

**MONTANA MOUNTAIN MINING REVIEW
AND ACID ROCK DRAINAGE POTENTIAL**

NTS 105D/2
YUKON TERRITORY

Prepared For:

Environmental Services,
Public Works and Government Services Canada

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EXECUTIVE SUMMARY

This literature-based study summarizes the history of mining, geology as it relates to acid rock drainage, and water quality in the Montana Mountain area. The study area, from Carcross to the British Columbia border has been actively explored and intermittently mined for 100 years. Most of the activity was focussed in two periods, from 1905 to 1921, and 1965 to 1971. Most of the physical disturbance of the landscape has occurred since the introduction of bulldozer trenching and road building in the 1960's. The mining and exploration has also been focussed geographically in the area from the Venus Mine to the Arctic Caribou/ Big Thing Mine. Several mineral occurrences are also known along the western side of the study area, but have had little physical work conducted on them. The gold-silver veins discovered in the study area are rich in metals, but small in volume.

The water from adits and tailings ponds is of poor quality, but has had little impact on nearby creeks and lakes. The capping of the Venus tailings in 1995 is expected to substantially improve the quality of the local environment. The impact of mining on the water quality of Tagish Lake is not a health concern.

Stream sediment and soil geochemical testing indicates widespread high metal levels throughout the study area, including large areas not disturbed by mining. The high natural background metal levels may be reflected in creek water, but very few creeks in the study area have been tested for water quality.

Several of the rock types present in the study area contain zones enriched in iron sulphides, which could produce natural Acid Rock Drainage. In many of these zones there is also a substantial carbonate content which buffers acid production. This is thought to be the case for veins and disseminated iron sulphide zones in the Montana Mountain Volcanics, such as the Venus and Montana Mines. The volcanic rocks contain significant calcite, and streams draining this area are neutral to basic.

The altered phase of the Montana Mountain Pluton, which hosts the Arctic Caribou/ Big Thing Mine is considered to be the only large geological unit that may produce natural Acid Rock Drainage. This unit contains significant concentrations of iron sulphides, and only minor carbonate. The creeks that drain this unit are slightly acidic.

It is recommended that any future Acid Rock Drainage testing be geologically based, in order to be more conclusive. Future water quality testing should include more samples from undisturbed areas to better characterize background quality. A site safety investigation of all adits and shafts in the study area is recommended, however sealing of mines should only be done in consultation with the owner of the mineral rights.

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1.0 INTRODUCTION

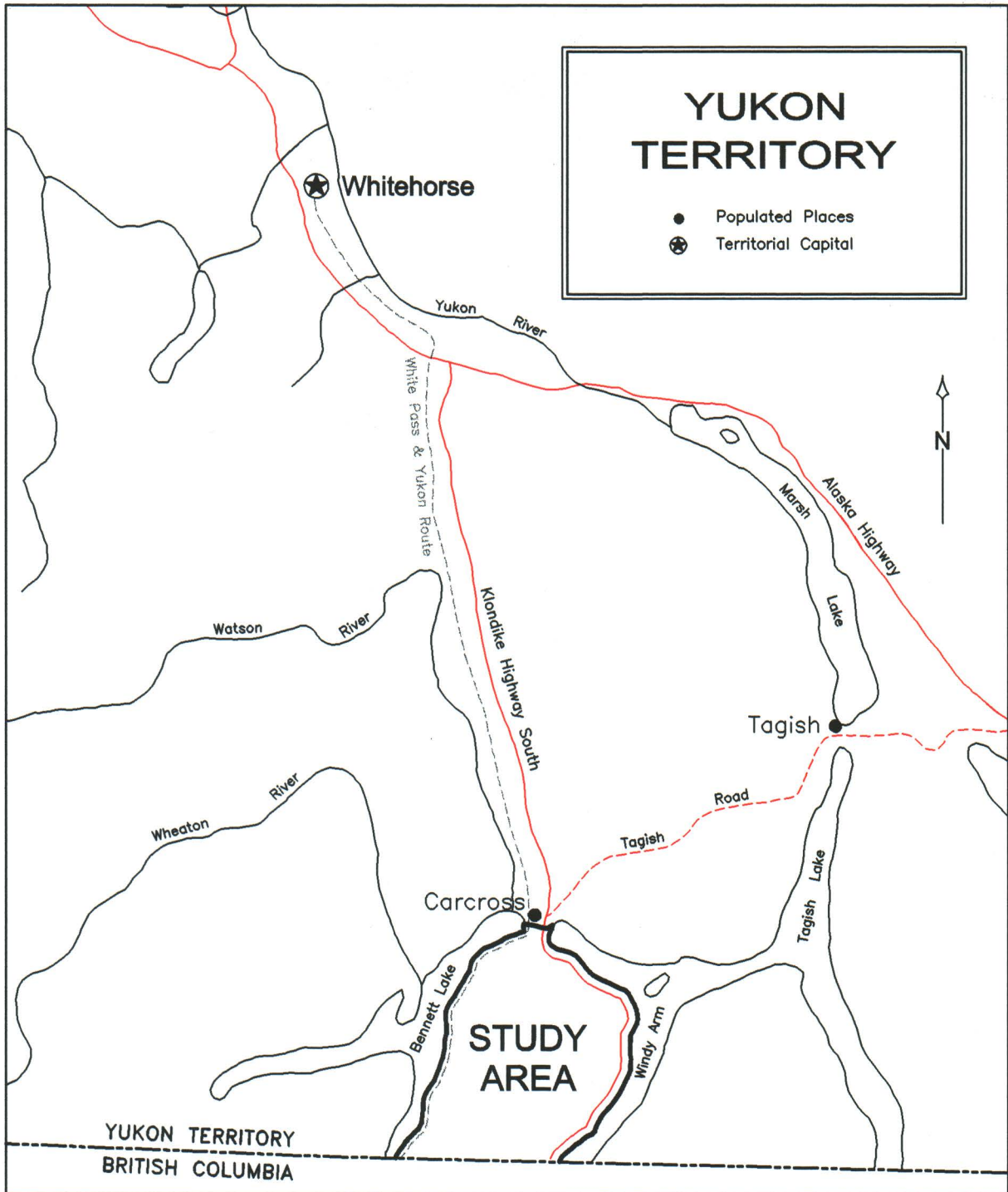
The primary purpose of this report is to provide a summary of historical mining activity and a qualitative assessment of acid rock drainage (ARD) potential in the Montana Mountain area, south of Carcross, Yukon. The report is based on a literature review, and was commissioned by Environmental Services, Public Works and Government Services Canada to provide a context for more specific government environmental studies of past-producing mines and associated tailings ponds in the study area. The geology and physiography of the study area are reviewed with an emphasis on mineralization, distribution of metals in rock, soil and stream sediments, and water quality.

1.1 STUDY AREA

The area studied in this report is referred to as the Montana Mountain area, and includes the entire area south of the village of Carcross, Yukon and north of the British Columbia border. This mountainous area extends about 18km north-south and 15km east-west, and lies between Bennett Lake and Windy Arm of Tagish Lake (Figure 1). The South Klondike Highway follows the eastern edge of the study area along the shore of Windy Arm, and the White Pass and Yukon Route Railway follows the western edge of the study area along Bennett Lake.

1.2 OTHER PWGSC PROJECTS

Several other Public Works and Government Services Canada (PWGSC) projects have been conducted on mine properties within the study area in recent years. The main purpose of these studies and work projects has been to assess environmental and safety risks, propose mitigation options, and supervise the work deemed necessary. The Venus mine tailings pond on the shore of Windy Arm near Poolsy Creek was determined to be an environmental hazard. An impermeable cover was placed over the pond in 1995 (Armstrong et. al. 1995), and follow-up studies are in progress. Environmental assessment studies at the Venus and Big Thing mines were conducted in 1995 and 1998, with an emphasis on ARD potential (PUBLIC WORKS and GOVERNMENT



YUKON TERRITORY

- Populated Places
- ⊛ Territorial Capital



Lambert Conformal Conic Projection



<p>Montana Mtn. Mining Review and Acid Rock Drainage Potential PWGSC Environmental Services</p>		
<p>LOCATION MAP STUDY AREA</p>		
<p><i>William D. Mann, Geological Consultant</i></p>		
SCALE: 1 : 500,000	FILE: 248_L1	DATE: 98.11.10
NTS: 105 D/2	DRAWN:	FIGURE 1

SERVICES CANADA, 1997a, b, c). The Arctic Gold and Silver tailings pond is the subject of a study in progress.

This report will provide background data to support these studies, provide detailed maps showing their settings, identify other mine workings in the area, and add geological data that will aid in ARD prediction.

1.3 METHODS AND DATA SOURCES

This report is based on a literature review, with no field work component. A wide variety of data is available from published and unpublished reports by many branches of government, universities and mining companies. The reports span about 100 years, and are of varying quality and reliability. Most of the mining records for the early part of the century have been lost. Fortunately much of this data is presented in a recent historical account of the Windy Arm Stampede (Lundberg, 1996). Some mining company assessment reports remain confidential, and were not available for review.

In addition to literature research the author interviewed geologists who have mapped and conducted mineral exploration in the area. These interviews added greatly to the report, as many of the details important to ARD assessment are not routinely recorded during regional mapping.

The report is supported by several maps, which provide an important visual representation of physiography, geology and mining activity. Air photos at 1:20,000 scale from a survey flown in September, 1995 were essential for providing the locations of most trenches and roads. The air photos are excellent for documenting major physical disturbances, especially where the work was not recorded or the assessment files are closed. There has been some bulldozer trenching conducted since 1995 that is not recorded on the map. Some of the older underground workings are too small to be distinguishable on the photos.

