs for emergency evacuation.

Secondary vehicles and vessels will also be used to place forward point anchors (such as on the river ice) where winching may be required in order to overcome difficult sections of the route.

3.6 Communications

Telecommunications are an essential component of marine transportation, and are particularly important in remote locations that do not have other available communication systems. A satellite link between the barge landing site, the vessels, and Juneau will be established to provide reliable, constant communication for crews operating the system.

4. Barging Operations

The barging operation consists of two operational components- a marine component that will handle transportation between Juneau and the Taku Inlet, and a river component that will operate on the Taku River up to the barge landing site. This system will use vessels and equipment best suited to the particular conditions expected to be encountered along the route, and will be coordinated to provide a transportation system that is reliable, safe, and efficient.

There will be two discrete bases of operations: AML's facility in Juneau and the barge landing site at the confluence of the Tulsequah and Taku Rivers. It is proposed that two separate crews will operate the transportation system - a Juneau-based crew that is responsible for the marine portion of the system, and a crew based at the mine that will be responsible for the river portion of the system.

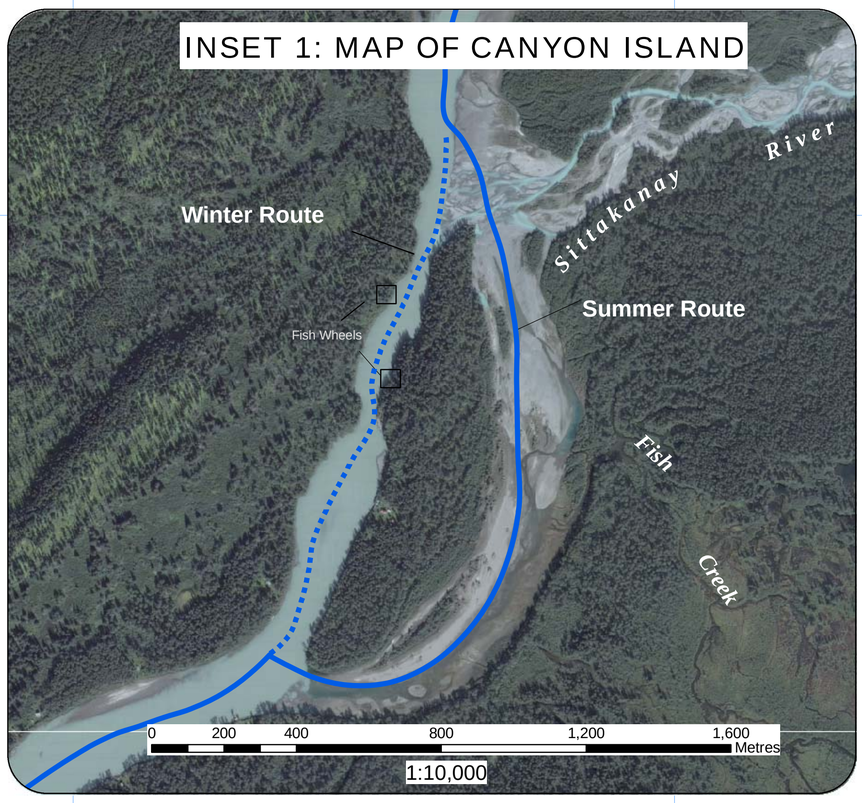
4.1 Route Overview

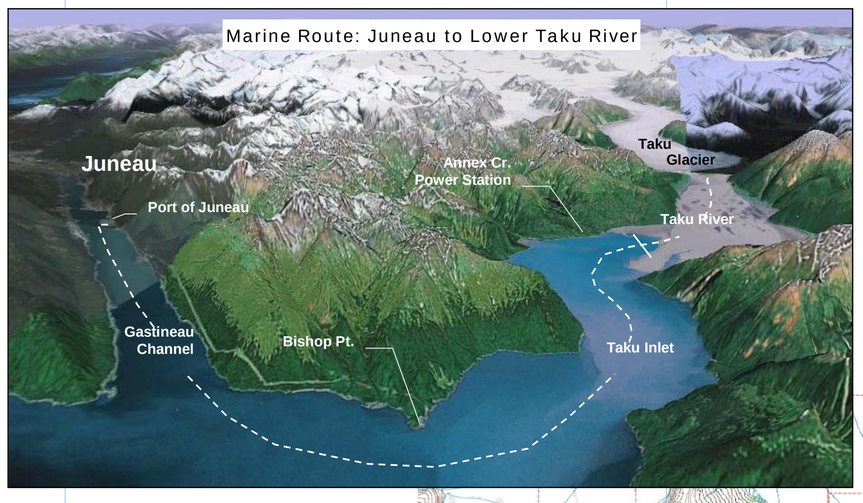
Figures 4-1 and 4-2 show the proposed shipping route between the mine site and Juneau, Alaska, and from Juneau to Skagway. Regular commercial barging services between Juneau and Skagway will be used to move the containers of concentrate to the existing loading facilities at Skagway. Given that this is an established service, this portion of the transportation route is not included within the scope of this assessment. An atlas containing detailed maps of the barging route is included in Appendix C.

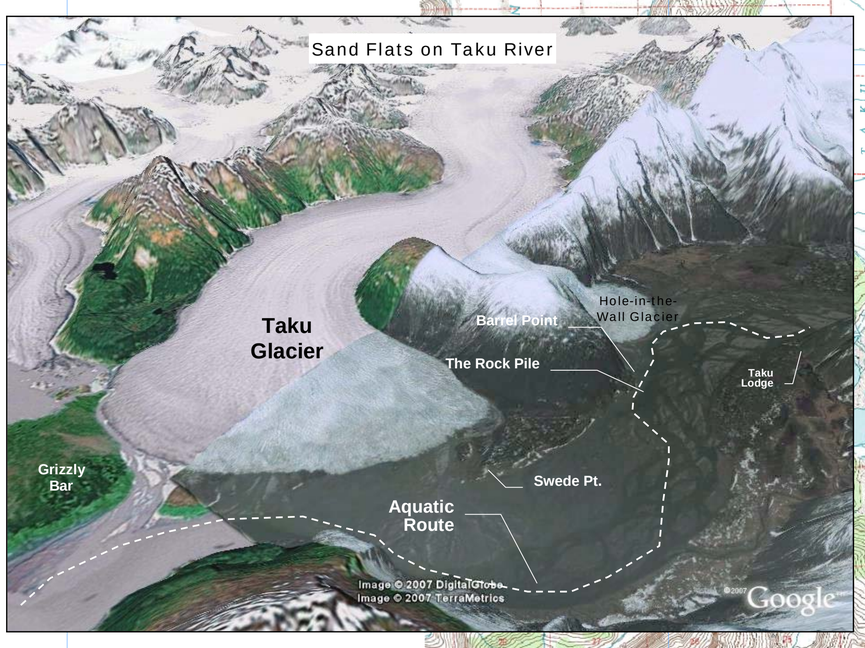
The barge operations in Gastineau Channel and the deep water of Taku Inlet will be fully aquatic year round, and will utilize marine shipping channels through this area. A conventional marine tug will be used to tow the ACB through these waters. The route along the Taku River will vary according to the season, and will also depend on the daily water levels in the river during the open water season. The entire route along the Taku River in both the US and Canada is below the ordinary high water mark of the Taku River.

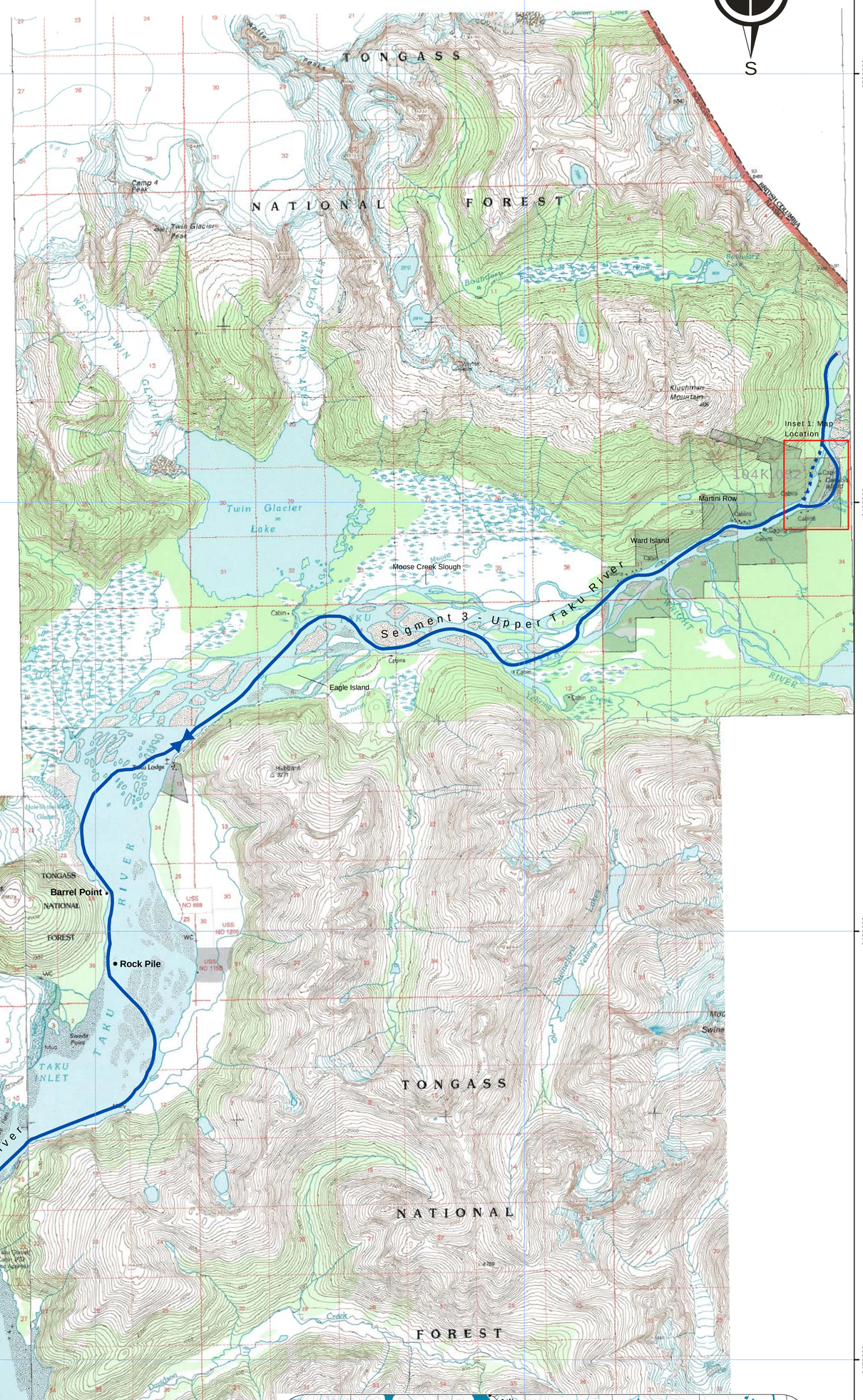
The proposed route has been developed based on both summer and winter site visits by the proponent and the ACB designer in 2006 and 2007, and on local knowledge of the river provided by long-time Taku River residents and riverboat operators. The route benefits from the local knowledge of many years and seasons on the river and its fluctuating conditions. Furthermore, it incorporates considerations for other river users and existing river traffic.

