GOVERNMENT OF YUKON

FORMER CLINTON CREEK ASBESTOS MINE HAZARD ASSESSMENT REPORT

Prepared for

Government of Yukon

Prepared by

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Mr. Hugh Copland, P.Eng., P.Geo., Project Manager
Government of Yukon. Energy, Mines and Resources
Box 2703 (K-419)
Whitehorse, Yukon
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Dear Mr. Copland:

RE: Former Clinton Creek Asbestos Mine – Hazard Assessment Program

This report summarizes the findings from our Hazard Assessment Program at the former Clinton Creek Asbestos Mine. The program was undertaken to identify and classify human health and safety hazards at the mine site and provide recommendations for potential corrective (i.e. risk mitigation) measures. The main hazards identified are related to derelict structures such as the crusher building, tram towers and utilidors, open pit wall instabilities, and the presence of asbestos fibres around the mine site. In this regard, additional work will be required to properly assess the human health hazards, particularly those associated with airborne asbestos fibres.

A recommended course of action for 2004 is presented as a first step in an overall rehabilitation program intended to mitigate unacceptable hazards. Although stability of the tailings and waste rock piles do not necessarily pose an immediate physical hazard, stability of the piles will be assessed in 2004 to determine if continued monitoring and/or stabilization measures are required.

If we can be of further assistance please contact either Gil Robinson or Ken Skaftfeld directly.

Sincerely,

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ACKNOWLEDGEMENTS

We wish to express our appreciation to the people who assisted with the field program and provided valuable input during the reporting stage. A special thank you to Mr. Hugh Copland of the Government of Yukon who participated in much of the site reconnaissance work including the collection of water samples. SENES Consultants Ltd. provided valuable input in both the field and reporting stages with respect to the issue of airborne asbestos fibres, closure practices at former asbestos mines and provided recommendations related to detailed Human Health Risk Assessment. Matt Dodd of the Royal Roads University helped with the collection of water samples at the mine site and along Clinton Creek.

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1.0 INTRODUCTION

A Hazard Assessment Program was carried out at the former Clinton Creek Asbestos Mine in 2003 to identify and classify human health and safety hazards at the mine site and provide recommendations for potential corrective (i.e. risk mitigation) measures. Previous investigations at the mine site have focussed on the stability of the waste rock and tailings piles and the potential for development of a catastrophic breach of landslide dams, in particular at the Hudgeon Lake outlet. This report presents a summary of the identified hazards, their respective classifications and recommendations for the implementation of potential corrective (i.e. risk mitigation) measures. While no attempt has been made to quantify or measure the associated risks, they have been evaluated in a qualitative manner to determine hazard classifications and develop alternatives for hazard elimination and/or risk reduction.

The former Clinton Creek Asbestos Mine is located about 100 km northwest of Dawson City in the Yukon Territory, 9 km upstream of the confluence of Clinton Creek and the Forty Mile River. The main physical features of the mine include three open pits (Porcupine, Creek and Snowshoe Pits), two waste rock dumps (Porcupine Creek and Clinton Creek Waste Rock Dumps) and a tailings pile on the west side of Wolverine Creek (Wolverine Creek Tailings Pile) as shown on Drawing 01. The main infrastructure components of the mine site, some of which have been salvaged or demolished, include the crusher building, mill site (buildings, tunnels and conveyor systems), tram line from the crusher building to the mill site and a fertilizer/explosives storage facility.

Cassiar Mining Corporation operated the Clinton Creek Mine from 1968 until depletion of economic reserves in 1978. During this time, over 60 million tonnes of waste rock from the open pits was deposited into the Porcupine and Clinton Creek valleys forming the Porcupine and Clinton Creek waste rock dumps. Approximately 12 million tonnes of ore consisting of serpentinite rock and asbestos fibre was mined. The ore was transported in buckets by a tramway to the mill located on a ridge along the west side of Wolverine Creek. Approximately 10 million tonnes of asbestos tailings from the milling operation were deposited over the west slope of the Wolverine Creek valley forming the Wolverine Creek tailings pile. Landslides of both waste rock piles and the tailings pile have resulted in valley blockages and upstream impoundment of water.

Following closure of the mine in 1978, mine site decommissioning was undertaken during which most of the mill site structures were salvaged or demolished. It is believed that this work took place in the late 1970's and/or early 1980's. The decommissioning was only partially completed however, and several physical hazards related to the partially demolished infrastructure still exist. To the best of our knowledge, no work was undertaken to mitigate human health hazards associated with fugitive (airborne) asbestos fibres although a small trial vegetation plot was established on the tailings pile (Drawing 01). Concerns have also been previously raised with respect to downstream hazards associated with a breach of channel blockages resulting from landslides of the Clinton Creek and Porcupine Creek waste rock dumps and the Wolverine Creek tailings pile. The risks associated with these hazards have been discussed in previous reports (UMA 2000, UMA 2002 and UMA 2003a). To reduce the potential for a breach of the landslide dam at the Hudgeon Lake outlet, channel stabilization work in Clinton Creek was initiated in 2002 and is expected to be completed in 2004 (UMA 2003 and UMA 2003b).

An environmental review and screening environmental risk assessment was previously conducted by Royal Roads University in 1999 (RRU 1999), with the assistance of Indian and Northern Affairs Canada (INAC) personnel. The report assessed aquatic habitat (including water quality and fish populations), terrestrial habitat, and the geochemical stability of waste materials, based on limited sampling. Recommendations included the following:

1. Additional geophysical studies (these have since been undertaken – UMA 2000, 2002 and 2003a);
2. Measurement of asbestos fibre concentrations in air (see Section 5.0);
3. Investigation of re-vegetation for slope stabilization and limited asbestos fibre mobilization to air;
4. Additional aquatic sampling to assess seasonal and long-term variability of fish populations;
5. Assessment of aluminium and selenium tissue concentrations in stream invertebrates to confirm that these are not bio-accumulated from stream sediments at atypically high rates and
6. Assessment of effects of water-borne chrysotile asbestos on fish gills and fish health.

The first two recommendations have been addressed. With respect to the third recommendation, a sample of tailings was submitted for agronomic analysis in 2003 (Section 3.3) The issues related to aquatic habitat and fisheries (items 4, 5 and 6) are currently deemed to be of lower priority relative to physical hazards at the site and possible risks to humans from airborne asbestos fibre inhalation. The lower priority afforded aquatic issues is due to the continued presence of large numbers of fish (especially Arctic grayling) in creeks at and near the site. Limited effort to evaluating longer term trends in, and spatial distribution of, Chinook salmon fry may still be justified however.

2.0 HAZARD ASSESSMENT

In the context of this report, a hazard is defined as a condition at the mine site with the potential to result in injury, loss of life or illness. The hazard assessment program was intended to:

i) Identify and evaluate physical hazards e.g. crusher building, utilidor;

ii) Identify the characteristics (nature) of the hazards; and

iii) Classify the identified hazards (Section 2.2).

2.1 FIELD PROGRAM

The hazard identification field program was completed in two stages. The first stage involved identifying physical hazards, monitoring of waste rock and tailings pile movements and limited air sampling carried out during the field activities. The second stage was undertaken to further understand the potential human health and ecological hazards at the mine site related to water quality issues and airborne asbestos fibres. Mr. Hugh Copland of the Government of Yukon participated in both stages.

2.1.1 Stage 1 – Hazard Identification and Characterization

Site Reconnaissance

The first stage conducted from August 18 to August 22, 2003 by Ken Skaftfeld and Gil Robinson of UMA Engineering included a site reconnaissance and survey. The reconnaissance was conducted to identify potential hazards in areas where significant activity took place during operation of the mine or areas that were impacted by such activity. These included the tailings pile, the Wolverine Creek channel downstream of the tailings pile, the two waste rock dumps, the three open pits, the crusher building, the mill site and the ammonia-nitrate-fuel-ordinance (ANFO) storage facility where explosives were stored. The locations of the hazards were recorded using a hand held Global Positioning Survey (GPS) unit. Field notes and digital photographs of the identified hazards were also recorded. A complete set of digital photographs on compact disc is attached to this report under the Photographs appendix. A representative selection of photographs have been included in this report and where indicated, on the Drawings.

Subsequent to the August field work, additional site reconnaissance was conducted on September 8 and 9, 2003 by Doug Bright and Gil Robinson of UMA Engineering and Randy Knapp of SENES Consultants Limited. This work was undertaken to further evaluate the hazards associated with airborne asbestos fibres and develop a program (Stage 2) for water sampling and additional air sampling.

Site Survey

Underhill Geomatics from Whitehorse, Yukon completed a GPS survey of movement monitoring points on the Clinton Creek waste rock dump and the Wolverine Creek tailings pile. Ten new movement monitors were added to the tailing piles and seven new monitors were added to the waste rock dump. A profile survey of the Wolverine Creek channel was also completed. The on-set of winter prevented the completion of a second round of movement monitor surveying and a profile survey of the Clinton Creek channel across the waste rock pile that had been planned for September 2003. This work has been tentatively re-scheduled for the summer of 2004. Preliminary results of the survey are discussed in Sections 3.1 and 3.3. A geotechnical investigation at the tailings pile, originally scheduled for the Stage 1 program was put on-hold until movement of the tailings pile could be confirmed by surveying of the movement monitors.

Air Sampling

Eight air samples were collected during the first stage of the site investigation work. These samples were submitted to Enviro-Test Laboratories in Edmonton, Alberta to determine the concentration of asbestos fibres.

2.1.2 Stage 2 – Air and Water Sampling

The second stage was conducted on September 23 and 24, 2003 by Wayne Cormack of SENES Consultants Limited, Matt Dodd from Royal Roads University and Gil Robinson of UMA Engineering. Twenty-seven water samples were collected on the mine site and also upstream and downstream of the mine site. The samples were submitted to ALS Environmental in Vancouver, BC for testing of dissolved anions, nutrients and total metals. The results of the water quality testing are discussed in Section 4.0. Eight air samples and six soil samples were collected and submitted for testing at Chatfield Technical Consulting Limited in Mississauga, Ontario. The air sampling results are discussed in Section 5.0.

2.2 HAZARD CLASSIFICATION

Each hazard was classified based on the severity of the potential outcome due to exposure to that hazard (from a health and safety perspective). A four level classification system was used (negligible, low, moderate or high) based on the associated consequences as shown in Table 2-1. Those hazards associated with asbestos were not classified at this time because additional work is required (Section 8.2 and 8.3) to assess the risks associated with airborne asbestos fibres.

Table 2-1) Hazard Classification

Hazard Classification	**Potential Outcome**
Negligible	None Identified
Low	Small Risk of Serious Injury
Moderate	Potential For Serious Injury. Small Risk of Fatality
High	Severe Injury Likely or Possible Fatality

In lieu of a detailed risk assessment (for which there is a lack of data) or development of a risk matrix, the classification of hazards is intended to provide an intuitive means to assess the significance of the hazard and the need for measures to either eliminate the hazard or reduce the associated risks. The hazard classifications were also useful in determining priorities for the mitigation work which is expected to take longer than one construction season to complete Since hazards categorized as negligible will likely not require immediate risk mitigation, two data sets have been provided. Table 1 and Drawing 01 summarize all of the hazards associated with low, moderate or high classifications and also those not classified at this time. Table 2 and Drawing 02 summarize all hazards with a negligible rating.

3.0 DISCUSSION OF IDENTIFIED HAZARDS

3.1 WASTE ROCK DUMPS

The Clinton Creek and Porcupine Creek waste rock dumps consist of overburden and waste rock material from development of the open pits (Drawing 01). The current topography of the waste dumps, in particular the Clinton Creek dump, is largely due to landslides of the waste rock that occurred during operation of the mine and continued movement subsequent to mine closure. Relatively small creep movements are still believed to be occurring (UMA 1999).

3.1.1 Waste Rock Movements

The most significant hazard previously identified at the waste rock dump was continued degradation of the Clinton Creek channel through the Clinton Creek waste dump (UMA, 2002). Of particular concern were potential risks to human life and property downstream of the mine associated with a sudden breach of the channel blockage at the Hudgeon Lake outlet. In areas of significant relief such as the Clinton Creek valley, flooding from failures of channel blockages can be especially dangerous and unrelated to precipitation events that would normally be expected to produce flooding conditions. Although the potential exists for a sudden release of water due to a breach of the tailings pile in Wolverine Creek or the Porcupine Creek waste dump, the consequences of failures at these locations are considered less significant by comparison. These concerns were addressed in a risk assessment report (UMA 2000) and conceptual design of channel stabilization measures (UMA 2002).

The Clinton Creek channel downstream of Hudgeon Lake is currently being stabilized by flattening the grade of the channel immediately downstream of the Hudgeon Lake outlet using gabion drop structures. Stabilization of the channel began in 2002 when the first of a series of four gabion drop structures was constructed (UMA 2003). The second drop structure was constructed in 2003 (UMA 2003b) and the balance of the stabilization work (drop structures 3 and 4) is planned for 2004.

Monitoring of the Clinton Creek waste dump movements was undertaken on a regular basis from about 1976 to 1986. The monitoring program was re-initiated by INAC and UMA in 1999 with additional monitoring events in 2001 and 2003. The monitoring data shows that creep movements of the waste rock pile are continuing. Although the drop structures can tolerate some post-construction movements, maintenance or replacement of the structures may be required if these movements impact the serviceability of the channel stabilization works (UMA 2003a). Failure of the structures would once again increase the risk of a breach at the outlet, the consequences of which, have been previously reported. Should they be necessary, measures to stabilize the waste rock pile were discussed in the Conceptual Design Report (UMA 2002).

Recognizing the importance of quantifying waste rock movements, the survey monitoring program was expanded in 2003 by adding seven new monitoring points to the thirty-two existing points consisting of survey control points, standpipe piezometers, pit slope monitor points, channel closure pins and waste rock monitor points. The locations of these survey points are summarized in Table A-1 and illustrated on Drawing A-1 in Appendix A. Drawing A-2 (Appendix A) shows the locations of the survey benchmarks. Channel closure monitoring points were also established on both sides of the drop structure constructed in 2002 to measure deformation of the structure from waste rock movements. Similar monitoring points will be installed for the remaining drop structures once they are complete. Beginning in 2003, the survey method was switched from total station to GPS and a transformation routine was developed by Underhill Geomatics in Whitehorse to convert previous surveys completed in former mine grid co-ordinate system to the UTM NAD 83 (Zone 7) co-ordinate system. Table A-2 in Appendix A summarizes the benchmarks and conversion from the former mine grid to UTM. All future surveys will be conducted using GPS with UTM co-ordinates. The next round of monitoring is scheduled for the summer of 2004.

A summary of waste rock movements is provided in Table A-3. A detailed assessment of the movements will be prepared following the 2004 survey. The movement monitors have been categorized according to location on the waste rock dump; the upper slope monitors are located above elevation 450 m, the mid-slope monitors are located between elevation 420 m and 450 m and the lower slope monitors are located below elevation 420 m. The pit slope monitor points are included in a separate category since they provide data on pit wall movements rather than overall waste rock movements. The pit slope monitoring points will not yield any movement data until the next survey is completed in 2004.

Based on the survey monitoring carried out in 1999, 2001 and 2003, the rate of horizontal waste rock movements are estimated to range from 10 to 130 mm per year with an average of about 60 mm/yr. While the average annual movement of the waste rock pile is small compared to previous (historical) observations, should movements continue at this rate (e.g. 50 mm/year over 10 years = 500 mm) the integrity of the gabion drop structures may be compromised in the foreseeable future. The monitoring points on either side of the gabion drop structures will help to determine how much of the waste rock movement is reflected in deformation of the gabion drop structures.

3.1.2 Asbestos Fibres

Exposure to isolated pockets of asbestos fibres within the waste rock that may become airborne as a result of personal or demolition activity has been identified as a potential hazard at the waste rock dumps. In this regard, air quality monitoring should be carried on the waste rock dumps to assess the level of exposure to airborne asbestos fibres. Given the widespread and sporadic nature of the fibres throughout the waste rock, preventing vehicle access to the area is recommended at the locations shown on Drawing 01 (temporary road blocks were installed in September 2003).

3.2 OPEN PITS

The locations of the Porcupine, Creek and Snowshoe Pits are shown on Drawing 01. The Porcupine Pit is the largest of the three open pits. It is our understanding that movements of the Porcupine Pit wall occurred during active mining and similar movements have been on-going since closure of the mine. The two main hazards identified are ground movements associated with instabilities of the pit walls, rockfalls and the presence of exposed asbestos ore.

The pit wall instabilities are evident by tension cracks and slumping of large sections of ground around the perimeter of the pit (Photos 1 to 4). Many of these instabilities and associated movements appear recent and during our site reconnaissance in 2003, small slides were observed in the northwest corner of the Porcupine Pit. The most obvious hazard is associated with sudden failures of the pit wall or rockfalls into the open pits. The likelihood of both occurrences is increasing with time as the overburden and waste rock material weathers. Stability will only be achieved when the open pit walls eventually reach a stable angle. Rock fall hazards are associated with all three pits, in particular the Creek Pit where there is a pond possibly used for swimming.

The presence of raw unprocessed ore, including asbestos fibres, on the floor of the Snow Shoe and Creek Pits and near the entrance to the Porcupine Pit presents a potential human health hazard (Photograph 5). These locations should be included in the air monitoring program for 2004 (Section 5.0). If blocking access to these areas is not sufficient to reduce the risk of exposure to airborne asbestos fibres then the areas should be re-graded with a layer of fill (e.g. waste rock) at least 300 mm thick. Timing for permanently blocking access will be dependent on the schedule of other remedial activities (e.g. crusher building demolition).

Methods to mitigate the risks associated with exposure to the physical hazards associated with the open pits range from slope stabilization (slope flattening or berming) to restricting access into the hazardous areas. Given the cost and difficulty of effective slope stabilization, measures to restrict and/or prevent access into the open pits are recommended. In this regard, the main access to the open pits is via the two access points leading off the mine access road on to the waste rock dump. These locations were temporarily blocked with boulders at the end of the construction season in September 2003. Access to the Snowshoe Pit should be permanently blocked at the entrance road into the pit, as shown on Drawing 01. A further step would be to fence off the open pits entirely but given the remoteness of the site and limited access points, the requirement for such measures is questionable. Given the evidence of human activity in the Creek Pit, fencing this area off at the northeast entrance should be considered. It is also recommended that signs be posted warning of the hazards associated with trespassing in the open pit areas. These warning signs should be posted at the locations where site access is blocked.

3.3 WOLVERINE CREEK TAILINGS PILE AND CREEK CHANNEL

The tailings pile consists of a main pile at the top of the Wolverine Creek valley and two lobes, the north and south lobes, as shown on Drawing 01. The tailings consist of asbestos fibre and gravel sized serpentinite rejected during the milling process. The tailings were deposited at the top of the valley slope from 1968 to 1978 using a conveyor to end dump the tailings and a bull dozer to spread the pile. In 1974, a failure of the tailings pile (south lobe) blocked Wolverine Creek. The tailings had been creeping down the slope for some time before this event. This blockage was subsequently breached resulting in tailings being washed a significant distance downstream. The creek profile on Drawing 03 suggests that the majority of these tailings were deposited within the first 300 m downstream, although tailings can be found along the creek to the confluence with Clinton Creek. After the breach event, tailings deposition was shifted farther to the north where downslope movements also occurred forming the north lobe (UMA 2003a). The hazards identified at this area include the downstream physical hazards associated with a potential breach of tailings blocking the channel and the human health hazards associated with the presence of ai

Physical hazards associated with a breach of the tailings are discussed
Report (UMA 2000). The consequences of a breach of the tailings are c
breach of the Hudgeon Lake outlet because the volume of water store
relatively small in comparison to the waste rock dump. Also, the rock-li
downstream of the south lobe, installed in 1978, help reduce the likelih
the rock lined channel has performed reasonably well over the year
identified the need for future maintenance to maintain its serviceability.
should be given to replacing this portion of the channel with gabion drop structures. In the short

Does this recommend to put gabions in Wolverine Ck remain an option or recommendat?

term, continued monitoring of tailings pile movements is recommended to further assess the need for stabilization. A centerline profile and some cross-sections of Wolverine Creek were surveyed in 2003 to assist in this evaluation and provide information for any future designs (Drawings 03 and 04). A preliminary review of the tailings stability and possible stabilization options are provided in UMA 2003a.

A recommendation to assess the tailings pile movements was made in the Environmental Liability Report (UMA 2003a). Comparison of conditions observed along the creek channel across the toe of the tailings pile in 1998 and 2003 suggested that the advancement of the tailings may be much less than previously thought. As a result, the drilling program planned for 2003 was subsequently put on-hold and the movement monitoring program, initiated around 1977 and discontinued around 1986, was re-instated. Twenty of the original monitors were located and ten new monitor points were added on the tailings piles. Five alignment pins were also positioned across the bottom of each lobe to serve as visual indicators of gross movements. The monitor locations are illustrated on Drawing A-3 and a list of the monitors is provided on Table A-4, both in Appendix A. The locations of the monitors were established using a GPS survey. At least one additional monitoring survey is required to assess current movement rates of the tailings. The next round of monitoring, scheduled for the summer of 2004, will provide data for an assessment of tailings movements and review of stabilization measures.

Although a thin weathered layer (< 300 mm thick) has formed on the tailings and may be helping to reduce the release of fugitive asbestos fibres, air samples collected during the site investigation suggest that there is potential for asbestos fibres to become airborne (Section 5.0). The fibres may become airborne either by human activities, movements of tailings from instabilities of the pile(s), or environmental effects such erosion from wind or surface water run-off. The need for remedial work on the tailings to reduce the level of fugitive asbestos fibres should be assessed after the 2004 air monitoring program (Section 8) is completed. To evaluate the possibility of covering the tailings with a vegetative cover, a sample of the tailings was submitted by the Government of Yukon for agronomic analysis. The results indicate that the tailings are not very fertile and likely not capable of supporting vegetation (Appendix B). These results are consistent with the results of a trial vegetation plot on the top of the tailings pile around the time of mine closure (Drawing 01). Within this plot, it appears that some cover material (type and thickness unknown) was placed over the tailings and seeded. Observations indicate that the plot is not flourishing.

Downstream of the tailings pile, deposits of asbestos tailings can be found along the Wolverine creek channel to the confluence with Clinton Creek, a distance of approximately 800 m

(Photograph 6). The tailings are exposed along the flanks of the channel and the flood plain to the valley slopes. Deposits up to 2 m thick were noted. Asbestos fibres can also be seen hanging from trees within the channel (Photo 6). To further assess the risk associated with this potential hazard, air monitoring in 2004 should include the Wolverine Creek channel. To reduce the risk of exposure to fugitive asbestos fibres, particularly in the short term, the outwash area at the mine site access road should be covered and a stable channel provided to prevent the asbestos from being re-exposed by erosion. The road along the east side of Wolverine Creek should also be blocked at the mine site access road as shown on Drawing 01.

3.4 CRUSHER BUILDING

The crusher building is located on a rock outcrop between the three open pits (Drawing 01 and Photo 7). Details of the crusher process were obtained from an article originally printed in The Western Miner (Stevens 1969). During operation of the mine, ore was dumped into a hopper on the west side of the crusher building. The hopper fed the primary crusher from where the ore was transferred by belt conveyors to a screen deck. Ore passing through the screen deck was discharged to the tramway feeder. Oversize material from the screen deck was directed to a secondary crusher and then discharged to the tramway feeder. The tramway feeder loaded the crushed ore into buckets which were then moved onto the tramway for transport up to the mill site. The tramway feeder is located at the bottom of the crusher building on the east side where the former ore bucket maintenance area is also located. For the purposes of this report, the tramway feeder and ore bucket maintenance area are considered part of the crusher building, but not the tramway.

With the exception of the primary and secondary crushers and the screen deck, most of the main components of the crusher building were not removed during the mine decommissioning leaving behind a number of significant physical and human health hazards (Table 1). Photographs 7 to 11 illustrate the general components and condition of the crusher building. Identified hazards include loose tin corrugated sheeting, partially disassembled internal workings, high fall points, loose hanging ore buckets and asbestos fibres. Asbestos fibres on the roof of the building, inside the building, in the ore buckets and in the surrounding area (for example about 50 m west of the truck dump area of the crusher building shown in Photos 12 and 13) are considered likely human health hazards. The risks associated with these hazards are best mitigated by demolishing and landfilling the building and covering asbestos on the ground in the area of the crusher building with clean fill. The crusher building should be demolished and landfilled and the asbestos fibres around in the immediate area should either be covered or landfilled.

3.5 TRAMWAY TOWERS

The former tramway is located between the crusher building and the mill site, as shown on Drawing 01. The tramway was specially designed and constructed by the Riblet Tramway Company of Spokane, Washington to transport ore from the crusher building to the mill, which is located on a plateau on the north side of the Clinton Creek valley (west side of the Wolverine Creek valley). The tramway was about 1,600 m long and lifted the ore about 150 m in elevation. Approximately 270 tonnes of ore per hour was conveyed to the mill using 70 ore buckets supported on a 57 mm diameter cable. Approximately 1.3 tonnes of ore was carried in each bucket, which weighs about 570 kg.

Twelve tram towers (Towers 1 to 12 on Drawing 01), not including the tram terminus building at the mill site, were constructed to support the cable. Towers 2 and 11 have been cut down. The other towers and most of the tram terminus building are still standing. With the exception of Tower 3, which is a massive block of concrete (Photograph 14), the towers were constructed with 2 – 600 mm diameter steel pipes set into a concrete base foundation (Photos 15 to 17). The cable(s) from the tramway was found in the bush behind the tram tower terminus structure. Some pieces of cable were also observed along side the towers.

The hazards associated with the tram towers include high fall heights and the presence of asbestos. Ladders on each tower (except Tower 1) provide access to the top of the tower where a wood platform is located (Photograph 15). The decking and ladders should be removed. The exposed pipe base at Towers 2 and 11 should be cut flush to the footing and then backfilled. Asbestos fibres are present along the tram line, in particular at the base of the towers. A significant mound of asbestos ore is located at the base of Tower 3 (Photograph 14). The majority of the asbestos along the tram line is relatively well protected from wind. The main concern is likely to be disturbance of the asbestos by casual users of the site and workers undertaking hazard mitigation work at the towers. As a minimum, the asbestos should be levelled and covered with a minimum of 300 mm of clean cover material.

The tram terminus building is located on the mill site. The structure consists of nine steel pipe supports and a building housing the tram drive components (Photos 18 and 19). The building is clad with asbestos fibre board. Seven of the steel pipe supports have been removed and some components of the building have been removed. Identified hazards include loose or falling structural materials, asbestos exposure and high falls (from ladders up to the top of the structure). As a minimum, ladders leading up to the top of the structure should be cut off and any loose structural material removed or secured. Ideally, the structure should be demolished and landfilled. The bottoms of the seven pipe supports that have been removed should be cut flush and backfilled.

3.6 MILL SITE

Drawing 05 illustrates the former locations of the main buildings on the mill site including the dryer building, dry rock storage building, mill building, fibre storage building, service building and the office building. These buildings were demolished during the mine decommissioning in the late 1970's and early 1980's. Infrastructure that remains on site includes two, 1.3 million litre steel tanks (now empty) for fuel and water storage, a buried utilidor used to supply water and steam, two conveyor tunnels, concrete foundations from the demolished buildings, and two small two-storey concrete buildings which were originally part of the office building (Photo 20).

The hazards identified at the mill site include:

- Asbestos fibres covering a large area;
- Utilidor;
- Conveyor tunnels;
- Above ground storage tanks;
- Above grade foundations;
- Dry Rock Storage Building area;
- Service Building foundation (open pits).

3.6.1 Asbestos Fibres

Asbestos fibres were widely spread across the mill site and surrounding areas in various concentrations during milling operations. Aerial photographs from 1976 (Drawing 06) show a light grey tone across much of the mill site, except on well travelled areas such as the roadways. Significant amounts of asbestos fibres were found at the tram line terminus building, the conveyor tunnels, on the two concrete utilidor box structures and in the area of the former dry rock building, the service building and the mill building. Air monitoring results collected during the field program in 2003 indicate that human activity on the mill site can result in airborne asbestos fibres (Section 5.0). An asbestos abatement plan should be developed after the human health risk assessment (HHRA) discussed in Section 8 has been completed.

3.6.2 Utilidors

The utilidor consists of a series of tunnels, approximately 1200 mm in diameter, made of what appears to be steel boiler plate material. The utilidor houses water and steam lines, running from the water tank to the two concrete utilidor boxes, the south end of the service building and the former office building (Drawing 05). Some of the lines have insulation believed to be asbestos. Several access points into the utilidor were discovered including: pits in the office and service buildings, a plywood covered manhole, two concrete utilidor boxes and a partially buried shaft at the water tank (Hazards #13, 16, 17, 18, 23 and 24 on Drawing 05). The risks associated with the access points should be mitigated by backfilling all the access points, including the utilidor boxes. In the short term, providing secure covers on all the utilidor access points should be considered.

3.6.3 Conveyor Tunnels

There are two conveyor tunnels, one located near the former dryer building (Tunnel #1 – Hazard #22) and one near the former dry rock building (Tunnel #2 – Hazards #25 and 26). The concrete tunnels are about 50 m long and slope down from grade at the entrance to about 3 m below surface. The bottom ends of the tunnels are partly filled with water and they are heavily coated with asbestos fibres inside and out. Tunnel #2 has some loose concrete hanging at the entrance and part of an old conveyor is still in-place at the bottom end. Immediate action is recommended to seal off access into the conveyor tunnels. Long term action should involve demolishing and/or backfilling of the entire structures.

3.6.4 Above Ground Storage Tanks

The two steel storage tanks (Water Tank – Hazard #24 and Diesel Fuel Tank – Hazard #28) are deteriorating, in particular the roof of the water storage tank which is badly corroded. Hazards include access ladders leading to the roofs and access into the tanks via open hatches near the bottom of the tank walls. In the short term, the ladders should be cut-off the tanks and access points welded shut. In the long term, consideration should be given to demolishing and landfilling the tanks.

3.6.5 Above Grade Foundations

There are approximately twelve above grade concrete foundations located at the former mill and dryer buildings. Hazards identified include protruding rebar, loosely hanging steel chutes, scattered debris and asbestos fibres (Hazard #19). The exposed rebar and steel chutes should be cut off. Scattered debris should be cleaned up and landfilled.

3.6.6 Dry Rock Storage Building

Ground surface depressions and one partially filled void (Hazards #27 and 45) were noted at the former Dry Rock Storage Building. Records (Stevens 1969) indicate that sub-floor conveyors were used in the building to transport the asbestos fibres to the main conveyor where it was conveyed to the mill building. Test pits should be excavated to check for buried shafts, starting at obvious locations such as conveyor Tunnel #2. Any depressions or voids should be backfilled.

3.6.7 Service Building

The service building foundation contains three pits. One is part of the utilidor located at the south end of the building (Hazard #17). The other two are located at the north end of the building (Hazard #44). All the pits should be backfilled.

3.7 ANFO STORAGE FACILITY

The ammonium nitrate fuel ordnance (ANFO) storage facility is located approximately 500 m south of the Porcupine Pit. ANFO is a type of explosive based on ammonium, nitrate, fuel oil and additives. Stevens 1969 indicated that 1,360 tonnes of ammonium nitrate explosives were used each year at the open pits. The storage facility consists of a 1.3 million litre steel storage tank for the ammonium nitrate, a storage tank loading system (hopper and conveyor) and unloading system (conveyor). Photographs 21 to 24 illustrate the components of the facility. Although not visible on the 1999 aerial photography of the mine site, air photos from 1976 indicate that there were two buildings located about 200 m west of the storage tank (Hazard #67A on Drawing 01). These buildings may have been used for storing fuel oil, additives and/or TNT required to make and detonate the ANFO. This area was not inspected in 2003 and should be checked for hazards in 2004.

Hazards at the ANFO facility include fall points, weathered wooden staircase, poor structural condition (rusted) of the storage tank and the remaining ammonium nitrate in the tank. Even though the ANFO facility is not accessible by vehicle (except possibly by ATV), it is recommended that the facility be demolished and landfilled. The remaining ammonium nitrate in the tank, estimated to be about 150 m^3 in volume (Photograph #25), should be tested for its chemical make up. If the test results show that it is ammonium nitrate (i.e. fertilizer), then it may be possible to spread the fertilizer out over the surrounding area.

3.8 MISCELLANEOUS ITEMS

A number of features were identified during the site investigation including:

- Former water intake – Hudgeon Lake;
- Old mining equipment (north of crusher building);
- Small wooden building (Creek Pit);
- Steel frame (Creek Pit).

The former water intake on Hudgeon Lake is located at the Easter Creek outlet into Hudgeon Lake. Identified hazards include a weathered wooden staircase, some partially exposed water line pipe and two old power poles and power lines just off the shoreline (Photos 26 to 28). The stairs should be demolished and the power poles and line removed from the lake as they may pose a boating hazard.

The old electric powered mining equipment, a Northwest shovel (1.9 m^3) and a Bucyrus-Erie 40-R rotary drill (Stevens 1969), are located about 200 m north of the crusher building (Photograph 29). The equipment represents a climbing and fall hazard along with some possible environmental concerns related to transformer oil and lubricants in the mechanical components of the machines (e.g. gear boxes, transmissions, final drives). The drill also has an air filter at the front end believed to have been used to capture asbestos dust (Photograph 30). The filters are caked with asbestos dust. The equipment is an attraction to site visitors and should either be salvaged or landfilled. The transformer oil should be sampled in 2004 and tested to check for chemical make up.

A small derelict wooden shelter (Photograph 31) and a tall steel frame (Photograph 32) are located in the vicinity of the Creek Pit. The wooden shelter should be demolished and landfilled. The steel frame represents a climbing / fall hazard and should either be salvaged or landfilled.

4.0 WATER SAMPLING PROGRAM

A water sampling program was undertaken to provide additional insight into the influence of geological conditions on the concentration of various elements in the Clinton Creek catchment, including the Porcupine and Wolverine Creek tributaries.

4.1 2003 FIELD PROGRAM

Open pit areas, waste rock dumps, the former mine site and the tailings deposit remain poorly vegetated. Surface runoff or infiltrating water from these areas might represent a source of metals/metalloids and chrysotile asbestos fibres to Hudgeon Lake, Wolverine and Porcupine Creeks; Clinton Creek, Forty Mile River, and ultimately the Yukon River. A limited water quality evaluation and aquatic habitat assessment were carried out in 1999 (RRU, 1999); however, additional assessment of water quality within the watershed was carried out during the fall of 2003 to add to the overall knowledge base and address a few outstanding questions from the 1999 program (as discussed in Section 1). The samples collected in 2003 were not tested for chrysotile asbestos fibres, since the previously collected data provides an indication about the range of concentrations found in Clinton Creek and the Forty Mile River.

Grab samples were collected from surficial flows in the area of the mine site on September 23 and 24, 2003 by Matt Dodd (Royal Roads University) and Hugh Copland (Government of Yukon). Sample locations are provided on Table 4-1 below and Drawing C1 in Appendix C.

Table 4-1: Surface Water Sampling Stations

Water Body	Number of Sites Sampled	Potentially Affected Locations	Upstream Reference Site
Hudgeon Lake	6	Hl-03-01,02,04,05,06	HL-03-03
Wolverine Creek	5	WC-03-02,03,04	WC-03-01
Porcupine Creek	4	PC-03-01,02,03,04	
Porcupine Pit	1	PP-03-01	
Clinton Creek	7	CC-03-01 to 07	
Forty Mile River	2	FM-03-02	FM-03-01
Eagle Creek	1		EC-03-01
Mickey Creek	1		MC-03-01
Total Sites Sampled	**27**		

Twenty-seven sites were sampled. Where feasible, locations were sampled upstream, adjacent to and downstream from mine runoff areas. The Eagle Creek and Mickey Creek sites were chosen as reference sites with metal/metalloid concentrations potentially reflective of local geology in the absence of mine-related sources.

The water samples were analyzed for anions, nutrients, and metals/metalloids as listed in Tables C-1 and C-2, located in Appendix C. Test results from the reference sites listed in Table 4-1 are shaded in Tables C-1 and C-2. The data is either compared to British Columbia Approved Water Quality Guidelines for Freshwater Life Protection (where no CCME Aquatic Life Guidelines currently exist) or the relevant Canadian Council of Ministers of the Environment (CCME) Guidelines. Sample results exceeding the guideline values are bolded in the tables.

In comparing upstream and downstream results, and comparing the water sample data to relevant guidelines for freshwater life protection, the following conclusions were made:

1) **Anions:** All local water bodies exhibit high sulfate levels. For Wolverine Creek and upper Clinton Creek (including Hudgeon Lake), the concentrations appear to be based on background mineralization, with no apparent additional contribution from mine area runoff. The highest sulfate levels were observed in one sample from Porcupine Pit (2,290 mg/L) – an order of magnitude higher than in Hudgeon Lake or the upper sites on Clinton Creek. Sulfate concentrations around 1,000 mg/L were found in samples from Porcupine Creek downstream from Porcupine Pit contributions. The influence on the Clinton Creek watershed of sulfate inputs from the Porcupine Creek watershed appear to be minimal in light of the low sulfate concentrations at all Clinton Creek sites. This is probably due to the relative volumes of the two systems, which results in substantial dilution of Porcupine Creek water as it enters Clinton Creek. The elevated sulfate in Porcupine Pit water may be due to enhanced solubilizaton from magnesium sulfate minerals. Samples from Mickey Creek and the Forty Mile River upriver from the Clinton Creek inflow exhibited low sulfate concentrations, likely reflecting different prevailing geological conditions in the catchments.

2) **Nutrients:** Ammonia-N and nitrate N were analyzed to examine possible influences of residual ammonia or nitrate from mining explosives (ANFO: Ammonia Nitrate Fuel Ordnance) used historically in the open pits. No evidence was found of water quality effects from residual ammonia or nitrate.

3) **Wolverine Creek**: Wolverine Creek flows across the toe of the tailings pile (north and south lobes), and could receive surface and subsurface runoff from both the tailings and former mill site. All substances assessed exhibited similar concentrations in the upstream reference sample and the other four samples. It is concluded, therefore, that the mill site and tailings deposit do not currently have negative effects on water quality in the watershed.

4) **Porcupine Pit**: The only exceedance of aquatic life water quality guidelines was for sulfate, as previously discussed, and boron (5.3 mg/L compared with a British Columbia Water Quality Guideline of 1.2 mg/L). Boron concentrations in samples farther down Porcupine Creek, however, were all less than the analytical detection limit (< 0.1 mg/L). Other substances elevated in the Porcupine Pit sample relative to all other surface water samples (including those from Porcupine Creek) included antimony, iron, lithium, manganese, molybdenum, nickel, potassium, sodium, and uranium. This is attributed to a combination of dissolution from waste rock in the pit and the further concentration of cations and other metal species through evapotranspiration. Since the water characteristics (i.e. ion concentrations) in the pit are very different from Porcupine Creek, which emerges from an area of subterranean flow from beneath Porcupine Waste Dump adjacent to the Porcupine Pit (Drawing 01), it is likely that standing water in the pit does not have a strong hydrological link with Porcupine Creek.

5) **Porcupine Creek**: Samples PP-03-01 to 03 exhibited arsenic in excess of the CCME water quality guideline for freshwater life protection. This is further discussed below. No other samples exceeded the arsenic water quality guideline. Porcupine Creek samples also exhibited elevated selenium, attributed to geological source materials in the watershed, possibly augmented by mine disturbance.

6) **Hudgeon Lake:** Surface grab samples from Hudgeon Lake exhibited elevated iron and cadmium, probably due to anoxic bottom conditions. There is a lack of iron and cadmium elevation in the sample from the creek draining into Hudgeon Lake from the north (sample HL-03-03)

7) **Clinton Creek:** The influence of elevated cadmium and iron in Hudgeon Lake surface waters on Clinton Creek is spatially limited to upstream from Forty Mile River. There was no evidence of impacted water quality in Forty Mile River.

The water sample results provide additional insights into the influence of local geological conditions on the concentrations of various elements in the Clinton Creek catchment, including the Porcupine Creek and Wolverine Creek tributaries. The results suggest that neither nickel nor chromium are liberated to the water under alkaline conditions. This is consistent with observations elsewhere of metal leachability from serpentinite or other asbestos bearing materials.

The water quality of the assessed substances, with the exception of chrysotile asbestos fibres and sediment, in the Wolverine Creek drainage (and subsequently in Clinton Creek or Forty Mile River) is not affected by the tailings pile and mill site drainage. The upstream reference sample has a similar water chemistry to samples collected adjacent to, or downstream from, the two lobes of the tailings deposit.

The Porcupine Creek drainage just upstream from where it enters Clinton Creek has elevated levels of arsenic and sulfate relative to the other sampling locations. The obvious source of these is the local geological conditions, although the extent to which the pit and waste rock exacerbate dissolution and release from the geological source material cannot be determined since upstream reference samples could not be obtained in the time available. Regardless, dilution of the Porcupine Creek inflow once it joins the Clinton Creek flows results in arsenic concentrations lower than water quality guidelines for the protection of aquatic life.

The single Porcupine Pit sample collected revealed elevated levels of antimony, boron, and a large number of other cations or other metal species. This sample has a different composition than the Porcupine Creek samples, so there is likely some unique geochemical processes (or concentration of substances as a result of evapotranspiration) occurring in the water ponded in the pit relative to the larger watershed. Elevated boron and antimony levels within the Porcupine Pit have not obviously influenced water quality in Clinton Creek, however.

Probably the most important finding is the elevated cadmium and iron in surface water samples from Hudgeon Lake, with an associated elevation of cadmium in the upper reaches of Clinton Creek, and elevation of iron in the water downstream as far as the confluence with the Forty Mile River. The elevated iron is very likely associated with the severely anoxic conditions in the impounded lake. Sulfate levels were lowest in samples from Hudgeon Lake, something that would be expected based on depletion by sulfate-reducing bacteria (SRBs) using the organic debris especially near the bottom of the lake. Enhanced sulfate reductions and anoxic conditions are well known to be accompanied by dissolution of iron oxyhydroxides from sediments into the surrounding water. Since iron and managanese oxyhydroxides are important adsorptive phases for various other cationic substances, their dissolution is typically accompanied by the solubilization of other metals, including cadmium.

The overall interpretation for cadmium is less clear, however, since the Eagle Creek sample chosen as a reference sample from an unaffected tributary, had a similar cadmium concentration to the Hudgeon Lake and upper Clinton Creek samples. Although the analytical detection limits for cadmium for some samples were too high to draw any firm conclusions, the presence of cadmium in Eagle Creek suggests naturally elevated concentrations. All cadmium results were lower than the Canadian drinking water guidelines of 0.005 mg/L, so it is concluded that there are no human health risks associated with cadmium in surface waters from the Clinton Creek watershed.

4.2 ROLE OF DIFFERENT MINERALS IN METAL / METALLOID RELEASE TO SURFACE WATERS

The leachability of different minerals/waste materials at the Clinton Creek Mine site was evaluated based on collection of representative samples by Hugh Copland (Government of Yukon). Seven samples were examined, as follows:

CC 03-01: Quartz-carbonate altered serpentinite (gabion basket fill) including fines, collected from the first gabion drop structure at the Hudgeon Lake outlet;

CC 03-02: Black argillite fill material, collected from creek channel between Hudgeon Lake and the first gabion drop structure;

CC 03-03: Quartz-carbonate altered serpentinite; coarse material only, collected from the first gabion drop structure at the Hudgeon Lake outlet;

CC 03-04: Quartz-carbonate altered serpentinite; fines only, collected from 75 mm down gravel fill stockpile near Hudgeon Lake;

CC 03-05: Quartz-carbonate altered serpentinite; coarse only, collected from gabion fill stockpile near Hudgeon Lake;

CC 03-06: Black argillite, collected from waste dump near Hudgeon Lake outlet; and

CC 03-07: Tailings sample from upper area of south tailings lobe.

These samples were analyzed for 36 elements by digestion followed by ICP-MS, leachability based on the modified Special Waste Extraction Procedure (SWEP), and acid-base accounting (ABA) analysis. The ICP metal/metalloid results for the bulk samples, indicative of total concentrations including leachable and non-leachable components, are provided in Table C-3. The Special Waste Extraction Procedure (SWEP) is designed to assess mobilization into water under conditions similar to or worse than might be encountered in the environment (based on pH). The results of the SWEP analyses for the same seven samples are provided in Table C-4.