It was decided to include underground plans of the two main mine areas (Venus and Arctic/Big Thing) to aid in evaluating safety and environmental problems and solutions. The mine plans indicate flow patterns for water, and reveal, for example that it would be ineffectual to place mineralized waste underground at the Big Thing mine (a proposed "Phase II" ARD remedy), as this mine is drained by the Peerless adit.

The Yukon Minfile database of mineral occurrences was used as the basis for

documenting mining and mineral exploration activity in the study area. In many cases it has been necessary in this study to subdivide a Minfile occurrence number to identify separate deposits or work areas that were combined for Minfile purposes.

2.0 STUDY AREA PHYSIOGRAPHY AND WATER QUALITY

The study area is part of the Yukon Plateau, and lies just east of the Coast Mountains of the Boundary Range. Gentle slopes at the north end of the study area give rise to rugged mountains in the south. There is over 1500m of topographic relief between the peak of Montana Mountain (elevation 2205m) and the big lakes (elevation 656m). Many small creeks drain the area into Bennett and Tagish Lakes, part of the Southern Lakes system, which forms the headwaters of the Yukon River (fig. 2).

2.1 CLIMATE AND PRECIPITATION

The study area lies within the Cordilleran climatic region, which is characterized by long cold winters and warm summers. The climate of Yukon, including the study area is reported by Wahl et. al. (1987), and summarized here. Temperature and precipitation data is available for Carcross, at the north end of the study area. Carcross receives mean total precipitation of 211.4mm, 56.1% as rain and 43.9% as snow (figure 3). The mean monthly temperature at Carcross ranges from a low of about -20° C in January to a high of about 12° C in July (fig. 4). This area is one of the driest parts of the Yukon as it lies within the rain shadow of the Coast Mountains.

The climate for most of the study area is thought to be somewhat different than at Carcross, due to increased elevation. Precipitation is generally thought to increase with elevation to about the 1500 to 2000m level in Yukon. As well, the percentage of solid to liquid precipitation would increase such that most precipitation at the peak of Montana Mountain would be as snow. Variation within the mountainous part of the study area is also expected, as precipitation is affected by slope, aspect, elevation, orientation and degree of shelter.

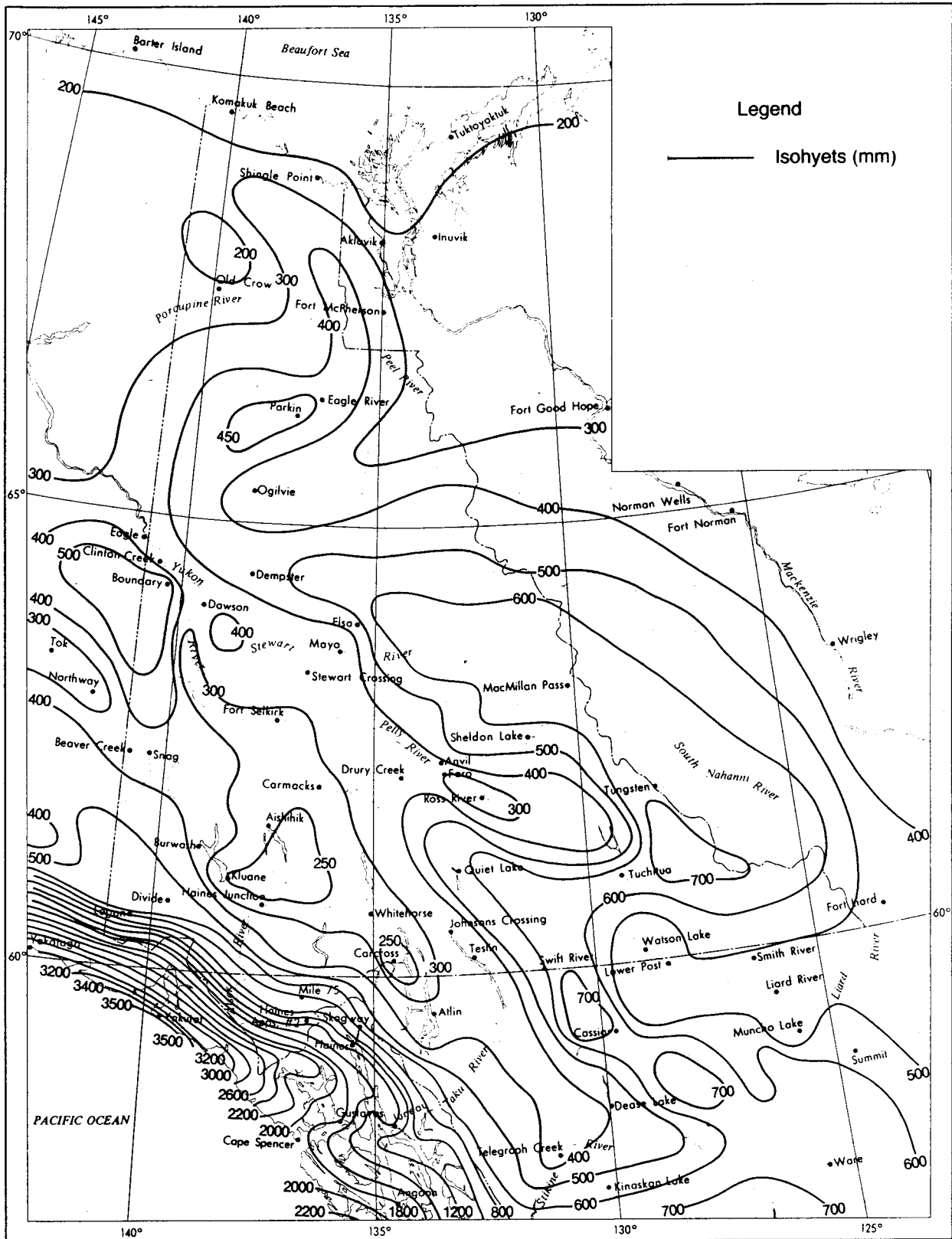


Figure 3 Annual mean total precipitation

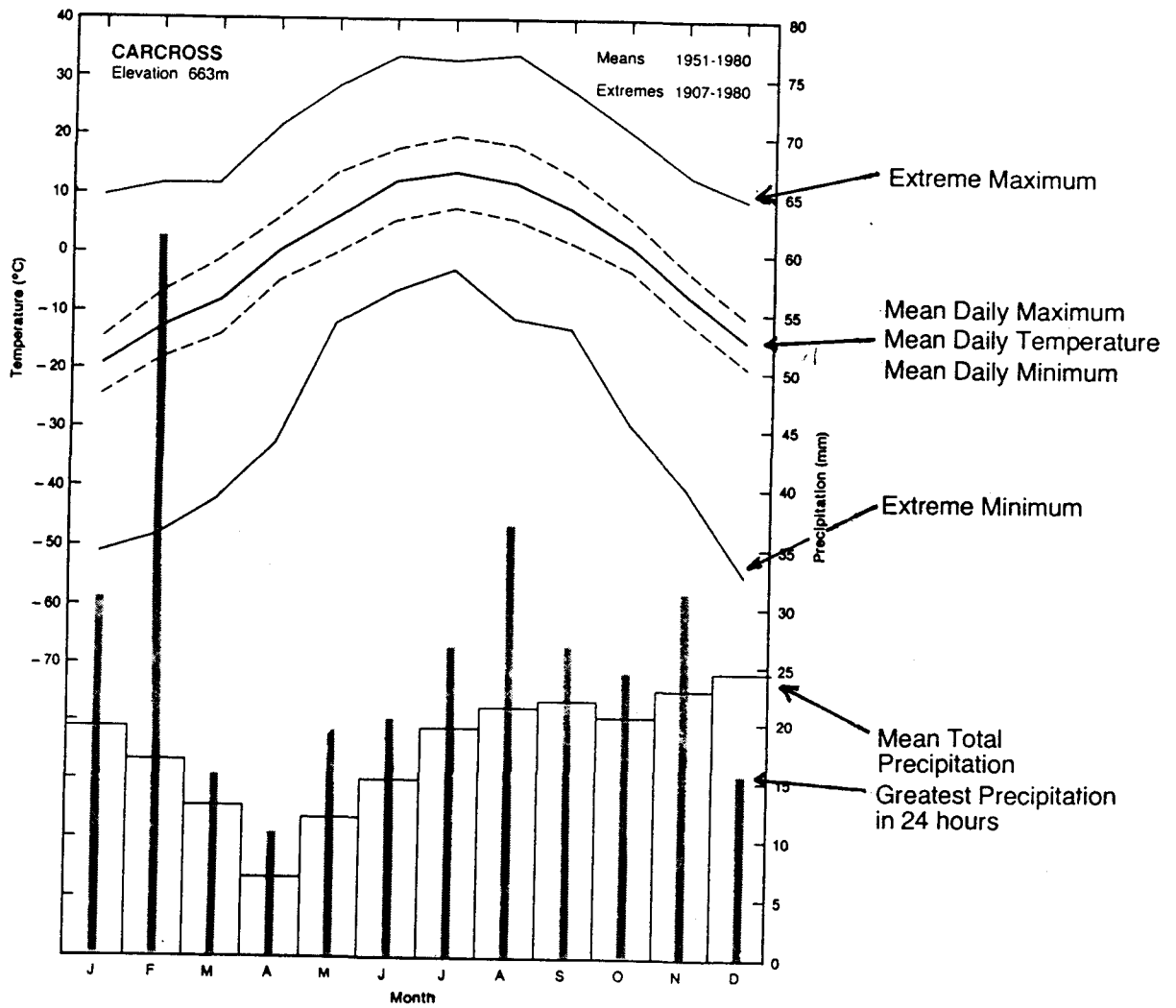


Figure 4 Temperature and precipitation means and extremes.