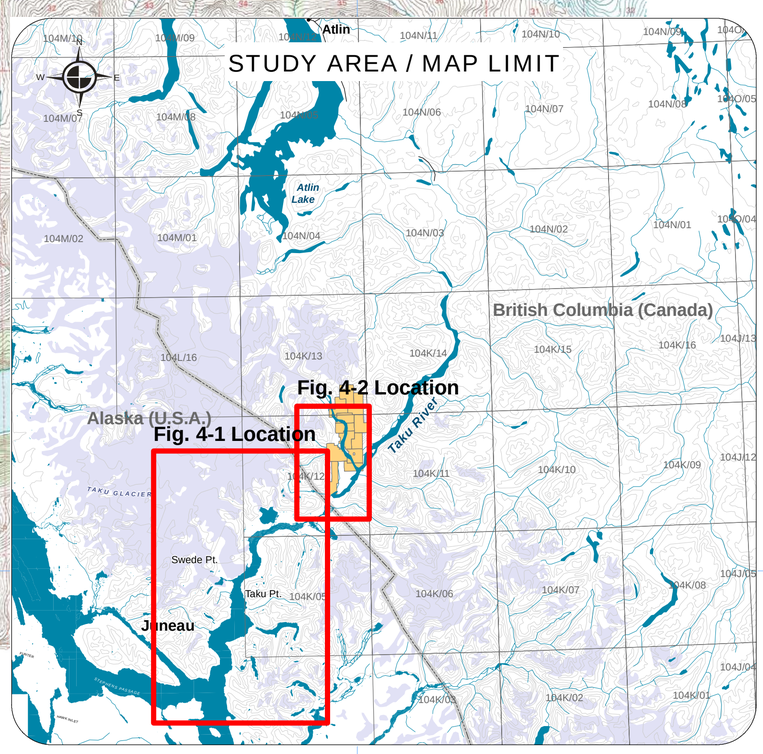
The route between Juneau and the barge landing site can be broken into several distinct sections, as outlined in Table 4.1. Figures 4-1 and 4-2 show in detail the Alaskan and Canadian portions of the route respectively. Each section of the route is described, and where applicable, the winter/summer and low/high water options are described.











Proposed Barge Route - Taku River Alaska

Tulsequah Chief Mine, Air Cushion Barge Access Alternative

Redfern Resources Ltd.

Legend

- Proposed Barge Route
- Winter Route

Data Sources

Georeferenced maps acquired from the US Geological Survey, at 1: 63 360 scale.

1. Juneau B-1 Quadrangle
2. Juneau A-1 Quadrangle
3. Taku River C-6 Quadrangle
4. Taku River B-6 Quadrangle

Scale: 1: 70,000

1 centimetre = 700 metres

Kilometres: 0 1.25 2.5 5

Miles: 0 1.25 2.5 5

Projection: UTM Zone 8, NAD 83

Prepared By: SM Reviewed By: FKP Project Number: 70142 Date Issued: July 27. 2007

Gartner Lee

Figure Number: 4-1

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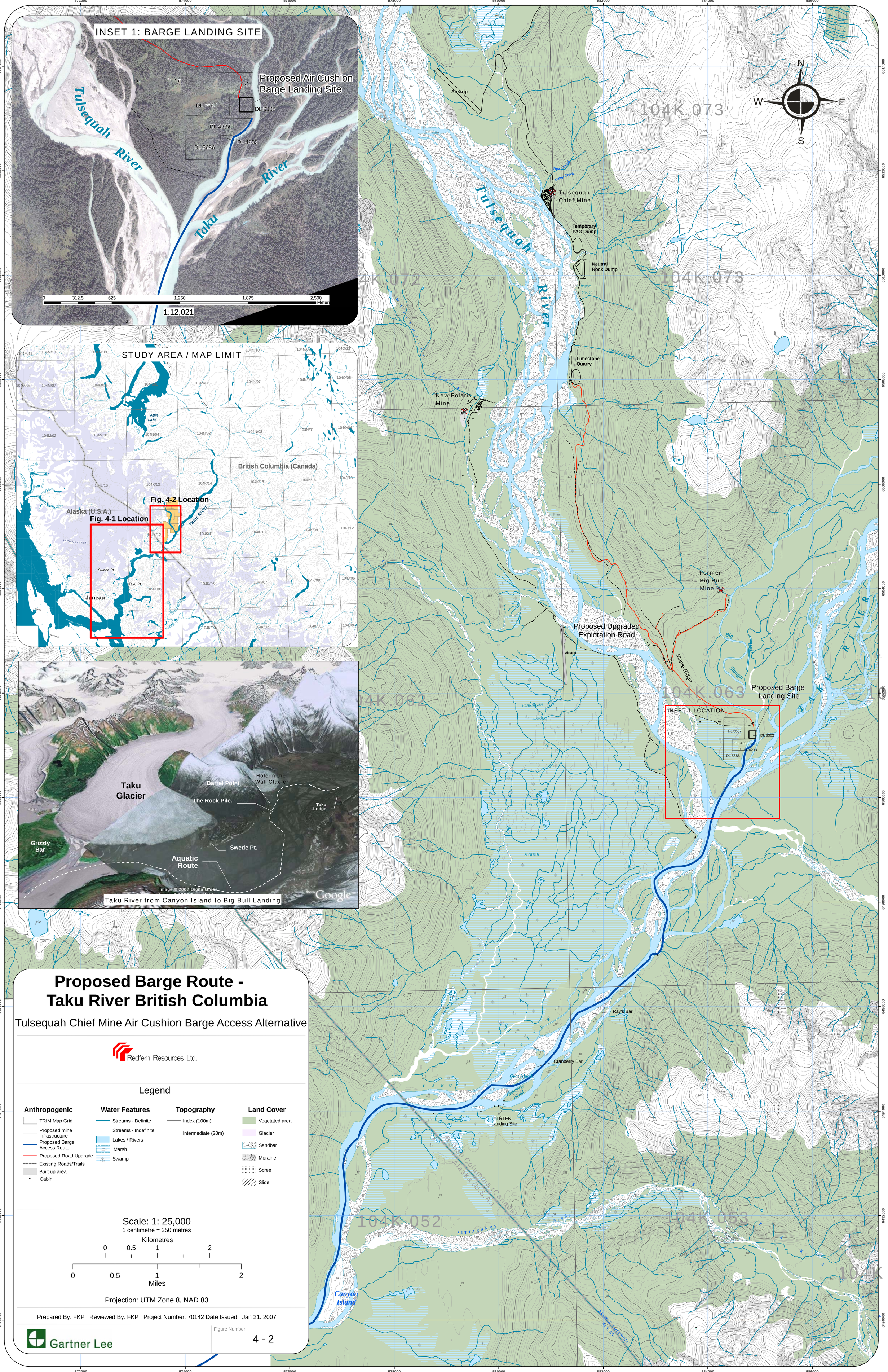

Proposed Barge Route - Taku River British Columbia

Tulsequah Chief Mine Air Cushion Barge Access Alternative

Redfern Resources Ltd.