The quartz-carbonate altered serpentinite exhibits naturally elevated levels of arsenic, antimony, barium, boron, chromium, cobalt, mercury, nickel, and magnesium. This is expected for serpentinite minerals. The tailings sample had a similar composition. Cadmium was not detected in the serpentinite samples, but was detected in the two samples of argillite. The one tailings sample had a very high concentration of boron relative to the other samples. Overall, the SWEP results confirm that the Clinton Creek waste rock materials (i.e. argillite) have very limited leachability. Serpentinite soils exhibited a higher concentration of leachable arsenic and antimony than argillite samples. Cadmium was not leached from either the argillite or serpentinite samples under the extraction conditions used. This further suggests that the cadmium in Hudgeon Lake surface waters is released from argillite-type minerals, but only under reduced conditions. The SWEP test does not simulate potential for mobilization under strongly reduced conditions.

The results of acid-base-accounting (ABA) trials indicate that the host rock (i.e. serpentinite) and waste rock (i.e. argillite) contains only small amounts of sulfide minerals (related to acid generating potential) and sulfate relative to the large neutralization potential (Table C-5). As expected, there is no potential for acidic rock drainage from the argillite material forming the waste rock dumps.

The screening level risk assessment (SLRA) conducted for Clinton Creek (SENES 2003) as part of site ranking under the Federal Contaminated Sites Accelerated Action Program identified possible ecological risks at the site owing to elevated metal concentrations in surficial soils and sediments. The preceding evaluation, however, suggests that metals would not be leachable, and therefore would not be bioavailable to aquatic life with a few key exceptions:

- The sample results indicate that cadmium and iron may be dissolved and enter Hudgeon Lake surface waters, and then Clinton Creek, at concentrations of concern as a result of reductive dissolution from bottom sediments. A possible mineral source of the cadmium is argillite.

- Arsenic was mobilized from some of the quartz carbonate altered serpentinite samples during the SWEP test. Arsenic was also observed at concentrations above CCME water quality guidelines for freshwater life protection in three water samples from the lower Porcupine Creek (PC-03-01 to 03). There remains the possibility that the open pit and waste rock areas, therefore, could enhance arsenic inputs into the watershed in addition to that associated with natural geological conditions in the area. It should be noted, however, that arsenic concentrations in samples from Clinton Creek and Forty Mile River were lower than the guideline for freshwater aquatic life protection.

- The Clinton Creek watershed exhibits high levels of sulfate in water in comparison with many other natural water courses. However, the sulfate is attributed to natural mineralization and it is assumed that the freshwater organisms in the watershed have adapted to such conditions. Sulfate levels were higher in water samples from the lower Porcupine Creek (PC-03-01 to 03), indicating enhanced leaching from waste rock in the Porcupine Pit area; however, dilution of Porcupine Creek by Clinton Creek results in no evident elevation of sulfate levels in Clinton Creek beyond the estimated background concentrations.

5.0 AIR SAMPLING PROGRAM

Eight air samples were collected during the first stage of the site investigation work. These samples were submitted to Enviro-Test Laboratories in Edmonton, Alberta to determine the concentration of asbestos fibres. An additional eight air samples and six soil samples were collected during the second stage of the investigation and were submitted for testing at Chatfield Technical Consulting Limited in Mississauga, Ontario.

The test results from the air samples collected indicate that exposure to asbestos fibres is likely to occur during any activity in areas of the mine site where the ground surface is covered with asbestos. Although airborne fibre levels measured indicate concentrations that are below the Yukon 8-hour permissible exposure limit of 0.5 fibres/ml, it is expected that exposures would be higher than those measured to date during construction, demolition or certain types of recreational activity, particularly under dry site conditions. A comprehensive air monitoring report, including lab test results, is included in Appendix D.

6.0 SCREENING LEVEL (Preliminary Quantitative) SITE SPECIFIC RISK ASSESSMENT

A Screening Level Risk Assessment (SLRA) was conducted by SENES Consultants Ltd. (2003) for INAC under the framework of the Federal Contaminated Sites Accelerated Action Program (FCSAAP). This involved a preliminary quantitative evaluation of human health risks at the mine site from exposure to metals, airborne asbestos fibres, or physicals hazards.

The report (SENES 2003) included the following elements, albeit at a desktop/screening level:

- Receptor characterization;
- Exposure assessment;
- Hazard assessment; and
- Risk characterization.

The total measured concentrations of metals/metalloids in surface waters, soil, or creek sediment were used in the assessment, based on 1998 field data (RRU 1999). In addition, the assessment was based on airborne concentrations of asbestos fibres, measured in 2003, using small "personal air sampler" filter units (Section 5.0).

The SLRA considered possible negative implications for human health assuming that children and adults might be exposed to contaminants of concern at the site for up to twelve months of the year. Exposure pathways that might result in human health risks include inhalation of airborne asbestos fibres, or the ingestion/internalization of metals/metalloids through incidental soil ingestion or fugitive dust inhalation, dermal exposure, or consumption of local drinking water, fish and wild game. The extent of exposure was assumed using the available estimates for drinking water consumption, inhalation rates and body weight for the general Canadian population. Assumptions about diet – for example, consumption rates for fish, animals and birds - were obtained from a food survey for indigenous populations in the Northwest Territories.

The screening level human health risk assessment was conducted using assumptions that result in an over-estimate of contaminant exposure. As noted above, it was assumed that humans were exposed based on obtaining food and water from the site all year round; however, soil ingestion and dermal contact with exposed soil were limited to the summer months (about three to four months per year) owing to the presence of snow cover for much of the year.

The estimated exposures (or intakes) by the human receptors were compared to intake levels considered to be protective of human health (i.e. reference doses). A ratio of the estimated exposure divided by the protective threshold for exposure is referred to as the "Hazard Quotient" (HQ). If the hazard quotient for a screening level risk assessment exceeds 0.2, then possible risks to humans should not be ruled out without further, more detailed evaluations. For potentially carcinogenic substances, evidence that exposures at the site can result in an increased (incremental) cancer incidence in the population that is greater than 1 additional cancer case in a population of 100,000 individuals is taken to mean that risk management strategies should be implemented to reduce the risks or more detailed evaluation of the risks is required in order to provide more realistic risk estimates.

Hazard quotients and estimated cancer risks developed in the SLRA are reproduced here, in Tables 6-1 and 6-2. Values in bold are those exceeding the designated levels for this site (0.2 for the HQ, and 1 x 10^{-5} for the incremental cancer risk level).

Hazard quotients for antimony, barium, chromium, and nickel (Table 6-1) suggested a need for risk management and/or more detailed analysis. Note that in Section 4.0, it is concluded that metals/metalloids are not readily mobilized from the host rock that occurs in the area, mine wastes, or associated soils/sediments into water. This would limit the extent of uptake into humans from some of the exposure pathways relative to the simplistic assumptions used for the SLRA. Chromium and nickel that are tightly bound in minerals for example, have very little potential for entering water courses, or for being taken up into plants. We do not know, however, the extent to which metals might be digested and internalized into humans if soil samples were ingested and subjected to the higher acidity conditions of the human stomach.

Asbestos inhalation; inhalation of particles containing chromium; and the inhalation, ingestion or dermal uptake of arsenic might cause cancer in humans if it occurs at excessive levels. Preliminary quantitative estimates of the cancer risks (Table 6-2) suggested possible issues with asbestos inhalation and arsenic exposures. In several cases, near worst-case assumptions about human exposures resulted in a calculated incremental cancer risk of greater than 1 x 10^{-5} (greater than 1 additional case in a population of 100,000).

Table 6-1) Calculated Hazard Quotient Values

Contaminant	**Hazard Quotient**	
	Adult	**Child**
Aluminum	0.1	0.2
Antimony	**1.5**	**2.4**
Barium	**1.0**	**1.6**
Chromium	**2.5**	**4.3**
Cobalt	0.04	0.07
Lead	**0.5**	**0.9**
Manganese	**0.8**	**1.2**
Molybdenum	0.2	0.2
Nickel	**1.9**	**2.9**

Table 6-2) Calculated Risks of Carcinogenic Effects

Contaminant	**Risk Level**	
	Adult	**Composite**
Arsenic	**2.6 x 10^{-2}**	**6.6 x 10^{-2}**
Asbestos	**4.5 x 10^{-3}**	**8.9 x 10^{-3}**
Chromium	4.3 x 10^{-6}	**1.2 x 10^{-5}**
Cobalt	9.4 x 10^{-8}	2.5 x 10^{-7}
Nickel	1.8 x 10^{-7}	4.8 x 10^{-7}

The assumptions and estimates used resulted in a prediction that the main source of contaminants other than asbestos to humans, and the main driver of potential risks, was through the consumption of fish. Again, this may not be reasonable, since the metals/metalloids have very limited potential to leach into the Clinton Creek, Forty Mile River watershed. In addition, arsenic in fish tissues is often found primarily in a form of organoarsenic, which is different from the form that is suspected to be carcinogenic. Complex organoarsenic compounds tend to be non-carcinogen and have only low toxicity based on other types of responses.

For asbestos, the air pathway and fibre inhalation was the only exposure route considered. The weight of scientific evidence indicates that there are no direct cancer risks to humans from skin exposure to chrysotile asbestos fibres or through the ingestion of food and water.

Whereas any conclusions about possible human health risks from metals/metalloids are strongly dependent on various assumptions about the extent of human exposures and contaminant viability, imminent physical hazards at the site provide a much more clear-cut case of possible human health risks. There are a number of major physical features at the Clinton Creek Mine site that pose potential risks to people and the environment. Some of these include unstable waste rock dumps, tailings pile and high open pit walls, partially demolished structures and other mine equipment.

For physical hazards, a preliminary semi-quantitative prediction of fatality rates for the Clinton Creek mine site was developed by combining an average annual fatality rate (based on United States statistics for abandoned mine sites) with an accessibility factor (which determines how accessible the site is), a hazard factor (which rates the hazards on the site) and a scaling factor (which accounts for the scale (size) of the mining operation). For the Clinton Creek site the annual fatality rate was estimated to equal 5.4×10^{-6}.

The metrics of the calculation are probably more useful than the actual estimated rate itself. For example, an increase in site access by people would directly increase the estimated fatality risk. The greater the degree of physical instability of structures, the greater the fatality risks. Activities that limit access and/or stabilize or remove physical hazards, therefore, will reduce fatality risks.

7.0 REVIEW OF ASBESTOS MINE SITE RECLAMATION PRACTICES

A review of the status of mine site reclamation at abandoned asbestos mines around the world, with a focus on mine sites where chrysotile asbestos has been extracted from serpentine ore, has been completed. The full report is provided in Appendix E. Depending on the location and site conditions, residual chrysotile asbestos fibres in surficial materials (soils at the former mill site or surrounding areas, tailings material, mined areas, waste rock piles, access routes) could pose a risk to human health based on mobilization to air followed by inhalation.

For the hundreds of asbestos mine sites developed and then abandoned in the 1970s through 1990s, the potential for residual health and environmental issues merits closer examination, especially in the countries that were major producers of the world's chrysotile asbestos supply; i.e. Canada, China, Russia, South Africa, and Zimbabwe. Ongoing concerns about soils contaminated with asbestos are not limited to these countries, however, and limited consideration has been given to future human health risks associated with abandoned asbestos mines in the United States, Australia, India, China, Portugal, Turkey, Brazil, Finland, Cyprus, Swaziland and elsewhere. Within Canada, major asbestos mines were located in the Yukon (Clinton Creek – 1968 to 1978), British Columbia (Cassiar Asbestos Mine), Quebec (especially the Thetford and Jeffrey mines) and Newfoundland (Baie Verte Asbestos Mine -1955 to 1981, 1982 to 1990).

Closed asbestos mines present many of the reclamation concerns that arise at other mines sites. These include physical hazards such as possible pit wall collapse, unstable waste rock piles and tailings deposits, air and water erosion, unsafe buildings and structures. Asbestos waste is chemically stable and does not produce acidic drainage or leach material levels of metals. The primary issues for closure, therefore, are control of exposure to asbestos and management of physical hazards.

The vast majority of chrysotile asbestos mines worldwide have not been adequately reclaimed, either from the perspective of establishing sustained plant community growth or for minimizing human health risks from soil-borne asbestos fibres. Two notable exceptions are the Atlas and Coalinga mines in California that have been reclaimed largely in consideration of concerns about mobilization of chrysotile asbestos fibres from the affected watersheds into the drinking water supply for the City of Los Angeles. Much of the reclamation effort, therefore, was aimed at re-directing surface water flows and curtailing soil erosion. Some effort was directed to limiting more direct (airborne) human exposures, primarily by exclusion of humans from critical areas. There is very little documentation on re-vegetation success: Limited accounts suggest that the re-establishment of vegetation has been successful for soils that were predominantly sand, fine rock and clays (e.g. in ore extraction areas) but much less so in tailings material. The now abandoned vermiculate mine, a source of amphibole asbestos fibres, in Libby, Montana, as well as the associated town site has attracted massive public attention over the last half decade. It has been declared a superfund site. Massive efforts are underway to reduce human health risks at the site, through large scale soil removal and capping efforts.

Many of the asbestos mine sites have yet to be seriously considered for reclamation/restoration work, since the sites have not been formally abandoned, pending the possible rebound in the global market for chrysotile asbestos fibre. This is the case for the British Columbia Cassiar Asbestos Mine. The basic regulatory requirements for reclamation at the Cassiar Asbestos Mine are similar to any other active mine in British Columbia, however, and reclamation activities will likely include re-contouring as well as the capping of bedrock and tailings with 0.5 m of overburden of suitable quality for the establishment of vegetative communities.

Tailings material from abandoned chrysotile asbestos mines may be a viable source of magnesium (typically 12 to 30% of the dry weight of chrysotile asbestos tailings), and a re-extraction operation has commenced at one of the major Quebec mine sites. The economic viability of magnesium extraction from tailings, however, depends on the availability of a cheap source of power. Magnesium extraction through smelting technologies requires consideration of environmental issues common to some other smelting processes, such as aluminum smelting. Finally, some consideration has been given to the use of chrysotile asbestos tailings to sequester atmospheric CO_2, a greenhouse gas. Overall, business speculations about future economic opportunities at abandoned and non-operating chrysotile asbestos mine sites need to be carefully considered as a possible hindrance to environmental risk reduction and restoration initiatives.

The scientific literature provides many studies on types of plants that can adapt to growth on undisturbed or disturbed, metal-rich and alkaline serpentine soils. Serpentine soils contain very low levels of plant nutrients such as nitrogen, phosphorous and potassium relative to many other soil types. This knowledge is of direct relevance for restoration of plant communities in mineral extraction areas, waste rock areas, abandoned mill sites or town sites, and road works. Limited information could be found on the potential for revegetation of tailings deposits, including reference to poor vegetation establishment at the Coalinga mine site, California. A limited revegetation trial in 1985 at the Clinton Creek tailings area has been carried out, but the documentation of this could not be located. A trial of asbestos mine-tailings re-vegetation undertaken in Quebec in the 1970s underscores the technical and financial challenges associated with re-vegetation of serpentine asbestos tailings deposits.

A few of the abandoned or non-operating chrysotile asbestos mines world-wide (or other sites with high concentrations of asbestos fibres in surface soils) have been evaluated using a detailed human health risk assessment. Many areas have been neglected, however, based on the premise that the sites are remote, and human exposure would therefore be limited.

8.0 RECOMMENDATIONS

8.1 ADDRESSING IDENTIFIED HAZARDS

A total of eighty-six potential mine site hazards were identified and classified based on the severity of the potential outcome due to exposure to that hazard. Of these, 31 have been classified as negligible, with no action required (Table 2). Of the remaining 55 potential hazards, 10 were not classified, 18 were classified as low, 9 as moderate and 18 as high (Table 1). The 10 hazards not classified at this time are hazards related to the presence of asbestos fibres for which the risks and consequences can not be properly evaluated until a detailed HHRA is completed (Section 8.2). It is recommended that measures be taken to either remove the hazards or reduce the risks associated with all low to high hazards. The majority of the hazards cannot be addressed without generating airborne asbestos fibres as a result of the construction activities. Most of the hazard mitigation work will require the implementation of a Health and Safety and Emergency Response Program and air monitoring at the work site(s). A Health and Safety and Emergency Response Program was prepared by SENES Consultants Ltd., based on previous programs for the channel stabilization work at the mine site but with focus on the protection of workers from asbestos fibres. This plan is included in Appendix G. The air monitoring program to be implemented during hazard mitigation activities is described in Section 8.3.1

Since it may not be possible to address all of the identified hazards in a single construction season, the hazards with the highest classification should be addressed first although hazards associated with the presence of asbestos fibres, in particular, will have to wait until a human health risk assessment (HHRA) is completed in 2004. The risk level associated with asbestos fibres needs to be evaluated through the HHRA, including the air monitoring program (Sections 8.2 and 8.3, respectively). If human health risks cannot be ruled out based on the collection of relevant air quality data, then other courses of action might be required. The greatest level of risk assessment effort anticipated to lead to appropriate risk management solutions would be to derive a site-specific remediation guideline for asbestos fibres in soils, which can be used to guide site remediation activities.

It is expected that the materials resulting from demolition can be landfilled on site. However, some materials (i.e. structural steel, copper wiring, tramway components, mining equipment, conveyors) may be salvageable. Liability issues related to salvaged materials need to be considered, particularly for materials contaminated with asbestos (e.g. structural steel in the crusher building). The original manufacturer of the tramway (the Riblet Tramway Company) has indicated on their corporate website (ww.riblet.com) that there is some interest in used tramway parts.

It is recommended that demolition of the crusher building (Hazard #82) be considered a high priority for 2004. A proposed landfill, located about 250 m north of the crusher building as shown on Drawing F-1 in Appendix F should be suitable for all non-hazardous debris. Other non-hazardous demolition waste, including asbestos, could likely be co-located in the landfill. In this regard, it may be preferred to demolish the ANFO storage facility (Hazard #66) at the same time as the crusher building. Cover material can be obtained from the immediate area or from the waste rock dump to the west. The need for a synthetic liner will be evaluated before construction.

While work is being conducted at the crusher building other hazards that should be addressed in 2004 include but are not limited to:

- Covering exposed asbestos west of the crusher building (Hazard #80);
- Blocking access to the Snowshoe Pit (Hazard # 77, 78);
- Demolishing and landfilling the steel frame and wooden building located in the Creek Pit (Hazard # 83 and 84);
- Removing ladders from tramway towers (Hazard #'s 52 and 54 to 61);
- Removing the ladder from the tram terminus structure (Hazard #48);
- Removing ladders from the storage tanks (Hazards # 24 and 28);
- Installing steel plates over openings to fuel storage tank (Hazard #28);
- Covering entrances to conveyor tunnels (Hazard #22 and 25);
- Placing covers over or backfilling utilidor access points (Hazard #'s 13, 16, 17, 18, 23 and 24);
- Backfilling the pits in the service building floor (Hazard #44); and
- Placing temporary or permanent road blocks on to the waste rock dump after the 2004 construction season (Hazard # 63, 68, 69, 70, 71, 72, 76 and 85).

A strategy to deal with hazards created by the asbestos fibres around the mine site can be developed once the HHRA (Section 8.2) is completed. The Health and Safety plan (Appendix G) developed for the Crusher Building demolition will need to be incorporated into the contracts for this work.

8.2 SITE SPECIFIC HUMAN HEALTH RISK ASSESSMENT

In light of the conclusions of the Screening Level Risk Assessment (SENES 2003 and Section 6.0), it cannot be concluded at the present time that human health risks are acceptably low in the absence of either the implementation risk management strategies or more detailed analysis. Risk management through the reduction of many of the identified physical hazards should be practically achievable, since it is anticipated to be relatively cost-efficient and require a limited level of effort. On the other hand, risk management approaches to reduce inhalation exposures to airborne chrysotile asbestos fibres, or reduce possible exposures to arsenic, antimony, chromium, nickel or other metals/metalloids is expected to be challenging given the scale of areas of concern, including the open pits, waste rock dumps, tailings deposit, and mill site area. The need for further risk management activities such as construction of exclusion barriers, capping with clean soil, soils stabilization, and/or re-vegetation should be evaluated using much more realistic estimates of the actual human health risks from current site conditions.

8.2.1 General

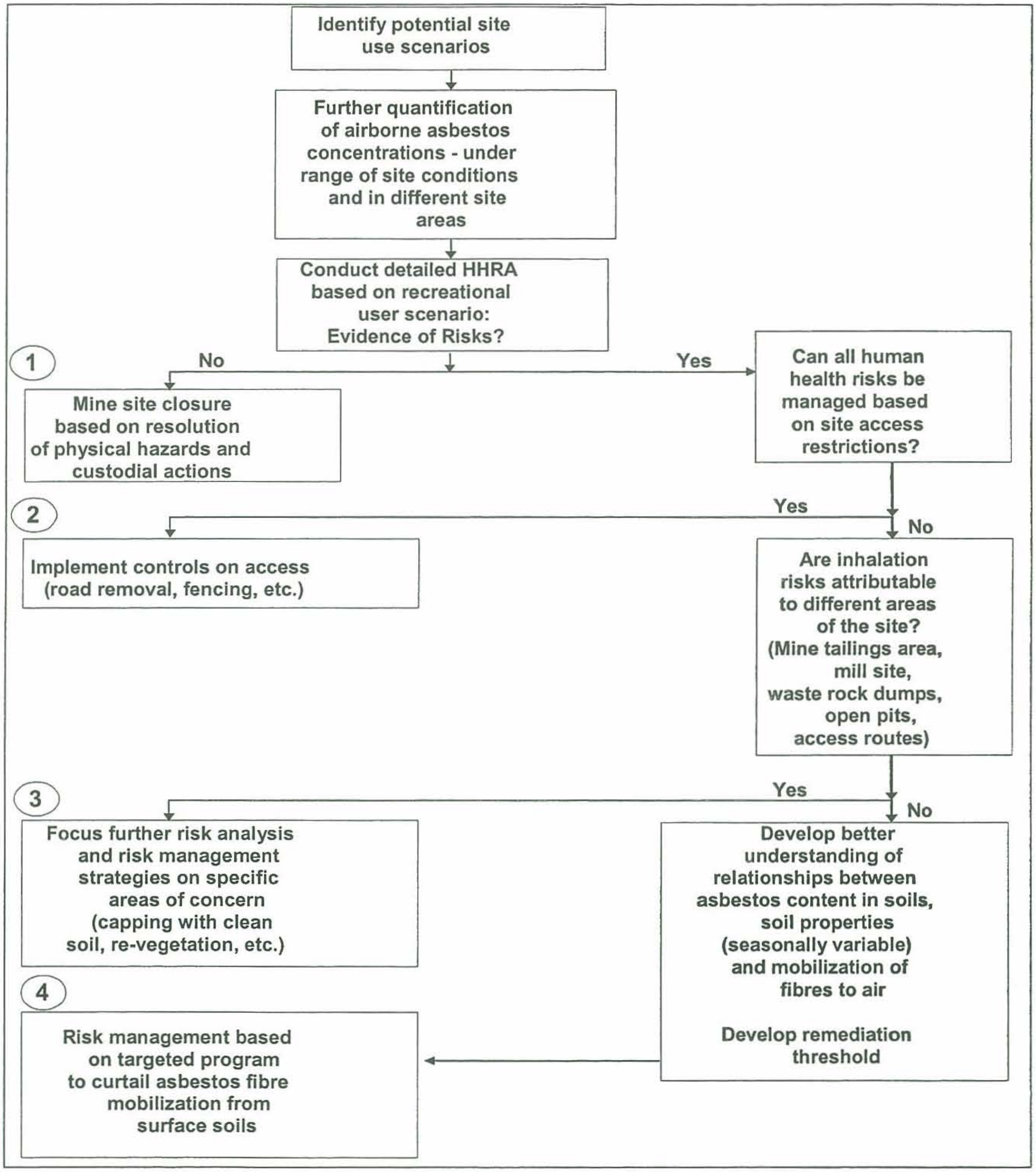
Widespread existence of loose asbestos fibres on the ground, abandoned equipment and structures at the former Clinton Creek asbestos mine are potential sources for airborne contamination. As a part of the overall mine closure plan, actual asbestos inhalation risks from occasional site visits needs to be better evaluated. This can be done with a limited, highly focussed and staged air monitoring program.

It is assumed that potential human health risks, as identified in the SLRA, from contaminants of potential concern other than asbestos can be ruled out based on a critical evaluation of exposure scenarios and evidence for limited bioaccessibility (see below). This would leave the issue of possible mobilization into air of soil-borne asbestos fibres and possible inhalation by humans visiting the site. This risk scenario, in fact is highly similar to those for other abandoned asbestos mines world-wide where a formal environmental risk assessment has been carried out.

8.2.2 Further Evaluation of Risks from Airborne Asbestos

Figure 8-1 provides an approach for focused effort on the additional assessment of human health risks, while maintaining a focus on viable risk management and mine site closure options.

Figure 8-1) HHRA Approach



Four different possible exit points from the human health risk are envisioned. A minimum requirement for any further assessment, however, is better information on airborne asbestos concentrations at the site under a range of conditions, including –

1) Different locations on the mine site, such as:

    - Open pits;
    - Waste rock dumps;
    - Crusher building;
    - Tramway;
    - Former mill site;
    - Tailings area (including Wolverine Creek);
    - Access roads; and
    - River banks and flood plains farther down Clinton Creek, Forty Mile River and the Yukon river, where asbestos-containing water has left fibres after the fall of water levels in a form that may be amenable to airborne distribution after the dessication of sediments.

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2) Under different meteorological and climatic conditions, especially during periods in which soils are dry.

3) Based on different levels of disturbance, as associated with:

    - Ambient conditions;
    - Walking across the mine site;
    - Camping at the mine site; and
    - Vehicular traffic, including use of All Terrain Vehicles (ATVs).

If sufficient data for the range of scenarios covered above (or for some other worst case scenario) suggest that risks of mesenthelioma or other asbestos-type human health risks are *de minimus*, then this has a direct bearing on the decisions that might be made by site managers with regard to site remediation, reclamation and closure.

If, on the other hand, human health risks cannot be ruled out based on the collection of relevant air quality data, then other courses of action might be required. The greatest level of risk assessment effort anticipated to lead to appropriate risk management solutions would be to derive a site-specific remediation guideline for asbestos fibres in soils, which can be used to guide site remediation activities.

8.2.3 Linking Airborne Asbestos and Soil Fibre Concentrations

Air modelling of dust generation might be used in support of carrying out the calculation of asbestos concentrations in soil beyond which risks of mesenthelioma increase. Note that this approach is confounded by the fact that different activities might result in different potential for mobilization into air. Use of ATVs on the site, for example, would be expected to create very different airborne exposure conditions than walking across an area of asbestos-contaminated soil.

The following models are available and can be used depending on site specific measured data for soil and air concentrations. Adjustment to the models can be made to enhance the estimates and to reduce the uncertainty associated with the model results.

- The Copeland model described in Compilation of Air Pollution Emission Factors (US EPA, 1985).
- The model described by Horie et al., 1992 in a California Air Resources Board Final Report.

In addition to this, it may be appropriate to develop site-specific correlational models, relating airborne asbestos fibre concentrations to a number of independent variables, including area of concern (see above), chrysotile asbestos fibre content, soil texture, soil moisture, soil compaction, and percent vegetative cover.

8.2.4 Human Health Risks from Contaminants Other than Asbestos

The Screening Level Risk Assessment identified possible risks associated with human exposures to several metals/metalloids which occur at naturally high levels in serpentinite and/or argillite minerals in the Clinton Creek area. A detailed risk assessment is needed to critically evaluate the dependence of risk calculations on various assumptions, and to confirm the most important possible exposure pathway for each contaminant of potential concern.

Soil ingestion and fugitive dust inhalation might be important pathways for some metals (e.g. chromium), and there are merits in evaluating these through an air quality sampling program similar to that proposed for the examination of chrysotile asbestos fibres in air at different areas of the Clinton Creek mine site, and during different weather conditions. For arsenic, it is possible to assess the "bioaccessibilty" once soil particles have been ingested, and based on conditions that simulate the human digestive tract; i.e. based on the use of a Physiological Based Extraction Test. The degree to which the arsenic or other elements are bioaccessible determines the extent to which they might become internalized and contribute to contaminant risks in humans.

8.3 MONITORING

8.3.1 Air Monitoring

An air monitoring program is recommended for the 2004 season in order to provide data to supplement the results obtained from air sampling completed by SENES Consultants Limited in September 2003 and by UMA Engineering Ltd. in September 2002 and August 2003 (Section 5.0). The purpose of the recommended air sampling program is to:

- Provide data (ambient levels of asbestos fibres) to be used in the recommended detailed human health risk assessment (Section 8.2);
- Establish ambient levels of airborne asbestos fibres under drier conditions than existed during sampling conducted in September 2003; and
- Assess worker exposures during construction/demolition (i.e. hazard mitigation) activities in order to evaluate the level of respiratory protection equipment and the efficiency of the dust and fibre control measures.

Samples collected to determine ambient levels of asbestos fibres should be analyzed by Transmission Electron Microscopy (TEM) and also by Phase Contrast Microscopy (PCM), as was done previously. The major differences between the PCM and TEM methods are that PCM does not differentiate between asbestos and non-asbestos fibres, and thin fibres (i.e., less than about 0.25 micrometers in diameter) are not detected by PCM. The TEM method allows for differentiation of asbestos from non-asbestos fibres and fibres of all diameters can be detected. Occupational exposure limits for asbestos and most epidemiology studies are based on the use of data analyzed using PCM methodology.

Ambient air samples should be collected at the same locations where samples were collected previously and should be extended to include Wolverine Creek and other areas of the mine site such as the open pits and other areas of the waste rock dumps. Airborne asbestos concentrations at property boundaries and at locations where members of the general public may be expected to spend time or the locations where mine site access to the public may be blocked, would also be important. Due to the cost of TEM analysis ($400 per sample versus $35 for PCM), it is recommended that PCM analyses be utilized for the majority of the samples. However, to provide correlation between the TEM and PCM analyses, it is recommended that at least 24 samples be collected, during four separate sampling events, and analyzed using both the PCM and TEM methods.

A minimum of ten soil samples should be collected, one from each air sampling location and some from other representative areas of the mine site. The samples should be anlayzed using polarized light microscopy (PLM) at a cost of about $35 per sample. These results may help to evaluate possible correlations between air and soil asbestos concentrations.

During hazard mitigation activities, air sampling to determine worker exposure should be performed using the PCM method. Both "area" and "personal" samples should be collected. "Area" samples are collected by locating an air sampling device in one location for the duration of the sampling period. "Personal" samples are collected whereby the sampling pump and filter are worn by a worker during the course of work activities. As a minimum, one area and one personal sample should be collected each day at the work site. In addition, two or three area samples should be collected within a 500 m radius of the work site to detect airborne asbestos away from the restricted work area. Baseline readings should be collected before and after the hazard mitigation activities.

TEM analysis has to be undertaken at a qualified laboratory. Chatfield Technical Consulting Limited in Mississauga performed the TEM analysis for the samples collected in September 2003 (Section 5.0). PCM analysis can also be performed by a qualified laboratory, however, for determination of worker exposures during hazard mitigation activities, it would be preferable to have quicker turnaround times for the results. This could be achieved by having a trained analyst equipped with a phase contrast microscope on site. Samples could then be analyzed on the same day that they are collected. (Note: the analyst could be the same person who collects the air samples and provides a site inspection/health and safety function during the hazard mitigation work.)

Another air monitoring option is the use of a direct-reading instrument known as a Fibrous Aerosol Monitor (FAM). These instruments are designed and calibrated to measure airborne fibres of the same length and diameter as PCM. The advantage of the FAM is the direct measurement capability. The disadvantages are significant, however, and include cost (purchase price of a new unit is approximately $35,000) and sensitivity of the equipment. Experience has shown that the devices are easily knocked out of calibration and because they require factory calibration, they are not recommended for this application.

8.3.2 Meteorological Station

Use and interpretation of ambient air concentrations of asbestos requires reliable meteorological data (wind speed and direction and precipitation). The closest station to the Clinton Creek site is the Dawson City Airport meteorological station, about 100 km away. Given the mountainous nature of terrain, the data from Dawson City Airport can not be used for the mine site. Therefore, site specific meteorological data is required. This can be accomplished by purchasing or renting a meteorological station. A quote of $15,000 was provided by Campbell Scientific for the purchase of a solar powered meteorological station that would record wind speed and direction, temperature, humidity, barometric pressure and rainfall. The quote is provided in Appendix H. This does not include any setup expenses such as testing to ensure proper operation. Meteorological stations can be rented for about $1,000 for a 4 month period but the rental firms typically require that their personnel install the station. Zephyr North in Burlington, Ontario provided the rental quote.

8.3.3 Waste Rock Dump and Tailings Pile Monitoring

One monitoring survey event of the tailings and waste rock monitors should be conducted in the summer of 2004 after which a monitoring report should be prepared. Recommendations for continued monitoring will be provided at that time. Movement monitoring is required to assess the current movement rates of the Clinton Creek waste rock dump and the tailings pile. If creep movements of the waste rock dump continue, stabilization measures may be required to maintain the serviceability of the gabion drop structures at the Hudgeon Lake Outlet. Measurement of current movement rates of the tailings pile is required to assess the feasibility of various remedial options, if required, for the tailings pile which may include stabilization of the tailings pile and/or creek stabilization, particularly at the toe of the tailings.

Respectfully submitted,

UMA ENGINEERING LTD.

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June 29/04

for Doug Bright, PhD.
Senior Environmental Scientist
Earth & Environmental

PERMIT TO PRACTICE
Signature
Date June 29/04.
PERMIT NUMBER: PP066
Association of Professional Engineers
of Yukon

9.0 REFERENCES

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TABLES

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
OPEN PITS								
63	7,146,393	513,312	458,459	Porcupine Pit	Slope Failure	Recent slide on SE side of pit wall.	moderate	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
68	7,146,438	512,750	486, 499 - 501	Porcupine Pit	Slump Block on West Corner of Pit	Appears recent. Ground has dropped 10 - 15m into open pit.	low	Restrict access to pit. Block access roads as shown on Drawing 01. 2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.
69	7,146,597	512,722	487, 499 - 501	Porcupine Pit	Head Scarp	Head scarp for slump block into NW side of open pit.	low	Restrict access to pit. Block access roads as shown on Drawing 01. 2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.
70	7,146,667	512,747	488, 489, 499 - 501	Porcupine Pit	Head Scarp	Head scarp for slump block into NW side of open pit. Scarp 23m high. Evidence of recent movements. Also multiple slump blocks on waste rock dump side.	low	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
71	7,146,760	512,875	491 - 493, 499 - 501	Porcupine Pit	Head Scarp	Pit wall unstable with recent movement into open pit. Also movement towards waste rock dump.	low	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
72	7,146,772	512,943	494 - 496, 499 - 501	Porcupine Pit	Slope Failure	Head scarp and recent slump blocks with movement into open pit.	low	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
73	7,146,838	513,334	502	Porcupine Pit	Raw asbestos ore	Asbestos fibres on ground over 50 X 50m area.	**TBD**	Restrict access to pit. **2004 air monitor results may reveal need to re-grade area with 300 to 600 mm of cover material such as waste rock. (thickness dependent on potential for erosion)**
74	7,146,354	513,562	503	Creek Pit	Raw asbestos ore	Asbestos fibres behind windrow of boulders. Area about 20 X 20m. Also 20 X 50m area on E side of boulders.	**TBD**	Restrict access to pit. **2004 air monitor results may reveal need to re-grade area with 300 to 600 mm of cover material such as waste rock. (thickness dependent on potential for erosion)**
76	7,146,553	513,855	504	Creek Pit	Tension Cracks	Evidence of recent slumping and 25mm wide tension cracks.	low	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
85	N/A	N/A	503, 504 598-601, 606, 607, 609	Creek Pit	Open Pit	Pit wall unstable with evidence of recent debris /rock fall on W side near crusher. Area may be used for swimming.	high	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**

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LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
77	7,146,649	513,932	505	Snowshoe Pit	Pit Wall Slide	Start of Slide on S side of open pit. Slumping and tension cracks are visible on benches above slide.	low	Restrict access to pit. Block access roads as shown on Drawing 01. **2004: Temporarily block access until mine closure works are complete, then provide permanent blockage.**
78	7,146,757	514,128	507	Snowshoe Pit	Raw asbestos ore	Thick layer of asbestos fibre on flat area above main pit.	TBD	Restrict access to pit. 2004 air monitor results may reveal need to re-grade area with 300 to 600 mm of cover material such as waste rock. (thickness dependent on potential for erosion)
TAILINGS PILE AND WOLVERINE CREEK								
1	7,148,416	513,191	391, 392	Tailings Pile (near Mill Site)	Partially Buried Debris	Metal debris: Drums, structural steel, boiler, bicycle frame, hot water tank, tires, wire, milled asbestos samples	TBD	
	n/a	n/a	402 to 448 516 to 520 684 to 691	Tailings Pile & Wolverine Creek	Asbestos: Tailings pile and deposits in Wolverine Creek.	Potential for generation of fugitive asbestos dust and exposure to site users on tailings pile and along Wolverine creek.	TBD	**2004: Assess stability of tailings pile movement. Air monitoring program to determine levels of fugitive asbestos dust.** Cover asbestos and stabilize channel in outwash area at mine access road.
CRUSHER BUILDING								
80	7,146,727	543,550	586 - 588	Crusher Bldg.	Tension Cracks and Asbestos Fibres	Tension cracks in area 50m west of crusher building. Evidence of settling, slope movement. 200mm thick layer of asbestos fibres covering the area.	TBD	Asbestos fibres are main hazard. **2004: Push asbestos into adjacent pit, cover with waste rock and flatten slope to 3H:1V slope. Complete work during crusher building demolition.**
82	N/A	N/A	506, 555 - 562, 565 - 567, 569 - 574, 577 - 579, 594 603 - 605	Crusher Bldg.	Crusher Building / Tramway (Towers #1 and #2)	Crusher Building. Warped structural elements (beams from fire inside ore bucket maintenance area). Unsecured sheet metal siding, numerous climbing/fall hazards, significant mounds of asbestos in and around building. Loosely hanging ore buckets. Tram Tower #1 in-place. Tram tower #2 removed.	high	**2004: Demolish structure including tram line tower and equipment. Landfill all asbestos fibres and structural materials. Salvage may be an option for some materials if they can be cleaned of asbestos.**
TRAMWAY								
61	N/A	N/A	538 - 546, 553	Tramway	Tram Tower	Tram Tower #3: Large concrete structure for first tram tower on north side of Clinton creek. Large mound of asbestos ore 5m deep over 20m x 20m area on south side of structure. Ladder rungs on north side of structure accessing superstructure.	moderate	Cover asbestos at base of tower. **2004: Remove ladder rungs, protruding steel re-bar, cable guide frame.**
60	7,147,470	513,450	535 - 537	Tramway	Tram Tower	Tram Tower #4. Erosion of soil around W side of concrete base. 0.5m layer of asbestos fibres for 30m S of tower. Ladder accessing timber platform.	moderate	**2004: remove timber deck and ladder.**

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LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates Northing (m)	UTM Co-ordinates Easting (m)	CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
59	7,147,526	513,436	534	Tramway	Tram Tower	Tram Tower #5. Asbestos fibres in area. Ladder accessing timber platform. Wood pole laying down beside tower.	moderate	**2004: remove timber deck and ladder.**
58	7,147,731	513,368	532, 533	Tramway	Tram Tower	Tram Tower #6. Asbestos fibres in area. Ladder accessing timber platform. Minor concrete deterioration. Tower adjacent to mill road.	high	**2004: remove timber deck and ladder.**
57	7,147,737	513,363	530, 531	Tramway	Tram Tower	Tram Tower #7. Mound of asbestos fibres between tower and road. Ladder accessing timber platform.	high	Cover asbestos at base of tower. 2004: remove timber deck and ladder.
56	7,147,775	513,356	529	Tramway	Tram Tower	Tram Tower #8. 300mm of asbestos fibres on S side of tower. Wood pole laying down beside tower. Ladder accessing timber platform.	high	Cover asbestos at base of tower. **2004: remove timber deck and ladder.**
55	7,147,836	513,320	528	Tramway	Tram Tower	Tram Tower #9. Tram cable on ground. Asbestos fibres: 75mm layer, 2m wide, 10m long S of tower. More fibre between Tower 9 and 8. Wood pole laying down beside tower. Ladder accessing timber platform.	high	Cover asbestos at base of tower. **2004: remove timber deck and ladder.**
54	7,147,886	513,317	525 - 527	Tramway	Tram Tower	Tram Tower #10. Power cable and tram cable on ground. Wood pole laying down beside tower. Asbestos fibre on ground around tower. Ladder accessing timber platform.	high	Cover asbestos at base of tower. **2004: remove timber deck and ladder.**
62	7,147,994	513,287	580 - 582	Tramway (Mill Area)	Tram Tower	Tram Tower #11. Pipe supports cut 150mm above concrete pad. Asbestos fibres in immediate area.	low	Cut pipe flush with concrete, backfill around concrete base and fill in tower pipe holes. Cover asbestos fibres.
52	7,148,067	513,261	521 - 523	Tramway (Mill Area)	Tram Tower	Tram Tower #12 partially buried in 50mm mill overs.	high	**2004: Remove timber deck, cable guide frame and ladder.**
48	7,148,282	513,197	396 - 401	Tramway (Mill Area)	Tram Terminus Structure	Surface debris scattered in area with significant tailings and asbestos. Building in poor condition and contains corrugated asbestos board, steel debris and tram drive transmission and brake. Roof heavily covered with asbestos dust. Hydrocarbon staining on floor. Ladder access to top of steel structure.	high	Demolish building and steel tram structure. Steel tram structure may be ok too leave as long as strucutral members are not loose. May be able to salvage steel and/or tram drive/brake. **2004: Cut off ladder.**

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
					MILL AREA			
13	7,147,978	513,041	326, 327	Mill Area (Utilidor)	Former office building - east side, 2 storey concrete structure.	4m X 4m structure, top floor empty, basement contains cast iron pipe, galvanized pipe, duct work and wood debris. 2.3m deep pit in NE corner is open and contains pipes that head through connecting utilidor tunnel towards mill site	high	**2004: Clean up debris on lower floor, backfil pit or bolt steel grate/cover over pit opening.**
16	7,148,026	513,076	330 - 332	Mill Area (Utilidor)	Boiler plate utilidor manhole	1.2m diam., 3.2m deep shaft containing pipe from concrete structure (Photo 329) and tunnel to mill site. 12mm thick plywood cover (not secured). Fibreglass and asbestos pipe insulation.	high	**2004: Backfill manhole or bolt/weld steel grate/cover over manhole.**
17	7,148,068	513,081	333, 334	Mill Area (Utilidor)	Former Service Building: Concrete foundation with utilidor tunnel at SE end.	SW corner of foundation has open pit with tunnel connecting to Feature 16 and smaller shaft to N (also open). Shaft opening is 0.6m x 0.6m and is 3m deep. Smaller shaft has 0.6m x 0.6m opening and is 2.5m deep. Mounded area on outside of corner may be backfill for another shaft. Considerable corrugated asbestos board in area.	high	**2004: Expose pit and backfill.**
18	7,148,104	513,135	335, 336	Mill Area (Utilidor)	Utilidor access structure.	Concrete structure 2.5m x 5m and 1m above grade. Access hatch in corner uncovered with metal rungs to bottom of structure at 3m deep. Asbestos fibres in and around structure.	high	Remove concrete cover and backfill structure. Cover asbestos fibres in surrounding area. **2004: Remove asbestos from top of structure and bolt steel grate/cover over opening.**
23	7,148,144	513,133	347, 348	Mill Area (Utilidor)	Utilidor access structure.	Concrete structure 2.9m x 4.2m and 1m above grade. Access hatch in corner uncovered with metal rungs to bottom of structure at 3m deep. Asbestos fibres in and around structure.	high	Remove concrete cover and backfill structure. Cover asbestos fibres in surrounding area. **2004: Remove asbestos from top of structure and bolt steel grate/cover over opening.**