2.2 WATER FLOW

There is limited water flow data available for the study area (Yukon Water Resources Hydrometric Program Historical Summary 1975-1994). 12 crest gauge readings during a three-year period are available for Pooly Creek, with a maximum stream flow of 1.51 cubic metres per second. At Big Thing Creek, which is thought to have the largest catchment in the study area a continuous flow meter was in place from June 7 to September 17, 1978, and a crest gauge was read 12 times from 1978 to 1980. A maximum flow of 2.57 cubic metres per second was recorded. Full records are available in Appendix 1. The creeks in the study area are frozen to the bottom during winter. Long term year round flow readings are available for the Wheaton and Watson Rivers, which flow into Bennett Lake to the west and north of the study area. These flow patterns are not thought to be representative of the study area because both of these rivers have headwaters in the Coast Mountain Ranges, which receive greater precipitation. Also the catchment areas of these rivers extend 40 to 50 km away from the study area.

2.3 WATER QUALITY

Water quality data has been collected intermittently from several locations within the study area since 1970. Most of the data is from the streams draining the most seriously disturbed areas – the Venus and Big Thing mines and their tailings ponds. There is limited data to indicate background water quality. The water samples available have been analyzed for differing parameters, using various analytical techniques with varying detection limits. Comparison of results is therefore general in nature.

The earliest water quality data from the study area found during research for this report is DIAND sampling at Windy Arm (DINA identity number 9AA-M2) and of Tank Creek below the Arctic tailings pond (DINA identity number 9AA-S1, 9AA-S3). The results from these samples indicate no ARD, however the data and methods are poorly documented, and are not used in this report. Eight reports written by government scientists since 1975 are available which document water quality in the study area, and are summarized below.

2.3.1 VENUS MINE AREA WATER QUALITY

Several studies were conducted on the Venus 1970 era tailings pond (Robson & Weagle, 1978, Jack, 1981, Godin & Osler, 1985). All documented poor water quality in and adjacent to the pond. Capping of the pond in 1995 is thought to have solved the problems, and a follow-up study is in progress to check this. Note that the tailings from the 1908 era Venus mill were discharged directly into Windy Arm.

Water flowing from the Venus Mine 2600 and 2700 level adits (fig. 6) was sampled in the 1981 and 1985 studies, and again in 1997 (PUBLIC WORKS and GOVERNMENT SERVICES CANADA, 1997c). The seven water samples collected in these studies from the adits indicated high pH and low sulphate, and therefore no ARD. Levels of arsenic, zinc and iron (Table 1) were noted to be a concern in these samples as they exceed CCME Freshwater Aquatic Life Remediation Criteria (CCME, 1991). The Phase II study recommended further study to determine the impact of Venus mine on Tagish Lake, as Whitehorse and other communities receive drinking water downstream. The 1981 study collected 28 lake water samples, 20 from 10 locations in the B.C. portion of Windy Arm, 6 from 3 locations just offshore from the tailings pond, and 2 from a location just offshore from the Venus Mine. All samples were below the detection limit of 0.15 mg/L arsenic, and it was concluded that arsenic in Windy Arm was not a health threat (Jack, 1981, p. 18). The Robson and Weagle (1978) study analyzed 18 lake water samples from 6 locations in Windy Arm, including 3 stations near the tailings pond, and one near the mine. The highest arsenic value was 0.023 mg/L, collected near Bove Island, about 12 kilometres north of the tailings pond. Only 2 of the 18 samples were above 0.005 mg/L, indicating low arsenic levels in the waters of Windy Arm.

The combined water flow from the Venus adits is estimated to be 0.01 m³/sec (2 adits @ 5L/sec). The mean annual flow of the Yukon River at Whitehorse is 232 m³/sec (Slaney & Co., undated). Given the large dilution afforded by Tagish Lake, and in light of the arsenic results from the studies cited above, it is highly unlikely that there are any health risks associated with arsenic inputs from the Venus mine. Note that there are high natural levels of arsenic and other metals in soils and stream sediments (and possibly water) throughout much of the study area, and therefore the arsenic in Windy Arm is only partly attributable to the Venus Mine.

TABLE 1. ADIT WATER QUALITY

PARAMETER	BIG THING ADIT	PEERLESS ADIT	VENUS 2700 ADIT	CCME Freshwater Aquatic Life Remediation Criteria
pH	5.1	7.3 (6.4?)	8.8	6.5 – 9.0
Arsenic mg/L	0.7	<0.02	0.5	0.05
Copper mg/L	0.02	<0.01	<0.01	0.002 – 0.004
Iron mg/L	5.08	0.1	0.35	0.3
Zinc mg/L	0.168	0.056	0.184	0.03
Sample number	BTWQ/A103	ACWQ/A101	VEWQ/A101	

2.3.2 ARCTIC GOLD AND SILVER TAILINGS AREA WATER QUALITY

The 1969 era Arctic mine tailings pond area has been the subject of two studies (Weagle et. al., 1976, Roach, 1997). The tailings are generating acid, and runoff flows into an adjacent beaver pond at the headwaters of Tank Creek. Despite this, Roach concluded that there is no measurable impact on the water quality of the beaver pond or Tank Creek. This may be due to the small volume of tailings present. The tailings pond is the subject of a detailed PWGSC study in progress.

2.3.3 ARCTIC CARIBOU/ BIG THING MINE AREA WATER QUALITY

Phase II Environmental Assessments were conducted at the "Arctic Mine" (fig. 7), with one report on the Big Thing and Arctic Caribou site on the south side of Sugarloaf Hill (PUBLIC WORKS and GOVERNMENT SERVICES CANADA, 1997b). Another report covers the Peerless adit on the north-west side of the hill, referred to in that report as Arctic Caribou (PUBLIC WORKS and GOVERNMENT SERVICES CANADA, 1997a). Water from adits at both sites exceeded CCME Freshwater Aquatic Life Remediation Criteria for at least one parameter (Table 1). The reports concluded that both mines had little impact on water quality of the adjacent streams. The water flow rate from the adits was low to nil when sampled, as the Arctic Mine is known to glaciare, therefore water that enters the mine tends to remain as ice. It is important to note that the Peerless adit is connected by a raise to the Arctic Mine, and drains at least part of it. An ice plug forms

at the Peerless adit during the winter, and water backs up in the long adit until the ice thaws. The eroded gully and outwash fan near the adit was likely formed by water released in this manner.

2.3.4 REGIONAL STREAM WATER GEOCHEMISTRY

The most extensive source of water quality data is from a 1985 Geological Survey of Canada regional stream geochemical survey (Open File 1218, 1985). This survey covers most of the creeks in the study area, and several branches of the largest creeks. Most of the data collected in this study is from analysis of stream sediments for metals rather than water analysis. However, general water quality can be inferred from the high metal content of stream sediments in many of the streams in the study area, and this subject is discussed in section 3.3.5. The geochemical survey tested water for pH, fluorine and uranium. The results for fluorine and uranium in the study area are within the regional background values. The results of water pH are plotted on the Hydrology map (fig. 2), and reveal a significant pattern. All of the samples with acidic pH (less than 6.5) are located in the central part of the study area, and drain the altered portion of the Montana Mountain granitic pluton, the rock unit that hosts the Big Thing mine. Some of the most acidic samples were collected from streams draining areas with no noticeable disturbance. Twenty of thirty-three streams sampled, from other parts of the study area had neutral to alkaline pH (greater than or equal to 7.0). The two most alkaline samples reported in the study area were collected from the Venus Mine adits during Phase II Environmental Assessments (pH 8.6 & 8.8).

Most of the stream drainage areas in the study area have had some physical disturbance from mining and mineral exploration, however Pooly, Big Thing, Montana, McDonald and Tank Creeks drain all of the areas considered to be significantly disturbed. Knob Creek may be somewhat disturbed by the Jean mine at its headwaters. A few creeks (e.g. Wynton and several un-named creeks) have no known mining development or road work upstream of the Highway or Railway, and would be suitable for background water quality sampling. The construction of the South Klondike Highway and the White Pass and Yukon Route Railway may have had significant impact on every stream in the study area, as well as direct impacts on the big lakes.

3.0 GEOLOGY AND ACID ROCK DRAINAGE POTENTIAL

The study area is underlain by complex geology (fig. 5). Various types of sedimentary and metamorphic rocks are intruded by several ages of igneous rocks, and cut by many major faults. Numerous small to medium-sized polymetallic precious metal-rich vein deposits are found in the area, especially in a Northwest-trending belt from the Venus mine in the southeast to the Big Thing mine in the centre of the study area. Phase II Environmental Assessment studies have indicated ARD potential for mineralized rock at the Big Thing/ Arctic Caribou and Venus mines (PUBLIC WORKS and GOVERNMENT SERVICES CANADA, 1997a). These studies contain the only known ARD test results in the study area. ARD tests are reported to have been conducted on rusty, pyritic rock dumped into Windy Arm near the Venus mine during construction of the South Klondike Highway circa 1984, but no results of this testing were found. This study reviews the geology and geochemistry of the area and attempts to identify areas with acid-consuming potential and areas that may have ARD potential unrelated to mining. The environmental effects related to mining are compared to the existing background.

3.1 GEOLOGY OVERVIEW

The study area lies within the Intermontane Superterrane, a northern Cordilleran belt of rocks composed of accreted exotic terranes (Hart and Radloff, 1990). In the study area the Intermontane is represented by the northern Cache Creek Terrane (Cache Creek Group ophiolitic rocks) and the Stikine Terrane (Lewes River Group volcanic flows and associated sedimentary rocks). These terranes are overlapped by Laberge Group sedimentary rocks of the Whitehorse Trough. The Coast Plutonic Complex forms a belt which lies just west of the study area, and intrusive rocks in the study area are associated with this Complex. The Montana Mountain Volcanic Complex forms an isolated, fault-bound area in the southeast part of the study area, extending into B.C. Rocks in the study area are cut by numerous faults, including the Nahlin Thrust Fault which forms the boundary between the Cache Creek Group and the Lewes River Group. The Wynton Creek Fault is a major transcurrent fault that cuts from Windy Arm to Bennett Lake across the study area.