Legend

Anthropogenic
- TRIM Map Grid
- Proposed mine infrastructure
- Proposed Barge Access Route
- Proposed Road Upgrade
- Existing Roads/Trails
- Built up area
- Cabin

Water Features
- Streams - Definite
- Streams - Indefinite
- Lakes / Rivers
- Marsh
- Swamp

Topography
- Index (100m)
- Intermediate (20m)

Land Cover
- Vegetated area
- Glacier
- Sandbar
- Moraine
- Scree
- Slide

Scale: 1: 25,000
1 centimetre = 250 metres

Kilometres: 0 0.5 1 2
Miles: 0 0.5 1 2

Projection: UTM Zone 8, NAD 83

Prepared By: FKP Reviewed By: FKP Project Number: 70142 Date Issued: Jan 21. 2007

Gartner Lee

Figure Number: 4 - 2

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Table 4-1. Barge Route Segments and Distances

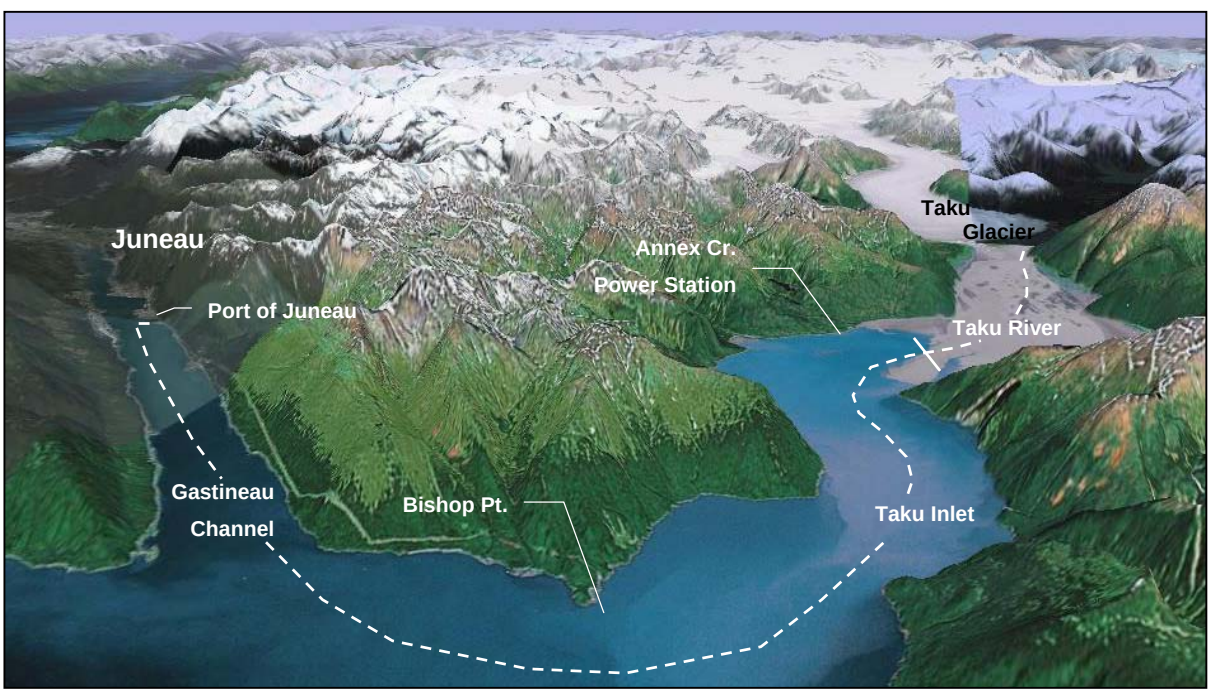
Segment No.	Description	Distance Km (mi)	
		Segment	Cumulative
1	**Marine Route**: Gastineau Channel; Taku Inlet to Annex Creek	35 (22)	35 (22)
2	**Lower Taku River** Annex Creek to Taku Lodge	27 (17)	62 (38)
3	**Upper Taku River**: Taku Lodge to Tulsequah confluence	33 (20)	95 (39)

The route will be plotted using high resolution Global Positioning System (GPS). The shallow draft tug and amphitracs will be fitted with real time GPS which will allow the crew to follow the route in all weather conditions. It is also important to note that the route may be modified from season to season and from year to year, based on operating experience gained by the barge masters and to adjust to the changing river environment and other operating conditions that may be encountered.

4.1.1 Marine Route: Juneau to Taku Inlet

The Gastineau Channel is open only at the south end, with the City of Juneau and its port situated at the north end of the channel. This dictates that all marine traffic to Juneau travels through the Gastineau Channel. Marine traffic is quite heavy and includes cruise ships and pleasure craft in summer. The channel is fairly well protected and is not subject to the heavy swells and winds of the Taku Inlet. An oblique view of the marine route is provided in Figure 4-3.

Figure 4-3. Marine Route: Juneau to Lower Taku River



The Taku Inlet portion of the marine route is open water year round, and is highly susceptible to storms, high winds, and high swells. In winter, the prevailing wind is from the north. This trend reverses in summer. The following extract from a brochure published by the National Oceanic and Atmospheric Administration describes extreme wind conditions in this region:

> *The term "gap winds" refers to locally strong winds accelerating through gaps in terrain. In southeast Alaska, gap winds commonly occur in the winter at the mouths of large rivers such as the Taku and Stikine. Gap winds are generally caused when there is a large pressure difference across a range of mountains.*
>
> *"Taku" winds blow down the steep slopes of Salisbury Ridge near the mouth of the Taku River and hit Douglas (Channel) with full force…occurring an average of four times a year between October and April".*

The route taken by the marine tug will follow the shipping channel in the Gastineau Channel, and more or less follow the center of the Inlet to the upstream limit of the deep water. At this point, the marine tug will rendezvous with the shallow draft tug or amphitrac (depending on the season), swap the inbound ACB with the outbound ACB and return to Juneau.

4.1.2 Lower Taku River - Taku Inlet to Taku Lodge

Sandy sediment deposited by the Taku Glacier is deposited at the mouth of the Taku River, causing the formation of extensive sand bars across the width of the river channel. The river is a series of braided, shallow channels interspersed with sandbars extending upstream of Annex Creek to the Taku Lodge (Figure 4-4). This represents approximately a 27 km (17 mile) reach of the river. With the high sediment load carried by the river, the mouth of the river will migrate downstream indefinitely.

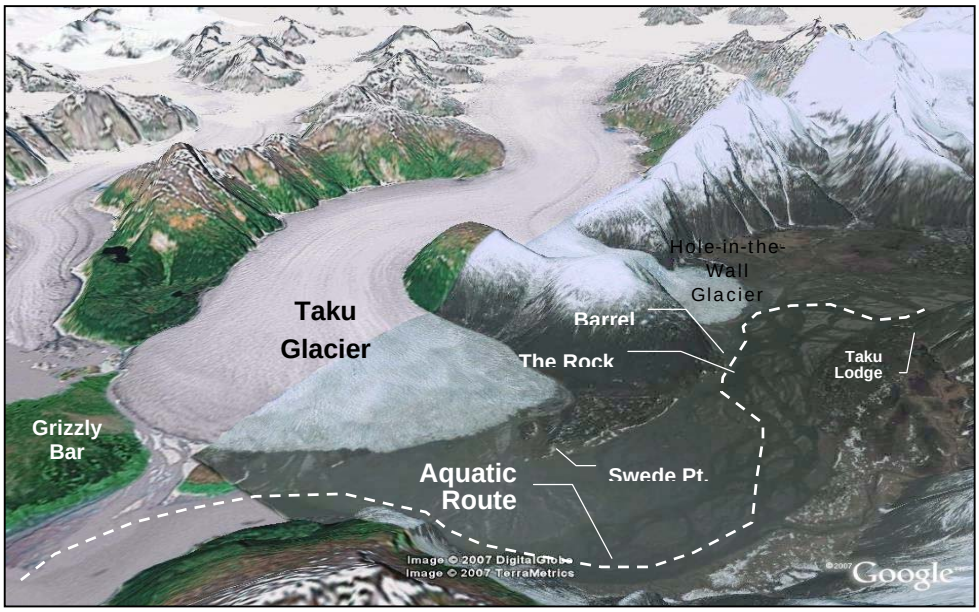


Figure 4-4. Route through the Sand Flats on Lower Taku River

River Depth and Tidal Influence

Through this section, the river channel depths vary between <1 m to 4.5 m (14ft) depending on the river discharge and tidal influence. Moving upstream from the Taku Inlet, the influence of the tide on the depth of water in the river decreases, reaching the upstream limit of tidal influence near Taku Lodge. Here, the tide contributes only 10 cm (4 inches) of additional depth at river discharge of 500 m^3/s (low flows). At higher river discharge, the tide provides a similar contribution, but the river depth is greater as a result of the higher river discharge combined with tidal assist. Figure 4-5 illustrates the bathymetry of the river channel during summer flows, and at mean low water (low tide). An analysis of the channel depth at various river and tidal conditions through this section of the river is contained in Appendix A.

During the period from about early May until early October, the historical mean monthly river discharge varies between 500 m^3/s in spring and fall, to over 1,000 m^3/s during June (Figure 4-6).

Between late May and mid August, the river discharge, combined with medium to higher tides, provides sufficient depth of water for a shallow draft tug to operate successfully through this section of the river. The tug would follow the main channel through this part of the river, as approximated on Figure 4-4. This channel has been identified through the knowledge and experience of local river users, as well as through bathymetric analysis completed both in 1997 and again in 2007 in this section of the river. Though the channel does migrate somewhat over time, it is interesting to note that the main channel has not shifted significantly during the ten years since the 1997 bathymetric analysis was undertaken.

During winter, once the river ice is sufficiently thick and/or land fast, the river operation would be on ice and snow upstream of the tidal influence, and would follow the easiest route along the floodplain.