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
24	7,148,183	513,112	349 - 353	Mill Area	Water Storage Tank and water pump house foundation.	White water storage tank (V ~ 1.4 Million litres) with concrete foundation on SE side which is partially backfilled (opening to utilidor). Pipes from utilidor protruding from within the foundation (Photo 349). Ladder on SW side of tank has rusted attachments to tank. Pipe and structural steel protrude from tank. Roof of tank is rusted, 1 corrosion hole visible.	high	**2004: Cut off ladder to tank roof. Cutoff protruding pipes and bury water house foundation/utilidor access shaft.**
28	7,148,310	513,050	364, 365	Mill Area	Fuel Storage Tank	Blue fuel storage tank: V ~ 1.4 Million litres. 5m X 5m foundation and concrete slab with 0.6m grade beam on S side of tanks, likely from former pump house. Tank has an earth berm around the perimeter, ladder to roof and buried pipes on W side. Entrance hatch on SW side open where tank can be entered. Hatch on roof also open. Slight hydrocarbon odour detected at hatches.	high	**2004: Cut off ladder to tank roof. Seal access into tank (weld steel plate over opening).**
22	7,148,135	513,192	343 - 346	Mill Area	Conveyor Tunnel #1 From Dryer Building	Opening 40m from entrance. Exterior and interior contains significant asbestos dust. Lower end of conveyor tunnel has been poorly backfilled with tailings.	high	Demolish/backfill tunnel with clean material. **2004: Remove asbestos dust from exterior. Backfill or cover entrance.**
25	7,148,177	513,087	354, 355	Mill Area	Conveyor Tunnel #2: dry rock storage to mill.	Entrance damaged with large concrete piece hanging by reinforcing steel. Numerous pieces of protruding reinforcing steel. Tunnel has up to 0.2m of asbestos dust. Part of conveyor visible in tunnel. Bottom end of tunnel filled with water at about 25m from entrance.	high	Demolish/backfill tunnel with clean material. Landfill conveyor. **2004: Remove asbestos dust from exterior. Cut off loose concrete and protruding re-bar. Backfill or cover entrance. Backfill opening at lower end.**

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
26	7,148,233	513,062	357 - 362	Mill Area	Conveyor Tunnel #2: dry rock storage to mill.	Depression in ground coincident with opening to conveyor tunnel about 45m from entrance. This was the location where dry rock was loaded on to the conveyor. Opening was partially backfilled, small void and steel support visible at surface (Photo 361). Equipment still inside tunnel includes: catwalk, conveyor, dust control piping. Void leads to water filled tunnel with pipes, ramps and stairs visible. Confirmed this is connected to conveyor tunnel.	moderate	Pump out water, remove equipment and backfill tunnel.
27	7,148,279	513,154	363	Mill Area	Former Dry Rock Storage Building	Partially buried metal, concrete and wood debris with significant asbestos fibre/dust in area. Depression may have been a result of removing concrete floor and sub-floor conveyors.	low	Check for sub-floor conveyor tunnels.
45	7,148,281	513,161	389	Mill Area	Former Dry Rock Storage Building	Depression in ground surface over footprint of former building. Concrete rubble with voids. Depression may have been a result of removing concrete floor and sub-floor conveyors.	low	Check for sub-floor conveyor tunnels.
4	7,148,339	513,183		Mill Area	Concrete footing.	3m x 6m concrete slab with exposed re-bars and covered with asbestos.	low	**Cut-off rebar.**
19	7,148,092	513,142	337	Mill Area	Former Mill Building: Concrete Structure	Deteriorated structure with steel chutes attached to underside. Deteriorated concrete and exposed re-bars.	low	**Short term (2004+): Remove overhanging steel chutes. Remove loose concrete and exposed, protruding re-bar.**
44	7,148,161	513,032	387, 388	Mill Area	Former Service Building: Concrete foundation with pits.	Pits in NW corner of concrete slab. One pit 0.5m x 5m by 2m deep. Second pit 1m x 10m is filled with debris including asbestos board.	moderate	**2004: Backfill openings with clean fill.**
7	7,147,952	513,263	318	Mill Area	Surface Debris	Asbestos tailings over 50m x 50m area. Also, galvanized metal couplers for 1.2m CSP.	**TBD**	**2004: Air monitoring required to assess exposure levels or risk to asbestos fibres.**
8	7,147,975	513,222	319	Mill Area	Partially Buried Debris	Area covered with 50mm mill overs and tailings. Also, steel pipe, asbestos board.	**TBD**	**2004: Air monitoring required to assess exposure levels or risk to asbestos fibres.**

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality
moderate	Potential For Serious Injury. Small Risk of Fatality
low	Small Risk of Serious Injury
Negligible	None Identified (Table 2)
TBD	To Be Determined

TABLE 1) HAZARD SUMMARY (Low to High Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Comments	Hazard Classification	Recommended Mitigation Measures
	Northing (m)	Easting (m)						
9	7,147,946	513,182	321	Mill Area	Asbestos Tailings	General area covered with asbestos tailings.	**TBD**	**2004: Air monitoring required to assess exposure levels or risk to asbestos fibres.**
14	7,147,981	513,051	328	Mill Area	Former office building: concrete footing	3m long, partly buried with exposed reinforcing steel	low	**2004: Cutoff re-bar.**
15	7,148,004	513,060	329	Mill Area	Former office building: concrete grade beam.	20m long, partly buried with exposed reinforcing steel	low	**2004: Cutoff re-bar.**
33	7,148,472	512,960	372	Mill Area	Wood Box Culvert	Partially collapsed	low	Excavate and backfill culvert.
42	7,148,092	512,940	385	Mill Area	Shaft and Partially Buried Debris	25 X 30m mounded area with 1m diam. by 1m deep open CMP at SE corner with 50mm pipe spanning top. This may be part of the water supply system, may lead to water tank or old office building. Also vehicle wheel visible in cover (remainder of cover good)	low	Backfill CMP.
ANFO STORAGE FACILITY								
66	7,145,891	512,754	462 - 473	ANFO Facility	Fertilizer storage tank	ANFO storage tank: (V ~ 1.4 million litres) Unloading conveyor, hopper and loading conveyor. Tank is badly corroded with some fertilizer remaining in bottom (V~150m^3). Four creosote poles and wooden stairs (rotten).	moderate	Demolish and landfill tank, conveyors, tank loading area. **Possible work for 2004 if co-located in crusher building landfill.**
66A	n/a	n/a	n/a	ANFO Facility	Former building site	Two buildings visible on 1976 air photos but not on the 1999 air photos.	**TBD**	**2004: Complete site reconnaissance to check area for hazards.**
MISCELLANEOUS								
5	7,147,560	512,001	307 - 312, 317	Hudgeon Lake	Former Water Intake	2 untreated wood poles in Hudgeon Lake, hydro lines in water, wooden stairs, misc scattered wood and metal debris.	moderate	Demolish wooden stairs. Remove Poles and power lines from water
81	7,146,913	513,678	575, 589 - 593	200m north of Crusher Bldg.	Heavy Equipment	Drill and shovel. Drill has electrostatic precipitator with asbestos laden filters. Shovel may contain transformer oil.	moderate	Sample and test transformer fluid from drill. Recover fluid after contents verified. Remove and landfill air filters on drill. Options for equipment include: salvage or landfillling.
83	7,146,774	513,785	595	Creek Pit	Steel Frame	Tubular steel frame across road to pit. May have been for service/inspection. Can be climbed.	low	**2004: Salvage or landfill with crusher building demolition**
84	7,146,739	513,783	596, 597	Creek Pit	Small wooden shelter.	Plywood structure in poor condition.	low	**2004: Salvage or landfill with crusher building demolition**

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality (Table 1)
moderate	Potential For Serious Injury. Small Risk of Fatality (Table 1)
low	Small Risk of Serious Injury (Table 1)
Negligible	None Identified

TABLE 2) HAZARD SUMMARY (Negligible Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Hazard Classification	Comments
	Northing (m)	Easting (m)					
WASTE ROCK DUMPS							
65	7,145,875	542,955	460, 461	Porcupine. Cr. Waste Rock	Partially Buried Debris	Negligible	Truck chassis, barrels, cable spool on slope.
TAILINGS PILE							
51	7,148,083	513,385	518	Tailings Pile	Tension Cracks	Negligible	100mm wide tension cracks in road to top of S Lobe. Recent movement towards ravine between lobes.
50	7,148,118	513,271	516, 517	Tailings Pile (near Mill Site)	Partially Buried Debris	Negligible	Structural steel from conveyor supports protruding from cover.
CRUSHER BUILDING							
79	7,146,773	513,605	576, 585	Crusher Building	Surface Debris	Negligible	Metal debris along E side of road into crusher.
TRAMWAY							
54 to 61				Tramway	Former power line	Negligible	Power line poles laying down beside tram towers 3 to 10 on north side of Clinton creek.
MILL AREA							
2	7,148,340	513,158		Mill Area	Partially Buried Debris	Negligible	Metal & Wood Debris: Truck chassis, misc wood, galvanized metal culverts, barrels
3	7,148,340	513,158	390	Mill Area	Surface Debris	Negligible	16 - 6m long cast iron pipes
10	7,147,991	513,141	322	Mill Area	Surface Debris	Negligible	6- 10m long pieces of reinforcing steel, misc wood
11	7,147,949	513,057	323	Mill Area	Partially Buried Debris	Negligible	Debris over slope includes wood, wire, galvanized pipe, asbestos board
12	7,147,998	513,041	324, 325	Mill Area	Former office building - west side, 2 storey concrete structure.	Negligible	4m X 4m structure, both floors empty, misc wood and metal debris scattered in area
20	7,148,111	513,178	338, 339	Mill Area	Former Mill & Dryer Building: Concrete Foundations	Negligible	Misc concrete footings and structures. Walls up to 1m thick. Concrete in good condition. Total volume about 60 cubic metres
21	7,148,094	513,218	340 - 342	Mill Area	Partially Buried Debris	Negligible	Structural steel protruding from pile of 50mm mill overs.
29	7,148,342	513,074	366	Mill Area	Tension Cracks and Asbestos Fibres	Negligible	Metal debris in NE corner of 20 X 20 X 2m high gravel pad
30	7,148,366	513,106	367 - 369	Mill Area	Surface Debris	Negligible	Includes pipe, wood, car, tram cable and heavy equipment parts in bush area.
31	7,148,420	513,063	370	Mill Area	Surface Debris	Negligible	Debris in cleared area includes rope, guy anchor, wood, steel strapping covered by thin layer of asbestos dust
32	7,148,459	512,983	371	Mill Area	Wood Poles	Negligible	7m long treated (creosote)
34	7,148,466	512,885	373, 374	Mill Area	Surface Debris and Partially Buried Debris	Negligible	Tram cable & wood located in bush on S side of clearing. Barrel with black solidified contents (spilled on ground- Photo 374). Debris extends along entire edge of clearing. Partially buried debris further west includes reinforcing steel, chain, tram cable, battery fragments and sharp pieces of protruding metal.

Client: Government of Yukon
Project: Former Clinton Creek Asbestos Mine - Hazard Assessment Program
Job No.: 6029-005-00

LEGEND

Hazard Class.	Potential Outcome
high	Severe Injury Likely or Possible Fatality (Table 1)
moderate	Potential For Serious Injury. Small Risk of Fatality (Table 1)
low	Small Risk of Serious Injury (Table 1)
Negligible	None Identified

TABLE 2) HAZARD SUMMARY (Negligible Classification)

Feature ID	UTM Co-ordinates		CD Photo Ref. #	Location	Description	Hazard Classification	Comments
	Northing (m)	Easting (m)					
35	7,148,400	512,818	375	Mill Area	Partially Buried Debris	Negligible	Metal debris also extends into pad.
36	7,148,398	512,758	376 - 378	Mill Area	Surface and Partially Buried Debris	Negligible	Heavy equipment including shovel bucket and arm, large steel and timber skid, earth scraper. Also tram cable on wood spool.
37	7,148,351	512,665	379	Mill Area	Partially Buried Debris	Negligible	Small amount of metal debris along cut line.
38	7,148,251	512,848	380, 381	Mill Area	Partially Buried Debris	Negligible	8 to 10 half sections of 1.2m diam. CMP, also asbestos board, wood and plastic pipe.
39	7,148,261	512,903	382	Mill Area	Surface Debris	Negligible	50 X 75m gravel pad with pieces of wood foundation (untreated), scattered metal and battery (Photo 382) fragments.
40	7,148,133	512,970	383	Mill Area	Partially Buried Debris	Negligible	30 X 30m mounded area with wood, cast iron pipe, wire, power cable. Suspect wood poles buried here as well.
41	7,148,110	512,940	384	Mill Area	Partially Buried Debris	Negligible	Includes untreated wood, metal in backfill at up gradient end of 2.5m deep, 50m long channel. 3 power lines run parallel to channel along alignment to former Hudgeon Lake water intake.
43	7,148,057	512,980	386	Mill Area	Partially Buried Debris	Negligible	Series of 3 - 4m high mounds with scattered debris around perimeters and partially buried wood stave pipe.
46	7,148,331	513,238	393, 395	Mill Area	Surface and Partially Buried Debris	Negligible	Surface debris against tailings pile includes galvanized metal siding, asbestos board and wood. Partially buried metal debris also visible.
47	7,148,314	513,259	394	Mill Area	Partially Buried Debris	Negligible	Partially buried metal in tailings pile, approx 10m x 50m x 3m high. Includes barrels and strapping.
49	7,148,027	513,208	509, 510	Mill Area	Former fibre storage building- concrete foundation	Negligible	Slab on grade with 1.7m high knee walls.
53	7,148,044	513,291	524	Mill Area	Transformer pad	Negligible	1 X 1m concrete base with fence posts around. Barbed wire attached to top of posts but chain link is missing.
ANFO STORAGE FACILITY							
67	7,146,032	512,730	474, 475	ANFO Facility	Scattered Surface Debris	Negligible	Scattered wood debris on raised gravel pad about 20mx 50m x 1.2m high.
MISCELLANEOUS							
6	7,148,436	512,137	313 - 316	Easter Creek	Former Water Intake	Negligible	Original water intake on Easter Creek: timber cribbing on creek banks, remnants of pipe insulation and wood supports on valley slope

DRAWINGS

Plot Scale: 1:1
Plot Time: Jun 16, 2004 – 10:21am
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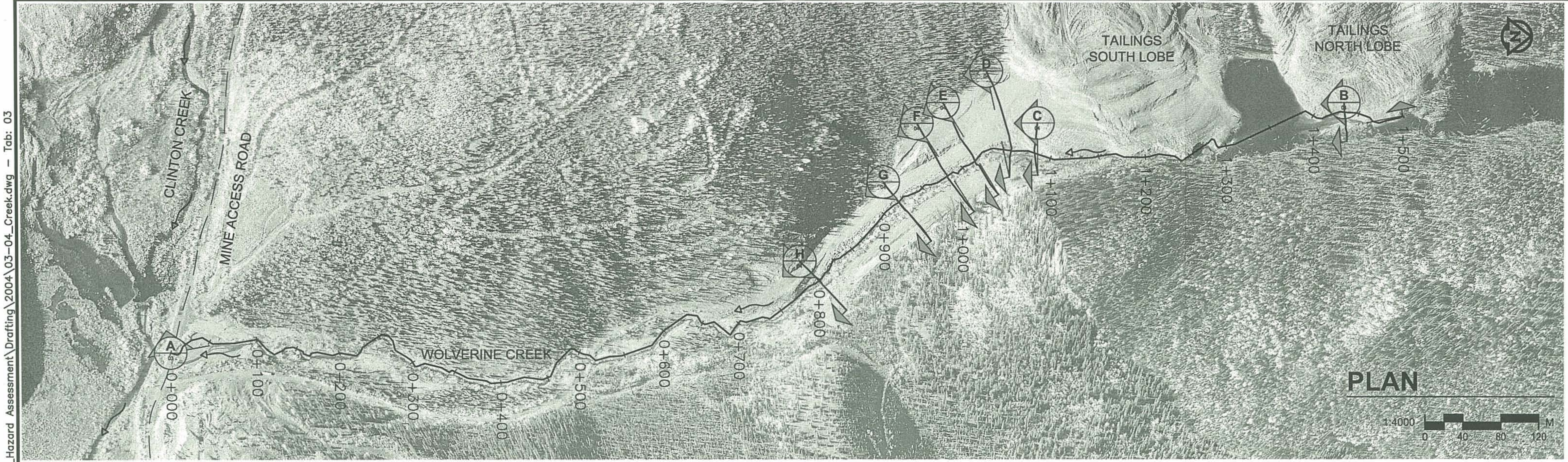

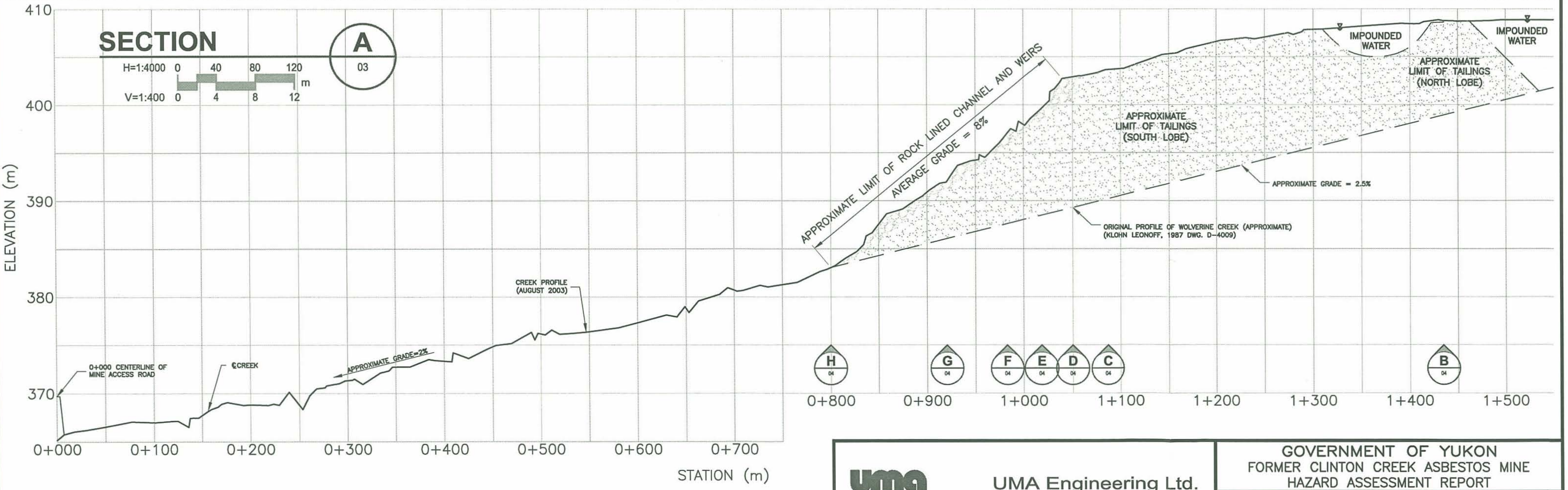

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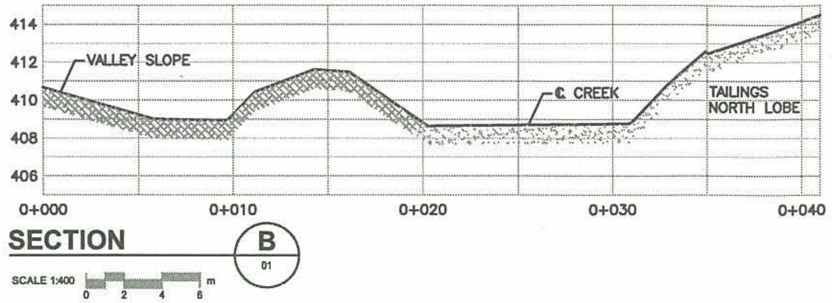
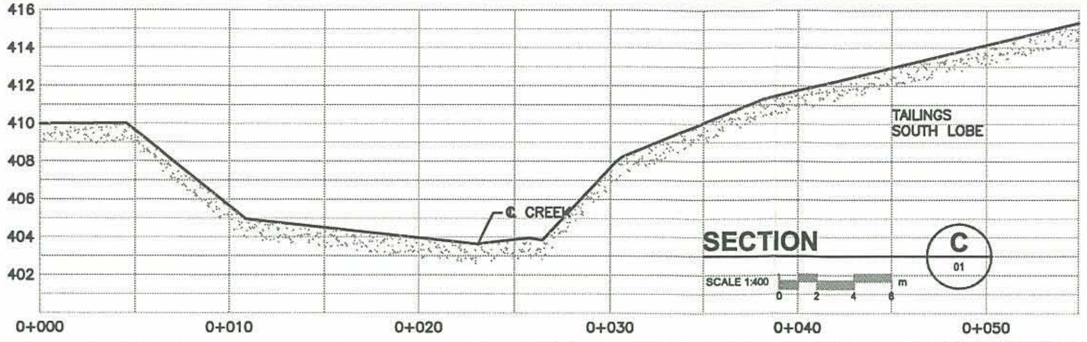
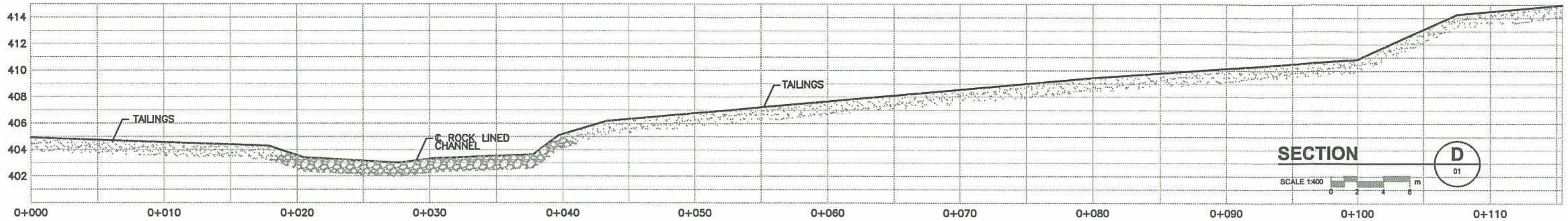
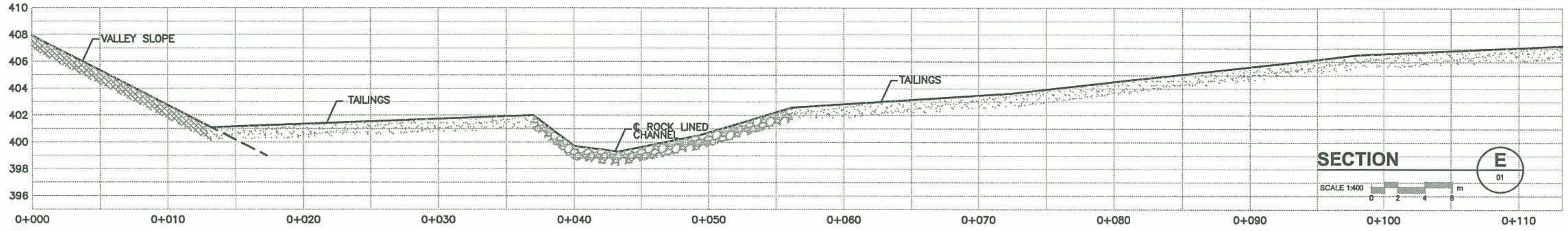
GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

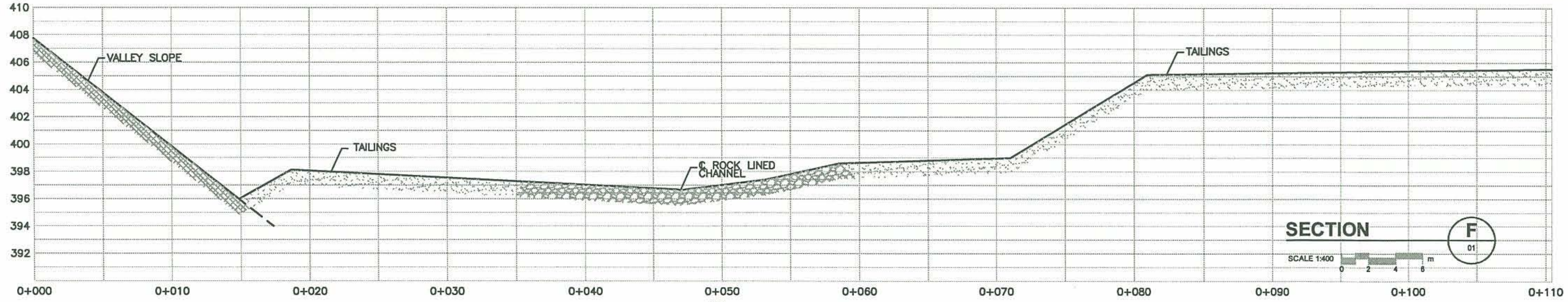
TITLE:	WOLVERINE CREEK PLAN / PROFILE		
JOB No.	6029–005–00	DATE:	JUNE 2004
SCALE:	AS SHOWN	DWG. No.	03
CHECKED:	GR		

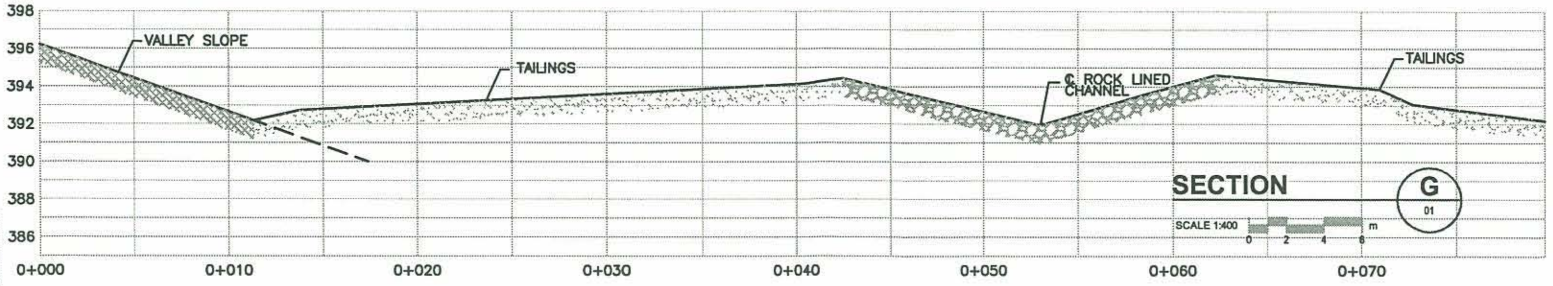


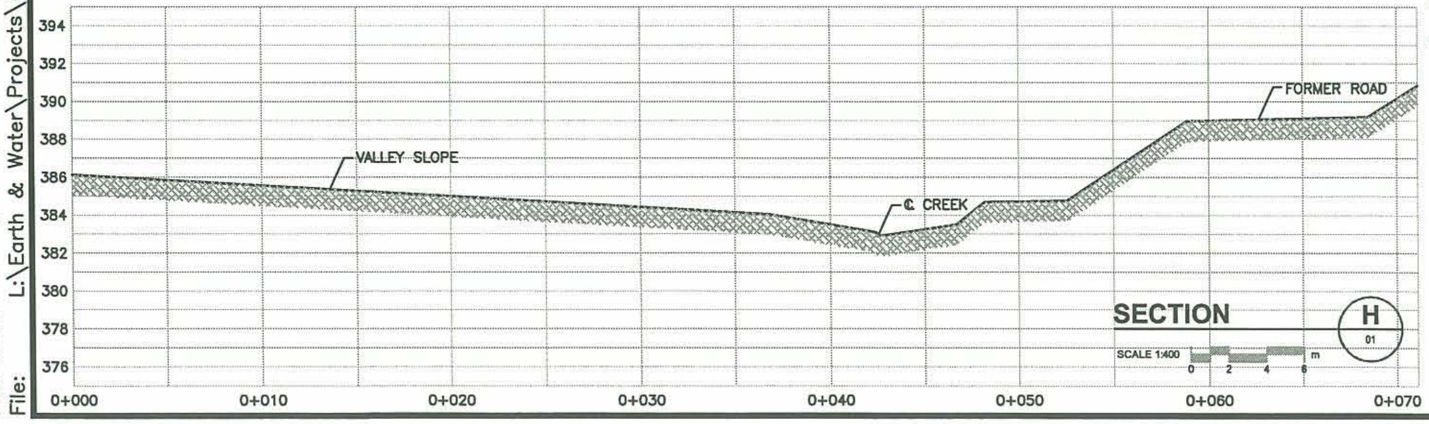












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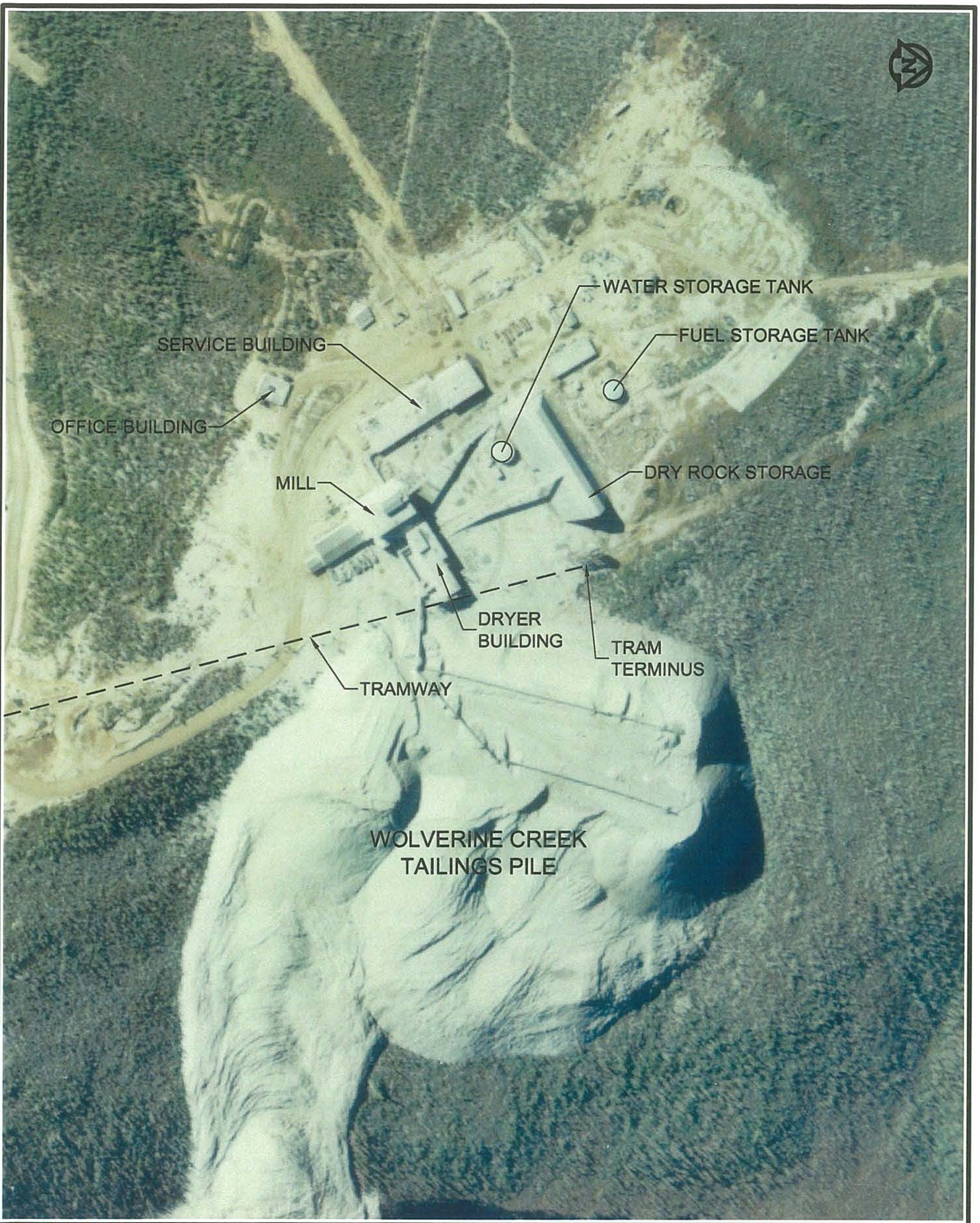
GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

TITLE: WOLVERINE CREEK SECTIONS

JOB No. 6029-005-00
DATE: JUNE 2004
SCALE: AS SHOWN
DWG. No. 04
CHECKED: GR



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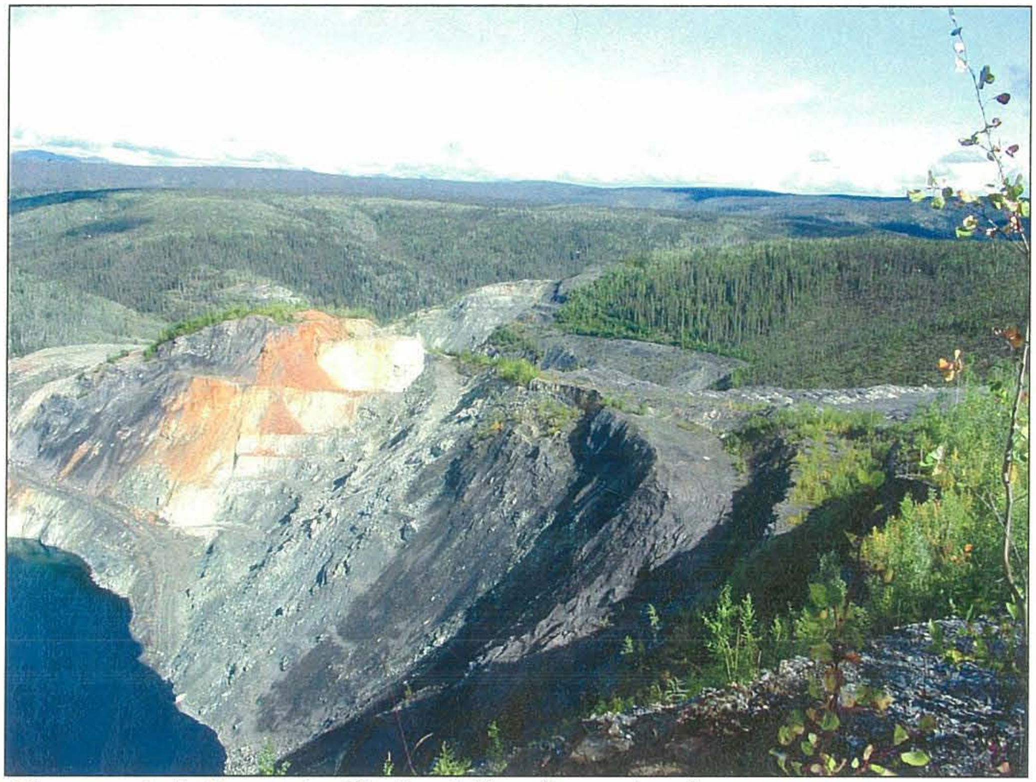
GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE HAZARD ASSESSMENT REPORT

TITLE:	MILL SITE – 1976		
JOB No.	6029-005-00	DATE:	JUNE 2004
SCALE:	1:5,000 (APPROX)	DWG. No.	06
CHECKED:	GR		

cale:
Plot Time: Jun 16, 2004 – 10:24am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\06_Mill.dwg – Tab: 06

PHOTOGRAPHS

(Printed and Digital)



Photograph 1) Porcupine Pit: Instability of east pit wall.

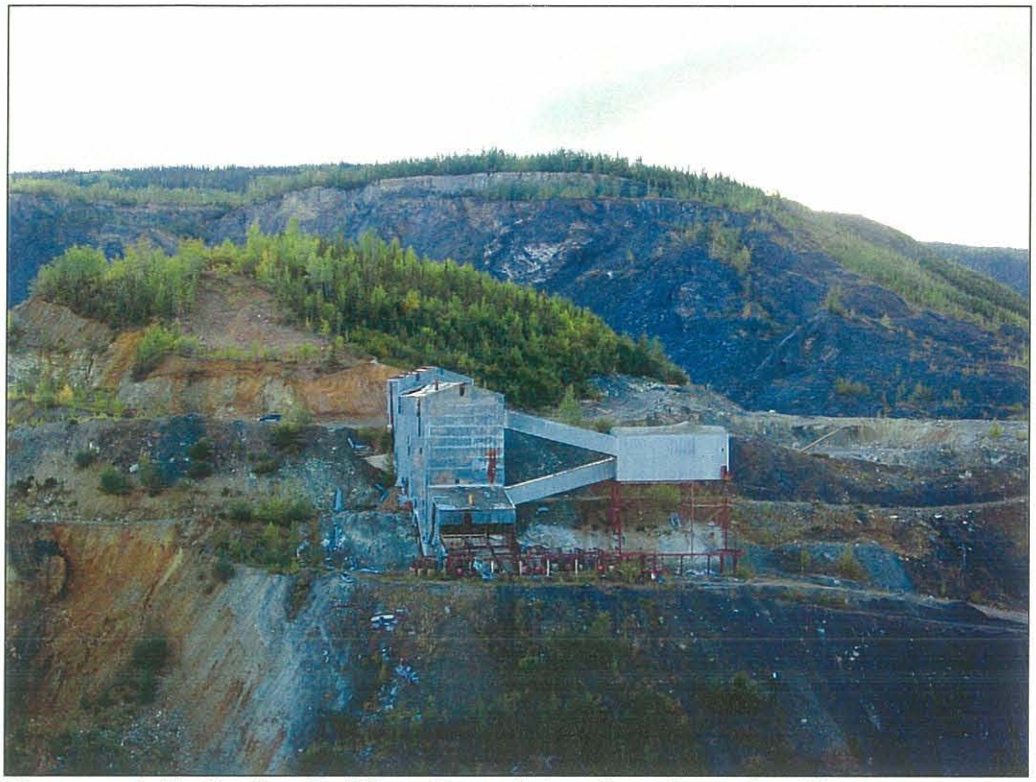
Photograph 2) Porcupine Pit: Instability of west pit wall.

Photograph 3) Snowshoe Pit: Pit wall instabilities, debris slides.

Photograph 4) Creek Pit: Steep pit walls, loose boulders.

Photograph 5) Asbestos ore found in Snowshoe Pit and entrance to Porcupine Pit.

Photograph 6) Tailings deposits found along full length of Wolverine Creek.

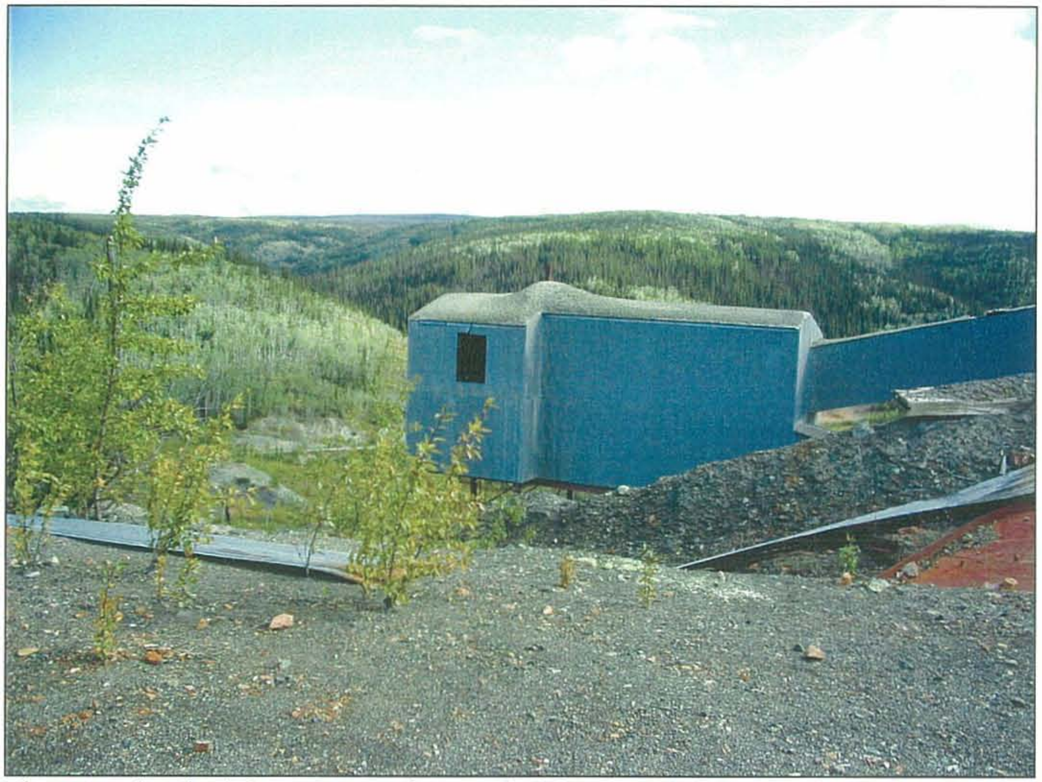


Photograph 7) Crusher Building: General view from Snowshoe Pit.

Photograph 8) West side of Crusher Building: Former ore bucket maintenance area, tramway feed.

Photograph 9) View from inside Crusher Building, lower level. Scattered debris and asbestos.

Photograph 10) View from inside Crusher Building, upper levels. High fall hazards, scattered debris and asbestos.

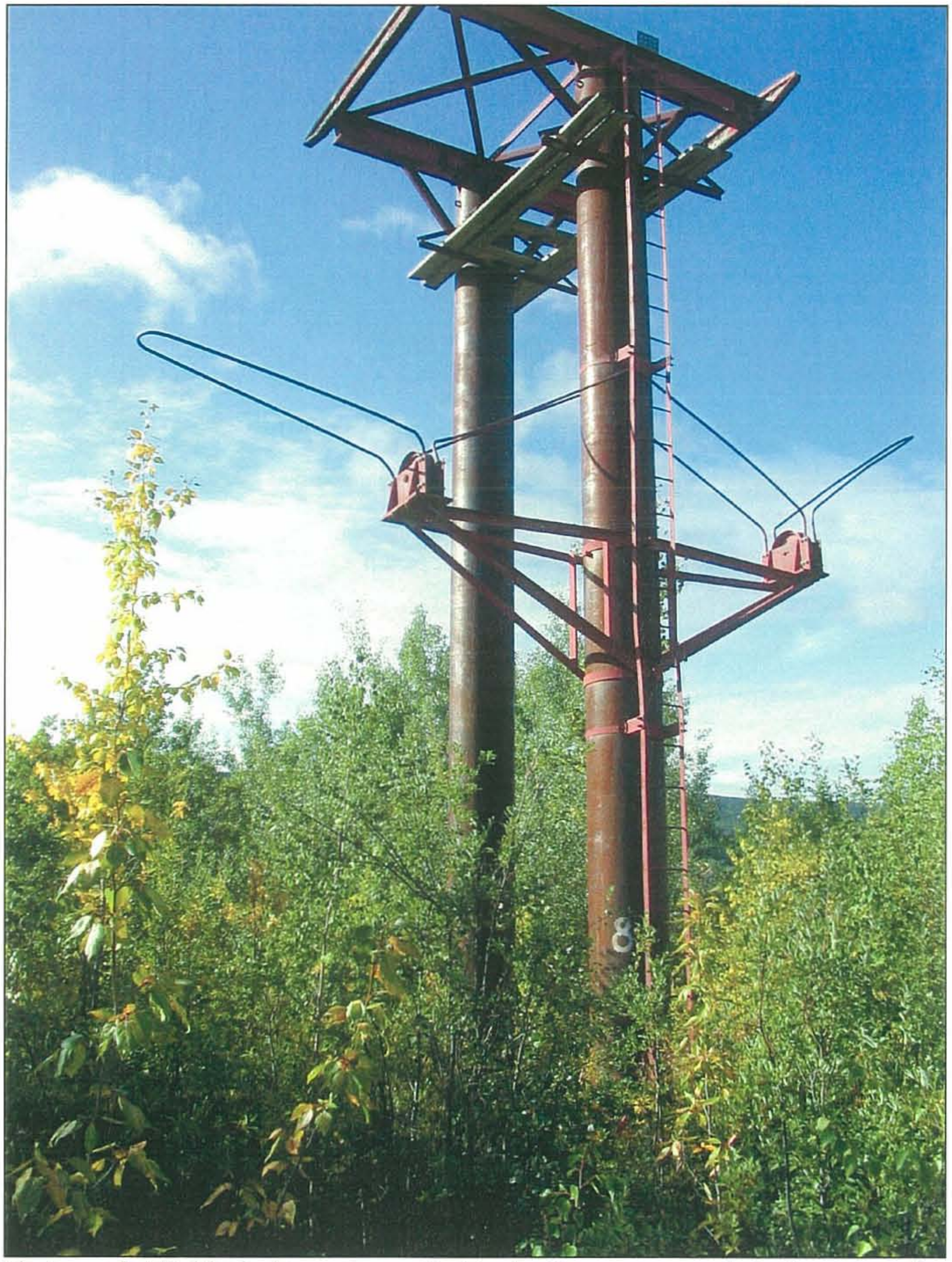


Photograph 11) Asbestos covering roof of Crusher Building.