Polymetallic precious metal veins are common and widely distributed within the study area, but represent only a small fraction of a percent of the rocks in the area.

3.2 ACID ROCK DRAINAGE OVERVIEW

Acid Rock Drainage (ARD) is a natural process whereby iron sulphide minerals are oxidized to produce sulphuric acid and ferric iron (amongst other products), which leach metals from rock and cause contamination of water or soil. This process can be termed Acid Mine Drainage where mining has caused an acceleration of the process by increasing the surface area of sulphide minerals exposed to the environment.

The ARD process requires iron sulphide minerals in significant concentration (greater than 0.3%) exposed to water, oxygen and a common bacterium which "catalyzes" the oxidation, Thiobacillus ferrooxidans. This reaction causes a fall in pH (acidity increase) to about 2.5 to 3.0, the optimum pH for the bacterium to flourish. In this environment heavy metals are easily solubilized. Since this process occurs naturally, measuring the levels of metals in water, soil and stream sediments is a useful tool in exploration for metallic mineral deposits. The oxidized, rusty orange to yellow rocks and soils often produced by natural ARD are called gossans, which are an obvious target for mineral exploration.

The mineral species present play an important role in ARD. Of the iron sulphide minerals pyrrhotite is more easily oxidized than pyrite. Other sulphide minerals present are broken down during ARD, but are not a driving force of the process. ARD can be prevented by the buffering action of minerals with neutralizing potential. Calcite is the most reactive of the carbonate minerals, and is most effective at neutralizing acid. The other carbonate minerals (e.g. dolomite, ankerite, siderite) also react quickly with acid. Many other common minerals have some neutralizing potential, but react more slowly. Examples of these minerals present in the study area include biotite, plagioclase feldspar, chlorite and olivine. Pyrrhotite is not present in the veins mined, but occurs locally in the study area. Pyrite is abundant in veins and disseminations in many parts of the study area. Calcite is a common accessory mineral in many rocks in the study area, and is the dominant constituent in limestone.

3.3 STUDY AREA ARD POTENTIAL

The amount and distribution of iron sulphide and carbonate minerals present in the study area must be known in order to fully assess the potential for ARD, but is only partially known. The presence of these minerals is not always recorded during regional geological mapping unless the minerals are a diagnostic feature of a mappable geological unit. Iron sulphides are typically a minor, erratically distributed geological feature. Carbonates are the dominant component of limestone units, but are also a common accessory mineral in many other rock types. Carbonates may be present in quantities adequate to prevent ARD, but not be documented in the geological literature. The following assessment of ARD potential is therefore only qualitative, based on information gleaned from government and industry reports, theses, interviews with geologists who have mapped the area, and inferred from geochemical and water quality data.

3.3.1 CARBONATE-RICH UNITS

There are three limestone units mapped in the study area: two units within the Aksala Formation of the Lewes River Group present on the west side of the study area, and one unit within the Horsefeed Formation of the Cache Creek Group in the north-east part of the study area. There are also minor carbonate or limestone beds present within the Kedahda and Nakina Formations of the Cache Creek Group. Limestone (calcium carbonate) units have a huge potential for neutralizing acid, so acid rock drainage is not possible in these areas shown on the Geology map in blue patterns (fig. 5). Geological units with minor beds of limestone may have local pockets of ARD, but these would likely be neutralized close to source by the carbonate. The contact between Nansen Volcanics and the Nakina Formation has abundant calcite present (Roots, 1980). Many of the other geological units in the study area are thought to have a carbonate component that has not been documented.

3.3.2 IRON SULPHIDE-RICH UNITS

Areas high in iron sulphides are indicated on the Geology map (fig.5) as orange shaded areas. Also, units indicated in the map legend to be orange weathering may or may not

geology and mineralogy of the two major mines is discussed below.

3.3.4.1 VENUS MINE ARD POTENTIAL

The Venus vein extends for a strike length of about two kilometres, and has been developed by numerous adits, shafts and pits over the years, many of which are interconnected (fig. 6). The Vault, Venus No. 1, Venus No. 2, Venus Extension, Maybelle and "Venus Mine" are all developed on different portions of this vein. The vein averages about one metre wide, with an alteration envelope about 3 metres wide, but thickens significantly where high grade ore shoots are formed. The vein has massive bands of sulphide minerals in quartz, with only traces of calcite. The alteration zone contains significant pyrite and arsenopyrite, but is also rich in carbonate (Walton, 1987). Thin quartz-calcite veinlets commonly cut the alteration. The vein is offset by normal faults up to one metre wide that are calcite-rich, and ankerite is present in clay seams that form the hangingwall and footwall of the vein. The host rock is Montana Volcanics, which are commonly calcite-rich. The vein is partly oxidized near surface, and Cairnes (1906) noted that the carbonate minerals cerussite (lead) and malachite (copper) were amongst the chief minerals in the Venus #1 mine.

The Phase II Environmental Assessment indicated that three of fourteen samples collected from mineralized portions of the waste rock piles at the Venus 2600 and 2700 levels (referred to as adits #2 and #1 in the Phase II report) were currently generating acid, based on paste pH. The other 11 mineralized samples had neutral paste pH values (pH 6.7 to 8.1). The six unmineralized samples collected had alkaline paste pH values (8.3 to 8.8), and neutralization potential to acid potential (NP:AP) ratios of 2.2 to 14.4. The Assessment concluded that the unmineralized waste has low potential to generate acid. However, when these NP:AP ratios are considered with sulphur assays that show a maximum content of 0.35% S, knowing that the sulphur is not from pyrrhotite, and that much of the NP is due to calcite, it is clear that the unmineralized waste rock has no potential to generate acid, and likely has considerable potential to consume acid.

The ore and mineralized waste rock has potential to generate acid, but note that the sulphide-rich tailings from the Venus mine failed to generate acid even when inoculated with *Thiobacillus ferrooxidans* (Davidge, 1984). The tailings study concluded that Venus tailings showed little or no oxidation potential, and that the acid-

consuming nature of the tailings prevents the bacterium from becoming established even though the acid-producing potential is greater than the acid-consuming potential. A subsequent study (Rock Group, 1994) concluded that acid generation from the tailings was likely at some time in the future due to the NP:AP ratio being less than 1:1 and the presence of SO₄ and metals in solution indicating some oxidation in progress. The Venus tailings pond was capped in 1995 to maintain a permanent saturated state which prevents oxidation. A follow-up study is in progress to determine the effectiveness of the capping project.

3.3.4.2 ARCTIC CARIBOU/ BIG THING MINE ARD POTENTIAL


The Arctic Caribou, Big Thing, Peerless and Pride of Yukon mines are all developed on the same series of veins present on Sugarloaf Hill, and are now collectively referred to as the "Arctic Mine." The Big Thing mine is an inclined adit that follows the Main vein (or "Number 2" vein) down dip from the south side of the hill. The Peerless adit is a long tunnel from the northwest side of the hill which cuts the veins much lower than the other mines, and is connected to them by raises (fig. 7). The Peerless adit therefore drains the other mines. Note that the Peerless is referred to as the Arctic Caribou mine in the Phase II Environmental Assessment. The Big Thing and Peerless mines were constructed and mined in the 1906-1916 era. Ore was hand sorted and direct-shipped to smelters from the Big Thing. The Peerless saw very little production of ore, but some mineralized veins were drifted on from this adit. The Pride of Yukon and other small workings are essentially lost in the extensive bulldozer trenches that surround the Arctic Mine area.

The Arctic Gold and Silver Mine built a mill 4 kilometres north of the Arctic Caribou mine, and drove two horizontal adits near the old Big Thing adit in the 1965 to 1970 era. The adits were connected to the Big Thing and Peerless workings, and production was again focussed on the Number 2 vein, although several other veins were explored with drifts. Very little data is available on the lower (700 level) adit, thought to be driven in 1969, but it is known to connect to the other workings.





The entire workings of the Arctic Mine are hosted in granite of the Montana Pluton, described above. The altered portion of this granite is thought to have inherent ARD potential. Altered, mineralized granite is reported to begin about 280 metres southeast