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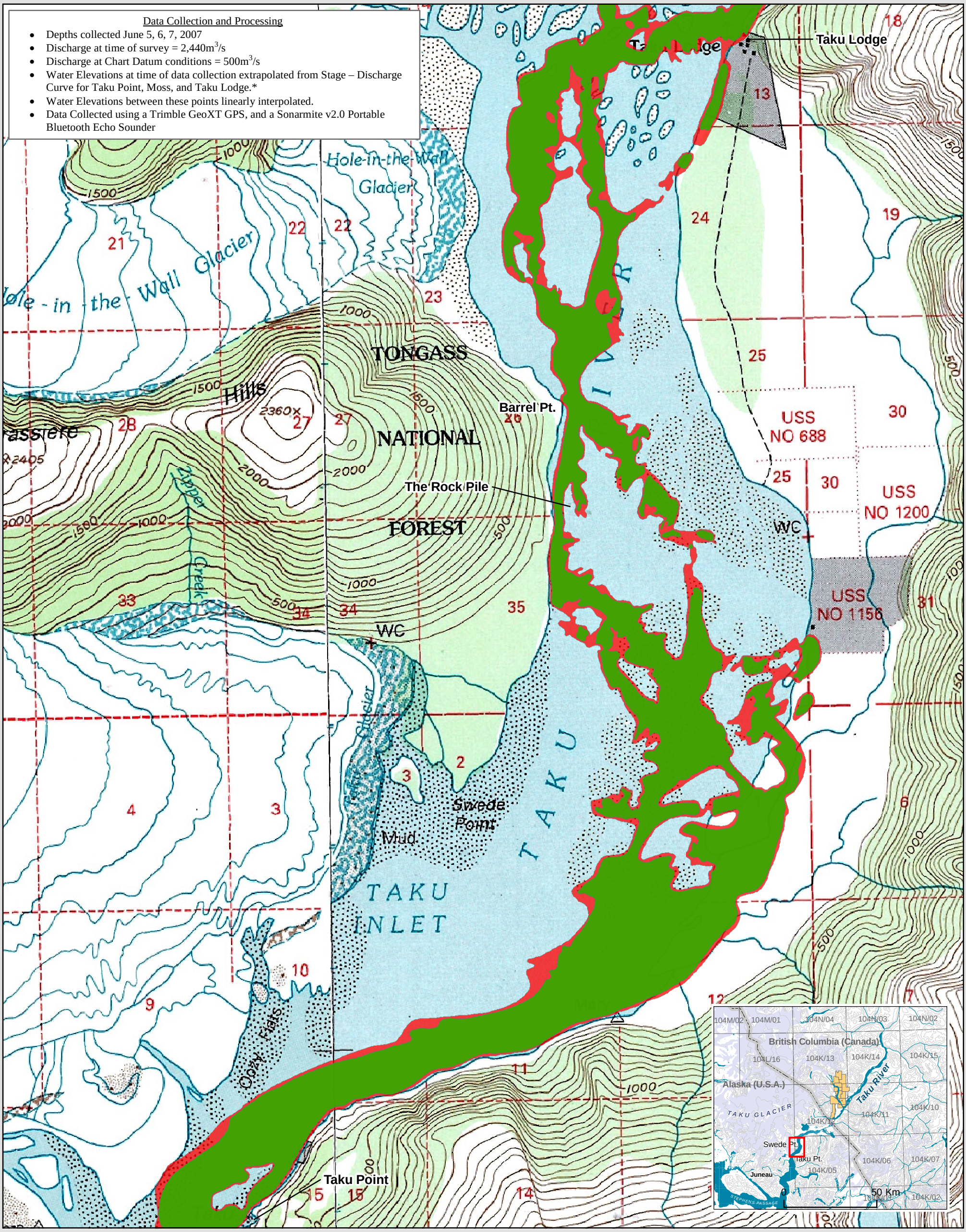


Map Sources/Notes:
Water Depth Measurements Collected on June 5-7/2007 by Gartner Lee Ltd. field staff.
*'Figure 5.1 Stage - Discharge Relationship for Lower Taku River' (Larson, M., Byres, R., 1995)
Topographic Images derived from Digital Raster Graphic (DRG) Images produced by the USGS.

Kilometres
0 0.25 0.5 1
0 0.25 0.5 1
Miles

1:30,000
UTM Zone 8N, NAD 83

File Name: 70142_Fig4-5_T_O7_07.mxd
Reviewed By: FP
Date Issued: July 2007
Prepared By: JW
Project Number: 70142

Legend

- Areas with > 3 ft of water
- Areas with between 2 and 3 ft of water
- Areas with < 2 ft of water

Redfern Resources Ltd.

Bathymetry of Lower Taku River:

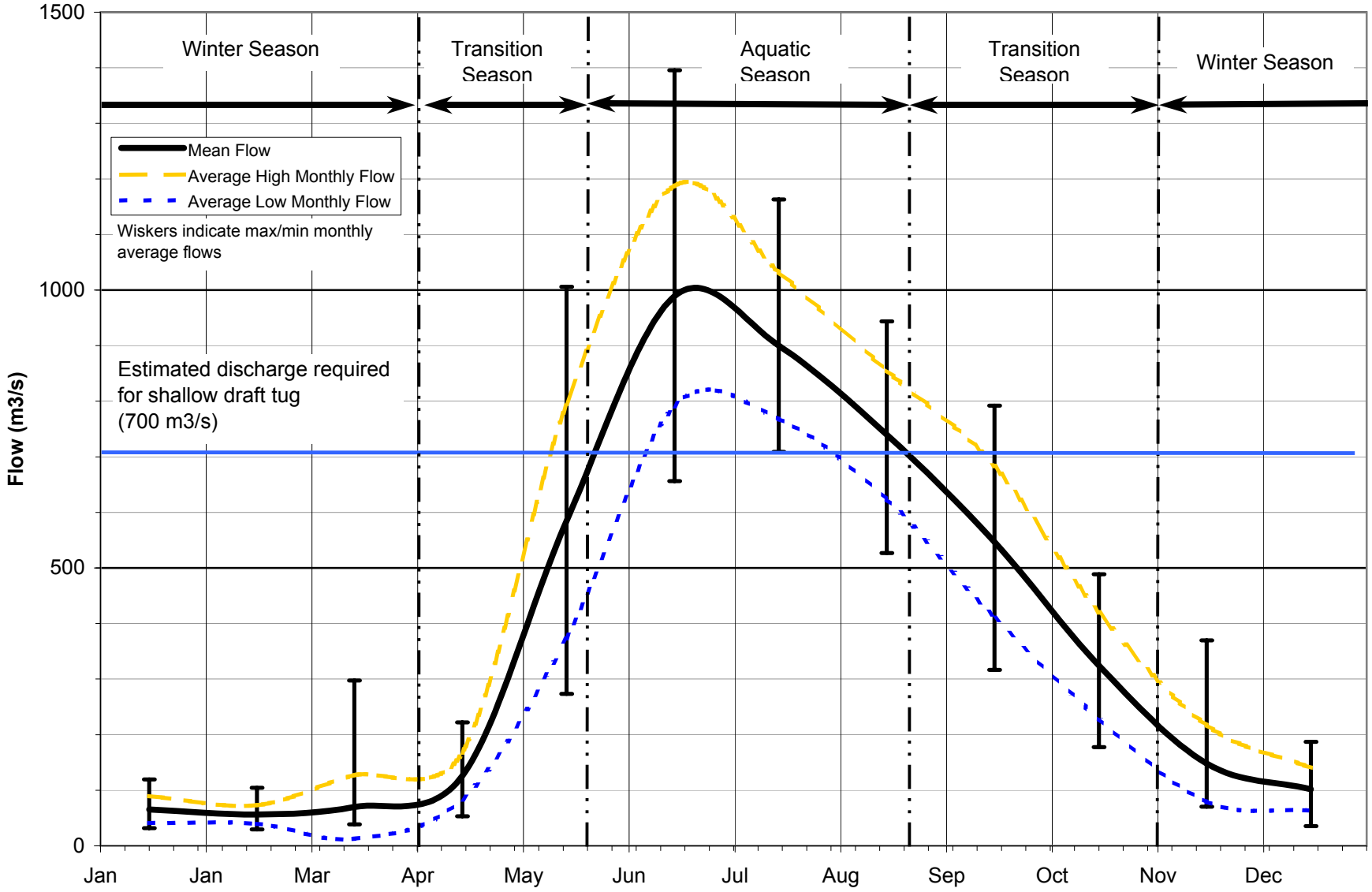
Summer River Discharge (700m³/s) and Mean Low Low "0 ft" Tide (MLLW)

Gartner Lee

Figure 4-5
Version 1

Figure 4-6. Taku River Hydograph at Canyon Island

1986 - 2006



70142_Figure_4-6_Taku_hydrograph.xls

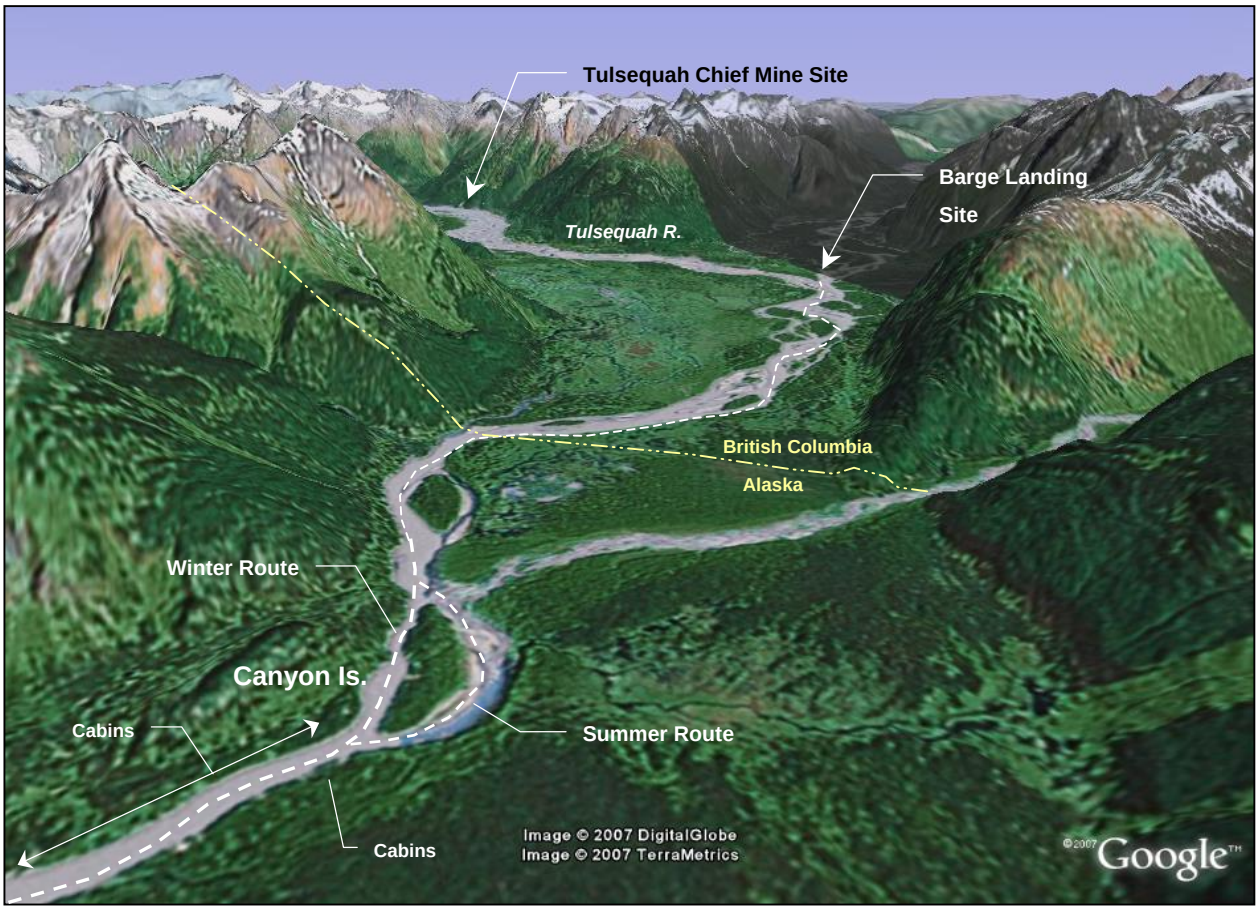
4.1.3 Taku River – Taku Lodge to Tulsequah River Confluence