Photograph 12) Asbestos covered area 50m west of Crusher Building.

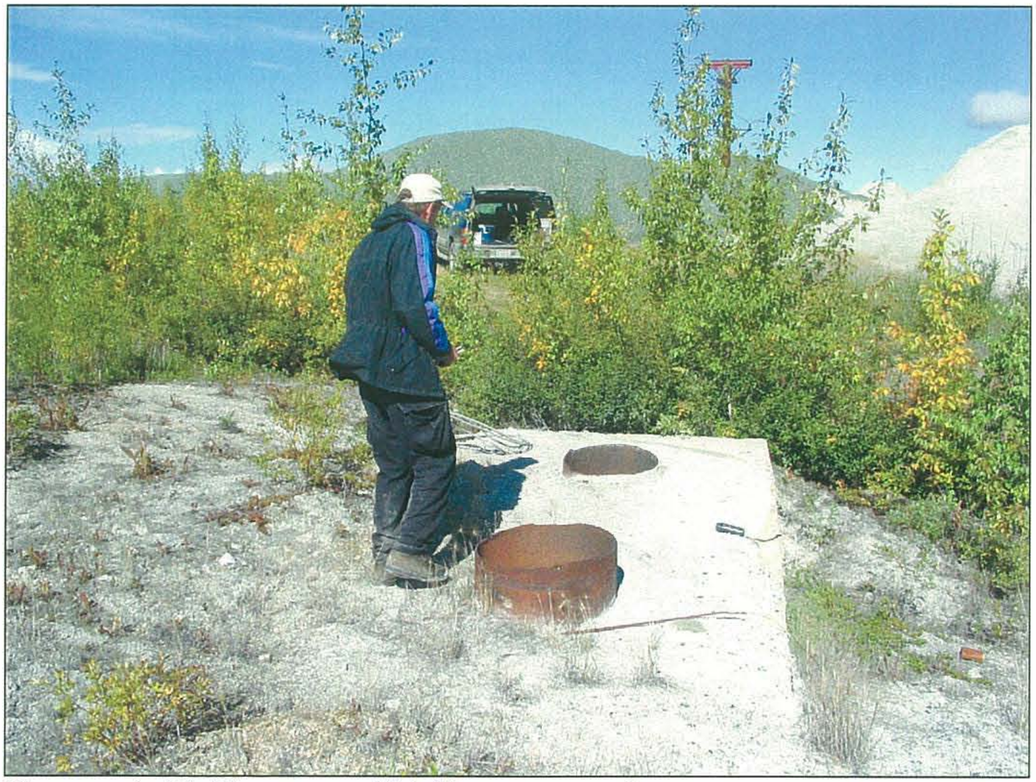
Photograph 13) Asbestos covered area 50m west of Crusher Building. 300 mm thick layer of asbestos.

Photograph 14) Tram Tower #3: Concrete structure and significant amount of asbestos ore laying on ground surface.



Photograph 15) Typical tram tower. Ladder leading up to wood planks at top of tower.

Photograph 16) Typical tram tower base.



Photograph 17) Tram tower #11: Tower removed.

Photograph 18) Tram terminus structure located on the Mill site.

Photograph 19) General view inside the tram terminus structure.

Photograph 20) Aerial view of the Mill site from October 2003.

Photograph 21) ANFO Facility: View of unloading conveyor, wooden staircase and tank.

Photograph 22) ANFO Facility: Bottom sides of tank are badly rusted.

Photograph 23) ANFO Facility: Storage tank loading facility. Steel hopper.

Photograph 24) ANFO Facility: Conveyor from hopper to tank.

Photograph 25) ANFO Facility: Approximately 150 m^3 of ammonium nitrate remaining in the tank.

Photograph 26) Power pole and line in Hudgeon Lake.

Photograph 27) Buried water line near the shore of Hudgeon Lake.

Photograph 28) Wooden staircase down to former water intake on Hudgeon Lake.

Photograph 29) Abandoned mining equipment (shovel and drill).

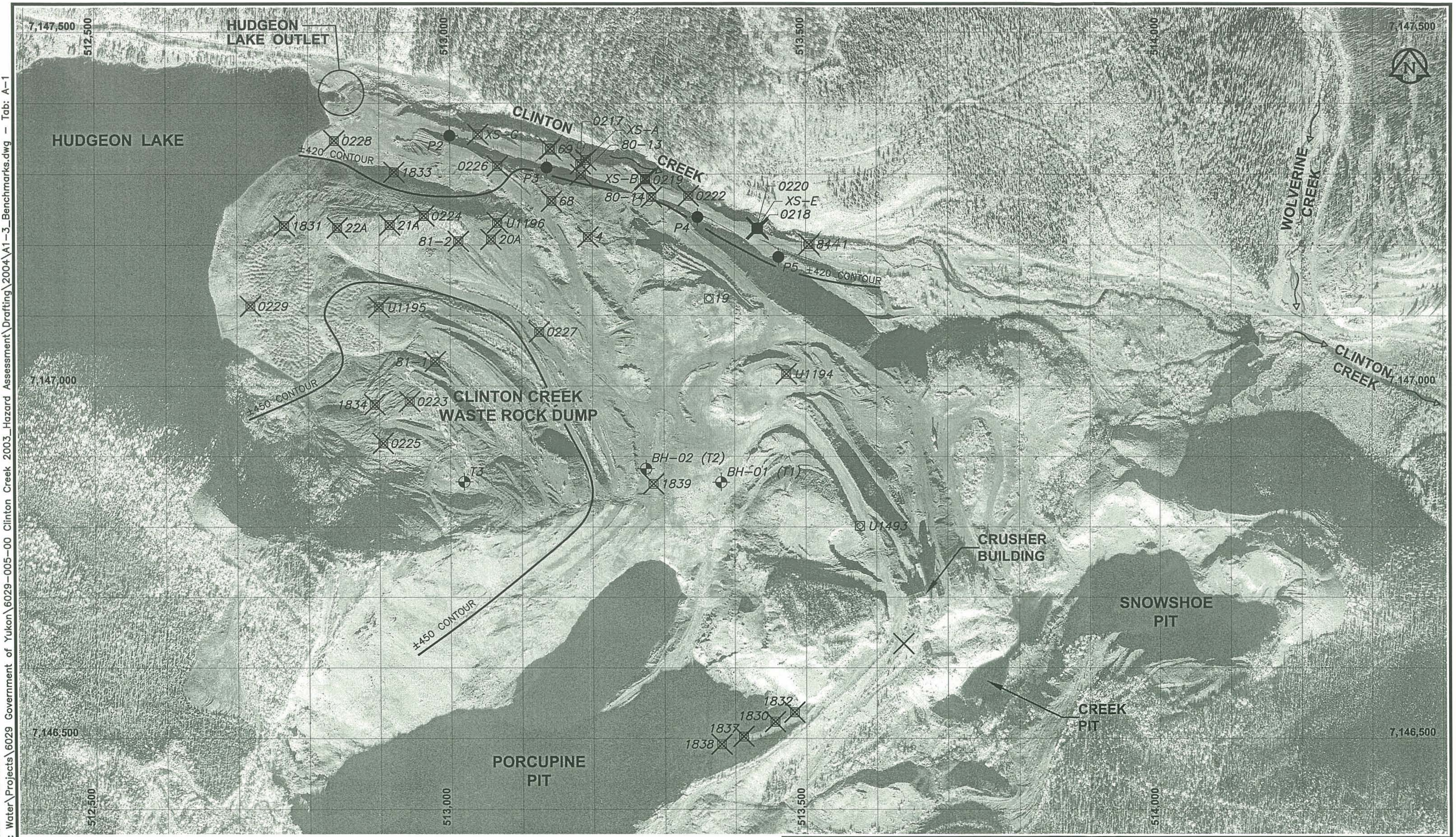
Photograph 30) Air filter on drill. Filter caked with asbestos dust.

Photograph 31) Wooden structure located in the Creek pit.

Photograph 32) Steel frame located in the Creek pit.

Appendix A

WASTE ROCK AND TAILINGS MONITORING PROGRAM



20A ⊠ MONITOR LOCATION (ACTIVE)

P2 ● PIEZOMETER LOCATIONS

T3 ⊕ THERMISTOR LOCATION

∿ ELEVATION 450± UPPER SLOPE

∿ ELEVATION 420-450 MID SLOPE

∿ ELEVATION <420 LOWER SLOPE

GRID UTM ZONE 07W NAD83

UTM Zone 7 NAD83
Photography Date: September 1999
Photography Scale: 1:5,000
Image Resolution: 0.25m
Contour Interval: 1.0m
Control: Supplied by Underhill Geomatics, Whitehorse Yukon

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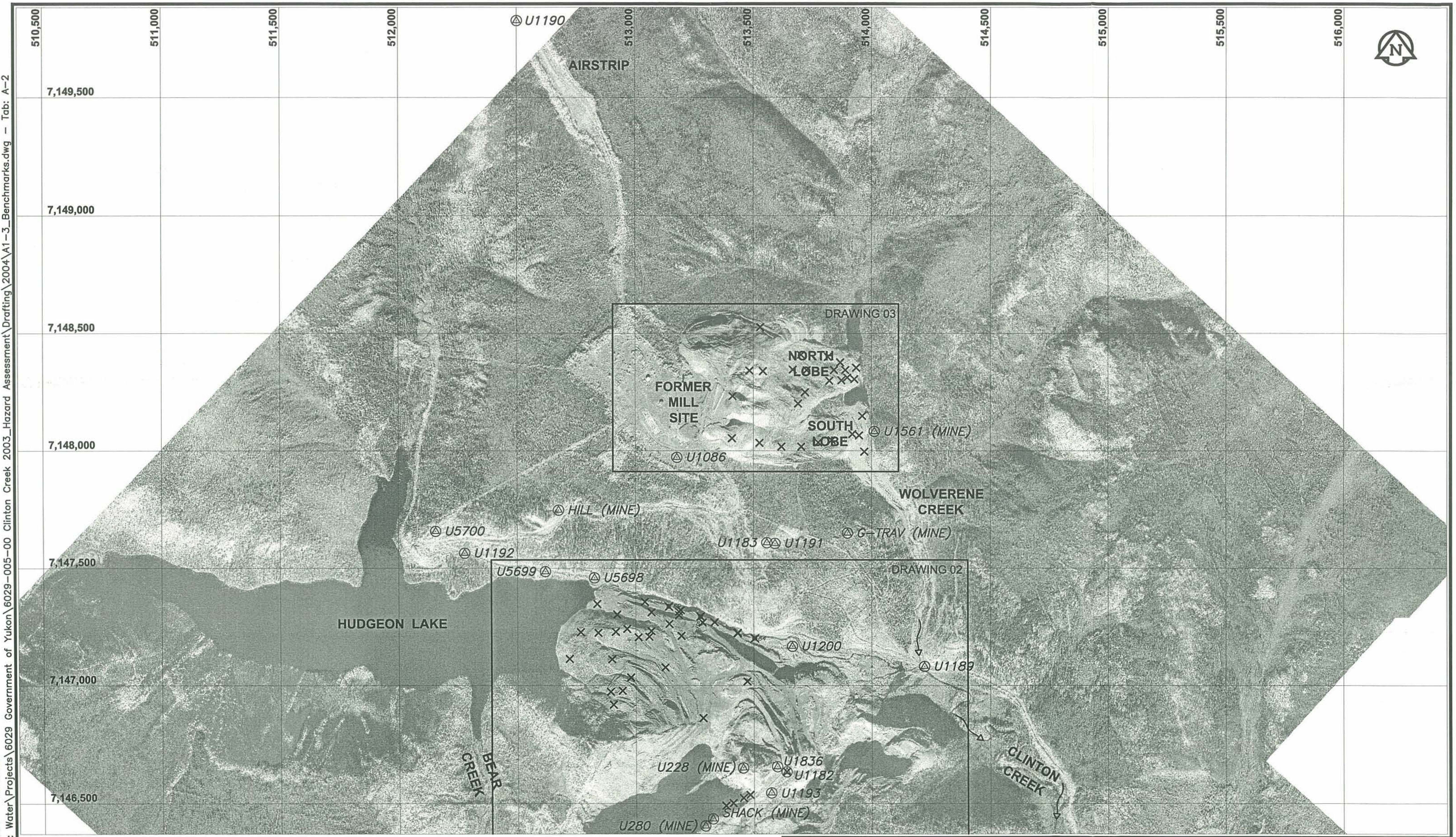
GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

TITLE: LOCATION OF WASTE ROCK MONITORING MONUMENTS

JOB No.	6029-005-00	DATE:	JUNE 2004
SCALE:	1:5000	DWG. No.	A-1
CHECKED:	GR		

Plot Scale: 1:1
Plot Time: Jun 16, 2004 - 10:29am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\A1-3_Benchmarks.dwg - Tab: A-1



Ⓐ U5700 BENCHMARK

Ⓐ U228 (MINE) LOCAL MINE BENCHMARKS

UTM Zone 7 NAD83
Photography Date: September 1999
Photography Scale: 1:5,000
Image Resolution: 0.25m
Contour Interval: 1.0m
Control: Supplied by Underhill Geomatics, Whitehorse Yukon

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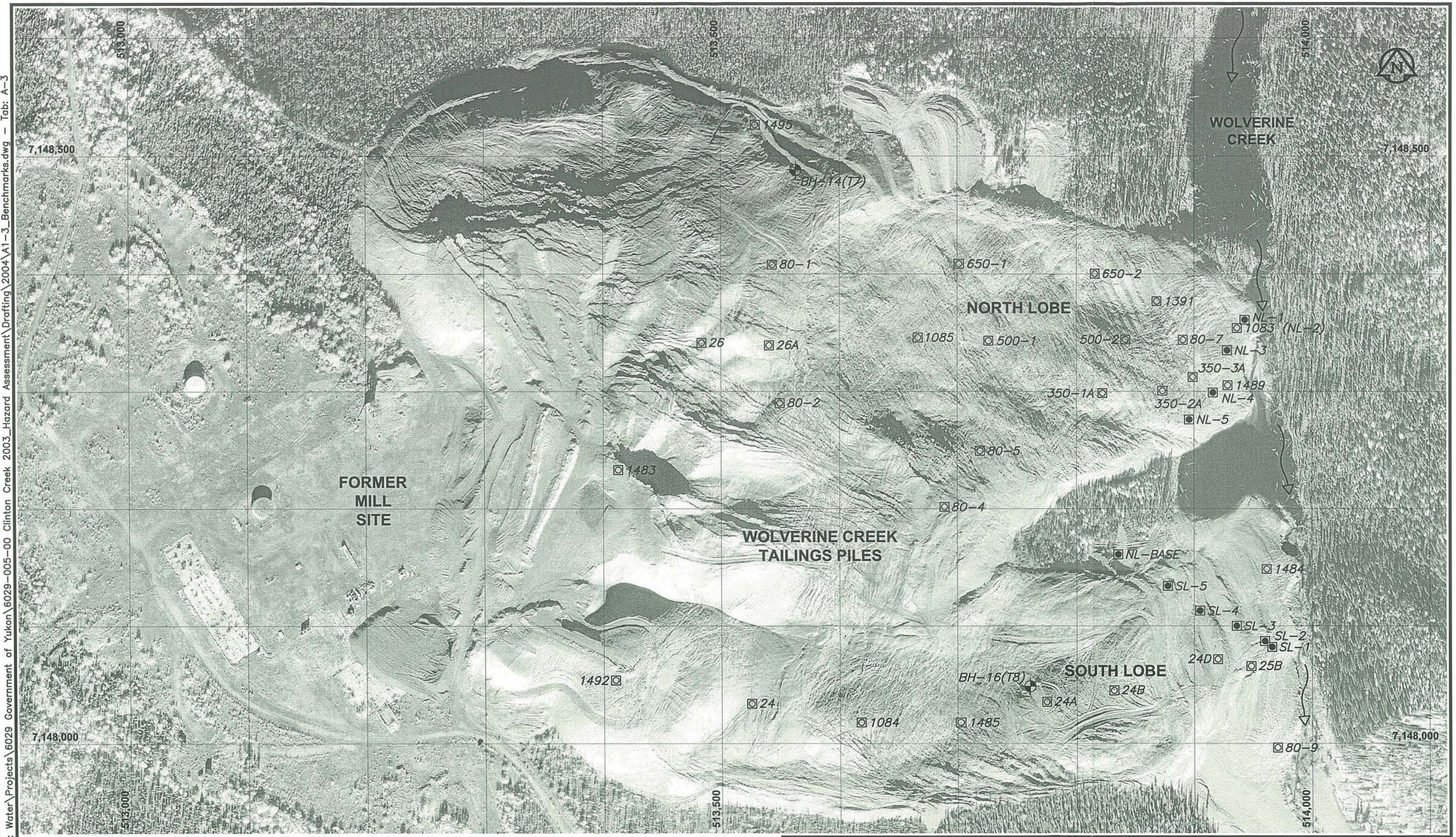
GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

TITLE:	BENCHMARK LOCATIONS		
JOB No.	6029-005-00	DATE:	JUNE 2004
SCALE:	1:15,000	DWG. No.	A-2
CHECKED:	GR		

Plot Scale: 1:1
Plot Time: Jun 16, 2004 - 10:33am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\A1-3_Benchmarks.dwg - Tab: A-2

Plot Scale: 1:1
Plot Time: Jun 16, 2004 - 11:04am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\A1-3_Benchmarks.dwg - Tab: A-3



24 ◻ MONITOR LOCATION (ACTIVE)
NL-01 ■ ALIGNMENT PIN
BH-14 (T7) ⊕ 1978 TEST HOLE LOCATION

GRID UTM ZONE 07W NAD83

COMPASS BEARING FROM NL-BASE ALONG PINS NL-1 TO NL-5
DECLINATION: 30°
BEARING: 208°

COMPASS BEARING FROM NL-BASE ALONG PINS SL-1 TO SL-5
DECLINATION: 30°
BEARING: 121°

UTM Zone 7 NAD83
Photography Date: September 1999
Photography Scale: 1:5,000
Image Resolution: 0.25m
Contour Interval: 1.0m
Control: Supplied by Underhill Geomatics, Whitehorse Yukon

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GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

TITLE:	TAILINGS PILE MONITORING MONUMENTS		
JOB No.	6029-005-00	DATE:	JUNE 2004
SCALE:	1:3000	DWG. No.	A-3
CHECKED:	GR		

Client: Government of Yukon
Project: Clinton Creek Asbestos Mine
UMA Job No.: 6029-005-00-02

Upper Slope Elevation > 450m
Mid-Slope Elevation 420 to 450m
Lower Slope Elevation < 420m

TABLE A-1) CLINTON CREEK WASTE ROCK DUMP INSTRUMENTATION

Description	ID	Location	Type	Stick Up		Serial No on Prism	Marker Cone	Monitor Tag	Underhill Geomatics Tag	Underhill Survey (Aug 21/03) UTM NAD 83			Comments
				(cm)	(feet)					Northing	Easting	Elevation	
Movement Monitor	0225	Upper Slope						0225	0225	7,146,918.716	512,905.221	475.17	New Pin, NEW2 in Gil's Field Book
Movement Monitor	0223	Upper Slope						0223	0223	7,146,978.053	512,942.739	467.22	New Pin, NEW in Gil's Field Book
Movement Monitor	1834	Upper Slope						1834	1834	7,146,973.618	512,893.433	461.12	New Pin, NEW4 in Gil's Field Book
Movement Monitor	UU1195	Upper Slope	Bench Mark	NA						7,147,111.936	512,899.532	456.59	Need 1999 & 2001 data
Movement Monitor	81-1	Upper Slope		143	4.69					7,147,034.819	512,978.933	455.27	Old Pin
Movement Monitor	21-A	Mid-Slope	Prism	121	3.97					7,147,228.197	512,915.152	446.54	Old Pin with prism
Movement Monitor	20-A	Mid-Slope	Prism	130	4.27					7,147,207.859	513,057.137	445.83	Old Pin with prism
Movement Monitor	22-A	Mid-Slope		122			YES			7,147,224.290	512,841.309	444.99	
Movement Monitor	0224	Mid-Slope						0224	0224	7,147,241.091	512,963.327	444.85	Old pin found
Movement Monitor	UU1196	Mid-Slope	Bench Mark	NA						7,147,231.232	513,066.175	444.08	Need 1999 & 2001 data
Movement Monitor	81-2	Mid-Slope		135	4.43		YES			7,147,205.285	513,011.562	443.75	Old Pin, NEEDS TAG
Movement Monitor	0227	Mid-Slope						0227	0227	7,147,076.844	513,124.776	439.48	New Pin, NEW5 in Gil's Field Book
Movement Monitor	0229	Mid-Slope						0229	0229	7,147,113.528	512,719.142	437.43	Old Pin found, WR-1 in Gil's Field Book
Movement Monitor	4	Mid-Slope		52	1.71					7,147,211.284	513,193.636	435.18	Old Pin, TAG REQUIRED.
Movement Monitor	68	Mid-Slope		120	3.94		YES			7,147,262.029	513,142.415	434.42	Has Tag
Movement Monitor	UU1194	Mid-Slope	Bench Mark	NA						7,147,017.321	513,472.438	433.19	Need 1999 & 2001 data
Movement Monitor	1831	Mid-Slope						1831	1831	7,147,227.179	512,766.646	432.85	New Pin, NEW3 in Gil's Field Book
Movement Monitor	19	Mid-Slope	3/4" diam. Bar	156	5.12		YES			7,147,124.347	513,365.638	429.24	located 3m east of #19-B
Movement Monitor	19-B	Mid-Slope	1/2" diam. Bar	62	2.03					7,147,126.637	513,363.485	429.13	was 19. Should be 19-B
Movement Monitor	1839	Mid-Slope	Marker					1839	1839	7,146,861.354	513,285.180	428.66	Marker Pin for T2
Movement Monitor	0226	Lower Slope						0226	0226	7,147,311.525	513,066.355	426.46	Was Underhill tag CP1635-1
Movement Monitor	1833	Lower Slope	3/8" Steel Pin					1833	1833	7,147,302.699	512,921.250	418.34	New Pin, NEW6 in Gil's Field Book
Movement Monitor	XS-G	Lower Slope	3/4" Steel Pin							7,147,356.110	513,038.841	416.54	XS-G in previous UMA survey
Piezometer	P2	Lower Slope	1" white pipe							7,147,354.357	512,999.352	416.10	P1 destroyed
Piezometer	P3	Lower Slope	1" white pipe							7,147,309.317	513,135.578	415.35	
Movement Monitor	69	Lower Slope	Marker?	54	1.77					7,147,335.532	513,140.577	414.90	Mon 69 in previous UMA survey
Movement Monitor	0217	Lower Slope	Marker	33	1.08			0217	0217	7,147,314.731	513,183.178	414.87	XS-A in previous UMA survey
Movement Monitor	0228	Lower Slope						0228	0228	7,147,346.995	512,836.840	413.95	TBM Trailer
Movement Monitor	80-13	Lower Slope	3/8" Steel Pin							7,147,299.401	513,183.839	413.08	Found on South Side of Road
Movement Monitor	XS-A	Lower Slope	3/4" Steel Pin	33	1.08					7,147,320.214	513,190.989	411.33	Nearly in Creek
Movement Monitor	0219	Lower Slope	Marker			NA		0219	0219	7,147,292.121	513,274.646	404.60	Monitor 83 in previous UMA Survey
Movement Monitor	XS-B	Lower Slope	3/4" Steel Pin	64	2.10					7,147,293.649	513,274.196	404.28	Nearly in Creek
Movement Monitor	80-14	Lower Slope	3/4" Steel Pin			NA		No	No	7,147,267.767	513,283.109	403.77	Found on South Side of Road
Movement Monitor	0222	Lower Slope	Marker	58	1.90			0222	0222	7,147,269.485	513,334.964	398.01	XS-C in previous UMA Survey
Piezometer	P4	Lower Slope	1" white pipe							7,147,239.500	513,347.557	397.28	
Movement Monitor	0220	Lower Slope	Marker	72	2.36	NA		0220	0220	7,147,223.417	513,430.902	388.65	XS-E in previous UMA Survey
Movement Monitor	0218	Lower Slope	Marker	67	2.20	NA		0218	0218	7,147,222.214	513,433.185	388.04	Mon-X in previous UMA Survey
Movement Monitor	XS-E	Lower Slope	3/4" Steel Pin	NA		NA		No	No	7,147,224.703	513,432.222	387.53	
Piezometer	P5	Lower Slope	1" white pipe							7,147,182.931	513,461.461	387.21	
Movement Monitor	84-1	Lower Slope	Marker	54	1.77					7,147,201.069	513,504.647	381.77	
PORCUPINE PIT SLOPE MONITORS													
Movement Monitor	1832	West pit slope	Marker					1832	1832	7,146,537.063	513,483.131	473.62	Pit Slope Monitor
Movement Monitor	1830	West pit slope	Marker					1830	1830	7,146,523.769	513,455.681	471.67	Pit Slope Monitor
Movement Monitor	1837	West pit slope	Marker					1837	1837	7,146,502.874	513,411.468	470.22	Pit Slope Monitor
Movement Monitor	1838	West pit slope	Marker					1838	1838	7,146,491.909	513,380.524	468.34	Pit Slope Monitor, labelled as 320
1978 TEST HOLE LOCATIONS (WITH THERMISTORS)													
BH - 1 (T1)	T1	Mid-Slope	cable	NA						7,146,863.402	513,381.017	422.96	Borehole / Thermistor
BH - 2 (T2)	T2	Mid-Slope	cable	NA						7,146,882.784	513,274.725	424.28	Borehole / Thermistor
BH-4 (T3)	T3	Upper Slope	cable	NA									Borehole / Thermistor - cable cut
BH-6 (T4)	T4	Lower Slope											not looked for in 2003

Client: Government of Yukon
Project: Clinton Creek Asbestos Mine
UMA Job No.: 6029-005-00

TABLE A-2) BENCHMARKS AT CLINTON CREEK MINE

UTM NAD83 ZONE 7N

Based on 1999 Air Photo Control (U1189 Destroyed)
Set new Control Points U1086 and U1836. Tied 2001 Control Points in stable areas

	Northing (m)	Easting (m)	Elevation (m)	ID
1086	7,147,972.205	513,176.707	590.950	U1086
1182	7,146,634.155	513,637.686	465.460	U1182
1190	7,149,824.696	512,500.926	609.520	U1190
1191	7,147,605.454	513,589.857	528.930	U1191
1192	7,147,564.047	512,278.761	441.290	U1192
1193	7,146,545.113	513,572.457	456.430	U1193
1200	7,147,166.861	513,662.996	375.480	U1200
1836	7,146,656.183	513,597.724	476.540	U1836
5698	7,147,458.764	512,825.164	415.050	U5698
5699	7,147,485.368	512,618.332	425.550	U5699
5700	7,147,657.353	512,155.907	481.380	U5700

Local Mine Ground Control Transformed to UTM

Transformation based on U5698,U5699,U5700,U1182 common 2001 and 2003 ties.(U1184 not found)
Used U5698 as base. LDD handles scale to ground and rotation -0°17'15" to grid. Manually scale to metric.
Elevation differences based on U1561 (UTM = 423.803m., LOCAL = 1389.87ft.)

	Northing (m)	Easting (m)	Elevation (m)	ID
228	7,146,650.833	513,454.406	500.740	U228
280	7,146,404.795	513,292.824	501.030	U280
300	7,147,747.252	512,674.428	509.290	HILL
400	7,146,435.213	513,325.619	495.390	SHACK
900	7,147,649.576	513,899.213	489.860	GTRAV
1561	7,148,082.327	514,012.370	423.800	U1561

LOCAL MINE GROUND SYSTEM(feet)

2003 GPS Control transformed to ground

	Northing (ft)	Easting (ft)	Elevation (ft)	ID
1086	113,283.833	107,216.924	1,938.260	U1086
1182	108,884.267	108,707.955	1,526.550	U1182
1190	119,375.619	105,029.244	1,999.190	U1190
1191	112,073.197	108,566.986	1,734.780	U1191
1192	111,958.873	104,262.818	1,447.250	U1192
1193	108,593.080	108,492.379	1,496.920	U1193
1200	110,632.388	108,799.766	1,231.340	U1200
1836	108,957.224	108,577.153	1,562.900	U1836
5698	111,604.300	106,054.560	1,361.160	U5698
5699	111,695.030	105,376.109	1,395.610	U5699
5700	112,267.162	103,861.093	1,578.780	U5700

Local mine control from historical files

	Northing (ft)	Easting (ft)	Elevation (ft)	ID
228	108,941.540	108,107.020	1,642.290	U228
280	108,136.470	107,572.500	1,643.240	U280
300	112,553.880	105,564.450	1,670.330	HILL
400	108,235.800	107,680.660	1,624.750	SHACK
900	112,213.030	109,583.730	1,606.590	GTRAV
1561	113,631.480	109,961.620	1,389.870	U1561

Client: Government of Yukon
Project: Clinton Creek Asbestos Mine
Job No.: 6029-005-00
Date: 20-Aug-03

TABLE A-3) Waste Rock Dump Stability - MOVEMENT SUMMARY

Date	Lower Slope Monitors	Horizontal Movement			Mid Slope Monitors	Horizontal Movement			Upper Slope Monitors	Horizontal Movement		
		total (metres)	incremental (metres)	rate (metres/year)		total (metres)	incremental (metres)	rate (metres/year)		total (metres)	incremental (metres)	rate (metres/year)
19-Jun-01	**69**	0.19	0.19	0.10	**4**	0.06	0.06	0.03	**81-1**	3.26	0.12	0.06
20-Aug-03		0.22	0.03	0.01		0.10	0.05	0.02		3.38	0.12	0.06
19-Jun-01	**80-13**	n/a			**19**	7.75	0.22	0.11	**223**	n/a		
20-Aug-03						7.94	0.19	0.09				
19-Jun-01	**80-14**	n/a			**20A**	9.00	0.22	0.11	**225**	n/a		
20-Aug-03						9.17	0.17	0.08				
19-Jun-01	**84**	0.13	0.13	0.07	**21A**	9.45	0.20	0.10	**1195**	0.10	0.09	0.05
20-Aug-03		0.10	0.04	0.02		9.50	0.11	0.05		0.20	0.10	0.05
19-Jun-01	**217**	0.05	0.05	0.02	**22A**	12.02	0.19	0.10	**1834**	n/a		
20-Aug-03		0.08	0.09	0.04		12.23	0.22	0.10		n/a		
19-Jun-01	**218**	0.07	0.07	0.04	**68**	7.86	0.02	0.01				
20-Aug-03		0.15	0.07	0.03		7.86	0.07	0.03				
19-Jun-01	**219**	0.17	0.17	0.09	**81-2**	2.70	0.15	0.08				
20-Aug-03		0.15	0.03	0.02		2.73	0.07	0.03				
19-Jun-01	**220**	0.25	0.25	0.13	**224**	n/a						
20-Aug-03		0.34	0.11	0.05								
19-Jun-01	**222**	0.06	0.06	0.03	**227**	n/a						
20-Aug-03		0.06	0.04	0.02								
19-Jun-01	**226**	n/a			**229**	n/a						
20-Aug-03												
19-Jun-01	**228**	n/a			**1194**	0.09	0.08	0.04				
20-Aug-03						0.18	0.09	0.04				
19-Jun-01	**1833**	n/a			**1196**	0.17	0.16	0.08				
20-Aug-03						0.25	0.08	0.04				
19-Jun-01	**P2**	0.17	0.17	0.09	**1831**	n/a						
20-Aug-03		0.42	0.25	0.11								
19-Jun-01	**P3**	0.11	0.11	0.06								
20-Aug-03		0.11	0.04	0.02								
19-Jun-01	**P4**	n/a										
20-Aug-03												
19-Jun-01	**P5**	n/a										
20-Aug-03												
19-Jun-01	**XS-A**	n/a										
20-Aug-03												
19-Jun-01	**XS-B**	n/a										
20-Aug-03												
19-Jun-01	**XS-E**	n/a										
20-Aug-03												
19-Jun-01	**XS-G**	0.19	0.19	0.10								
20-Aug-03		0.39	0.20	0.09								
	Lower Slope Monitors				**Mid Slope Monitors**				**Upper Slope Monitors**			
	1999 to 2001	average	0.14	0.07		average	0.14	0.07		average	0.11	0.06
	2001 to 2003	**average**	**0.09**	**0.04**		**average**	**0.12**	**0.05**		**average**	**0.11**	**0.05**
	1999 to 2001	maximum	0.25	0.13		maximum	0.22	0.11		maximum	0.12	0.06
	2001 to 2003	**maximum**	**0.25**	**0.11**		**maximum**	**0.22**	**0.10**		**maximum**	**0.12**	**0.06**
	1999 to 2001	minimum	0.05	0.02		minimum	0.02	0.01		minimum	0.09	0.05
	2001 to 2003	**minimum**	**0.03**	**0.01**		**minimum**	**0.05**	**0.02**		**minimum**	**0.10**	**0.05**

Client: Government of Yukon
Project: Clinton Creek Asbestos Mine
UMA Job No.: 6029-005-00-02

TABLE A-4) TAILINGS PILE INSTRUMENTATION SUMMARY

Description	ID	Location	Stick Up		Serial No on Prism	Marker Cone	Monitor Tag	Underhill Geomatics Tag	Underhill Survey (Aug 21/03) UTM NAD 83			Comments
			(cm)	(feet)					Northing	Easting	Elevation	
SOUTH LOBE												
Movement Monitor	1492	Upper Slope	n/a	n/a	n/a	NO			7,148,053.739	513,409.910	610.07	
Movement Monitor	1483	Upper Slope	n/a	n/a	n/a	NO			7,148,233.008	513,412.665	609.08	
Movement Monitor	24	Upper Slope	127	4.17	A1018	NO			7,148,033.826	513,525.343	549.69	
Movement Monitor	1084	Mid Slope	n/a	n/a	n/a	NO	1084	1084	7,148,017.968	513,617.953	516.26	installed in August 2003
Movement Monitor	1485	Mid Slope	n/a	n/a	n/a	NO	1485	1485	7,148,017.906	513,702.374	480.46	installed in August 2003
Movement Monitor	24-a	Mid Slope	126	4.13	N/A	NO			7,148,035.281	513,774.681	465.27	
Movement Monitor	24-b	Mid Slope	138	4.53	N/A	NO			7,148,045.085	513,832.262	446.30	
Movement Monitor	24-d	Lower Slope (toe)	116	3.81	A1015	YES			7,148,071.590	513,920.048	422.39	
Movement Monitor	25-b	Lower Slope (toe)	90	2.95	N/A	YES			7,148,065.684	513,948.293	422.02	
Movement Monitor	1484	Lower Slope (toe)	n/a	n/a	n/a	NO	1484	1484	7,148,148.485	513,961.520	417.94	installed in August 2003
Movement Monitor	80-9	Lower Slope (toe)	141	4.63	A0359	NO			7,147,996.441	513,970.693	411.11	
NORTH LOBE												
Movement Monitor	26	Upper Slope	110	3.61	A1227	YES			7,148,341.454	513,483.525	575.11	
Movement Monitor	1495	Upper Slope	n/a	n/a	n/a	NO	1495	1495	7,148,526.589	513,528.921	529.06	installed in August 2003
Movement Monitor	26-a	Upper Slope	123	4.04	A0282	YES			7,148,339.301	513,540.503	557.82	
Movement Monitor	80-1	Upper Slope	105	3.44	A3267	NO			7,148,407.979	513,543.037	555.71	
Movement Monitor	80-2	Upper Slope	114	3.74	N/A	NO			7,148,290.046	513,549.412	552.78	
Movement Monitor	1085	Mid Slope	n/a	n/a	n/a	NO	1085	1085	7,148,346.053	513,666.411	488.88	installed in August 2003
Movement Monitor	80-4	Mid Slope	104	3.41	A0326	NO			7,148,201.560	513,688.819	501.73	
Movement Monitor	650-1	Mid Slope	97	3.18	A0283	YES			7,148,408.733	513,701.263	483.95	
Movement Monitor	80-5	Mid Slope	107	3.51	A0388	NO			7,148,249.320	513,718.337	481.19	
Movement Monitor	500-1	Mid Slope	118	3.87	N/A	YES			7,148,343.223	513,725.526	474.09	
Movement Monitor	650-2	Mid Slope	135	4.43	A0287	YES			7,148,400.264	513,815.951	439.87	
Movement Monitor	350-1a	Mid Slope	150	4.92	N/A	YES			7,148,298.589	513,822.456	448.09	
Movement Monitor	500-2	Mid Slope	123	4.04	A1022	YES			7,148,344.355	513,842.069	438.14	
Movement Monitor	1391	Lower Slope (toe)	n/a	n/a	n/a	NO	1391	1391	7,148,376.828	513,868.790	432.49	installed in August 2003 **(SURVEY ID = 1491)**
Movement Monitor	350-2a	Lower Slope (toe)	108	3.54	N/A	YES			7,148,300.515	513,873.672	428.71	
Movement Monitor	80-7	Lower Slope (toe)	100	3.28	N/A	NO			7,148,344.007	513,890.726	422.54	
Movement Monitor	350-3a	Lower Slope (toe)	85	2.79	N/A	YES			7,148,312.228	513,899.001	417.39	
Movement Monitor	1489	Lower Slope (toe)	n/a	n/a	n/a	NO	1489	1489	7,148,305.231	513,928.450	413.70	installed in August 2003
Movement Monitor	1083	Lower Slope (toe)	n/a	n/a	n/a	NO	1083	1083	7,148,354.005	513,936.369	414.10	installed in August 2003
Test Holes												
Test Hole / Thermistor	BH-13 (T6)											Thermistor - not found
Test Hole / Thermistor	BH-14 (T7)	North lobe, upper	n/a	n/a	n/a	NO			7,148,488.356	513,563.012	530.33	Thermistor
Test Hole / Thermistor	BH-16 (T8)	South lobe, mid	n/a	n/a	n/a	NO			7,148,048.485	513,760.297	464.94	Thermistor

Appendix B

AGRONOMIC LAB TEST RESULTS

NORWEST LABS

Analytical Report

Norwest Labs
7217 Roper Road
Edmonton, AB. T6B 3J4
Phone: (780) 438-5522
Fax: (780) 438-0396

Bill to: YTG Energy, Mines and Resources
Report to: YTG Energy, Mines and Resources
Box 2703 (K-419)
Whitehorse, YT, Canada
Y1A 2C6
Attn: Hugh Copland
Sampled By: H. Copland
Company: GY

Project
ID:
Name: Clinton Creek
Location:
LSD:
P.O.: GN0353-3071-00116
Acct. Code:

NWL Lot ID: 271509
Control Number:
Date Received: Nov 25, 20
Date Reported: Dec 05, 20
Report Number: 488111

Page: 1 of 3

NWL Number 271509-1
Sample Date Sep 22, 2003
Sample Description CC03-08
Matrix Soil - general

Analyte		Units	Results	Results	Results	Detectio
Available Nutrients						
Nitrate - N	Available	mg/kg	3			1
Phosphorus	Available	mg/kg	<5			5
Potassium	Available	mg/kg	21			10
Sulphate-S	Available	mg/kg	3			1
Classification						
C:N Ratio			>80			
Organic Matter		%	1.67			0.09
Nitrogen	Total	%	<0.01			0.01
Carbon	Total Organic	%	0.83			0.05
Cation Exchange Capacity		meq/100g	14.9			
Physical and Aggregate Properties						
Moisture at 1/3 bar		%	15.8			0.1
Moisture at 15 bar		%	4.3			0.1
Texture			Sandy Loam			
Sand	Soil Texture	% by weight	68.0			0.1
Silt	Soil Texture	% by weight	26.8			0.1
Clay	Soil Texture	% by weight	5.2			0.1
<50 um	Soil Texture	% by weight	32.00			
Salinity						
pH	Saturated Paste	pH	8.6			
Electrical Conductivity	Saturated Paste	dS/m at 25C	0.26			0.01
SAR	Saturated Paste		0.0			
% Saturation		%	130			
Calcium	Saturated Paste	meq/L	1.11			0.01
Calcium	Saturated Paste	mg/kg	28.8			
Magnesium	Saturated Paste	meq/L	1.65			0.02
Magnesium	Saturated Paste	mg/kg	25.8			
Sodium	Saturated Paste	meq/L	0.05			0.04
Sodium	Saturated Paste	mg/kg	2			
Potassium	Saturated Paste	meq/L	0.05			0.03
Potassium	Saturated Paste	mg/kg	3			
Chloride	Saturated Paste	meq/L	0.07			0.03
Chloride	Saturated Paste	mg/kg	3			
Sulphate-S	Saturated Paste	meq/L	0.11			0.06
Sulphate-S	Saturated Paste	mg/kg	2.4			

Analytical Report

Bill to: YTG Energy, Mines and Resources
Report to: YTG Energy, Mines and Resources
Box 2703 (K-419)
Whitehorse, YT, Canada
Y1A 2C6
Attn: Hugh Copland
Sampled By: H. Copland
Company: GY

Project
ID:
Name: Clinton Creek
Location:
LSD:
P.O.: GN0353-3071-00116
Acct. Code:

NWL Lot ID: 271509
Control Number:
Date Received: Nov 25, 2003
Date Reported: Dec 05, 2003
Report Number: 488111

Page: 2 of 3

NWL Number 271509-1
Sample Date Sep 22, 2003
Sample Description CC03-08
Matrix Soil - general

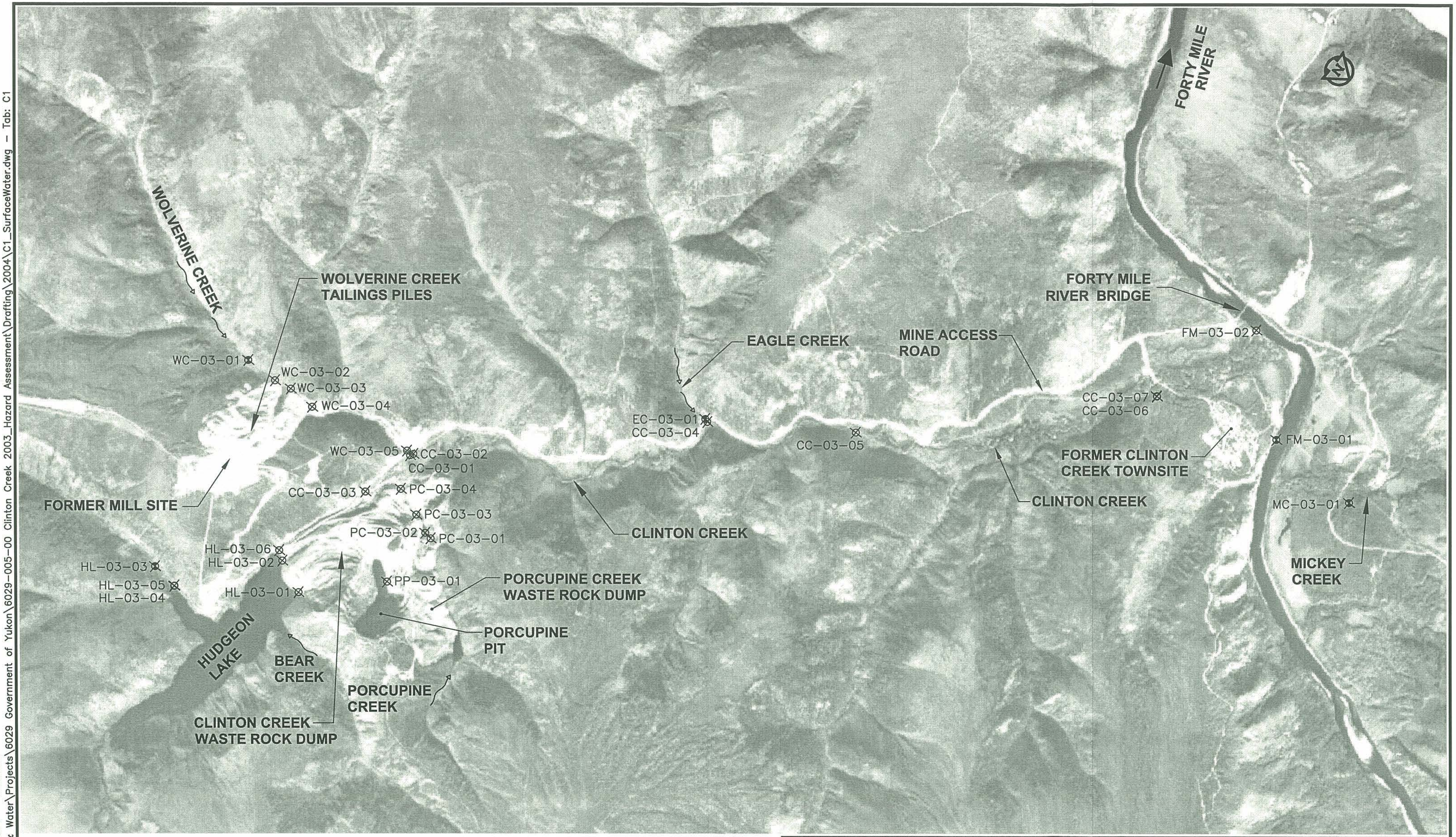
Analyte		Units	Results	Results	Results	Detection Limit
Salinity - Continued						
TGR	Saturated Paste	T/ac	<0.1			
Soil Acidity						
pH	Acid 0 meq/100g	pH	8.3			0.5
pH	Acid 1 meq/100g	pH	8.2			0.5
pH	Acid 2 meq/100g	pH	8.0			0.5
pH	Acid 4 meq/100g	pH	7.7			0.5
pH	Acid 8 meq/100g	pH	7.5			0.5
pH	Acid 12 meq/100g	pH	7.4			0.5

Approved by: RL Neumann

Randy Neumann, BSc
Vice President, Environmental

Appendix C

WATER SAMPLING PROGRAM
LAB TEST RESULTS
AND
SAMPLE LOCATIONS



HL-03-03 ☒	UPSTREAM REFERENCE SAMPLE (TYP)
CC-03-07 ☒	WATER SAMPLE

UTM Zone 7 NAD83
Photography Date: September 1999
Photography Scale: 1:5,000
Image Resolution: 0.25m
Contour Interval: 1.0m
Control: Supplied by Underhill Geomatics, Whitehorse Yukon

UMA Engineering Ltd.
• Consulting • Engineering • Construction • Management Services

GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

TITLE:	SURFACE WATER SAMPLING LOCATIONS		
JOB No.	6029-005-00	DATE:	JUNE 2004
SCALE:	1:15,000	DWG. No.	C-1
CHECKED:	GR		

Plot Scale: 1:1
Plot Time: Jun 16, 2004 - 10:38am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\C1_SurfaceWater.dwg - Tab: C1

Table C - 1: Anion and Nutrient Concentrations (mg/L) in Surface Water Samples.