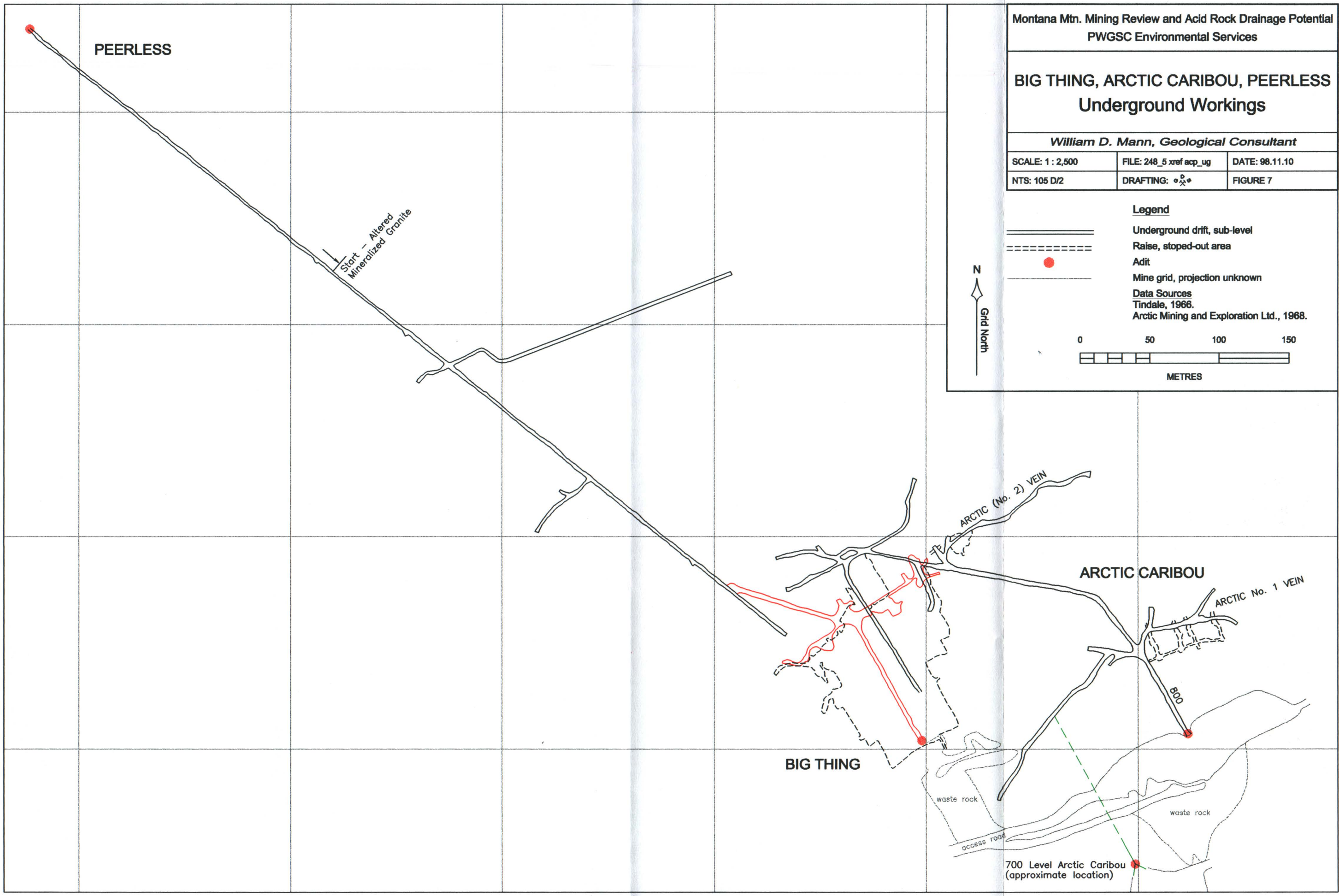
BIG THING, ARCTIC CARIBOU, PEERLESS Underground Workings

William D. Mann, Geological Consultant

SCALE: 1 : 2,500	FILE: 248_5 xref acp_ug	DATE: 98.11.10
NTS: 105 D/2	DRAFTING: 	FIGURE 7

Legend

-  Underground drift, sub-level
-  Raise, stoped-out area
-  Adit
-  Mine grid, projection unknown
- Data Sources
- Tindale, 1966.
- Arctic Mining and Exploration Ltd., 1968.



of the Peerless portal, and is more or less continuous south of that point (Tindale, 1966). The quartz veins here are sulphide-rich, with abundant pyrite and arsenopyrite, moderate galena and sphalerite, minor chalcopyrite and trace molybdenite. A phyllic type of hydrothermal alteration envelopes the vein up to 10 metres into the wallrock (Craig Hart, pers. com.) The alteration consists of quartz-sericite-pyrite, with minor arsenopyrite. Some siderite veinlets are reported adjacent to the vein (Roots, 1980), but carbonates are generally very sparse.

3.3.5 SOIL, STREAM SEDIMENT AND LAKE SEDIMENT GEOCHEMISTRY

Geochemical analysis of soils and sediments has been used as a mineral exploration tool for decades, and has been used more recently to characterize possible contaminated sites. Metals from the bedrock are mobilized into the soils by weathering and oxidation, especially if natural ARD is affecting mineralized rock. Metals may be very widely dispersed from the bedrock source, or may be restricted to an area close to the source. Stream and lake sediments reflect relatively large source areas, and are usually used as regional exploration tools to identify large mineralized areas, while soil surveys are used to locate bedrock mineralization or specific areas of interest. The abundance of metals in soils varies with soil type, depth of sample in the soil profile, underlying rock type, direction of glacial movement, groundwater chemistry and flow patterns, metal solubility and other factors. The analytical results of a geochemical survey are generally subjected to a statistical analysis to identify anomalous values. The anomalies determined to be significant are usually followed up by more detailed exploration. The Geological Survey of Canada conducted a regional stream sediment geochemical survey of the Whitehorse map sheet, 105D, which includes the study area in 1985 (GSC O.F. 1218). The region was sampled at an average density of one sample per 13 km², with 33 sample sites within the study area. The sites include most of the creeks in the area, with separate samples for tributaries of the larger creeks. This data provides a broad indication of metallic mineralization throughout the study area, and establishes regional background and anomalous levels for each element and parameter analyzed. Many metals were found to be anomalous in the study area: arsenic, lead, cadmium, copper, cobalt, silver, iron, antimony, zinc and mercury. The samples anomalous in lead, zinc, silver and cadmium are located along the main mineralized trend from the

Venus Mine to the Big Thing Mine. Arsenic and antimony values are highest in the mine trend, but are also high in many creeks not associated with significant mining activity, such as Wynton, Dundalk and Knob creeks. Copper and cobalt are highest in the northwest part of the study area, away from any physical disturbance or known mineral occurrence. Iron is anomalous in many streams, with the highest values away from the mining areas. Mercury is weakly to moderately anomalous, with the highest value (132 ppb) collected from a pristine stream at the north end of the study area. Interestingly, the highest and third highest gold values were collected from streams with no known mineral occurrences.

In summary, stream sediment geochemistry indicates that anomalously high metal values are common in many parts of the study area, and are often not related to mining or known mineral occurrences. Arsenic in particular is highly to moderately anomalous in many streams, with values up to 11,200 ppm from a site on the south fork of Pooly Creek, above the Venus Mine.

Soil geochemical surveys have been used extensively by mining companies for exploration in the study area. The surveys typically cover an area of a few square kilometres with a grid of lines spaced 50m apart, with samples collected every 25m along the lines. Most of the surveys analyzed the soil for some or all of the following metals: arsenic, silver, lead, zinc, copper, gold and antimony. Seven geochemical assessment reports were studied, each of which identified broad areas of high metal content well beyond known mineralization.

The plateau above the Venus Mine was covered with a soil sample survey, and identified many zones of anomalous lead, zinc, arsenic and silver adjacent to and away from the known mineralized zones (Watson, 1987). This area is underlain by Montana Mtn. Volcanics, which host many of the showings in the study area. Further north, across the Nahlin Fault an arsenic and silver survey identified anomalies in an area underlain by Nakina Formation, a unit not known to host mineralization (Sevensma, 1968).

Extensive soil and stream sediment surveys on the AFI claims west of the Arctic Mine identified numerous lead, zinc, arsenic, silver and antimony anomalies (Keyser, 1986, Mackinnon, 1987). Follow-up trenching led to the discovery of the Snow and Flurry showings (Mackinnon, 1989). Stream sediments along the west flank of Brute Mtn. returned many arsenic and zinc anomalies (greater than 60 ppm As, 100 ppm Zn),

thought to be derived from formational enrichment of black argillites of the Laberge Group.

A large soil survey (1450 samples) at the Rigel claims resulted in anomalous values up to 592 ppm copper, 490 ppm lead, 6.7 ppm silver, and greater than 2000 ppm arsenic (Ouelette & Kettles, 1990). The anomalies are continuous for hundreds of metres and coincide with Aksala Formation volcanics and sediments. At the Dundalk occurrence, immediately north of Rigel a large anomalous area is present, dominated by a copper anomaly covering an area about 700 by 500 metres, with most values over 100 ppm, and up to 3,356 ppm (Wilkins & Mackinnon, 1989, Mackinnon, 1990). Arsenic, silver, lead, gold and zinc anomalies coincide with the copper anomaly.

Lake sediments from Windy Arm were analyzed for metals in two studies (Robson & Weagle, 1978, Jack, 1981). The surveys identified multi-metal anomalies adjacent to the Venus tailings pond. The lake sediments near the pond were contaminated by seepage, runoff and wind-blown tailings. It should be noted that the 1908 era Venus mill discharged tailings directly into Windy Arm, and would influence lake sediments in this area.

4.0 MINING AND EXPLORATION SITE SUMMARY

In this section of the report each of the significant mineral occurrences is reviewed, with an emphasis on physical work and acid-base accounting geology. A chronological summary of exploration and mining is presented separately in Appendix 2. Most of the occurrences are focussed along a trend from the Venus Mine to the Arctic Mine. The most intense activity occurred during the years 1905 to 1921, and 1965 to 1971.

<u>YUKON MINFILE NUMBER:</u>	105D 005	<u>MAP LABEL (THIS REPORT)</u>	5a
<u>SITE NAME(S)</u>	VENUS #1 & #2 Mines		
<u>LOCATION</u>	<u>LAT.</u> 60°01'00" N	<u>DRAINAGE</u>	WINDY ARM
	<u>LONG.</u> 134°38'00" W		
<u>GEOLOGY</u>	Polymetallic gold-silver vein, carbonate-pyrite alteration, Montana Mtn. Volcanics host. Cerussite and malachite (lead and copper carbonate minerals) are reported to be amongst the chief minerals in this mine (Cairnes, 1906).		

WORK HISTORY AND DESCRIPTION OF WORKINGS The Venus #1 was the first mine in the study area, beginning in 1901 (fig. 6). A 16m decline produced 15 tons of hand-sorted ore. The Venus #2 area was found to be superior, and was the major producing mine on the Venus vein from 1906 to 1920. A tramway was built to the beach, and the first Venus mill was built, which processed mainly Venus #2 ore. A level adit brought ore to the tramway. An inclined shaft follows the vein down from surface, and two internal shafts (winzes) are reported. 1830 tonnes of ore were produced 1906 to 1911, and a further 1556 tonnes in 1916 to 1920, mainly from Venus #2 mine. Work was also conducted during this period on the Vault and Venus Extension parts of the vein.