The section of the river upstream of Taku Lodge is characterized by a defined channel with sufficient depth and width to accommodate the shallow draft tug throughout the open water season (break up to freeze up). Private land holdings along this section include the Taku Lodge, located across from the Hole in the Wall Glacier, and about 70 recreational cabins located further upstream along a 5 km (3 mi.) long reach of the Taku River immediately downstream of Canyon Island.

4.1.3.1 Canyon Island

The route from Canyon Island to the barge landing at the confluence of the Taku and Tulsequah Rivers is shown on Figure 4-7.

Figure 4-7. Canyon Island to Barge Landing near Tulsequah River Confluence



At Canyon Island, there is a single, narrow channel on the west side of the island. At the narrowest point, the channel is approximately 90 m wide, and will not easily accommodate the width of the barge. During the summer season, there is considerable boat traffic through the narrows, and two seasonal fish counters are located immediately upstream and downstream of the narrows. There is also a Special Use fishery in July that contributes to increased river traffic at this location. For these reasons, the only practical route during the open water season is to navigate around the east side of Canyon Island (see Figure 4-8). At times, there will be insufficient depth in the east channel for the shallow draft tug. At such times, the ACB would be towed or winched across the sandbars on the east side of the island by the amphitrac. The shallow draft tug would pass through the narrows, meeting the ACB at the upstream or downstream end of the island (depending on direction of travel), reconnect to the ACB and continue to its destination. Again, the entirety of the route through this area will be below the ordinary high water mark.

Figure 4-8. View of Routes around Canyon Island, Looking Downstream

In winter, the route would follow the west channel as it is more direct, and would avoid the lead that tends to remain open throughout the winter along the east channel due to the inflow of warmer water from Fish Creek.

A mainstem channel that has sufficient depth to permit fully aquatic operations during the open water season characterizes the route north of Canyon Island to the landing site.

Floating logs are fairly common along the Taku River, and pose navigational hazards for river vessels. From time to time, it may be necessary to relocate snags that present navigational issues. River users have stated that relocating snags from the main channel would benefit all river traffic. It

is estimated that the 12 to 24 individual logs may be relocated during a season. The amphitrac will be fitted with a grapple mounted on the hydraulic arm. This grapple can be used to pick up the log and relocate it.

During winter, after freeze up, the Taku River remains completely frozen upstream from the mudflats to the barge landing area. Local residents on the river report that the west channel at Canyon Island is one the first parts of the river to freeze over and one of the last portions to breakup. Therefore, the west channel would be used as the primary winter route. The route would be entirely over ice and snow during this time using the wheels of the amphitrac. Icebreaking is neither contemplated nor desirable.

4.2 Marine Operations

The marine operations will utilize a conventional marine tug similar to those currently operating in southeast Alaskan waters. This tugboat will either be company owned, a contracted service, or supplied by AML. These tugs typically have a draft of 12 to 15 feet. This tug will shuttle the ACB between Juneau and the Taku Inlet year-round. AML reports that marine tugs are able to operate in most weather and sea conditions that occur in the area of operations, but will occasionally wait out a particularly severe storm. Operational decisions such as these are the responsibility of the tug captain, and are based on years of experience and familiarity with the coastal area, weather, and knowledge of the vessel's handling capability.

The marine tug and inbound ACB will rendezvous with the outbound ACB and shallow draft tug. This rendezvous will take place in deep water in the inlet, and the marine tug will take the outbound ACB and return to Juneau. The shallow draft tug will pick up the inbound ACB and return up river. During winter operations, two amphitracs will be used to shuttle the ACB along the frozen river corridor between the inlet and the barge landing site. During this period, the rendezvous area would be closer to the terminus of the river ice where it joins the shoreline.

4.3 River Operations

Operations on the Taku River will require use of both conventional and specialized equipment to be able to operate year-round. The Taku River experiences considerable variation in flow during the year, as shown on Figure 4.6. Average monthly flows during the period from about late May until mid-August range from 700 m^3/s to over 1,000 m^3/s, providing sufficient depth of water in the river channel to support a fully aquatic operation using a shallow draft tug. During the winter period, from early November until early to mid-April, the river is frozen and will support the use of amphitracs using soft tires to provide the best means of transporting the ACB along the river corridor. Operations during the shoulder seasons will require a combination of the amphitracs and the shallow draft tug to manoeuvre the ACB across the shallowest sections of the river, particularly near the Taku River Lodge where the sand flats are extensive throughout the river channel, and

tidal influence is at its upstream limit. The operations proposed during each of these seasons are described in detail below.

4.3.1 Summer Operations - late May to mid-August

For approximately three months, from about mid to late May until mid August, average monthly flows in the river combined with tidal assist provide sufficient depth across the sand flats to support fully aquatic operations using a shallow draft tug (draft $\leq$3 feet). The sand flats extend downstream of Taku Lodge to approximately Annex Creek, as shown on Figure 4-3. The shallow draft tug is fully capable of navigating through this section of the river during medium to high tides, as the tide provides between 8 and 16 feet of additional depth in the channel, diminishing with distance upstream. The tidal influence near Taku Lodge is minimal, and river discharge controls the depth of water at this location. River discharge in excess of 700 m^3/s is required to provide sufficient depth for the shallow draft tug to navigate through the shallows at this location. These shoals are the "pinch point" along the river, and govern the navigability of the river when operating with the shallow draft tug. This is why the season of operations for the shallow draft tug is limited to river discharge over 700 m^3/s to ensure sufficient depth of water through the shallowest sections of the route.

During this season, a conventional shallow draft tug will be used to shuttle the ACB up and down the river. The amphitrac will provide secondary propulsion and assist in manoeuvring the ACB where needed. The shallow draft tug will rendezvous with the marine tug to deliver the outbound ACB to the marine tug for transport to Juneau, and pick up the inbound ACB for transport to the mine. The rendezvous will take place in the open and deep waters of Taku Inlet.

A small powerboat will act as a pilot vessel to scout the river and advise other river traffic of the barge's progress will accompany the shallow draft tug. All vessels will be equipped with marine radios to communicate with other river traffic.

Canyon Island

Canyon Island represents a challenging section of the river to navigate due to the narrow channel, faster current and multiple users in this area. The ACB will be manoeuvred around the east side of Canyon Island, crossing over the sandbar at low water levels. The shallow draft tug will push the ACB up to the sandbar along the east shore of the island. From here, the ACB will be pulled or winched by the amphitrac across the sandbar to the opposite end of the island. The barge will be equipped with a Rolligon-type wheel that will be lowered to act as a keel to control side slippage when traversing sloping ground. The shallow draft tug will proceed through the deeper channel around the west side of the island (the narrows), re-connecting with the ACB at the opposite end of the island, and continuing travel up (or down) river. The pilot boat will precede the shallow draft tug and ACB to notify fishermen and other traffic of the barge's arrival at the island.

The shallow draft tug will carry approximately 6,400 litres of fuel on board, representing about 16 hours of continuous operations, and will be refuelled at the barge landing site. Periodic

maintenance of the shallow draft tug will be carried out at AML's existing facilities in Juneau. When this is required, the shallow draft tug will be escorted or towed by the marine tug into Juneau.

4.3.2 Winter Operations – early November to early April

The winter season typically spans the period from about early November until early or mid April, though there is considerable variation in the timing of freeze- up and break-up. During the winter when the river is frozen, two amphitracs will be used to tow the ACB over the ice and snow between the barge landing site and the inlet. Two amphitracs are needed to provide the necessary propulsion, increase travel speed, provide greater manoeuvrability, and provide mutual aid if needed. The amphitracs will operate using soft tires travelling on the snow and ice.

The outbound ACB will be pushed and towed by the amphitracs along the frozen surface of the river to the rendezvous at the terminus of the river ice in the inlet. Similar to the summer operations, the amphitracs will rendezvous with the marine tug, transfer the outbound ACB to the marine tug, and pick up the inbound ACB for the return trip up river. In winter, the rendezvous point will be close to shore at the terminus of the river ice in the inlet. Here the ice makes contact with the shore, and the inbound ACB will be winched onto the shelf ice by one of the amphitracs.

During the winter, the route will follow the west channel around Canyon Island to avoid the permanently open lead in the east channel (see Photo 4-1). This lead tends to remain open throughout the winter as warmer water from Fish Creek flows into the Taku River at this location.