Note: Concentration in bold exceed the guideline limits.

	Hardness	Bromide	Chloride	Fluoride	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N
BC Water Quality Guidelines (mg/L)			***150***	***0.3***	***100***	***1.98***	***40***	***0.02***
HL-03-01	209	<0.05	<0.5	0.11	***111**	0.017	0.16	0.002
HL-03-02	206	<0.05	<0.5	0.1	**112**	0.016	0.16	0.002
HL-03-03	322	<0.05	<0.5	0.19	**144**	<0.005	0.048	<0.001
HL-03-04	220	<0.05	<0.5	0.1	**112**	0.017	0.16	0.002
HL-03-05	212	<0.05	<0.5	0.1	**110**	0.016	0.16	0.002
HL-03-06	214	<0.05	<0.5	0.1	**112**	0.014	0.16	0.002
WC-03-01	362	<0.05	<0.5	0.15	**235**	<0.02	0.079	0.001
WC-03-02	364	<0.05	<0.5	0.15	**221**	<0.02	0.066	0.001
WC-03-03	346	<0.05	0.8	0.12	**206**	<0.02	0.11	0.008
WC-03-04	342	<0.05	0.8	0.12	**208**	<0.02	0.12	0.012
WC-03-05	364	<0.05	1.1	0.14	**202**	<0.02	0.098	0.005
PP-03-01	2630	0.14	40	0.07	**2290**	<0.005	0.5	0.023
PC-03-01	1440	<0.05	0.8	**0.3**	**1090**	<0.005	0.31	<0.001
PC-03-02	1410	<0.05	0.8	0.29	**1070**	<0.005	0.32	<0.001
PC-03-03	1250	<0.05	0.7	0.28	**966**	0.011	0.35	0.001
PC-03-04	1630	<0.05	3.7	0.17	**1200**	<0.005	0.38	0.002
CC-03-01	300	<0.05	<0.5	0.11	**164**	<0.02	0.15	0.002
CC-03-02	305	<0.05	0.6	0.12	**169**	<0.02	0.14	0.002
CC-03-03	254	<0.05	<0.5	0.11	**133**	<0.02	0.16	0.002
CC-03-04	282	<0.05	0.8	0.12	**161**	<0.02	0.16	0.002
CC-03-05	405	<0.05	1.4	0.13	**237**	<0.02	0.13	0.002
CC-03-06	419	<0.05	1.6	0.13	**242**	<0.02	0.12	0.002
CC-03-07	425	<0.05	1.6	0.12	**242**	<0.02	0.13	0.002
FM-03-01	113	<0.05	1.1	0.11	43	<0.02	0.14	0.001
FM-03-02	299	<0.05	1.4	0.12	**150**	<0.02	0.12	0.001
EC-03-01	257	<0.05	<0.5	0.13	**115**	<0.02	0.18	<0.001
MC-03-01	131	<0.05	<0.5	0.08	45	<0.02	0.32	<0.001

Table C - 2: Metal/Metalloid Concentrations (mg/L) in Surface Water Samples.

Note: Concentration in bold exceed the guideline limits.

Sample ID	Water Quality Guideline	Source	HL-03-03	HL-03-01	HL-03-02	HL-03-04	HL-03-05	HL-03-06	PP-03-01	PC-03-01	PC-03-02	PC-03-03	PC-03-04	WC-03-01	WC-03-02	WC-03-03	WC-03-04	WC-03-05	CC-03-01	CC-03-02	CC-03-03	CC-03-04	CC-03-05	CC-03-06	CC-03-07	FM-03-01	FM-03-02	EC-03-01	MC-03-01
			(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)
Aluminum	0.005-0.1	CCME	0.014	0.174	0.188	0.123	0.132	0.148	<0.05	<0.03	<0.03	<0.03	<0.03	0.046	0.026	0.026	0.025	0.031	0.081	0.06	0.111	0.048	0.04	0.07	0.03	0.039	0.035	0.023	0.011
Antimony			0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.023	0.003	<0.003	0.003	<0.003	<0.0005	<0.0005	0.0009	0.0009	0.0014	<0.0005	0.0006	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.0005	<0.0005	<0.0005	<0.0005
Arsenic	0.005	CCME	0.0007	0.0009	0.0009	0.0007	0.0007	0.0007	<0.005	**0.017**	**0.016**	**0.016**	0.003	<0.0005	0.0005	0.0008	0.0008	0.0018	0.001	0.0011	0.0007	0.0007	<0.001	<0.001	<0.001	<0.0005	0.0005	0.0006	<0.0005
Barium			0.05	0.05	0.05	0.05	0.05	0.05	<0.02	0.02	<0.02	0.02	0.03	0.04	0.05	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.04	0.04	0.04	0.04	0.05	0.06	0.05
Beryllium			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001
Boron	1.2	BC	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	**5.3**	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	0.000017	CCME	**<0.00005**	**0.00007**	**0.00009**	**0.00007**	**0.00006**	**0.00006**	**<0.0005**	**<0.0003**	**<0.0003**	**<0.0003**	**<0.0003**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**<0.00005**	**0.00006**	**0.00005**	**0.00006**	**0.00007**	**<0.0001**	**<0.0001**	**<0.0001**	**<0.00005**	**<0.00005**	**0.00005**	**<0.00005**
Calcium			60.5	43.9	43.2	46.8	44.9	45.3	139	316	310	278	231	67.4	67.7	56.7	55.8	54.6	59.1	56.5	52.7	59.4	69.8	72.5	74.1	29	56.3	60.4	35
Chromium	0.0089	CCME (Cr(III))	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.01	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.002	<0.002	<0.001	<0.001	<0.001	<0.001
Cobalt			<0.0003	0.0007	0.0008	0.0005	0.0004	0.0005	<0.003	<0.002	<0.002	<0.002	<0.002	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.0005	0.0005	0.0004	<0.0003	0.0007	0.0007	0.0007	<0.0003	<0.0003	<0.0003	<0.0003
Copper	0.002-0.004	CCME	0.001	**0.004**	**0.004**	**0.004**	**0.003**	**0.003**	<0.01	<0.005	<0.005	<0.005	<0.005	0.002	0.002	0.002	0.002	0.002	**0.003**	**0.003**	**0.003**	**0.003**	0.002	0.002	**0.003**	0.002	**0.003**	0.002	0.002
Iron	0.3	CCME	0.17	**0.63**	**0.67**	**0.4**	**0.36**	**0.41**	0.04	<0.03	<0.03	<0.03	<0.03	0.19	0.2	0.17	0.17	0.09	**0.31**	**0.28**	**0.35**	0.17	**0.33**	**0.33**	**0.34**	0.09	0.14	0.05	<0.03
Lead	0.001-0.007	CCME	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.0005	<0.0005	<0.0005	<0.0005
Lithium			0.007	<0.005	<0.005	<0.005	<0.005	<0.005	0.16	<0.03	<0.03	<0.03	0.04	<0.005	<0.005	<0.005	<0.005	0.008	0.005	0.006	0.005	<0.005	0.01	0.02	0.02	<0.005	0.012	<0.005	<0.005
Magnesium			41.4	24.1	23.8	25.2	24.3	24.5	554	158	154	135	257	46.9	47.4	49.5	49.2	55.2	37.1	39.8	29.6	32.4	55.9	57.7	58.4	9.7	38.6	25.8	10.7
Manganese	1.9	BC	0.079	0.16	0.16	0.17	0.16	0.16	0.021	<0.002	<0.002	<0.002	<0.002	0.041	0.065	0.047	0.044	0.034	0.11	0.095	0.097	0.052	0.18	0.2	0.2	0.0112	0.0685	0.006	0.0029
Mercury	0.0001	CCME	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	0.073	CCME	<0.001	0.001	0.001	0.001	0.001	0.001	0.01	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	0.001	0.001	<0.002	<0.002	<0.002	<0.001	0.001	0.001	<0.001
Nickel	0.025-0.150	CCME	0.002	0.008	0.005	0.005	0.005	0.005	0.05	0.022	0.022	0.022	0.092	0.003	0.003	0.005	0.006	0.014	0.01	0.011	0.006	0.008	0.019	0.02	0.02	0.002	0.009	0.004	0.001
Potassium			<2	<2	<2	<2	<2	<2	5	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Selenium	0.001	CCME	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.01	**0.011**	**0.012**	**0.016**	<0.005	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.001	0.001	**0.002**	<0.002	<0.002	<0.002	<0.001	<0.001	**0.003**	<0.001
Silver	0.0001	CCME	<0.00002	<0.00006	<0.00003	<0.00002	<0.00002	<0.00002	<0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.00002	<0.00002	<0.00002	<0.00002	<0.00004	<0.00002	<0.00002	<0.00002	<0.00002	<0.00004	<0.00004	<0.00004	<0.00002	<0.00002	<0.00002	<0.00002
Sodium			3	2	2	2	2	2	40	3	3	3	11	3	4	3	3	4	3	3	2	4	5	5	5	5	5	3	<2
Thallium			<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0004	<0.0004	<0.0004	<0.0002	<0.0002	<0.0002	<0.0002
Tin			<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.005	<0.003	<0.003	<0.003	<0.003	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.0005	<0.0005	<0.0005	<0.0005
Titanium			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium			0.0049	0.0018	0.0019	0.0019	0.0018	0.0018	0.01	0.006	0.006	0.005	0.006	0.0044	0.004	0.0029	0.0028	0.0021	0.002	0.0021	0.0023	0.0021	0.0023	0.0024	0.0024	0.0012	0.0019	0.0019	0.0013
Vanadium			<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	0.03	CCME	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.05	<0.03	<0.03	<0.03	<0.03	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.01	<0.01	<0.01	<0.005	<0.005	<0.005	<0.005

Table C - 3: Elemental Results for Bulk Samples of Serpentinite Rock, Argillite Waste Rock and Tailings (mg / kg, ppm)

Sample:	**CC03 - 01**	**CC03 - 03**	**CC03 - 04**	**CC03 - 05**	**CC03 - 02**	**CC03 - 06**	**CC03 - 07**
Material:	*Serpentinite*	*Serpentinite*	*Serpentinite*	*Serpentinite*	*Argillite*	*Argillite*	*Tailings*
Element	(mg/kg, ppm)	(mg/kg, ppm)	(mg/kg, ppm)	(mg/kg, ppm)	(mg/kg, ppm)	(mg/kg, ppm)	(mg/kg, ppm)
Aluminum	1,100	700	1,400	600	19,600	22,300	2,800
Antimony	6.9	10.4	8.5	9.1	0.3	0.5	1.5
Arsenic	31	63	41	8.3	3.2	8.5	7.7
Barium	500	326	822	298	82	208	117
Bismuth	<0.1	<0.1	<0.1	<0.1	0.2	0.4	<0.1
Boron	12	8	12	2	1	< 1	153
Cadmium	<0.1	<0.1	<0.1	<0.1	0.6	0.9	<0.1
Calcium	32,700	19,400	37,100	24,300	15,900	17,000	3,600
Chromium	507	531	671	450	39	38	1,402
Cobalt	58	54	66	55	8.8	17	86
Copper	13	4.2	10	24	24	40	9.6
Gallium	< 1	1	1	< 1	5	6	1
Gold	24	3.2	4.5	4.1	1.3	0.5	2.3
Iron	35,700	37,400	36,400	33,700	32,500	40,900	46,200
Lanthanum	< 1	< 1	1	< 1	12	9	< 1
Lead	0.9	0.7	1	0.5	7.4	21.4	0.6
Magnesium	121,500	126,300	121,000	121,200	13,300	13,100	168,700
Manganese	860	768	1,039	619	522	580	622
Mercury	1.82	1.61	1.3	1.69	0.04	0.13	0.01
Molybdenum	0.2	0.3	0.3	0.2	1.5	8.1	0.2
Nickel	1,185	1,064	1,305	1,219	49	53	1,759
Phosphorus	20	10	40	<10	490	620	10
Potassium	200	100	200	100	1,000	1,300	<100
Scandium	5.4	6.4	6.6	5.1	2.1	3	6
Selenium	< .5	< .5	0.5	0.5	1.3	2.4	< .5
Silver	<0.1	<0.1	<0.1	<0.1	0.1	0.2	<0.1
Sodium	80	90	70	60	230	260	40
Strontium	137	101	137	123	96	99	56
Sulfur	2,300	2,300	1,000	1,500	1,600	4,100	900
Telurium	0.3	0.2	0.4	0.3	0.1	0.1	<0.1
Throium	0.1	<0.1	0.2	<0.1	3.9	5	<0.1
Titanium	10	10	10	10	20	10	30
Tungsten	0.5	0.7	0.9	0.4	<0.1	0.1	0.2
Uranium	0.1	0.1	0.2	0.1	0.6	2	0.1
Vanadium	22	22	21	18	21	27	23
Zinc	10	7	13	7	113	119	9

Table C - 4: Results of Modified SWEPs (50g dry weight:1L DI)

Concentrations in mg/L, unless indicated otherwise.

Sample:	**CC-03-01**	**CC-03-03**	**CC-03-04**	**CC-03-05**	**CC-03-02**	**CC-03-06**	**CC-03-07**
Material:	*Serpentinite*	*Serpentinite*	*Serpentinite*	*Serpentinite*	*Argillite*	*Argillite*	*Tailings*
pH	9.15	9.34	9.18	9.36	8.52	8.21	9.83
EC (uS/cm)							
Dissolved Metals							
Aluminum Al	0.017	0.023	0.012	0.019	0.26	0.081	0.006
Antimony Sb	0.003	0.003	0.003	0.002	<0.001	<0.001	0.005
Arsenic As	0.005	0.006	0.004	<0.001	<0.001	<0.001	<0.001
Barium Ba	0.46	0.35	0.43	0.55	0.008	0.018	0.094
Beryllium Be	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bismuth Bi	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron B	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.16
Cadmium Cd	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Calcium Ca	6.71	4.99	5.06	3.41	37.2	118	1.62
Chromium Cr	0.004	0.003	0.005	0.003	<0.001	<0.001	0.003
Cobalt Co	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper Cu	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Iron Fe	<0.05	<0.05	<0.05	<0.05	<0.05	0.18	<0.05
Lead Pb	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium Li	0.003	0.002	0.003	0.002	0.002	0.004	0.001
Magnesium Mg	7.95	8.68	7.86	8.61	5.62	10.3	43.7
Manganese Mn	<0.001	<0.001	<0.001	<0.001	0.003	0.01	<0.001
Mercury Hg	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Molybdenum Mo	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0039	0.014	0.0009
Nickel Ni	0.002	<0.001	0.002	<0.001	0.001	<0.001	<0.001
Phosphorus PO4	0.1	0.1	0.1	0.09	0.1	0.17	0.1
Potassium K	0.91	0.66	0.96	0.64	2.2	2.63	0.48
Selenium Se	<0.001	<0.001	<0.001	<0.001	0.007	<0.001	<0.001
Silicon SiO2	5.81	3.68	6.82	3.44	2.72	2.26	0.54
Silver Ag	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sodium Na	0.25	0.23	0.26	0.15	1.18	0.98	0.94
Strontium Sr	0.072	0.057	0.059	0.052	0.16	0.54	0.041
Tellurium Te	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Thallium Tl	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Thorium Th	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Tin Sn	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Titanium Ti	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium U	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0006	< 0.0005
Vanadium V	0.002	0.001	0.001	<0.001	<0.001	<0.001	<0.001
Zinc Zn	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zirconium Zr	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01

Table C - 5: ABA Results for Clinton Creek Samples (Sobek Method)

Sample	*Material*	Paste PH	Total Sulfur (Wt.%)	Sulfate Sulfur (Wt.%)	Sulfide Sulfur* (Wt.%)	Maximum Potential Acidity** (Kg CaCO3/ Tonne)	Neutralization Potential (Kg CaCO3/Tonne)	Net Neutralization Potential (Kg CaCO3/Tonne)	Fizz Rating
CC03-01	*Serpentinite*	8.5	0.16	<0.01	0.16	5.0	438.4	433.4	moderate
CC03-03	*Serpentinite*	8.8	0.25	<0.01	0.25	7.8	441.0	433.2	moderate
CC03-04	*Serpentinite*	8.6	0.12	<0.01	0.12	3.8	434.7	431.0	moderate
CC03-05	*Serpentinite*	9	0.14	<0.01	0.14	4.4	430.9	426.5	moderate
CC03-02	*Argillite*	7.6	0.17	0.08	0.09	2.8	51.5	48.7	moderate
CC03-06	*Argillite*	7.6	0.59	0.22	0.37	11.6	47.7	36.1	moderate
CC03-07	*Tailings*	9	0.06	0.03	0.03	0.9	261.3	260.4	moderate

ALS Environmental

CHEMICAL ANALYSIS REPORT

Date:	October 14, 2003
ALS File No.	T4585
Report On:	6029-00500 Water Analysis
Report To:	**UMA Engineering Ltd.** 301 - 546 Yates Victoria, BC V8W 1K8
Attention:	**Mr. Doug A. Bright**
Received:	September 29, 2003

ALS ENVIRONMENTAL
per:

Brent Mack

Brent C. Mack, B.Sc. - Project Chemist
Leanne Harris, B.Sc. - Project Chemist

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Victoria, BC
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Attention: **Mr. Doug A. Bright**

Received: September 29, 2003

ALS ENVIRONMENTAL
per:

Brent Mack

Brent C. Mack, B.Sc. - Project Chemist
Leanne Harris, B.Sc. - Project Chemist

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		PC-03-01	PC-03-02	PC-03-03	PC-03-04	PP-03-01
Sample Date		03 09 23	03 09 23	03 09 23	03 09 23	03 09 23
Sample Time		15:45	15:55	16:25	16:45	17:10
ALS ID		*1*	*2*	*3*	*4*	*5*
Physical Tests						
Hardness	CaCO3	1440	1410	1250	1630	2630
Dissolved Anions						
Bromide	Br	<0.05	<0.05	<0.05	<0.05	0.14
Chloride	Cl	0.8	0.8	0.7	3.7	40.0
Fluoride	F	0.30	0.29	0.28	0.17	0.07
Sulphate	SO4	1090	1070	966	1200	2290
Nutrients						
Ammonia Nitrogen	N	<0.005	<0.005	0.011	<0.005	<0.005
Nitrate Nitrogen	N	0.313	0.319	0.350	0.379	0.499
Nitrite Nitrogen	N	<0.001	<0.001	0.001	0.002	0.023

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< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		PC-03-01	PC-03-02	PC-03-03	PC-03-04	PP-03-01
Sample Date		03 09 23	03 09 23	03 09 23	03 09 23	03 09 23
Sample Time		15:45	15:55	16:25	16:45	17:10
ALS ID		*1*	*2*	*3*	*4*	*5*
Total Metals						
Aluminum	T-Al	<0.03	<0.03	<0.03	<0.03	<0.05
Antimony	T-Sb	0.003	<0.003	0.003	<0.003	0.023
Arsenic	T-As	0.017	0.016	0.016	0.003	<0.005
Barium	T-Ba	0.02	<0.02	0.02	0.03	<0.02
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	<0.01
Boron	T-B	<0.1	<0.1	<0.1	0.1	5.3
Cadmium	T-Cd	<0.0003	<0.0003	<0.0003	<0.0003	<0.0005
Calcium	T-Ca	316	310	278	231	139
Chromium	T-Cr	<0.005	<0.005	<0.005	<0.005	<0.01
Cobalt	T-Co	<0.002	<0.002	<0.002	<0.002	<0.003
Copper	T-Cu	<0.005	<0.005	<0.005	<0.005	<0.01
Iron	T-Fe	<0.03	<0.03	<0.03	<0.03	0.04
Lead	T-Pb	<0.003	<0.003	<0.003	<0.003	<0.005
Lithium	T-Li	<0.03	<0.03	<0.03	0.04	0.16
Magnesium	T-Mg	158	154	135	257	554
Manganese	T-Mn	<0.002	<0.002	<0.002	<0.002	0.021
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.005	<0.005	<0.005	<0.005	0.01
Nickel	T-Ni	0.022	0.022	0.022	0.092	0.05
Potassium	T-K	<2	<2	<2	<2	5
Selenium	T-Se	0.011	0.012	0.016	<0.005	<0.01
Silver	T-Ag	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002
Sodium	T-Na	3	3	3	11	40
Thallium	T-Tl	<0.001	<0.001	<0.001	<0.001	<0.002
Tin	T-Sn	<0.003	<0.003	<0.003	<0.003	<0.005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.006	0.006	0.005	0.006	0.010
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.03	<0.03	<0.03	<0.03	<0.05

Remarks regarding the analyses appear at the beginning of this report.
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< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		HL-03-01	HL-03-02	HL-03-03	HL-03-04	HL-03-05
Sample Date		03 09 23	03 09 23	03 09 23	03 09 23	03 09 23
Sample Time		17:50	18:05	18:45	19:00	19:05
ALS ID		*6*	*7*	*8*	*9*	*10*
Physical Tests						
Hardness	CaCO3	209	206	322	220	212
Dissolved Anions						
Bromide	Br	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	Cl	<0.5	<0.5	<0.5	<0.5	<0.5
Fluoride	F	0.11	0.10	0.19	0.10	0.10
Sulphate	SO4	111	112	144	112	110
Nutrients						
Ammonia Nitrogen	N	0.017	0.016	<0.005	0.017	0.016
Nitrate Nitrogen	N	0.161	0.162	0.048	0.160	0.164
Nitrite Nitrogen	N	0.002	0.002	<0.001	0.002	0.002

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File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		HL-03-01	HL-03-02	HL-03-03	HL-03-04	HL-03-05
Sample Date		03 09 23	03 09 23	03 09 23	03 09 23	03 09 23
Sample Time		17:50	18:05	18:45	19:00	19:05
ALS ID		*6*	*7*	*8*	*9*	*10*
Total Metals						
Aluminum	T-Al	0.174	0.188	0.014	0.123	0.132
Antimony	T-Sb	<0.0005	<0.0005	0.0006	<0.0005	<0.0005
Arsenic	T-As	0.0009	0.0009	0.0007	0.0007	0.0007
Barium	T-Ba	0.05	0.05	0.05	0.05	0.05
Beryllium	T-Be	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.00007	0.00009	<0.00005	0.00007	0.00006
Calcium	T-Ca	43.9	43.2	60.5	46.8	44.9
Chromium	T-Cr	0.002	<0.001	<0.001	<0.001	<0.001
Cobalt	T-Co	0.0007	0.0008	<0.0003	0.0005	0.0004
Copper	T-Cu	0.004	0.004	0.001	0.004	0.003
Iron	T-Fe	0.63	0.67	0.17	0.40	0.36
Lead	T-Pb	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Lithium	T-Li	<0.005	<0.005	0.007	<0.005	<0.005
Magnesium	T-Mg	24.1	23.8	41.4	25.2	24.3
Manganese	T-Mn	0.164	0.161	0.0786	0.172	0.162
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	0.001	0.001	<0.001	0.001	0.001
Nickel	T-Ni	0.008	0.005	0.002	0.005	0.005
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	0.001	0.001	<0.001	<0.001	<0.001
Silver	T-Ag	<0.00006	<0.00003	<0.00002	<0.00002	<0.00002
Sodium	T-Na	2	2	3	2	2
Thallium	T-Tl	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Tin	T-Sn	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.0018	0.0019	0.0049	0.0019	0.0018
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005	<0.005	<0.005	<0.005

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< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID			HL-03-06	WC-03-01	WC-03-02	WC-03-03	WC-03-04
Sample Date			03 09 23	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time			19:35	11:45	12:00	12:10	12:30
ALS ID			*11*	*12*	*13*	*14*	*15*
Physical Tests							
Hardness	CaCO3		214	362	364	346	342
Dissolved Anions							
Bromide	Br		<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	Cl		<0.5	<0.5	<0.5	0.8	0.8
Fluoride	F		0.10	0.15	0.15	0.12	0.12
Sulphate	SO4		112	235	221	206	208
Nutrients							
Ammonia Nitrogen		N	0.014	<0.02	<0.02	<0.02	<0.02
Nitrate Nitrogen		N	0.161	0.079	0.066	0.110	0.122
Nitrite Nitrogen		N	0.002	0.001	0.001	0.008	0.012

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File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		HL-03-06	WC-03-01	WC-03-02	WC-03-03	WC-03-04
Sample Date		03 09 23	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time		19:35	11:45	12:00	12:10	12:30
ALS ID		*11*	*12*	*13*	*14*	*15*
Total Metals						
Aluminum	T-Al	0.148	0.046	0.026	0.026	0.025
Antimony	T-Sb	<0.0005	<0.0005	<0.0005	0.0009	0.0009
Arsenic	T-As	0.0007	<0.0005	0.0005	0.0008	0.0008
Barium	T-Ba	0.05	0.04	0.05	0.04	0.04
Beryllium	T-Be	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	0.00006	<0.00005	<0.00005	<0.00005	<0.00005
Calcium	T-Ca	45.3	67.4	67.7	56.7	55.8
Chromium	T-Cr	<0.001	<0.001	<0.001	<0.001	0.001
Cobalt	T-Co	0.0005	<0.0003	<0.0003	<0.0003	<0.0003
Copper	T-Cu	0.003	0.002	0.002	0.002	0.002
Iron	T-Fe	0.41	0.19	0.20	0.17	0.17
Lead	T-Pb	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Lithium	T-Li	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	T-Mg	24.5	46.9	47.4	49.5	49.2
Manganese	T-Mn	0.161	0.0413	0.0651	0.0467	0.0435
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	0.001	<0.001	<0.001	<0.001	<0.001
Nickel	T-Ni	0.005	0.003	0.003	0.005	0.006
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.001	<0.001	<0.001	<0.001	<0.001
Silver	T-Ag	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Sodium	T-Na	2	3	4	3	3
Thallium	T-Tl	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Tin	T-Sn	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.0018	0.0044	0.0040	0.0029	0.0028
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005	<0.005	<0.005	<0.005

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RESULTS OF ANALYSIS - Water

Sample ID		WC-03-05	CC-03-01	CC-03-02	CC-03-03	CC-03-04
Sample Date		03 09 24	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time		12:45	12:50	12:55	14:30	14:50
ALS ID		*16*	*17*	*18*	*19*	*20*
Physical Tests						
Hardness	CaCO3	364	300	305	254	282
Dissolved Anions						
Bromide	Br	<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	Cl	1.1	<0.5	0.6	<0.5	0.8
Fluoride	F	0.14	0.11	0.12	0.11	0.12
Sulphate	SO4	202	164	169	133	161
Nutrients						
Ammonia Nitrogen	N	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate Nitrogen	N	0.098	0.154	0.140	0.159	0.158
Nitrite Nitrogen	N	0.005	0.002	0.002	0.002	0.002

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File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		WC-03-05	CC-03-01	CC-03-02	CC-03-03	CC-03-04
Sample Date		03 09 24	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time		12:45	12:50	12:55	14:30	14:50
ALS ID		*16*	*17*	*18*	*19*	*20*
Total Metals						
Aluminum	T-Al	0.031	0.081	0.060	0.111	0.048
Antimony	T-Sb	0.0014	<0.0005	0.0006	<0.0005	<0.0005
Arsenic	T-As	0.0018	0.0010	0.0011	0.0007	0.0007
Barium	T-Ba	0.05	0.05	0.05	0.05	0.06
Beryllium	T-Be	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	T-B	0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	<0.00005	0.00006	0.00005	0.00006	0.00007
Calcium	T-Ca	54.6	59.1	56.5	52.7	59.4
Chromium	T-Cr	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	T-Co	<0.0003	0.0005	0.0005	0.0004	<0.0003
Copper	T-Cu	0.002	0.003	0.003	0.003	0.003
Iron	T-Fe	0.09	0.31	0.28	0.35	0.17
Lead	T-Pb	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Lithium	T-Li	0.008	0.005	0.006	0.005	<0.005
Magnesium	T-Mg	55.2	37.1	39.8	29.6	32.4
Manganese	T-Mn	0.0336	0.113	0.0951	0.0973	0.0519
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	0.001	0.001	0.001	0.001	0.001
Nickel	T-Ni	0.014	0.010	0.011	0.006	0.008
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.001	0.001	0.001	0.001	0.002
Silver	T-Ag	<0.00004	<0.00002	<0.00002	<0.00002	<0.00002
Sodium	T-Na	4	3	3	2	4
Thallium	T-Tl	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Tin	T-Sn	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.0021	0.0020	0.0021	0.0023	0.0021
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005	<0.005	<0.005	<0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID			CC-03-05	CC-03-06	CC-03-07	EC-03-01	FM-03-01
Sample Date			03 09 24	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time			15:10	15:20	15:25	14:45	15:45
ALS ID			*21*	*22*	*23*	*24*	*25*
Physical Tests							
Hardness	CaCO3		405	419	425	257	113
Dissolved Anions							
Bromide	Br		<0.05	<0.05	<0.05	<0.05	<0.05
Chloride	Cl		1.4	1.6	1.6	<0.5	1.1
Fluoride	F		0.13	0.13	0.12	0.13	0.11
Sulphate	SO4		237	242	242	115	43
Nutrients							
Ammonia Nitrogen		N	<0.02	<0.02	<0.02	<0.02	<0.02
Nitrate Nitrogen		N	0.129	0.122	0.126	0.178	0.136
Nitrite Nitrogen		N	0.002	0.002	0.002	<0.001	0.001

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		CC-03-05	CC-03-06	CC-03-07	EC-03-01	FM-03-01
Sample Date		03 09 24	03 09 24	03 09 24	03 09 24	03 09 24
Sample Time		15:10	15:20	15:25	14:45	15:45
ALS ID		*21*	*22*	*23*	*24*	*25*
Total Metals						
Aluminum	T-Al	0.04	0.07	0.03	0.023	0.039
Antimony	T-Sb	<0.001	<0.001	<0.001	<0.0005	<0.0005
Arsenic	T-As	<0.001	<0.001	<0.001	0.0006	<0.0005
Barium	T-Ba	0.04	0.04	0.04	0.06	0.04
Beryllium	T-Be	<0.002	<0.002	<0.002	<0.001	<0.001
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	<0.0001	<0.0001	<0.0001	0.00005	<0.00005
Calcium	T-Ca	69.8	72.5	74.1	60.4	29.0
Chromium	T-Cr	<0.002	<0.002	<0.002	<0.001	<0.001
Cobalt	T-Co	0.0007	0.0007	0.0007	<0.0003	<0.0003
Copper	T-Cu	0.002	0.002	0.003	0.002	0.002
Iron	T-Fe	0.33	0.33	0.34	0.05	0.09
Lead	T-Pb	<0.001	<0.001	<0.001	<0.0005	<0.0005
Lithium	T-Li	0.01	0.02	0.02	<0.005	<0.005
Magnesium	T-Mg	55.9	57.7	58.4	25.8	9.7
Manganese	T-Mn	0.179	0.201	0.203	0.0060	0.0112
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.002	<0.002	<0.002	0.001	<0.001
Nickel	T-Ni	0.019	0.020	0.020	0.004	0.002
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.002	<0.002	<0.002	0.003	<0.001
Silver	T-Ag	<0.00004	<0.00004	<0.00004	<0.00002	<0.00002
Sodium	T-Na	5	5	5	3	5
Thallium	T-Tl	<0.0004	<0.0004	<0.0004	<0.0002	<0.0002
Tin	T-Sn	<0.001	<0.001	<0.001	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.0023	0.0024	0.0024	0.0019	0.0012
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.01	<0.01	<0.01	<0.005	<0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID			FM-03-02	MC-03-01
Sample Date			03 09 24	03 09 24
Sample Time			16:10	16:20
ALS ID			*26*	*27*
Physical Tests				
Hardness	CaCO3		299	131
Dissolved Anions				
Bromide	Br		<0.05	<0.05
Chloride	Cl		1.4	<0.5
Fluoride	F		0.12	0.08
Sulphate	SO4		150	45
Nutrients				
Ammonia Nitrogen		N	<0.02	<0.02
Nitrate Nitrogen		N	0.123	0.320
Nitrite Nitrogen		N	0.001	<0.001

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

RESULTS OF ANALYSIS - Water

Sample ID		FM-03-02	MC-03-01
Sample Date		03 09 24	03 09 24
Sample Time		16:10	16:20
ALS ID		*26*	*27*
Total Metals			
Aluminum	T-Al	0.035	0.011
Antimony	T-Sb	<0.0005	<0.0005
Arsenic	T-As	0.0005	<0.0005
Barium	T-Ba	0.05	0.05
Beryllium	T-Be	<0.001	<0.001
Boron	T-B	<0.1	<0.1
Cadmium	T-Cd	<0.00005	<0.00005
Calcium	T-Ca	56.3	35.0
Chromium	T-Cr	<0.001	<0.001
Cobalt	T-Co	<0.0003	<0.0003
Copper	T-Cu	0.003	0.002
Iron	T-Fe	0.14	<0.03
Lead	T-Pb	<0.0005	<0.0005
Lithium	T-Li	0.012	<0.005
Magnesium	T-Mg	38.6	10.7
Manganese	T-Mn	0.0685	0.0029
Mercury	T-Hg	<0.00005	<0.00005
Molybdenum	T-Mo	0.001	<0.001
Nickel	T-Ni	0.009	0.001
Potassium	T-K	<2	<2
Selenium	T-Se	<0.001	<0.001
Silver	T-Ag	<0.00002	<0.00002
Sodium	T-Na	5	<2
Thallium	T-Tl	<0.0002	<0.0002
Tin	T-Sn	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01
Uranium	T-U	0.0019	0.0013
Vanadium	T-V	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

Appendix 1 - QUALITY CONTROL - Replicates

Water			PP-03-01	PP-03-01	WC-03-04	WC-03-04
			03 09 23 17:10	QC # 356859	03 09 24 12:30	QC # 356860
Physical Tests						
Hardness	CaCO3		2630	2580	342	342
Dissolved Anions						
Bromide	Br		0.14	0.15	<0.05	<0.05
Chloride	Cl		40.0	39.9	0.8	0.8
Fluoride	F		0.07	0.06	0.12	0.13
Sulphate	SO4		2290	2300	208	208
Nutrients						
Nitrate Nitrogen		N	0.499	0.509	0.122	0.123
Nitrite Nitrogen		N	0.023	0.024	0.012	0.011

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

Appendix 1 - QUALITY CONTROL - Replicates

Water		PP-03-01	PP-03-01	WC-03-04	WC-03-04
		03 09 23 17:10	QC # 356859	03 09 24 12:30	QC # 356860
Total Metals					
Aluminum	T-Al	<0.05	<0.05	0.025	0.025
Antimony	T-Sb	0.023	0.022	0.0009	0.0009
Arsenic	T-As	<0.005	<0.005	0.0008	0.0008
Barium	T-Ba	<0.02	<0.02	0.04	0.04
Beryllium	T-Be	<0.01	<0.01	<0.001	<0.001
Boron	T-B	5.3	5.2	<0.1	<0.1
Cadmium	T-Cd	<0.0005	<0.0005	<0.00005	<0.00005
Calcium	T-Ca	139	135	55.8	55.5
Chromium	T-Cr	<0.01	<0.01	0.001	0.001
Cobalt	T-Co	<0.003	<0.003	<0.0003	<0.0003
Copper	T-Cu	<0.01	<0.01	0.002	0.002
Iron	T-Fe	0.04	0.03	0.17	0.20
Lead	T-Pb	<0.005	<0.005	<0.0005	<0.0005
Lithium	T-Li	0.16	0.15	<0.005	<0.005
Magnesium	T-Mg	554	545	49.2	49.3
Manganese	T-Mn	0.021	0.021	0.0435	0.0432
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	0.01	0.01	<0.001	<0.001
Nickel	T-Ni	0.05	0.05	0.006	0.006
Potassium	T-K	5	5	<2	<2
Selenium	T-Se	<0.01	<0.01	<0.001	<0.001
Silver	T-Ag	<0.0002	<0.0002	<0.00002	<0.00002
Sodium	T-Na	40	40	3	3
Thallium	T-Tl	<0.002	<0.002	<0.0002	<0.0002
Tin	T-Sn	<0.005	<0.005	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01
Uranium	T-U	0.010	0.010	0.0028	0.0028
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.05	<0.05	<0.005	<0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

Appendix 1 - QUALITY CONTROL - Replicates

Water			FM-03-01	FM-03-01
			03 09 24 15:45	QC # 356861
Physical Tests				
Hardness	CaCO3		113	115
Dissolved Anions				
Bromide	Br		<0.05	<0.05
Chloride	Cl		1.1	1.1
Fluoride	F		0.11	0.10
Sulphate	SO4		43	43
Nutrients				
Nitrate Nitrogen		N	0.136	0.138
Nitrite Nitrogen		N	0.001	0.001

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

File No. T4585

Appendix 1 - QUALITY CONTROL - Replicates

Water		FM-03-01	FM-03-01
		03 09 24 15:45	QC # 356861
Total Metals			
Aluminum	T-Al	0.039	0.039
Antimony	T-Sb	<0.0005	<0.0005
Arsenic	T-As	<0.0005	<0.0005
Barium	T-Ba	0.04	0.04
Beryllium	T-Be	<0.001	<0.001
Boron	T-B	<0.1	<0.1
Cadmium	T-Cd	<0.00005	<0.00005
Calcium	T-Ca	29.0	29.8
Chromium	T-Cr	<0.001	<0.001
Cobalt	T-Co	<0.0003	<0.0003
Copper	T-Cu	0.002	0.002
Iron	T-Fe	0.09	0.10
Lead	T-Pb	<0.0005	<0.0005
Lithium	T-Li	<0.005	<0.005
Magnesium	T-Mg	9.7	9.8
Manganese	T-Mn	0.0112	0.0115
Mercury	T-Hg	<0.00005	<0.00005
Molybdenum	T-Mo	<0.001	<0.001
Nickel	T-Ni	0.002	0.002
Potassium	T-K	<2	<2
Selenium	T-Se	<0.001	<0.001
Silver	T-Ag	<0.00002	<0.00002
Sodium	T-Na	5	5
Thallium	T-Tl	<0.0002	<0.0002
Tin	T-Sn	<0.0005	<0.0005
Titanium	T-Ti	<0.01	<0.01
Uranium	T-U	0.0012	0.0012
Vanadium	T-V	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005

Remarks regarding the analyses appear at the beginning of this report.
Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Appendix 2 - METHODOLOGY

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows

Conventional Parameters in Water

These analyses are carried out in accordance with procedures described in "Methods for Chemical Analysis of Water and Wastes" (USEPA), "Manual for the Chemical Analysis of Water, Wastewaters, Sediments and Biological Tissues" (BCMOE), and/or "Standard Methods for the Examination of Water and Wastewater" (APHA). Further details are available on request.

Dissolved Anions in Water by Ion Chromatography

This analysis is carried out using procedures adapted from APHA Method 4110 "Determination of Anions by Ion Chromatography" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Anions are determined by filtering the sample through a 0.45 micron membrane filter and injecting the filtrate onto a Dionex IonPac AG17 anion exchange column with a hydroxide eluent stream. Anions routinely determined by this method include: bromide, chloride, fluoride, nitrate, nitrite and sulphate.

Recommended Holding Time:
Sample: 28 days (bromide, chloride, fluoride, sulphate)
Sample: 2 days (nitrate, nitrite)
Reference: APHA and EPA
For more detail see ALS Environmental "Collection & Sampling Guide"

Fluoride in Water

This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode.

Recommended Holding Time:
Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Ammonia in Water by Colourimetry

This analysis is carried out, on unpreserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using the phenate colourimetric method.

Recommended Holding Time:
Sample: 1 day
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotplate or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by atomic absorption/emission spectrophotometry (EPA Method 7000 series), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Recommended Holding Time:

Sample:	6 months
Reference:	EPA
For more detail see:	ALS "Collection & Sampling Guide"

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic absorption and/or fluorescence spectrophotometry (EPA Method 7470A/7471A/245.7).