YUKON MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5b

SITE NAME(S) VAULT

LOCATION LAT. 60°02'00" N DRAINAGE POOLY CREEK

LONG. 134°37'00" W

GEOLOGY Polymetallic gold-silver vein, carbonate-pyrite alteration, Montana Mtn. Volcanics host.

WORK HISTORY AND DESCRIPTION OF WORKINGS Work began at the Vault claim in 1906, and probably ended about 1911 (fig. 6). A camp was built on ledges blasted into the cliffs of Poolsy canyon, where the north end of the Venus vein is exposed. A tramway was built to carry materials and people to and from the site. Adits followed the Venus vein on two levels, and extend at least 100 meters into the mountain.

YUKON MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5c

SITE NAME(S) VENUS MINE, VENUS EXTENSION, MAYBELLE

LOCATION LAT. 60°01'00" N DRAINAGE WINDY ARM

LONG. 134°38'00" W

GEOLOGY Polymetallic gold-silver vein, carbonate-pyrite alteration, Montana Mtn. Volcanics host.

WORK HISTORY AND DESCRIPTION OF WORKINGS Mining began at Venus Extension in 1906, with an adit at the 2900 level and two inclined shafts (fig. 6). The Maybelle adit was driven nearby in 1921. The 1970 era Venus Mine was located here, with major adits at the 2600 and 2700 levels, and sublevels established at 2650, 2800 and 2850. The levels were interconnected by raises and stopes, including a raise to the 2900 level Extension adit. Production stoping here fed the second Venus mill, and associated tailings pond beside Windy

Arm. The road to Carcross was improved, and roads established to the portals. Work at Venus in 1979 to 1984 included construction of the third Venus mill, built in B.C. but never used.

Underground work in this period included crosscuts to the west on the 2600 level, drilling down-dip, and some sublevel drifting.

A 1984 survey of Radon gas in the workings led to the abandonment of some headings, where radiation levels were too high despite forced air ventilation (Bob Stirling, pers. com.).

YUKON MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5d
SITE NAME(S) NIPPER
LOCATION LAT. 60°01'00" N DRAINAGE WINDY ARM
LONG. 134°38'00" W
GEOLOGY Polymetallic gold-silver vein, carbonate-pyrite alteration, Montana Mtn. Volcanics host.
WORK HISTORY AND DESCRIPTION OF WORKINGS Three short adits were mined here at the south end of the Venus vein, and on other narrow veins.

MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5e
SITE NAME(S) URANUS
LOCATION LAT. 60°01'45" N DRAINAGE POOLY CREEK
LONG. 134°39'00" W
GEOLOGY Polymetallic gold-silver vein, carbonate-pyrite alteration, Montana Mtn. Volcanics host. Dolomite noted in vein (Roots, 1982).
WORK HISTORY AND DESCRIPTION OF WORKINGS Developed 1904 to 1908, with workings on both sides of a ridge between the south fork and main branch of Pooly Creek, about 1 km west of the Venus mine. There are six workings on the north side of the ridge, and two on the south side. Most of the adits are thought to be short (less than 10m), however the lowest adit on the south side follows the vein for 49m. The vein is similar to the Venus. Trenches are present along the top of the ridge. The vein was drilled by United Keno Hill in 1984, and an access road built.

MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5f
SITE NAME(S) M & M (Mackenzie and Mann)
LOCATION LAT. 60°02'00" N DRAINAGE POOLY CREEK

LONG. 134°38'00" W

GEOLOGY Polymetallic silver vein, low Au, Pb, Zn, Cu, very high Ag, Montana Mtn. Volcanics host. Maximum vein width 30cm.

WORK HISTORY AND DESCRIPTION OF WORKINGS 3 adits were driven into an extremely steep, rubbly slope across the canyon and upstream from the Vault. The mining was done ca. 1906, with some trenching in 1914. The longest adit is 29m.

MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5g

SITE NAME(S) RUBY SILVER, (RED DEER)

LOCATION LAT. 60°01'00" N DRAINAGE WINDY ARM

LONG. 134°38'00" W

GEOLOGY Polymetallic silver vein, very high grade, Montana Mtn. Volcanics host, some felsic dyke rock.

WORK HISTORY AND DESCRIPTION OF WORKINGS Adit at least 5m, blast pits. Work done some time in 1906- 1920 era. Part of the Dail & Fleming group of properties. The vein occurs at the top of the ridge above the Venus mine.

MINFILE NUMBER 105D 005 MAP LABEL (THIS REPORT) 5h

SITE NAME(S) HUMPER

LOCATION LAT. 60°01'00" N DRAINAGE WINDY ARM

LONG. 134°38'00" W

GEOLOGY Polymetallic silver vein, low Au, Pb, Zn, Cu, very high Ag, Montana Mtn. Volcanics host. Maximum vein width 30cm.

WORK HISTORY AND DESCRIPTION OF WORKINGS Several adits and trenches cut into cliffs about 1 km south-west of Venus.

MINFILE NUMBER 105D 006 MAP LABEL (THIS REPORT) 6a

SITE NAME(S) MONTANA

LOCATION LAT. 60°03'02" N DRAINAGE POOLY CREEK

LONG. 134°39'53" W

GEOLOGY Polymetallic silver-gold vein, Montana Mtn. Volcanics host.

WORK HISTORY AND DESCRIPTION OF WORKINGS 1905-1907 210m adit and 98m inclined shaft. Second adit 244m in 1967. Surface roads and trenches.

MINFILE NUMBER 105D 006 MAP LABEL (THIS REPORT) 6b
SITE NAME(S) JOE PETTY
LOCATION LAT. 60°02'15" N DRAINAGE POOLY CREEK
LONG. 134°38'45" W
GEOLOGY Polymetallic silver-gold vein, Montana Mtn. Volcanics host.
WORK HISTORY AND DESCRIPTION OF WORKINGS 1905 adit 44m, inclined shaft 6m, trenches. 1988, 1989 drilling.

MINFILE NUMBER 105D 006 MAP LABEL (THIS REPORT) 6c
SITE NAME(S) MOUNTAIN HERO
LOCATION LAT. 60°03'02" N DRAINAGE MONTANA CREEK
LONG. 134°39'53" W
GEOLOGY Weak polymetallic silver-gold vein, Montana Mtn. Volcanics host.
WORK HISTORY AND DESCRIPTION OF WORKINGS Immediately north of the Montana, 3 adits 1905-1906 sought extension of Montana vein. Tramway built from Conrad to Mountain Hero, 1905. Stone house built here. Road from Arctic Mine to Montana Mine passes through here.

MINFILE NUMBER 105D 006 MAP LABEL (THIS REPORT) 6d
SITE NAME(S) RIDGE (RAT CLAIMS)
LOCATION LAT. 60°04'30" N DRAINAGE MONTANA CREEK
LONG. 134°42'15" W
GEOLOGY Polymetallic gold-silver vein. Granitic host rock- Montana Pluton.
WORK HISTORY AND DESCRIPTION OF WORKINGS 1993 trenching and 10 drillholes. Closed assessment report. Location about 1km west of the Arctic mine.

MINFILE NUMBER 105D 006 MAP LABEL (THIS REPORT) 6e
SITE NAME(S) MAC
LOCATION LAT. 60°01'00" N DRAINAGE MONTANA CREEK
LONG. 134°38'00" W
GEOLOGY Arsenic-silver geochemical anomalies. Nakina Formation metabasite country rock.

WORK HISTORY AND DESCRIPTION OF WORKINGS A 1968 soil sample survey was followed up by road construction to one anomaly on the north side of Montana Creek, and several small backhoe trenches on another anomaly about 1 km further south. The trenches are about 2km east of the Montana mine. The road and trench work was not filed for assessment.

MINFILE NUMBER 105D 007 MAP LABEL (THIS REPORT) 7a,b
SITE NAME(S) THISTLE, AURORA (COLUMBIA)
LOCATION LAT. 60°02'42" N DRAINAGE POOLY CREEK
LONG. 134°41'45" W

GEOLOGY Polymetallic silver-gold veins, Montana Mtn. Volcanics host. Calcite is common in the Aurora vein (Walton, 1987).

WORK HISTORY AND DESCRIPTION OF WORKINGS The Thistle, Aurora and Columbia veins were all test mined in the 1905- 1907 era. A stone house was built here in 1905. All are located near Aurora Lake, but it is uncertain which vein is which. The Columbia is reported to be just above Aurora Lake. Bulldozing is reported from 1970. Two adits of unknown origin are present about 500m to the southeast of the lake, likely from the same era.

MINFILE NUMBER 105D 008 MAP LABEL (THIS REPORT) 8a
SITE NAME(S) JEAN (KODIAK)
LOCATION LAT. 60°03'49" N DRAINAGE KNOB, BIG THING CREEK
LONG. 134°42'49" W

GEOLOGY Narrow polymetallic gold-silver vein. Montana Mtn. Pluton host.

WORK HISTORY AND DESCRIPTION OF WORKINGS Hand trenching 1936- 1939 era. Adit mined in 1961-1962, 69m long. 4 underground drillholes 1967. 9 drillholes in 1986, 10 in 1993. Many roads/ trenches.

MINFILE NUMBER 105D 008 MAP LABEL (THIS REPORT) 8b
SITE NAME(S) SNOW (FLURRY, AFI)
LOCATION LAT. 60°05'00" N DRAINAGE MCDONALD CREEK (?)
LONG. 134°42'00" W

GEOLOGY Polymetallic gold-silver vein. Montana Mtn. Pluton host.

WORK HISTORY AND DESCRIPTION OF WORKINGS An access road was built in 1988 and 1989 from the Peerless portal area to the AFI claims. Trenching discovered the Snow and Flurry veins, which are similar to the Arctic Mine about 2km to the east.