Photo 4-1. View Looking Upstream of Open Leads in East Channel at Canyon Island

Winter operations will likely include some route grooming to expedite travel, such as levelling areas of rubble ice or pressure ridges. The hydraulic arm on the amphitrac can be fitted with a flail that will be used to break down areas of jumble ice that impede travel. The ACB will be fitted with a set of rollers mounted on the front of the barge that can be lowered hydraulically to compact the snow in front of the ACB. This will help pack the route to reduce the amount of snow being blown around by the ACB, thereby improving operational visibility.

The amphitracs will be equipped with sophisticated navigational equipment so that they are able to navigate in whiteout conditions along the river. Weather reports will be monitored daily however the barge masters will be ultimately responsible for making decisions concerning the safety of the vessels and crew. During periods of extremely heavy snowfall, operations will be curtailed and the snow will be packed down along the route using a roller bar on the amphitrac before operations recommence. As the snow is compacted, the route will take on the appearance of a winter trail the width of the ACB.

Crossing Open Leads

Occasionally, the amphitracs will encounter patches of open water, such as downstream of Canyon Island where the leads may be open for up to 100 m. Shorter leads may also be encountered upstream of the island, but for the most part can be avoided. The amphitrac would need to travel from the ice to the water, and back onto ice. In these instances, one of the amphitracs will proceed ahead of the barge, using the Archimedes screws to propel it through the open water and assist in crawling up onto the ice surface. Once on the ice, the amphitrac will use an ice auger to anchor itself in position, then winch the barge across the lead and up onto the ice. The second amphitrac would follow the barge, assisting in manoeuvring the barge if needed.

4.3.3 Shoulder Season Operations (Spring and Fall)

Between the Taku Lodge and Annex Creek, a distance of about 27 km (17miles), sand flats are exposed at periods of low water. The logistics of the shoulder season operations will depend greatly on the depth of water available in the river channel near the Taku Lodge, and the timing of freeze-up and break-up on the river. The latter will dictate the timing of the transition from tires on ice and snow to using the Archimedes screws in water, to using the shallow draft tug once there is sufficient depth in the river channel.

Above Taku Lodge, the shallow draft tug will commence operations in the spring after the river has broken up, usually in the month of April, and water is freely flowing through the mainstem of the river. The tug will operate between the barge landing site and Taku Lodge for a period of about six or seven weeks until the river discharge increases sufficiently to provide enough depth to navigate through the shoals near Taku Lodge. From this time onwards, the shallow draft tug would be able to complete the entire river trip until about mid-August when river levels drop off and there are likely to be times when the tug would be unable to navigate through the shoals near Taku Lodge. From this point on, the shallow draft tug would remain upstream of the Taku Lodge, and the amphitracs

would provide amphibious operations through the sand flats until freeze-up, which generally occurs sometime in November.

A typical round trip on the river during the shoulder seasons would involve the following:

- ACB is loaded at the barge landing site and taken downstream by the shallow draft tug, accompanied by two amphitracs for additional maneuverability and extra propulsion.
- Just upstream of Taku Lodge, the shallow draft tug would hand off the ACB to the amphitracs, which would shuttle the ACB across the sand flats to the rendezvous with the ocean tug in the Taku Inlet.
- The amphitracs would transfer barges with the marine tug and proceed upstream with the supply-laden ACB.
- Having crossed the sand flats, the amphitracs would meet the shallow draft tug just upstream of Taku Lodge and the supply-laden ACB would then be towed upstream by the tug, assisted by the amphitracs, to the barge landing site where the barge would be unloaded.
- The shallow draft tug would anchor just upstream of the sand flats during the time that it would take the amphitracs to cross the shallows and rendezvous with the marine tug.
- As a contingency, the amphitracs will be able to winch the barge across difficult sections of the sand flats. This will be accomplished by one amphitrac proceeding ahead of the barge, anchoring itself on the sand bar, and winching the barge across the sandbar, assisted by the second amphitrac pushing the barge.

4.3.4 Estimated Transit Times

During aquatic operations on the river, and assuming an average upstream transit speed of 7 km/h (4.4 mph), and an average downstream transit speed of about 15 km/h (9.3 mph) the total time needed to complete the 55 km round trip on the river is estimated to be 17 hours, including the extra time required to navigate Canyon Island and the sand flats, and to swap barges with the marine tug. Two crews will be needed for the river operations, so that each crew would be available for an eight or nine hour shift. The round trip transit time for the marine crew is estimated to be 12 hours, allowing for two hours to complete the rendezvous with the river-based crew and equipment.

During the winter, when the amphitracs are shuttling the barges along the frozen river corridor, transit times are anticipated to be slightly shorter, as the more direct route around the west side of Canyon Island will be used, and travel time will not be influenced by river velocity, etc. Weather is always a factor that will influence the transit time.

5. Land-Based Facilities and Operations

A 12.5 km road will be used to transport concentrate from the Tulsequah Chief mine site to the proposed air cushion barge (ACB) landing site on the Taku River. Mine supplies will also require surface transport from the barge landing to the mine site. The proposed road would utilize the previously approved 4 km section of road between the mine site and the limestone quarry, and the 8.5 km exploration road that would need to be upgraded to an all-weather access road for the life of the mine. The proposed access road alignment is shown on Figure 5-1.

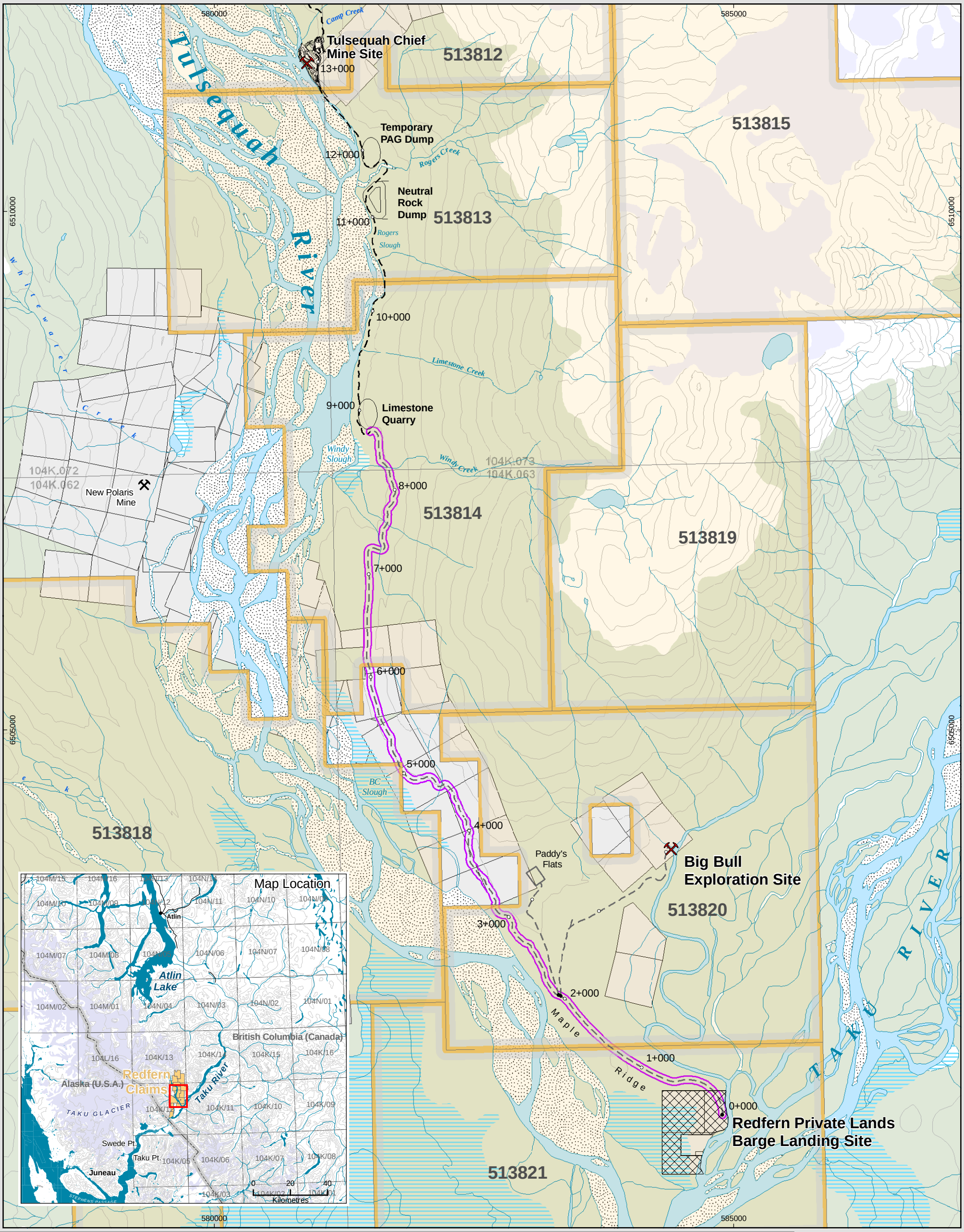
5.1 Scope of Works

For the purposes of this Project Certificate Amendment, only the 8.5 km section of the road south of the limestone quarry is included in the scope of the amendment, as the remaining 4 km section of the road was included in the original scope of the Tulsequah Chief project and previously approved. For the purposes of this assessment, the activities related to the proposed access road consist of:

1. upgrading 8.5 km of the Big Bull exploration road to an all-weather standard road;
2. year-round operation and maintenance of the access road for haulage of containerized mineral concentrate and mine supplies for the life of the mine; and
3. deactivation of the access road upon mine closure.

Overall, the proposed road extension to the barge landing site will generally be constructed, operated and decommissioned to a standard similar to the originally proposed and reviewed 160 km mine access road to Atlin. The design and operating parameters for the Atlin mine access road are described in:

- Chapter 6.12 and Chapter 10 of the *Tulsequah Chief Project Report, Volume II, Project Description* (Rescan Environmental Services Ltd. 1997); and
- The Tulsequah Chief Project Application for Special Use Permit & Mining Right of Way Act Authorization (Redfern Resources Ltd. 1998).