Recommended Holding Time:

Sample:	28 days
Reference:	EPA

For more detail see ALS Environmental "Collection & Sampling Guide"

Ammonia in Water by Selective Ion Electrode

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

Recommended Holding Time:

Sample: 28 days
Reference: APHA
For more detail see ALS Environmental "Collection & Sampling Guide"

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End of Report

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CLIENT: [illegible] ENGINEERING [illegible]
ADDRESS: [illegible]
CITY: [illegible] PROV.: BC POSTAL CODE:
CONTACT: [illegible] BRIGHT SAMPLER: M DODD
TELEPHONE: 250 475-6315 FAX:
PROJECT NAME/NO.: A029-00500
P.O. NO.: QUOTE NO.: ~~[illegible]~~
DATE SUBMITTED: SEPT 26, 2003 ALS CONTACT: [illegible] CHEN

ALS Environmental

1988 Triumph Street
Vancouver, BC Canada V5L 1K5
TEL: 604-253-4188, 1-800-665-0243
FAX: 604-253-6700

#2 - 21 Highfield Circle SE
Calgary, AB Canada T2G 5N6
TEL: 403-214-5431, 1-866-722-6231
FAX: 403-214-5430

www.alsenviro.com

ANALYSIS REQUESTED

PAGE ____ OF ____

LAB USE ONLY 74555	SAMPLE IDENTIFICATION	Y	M	D	DATE / TIME COLLECTED	MATRIX	METALS (TOTAL)	ANIONS SCAN	NOTES
1	PC-03-01	03	09	23	2:45 PM	Water	X	X	
2	PC-03-02	03	09	23	3:35 PM	|	X	X	
3	PC-03-03	|	|	|	4:25 PM	|	X	X	
4	PC-03-04	|	|	|	4:45 PM	|	X	X	
5	PP-03-01	|	|	|	5:10 PM	|	X	X	
6	HL-03-01	|	|	|	5:50 PM	|	X	X	
7	HL-03-02	|	|	|	6:05 PM	|	X	X	
8	HL-03-03	|	|	|	6:45 PM	|	X	X	
9	HL-03-04	|	|	|	7:00 PM	|	X	X	
10	HL-03-05	|	|	|	7:[illegible] PM	|	X	X	
11	HL-03-06	↓	↓	↓	7:35 PM	↓	X	X	
					: AM PM				
	[illegible]-03-01				[illegible]:[illegible] AM PM				
	[illegible]				3:[illegible] AM PM				
	[illegible]-02	|	|	|	4:10 AM PM				
	[illegible]	[illegible]	[illegible]	[illegible]	4:[illegible] AM PM				

FOR LAB USE ONLY

TURN AROUND REQUIRED:

☐ ROUTINE (7 - 10 WORKING DAYS)

☐ RUSH (SPECIFY DATE): ____________ (SURCHARGES MAY APPLY)

SPECIAL INSTRUCTIONS (BILLING DETAILS, QC REPORTING, ETC.):

RELINQUISHED BY:	DATE / TIME	RECEIVED BY:	DATE / TIME
M Dodd	DATE Sept 26, 03 TIME 12:00	[illegible]	DATE [illegible] TIME [illegible]
	DATE TIME		DATE TIME

FOR LAB USE ONLY

COOLER SEAL INTACT UPON RECEIPT?
☐ YES ☐ NO ☐ N/A

SAMPLE TEMPERATURE UPON RECEIPT: [illegible] °C

REPORT COPY

SEE WHITE PAPER CO. FOR

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CLIENT: UMA ENGINEERING
ADDRESS: 200 - 415 Gorge Rd
CITY: VICTORIA PROV.: BC POSTAL CODE:
CONTACT: Doug Bright SAMPLER: [illegible]
TELEPHONE: 250 - 475 6355 FAX: "
PROJECT NAME/NO.: [illegible]
P.O. NO.: QUOTE NO.:
DATE SUBMITTED: ALS CONTACT: [illegible]

ALS Environmental

1988 Triumph Street
Vancouver, BC Canada V5L 1K5
TEL: 604-253-4188, 1-800-665-0243
FAX: 604-253-6700

#2 - 21 Highfield Circle SE
Calgary, AB Canada T2G 5N6
TEL: 403-214-5431, 1-866-722-6231
FAX: 403-214-5430

www.alsenviro.com

ANALYSIS REQUESTED PAGE ___ OF ___

FOR LAB USE ONLY

LAB USE ONLY	SAMPLE IDENTIFICATION	Y	M	D	TIME	MATRIX	[illegible]	Ammonia Scan	NOTES
[illegible]	WC-03-01	03	09	24	11:45 AM	[illegible]	X	X	
[illegible]	WC-03-02				12:20 PM		X	X	
[illegible]	WC-03-03				12:10 PM		X	X	
[illegible]	WC-03-04				12:30 PM		X	X	
16	WC-03-05				12:45 PM		X	X	
[illegible]	WC-03-[illegible]				12:50 PM		X	X	
[illegible]	CC-03-02				12:55 PM		X	X	
[illegible]	CC-03-03				2:20		X	X	
20	CC-03-04				2:50 PM		X	X	
[illegible]	CC-03-05				3:10 PM		X	X	
22	CC-03-06				3:20 PM		X	X	
[illegible]	CC-03-07				3:25 PM		X	X	
24	EC-03-01				2:45 PM		X	X	
[illegible]	FM-03-01				3:45 PM		X	X	
26	FM-03-02				4:10		X	X	
[illegible]	FM[illegible]-03-0[illegible]				4:20		X	X	

TURN AROUND REQUIRED:
☒ ROUTINE (7 - 10 WORKING DAYS)
☐ RUSH (SPECIFY DATE): ____________ (SURCHARGES MAY APPLY)
SPECIAL INSTRUCTIONS (BILLING DETAILS, QC REPORTING, ETC.):

RELINQUISHED BY:	DATE Sept [illegible]	RECEIVED BY:	DATE 03/9/25
	TIME [illegible]		TIME [illegible]
RELINQUISHED BY:	DATE	RECEIVED BY:	DATE
	TIME		TIME

FOR LAB USE ONLY

COOLER SEAL INTACT UPON RECEIPT? ☐ YES ☐ NO ☐ N/A

SAMPLE TEMPERATURE UPON RECEIPT: 7 °C
FROZEN? ☐ YES ☐ NO

REPORT COPY

SEE WHITE PAPER CO. FOR SOURCE VERSION 05 GLP

Appendix D

AIR MONITORING REPORT

SENES Consultants Limited

121 Granton Drive
Unit 12
Richmond Hill, Ontario
Canada L4B 3N4

Tel: (905) 764-9380
Fax: (905) 764-9386
E-mail: senes@senes.ca
Web Site: http://www.senes.ca

33587

25 March 2004

UMA Engineering Ltd.
1479 Buffalo Place
Winnipeg, MB
R3T 1L7

Attention: Mr. Gil Robinson

Re: **Air Sampling for Asbestos Fibres**
Clinton Creek Abandoned Asbestos Mine

Dear Sirs:

We are pleased to submit our final report on the air sampling program carried out at the Clinton Creek site during the week of 22 September 2003. The program was undertaken to provide information to be used by SENES Consultants Limited (SENES) to assist UMA Engineering Ltd. (UMA) in planning for next years activities at the site and to assist in completing a screening level human health risk assessment.

1.0 METHODOLOGY

Eight air samples were collected by drawing air through 0.8 mm pore size 25 mm diameter cellulose ester membrane filters using small battery-powered air sampling pumps. One travel blank (AIR-8B) was also analyzed to check for background levels of fibres. Samples were analyzed by the Chatfield Technical Consulting Limited (Chatfield) laboratory in Mississauga, Ontario using two methods - Phase Contrast Microscopy (PCM) and Transmission Electron Microscopy (TEM). The major differences between the PCM and the TEM methods are that PCM does not differentiate between asbestos and non-asbestos fibres, and thin fibres (i.e. less than about 0.25 μm (micrometres) diameter) are not detected by PCM. The TEM method allows for differentiation of asbestos from non-asbestos fibres and fibres of all diameters can be detected. Occupational exposure limits for asbestos and most epidemiology studies are based on the use of data analyzed using PCM methodology.

Seven of the eight air samples collected were "area" samples. The other sample was a "personal" sample. "Area" samples are typically collected by placing a sampling pump and filter at a stationary location (affixed to a piece of equipment, for example) in the area of interest. "Personal" samples are collected by attaching the sampling pump and filter on a person, with the sample filter situated as closely as possible to the breathing zone in order to provide an estimate of actual exposure to airborne fibres.

Six bulk samples of material collected from ground surfaces at various locations on the site were also forwarded to Chatfield for analysis of asbestos content by Polarized Light Microscopy (PLM).

2.0 RESULTS

Results of analysis of air samples are presented in Table 2.1. Sampling locations are shown on the site plan prepared by UMA provided in Appendix A. Laboratory reports for air sample analysis are provided in Appendix C1 (PCM) and C2 (TEM).

Results of analysis of bulk samples are presented in Table 2.2. Laboratory reports for bulk sample analysis are provided in Appendix C3.

3.0 SITE CONDITIONS

At the time of the air sampling program in September 2003, the ground surface at the site was damp due to recent precipitation events and partially covered with a layer of snow (<20 mm thick). Temperatures during the day were about +5°C. Wind speed was significant, particularly in open areas. It is considered likely that levels of airborne asbestos fibres would be higher than those measured on 24 and 25 September 2003 at times when drier conditions exist. Photographs of the sampling locations are presented in Appendix B.

Air sample location AIR-1A was located about 100 m west of the former crusher building, which is centred between the three former open pits. The area is covered with asbestos fibres similar in gradation to the asbestos tailings. A crust has formed on the surface of the asbestos fibres. Other potential sources of asbestos at this site include asbestos fibres blowing off the roof of the crusher building. A bulk sample was taken from this location. (See Photograph Nº 1 in Appendix B.)

Air sample location AIR-2 was located at the base of the crusher building near the former tram line. Asbestos fibres similar to the gradation of the tailings are prominent all around the immediate area and on the roof of the crusher building. A bulk sample was taken from this location. (See Photograph Nºs 2 and 3 in Appendix B.)

Air sample location AIR-3 was located near the ramp down into the Porcupine Pit. The area is covered with a combination of serpentine rock and raw unprocessed asbestos fibres that are typically less than 20 mm long. A bulk sample was taken from this location. (See Photograph Nº 4 in Appendix B.)

Air sample location AIR-4 was located just upstream of the confluence of Wolverine Creek and Clinton Creek. The area is readily accessible just off the main access road to the mine. The area is covered with asbestos tailings deposited in 1974 after the tailings pile blocked Wolverine Creek and was subsequently breached. (See Photograph Nº 5 in Appendix B.)

Air sample location AIR-5 was located on a former roadway about 100 m off of the road up to the mill site. There are no obvious sources of asbestos fibre deposits at this location. (See Photograph Nº 6 in Appendix B.)

Air sample location AIR-6 was located on the tailings pile at the top of the mountain near the former mill site. Although a crust has formed on the tailings pile, this area is expected to have higher exposure levels. Wind speed at the top of the tailings pile is likely greater than other areas of the mine site as this is the highest spot at the site, at least 150 m higher than air sample locations AIR-1A to AIR-5. A bulk sample was taken from this location. (See Photograph Nº 7 in Appendix B.)

Air sample location AIR-7 was located on the former mill site area about 300 m west of AIR-6. Asbestos fibres can be found across the entire mill site, likely deposited during operation of the mine and due to asbestos fibres blowing off the tailings pile. Wind speeds around the mill site are expected to be similar to those at AIR-6. A bulk sample was taken from this location. (See Photograph Nº 8 in Appendix B.)

Air Sample AIR-8P was a "Personal" air sample collected while traversing the mill site area, including the area where AIR-7 was collected.

4.0 DISCUSSION

Review of the PCM results presented in Table 2.1 indicates that the total airborne fibre level was below the "limit of detection" in all samples except for the personal sample worn by the writer (Sample Air-8P). The estimated limit of detection for the PCM method is 7 fibres/mm^2 filter area (which equates to approximately 5.5 fibres in 100 fields of view). A "field of view" is the area within the boundaries of the graticule, which is observed under the microscope for fibre counting purposes. Where less than 5.5 fibres are counted in 100 fields, the result is reported as less than the calculated detection limit, which is based on the number of fibres as well as on the volume of air sampled. Two fibres were detected in the "blank" sample filter. This is within the acceptable limit specified by the NIOSH method, as discussed above.

The TEM laboratory report in Appendix C presents results in terms of:

1. asbestos structures greater than 0.5 micrometres in length (Tables 1, 2 and 3 in Appendix C2);

2. asbestos fibres and bundles greater than 5 micrometres in length (Tables 4, 5 and 6 in Appendix C2); and

3. PCM-equivalent fibres and bundles (i.e. length greater than 5 micrometres, width greater than 0.20 micrometres and length to width ratio greater than or equal to 3:1) (Tables 7, 8 and 9 in Appendix C2).

Asbestos structures include asbestos fibres, bundles, clusters and matrices. Fibres are particles with a length to width (aspect) ratio of 3 to 1 or greater with substantially parallel sides. Bundles are particles composed of fibres in a parallel arrangement with each fibre closer than the diameter of one fibre. Clusters are particulates with fibres in a random arrangement such that all fibres are intermixed and no single fibre is isolated from the group. Matrices are fibres with one end free and the other end embedded or hidden by a particulate.

Tables 7, 8 and 9 in the TEM laboratory report present data for "*PCM-Equivalent Fibres and Bundles*" which is fibres and bundles longer than 5 micrometres, greater than 0.20 micrometres in width, and with an aspect ratio greater than or equal to 3:1. The results of analysis by TEM are shown under the heading "TEM Analysis for Asbestos". The fibre concentration determined by PCM is reproduced under the heading "PCM Fibre Count". This presentation of the data allows for comparison of PCM and TEM results, although in this case it is difficult to draw any conclusions because of the relatively low number of fibres detected in each of the samples.

Review of the TEM results in Table 2.1 shows that detectable levels of asbestos fibres (and bundles) longer than 5 micrometres were found in two samples - Sample AIR-6 - the area sample collected at the tailings area, and in Sample AIR-8P, the personal sample worn by the writer. Results of analysis for all other samples indicated airborne levels of asbestos fibres which were below the level of analytical sensitivity, as indicated by the "less than" sign in front of the reported result. Detectable levels of asbestos structures longer than 0.5 micrometres were reported for four samples - Samples AIR-6, AIR-8P, AIR-2 (area sample collected at the base of the Crusher Building), and AIR-4 (area sample collected at the Contractor's Camp site). The detection of "small" fibres at the Contractor's Camp site indicates the potential for the presence of larger fibres. Additional air sampling should be carried out in this area.

The highest fibre levels measured by both PCM and TEM methods were in the personal sample (AIR-8P) which is as would be expected given that the asbestos on the ground surface was disturbed creating airborne fibre through the action of walking across the site.

The personal sample (AIR-8P) was worn by the writer while walking across various parts of the site over a period of about 3 hours. Again, it is evident that exposures to airborne fibres would be higher than those indicated by the current results under drier conditions and also during any activities that would result in disturbances of the asbestos on the ground surface or on other surfaces (e.g. crusher building, utilidor boxes, etc.).

A summary of results of air sample analysis by PCM for samples collected by UMA in September 2002 and in August 2003 is provided in Table 3.1. Laboratory reports are provided in Appendix C4. Review of the data shows that detectable levels of airborne fibres were measured in each of the samples. Airborne fibre levels detected in two of the personal samples (0.22 f/ml and 0.10 f/ml) were elevated in comparison to the results of other samples collected by UMA and by SENES. It is our understanding that conditions were relatively warm and dry when the samples were collected in August 2003, although some rainfall occurred overnight which dampened the ground surface.

For comparison purposes, the permissible 8-hour limit prescribed by the Yukon Occupational Health Regulations (O.I.C. 1986/164) is 0.5 f/ml for chrysotile asbestos. The Regulations also define a "restricted area" as "an area of a work site in which there is a reasonable potential for worker exposure to airborne asbestos in an amount equal to or greater than 25% of the 8-hour Occupational Exposure Limit" (i.e. 25% of 0.5 f/ml = 0.125 f/ml) and prescribes requirements related to access, personal protective equipment, and work practices in such areas. More stringent permissible exposure limits exist in some other jurisdictions as shown in Table 3.2. The exposure limits are based on total fibre counts by PCM methodology, except for the Minnesota Department of Health Indoor Air Value, which is based on asbestos fibre levels measured by TEM. It is important to note that these limits are for occupational exposures to workers. We are not aware of any published exposure limits for the general public. Potential exposure limits applicable to occasional users of the site could be developed through completion of a detailed human health risk assessment.

The results of analysis of bulk samples of material collected from the ground surface indicates that all of the samples contained chrysotile asbestos, at concentrations ranging from 60 to 70% to 80 to 90%. Although no information was provided by the laboratory regarding fibre sizes, in general, it can be assumed that disturbance of the asbestos material will result in breakage of the asbestos structures into smaller entities, including fibres of respirable size.

In summary, the test results from air samples collected by SENES and UMA indicate that exposure to asbestos fibres is likely to occur during any activity in areas of the site where the ground surface is covered with asbestos. Although airborne fibre levels measured indicate concentrations that are below the Yukon 8-hour permissible exposure limit of 0.5 f/ml, it is expected that exposures would be where higher than those measured to date during construction, demolition or certain types of recreational activity, particularly when drier conditions prevail.

5.0 CLOSURE

We trust that the enclosed is suitable for your current purpose. Please call if you have any questions.

Yours truly,

SENES CONSULTANTS LIMITED

Wayne J. Cormack, M.Eng., CIH

cc: Douglas B. Chambers, Ph.D.
Mehran Monabbati

TABLE 2.1

RESULTS OF AIR SAMPLE ANALYSIS
CLINTON CREEK ABANDONED ASBESTOS MINE
24 and 25 September 2003

SAMPLE Nº	SAMPLE LOCATION	UTM COORDINATES	SAMPLE VOLUME (ℓ OF AIR)	PCM AIRBORNE FIBRE CONCENTRATION(1) (f/mℓ)	TEM AIRBORNE ASBESTOS CONCENTRATION(2)	
					(f/mℓ)	(s/mℓ)
AIR-1A	Waste rock area, west of crusher building	N 7146725 E 513547	662.9	<0.0041	<0.00372	<0.00372
AIR-2	Base of crusher building, east side	N 7146721 E 513687	1294.8	<0.0021	<0.00189	0.049
AIR-3	Waste rock area, north of Porcupine Pit	N 7146862 E 513358	1185.8	<0.0023	<0.00208	<0.00208
AIR-4	Wolverine Creek at contractor's camp site	N 7147130 E 514154	1044.0	<0.0026	<0.00237	0.021
AIR-5	North side of Hudgeon Lake	N 7147505 E 512161	1126.0	<0.0024	<0.00222	<0.00222
AIR-6	Tailings area	N 7148273 E 513373	1700.0	<0.0016	0.0088	0.019
AIR-7	Mill site	N 7148156 E 513133	1185.0	<0.0023	<0.00208	<0.00208
AIR-8P	Personal sample, W. Cormack	—	464.4	0.019	0.043	0.18
AIR-9B	"Blank" sample filter	—	—	<0.0027(3)	<0.00247(3)	<0.00247(3)

NOTE:

(1) PCM results are presented as fibres (of any type) longer than 5 micrometres per mℓ of air (f/mℓ). Values quoted as "less than" are the estimated limits of detection specified by the method used.

(2) TEM results are presented as asbestos fibres and bundles longer than 5 micrometres per mℓ of air (f/mℓ) and as asbestos structures longer than 0.5 micrometres per mℓ of air (s/mℓ). Values quoted as "less than" are the analytical sensitivities.

(3) A total of 2.0 fibres were counted by PCM and 0.0 fibres were counted by TEM in the "blank" sample filter analyzed for quality control purposes. The airborne fibre concentrations shown for the "blank" sample are based on calculations using 1,000 ℓ as the assumed air volume.

<	Less than.
f/mℓ	Fibres per millilitre of air.
s/mℓ	Structures per millilitre of air.

TABLE 2.2

SUMMARY OF RESULTS OF ANALYSIS OF BULK SAMPLES OF MATERIAL FOR ASBESTOS CONTENT

SAMPLE DESCRIPTION	ASBESTOS CONTENT
Material from ground surface at sample location AIR-1A, waste rock area, west of crusher building	80 - 90% chrysotile asbestos
Material from ground surface at sample location AIR-2A, base of crusher building, east side	80 - 90% chrysotile asbestos
Material from ground surface at sample location AIR-3A, waste rock area, north of Porcupine Pit	70 - 80% chrysotile asbestos
Material collected from surface of tailings pile at sample location AIR-6A	60 - 70% chrysotile asbestos
Material collected from top of utilidor box at sample location AIR-7A, mill site	60 - 70% chrysotile asbestos
Material from ground surface at mill site	60 - 70% chrysotile asbestos

TABLE 3.1

SUMMARY OF RESULTS OF PCM AIR SAMPLING PERFORMED BY UMA

DATE OF SAMPLING	SAMPLE DESCRIPTION	TOTAL AIRBORNE FIBRE CONCENTRATION (f/ml)
September 2002	Area sample collected in vicinity of creek channel repair work, just downstream of Hudgeon Lake	0.0075
		0.0054
		0.0113
		0.0102
		0.0109
12 August 2003	Area sample collected at bulldozer working at creek channel repair area, just downstream of Hudgeon Lake	0.03
20 August 2003	Personal sample collected during reconnaissance of mill site	0.22
		0.01
21 August 2003	Personal sample collected during survey of tailings pile	0.02
21 August 2003	Personal sample collected during reconnaissance of open pits	0.10
21 August 2003	Personal sample collected during reconnaissance of open pits	0.01

NOTE:

"Area" samples are collected by placing a sampling pump and filter at a stationary location (affixed to a stake or a piece of equipment, for example) in the area of interest.

"Personal" samples are collected by attaching the sampling pump and filter on a person with the sampling filter situated as closely as possible to the breathing zone.

TABLE 3.2

ASBESTOS EXPOSURE LIMITS FOR VARIOUS JURISDICTIONS

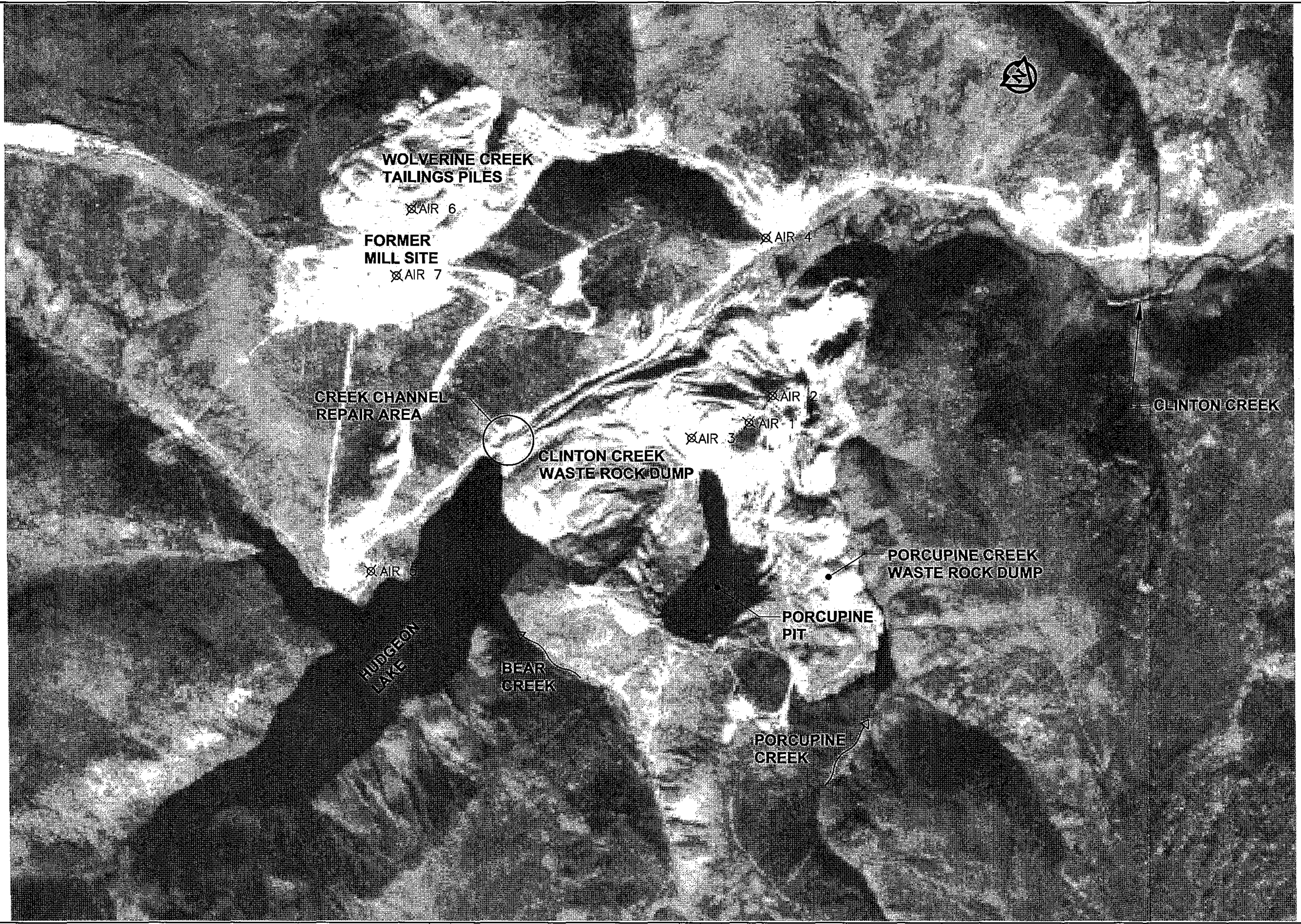
JURISDICTION	VALUE
Canada Labour Code	1 f/ml
ACGIH TLV-TWA	0.1 f/ml
OSHA PEL	0.1 f/ml
NIOSH REL TWA	0.1 f/ml
FRANCE OEL VME	0.3 f/ml
NORWAY OEL TWA	0.1 f/ml
SWITZERLAND OEL MAK-W	0.25 f/ml
Yukon PEL TWA	0.5 f/ml
Minnesota Department of Health Indoor Air	0.01 asbestos f/ml

NOTE:

ACGIH TLV-TWA	American Conference of Governmental Industrial Hygienists Threshold Limit Value - Time-Weighted Average.
OSHA PEL	U.S. Occupational Safety and Health Administration Permissible Exposure Limit.
NIOSH REL-TWA	U.S. National Institute for Occupational Safety and Health Recommended Exposure Limit – Time-Weighted Average.

APPENDIX A

SITE PLAN SHOWING
AIR SAMPLING LOCATIONS



LEGEND

☒ AIR 1 AIR SAMPLE

Plot Scale: 1:1
Plot Time: Jun 18, 2004 - 11:12am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\SENS_AirSampling01.dwg - Tab: 01

DO NOT SCALE

Date of Photography: September 1999

REV.	DESCRIPTION	DWN.	APP.	DATE
A	RECORD DRAWING / REPLOTTED	LJV		28Apr03

SEAL

SEAL

UMA Engineering Ltd.
• Consulting • Engineering • Construction • Management Services

APPROVED BY
OCTOBER, 2003
DATE
DRAWN BY: LJV
DESIGNED BY:
CHECKED BY: GR
CHECKED BY:
SCALE: APPROX. 1:15,000
JOB No. 6029-005-00

GOVERNMENT OF YUKON

FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSMENT REPORT

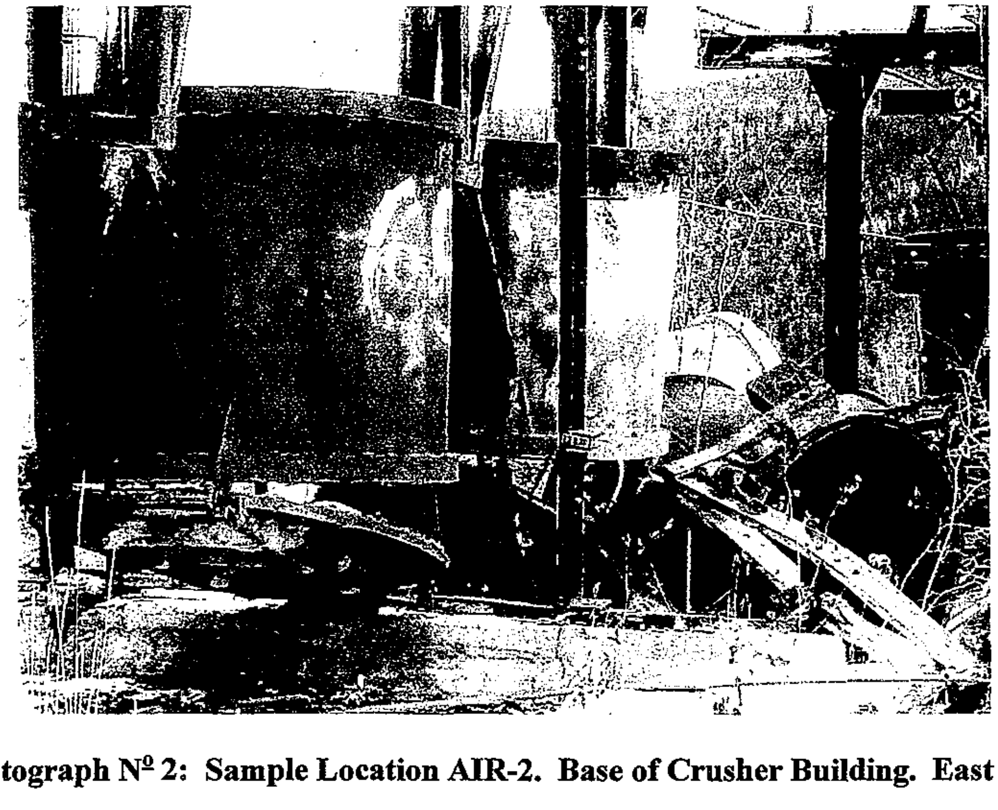
AIR SAMPLING LOCATIONS

01
DWG. No.
-
REV.

APPENDIX B

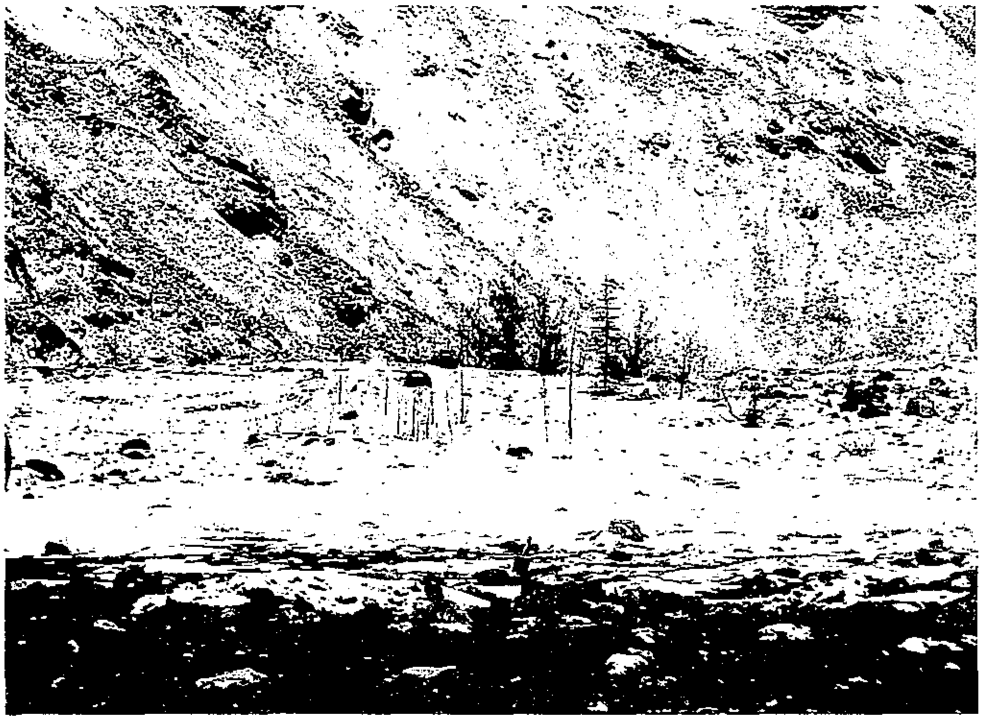
PHOTOGRAPHS

Photograph Nº 1: Sample Location AIR-1A. West of Crusher Building.



Photograph Nº 2: Sample Location AIR-2. Base of Crusher Building. East side.

Photograph Nº 3: Sample Location AIR-2. Base of Crusher Building. East side.



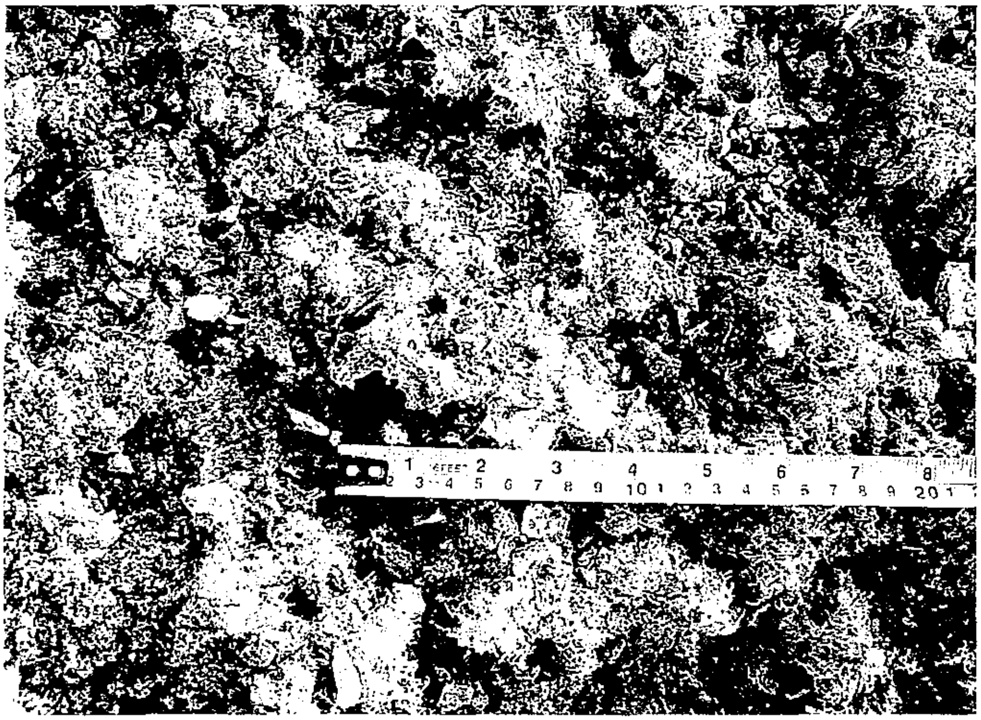
Photograph Nº 4: Sample Location AIR-3. Waste Rock Area. North of Porcupine Pit.

Photograph Nº 5: Sample Location AIR-4. Wolverine Creek at Contractor's Camp site.

Photograph Nº 6: Sample Location AIR-5. North side of Hudgeon Lake.

Photograph Nº 7: Sample Location AIR-6. Tailings area.

Photograph Nº 8: Sample Location AIR-7. Mill site.



Photograph Nº 9: Ground surface near Sample Location AIR-3.

APPENDIX C

LABORATORY REPORTS

APPENDIX C1

PCM AIR SAMPLE ANALYSIS
LABORATORY REPORT
(SENES SAMPLES)

CHATFIELD | TECHNICAL CONSULTING LIMITED

2071 Dickson Road
Mississauga, Ontario
CANADA L5B 1Y8
Telephone: (905) 896-7611
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Report Number 03P039

FIBRE COUNTING OF NINE MEMBRANE FILTERS BY PHASE CONTRAST MICROSCOPY

NIOSH METHOD 7400

CLINTON CREEK

DCS Project No. 33587

Prepared For:

Wayne J. Cormack, M.Eng., CIH
Decommissioning Consulting Services Limited
121 Granton Drive, Unit 11
Richmond Hill, Ontario
L4B 3N4

Dr. Eric J. Chatfield
President
Chatfield Technical Consulting Limited

2003-10-20

INTRODUCTION

Nine aerosol monitors were received on 2003-09-29 to be examined by phase contrast optical microscopy for determination of the concentration of fibres on each filter. Eight monitors were identified as samples and one monitor was an unused blank.

ANALYSIS

The filters were prepared and analyzed according to NIOSH Method 7400, Issue 2, 15 August 1994. In this method there is no provision for identification of specific minerals. Results are reported for all observed particles which are longer than 5 micrometres (μm) and have a length to width (aspect) ratio equal to or greater than 3:1. Samples are examined using a phase contrast optical microscope (PCM) with Köhler illumination and a Walton-Beckett graticule. The microscope is calibrated using an HSE/NPL Mark II Test Slide, and the examination is conducted at a magnification of 400. The estimated limit of detection is 7 fibres/mm^2 filter area.

RESULTS

For each filter, an equivalent airborne fibre concentration was calculated based on the number of fibres observed, the area of filter examined and the volume of air which was reported to have been drawn through the filter. The reported number of fibres counted is the actual number of fibres observed. An air volume of 1000 litres is assumed for calculation of the equivalent fibre concentration for the blank in which no air was drawn through the filter. The results are summarized in the following tables.

DISCUSSION

For samples collected and analyzed according to NIOSH Method 7400, the range of Method 7400 is from 100 to 1300 fibres/mm^2 of filter area. For filter loadings within this range, if compliance with a standard is to be demonstrated, the standard must be more than 213% higher than the measured airborne concentration in order that the measurement will have a 95% probability of being below the standard. Fibre densities reported below the range of the method have significantly degraded precision, and this reduced precision must be taken into account during comparison with a standard. Also, under the conditions of this examination, the instrumental resolution is inadequate to allow detection of fibres having widths less than about 0.2 μm; particles longer than 5 μm will be included only if their widths are greater than 0.2 μm, regardless of their lengths. Individual fibres of asbestos are often less than 0.05 μm in width, and therefore will not be detected even when they are longer than 5 μm. Since there is no provision for identification, all observed particles of the defined shape are included in the result. Many particles or aggregates of particles can appear to be fibres when viewed under the conditions of the PCM examination. Conversely, features which appear in PCM to be non-fibrous particles may actually be closely associated groups of fibres. Because of the limitations of the PCM technique, it is generally applied only where most airborne particles can be assumed to be asbestos.

RESULTS OF PHASE CONTRAST FIBRE COUNTS

TO: Decommissioning Consulting Services Ltd.
121 Granton Drive, Unit 11
Richmond Hill
Ontario
L4B 3N4

Attention: Mr. Wayne J. Cormack

ORDER NO: Memo 6 October 2003
PROJECT NO: DCS#33587

CHATFIELD TECHNICAL CONSULTING LIMITED
2071 Dickson Road
Mississauga, Ontario, Canada L5B 1Y8

Report Number: 03P039 / Table 1
2003-10-20

ANALYST:
Alice Liebert

Sample	Number of Fibres Counted	Number of Fields Examined*	Fibre Density On Filter Fibres/sq.mm	Air Volume Litres	Fibre Concentration Fibres/mL **
CLINTON CREEK Sample No. AIR-1A 24 Sept/03	3.0	100 (0)	3.8	662.9	<0.0041
CLINTON CREEK Sample No. AIR-2 23 Sept/03	1.0	100 (0)	1.3	1294.8	<0.0021
CLINTON CREEK Sample No. AIR-3 23 Sept/03	1.0	100 (0)	1.3	1185.8	<0.0023
CLINTON CREEK Sample No. AIR-4 23 Sept/03	3.5	100 (0)	4.5	1044.0	<0.0026

Fibre counts made using NIOSH Method 7400

Area represented by microscope field: 0.00785 sq.mm.

* Values in parentheses are the numbers of fields of view rejected in accordance with the fibre counting criteria.

** Values quoted as "less than" are the estimated limits of detection specified by the method used.

RESULTS OF PHASE CONTRAST FIBRE COUNTS

TO: Decommissioning Consulting Services Ltd.
121 Granton Drive, Unit 11
Richmond Hill
Ontario
L4B 3N4

Attention: Mr. Wayne J. Cormack

ORDER NO: Memo 6 October 2003
PROJECT NO: DCS#33587

CHATFIELD TECHNICAL CONSULTING LIMITED
2071 Dickson Road
Mississauga, Ontario, Canada L5B 1Y8

Report Number: 03P039 / Table 2
2003-10-20

ANALYST:
Alice Liebert

Sample	Number of Fibres Counted	Number of Fields Examined*	Fibre Density On Filter Fibres/sq.mm	Air Volume Litres	Fibre Concentration Fibres/mL **
CLINTON CREEK Sample No. AIR-5 23 Sept/03	2.0	100 (0)	2.5	1126.0	<0.0024
CLINTON CREEK Sample No. AIR-6 23 Sept/03	2.0	100 (0)	2.5	1700.0	<0.0016
CLINTON CREEK Sample No. AIR-7 24 Sept/03	1.0	100 (0)	1.3	1185.0	<0.0023
CLINTON CREEK Sample No. AIR-8P (WJC) 24 Sept/03	18.0	100 (0)	22.9	464.4	0.019

Fibre counts made using NIOSH Method 7400

Area represented by microscope field: 0.00785 sq.mm.

* Values in parentheses are the numbers of fields of view rejected in accordance with the fibre counting criteria.

** Values quoted as "less than" are the estimated limits of detection specified by the method used.

RESULTS OF PHASE CONTRAST FIBRE COUNTS

TO: Decommissioning Consulting Services Ltd.
121 Granton Drive, Unit 11
Richmond Hill
Ontario
L4B 3N4

Attention: Mr. Wayne J. Cormack

ORDER NO: Memo 6 October 2003
PROJECT NO: DCS#33587

CHATFIELD TECHNICAL CONSULTING LIMITED
2071 Dickson Road
Mississauga, Ontario, Canada L5B 1Y8

Report Number: 03P039 / Table 3.
2003-10-20

ANALYST:
Alice Liebert

Sample	Number of Fibres Counted	Number of Fields Examined*	Fibre Density On Filter Fibres/sq.mm	Air Volume Litres +	Fibre Concentration Fibres/mL **
CLINTON CREEK Sample No. AIR-9B 24 Sept/03	2.0	100 (0)	2.5	1000	<0.0027

Fibre counts made using NIOSH Method 7400

Area represented by microscope field: 0.00785 sq.mm.

* Values in parentheses are the numbers of fields of view rejected in accordance with the fibre counting criteria.

** Values quoted as "less than" are the estimated limits of detection specified by the method used.

\+ Assumed air volume for concentration calculation.

APPENDIX C2

TEM AIR SAMPLE ANALYSIS
LABORATORY REPORT

CHATFIELD | TECHNICAL CONSULTING LIMITED

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Report Number 03T007

ANALYSIS OF NINE AIR SAMPLE FILTERS BY TRANSMISSION ELECTRON MICROSCOPY FOR THE PRESENCE OF ASBESTOS

CLINTON CREEK

DCS Project No. 33587

Prepared For:

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121 Granton Drive, Unit 11
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L4B 3N4

E J Chatfield

Dr. Eric J. Chatfield
President
Chatfield Technical Consulting Limited

2003-10-22

INTRODUCTION

Nine aerosol monitor cassettes were received on 2003-09-29 for measurement of the amount of asbestos on the exposed surface of the filter in each cassette. Each cassette contained a 25 mm diameter mixed cellulose ester (MCE) filter of 0.8 micrometre (μm) nominal porosity. Eight monitor cassettes were identified as samples and one monitor cassette was an unused blank.

Transmission electron microscopy (TEM) specimens were prepared from the filters, using a direct-transfer preparation procedure. These specimens were examined for the presence of asbestos fibres. Results are reported for all asbestos structures which contain at least one asbestos fibre longer than 0.5 μm, and separately for asbestos fibres and fibre bundles longer than 5 μm. Results are also reported for asbestos fibres longer than 5 μm, wider than 0.20 μm and with a length to width (aspect) ratio equal to or greater than 3:1. These dimensions are considered to correspond to the fibres which would be included in a fibre count by phase contrast optical microsopy (PCM); fibres within this dimensional range are reported as PCM-equivalent fibres.

A sector from each of the filters was also prepared and analyzed by phase contrast microscopy, according to NIOSH Method 7400, Issue 2, 15 August 1994. These PCM analyses are described in our Report Number 03P039.

ANALYSIS

TEM specimens were prepared from the air sample filters by the method of Burdett and Rood (1). In this method, a solution consisting of dimethylformamide, glacial acetic acid and water is used to collapse the spongy filter structure to form a thinner film of transparent plastic. The collapsed filter is treated in a low temperature plasma asher to etch away a thin layer of plastic from the top surface of the filter, exposing any of the particles which may have become embedded in the plastic during the collapsing step. The etched filter is positioned on a rotating-tilting device in a high vacuum carbon coating unit, and a thin film of evaporated carbon is applied to the surface. Small pieces are then cut from the coated filter, placed on 200-mesh copper electron microscope grids, and the plastic is dissolved away by treatment in a Jaffe washer, using dimethylformamide as the solvent. The deposit from the original air sample, trapped in the carbon film and supported on the specimen grids, is ready for examination in the TEM.

The prepared grids were examined using an analytical transmission electron microscope (ATEM). The TEM technique incorporates fibre identification so that only asbestos fibres are reported. In the TEM, in addition to examining the morphology of each fibre, whenever possible the crystal structure of a fibre is examined by means of selected area electron diffraction (SAED) and the elemental composition of a fibre is obtained by energy dispersive X-ray analysis (EDXA).