MINFILE NUMBER 105D 009 MAP LABEL (THIS REPORT) 9a
SITE NAME(S) BIG THING, ARCTIC CARIBOU, PRIDE OF YUKON
LOCATION LAT. 60°04'35" N DRAINAGE BIG THING CREEK
LONG. 134°41'55" W

GEOLOGY Polymetallic gold-silver veins. Montana Mtn. Pluton host. Quartz-sericite-pyrite alteration with arsenopyrite. Minor carbonate in area.

WORK HISTORY AND DESCRIPTION OF WORKINGS 137m inclined shaft and 4 levels, 1906-1917 (fig. 7). About 2500 tonnes of ore from Big Thing (#2) vein shipped to smelter in this period. Connected to Peerless adit below in 1911, and drains through that tunnel. New adits in 1965, 1968, drifting mostly on #1 and #2 veins, production mostly #2 vein. Mill built 4 km north, 50,751 tonnes milled in 1968 and 1969.

MINFILE NUMBER 105D 009 MAP LABEL (THIS REPORT) 9b
SITE NAME(S) PEERLESS (Lower Camp)
LOCATION LAT. 60°04'35" N DRAINAGE Swamp that feeds McDonald
LONG. 134°41'55" W and Tank Creeks

GEOLOGY Polymetallic gold-silver veins. Montana Mtn. Pluton host. Quartz-sericite-pyrite alteration with arsenopyrite. Minor carbonate in area. Veins weaker than at Arctic. Most of the waste rock at the portal would be unmineralized, and about 75% of it has been there for 86 years.

WORK HISTORY AND DESCRIPTION OF WORKINGS 707m line-drive adit mined in 1911 to intersect Big Thing veins (fig. 7). Veins intersected were weak. Raise driven to connect with Big Thing, drains much of the Arctic Mine. Some drifting and raising on veins. In 1967 a 229m crosscut was driven to the southeast to intersect the postulated intersection of the #1 and #2 veins.

Note: the washout fan described near the portal in the Phase II Environmental Assessment may be produced by rapid escape of water built up in the adit behind an ice plug, when the plug melts.

MINFILE NUMBER 105D 010 MAP LABEL (THIS REPORT) 10a
SITE NAME(S) CARCROSS
LOCATION LAT. 60°08'00" N DRAINAGE TANK CREEK
LONG. 134°44'00" W
GEOLOGY Minor copper and molybdenum in granodiorite.
WORK HISTORY AND DESCRIPTION OF WORKINGS 1966 bulldozer trenching. 1968, 2
drillholes. Other grassroots work done in this area.

MINFILE NUMBER 105D 010 MAP LABEL (THIS REPORT) 10b
SITE NAME(S) MARKMOLY
LOCATION LAT. 60°08'00" N DRAINAGE TANK CREEK
LONG. 134°44'00" W
GEOLOGY Minor copper and molybdenum in granodiorite (?). Narrow quartz-molybdenite
veins.
WORK HISTORY AND DESCRIPTION OF WORKINGS Not well documented, probably similar
to Carcross occurrence. Roads noted in this area.

MINFILE NUMBER 105D 011 MAP LABEL (THIS REPORT) 011
SITE NAME(S) KNOB HILL (UTIO)
LOCATION LAT. 60°05'00" N DRAINAGE Un-named Creeks
LONG. 134°48'00" W Bennett Lake
GEOLOGY Copper showing in greenstone of Lewes River Group.
WORK HISTORY AND DESCRIPTION OF WORKINGS Three 3m adits and some hand trenches
in 1922- 1924. 5 holes drilled on UTIO in 1956 near MP 64 on the railroad.

MINFILE NUMBER 105D 073 MAP LABEL (THIS REPORT) 073
SITE NAME(S) RAILROAD
LOCATION LAT. 60°02'00" N DRAINAGE DUNDALK CREEK
LONG. 134°46'00" W
GEOLOGY High grade silver vein, near Wynton Creek Fault contact between Laberge Group
argillite and Povoas Formation basalt.

WORK HISTORY AND DESCRIPTION OF WORKINGS An 18m adit and numerous hand trenches are reported, mined ca. 1950. This occurrence is poorly documented.

MINFILE NUMBER 105D 097 MAP LABEL (THIS REPORT) 097
SITE NAME(S) CONRAD
LOCATION LAT. 60°04'00" N DRAINAGE BIG THING CREEK
LONG. 134°35'00" W

GEOLOGY No known showings. Underlain by Nakina Formation metabasite.

WORK HISTORY AND DESCRIPTION OF WORKINGS Little work was done in this area. A bulldozer road was pushed for about 1km on the north side of Big Thing creek from a gravel pit near the highway.

MINFILE NUMBER 105D 156 MAP LABEL (THIS REPORT) 156a
SITE NAME(S) HOWARD (ROOTS)
LOCATION LAT. 60°04'14" N DRAINAGE BIG THING CREEK
LONG. 134°42'15" W

GEOLOGY Polymetallic gold-silver vein, Montana Mtn. Volcanics host.

WORK HISTORY AND DESCRIPTION OF WORKINGS 1905-1906 adit. Second adit 10m in 1950's. Poorly documented, shown on 1906 map (Lundberg, 1996). Adits covered by snow until August.

MINFILE NUMBER 105D 156 MAP LABEL (THIS REPORT) 156b
SITE NAME(S) ART (RAT)
LOCATION LAT. 60°02'42" N DRAINAGE BIG THING CREEK
LONG. 134°41'45" W

GEOLOGY Polymetallic gold-silver vein, Montana Mtn. Pluton host.

WORK HISTORY AND DESCRIPTION OF WORKINGS Roads and trenches, one drillhole in 1975, 3 holes in 1979. Extensive bulldozer and backhoe trenching in 1990.

MINFILE NUMBER 105D 181 MAP LABEL (THIS REPORT) 181
SITE NAME(S) RIGEL
LOCATION LAT. 60°00'32" N DRAINAGE DUNDALK CREEK
LONG. 134°47'45" W

GEOLOGY Geochemical anomalies associated with Aksala Formation volcanics.

5.0 CONCLUSIONS

The water quality in the study area, where known, meets CCME Freshwater Aquatic Life remediation criteria except for the water flowing from the Venus and Arctic mines and associated tailings ponds. The creeks adjacent to the Arctic Mine (Arctic Caribou/ Big Thing and Peerless Mines) show little or no impact from the poor quality mine waters. Similarly, runoff from the Arctic Gold and Silver tailings pond has no measurable impact on the water quality of Tank Creek, which meets Freshwater Aquatic Life criteria. The Venus mine runoff, while above Freshwater Aquatic Life criteria in arsenic, zinc and iron is so greatly diluted in Windy Arm that human health risks from these metals are unlikely. The metals in the Venus mine water may be at local background levels, but there has been no background water quality testing of creeks draining the Montana Mountain Volcanic complex. Metal levels in soils and stream sediments are known to be very high in many parts the study area, often in areas undisturbed by mining. Metals which are anomalous compared to the regional background include arsenic, lead, cadmium, copper, cobalt, silver, iron, antimony, zinc and mercury.

Acid Rock Drainage Potential at Venus Mine is limited, as about half of the sulphide minerals present are not iron sulphides, and the iron sulphide is present as pyrite, not the more easily oxidized pyrrhotite. There is considerable carbonate present in the mineralized zone. The unmineralized waste rock has no ARD potential, and is thought to have moderate to high net potential to consume acid, as the rock has low sulphide content, and contains calcite. The alkaline mine water is further indication of low net ARD potential. Additional hazards at Venus include steep open shafts not identified in the Phase II report, and very high radon levels in the underground workings.

The Arctic Mine is enriched in pyrite, arsenopyrite and other sulphide minerals, but has only minor carbonate content. The acidic nature of the waste rock is a concern; fortunately the volume of waste rock is low and the water flow through the mine is low. The Arctic Mine is hosted by an altered granitic rock, a phase of the Montana Mountain Pluton that may have natural potential for ARD. This unit has significant concentrations of pyrite, and very little carbonate. Streams draining this altered granite tend to be slightly acidic.

Iron sulphide-rich zones in addition to the Montana Mountain Pluton are fairly common in the study area, especially within the Montana Mountain Volcanic Complex. These zones are either small in size, or are buffered by significant carbonate content and are not likely to produce significant natural acid rock drainage.

The effects of mining on water quality appear to be quite limited, mainly due to the small volumes of mineralized rock disturbed. The mines other than Venus and Arctic are very small (less than 10% of the tonnage) than these two mines, and are unlikely to have significant impact on water quality. Water quality is not known for most of the study area, but may be locally affected by the high natural metal levels common in some geological units, soils and stream sediments in the study area.

The most obvious environmental damage is disturbance of the landscape by bulldozer trenching and road building. This damage is mainly aesthetic in nature, but facilitates an increase in human access which leads to further impacts. The largest landscape disturbance in the study area is the South Klondike Highway.

6.0 RECOMMENDATIONS

Future Acid Rock Drainage studies would be improved by adding simple, inexpensive field tests to confirm the presence or absence of calcite and pyrrhotite (dilute HCl to indicate calcite, a magnet to differentiate pyrrhotite from pyrite). Knowledge of the presence of these minerals allows for more conclusive interpretation of the ARD chemical analyses.

Water quality testing should include more background samples, as there are high background metal levels in soils and sediments in the study area. Pooly Creek should be sampled for comparison with the Venus mine water, as it drains an area of similar geology.

Some of the Phase II studies recommend sealing of adits. It is recommended that the owner of mineral rights be contacted prior to sealing, as this could negatively impact property value. Communication may lead to co-operation, and improvements in the site condition at no cost to taxpayers. Also, data such as base maps may be made available. The Phase II study of the Big Thing Mine recommended the burial of the mine hoist gear. It is recommended that this machinery be saved, as it is probably at least 90 years old, and could be considered a Yukon heritage artifact. The Phase II study of

Venus Mine recommended burning of the headframe/ loading platform at the Venus #2 Mine, which is at least 80 years old. This structure is a companion to the old Venus mill (Midnight Arts, 1995), and therefore may be considered a heritage structure, and should not be destroyed.