Map Sources/Notes:
Basedata TRIM (1:20,000)
Exploration road alignment (cartographic representation by Gartner Lee Limited), Wardop Engineering
Mine layout, Wardrop Engineering
All other data, Gartner Lee Limited

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File Name: 70142_Figure_5-1.mxd
Reviewed By: FKP
Date Issued: July 2007
Prepared By: GS
Project Number: 70142

Legend

- Approved Onsite Mine Road
- Big Bull Mineral Exploration Road
- Proposed Upgrade Haul Road
- Redfern Claim Block
- Crown Grants
- Private Land
- Swamp / Marsh
- Sandbar
- Glacier

Redfern Resources Ltd.

Environmental Ammendement of Tulsequah Chief Proposed Alternative Access

Proposed Upgraded Haul road

30 July, 2007

Gartner Lee

Figure 5-1
Version 1

5.2 Regulatory Environment

The entire length of the access road extension is located on mineral claims and Crown Grants held by Redfern Resources Ltd. The claims and Grants crossed by the proposed road are shown on Figure 5-1. Accordingly, the upgrade of the Big Bull exploration road and operation of the road extension as year-round access road is considered part of the mine's on-site infrastructure. It is assumed, therefore, that the road will be permitted under the *Mines Act* as an amendment to the project's Mine Plan and Reclamation Program, similar to other on-site mine roads.

5.3 Haulage

5.3.1 Concentrate Handling and Storage

Zinc, lead and copper concentrate will be stored and hauled in weather-sealed, half-height 20 ft. standard-dimension intermodal ISO containers (also known as "shipping containers" or "isotainers", Photo 2-1). Sea containers are the standard method of handling and transporting all manner of goods and materials around the globe. Use of standard-dimension intermodal containers allows for the concentrate to be handled by normal container handling equipment at the ports of Juneau and Skagway.

Concentrate containers will be dedicated to a given concentrate product and loaded with 36 tonnes of concentrate. Containers will be sealed in the mill building and will not be opened until arrival at the bulk ship loading facility in Skagway, Alaska. The concentrate loading facility is enclosed in the mill building. The facility allows for loading of three product containers. There is no bulk concentrate storage on-site.

Typically, eight truck trips per day are needed to haul concentrate containers between the mine site and the barge landing. On each day, on average 7 to 8 trips would backhaul fuel, cement and supplies.

The concentrates will be transported from the mill site directly to the barge landing site, or to the container storage area located on Paddy's Flat (Figure 5-1). The marshalling yard at the barge landing is located on a bench at the toe of Maple Ridge, and will provide storage capacity for approximately 50 containers, or approximately one-week's production.

Additional storage space will be located at Paddy's Flats located approximately 2 km north of the barge landing site, accessed from a short spur road east of the proposed mine access road. The area is a large, flat, well-drained glaciofluvial terrace that was the previous site of a sawmill. A two-hectare area will be developed. The site will be cleared, graded, and prepared on the natural ground that consists of mostly sand and gravel.

5.4 Road Upgrade

5.4.1 Road Design

It is proposed that upgraded barge landing access road design will generally be consistent with the road previously assessed and approved Atlin access road design as per the Project Description Report (Rescan 1996) and the Special Use Permit application (Redfern Resources 1999). The road design and upgrade will be in accordance with Section 6 of BC Regulation 126/94 (BC Mines Act), the EMPR *Handbook for Mineral and Coal Exploration in British Columbia*, the *Forest Road Engineering Guidebook*, and the British Columbia Ministry of Transportation and Highways *BC Supplement to the TAC Geometric Design Guide*, *2001 Edition*, where applicable.

The road will be a single lane roadway, designed to have a stabilized road width of 5 m. The road will be positioned on a right-of-way with a minimum cleared width of 20 m. Clearing widths may be increased to ensure that vegetation is cleared 3 m past the toe of the roadway embankment. The wide clearing width is required to provide adequate exposure of the road bed to sun and wind which improves visibility in general and enhanced drying of the road in spring.

Roadside turnouts will be required to allow oncoming vehicles to pass. The 5 m wide x 30 m long turnouts will be spaced typically 250 m to 500 m apart (depending on terrain and avalanche considerations) and will increase the stabilized road width to 10 to 11 m.

The road will be designed with a maximum grade of 8% for loaded truck over sustained intervals. The maximum road gradient may be up to 10% for pitches less than 200m long subject to site-specific factors such as topography, road use or road surfacing. The road has a design speed of 40 km/hr and restrictions to 30 km/h on horizontal curves tighter than 65 m.

The road will be surfaced with 200 mm of gravel or crush rock to minimize erosion and allow year-round use by the concentrate trucks. However, performance during the first spring break-up period will be monitored and additional surfacing will be immediately placed in any areas where soft spots develop. The road maintenance requirements during this period would undoubtedly be more than in subsequent years, when normal road grading and ditch clean-out activities will suffice.

5.4.2 Road Upgrading

Road upgrading activities will be limited to those required to bring the exploration road up to a standard that meets the design objective as described above. Specifically, construction activities will include the following elements:

1. occasional widening of the cleared right-of-way to improve sight lines where required for safety;
2. minor improvements of road grades in areas where the grade of the exploration road exceed design objectives;
3. minor improvement to the existing alignment (e.g. <20 m laterally) to improve curves, safety and to accommodate grade improvements;

4. addition of pullouts from one every 1,000 m to one every 250 m and lengthening the existing pullouts from 20 m to 30 m long;
5. upgrading the road surface from compacted coarse material to 200 mm thick crushed rock road surface;
6. flattening sustained sections with grades of 10% to 8% along the existing exploration road, according with the roadway design requirements, as described previously,
7. addition of truck run-away lanes and guard rails where required for safety; and
8. revegetation of all exposed soils within the first year following the upgrade construction.

The temporary exploration access road is 5 m wide and therefore significant road widening is not required except in the areas noted above.

5.4.3 Stream Crossings

South of the limestone quarry the proposed access road crosses six streams, as shown on Figure 5-1. All of these crossings are located upstream of the portion of the streams utilized by fish. Therefore, fish passage structures are not required on any of these stream crossings. All stream crossings and culverts installed along the exploration road are designed and built to accommodate the heavy construction equipment, and to withstand the 1 in 100 year floods. As such, these structures are adequate to meet the needs of the year-round haul road. Upgrading of these stream-crossing structures is not required, therefore, and no work associated with the stream crossings is proposed as part of the barge landing access road upgrade.

5.5 Operation

Operations on the access road will be carried out year-round. Heavy snowfalls will temporarily close the road; however given the relatively short length of the road, snow ploughing should be able to open the roadway in relatively short time. Avalanche hazard assessment indicates that no avalanche paths intersect the proposed barge landing access road south of the limestone quarry.

As the proposed road is one-lane with pullouts, road traffic will be radio controlled. Concentrate haul trucks will complete approximately eight round trips per day. In-bound mine supplies will constitute another seven to eight truckloads daily, on average. Based on an average speed of 30 to 35 km/h, average travel time from the mine site to the barge landing site will be 20 to 25 minutes. Light vehicle traffic should be very limited as personnel transfer is not going to occur using the ACB and barge crews will be bunked at the barge landing site. There will be limited traffic for inspection and maintenance of the roadway.

Road maintenance activities will consists of:

- annual surface grading and spot-resurfacing when required;
- snow ploughing in winter months;
- sanding of the road in winter to ensure traction and safety;

- inspection, maintenance and clearing of debris from culverts;
- inspection and maintenance of bridges and major structures, where required;
- inspection and maintenance (cleaning-out) of ditches, when required;
- inspection for erosion and implementation of additional erosion control measures, where required; and
- vegetation control when required for visibility and safety.

Salt will not be used extensively for de-icing the road surface. No vehicle maintenance or refuelling is proposed along the access road. The mine's fuel and hazardous materials handling and spill contingency plan will be expanded to include provisions for operations on the access road. Spill response and clean up equipment will be stationed at the Tulsequah Chief mine, the barge landing site, and at the storage area at Paddy's Flats. Emergency response equipment should be no more than ten minutes travel from any point along the access road.

5.6 Decommissioning

The barge landing access road will be utilized solely for the purposes of mining and will be operated by Redfern Resources Ltd. Upon completion of final reclamation work at the mine (including the removal of all buildings and equipment from the site), the access road will be fully deactivated. The access road will be one of the last components to be deactivated as it will be used to transport materials out from the mine site, including the equipment used to reclaim the site. Funding will be in place to provide for this eventuality in the form of a Reclamation Bond. Full deactivation will entail removal of all fill materials and/or contouring the road prism to a stable configuration. All culverts and bridges will be removed and the watercourse returned to their pre-road conditions. Compacted surfaces will be ripped and drainage patterns restored to pre-road conditions.

5.7 Barge Landing Site

The proposed barge landing site is located on the Taku River near its confluence with the Tulsequah River. A conceptual layout of the landing site is shown on Figure 5.2. Several alternative landing sites were considered, including a site closer to the mine itself. The preferred landing site adjacent to the Taku River was selected as it allows a fully aquatic operation up to the landing site and avoids transporting materials and concentrate along the shallow, heavily braided Tulsequah River floodplain upstream to the mine site. The landing site is in a side channel known as the Big Bull slough, about 400 m upstream of the river confluence. The landing site will be located on District Lot 6302 that is owned by Redfern. No modifications of the channel, in-stream structures, or in-stream works are proposed. The barge landing site will consist of:

- a cleared and surface area approximately 1.8 ha in size for landing the barges and setting them down off hover;

- two earth-filled, log crib loading ramps, approximately 1.2 m high;
- two sets of docking winches for pulling the ACBs on shore; and
- space for four days of container storage (concentrate empty and full, supplies empty and full) in the adjacent landing yard.