During the TEM examinations, a fibre was defined as a particle with parallel or stepped sides and a length to width (aspect) ratio equal to or greater than 3 to 1. A PCM-equivalent fibre was defined as a particle with a length to width (aspect) ratio equal to or greater than 3 to 1, a length greater than 5 μm, and a width greater than 0.20 μm. The practical lower length limit for routine identification of asbestos fibres in the TEM is 0.5 μm. Fibres were classified according to the identification categories shown in Figure 1. Each reported asbestos-containing structure was classified morphologically as a fibre, a fibre bundle, a cluster of fibres, or a matrix containing asbestos and other types of particle, according to the definitions in ISO 10312 (2); the classification codes are described in Figure 2. Data recorded according to these classifications allows comparison of the results with all known current airborne asbestos regulations and guidelines. Chrysotile is reported on the basis of the characteristic tubular morphology with confirmation by SAED and EDXA whenever possible. The reporting of amphibole is based on random orientation SAED combined with EDXA.

RESULTS

The detailed analytical data for these TEM analyses are given in Appendix A. For each sample, an equivalent concentration of airborne asbestos was calculated based on the number of asbestos-containing structures observed during the TEM examination, the portion of the filter examined and the volume of air which was reported to have been drawn through the filter. For Sample No. AIR-9B, an air volume of 1000 litres was assumed for the calculation of equivalent airborne concentrations.

The results are summarized in Tables 1 to 9. Tables 1, 2 and 3 give the results for asbestos structures which contain at least one asbestos fibre longer than 0.5 μm. Tables 4, 5 and 6 give the results for asbestos fibres and fibre bundles longer than 5 μm. Tables 7, 8 and 9 give the results for PCM-equivalent asbestos fibres. Also shown in Tables 7, 8 and 9 are the results of the PCM fibre counts (from Report 03P039).

When fewer than 4 asbestos-containing structures are detected in the portion of the sample which is examined, it is not possible on statistical grounds to quote a reliable mean concentration, although the 95% confidence interval for the concentration can be specified. For a count of 4 or more asbestos-containing structures, both a mean concentration and the 95% confidence interval for the concentration can be specified. The upper 95% confidence limit is that concentration below which 97.5% of repeat measurements should occur.

It should be recognized that these results represent the levels of airborne asbestos only at the time of sampling and that disturbances to asbestos-containing materials can cause asbestos to become airborne.

DISCUSSION

In Canada, all existing legislation and environmental guidelines concerning permissible airborne asbestos fibre concentrations are expressed in terms of those fibres having lengths exceeding 5 μm.

For control of the airborne fibre concentrations in workplaces where asbestos is in use, the Ontario Ministry of Labour (MOL) currently applies a time-weighted average exposure limit of 0.1 fibre/mL (fibres longer than 5 μm) where amosite and/or crocidolite is known to be present (3) and also a limit of 0.1 fibre/mL (fibres longer than 5 μm) for all other types of asbestos (4). The specified measurement technique is phase contrast optical microscopy (PCM). The detection limit for the MOL method (3) is generally considered to be approximately 0.1 fibre/mL. For PCM samples collected and analyzed according to NIOSH Method 7400 (5), the specified range is from 100 to 1300 fibres/mm^2 of filter area. For filter loadings within this range, if compliance with a standard is to be demonstrated, the standard must be more than 213% higher than the measured airborne concentration in order that the measurement will have a 95% probability of being below the standard. Fibre densities reported below the range of the method have significantly degraded precision, and this reduced precision must be taken into account during comparison with a standard. The estimated limit of detection for NIOSH Method 7400 is 7 fibres/mm^2 filter area. In both of these PCM techniques, <u>all</u> particles are reported which are visible in phase contrast illumination at a magnification of 400, are longer than 5 μm and which have a length to width (aspect) ratio equal to or greater than 3 to 1. In the MOL method particles must also be less than 3 μm in width. There is no provision for identification of specific mineral particles. Under the conditions of this examination, the instrumental resolution is inadequate to allow detection of fibres having widths less than about

0.2 μm; particles longer than 5 μm will be included only if their widths are greater than 0.2 μm, regardless of their lengths. Individual fibres of asbestos are often less than 0.05 μm in width, and therefore will not be detected even when they are longer than 5 μm. Because of these limitations, this measurement technique is generally applied only where most airborne fibres are likely to be asbestos, such as in the asbestos industry or in work areas where asbestos is being manipulated.

In the general environment, when airborne asbestos fibres are present they are usually too small in diameter to be detected by phase contrast microscopy, and also many other types of airborne fibres are present. For control of asbestos fibre concentrations in the outside atmosphere, to which the general public may be exposed continuously, the Ontario Ministry of the Environment & Energy (MOEE) applies a "guideline" of 0.04 fibre/mL (fibres longer than 5 μm), measured by transmission electron microscopy (6). This TEM technique incorporates fibre identification so that only asbestos fibres are reported. In addition, the instrumental resolution of the TEM is adequate to allow detection of even the very fine asbestos fibres.

For comparison with guidelines based on TEM measurement, the determination of the concentration of airborne asbestos must be by transmission electron microscopy. This is because, in areas where asbestos is not the principal source of airborne dust, the concentration of airborne asbestos is not necessarily correlated with the total fibre concentration. Moreover, many particles or aggregates of particles can appear to be fibres when viewed under the conditions of the PCM examination. Conversely, features which appear in PCM to be non-fibrous particles may actually be closely associated groups of fibres, and fine fibres will not be detected. In these circumstances it is not possible to predict the airborne asbestos level from the result of a measurement made by PCM. In addition, the detection limit of a PCM measurement is not sufficiently sensitive to allow its use for monitoring environmental airborne asbestos concentrations.

In this study, specimens prepared from the sample filters were examined using the more sensitive transmission electron microscope technique for determination of the concentrations of asbestos structures which contain at least one asbestos fibre longer than 0.5 μm.

REFERENCES

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4. Ontario Ministry of Labour (2000): Updated OEL's for Certain Designated Substances, Effective September 30, 2000.

5. National Institute for Occupational Safety and Health (NIOSH) (1994): NIOSH Method 7400, Issue 2, 15 August 1994. NIOSH Manual of Analytical Methods, U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, Cincinnati, Ohio.

6. Ontario Ministry of the Environment, Air Resources Branch (1989): List of Ambient Air Quality Criteria, Standards, Tentative Design Standards, Guidelines, and Provisional Guidelines as of 29 Mar. 1989.

FIGURE 1. FIBRE CLASSIFICATION CATEGORIES

CLASSIFICATION OF FIBRES WITH TUBULAR MORPHOLOGY

TM - Tubular Morphology, not sufficiently characteristic for classification as chrysotile

CM - Characteristic Chrysotile Morphology

CD - Chrysotile SAED pattern

CQ - Chrysotile composition by Quantitative EDXA

CMQ - Chrysotile Morphology and composition by Quantitative EDXA

CDQ - Chrysotile SAED pattern and composition by Quantitative EDXA

NAM - Non-Asbestos Mineral

CLASSIFICATION OF FIBRES WITHOUT TUBULAR MORPHOLOGY

UF - Unidentified Fibre

AD - Amphibole by random orientation SAED (shows layer pattern of 0.53 nm spacing)

AX - Amphibole by qualitative EDXA. Spectrum has elemental components consistent with amphibole

ADX - Amphibole by random orientation SAED and qualitative EDXA

AQ - Amphibole by quantitative EDXA

AZ - Amphibole by one Zone Axis SAED pattern

ADQ - Amphibole by random orientation SAED and Quantitative EDXA

AZQ - Amphibole by one Zone Axis SAED pattern and Quantitative EDXA

AZZ - Amphibole by two Zone Axis SAED patterns with consistent inter-axial angle

AZZQ - Amphibole by two Zone Axis SAED patterns, consistent inter-axial angle and Quantitative EDXA

NAM - Non-Asbestos Mineral

FIGURE 2. STRUCTURE MORPHOLOGICAL CLASSIFICATION CODES

F - Fibre: elongated particle with parallel or stepped sides and a length to width (aspect) ratio equal to or greater than 3 to 1

B - Bundle: fibres which are parallel and apparently attached along their lengths

CC - Cluster - Compact: tightly bound aggregate of randomly oriented fibres and/or bundles in which dimensions of individual fibres cannot be measured

CD - Cluster - Disperse: open aggregate of randomly oriented fibres and/or bundles in which dimensions of some of the individual fibres can be measured

CF - Cluster Fibre: a fibre which is part of a disperse cluster

CB - Cluster Bundle: a bundle which is part of a disperse cluster

CR - Cluster Residual: portion of cluster remaining after cluster fibres and cluster bundles have been documented

MC - Matrix - Compact: aggregate of randomly oriented fibres and/or bundles and non-fibrous particles in which dimensions of individual fibres cannot be measured

MD - Matrix - Disperse: aggregate of randomly oriented fibres and/or bundles and non-fibrous particles in which dimensions of some of the individual fibres can be measured

MF - Matrix Fibre: a fibre which is part of a disperse matrix

MB - Matrix Bundle: a bundle which is part of a disperse matrix

MR - Matrix Residual: portion of matrix remaining after matrix fibres and matrix bundles have been documented

xx - two digits are recorded along with a structure code of CC, CD, CR, MC, MD, or MR. The first digit is the number of fibres and/or bundles with a minimum length of 0.5 µm in the structure; the second digit is the number of fibres and/or bundles longer than 5 µm in the structure. Either of these two digits is replaced by " + " if the estimated number of fibres and/or bundles exceeds 9.

TABLE 1. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

STRUCTURES GREATER THAN 0.5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Structure Concentration, Structures/mL			Structures per Square Millimetre	Volume of Air Sampled Litres	Number of Structures Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK	Chrysotile	ND	0 - 0.012	0.00372	0	662.9	0
Sample No. AIR-1A	Amphibole	ND	0 - 0.012	0.00372	0	662.9	0
24 Sept/03	Total	ND	0 - 0.012	0.00372	0	662.9	0
CLINTON CREEK	Chrysotile	0.049	0.032 - 0.072	0.00189	165.0	1294.8	26
Sample No. AIR-2	Amphibole	ND	0 - 0.0057	0.00189	0	1294.8	0
23 Sept/03	Total	0.049	0.032 - 0.072	0.00189	165.0	1294.8	26
CLINTON CREEK	Chrysotile	ND	0 - 0.0063	0.00208	0	1185.8	0
Sample No. AIR-3	Amphibole	ND	0 - 0.0063	0.00208	0	1185.8	0
23 Sept/03	Total	ND	0 - 0.0063	0.00208	0	1185.8	0
CLINTON CREEK	Chrysotile	0.021	0.0097 - 0.041	0.00237	57.9	1044.0	9
Sample No. AIR-4	Amphibole	ND	0 - 0.0071	0.00237	0	1044.0	0
23 Sept/03	Total	0.021	0.0097 - 0.041	0.00237	57.9	1044.0	9

* - No mean value is reported when fewer than 4 countable structures were detected in the portion of sample examined
ND - No Countable Structures Detected
NSS - Not Statistically Significant (1 to 3 countable structures detected)

TABLE 2. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

STRUCTURES GREATER THAN 0.5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Structure Concentration, Structures/mL			Structures per Square Millimetre	Volume of Air Sampled Litres	Number of Structures Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK	Chrysotile	NSS	0 - 0.013	0.00222	6.5	1126.0	1
Sample No. AIR-5	Amphibole	ND	0 - 0.0067	0.00222	0	1126.0	0
23 Sept/03	Total	NSS	0 - 0.013	0.00222	6.5	1126.0	1
CLINTON CREEK	Chrysotile	0.019	0.010 - 0.033	0.00147	84.3	1700.0	13
Sample No. AIR-6	Amphibole	ND	0 - 0.0044	0.00147	0	1700.0	0
23 Sept/03	Total	0.019	0.010 - 0.033	0.00147	84.3	1700.0	13
CLINTON CREEK	Chrysotile	ND	0 - 0.0063	0.00208	0	1185.0	0
Sample No. AIR-7	Amphibole	ND	0 - 0.0063	0.00208	0	1185.0	0
24 Sept/03	Total	ND	0 - 0.0063	0.00208	0	1185.0	0
CLINTON CREEK	Chrysotile	0.18	0.086 - 0.28	0.00534	219.2	464.4	34
Sample No. AIR-8P (WJC)	Amphibole	ND	0 - 0.016	0.00534	0	464.4	0
24 Sept/03	Total	0.18	0.086 - 0.28	0.00534	219.2	464.4	34

*	-	No mean value is reported when fewer than 4 countable structures were detected in the portion of sample examined
ND	-	No Countable Structures Detected
NSS	-	Not Statistically Significant (1 to 3 countable structures detected)

TABLE 3. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

STRUCTURES GREATER THAN 0.5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Structure Concentration, Structures/mL			Structures per Square Millimetre	Volume of Air Sampled Litres +	Number of Structures Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK Sample No. AIR-9B 24 Sept/03	Chrysotile	ND	0 - 0.0074	0.00247	0	1000	0
	Amphibole	ND	0 - 0.0074	0.00247	0	1000	0
	Total	ND	0 - 0.0074	0.00247	0	1000	0

*	-	No mean value is reported when fewer than 4 countable structures were detected in the portion of sample examined
ND	-	No Countable Structures Detected
NSS	-	Not Statistically Significant (1 to 3 countable structures detected)
+	-	Assumed air volume for concentration calculation

TABLE 3. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

STRUCTURES GREATER THAN 0.5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Structure Concentration, Structures/mL			Structures per Square Millimetre	Volume of Air Sampled Litres +	Number of Structures Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK Sample No. AIR-9B 24 Sept/03	Chrysotile	ND	0 - 0.0074	0.00247	0	1000	0
	Amphibole	ND	0 - 0.0074	0.00247	0	1000	0
	Total	ND	0 - 0.0074	0.00247	0	1000	0

*	-	No mean value is reported when fewer than 4 countable structures were detected in the portion of sample examined
ND	-	No Countable Structures Detected
NSS	-	Not Statistically Significant (1 to 3 countable structures detected)
+	-	Assumed air volume for concentration calculation

TABLE 5. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

FIBRES AND BUNDLES LONGER THAN 5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Fibre Concentration, Fibres/mL			Fibres per Square Millimetre	Volume of Air Sampled Litres	Number of Fibres Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK Sample No. AIR-5 23 Sept/03	Chrysotile	ND	0 - 0.0067	0.00222	0	1126.0	0
	Amphibole	ND	0 - 0.0067	0.00222	0	1126.0	0
	Total	ND	0 - 0.0067	0.00222	0	1126.0	0
CLINTON CREEK Sample No. AIR-6 23 Sept/03	Chrysotile	0.0088	0.0032 - 0.020	0.00147	38.9	1700.0	6
	Amphibole	ND	0 - 0.0044	0.00147	0	1700.0	0
	Total	0.0088	0.0032 - 0.020	0.00147	38.9	1700.0	6
CLINTON CREEK Sample No. AIR-7 24 Sept/03	Chrysotile	ND	0 - 0.0063	0.00208	0	1185.0	0
	Amphibole	ND	0 - 0.0063	0.00208	0	1185.0	0
	Total	ND	0 - 0.0063	0.00208	0	1185.0	0
CLINTON CREEK Sample No. AIR-8P (WJC) 24 Sept/03	Chrysotile	0.043	0.018 - 0.085	0.00534	51.6	464.4	8
	Amphibole	ND	0 - 0.016	0.00534	0	464.4	0
	Total	0.043	0.018 - 0.085	0.00534	51.6	464.4	8

* - No mean value is reported when fewer than 4 countable fibres were detected in the portion of sample examined
ND - No Countable Fibres Detected
NSS - Not Statistically Significant (1 to 3 countable fibres detected)

TABLE 5. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

FIBRES AND BUNDLES LONGER THAN 5 MICROMETRES

SAMPLE DESCRIPTION	FIBRE TYPE	Fibre Concentration, Fibres/mL			Fibres per Square Millimetre	Volume of Air Sampled Litres	Number of Fibres Counted
		Mean *	95% Confidence Interval	Analytical Sensitivity			
CLINTON CREEK	Chrysotile	ND	0 - 0.0067	0.00222	0	1126.0	0
Sample No. AIR-5	Amphibole	ND	0 - 0.0067	0.00222	0	1126.0	0
23 Sept/03	Total	ND	0 - 0.0067	0.00222	0	1126.0	0
CLINTON CREEK	Chrysotile	0.0088	0.0032 - 0.020	0.00147	38.9	1700.0	6
Sample No. AIR-6	Amphibole	ND	0 - 0.0044	0.00147	0	1700.0	0
23 Sept/03	Total	0.0088	0.0032 - 0.020	0.00147	38.9	1700.0	6
CLINTON CREEK	Chrysotile	ND	0 - 0.0063	0.00208	0	1185.0	0
Sample No. AIR-7	Amphibole	ND	0 - 0.0063	0.00208	0	1185.0	0
24 Sept/03	Total	ND	0 - 0.0063	0.00208	0	1185.0	0
CLINTON CREEK	Chrysotile	0.043	0.018 - 0.085	0.00534	51.6	464.4	8
Sample No. AIR-8P (WJC)	Amphibole	ND	0 - 0.016	0.00534	0	464.4	0
24 Sept/03	Total	0.043	0.018 - 0.085	0.00534	51.6	464.4	8

*	-	No mean value is reported when fewer than 4 countable fibres were detected in the portion of sample examined
ND	-	No Countable Fibres Detected
NSS	-	Not Statistically Significant (1 to 3 countable fibres detected)

TABLE 7. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

PCM-EQUIVALENT FIBRES AND BUNDLES

(Length >5 micrometres; Width >0.20 micrometres; Aspect Ratio ≥3:1)

SAMPLE DESCRIPTION	FIBRE TYPE	TEM ANALYSES FOR ASBESTOS					Volume of Air Sampled Litres	PCM FIBRE COUNT Fibres/mL
		Fibre Concentration, Fibres/mL			Fibres per Square Millimetre	Number of Fibres Counted		
		Mean*	95% Confidence Interval	Analytical Sensitivity				
CLINTON CREEK Sample No. AIR-1A 24 Sept/03	Chrysotile	ND	0 - 0.012	0.00372	0	0	662.9	-
	Amphibole	ND	0 - 0.012	0.00372	0	0	662.9	-
	Total Asbestos	ND	0 - 0.012	0.00372	0	0	662.9	-
	Fibres by PCM	-	-	-	-	-	662.9	<0.0041
CLINTON CREEK Sample No. AIR-2 23 Sept/03	Chrysotile	NSS	0 - 0.014	0.00189	12.7	2	1294.8	-
	Amphibole	ND	0 - 0.0057	0.00189	0	0	1294.8	-
	Total Asbestos	NSS	0 - 0.014	0.00189	12.7	2	1294.8	-
	Fibres by PCM	-	-	-	-	-	1294.8	<0.0021
CLINTON CREEK Sample No. AIR-3 23 Sept/03	Chrysotile	ND	0 - 0.0063	0.00208	0	0	1185.8	-
	Amphibole	ND	0 - 0.0063	0.00208	0	0	1185.8	-
	Total Asbestos	ND	0 - 0.0063	0.00208	0	0	1185.8	-
	Fibres by PCM	-	-	-	-	-	1185.8	<0.0023
CLINTON CREEK Sample No. AIR-4 23 Sept/03	Chrysotile	ND	0 - 0.0071	0.00237	0	0	1044.0	-
	Amphibole	ND	0 - 0.0071	0.00237	0	0	1044.0	-
	Total Asbestos	ND	0 - 0.0071	0.00237	0	0	1044.0	-
	Fibres by PCM	-	-	-	-	-	1044.0	<0.0026

* - No mean value is reported when fewer than 4 countable fibres were detected in the portion of sample examined by TEM
ND - No Countable Fibres Detected
NSS - Not Statistically Significant (1 to 3 countable fibres detected)

TABLE 8. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

PCM-EQUIVALENT FIBRES AND BUNDLES

(Length >5 micrometres; Width >0.20 micrometres; Aspect Ratio ≥3:1)

SAMPLE DESCRIPTION	FIBRE TYPE	TEM ANALYSES FOR ASBESTOS					Volume of Air Sampled Litres	PCM FIBRE COUNT Fibres/mL
		Fibre Concentration, Fibres/mL			Fibres per Square Millimetre	Number of Fibres Counted		
		Mean*	95% Confidence Interval	Analytical Sensitivity				
CLINTON CREEK Sample No. AIR-5 23 Sept/03	Chrysotile	ND	0 - 0.0067	0.00222	0	0	1126.0	-
	Amphibole	ND	0 - 0.0067	0.00222	0	0	1126.0	-
	Total Asbestos	ND	0 - 0.0067	0.00222	0	0	1126.0	-
	Fibres by PCM	-	-	-	-	-	1126.0	<0.0024
CLINTON CREEK Sample No. AIR-6 23 Sept/03	Chrysotile	NSS	0 - 0.0082	0.00147	6.5	1	1700.0	-
	Amphibole	ND	0 - 0.0044	0.00147	0	0	1700.0	-
	Total Asbestos	NSS	0 - 0.0082	0.00147	6.5	1	1700.0	-
	Fibres by PCM	-	-	-	-	-	1700.0	<0.0016
CLINTON CREEK Sample No. AIR-7 24 Sept/03	Chrysotile	ND	0 - 0.0063	0.00208	0	0	1185.0	-
	Amphibole	ND	0 - 0.0063	0.00208	0	0	1185.0	-
	Total Asbestos	ND	0 - 0.0063	0.00208	0	0	1185.0	-
	Fibres by PCM	-	-	-	-	-	1185.0	<0.0023
CLINTON CREEK Sample No. AIR-8P (WJC) 24 Sept/03	Chrysotile	ND	0 - 0.016	0.00534	0	0	464.4	-
	Amphibole	ND	0 - 0.016	0.00534	0	0	464.4	-
	Total Asbestos	ND	0 - 0.016	0.00534	0	0	464.4	-
	Fibres by PCM	-	-	-	-	-	464.4	0.019

*	-	No mean value is reported when fewer than 4 countable fibres were detected in the portion of sample examined by TEM
ND	-	No Countable Fibres Detected
NSS	-	Not Statistically Significant (1 to 3 countable fibres detected)

TABLE 9. SUMMARY OF RESULTS OF TRANSMISSION ELECTRON MICROSCOPY ANALYSES FOR AIRBORNE ASBESTOS

PCM-EQUIVALENT FIBRES AND BUNDLES

(Length >5 micrometres; Width >0.20 micrometres; Aspect Ratio ≥3:1)

SAMPLE DESCRIPTION	FIBRE TYPE	TEM ANALYSES FOR ASBESTOS					Volume of Air Sampled Litres +	PCM FIBRE COUNT Fibres/mL
		Fibre Concentration, Fibres/mL			Fibres per Square Millimetre	Number of Fibres Counted		
		Mean*	95% Confidence Interval	Analytical Sensitivity				
CLINTON CREEK Sample No. AIR-9B 24 Sept/03	Chrysotile	ND	0 - 0.0074	0.00247	0	0	1000	-
	Amphibole	ND	0 - 0.0074	0.00247	0	0	1000	-
	Total Asbestos	ND	0 - 0.0074	0.00247	0	0	1000	-
	Fibres by PCM	-	-	-	-	-	1000	<0.0027

*	-	No mean value is reported when fewer than 4 countable fibres were detected in the portion of sample examined by TEM
ND	-	No Countable Fibres Detected
NSS	-	Not Statistically Significant (1 to 3 countable fibres detected)
+	-	Assumed air volume for concentration calculations

APPENDIX A

Detailed Analytical Data

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-1; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-1A
24 Sept/03

Air Volume: 662.9 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 102.0 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-1; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-1A
24 Sept/03

Page 1 of 1

Grid Opening	Structure	Identif- ication*	Structure Type+	Length µm	Width µm	Comment
A-C4-3		**				
A-E4-1		**				
A-E4-6		**				
A-F4-4		**				
A-G4-3		**				
B-G4-4		**				
B-F4-6		**				
B-E4-4		**				
B-E4-3		**				
B-C4-1		**				
C-C4-6		**				
C-E4-1		**				
C-F4-3		**				
C-F4-4		**				
C-G4-3		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-2; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-2
23 Sept/03

Air Volume: 1294.8 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 102.5 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-2; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-2
23 Sept/03

Page 1 of 2

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
A-C4-1	1	CD	F	1.3	0.046	
	2	CD	CD70	2.3	2.3	
	3	CD	CB	1.6	0.093	
	4	CD	CB	1.5	0.14	
	5	CD	CB	1.4	0.14	
	6	CD	CB	1.2	0.14	
	7	CD	CB	1.2	0.093	
	8	CD	CR20	1.9	0.69	
A-E4-3		**				
A-E4-6		**				
A-F4-4		**				
A-G4-6		**				
B-G4-4		**				
B-F4-3		**				
B-E4-4		**				
B-C4-6	9	CDQ	CC+0	2.3	2.1	
B-C4-1		**				
C-C4-3		**				
C-E4-1		**				
C-F4-1	10	CD	F	0.83	0.046	
	11	CD	B	1.0	0.093	
	12	CM	CD20	0.93	0.69	
	13	CM	CB	0.93	0.046	
	14	CM	CF	0.56	0.046	
	15	CD	B	1.1	0.093	
	16	CD	B	0.83	0.093	
	17	CD	MD30	2.3	0.93	
	18	CD	MB	1.4	0.14	
	19	CD	MF	0.74	0.046	
	20	CD	MF	0.69	0.046	
	21	CM	F	1.1	0.046	
	22	CD	B	1.2	0.093	
	23	CD	CD30	1.9	1.2	
	24	CD	CB	1.9	0.19	
	25	CD	CB	0.93	0.093	
	26	CD	CB	0.83	0.046	
	27	CD	CD30	1.4	1.4	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-2
23 Sept/03

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
	28	CD	CB	1.4	0.14	
	29	CD	CB	1.2	0.093	
	30	CM	CB	0.56	0.046	
	31	CD	B	0.69	0.046	
	32	CDQ	MD+2	32	14	
	33	CDQ	MB	29	1.4	
	34	CDQ	MB	5.6	1.4	
	35	CDQ	MB	2.9	0.28	
	36	CDQ	MR+0	13	6.5	
	37	CD	MD30	2.7	0.93	
	38	CD	MB	1.4	0.046	
	39	CD	MF	0.83	0.046	
	40	CD	MF	0.56	0.046	
	41	CD	CD+0	4.2	1.9	
	42	CD	CB	1.6	0.19	
	43	CD	CB	1.6	0.14	
	44	CD	CB	1.4	0.093	
	45	CD	CB	1.3	0.093	
	46	CD	CB	1.3	0.093	
	47	CD	CR+0	2.8	1.9	
	48	CD	B	1.4	0.32	
	49	CD	B	0.93	0.23	
	50	CD	CD20	4.1	1.9	
	51	CD	CB	4.1	0.093	
	52	CD	CB	1.9	0.093	
	53	CD	B	1.0	0.14	
	54	CD	B	1.9	0.093	
	55	CD	B	2.8	0.23	
	56	CD	B	1.2	0.19	
	57	CD	MD30	1.4	1.4	
	58	CD	MF	1.3	0.046	
	59	CD	MB	1.1	0.19	
	60	CD	MB	0.69	0.046	
	61	CD	B	1.6	0.23	
C-F4-6		**				
C-G4-1		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-3
23 Sept/03

Air Volume: 1185.8 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 102.1 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-3; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-3
23 Sept/03

Page 1 of 1

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
A-H4-4		**				
A-G4-6		**				
A-F4-4		**				
A-F4-3		**				
A-E4-1		**				
B-C4-6		**				
B-E4-4		**				
B-F4-3		**				
B-G4-1		**				
B-H4-3		**				
C-G4-6		**				
C-G4-3		**				
C-F4-1		**				
C-E4-6		**				
C-C4-4		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-4
23 Sept/03

Air Volume: 1044.0 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 101.8 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-4; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-4
23 Sept/03

Page 1 of 2

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
A-C4-4		**				
A-E4-3		**				
A-F4-1		**				
A-F4-6		**				
A-G4-4		**				
B-H4-4	1	CD	MD+1	8.3	4.6	
	2	CD	MB	5.1	0.19	
	3	CD	MF	4.5	0.046	
	4	CD	MB	3.6	0.37	
	5	CD	MB	3.6	0.14	
	6	CD	MB	3.0	0.093	
	7	CD	MR+0	6.5	3.7	
B-H4-3		**				
B-G4-4	8	CD	CD31	9.3	0.69	
	9	CD	CB	9.3	0.093	
	10	CD	CB	1.0	0.093	
	11	CD	CB	0.69	0.046	
B-G4-3	12	CD	MD20	7.9	4.6	
	13	CD	MF	2.3	0.046	
	14	CD	MF	1.9	0.046	
B-F4-4	15	CD	MD40	2.3	1.9	
	16	CD	MF	1.0	0.046	
	17	CD	MF	1.0	0.046	
	18	CD	MB	0.69	0.046	
	19	CD	MB	0.69	0.046	
	20	CDQ	B	2.6	0.37	
	21	CD	B	1.4	0.093	
	22	CD	MD50	12	2.3	
	23	CD	MF	1.6	0.046	
	24	CD	MF	1.5	0.046	
	25	CD	MB	1.5	0.046	
	26	CD	MB	1.4	0.093	
	27	CD	MB	1.3	0.046	
C-C4-1		**				
C-E4-3		**				
C-F4-3	28	CD	B	1.2	0.093	
	29	CD	MD20	1.2	0.93	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-4
23 Sept/03

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
	30	CD	MB	1.4	0.093	
	31	CD	MB	1.0	0.14	
C-G4-1		**				
C-H4-3		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-5; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-5
23 Sept/03

Air Volume: 1126.0 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 101.4 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-5; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-5
23 Sept/03

Page 1 of 1

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
A-H4-1		**				
A-G4-6		**				
A-G4-1		**				
A-F4-3		**				
A-E4-4		**				
B-C4-1		**				
B-E4-1		**				
B-E4-6	1	CD	B	0.93	0.046	
B-F4-4		**				
B-G4-3		**				
C-G4-4		**				
C-F4-6		**				
C-E4-4		**				
C-E4-3		**				
C-C4-4		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-6; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-6
23 Sept/03

Air Volume: 1700.0 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 101.4 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-6; 2003-10-20

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-6
23 Sept/03

Page 1 of 2

Grid Opening	Structure	Identif-ication*	Structure Type+	Length µm	Width µm	Comment
A-C4-3		**				
A-E4-1		**				
A-F4-3		**				
A-F4-4		**				
A-G4-4	1	CD	MD10	2.8	1.9	
	2	CD	MB	1.6	0.093	
B-H4-1		**				
B-G4-6		**				
B-F4-6		**				
B-E4-4		**				
B-E4-3	3	CD	B	1.2	0.093	
C-C4-6		**				
C-E4-1		**				
C-E4-3	4	CD	F	9.4	0.046	
	5	CD	MD+0	6.5	5.6	
	6	CD	MB	2.5	0.046	
	7	CD	MB	1.6	0.14	
	8	CD	MB	1.4	0.093	
	9	CD	MR+0	6.5	4.2	
C-E4-4	10	CD	B	1.5	0.046	
C-F4-3	11	CD	MD40	2.3	1.4	
	12	CD	MF	2.3	0.046	
	13	CD	MF	1.2	0.046	
	14	CD	MB	0.79	0.23	
	15	CD	MF	0.74	0.046	
	16	CD	B	9.3	0.093	
	17	CD	B	1.9	0.046	
	18	CD	B	1.2	0.14	
	19	CD	CD40	4.2	2.3	
	20	CD	CF	3.0	0.046	
	21	CD	CB	2.1	0.093	
	22	CD	CF	1.1	0.046	
	23	CD	CB	0.65	0.093	
	24	CD	MD30	1.4	1.4	
	25	CD	MB	1.2	0.046	
	26	CD	MB	0.93	0.14	
	27	CD	MB	0.93	0.046	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-6
23 Sept/03

Grid Opening	Structure	Identif-ication*	Structure Type+	Length µm	Width µm	Comment
	28	CD	MD+4	28	14	
	29	CD	MB	9.3	0.093	
	30	CD	MB	7.3	0.23	
	31	CD	MB	6.0	0.093	
	32	CD	MB	5.6	0.14	
	33	CD	MB	3.9	0.46	
	34	CD	MR+0	13	9.3	
	35	CD	MR60	3.2	2.8	
	36	CD	B	2.3	0.046	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-7
24 Sept/03

Air Volume: 1185.0 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 102.0 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-7
24 Sept/03

Page 1 of 1

Grid Opening	Structure	Identification*	Structure Type +	Length µm	Width µm	Comment
A-H4-1		**				
A-G4-6		**				
A-F4-6		**				
A-F4-1		**				
A-E4-6		**				
B-C4-6		**				
B-E4-1		**				
B-F4-3		**				
B-G4-1		**				
B-G4-4		**				
C-G4-6		**				
C-F4-4		**				
C-F4-3		**				
C-E4-4		**				
C-C4-6		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-8; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-8P (WJC)
24 Sept/03

Air Volume: 464.4 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 101.7 μm

Number of Grid Openings Examined: 15

Analyst(s): AL

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-8P (WJC)
24 Sept/03

Page 1 of 3

Grid Opening	Structure	Identif-ication*	Structure Type+	Length µm	Width µm	Comment
A-H4-3		**				
A-G4-4	1	CD	F	0.93	0.046	
	2	CD	F	0.65	0.046	
	3	CM	F	0.60	0.046	
	4	CD	MD30	7.4	6.0	
	5	CD	MF	2.8	0.046	
	6	CD	MF	2.3	0.046	
	7	CD	MF	1.9	0.046	
	8	CDQ	F	3.1	0.093	
	9	CD	F	0.93	0.046	
A-G4-3	10	CD	F	1.0	0.046	
	11	CD	MD10	14	13	
	12	CD	MB	2.5	0.19	
	13	CD	CD+0	4.6	2.8	
	14	CD	CB	4.6	0.19	
	15	CD	CB	2.1	0.23	
	16	CD	CB	1.9	0.19	
	17	CD	CR+0	2.8	2.3	
A-F4-6	18	CD	F	1.5	0.046	
	19	CD	CD+0	4.6	2.8	
	20	CD	CF	2.8	0.046	
	21	CD	CB	1.4	0.093	
	22	CD	CB	0.93	0.093	
	23	CM	CF	0.69	0.046	
	24	CD	CR+0	3.2	2.8	
A-E4-1	25	CD	MD30	7.9	6.5	
	26	CD	MF	2.3	0.046	
	27	CD	MF	1.6	0.046	
	28	CD	MF	1.4	0.046	
	29	CD	B	9.0	0.14	
B-C4-6	30	NAM	F	5.3	1.3	AI
	31	CD	CD20	3.7	0.93	
	32	CD	CF	3.6	0.093	
	33	CD	CF	1.9	0.046	
	34	CD	MD30	6.0	5.6	
	35	CD	MB	2.7	0.14	
	36	CD	MF	1.0	0.046	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-8P (WJC)
24 Sept/03

Grid Opening	Structure	Identif-ication*	Structure Type+	Length µm	Width µm	Comment
	37	CD	MF	0.56	0.046	
	38	CD	MD51	6.5	5.2	
	39	CD	MB	6.5	0.093	
	40	CD	MB	3.7	0.14	
	41	CD	MB	1.6	0.046	
	42	CD	MF	0.93	0.046	
	43	CD	MF	0.93	0.046	
	44	CD	MD++	32	13	
	45	CD	MB	14	0.093	
	46	CD	MB	6.7	0.14	
	47	CD	MF	7.4	0.046	
	48	CD	MF	6.5	0.046	
	49	CD	MF	6.5	0.046	
	50	CD	MR++	26	8.3	
	51	CD	MD+0	10	1.4	
	52	CD	MB	2.3	0.093	
	53	CM	MR+0	2.3	1.4	
B-E4-1	54	CD	CD20	4.4	1.0	
	55	CD	CB	4.4	0.046	
	56	CD	CB	1.0	0.046	
	57	CD	MC+0	13	11	
B-E4-6	58	CD	F	1.8	0.046	
B-F4-1	59	CD	MD+0	6.9	2.3	
	60	CD	MF	1.4	0.046	
	61	CD	MB	1.4	0.093	
	62	CD	MB	1.3	0.14	
	63	CD	MF	1.3	0.046	
	64	CD	MB	0.93	0.046	
	65	CD	MR+0	6.9	2.3	
B-G4-1		**				
C-G4-6	66	CD	B	6.9	0.14	
	67	CD	MD20	5.6	4.2	
	68	CD	MF	1.0	0.046	
	69	CD	MF	0.93	0.046	
	70	CD	B	1.9	0.093	
	71	CD	F	0.93	0.046	
	72	CD	F	1.4	0.046	

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-8P (WJC)
24 Sept/03

Grid Opening	Structure	Identif-ication*	Structure Type+	Length µm	Width µm	Comment
	73	CD	F	1.6	0.046	
	74	CD	F	0.93	0.046	
C-F4-4	75	CD	B	1.2	0.093	
C-F4-3	76	CD	MD10	2.8	1.4	
	77	CD	MB	2.0	0.14	
	78	CD	MD+0	11	4.6	
	79	CD	MB	3.7	0.093	
	80	CD	MF	2.3	0.046	
	81	CD	MR+0	11	4.6	
C-G4-1	82	CD	MD10	9.3	7.9	
	83	CD	MB	2.8	0.046	
	84	CD	F	1.7	0.046	
C-E4-6		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

CHATFIELD TECHNICAL CONSULTING LIMITED
Report Number: 03T007
File: 03T007-9; 2003-10-20

SAMPLE ANALYSIS INFORMATION

SAMPLE: CLINTON CREEK
Sample No. AIR-9B
24 Sept/03

Assumed Air Volume: 1000.0 L

Area of Collection Filter: 385.0 sq. mm

Magnification Used for TEM Examination: 21600

Mean Dimension of Grid Openings: 102.0 μm

Number of Grid Openings Examined: 15

Analyst(s): GML

TEM ASBESTOS EXAMINATION - RAW DATA

SAMPLE: CLINTON CREEK
Sample No. AIR-9B
24 Sept/03

Page 1 of 1

Grid Opening	Structure	Identification*	Structure Type+	Length µm	Width µm	Comment
A-F4-6		**				
A-F4-1		**				
A-E3-6		**				
A-E4-3		**				
A-C5-4		**				
B-F4-3		**				
B-F3-6		**				
B-G4-1		**				
B-G5-3		**				
B-G3-4		**				
C-G3-1		**				
C-F4-4		**				
C-F3-3		**				
C-E4-6		**				
C-E5-1		**				

* Identification Codes Listed in Figure 1
\+ Structure Types Listed in Figure 2
** No Countable Structures Detected

APPENDIX C3

BULK SAMPLE ANALYSIS
LABORATORY REPORT

CHATFIELD | TECHNICAL CONSULTING LIMITED

2071 Dickson Road
Mississauga, Ontario
CANADA L5B 1Y8
Telephone: (905) 896-7611
Fax: (905) 896-1930

NVLAP Laboratory Code 101103-0

Wayne J. Cormack, M.Eng., CIH
Decommissioning Consulting Services Limited
121 Granton Drive, Unit 11
Richmond Hill, Ontario L4B 3N4

Report Number 03M032
2003-10-22; Page 1 of 3

RE: CLINTON CREEK

DCS Project Number 33587

Dear Mr. Cormack:

Six bulk samples were received on 2003-10-07 to be analyzed in accordance with the U.S. Department of Commerce, National Institute of Standards and Technology, NVLAP Accreditation for Asbestos Fiber Analysis. The attached tables give the results of the analyses, and refer to these samples only. The samples have been archived, and can be re-examined if required at a later time.

Particles were identified using polarized light microscopy (PLM), and confirmed by dispersion staining microscopy. When a sample is homogeneous and the individual components can be separated for examination, the detection limit for routine PLM analysis is approximately 0.5%. Samples which were received wet were dried before analysis.

If we can assist in the interpretation of these results, or in any other matter relating to asbestos measurement, please do not hesitate to call.

Yours sincerely,

E J Chatfield

Dr. Eric J. Chatfield
President

TO: Decommissioning Consulting Services Ltd.
121 Granton Drive, Unit 11
Richmond Hill
Ontario
L4B 3N4

Attention: Mr. Wayne J. Cormack

ORDER NO: Memo 6 October 2003
PROJECT: DCS#33587

CHATFIELD TECHNICAL CONSULTING LIMITED
2071 Dickson Road
Mississauga, Ontario, Canada L5B 1Y8

Report Number: 03M032 / Table 1
2003-10-22

ANALYST:
Alice Liebert

ANALYSIS OF BULK MATERIAL SAMPLES

SAMPLE DESCRIPTION	APPROXIMATE COMPOSITION				COMMENTS
	ASBESTOS FIBRE		OTHER COMPONENTS		
CLINTON CREEK At Location of Sample AIR-1 Bulk Sample Grey Fibrous Material	Chrysotile	80-90%	Non-Fibrous Material	10-20%	
CLINTON CREEK At Location of Sample AIR-2 Bulk Sample Dark Grey Fibrous Material	Chrysotile	80-90%	Non-Fibrous Material	10-20%	Sample was received wet and was dried before analysis.
CLINTON CREEK At Location of Sample AIR-3 Bulk Sample Dark Grey Fibrous Material	Chrysotile	70-80%	Non-Fibrous Material	20-30%	Sample was received wet and was dried before analysis.
CLINTON CREEK At Location of Sample AIR-6 Tailings Area Bulk Sample Brown Fibrous Material	Chrysotile	60-70%	Non-Fibrous Material	30-40%	

These results must not be used to claim product endorsement by NVLAP, any government agency, or Chatfield Technical Consulting Limited.

TO: Decommissioning Consulting Services Ltd.
121 Granton Drive, Unit 11
Richmond Hill
Ontario
L4B 3N4

Attention: Mr. Wayne J. Cormack

ORDER NO: Memo 6 October 2003
PROJECT: DCS#33587

CHATFIELD TECHNICAL CONSULTING LIMITED
2071 Dickson Road
Mississauga, Ontario, Canada L5B 1Y8

Report Number: 03M032 / Table 2
2003-10-22

ANALYST: Alice Liebert

ANALYSIS OF BULK MATERIAL SAMPLES

SAMPLE DESCRIPTION	APPROXIMATE COMPOSITION				COMMENTS
	ASBESTOS FIBRE		OTHER COMPONENTS		
CLINTON CREEK At Location of Sample AIR-7 Top of Concrete Structure Bulk Sample, 24 Sept/03 Grey Fibrous Material	Chrysotile	60-70%	Non-Fibrous Material	30-40%	
CLINTON CREEK Mill Site Bulk Sample Brown Fibrous Material	Chrysotile	60-70%	Non-Fibrous Material	30-40%	

These results must not be used to claim product endorsement by NVLAP, any government agency, or Chatfield Technical Consulting Limited.

APPENDIX C4

PCM AIR SAMPLE ANALYSIS
LABORATORY REPORT
(UMA SAMPLES)

ENVIRO-TEST QC REPORT

Workorder # L127450

Legend:

Limit	95% Confidence Interval (Laboratory Warning Limits)
DUP	Duplicate
RPD	Relative Percent Difference ((higher result-lower result)/Average, expressed as %)
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Materials
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material

Qualifier:

RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.
A	Method blank exceeds acceptance limit. Blank correction not applied, unless the qualifier "RAMB" (result adjusted for method blank) appears in the Analytical Report.
B	Method blank result exceeds acceptance limit, however, it is less than 5% of sample concentration. Blank correction not applied.
E	Matrix spike recovery may fall outside the acceptance limits due to high sample background.
F	Silver recovery low, likely due to elevated chloride levels in sample.
G	Outlier - No assignable cause for nonconformity has been determined.
H	Result falls within the 99% Confidence Interval (Laboratory Control Limits)
J	Duplicate results and limit(s) are expressed in terms of absolute difference.
K	The sample referenced above is of a non-standard matrix type; standard QC acceptance criteria may not be achievable.

ETL Enviro-Test LABORATORIES
Manitoba Technology Centre Ltd.
MTC

745 Logan Avenue
Winnipeg, Manitoba R3E 3L5
Tel: (204) 945-3705 Fax: (204) 945-0763
G.S.T. Reg #895929230RT

RECEIVED
SEP 03 2003
UMA ENGINEERING LTD.