It is recommended that a field survey be conducted of all known adits and shafts in the study area to determine safety. The survey should be conducted in August, as some of the adits are at high elevations and face north, and are covered in snow most of the year.

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APPENDICES

APPENDIX 1 Water Flow Data

APPENDIX 2 Chronological Summary Of Mining And Mineral Exploration

29AA002 - Big Thing Creek at Km 69.4 Carcross-Skagway Road

Location: 60°04'N 134°34'W
 Drainage Area: 36.2 sq km
 Record Length: 1978 R, 1979 - 1980 C
 Flow: Natural

Maximum Instantaneous			Minimum Instantaneous	
Year	Date	Discharge (m ³ /s)	Date	Discharge (m ³ /s)
1978	June 07	2.31 E	Sept. 17	0.060

Maximum Daily			Minimum Daily	
Year	Date	Discharge (m ³ /s)	Date	Discharge (m ³ /s)
1978	June 08	1.84 E	Sept. 17	0.090

Crest Gauge Summary

Year	Date	Discharge (m ³ /s)
1979	June 25	2.57
1980	Before June 17	2.26

Discharge Summary

Year	Date	Discharge (m ³ /s)	Year	Date	Discharge (m ³ /s)
1978	June 06	1.79	1979	May 18	0.075
	June 30	0.648		June 11	1.27
	July 24	0.568		June 25	2.57
	July 31	0.548		Aug. 28	0.362
	Aug. 18	0.484			
			1980	June 17	0.764
				July 14	0.736
				Sept. 17	1.28

Big Thing Creek at Km 69.4 Carcross-Skagway Road

1978 Daily Discharge in CMS

Day	May	June	July	Aug.	Sept.	Oct.
1			0.700	0.540	0.680	
2			0.560	0.580	0.840	
3			0.490	0.610	0.810	
4			0.970	0.730	0.630	
5			1.17	0.670	0.530	
6			1.27	0.460	0.440	
7		1.84	1.12	0.390	0.400	
8		1.84	1.11	0.420	0.330	
9		1.43	1.12	0.430	0.300	
10		1.28	1.19	0.430	0.300	
11		1.21	1.15	0.450	0.240	
12		1.41	1.12	0.340	0.240	
13		1.51	0.930	0.300	0.180	
14		1.49	0.700	0.300	0.180	
15		1.76	0.530	0.300	0.180	
16		1.56	0.440	0.270	0.120	
17		1.25	0.420	0.250	0.090	
18		0.880	0.440	0.400		
19		0.840	0.470	0.430		
20		0.880	0.790	0.330		
21		0.980	0.640	0.300		
22		1.11	0.720	0.290		
23		1.30	0.700	0.520		
24		1.19	0.600	0.640		
25		0.980	0.470	0.670		
26		0.900	0.340	0.530		
27		0.850	0.300	0.430		
28		0.710	0.500	0.350		
29		0.740	0.610	0.300		
30		0.870	0.520	0.300		
31			0.490	0.370		
Total		28.810	25.590	13.330	6.470	
Mean		1.200	0.730	0.430	0.380	
Max.		1.840	1.270	0.730	0.840	
Min.		0.710	0.300	0.250	0.090	

29AA001 - Pooly Creek at Km 74.0 Carcross-Skagway Road u/s of Highway Bridge

Location: 60°02'N 134°37'W
 Drainage Area: 13.3 sq km
 Record Length: 1978 - 1980 (flow only)
 Flow: Natural

Streamflow Summary

Year	Date	Discharge (m ³ /s)
1978	June 07	1.27 A
1979	June 25	1.51 A
1980	Sept. 17	0.968 A

Discharge Summary

Year	Date	Discharge (m ³ /s)	Year	Date	Discharge (m ³ /s)
1978	June 07	1.27	1980	June 17	0.634
	June 30	0.335		Sept. 17	0.968
	July 24	0.291			
	July 31	0.315			
	Aug. 18	0.180			
1979	May 17	0.021			
	June 11	1.04			
	June 25	1.51			
	July 11	1.46			
	Aug. 28	0.154			

APPENDIX 2

CHRONOLOGICAL SUMMARY OF MINING AND MINERAL EXPLORATION, MONTANA MTN. AREA

- 1896 William Ogilvie reports high grade silver specimen thought to be collected in the study area.
- 1899 Montana claim staked. White Pass and Yukon Route Railway constructed through study area.
- 1900 Mountain Hero claim staked.
- 1901 Venus and Uranus claims staked. Underground mining begins on Venus #1 claim (16m decline, 15 tons of ore produced).
- 1903 Joe Petty claim staked.
- 1904 Minor development work at Venus and Uranus.
- 1905 Mining begins in earnest at Montana, Mountain Hero, Venus and Uranus. Shafts and tunnels in progress in at least a dozen places totaling 762m (including Howard, Thistle). Mountain Hero tramway built, Conrad City started, road from Carcross built to Venus, stone houses built, B.C. border surveyed.
- 1906 Underground work starts at Vault, Joe Petty, Caribou, Pride of Yukon, Venus Extension, Humper, M&M, and Aurora, and continues at mines started in 1905. Venus 2 mine becomes the major Venus mine, tramway built to beach. Big Thing claim staked, tunnel started. Camp and tramway built at Vault. Montana, Thistle and Uranus reported to be producing ore. Road extended to B.C.
- 1907 Most mines allowed to glaciare, minor work at Montana, Vault, Venus, Big Thing. 185 tons of ore shipped from Venus.
- 1908 100 tpd concentrator built at Venus, milling started Oct. 10 with ore from Venus 2 mine. The mill worked sporadically and inefficiently, some ore produced was direct shipped. Water wheel installed at Pooly Creek to power mill. Underground work at Humper.
- 1909 Rich vein intersected at Big Thing at 137m. Venus concentrator shut down, town of Conrad abandoned. Wagon road built from Carcross to Big Thing.
- 1910 Minor underground work at Humper, surface cuts and extending 2 tunnels.
- 1911 Work at Venus, totals 1158m since 1905 in 4 adits and 3 shafts, about 1830 tons shipped to smelters. Big Thing mine very active, hydro power plant installed at foot of McDonald Creek. 75 man crew working an elaborate system of tunnels and drifts, including Peerless adit. 137m inclined shaft, 230m drifting on 4 levels. Big Thing closes, 2290 tonnes ore shipped 1910-1912.
- 1914 Only one resident in Conrad.
- 1915 Big Thing mine optioned, 245 tons ore shipped 1915-1916.
- 1916 Some mining at Venus and Big Thing.
- 1917 Venus, Big Thing and Dail & Fleming Group (Venus Extension, Red Deer, Nipper, Humper, Ruby Silver) re-opened.
- 1918 Venus mill re-opened. Power plant moved from McDonald Creek to Pooly Canyon.
- 1919 Venus mill closed. Treadwell examines Venus.
- 1920 Venus mine optioned, mined, ore shipped totals 2450 tonnes in period 1911- 1920.
- 1921 Maybelle adit worked at Venus. 3, 3m adits at Knob Hill.
- 1922 Hollinger examines Venus.
- 1929 Yukon Gold examines Venus.
- 1936 Inca Mining discovers vein parallel to Big Thing by surface trenching. Jean staked.

- 1939 Hand trenching at Jean.
- 1944 Fuel oil pipeline constructed along railroad. Date uncertain.
- 1946 Venus examined by Transcontinental Resources.
- 1950 Work at Railroad from 1950 to 1961 includes an 18m adit. Work at Howard in 1950's includes a 10m adit.
- 1956 5 holes drilled at Knob Hill.
- 1961 69m adit driven at Jean, into 1962.
- 1963 Venus examined by Giant Yellowknife.
- 1965 New adit at Big Thing, becomes Arctic Mine. Road to Carcross.
- 1966 381m of underground development at Arctic, into 1967. Testing at Venus, road to Carcross, minesite bulldozing. Bulldozing and drilling at Carcross occurrence.
- 1967 New 244m adit at Montana. Peerless adit crosscut 229m to southeast. Underground drilling at Peerless, Arctic, Jean, Montana. Arctic mill construction starts.
- 1968 Arctic mine starts – May to Dec. 1968 and March to Dec. 1969 50,751 tonnes milled. Second Venus mill built. Bulldozing at Joe Petty. Drilling at Carcross occurrence.
- 1969 2059m of drifting and 388m of raising at Venus 2600 and 2700. Arctic production stops.
- 1970 Venus production starts.
- 1971 Venus production stops. 58,900 tonnes milled Sept. 1970- June 1971.
- 1975 Arctic rehabilitation, small tonnage ore stockpiled, into 1976. Drilling and trenching at Art.
- 1979 Third Venus mill built in B.C., never operated. 295m of crosscuts driven at Venus from 2600 level, drilling. Drilling at ART.
- 1983 South Klondike highway built (approximate year).
- 1984 324m of drifting at Venus, 193m of raising, 108m of sublevel drifts, surface drilling of Venus and Uranus. Trenching and roads at Jean. Trenching at Knob Hill.
- 1985 Trenching at Art.
- 1986 Drilling at Jean.
- 1988 Trenching at ART, Ridge. Drilling at Joe Petty. Road and trenches at Snow.
- 1989 Drilling at Joe Petty. Road and trenches at Snow.
- 1990 Dozer and Hoe trenching at ART. Trenching near Arctic.
- 1993 Drilling at Ridge, trenching and blasting various places. Drilling at Jean.
- 1994 Venus tailings capped.
- 1995-1998 Trenching on claims held by Larry Barrett (RAT, MON, TB, BARB, NYAC).