The proposed landing site is likely subject to occasional inundation during floods. Therefore, the landing area would need to be elevated by approximately 0.3 to 0.6 m to raise it above flood levels and surfaced with an all-weather hard footing surface. Aggregate for fill can be sourced from a borrow pit located on Paddy's Flats, approximately 2 km north of the landing site. A marshalling yard, as shown on Figure 5.2, will be established just north of the barge landing site. The yard location is the current construction camp site at the base of Maple Ridge. This terrace will support a small camp for overnight accommodation of the river crew, as well as provide storage for up to one week's production of concentrate containers. The camp will be equipped with a potable water supply from an on-site well and an in-ground septic system. Both utilities are already being permitted through the Northern Health Authority. The marshalling yard area is at least 3 m above normal flood levels of the Taku River.

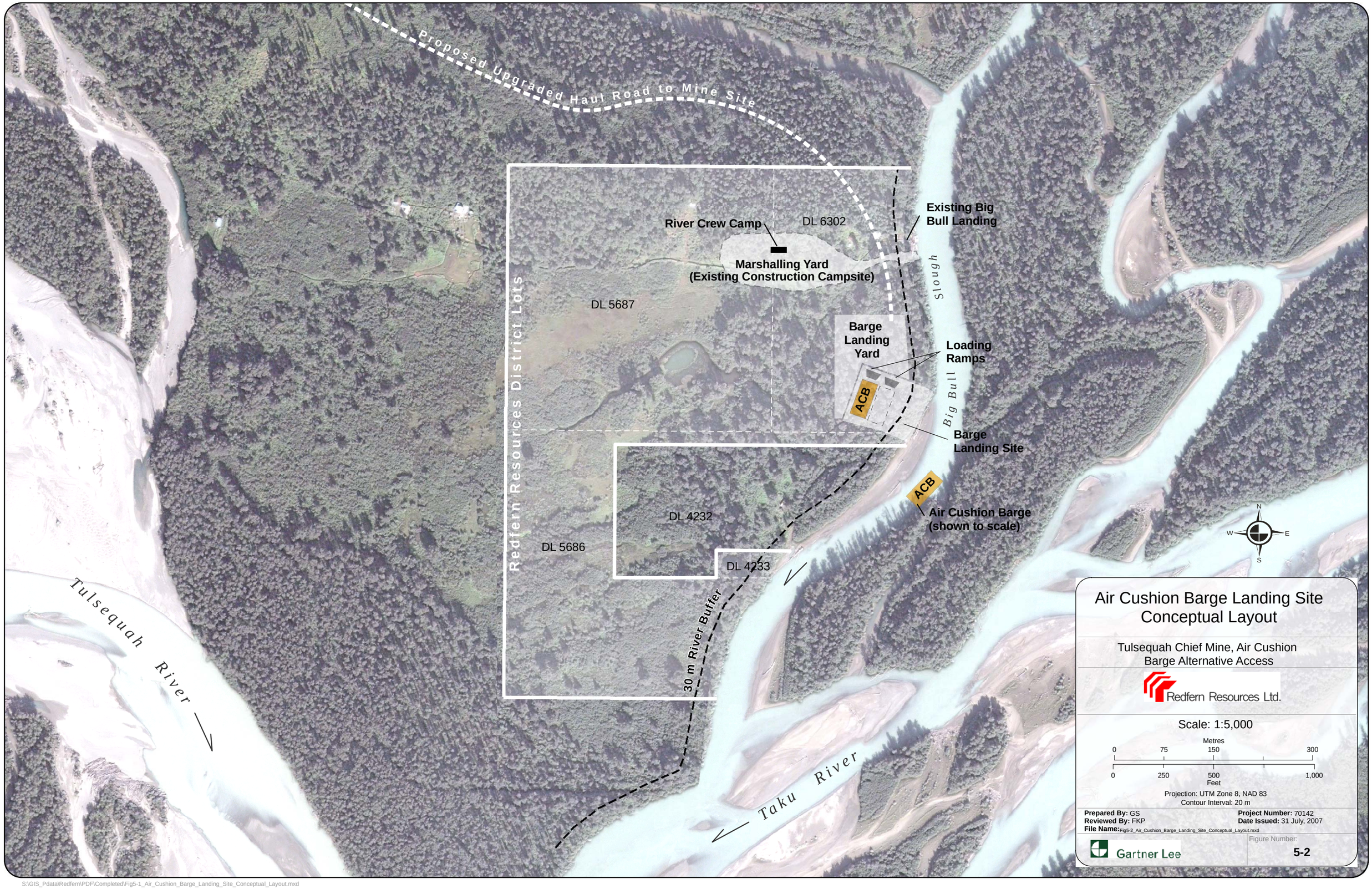
Paddy's Flats Storage Area

The landing site and marshalling yard will have a combined space to store containers for nine to ten days. A larger laydown and storage site will be located at a higher elevation, approximately 2 km north at Paddy's Flats (see Figure 5-1). The storage area will be located adjacent to the access road, near the intersection with the Big Bull exploration road and the mine access road. An area of approximately 2 ha will be cleared for storing concentrate containers and mine supplies. It is anticipated that delays in transportation due to poor weather and during river freeze-up and thaw periods may necessitate up to four weeks of storage capacity at this site. Up to 260 containers would be stored in the event of a prolonged delay. Loads will be taken from Paddy's Flats to the landing site and loaded onto the ACB and incoming supplies will be trucked up to Paddy Flats and stored there until they are taken to the mine.

A 12.5 km road will be developed between the landing site and the mine for transporting containerized mineral concentrate and supplies to and from the mine. This road will consist largely of upgrading an existing exploration road between the mine site and the Big Bull exploration property. See Section 5.4 for details of this road.

Loading and Unloading the ACB

On arriving at the site, the amphitrac will manoeuvre the barge in Big Bull slough parallel to the shore. It will be pulled near to the shore and winched to the landing site. The barge will settle gently on the ground when it comes off hover. The weight of the ACB will rest on the hull; the deflated skirts are not pinched under the hull, but fold to the side of the hull to prevent possible damage to the skirts. During loading and unloading, the amphitrac can either be parked at the landing area, or moored along shore depending on the preference of the operators. The shallow draft tug will moor in the channel during the loading/unloading procedures.



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5.8 Existing Docking Facilities

Juneau and Skagway Dock Facilities

The marine transport function for the mine will involve handling of materials and containerized concentrate at the Alaskan ports of Juneau and Skagway. Juneau has an established port facility operated by Alaska Marine Lines (AML), a division of Lynden Incorporated. AML will receive, store, and marshal inbound supplies and outbound concentrate containers in Juneau prior to movement by ACB to the mine site. It is anticipated that no significant modifications will be required for these facilities. The ACB will dock at the beach landing site along the eastern edge of the AML facilities. All maintenance of the fleet vessels and refuelling the marine tug and ACB will be done at the Juneau facilities.

Photo 5-1. Alaska Marine Lines' Facility in Juneau, Alaska

The concentrate containers from the mine will be shipped via conventional ocean barge from Juneau to Skagway. AML operates a weekly barge service between Juneau and Skagway that has sufficient capacity and frequency to transport the planned concentrate tonnage. This will ensure that concentrate containers do not accumulate over time at Juneau or Skagway, and that the existing storage facilities at both ports will be able to handle the anticipated need.

Skagway

Containerized mineral concentrate will be received from the conventional barge at AML's facility in Skagway. From there it will be delivered to the concentrate sheds and ship-loading facilities operated by the Alaska Industrial Development and Export Authority (AIDEA). AIDEA's 6.7-acre bulk ship loading facility at Skagway was constructed in 1968 to handle base metal concentrates from the Faro lead-zinc mine in the Yukon Territory. AIDEA is refurbishing its facility, and has recently concluded a multi-year agreement with Sherwood Copper's Minto Project for use of approximately one quarter of the facility's potential capacity. Dedicated mineral concentrate storage and handling facilities will be constructed by AIDEA at Skagway for the Redfern concentrates representing a further quarter of the facility's potential capacity. AIDEA's facility is permitted for

unloading, bulk loading and storage of mineral concentrate and as such is not discussed further in this assessment.

Photo 5-2. AIDEA's Concentrate Loading Facility in Skagway. Note Alaska Marine Lines' Yard at Left

6. Emergency Response Plans

The transportation of bulk quantities of fuel and chemicals requires that the shipping company comply with regulations both within Canada and the United States. A Spill Prevention and Contingency Plan will be prepared that meets the Alaskan and Canadian requirements.

Marine shipping in Canada is a heavily regulated industry and includes both Canadian and international law. Any shipping activities associated with the project will be subject to a legal regime that addresses the design (sea worthiness) and operation of ships or barges, the shipping activity itself, emergency response in the case of accidents, and the liability in the event of spills or accidents, environmental protection and compensation for loss or damage arising from shipping mishaps. The laws and regulations that are applicable to this project in Canadian waters include the *Canadian Shipping Act* (CSA), the *Marine Liability Act*, the *Fisheries Act*, the *Oceans Act*, and the *Navigable Waters Protection Act.*

In Alaska, Alaskan statutes as well as international law govern marine transport. *Title 46, Water Air, Energy and Environmental Conservation* governs the spill prevention and response related to shipping of hazardous substances (fuel). The proposed transport system will have spill prevention and contingencies plans in place to comply with these requirements.

6.1 Crew Safety

During operations, crew safety is paramount, and operating procedures will comply with all applicable safety requirements of the US Coast Guard and Transport Canada, Canadian Coast Guard. In addition to the government specified minimum requirements, extra safety equipment will be on board the vessels to respond to emergency situations. Additional equipment will include items such as emergency rations, thermal blankets, night-lights, ramp for snowmobile access to the deck, lifting harnesses, and burn first aid kits. There will be sufficient supplies on board for a crew survival up to five days.

Appendix A

Channel Depth Analysis of the Lower Taku River

Appendix B

Photo Log

Appendix C

Route Atlas

(Bound Separately)