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: KEN SKAFTFELD
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

DATE: 29-AUG-03

6029-005-00-02

Copies to:
J.G. Robinson
K. Skaftfeld
B. Copland
B. Hutchinson

Lab Work Order #: L127450 **Sampled By:** GR **Date Received:** 28-AUG-03

Project P.O. #:

Project Reference:

Comments:

Sample Specific Comments: L127450-1: No field blank submitted., L127450-2: No field blank submitted., L127450-3: No field blank submitted., L127450-4: No field blank submitted., L127450-5: No field blank submitted., L127450-6: Analysts were unable to analyse due to a faulty cassette. No field blank submitted., L127450-7: No field blank submitted., L127450-8: No field blank submitted.

APPROVED BY:

BARB BAYER
Project Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

LABORATORY ACCREDITATIONS:
- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN ASSOCIATION FOR ENVIRONMENTAL ANALYTICAL LABORATORIES (CAEAL)
FOR SPECIFIC TESTS AS REGISTERED BY THE COUNCIL (EDMONTON, CALGARY, GRANDE PRAIRIE, SASKATOON, WINNIPEG, THUNDER BAY, WATERLOO)
- AMERICAN INDUSTRIAL HYGIENE ASSOCIATION (AIHA) IN THE INDUSTRIAL HYGIENE PROGRAM (EDMONTON, WINNIPEG)
- STANDARDS COUNCIL OF CANADA IN COOPERATION WITH THE CANADIAN FOOD INSPECTION AGENCY (CFIA) FOR FERTILIZER AND FEED TESTING (SASKATOON) AND FOR MICROBIOLOGICAL TESTING IN FOOD (WINNIPEG)

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L127450-1 1 Sample Date: 12-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	36.9		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.03		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	563.5		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.300		0	L/min		28-AUG-03	MKC	R140321
Minutes	245		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-2 2 Sample Date: 20-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	113		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.22		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	195.0		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	78		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-3 3A Sample Date: 20-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	7.6		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	<0.01		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	367.5		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	147		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-4 3B Sample Date: 20-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	106		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.10		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	412.5		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	165		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-5 4 Sample Date: 21-AUG-03 Matrix: AIR CASSETTE								

ENVIRO-TEST ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L127450-5 4 Sample Date: 21-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	31.8		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.02		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	515.0		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	206		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-6 5 Sample Date: 21-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	<7.0		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	<0.01		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	295.0		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	118		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: Analysts were unable to analyse due to a faulty cassette. No field blank submitted.								
L127450-7 6 Sample Date: 21-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	235		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.10		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	946.0		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.750		0	L/min		28-AUG-03	MKC	R140321
Minutes	344		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								
L127450-8 7 Sample Date: 21-AUG-03 Matrix: AIR CASSETTE								
Asbestos Fibre Density								
Fibre Density	17.8		7	Fibres/mm2		28-AUG-03	MKC	R140321
Fibre Concentration	0.01		0.01	fibres/mL		28-AUG-03	MKC	R140321
Sample Volume	592.5		0	L		28-AUG-03	MKC	R140321
Flow Rate	2.500		0	L/min		28-AUG-03	MKC	R140321
Minutes	237		0	min		28-AUG-03	MKC	R140321
Flow Rate Based On	Rate provided by Client					28-AUG-03	MKC	R140321
Note: No field blank submitted.								

Refer to Referenced Information for Qualifiers (if any) and Methodology.

EIL Enviro-Test
LABORATORIES
A DIVISION OF EIL CHEMSPEC ANALYTICAL LIMITED

Report Date: 29-AUG-03

ENVIRO-TEST QC REPORT

Workorder: L127450

Client: UMA ENGINEERING
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

Contact: KEN SKAFTFELD

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
Product - Batch and Sample Number Relations:								
ASBESTOS-WP	4							
R140321		L127450-1	L127450-2	L127450-3		L127450-4	L127450-5	
		L127450-6	L127450-7	L127450-8				

Reference Information

Methods Listed (if applicable):

ETL Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On
ASBESTOS-WP	Air	Asbestos Fibre Density		NIOSH 7400, 1994

A measured volume of air is pumped through a cellulose ester filter to collect fibres. The filter is dissolved in hot acetone fumes, leaving fibres clearly visible on a microscope slide. Fibres longer than 5um are counted, using NIOSH 7400 (A Rules).

Results of < 100 fibres/mm2 or >1300 fibres/mm2 may have greater than optimal variability and may be biased.

When sampling performed by client, fibre concentration results are based on information provided by the client.

Sample results are corrected using field blank results. A comment will appear at the end of each sample result section if no field blank was submitted.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	Enviro-Test Laboratories - Winnipeg, Manitoba, Canada		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory warning units are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
< - Less than
D.L. - Detection Limit
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

Enviro-Test Laboratories has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, Enviro-Test Laboratories assumes no liability for the use or interpretation of the results.

Appendix E

ASBESTOS MINE SITE RECLAMATION PRACTICES

Reclamation Practices and Issues at Abandoned Asbestos Mines – A Review

Doug A. Bright, Ph.D.[1] and Randy Knapp, P. Eng.[2]

1): UMA Engineering Ltd., Victoria, BC; 2): SENES Consultants Ltd., Richmond Hill, ON

ABSTRACT

This paper reviews the status of mine site reclamation at abandoned asbestos mines around the world, with a focus on mine sites where chrysotile asbestos has been extracted from serpentine ore. Depending on the location and site conditions, residual chrysotile asbestos fibres in surficial materials (soils at the former mill site or surrounding areas, tailings material, mined areas, waste rock piles, access routes) could pose a risk to human health based on mobilization to air followed by inhalation.

For the hundreds of asbestos mine sites developed and then abandoned in the 1970s through 1990s, the potential for residual health and environmental issues merits closer examination, especially in the countries that were major producers of the world's chrysotile asbestos supply; i.e. Canada, China, Russia, South Africa, and Zimbabwe. Ongoing concerns about soils contaminated with asbestos are not limited to these countries, however, and limited consideration has been given to future human health risks associated with abandoned asbestos mines in the United States, Australia, India, China, Portugal, Turkey, Brazil, Finland, Cyprus, Swaziland and elsewhere. Within Canada, major asbestos mines were located in the Yukon (Clinton Creek – 1968 to 1978), British Columbia (Cassiar Asbestos Mine), Quebec (especially the Thetford and Jeffrey mines) and Newfoundland (Baie Verte Asbestos Mine -1955 to 1981, 1982 to 1990).

Closed asbestos mines present many of the reclamation concerns that arise at other mines sites. These include physical hazards such as possible pit wall collapse, unstable waste rock piles and tailings deposits, air and water erosion, unsafe buildings and structures. Asbestos waste is chemically stable and does not produce acidic drainage or leach material levels of metals. The primary issues for closure, therefore, are (i) control of exposure to asbestos and (ii) management of physical hazards.

The vast majority of chrysotile asbestos mines worldwide have not been adequately reclaimed, either from the perspective of establishing sustained plant community growth or for minimizing human health risks from soil-borne asbestos fibres. Two notable exceptions are the Atlas and Coalinga mines in California that have been reclaimed largely in consideration of concerns about mobilization of chrysotile asbestos fibres from the affected watersheds into the drinking water supply for the City of Los Angeles. Much of the reclamation effort, therefore, was aimed at re-directing surface water flows and curtailing soil erosion. Some effort was directed to limiting more direct (airborne) human exposures, primarily by exclusion of humans from critical areas. There is very little documentation on re-vegetation success: Limited accounts suggest that the re-establishment of vegetation has been successful for soils that were predominantly sand, fine rock and clays (e.g. in ore extraction areas) but much less so in tailings material. The now abandoned vermiculate mine, a source of amphibole asbestos fibres, in Libby, Montana, as well as the associated town site has attracted massive public attention over the last half decade. It has been declared a superfund site. Massive efforts are underway to reduce human health risks at the site, through large scale soil removal and capping efforts.

Many of the asbestos mine sites have yet to be seriously considered for reclamation/restoration work, since sites have not been formally abandoned, pending the possible rebound in the global market for chrysotile asbestos fibre. This is the case for the British Columbia Cassiar Asbestos Mine. The basic regulatory requirements for reclamation at the Cassiar Asbestos Mine are similar to any other active mine in British Columbia, however, and reclamation activities will likely include re-contouring as well as the capping of bedrock and tailings with 0.5 m of overburden of suitable quality for the establishment of vegetative communities.

Tailings material from abandoned chrysotile asbestos mines may be a viable source of magnesium (typically 12 to 30% of the dry weight of chrysotile asbestos tailings), and a re-extraction operation has commenced at one of the major Quebec mine sites. The economic viability of magnesium extraction from tailings, however, depends on the availability of a cheap source of power. Magnesium extraction through smelting technologies requires consideration of environmental issues common to some other smelting processes, such as aluminum smelting. Finally, some consideration has been given to the use of chrysotile asbestos tailings to sequester atmospheric CO_2, a greenhouse gas. Overall, business speculations about future economic opportunities at abandoned and non-operating chrysotile asbestos mine sites need to be carefully considered as a possible hindrance to environmental risk reduction and restoration initiatives.

The scientific literature provides many studies on types of plants that can adapt to growth on undisturbed or disturbed, metal-rich and alkaline serpentine soils. Serpentine soils contain very low levels of plant nutrients such as nitrogen, phosphorous and potassium relative to many other soil types. This knowledge is of direct relevance for restoration of plant communities in mineral extraction areas, waste rock areas, abandoned mill sites or town sites, and road works. Limited information could be found on the potential for revegetation of tailings deposits, including reference to poor vegetation establishment at the Coalinga Minesite, California. A limited revegetation trial in 1985 at the Clinton Creek tailings area has been carried out, but the documentation of this could not be located. A trial of asbestos mine-tailings re-vegetation undertaken in Quebec in the 1970s underscores the technical and financial challenges associated with re-vegetation of serpentine asbestos tailings deposits.

A few of the abandoned or non-operating chrysotile asbestos mines world-wide (or other sites with high concentrations of asbestos fibres in surface soils) have been evaluated using a detailed human health risk assessment. Many areas have been neglected, however, based on the premise that the sites are remote, and human exposure would therefore be limited.

INTRODUCTION

The Clinton Creek Abandoned Asbestos Mine (64° 27'00" N, 140° 43'00" W) is located approximately 100 km northwest of Dawson City in the west central Yukon, northern Canada, near the Alaska Border. Following ten years of operation and then abandonment in 1978, the site remains minimally vegetated and very little reclamation has been carried out for most of the site areas. This is in spite of the fact that surface soils and waste materials around the site contain appreciable concentrations of fine to medium sized chrysotile asbestos fibres. The tailings pile, for example is composed of approximately 15 to 40% by weight chrysotile asbestos (RRU, 1999: Table 1).

In areas throughout the world where there is naturally occurring asbestos from serpentinite rock, the percentages of asbestos in the soil range from 1% to as much as 50% in areas where asbestos has been mined.

Table 1: Summary of Chrysotile Asbestos Fibre Content in Soils, Sediments, Tailings and Surface Water at Clinton Creek (RRU, 1999)

Media	No. of Samples	Range of Asbestos Fibre Conc. (% by wt)
Background soil	2	<1 to 5
Waste rock	3	<1 to 7
Tailings	5	15 to 40
Creek/River Sediment	16	<1 to 10
Surface water	10	<1.1 million to 152 milion fibres / litre

The United States Environmental Protection Agency (EPA) considers mine waste that contains more than 1 volume percent asbestos hazardous. The California Air Resources Board considers asbestos contents of mine waste greater than 5 volume percent as a potential toxic hazard.

The human health risks of airborne asbestos at the Clinton Creek mine site have not been evaluated in detail; however, human exposures are currently limited to some extent by (i) infrequent visits by humans to the site, and (ii) seasonal weather conditions which result in freezing and snow coverage of asbestos contaminated soils during winter months and more limited potential for re-distribution of asbestos fibres from soil to air during wetter periods during the spring, summer and fall.

The Clinton Creek mine site geology includes a complex assemblage of ultramafic, igneous and metamorphic rocks, such as serpentinite, diorite, amphibolite, schist, shales (including graphitic forms including argillite), siltstone and limestone rocks (Stepanek and McAlpine, 1992). The asbestos ore body is composed of chrysotile asbestos veinlets embedded in jade green serpentine.

For the vast majority of abandoned or working asbestos mines, increased soil levels and possibly airborne levels of asbestos fibre may occur in at least **five major areas of concern**:

(i) **Mined areas** from which serpentinite parent materials were extracted;

(ii) **Waste rock areas** depending on the fidelity of separation of asbestos-bearing from non-asbestos bearing minerals;

(iii) **The mill site** where asbestos fibres were physically separated from the host rock;

(iv) "**Tailings**" or mill waste, generated as discards from the crushing and physical separation of longer, higher quality fibres from shorter fibres and other materials; and

(v) **Roadways or other access areas** affected by the storage, handling and transport of mined, pre-processed and final processed asbestos.

Each of these areas of concern potentially result in different risks in terms of mobilization of asbestos fibres from soil to air, or based on entrainment in surface runoff. Each type of area may also require very different approaches for how risks are managed, and for mine site reclamation.

In addition to issues associated with the management of human health or ecological risks, mine site reclamation in practice can largely be considered as "ecosystem reconstruction — the re-establishment of the capability of the land to capture and retain fundamental resources" (Cooke and Johnson, 2002). In practice, "the presence or absence of topsoil conserved on the site has been given the status of the primary practical issue for consideration in ecological restoration in mining" (Cooke and Johnson, 2002), and this issue may be particularly important for mining of serpentine materials. In most cases, little attention has been paid to the conservation and stockpiling of topsoil at chrysotile asbestos mine sites. In addition, the value of serpentine soils saved from disturbed areas, or finer waste materials from serpentine ore deposits, might be less than at other types of mine sites since such soils tend to exhibit high metal concentrations and low nutrient value.

Reclamation of abandoned chrysotile asbestos mines, therefore, may be particularly challenging based on the convergence of at least two issues: (i) there may be a stronger imperative for surface reclamation in order to limit potential human health risks of mobilized asbestos fibres, and (ii) re-vegetation might be particularly challenging even where adequate top soil has been stock-piled owing to the poor quality of the soil for supporting plant and tree growth.

This paper briefly reviews the current status of mine site reclamation practices for abandoned chrysotile asbestos mines.

SCOPE OF THE PROBLEM

The major portion of the world's supply of chrysotile asbestos has been produced by seven countries: Russia, China, Canada, Kazakhstan, Brazil, Zimbabwe and South Africa (Table 2). Within Canada, major asbestos mines were located in the Yukon (Clinton Creek – 1968 to 1978), British Columbia (Cassiar Asbestos Mine – 1953 to 1980), Quebec (see next paragraph) and Newfoundland (Baie Verte Asbestos Mine - 1955 to 1981, 1982 to 1990).

Table 2: Estimated World Production (in Millions of Tons) of Asbestos Fibre in 2001 and 2002 (USGS, 2003)

	2001	2002
Russia	750	750
China	360	360
Canada	**340**	**340**
Kazakhstan	235	235
Brazil	170	170
Zimbabwe	120	120
South Africa	16	14
United States	5	3
Other countries	54	50
World total	**2,050**	**2,040**

Within Quebec, three major chrysotile asbestos mines were in operation at the beginning of 2002, with the asbestos being sold mostly in developing and Asian countries. These included the Jeffrey Mine, in the town of Asbestos, Que., accounting for about 40% of the annual chrysotile fibre production, and two mines in Thetford, Que. All are located within a mineralized zone approximately 100 km south of Quebec City.

The Jeffrey Mine began production in the late 1800s. In the 1950s, the Jeffrey Mine deposit had ore reserves as large as 450 million tonnes (Wrucke and Shride, 1986). By the mid 1970s, this mine, which at that time was the largest known asbestos deposit in the world, had the capacity to produce 544,000 tonnes of asbestos fibre a year (Energy, Mines, and Resources Canada, 1976).

The Jeffrey Mine went into bankruptcy protection in November 2002, but has not been officially closed, pending possible changes in the global market demand for chrysotile asbestos. The mine was subsequently re-opened for a short period by provincial court order.

Photo 1: Tailings pile near Thetford Mines townsite (from Reynolds website)

Ongoing concerns about soils contaminated with asbestos are not limited to the major producing countries, and concern about current and future human health risks associated with abandoned asbestos mines has been voiced in the United States, Australia, India, China, Portugal, Turkey, Brazil, Finland, Cyprus, Italy, Swaziland and elsewhere.

Photo 2: Tailings and waste near Thetford Mines townsite (from Reynolds website)

While the world production of asbestos has dropped since its peak usage in the mid-1970s, the recent rate of decline, on a global production basis, has been minimal since 1996 (Table 3, and World Production figures: Table 2).

Table 3: Estimated European and World Production (in Millions of Tons) of Asbestos Fibre, 1990s (Albin et al., 1999)

Country/Region	1986	1990	1996
Former Soviet Union	2,500	2,300	720
Italy	115	20	--
Greece	51.4	66.0	78.0
Cyprus	13.0	--	--
Yugoslavia	8.6	6.6	1.2
Czechoslovakia	0.25	?	?
Bulgaria	0.3	0.3	0.5
Europe Total	2,689	2,393	799
World Total	4,300	4,100	2,290

A rough indication of the number of asbestos mine sites that have been developed can be gleaned from an appreciation of the amount of asbestos-bearing ore in host rock deposits world wide. Figure 1 is adapted from Orris (1986) and is based on the analysis of 50 major asbestos-bearing ore bodies, including Clinton Creek.

The Clinton Creek ore body is within the lower 50th percentile of size for asbestos-bearing serpentinite deposits. The Thetford, Quebec, deposits are among the largest internationally. Orris (1986) also indicated that the median grade for recovered asbestos fibres for the 50 deposits examined was 4.6% of the total ore weight. At Clinton Creek, approximately 5.9% of the ore was recovered as marketable chrysotile asbestos fibre; i.e. about 0.98 million tons of chrysotile asbestos over the course of the mine's ten year operational history. Comparing this figure to world production estimates for 2002 (Table 2), we note that the entire chrysotile asbestos production from the Clinton Creek mine site is only about 0.05% of the estimated global production for just 2002.

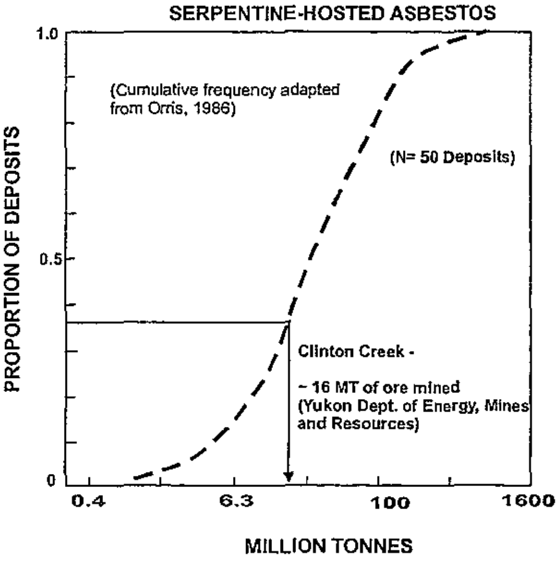

Figure 1: Expected Size Distribution of Serpentine-Hosted Asbestos Deposits Globally

It can reasonably be concluded, therefore, that challenges with reclamation at Clinton Creek are likely to be similar to or perhaps less challenging than at a large number of asbestos mine sites.

Much of the world's supply of amosite, recognized to be one of the most carcinogenic forms of asbestos was mined in South Africa (Davies et al., 2001). Several towns, such as Penge in the northern part of the Country, have been abandoned around former amosite asbestos mine sites, owing to levels of soil and air contamination now considered unsafe for humans.

There has been a strong recent interest especially in the United States in asbestos fibres in soils. In some cases, the recent concern is based on abandoned asbestos mines or manufacturing operations. For example, there are elevated asbestos levels in soils associated with former commercial asbestos mining operations in several western Massachusetts towns (Chester, Blandford, Plainfield, and Hinsdale) (MADEP, 2003). These mines were located at the southern edge of a geologic formation known as the "Talc-Serpentine District", in which naturally occurring asbestos extends from Western Massachusetts into Vermont.

Asbestos fibre contamination of soil has been detected at many urban and industrial brownfields sites, and following building demolition and contaminated site remediation. For example, soil asbestos contamination has been an issue at the World Trade Center site.

CASE STUDIES

Atlas Asbestos Mine, California

The Atlas Asbestos Mine Site (chrysotile asbestos) near Coalinga, California is an abandoned, open-pit mine with a mill and tailing piles that occupies approximately 176 ha. Chrysotile fibres are ubiquitous at the site, both in natural serpentine soils and rocks and as a milled product in the tailings area. The area is drained by intermittent streams, which drain into the White Creek and ultimately into the California Aqueduct. In early 1980, the Metropolitan Water District of Southern California detected elevated levels of asbestos in water samples from the California Aqueduct in Los Angeles. Atlas Mine was subsequently identified as one probable source.

A remedial action at the Atlas site was completed in 1999. The cleanup included:

1) dismantling and disposal of the mill building and other debris;
2) run-on/run-off controls (including stream diversion channels and sediment trapping dams);
3) a pilot revegetation project;
4) fencing to prevent disturbance of the remediated areas, and
5) deed restrictions of the affected parcels.

The US Environmental Protection Agency has delisted the site following its remediation.

According to the California Department of Toxic Substances Control –

"Overall the revegetation project was a success. Revegetation on the portions of the site that contained mostly asbestos was not nearly as successful as the portions that were over 50% soils or clays."

The remediation addressed re-vegetation of areas of the site other than tailings deposits. It appears that self-sustaining vegetative cover was not achieved for the tailings. In addition, the remediation was not guided by a prior evaluation of human health risks due to incidental and infrequent airborne exposures to chrysotile asbestos fibre. Instead, it appears that this issue was addressed through site exclusions and restrictive covenants.

Coalinga Asbestos Mine, California

The Coalinga Asbestos Mine site is a privately owned 225 ha tract of land located 27 km northwest of Coalinga, California in the same general geological formation as the Atlas mine site, within the Clear Creek Management Area. The mine was operated by the Coalinga Asbestos Company from 1962 to mid-1974, on land leased from the Southern Pacific Railroad. From November 1975 to October 1977, the Coalinga Asbestos Company assigned the lease to the Marmac Resource Company, which used the site to conduct a chromite milling operation.

The site includes asbestos mill tailings, an asbestos ore storage/loading area, an abandoned mill building, an inactive chromite mine (the Railroad Mine), filled-in chromite settling ponds, and debris.

Land uses in the vicinity of the mine are less restricted than for the Atlas mine site, and include mining, ranching, farming, and recreation (camping, hunting, hiking, gem collecting, and riding off-highway vehicles).

Chrysotile fibres are widely dispersed in soils and mine waste at the site, as is chromite, both as a result of natural mineralization and due to mining activities.

There are no residences within several miles of the mine; however, airborne hazards from this site were deemed to be potentially harmful. EPA performed extensive air monitoring to assess exposures of residents in the cities of Huron and Coalinga, which are more than 35 km from the site. The Coalinga property was identified along with the Atlas site as a probable contributor to elevated levels of chrysotile asbestos fibres (up to 25 billion fibres per liter) in the California Aqueduct.

Southern Pacific Land Company (SPLC) – now known as the Santa Fe Pacific Realty Corporation, is assuming responsibility for the site remediation. Remediation activities include the following:

1) grading and erosion minimization (cross canyon stream diversion, improvements to an existing sediment trapping dam);
2) hydraulic control structures,
3) existing mill demolition;
4) access restrictions (limiting access to the site by erecting a fence);
5) deed restrictions;
6) re-vegetation;
7) road paving through former mill site area to reduce dust.

Deed restrictions unilaterally filed in 1992 prohibit anyone in possession of the property from taking actions that might interfere with the remedy. Following the remedial actions, approximately 345,000 m^3 of contaminated soil was contained on-site. However, 217 ha – the majority of the site – was released for re-use.

No information was found on the particulars or success of re-vegetation, or of pre- versus post-remediation concentrations of chrysotile asbestos fibres in soil, sediment, air or surface waters.

In addition to the mine-site remediation activities, various steps were taken within the City of Coalinga to address various types of contamination. The EPA selected a remedy to clean up the 43 hectares of contamination in the City of Coalinga that resulted from the Atlas and Coalinga asbestos mines. The remedy included-

1) excavating and consolidating approximately 20,000 m^3 of asbestos, chromium, and nickel-contaminated soil and building debris;
2) building an underground waste management unit (WMU) to contain and dispose of contaminated soil and waste on site;
3) covering the WMU area with an impermeable cap;
4) re-grading the excavated area;
5) decontaminating the debris;
6) monitoring the soil, groundwater, and air; and
7) implementing deed restrictions on the use of the land.

The cleanup was completed in 1995. A five-year review was completed and found no health threat or actions were needed. A second five-year review, conducted in 2001, concluded that the remedial actions were effective in protecting human health.

For the overall Clear Creek Management Area, in which the Coalinga and Atlas mine sites are located, the California Bureau of Land Management has declared about 12,000 ha to be a "hazardous asbestos area" because of the natural occurrence of chrysotile. Another interesting aspect of the Clear Creek Management Area is the presence of about 4,000 ha of "barren hills" area. These are native serpentine soil areas that were de-vegetated in part through logging activity during the nineteenth century, and in part as a result of two major forest fires: one in 1942 and one on 1951. The poor ability of the serpentine soils to support plant growth, as well as erosion following de-vegetation are both contributing factors for their current barren condition.

Conditions that impede plant growth on natural or disturbed serpentine soils can also result in the presence of highly adapted and unique native plant communities. Among the diverse plant community are many rare plants that have adapted over the centuries to thrive in the nutrient-poor mountains that make up the New Idrian Serpentine Formation. The San Benito Evening Primrose, *Camissonia benitensis*, is found no other place on earth. This is also the only place where four conifer species (the Jeffrey Pine, Coulter Pine, Foothill Pine and Incense Cedar) are known to exist together.

Libby, Montana

Vermiculite was mined in Libby, Montana, from the 1920s until the mine closed in 1990. While in operation, the mine in Libby produced up to 80% of the world's annual supply of vermiculite. Vermiculite has been used in building insulation, potting soil and fertilizer. The vermiculite from the Libby mine contained tremolite-actinolite forms of asbestos.

In response to local concern and news articles about asbestos-contaminated vermiculite, the U.S. Environmental Protection Agency, Region 8 sent an Emergency Response Team to Libby, Montana in late November 1999. The EPA team collected nearly 700 samples (air, soil, dust, insulation). Tailings and waste rock contain at least 5 – 7% by weight of tremolite asbestos.

The site has been designated as a "Superfund" site under US Federal law, by the United States Environmental Protection Agency in recognition of the widespread contamination of the mine site and adjacent town site with asbestos. In August of 2003, a federal district court judge ordered the mine owner, Cambridge, Massachusetts-based W.R. Grace & Co. to reimburse the government for $54.5 million in cleanup costs at the Libby Superfund site. In a statement, the company said it could eventually be liable for $100 million in EPA ordered site cleanup spending.

The site remediation for the mine site and Libby town site includes large-scale soil excavation and removal, as well as soil capping to reduce asbestos fibre concentrations in surface soils. Remediation efforts are at an early stage. Some reclamation, however, has occurred. As areas were mined out, concurrent reclamation by the mining company was completed. In fact, various bonds were returned or reduced in the late 1990s; e.g. in a 50 hectare area of the site because vegetation on reclaimed areas continued to improve.

Woodsreef Asbestos Mine, New England, Australia

A remediation case study is described by the New South Wales Department of Mineral Resources. The open pit Woodsreef Asbestos Mine first commenced at Woodsreef in 1918, but ceased in 1923 as the product was uncompetitive with imported fibre. Large scale mining was carried out between 1970 and 1983 by Chrysotile Corporation of Australia.

During this latter period, approximately 500,000 tonnes of chrysotile asbestos fibres were produced from 100 million tonnes of mined material. The downturn in asbestos demand in the domestic and international markets resulted in the closing of the mine in 1983, without any significant reclamation or risk management work. Chrysotile Corporation no longer exists as a company and the mine is now classed as derelict.

Inadequate defaulted securities and the often proposed reopening of the mine were hindrances to suggested rehabilitation strategies. The lack of rehabilitation has been a source of public concern.

A 75 million tonne waste rock dump, a 24 million tonne tailings dump, the water-filled open pit, and the mill building remain on the site. The tailings dump covers approximately 43 ha and has an average height of 45 metres, with a maximum height of 70 metres. The two waste rock dumps cover an area of 117 ha.

Officers of the Departments of Mineral Resources, Land and Water Conservation and the Environment Protection Authority regularly monitored the site during its operation and have continued to do so since closure in 1983. In 1986, a government commissioned report was prepared which provided a range of options for site rehabilitation. Cost estimates were as high as $60 million USD, with a preferred option costed at around $6 million USD. At the time, consideration was being given to reprocessing the tailings and rehabilitation was deferred.

During 1992-93, the Departments of Mineral Resources and Land and Water Conservation spent $120,000 USD from Derelict Mined Lands Rehabilitation Program funds to establish sediment control and water management structures.

In 1996, the Derelict Mined Lands Rehabilitation Program commissioned an ecological and human health risk assessment of the mine site and surrounding areas. In parallel with the risk assessment, an examination into the potential for re-opening the mine was carried out by the Department of Mineral Resources, based on either market opportunities for chrysotile asbestos or recoverable metals such as magnesium. This study concluded that any re-opening of the mine was likely to be non-viable economically, pending technological developments in Canada on magnesium recovery from serpentine asbestos mine tailings.

The main findings of the environmental risk assessment were -

- The north and south open pits are highly unstable, with the old benches susceptible to erosion and mass movement. Tension cracks and scarps are evident.
- The lack of vegetation cover and the slope of the dump batters, ranging from 30° and 40°, has increased the risk of erosion and sedimentation of Ironbark and Nangahrah Creeks as well as settling dams and other drainage lines.
- Risks due to failure of the waste and tailings dumps were considered to be negligible.
- Asbestos inhalation was considered to be the dominant health risk presented by the site, accounting for 90% of the total risks. The risks however were not considered to be significant given the low level of exposure. The public concern of the hazard from Chrysotile asbestos was concluded to be overstated: Based on 1984 monitoring data, the ambient fibre levels at Woodsreef were well below the recommended 0.5 f/ml risk threshold.
- Ecological and public health risks due to chemical pollution and leaching were considered to be negligible.
- The mine is generally considered visually unattractive with limited revegetation, the stark grey-white colouring of the site, scattered refuse and the falling into disrepair of the seven-storey mill building and other mine structures.
- Trespassing by the public within the Woodsreef is another concern associated with the derelict mine, although no instances of injuries had been received.
- A social survey included in the study indicated that the local community believed that the aesthetic impact of the site did not warrant urgent attention.

The risk assessment report included the following recommendations:

- A program of monitoring airborne asbestos concentrations as a first priority.

- A monitoring program to examine sediment accumulations and off site movement.
- Installation of better security fencing.
- Removal of old mill buildings with disposal in the open pit.
- Up-grading or re-routing of the local access road which passes between the tailings dump and waste rock dump.

There are some lessons from this site that are likely to be relevant for the Clinton Creek mine site (and many of the other abandoned chrysotile asbestos mines). The major concern from a human health perspective is likely to be inhalation exposures to airborne asbestos fibres, and the magnitude of risks might be most strongly influenced by the extent of human use of the site. In the case of the Woodsreef and Atlas mines sites, human health risk management recommendations included prevention of human access to critical exposure areas through fencing and other exclusions measures.

Cassiar Asbestos Mine, British Columbia

Many of the world's asbestos mine sites have yet to be seriously considered for reclamation/ restoration work, since sites have not been formally abandoned, pending the possible rebound in the global market for chrysotile asbestos fibre. This is the case for the Cassiar Asbestos Mine in northern British Columbia. The basic regulatory requirements for reclamation at the Cassiar Asbestos Mine are similar to any other active mine in British Columbia, however, and reclamation activities will likely include re-contouring as well as the capping of bedrock and tailings with 0.5 m of overburden of suitable quality for the establishment of vegetative communities.

The following information comes from British Columbia Ministry of Energy and Mines reports. The property at Cassiar is maintained in good standing, although the mill building was destroyed by fire in the early 1980s. The concentrator and the air building, along with auxiliary camp facilities, survived the fire.

Cassiar Resources Inc. looked at the feasibility of reactivating the chrysotile production facility at Cassiar, but determined that rebuilding the plant is not in the company's current plan. In addition, Cassiar Resources Inc. has studied the magnesium production plans and determined that it will not actively pursue Cassiar's magnesium potential for the time being but will monitor developments. The development of hydro-electric resources or the availability of natural gas in northern British Columbia would greatly improve the prospects of magnesium production at Cassiar.

Other Asbestos Mine Sites

Passing reference was found in various internet sources for human health and environmental risk assessments, or for reclamation activities, at a few other mine sites.

Two phases of a study have been undertaken in evaluating the human health risks associated with various activities at an abandoned asbestos mine in South Africa. The name of the property could not be ascertained from the source. Additional details might be available from South African regulatory authorities. The Msauli and Gefco mines were the last producing mines in South Africa. Gefco Mine ceased production in 1997.

In Cyprus, an abandoned asbestos mine lying on the eastern side of Mt. Olympus in the Troodos Mountains is being remediated to lessen the potential problems from the asbestos and the unstable slopes created by the mining. Additional details might be available from Cyprus regulatory authorities.

PLANT GROWTH ON SERPENTINE SOILS AND ASBESTOS MINE WASTES

Serpentine soils tend to exhibit low levels of major plant nutrients (nitrogen, phosphorus, potassium and calcium) relative to other soil types, as well as elevated levels of trace metals/metalloids such as chromium, cobalt, nickel, magnesium, arsenic. Plant ecologists, have had a long-standing interest in plant and fungal communities and ecotypes found on natural serpentine soil deposits (Harrison, 1999; Kamaya et al., 2002; Martino et al., 2003; Meyer, 1980; Oberhuber et al., 1997; Reeves and Baker, 1984; Taylor and Levy, 2002; Wallace et al., 2002).

There are major features of such studies. Plant communities on serpentine and ultramafic soils tend to be highly adapted, and may include rare species. Succession of these communities is generally very slow (Slingsby et al., 2001) and is atypical since, closed vegetative communities are limited to shallow surficial soils that, once removed, cannot be easily re-developed from the underlying parent material. Plant community establishment in natural areas may be dependent on the presence of drift soils, which may form a relatively fragile and thin veneer, and may be spatially heterogeneous. Erosion, therefore, may be a critical factor for plant community establishment and succession in serpentine soil environments. Such features may also make plant communities vulnerable to drought stress.

On serpentine soils, like some other metal-rich soil types, the plant and soil invertebrate communities may have high metal tolerance, either through an adaptive strategy of metal exclusion or through a diametrically opposed strategy of hyper-accumulating at least some of the metals present.

Meyer (1980) conducted pot culture studies on barley growth in chrysotile asbestos mine tailings from Barraba, New South Wales, Australia. The tailings were found to be deficient in nitrogen, phosphorus, potassium and calcium, and barley grew normally only when superphosphate and gypsum were applied at rates equivalent to 5 and 16 tonnes per hectare respectively, together with the application of `normal' rates of nitrogen and potassium. Gypsum addition resulted in an increase in calcium concentrations in the soil porewater, but the majority of added calcium was taken up by the tailings, and this was accompanied by a major displacement of magnesium into solution. Elevated metals in the tailings such as chromium and nickel were not accompanied by elevated levels in soil porewater or plant tissue.

Moore and Zimmerman (1977) examined re-vegetation trials on asbestos tailings piles for the southeastern Quebec Thetford mines. Some of the tailings piles in the study region were virtually devoid of vegetation even though they were deposited up to 60 years prior. It was estimated that, in the asbestos mining belt of south-eastern Quebec, tailings deposits as of 1977 cumulative covered 5.5 km^2 of land surface and waste rock another ~9 km^2.

Moore and Zimmerman (1977) described the particle size distribution of the tailings examined in the study, and noted that the tailings tended to form a hard surface crust after 5 years, which may impede root development. This differs somewhat from personal observations of the asbestos tailings at Clinton Creek, which remain very loose due to large downslope movements of the tailings piles that occurred from the mid-1970's to mid-1980's and also creep movements that may still be occurring. A thin crust has formed over the much of the tailings pile at Clinton Creek.

Moore and Zimmerman (1977) noted that the few plants found on the tailings dumps were invariably associated with pockets of soil, overburden, or waste rock incorporated into the tailings. Species observed included ryegrass, foxtail barley, weedy composites, white sweat clover and vetch. Following various manipulations, it was concluded that vegetative cover could be maintained adequately over a three year period based on the application of at least 1 kg/m^2 of NPK fertilizer and 4 kg/m^2 of farmyard manure or sawdust. Even at these rates, however, signs of plant deficiency in Ca and N appeared. Seasonally low water potentials were considered to negatively affect seed germination and seedling growth at times. It was estimated that re-vegetation of tailings deposits using treatments necessary for sustained growth would cost between $2,960 CAN and $3,460 CAN per hectare in 1977 dollars.

Passaccione et al (2001) examined the growth of Virginia pine (*Pinus virginiana*) and the associated ectomycorrhizal community on serpentine soil plots in Maryland, USA, in comparison with plots on non-serpentine clay lenses in the same area. These soil types differ substantially in pH, Mg, and Ni concentrations, as well as in the availability of N and P. The serpentine soils also had a lower C:N ratio (10.7 versus 18.5), suggesting a greater pool of accessible N in the organic fraction.

Prasad and Freitas (1999) prepared a review paper on the use of plants adapted to serpentine soils for phytoremediaton of various metals. The issue of asbestos fibres in soils was not discussed, however.

Nonetheless, Prasad and Freitas (1999) provided a list of plant species (most of them of European origin) that have been shown by various researchers to be possible metal hyperaccumulators (Table 4).

Given the presence of elevated metals such as nickel and chromium in serpentine soils and asbestos mine waste, these might exhibit a higher tolerance to site conditions. Furthermore, this list should be cross-referenced against the list of plants that currently occur at the Clinton Creek abandoned mine site.

Baker *et al.* (2000) and Reeves and Baker (2000) also discuss the phenomenon of metal hyeraccumulation in plant species.

Peterson *et al.*(2003) examined the uptake of nickel, chromium and cobalt by the plant *Alyssum pintodasilva*, a member of the mustard family that is dominant in soils of Portuguese serpentine outcrops. Samples of grasshoppers, spiders, and other invertebrates were also collected from sample plots to examine trophic transfer of metals. Chromium and cobalt, occurring in high concentrations in the serpentine soil but not accumulated by *A. pintodasilvae*, were not elevated in the invertebrates. These invertebrates exhibited significantly elevated levels of nickel, however, as did the plants, and the flux of nickel into the food web was interpreted to be facilitated by the presence of hyper-accumulating plants.

TAILINGS RE-PROCESSING AS AN ALTERNATIVE TO RECLAMATION

In Canada and elsewhere there has been an interest in the production of magnesium from previously mined asbestos deposits. Tailings material from abandoned chrysotile asbestos mines may be a viable source of magnesium (typically 12 to 30% of the dry weight of chrysotile asbestos tailings), and a re-extraction operation has commenced at one of the major Quebec mine sites. In 2000, Noranda was the first company internationally to commercially re-process chrysotile asbestos tailings for magnesium recovery. Noranda built the Magnola magnesium plant in Danville Quebec, at a cost of $900 million. The plant uses serpentine tailings as its raw material, and has a production capacity of 60,000 tonnes/yr. This is close to 20% of world supply. The raw material source is a pre-existing 300-year supply of serpentine tailings from the Thetford Mines, which contain about 24 percent magnesium, located adjacent to the plant site.

Other Canadian projects where asbestos mine tailings re-processing has been or is still being considered include Cassiar Resources Inc. at Cassiar, British Columbia and the Canadian Magnesium Corporation at Baie Verte, Newfoundland and Labrador.

For the Magnola operation, the recovered serpentine-rich tailings are passed through a scalping screen to remove lumps of material.

Table 4: Plant Species with Potential as Hyper-Accumulators, and Which May be Found on Serpentine Soils

Latin Name	Family	Latin Name	Common Name
Acer saccharinum	Aceraceae	*Haumaniastrum*	Lamiaceae
Aeollanthus biformifolius	Lamiaceae	*Helianthus annuus*	Asteraceae
Agrostis capillaris	Poaceae	*Holcus lanatus*	Poaceae
A. gigantea	"	*Hordelymus*	"
A. stolonifera	"	*Hydrangea*	Hydrangeaceae
A. tenuis	"	*Hydrocotyl umbellata*	Apiaceae
Alyssum bertolonii	Brassicaceae	*Limnobium*	"
A. lesbiacum	"	*Lolium multiflorum*	Poaceae
A. montanum	"	*L. perenne*	"
A. murale	"	*Macadamia*	Proteaceae
A. pintodasilave	"	*Medicago sativa*	Fabaceae
A. serpyllifolium sub sp.	"	*Melilotus officinalis*	Fabaceae
Amaranthus retroflexus	Amaranthaceae	*Mimulus guttatus*	Caryophyllaceae
Anthoxanthum odoratum	Poaceae	*Minuartia hirsuta*	"
Arabidopsis thaliana	Brassicaceae	*M. verna*	"
Armeria maritima sub. sp.	Plumbaginaceae	*Nardus stricta*	Poaceae
Arrhenatherum pratensis	Poaceae	*Pelargonium*	Geraniaceae
Astragalus racemosus	Fabaceae	*Pinus pinaster*	Pinaceae
Avenella flexuosa	Poaceae	*Podophyllum peltatum*	Berberidaceae
Berkheya coddi	Asteraceae	*Polygonum*	Polygonaceae
Betula papyrifera	Betulaceae	*Populus tremula*	Salicaceae
B. pendula	"	*Quercus rubra*	Fagaceae
B. pubescens	"	*Q.ilex*	"
Brachypodium sylvaticum	Poaceae	*Ranunculus baudotti*	Ranunculaceae
Brassica juncea	Brasicaceae	*Rauvolfia serpentina*	Apocynaceae
B. napus	"	*Ricinus communis*	Euphorbiaceae
B. hordeaceus	"	*Rumex*	Polygonaceae
Bromus ramosus	Poaceae	*Salix viminalis*	Salicaceae
Calystegia sepium	Convolvulaceae	*Sebertia acuminata*	Sapotaceae
Carex echinata	Cyperaceae	*Silene compacta*	Carophyllaceae
Chrysanthemum	Asteraceae	*S. cucubalus*	"
Cochleria pyrenaica	Brassicaceae	*S. italica*	"
Colocasia esculenta	Araceae	*Solanum nigrum*	Solanaceae
Cynodon dactylon	Poaceae	*Sorghum sudanense*	Poaceae
Danthonia decumbens	"	*Thlaspi alpestre*	Brassicaceae
D. linkii	"	*T. arvense*	"
Datura innoxia	Solanaceae	*T. caerulescens*	"
Deschampsia caespitosa	Poaceae	*T. calaminare*	"
Echinochloa colona	Poaceae	*T. goesingense*	"
Epilobium hirsutum	Ongraceae	*T. montanum*	"
Eriophorum angustiflolium	Cyperaceae	*T. ochroleucum*	"
Eschscholtzia californica	Papaveraceae	*T. rotundifolium sub*	"
Fagopyrum esculentum	Poaceae	*Thinopyrum*	Poaceae
Fagus sylvatica	Fagaceae	*Trifolium pratense*	Fabaceae
Festuca rubra	Poaceae	*T. repens*	"
Fraxinus angustifolia	Oleaceae	*Viola arvensis*	Violaceae
Gossypium hirsutum	Malvaceae		

Typical composition of the feed is 40% MgO, 38% SiO_2, 5% Fe compounds (Fe_3O_4), 13% H_2O and varying amounts of CaO and Al_2O_3, depending on the location of the tailings pile. The feed is consistent in mineralogy, chemistry and size distribution because the bulk of the raw material has already been processed in the asbestos mining operations. The Magnola process is designed to accept the serpentine residues without additional feed preparation steps.

One tailings sample obtained from the Clinton Creek tailings area contained approximately 17% magnesium, while four samples of quart-carbonate altered serpentinite collected from the site contained 12.1 to 12.6% Mg (RRU, 1999).

Some consideration has been given to the use of chrysotile asbestos tailings to sequester atmospheric CO_2, a greenhouse gas (Wolf et al., 2004; Enick et al., 2001). In order for the carbonation of serpentine minerals to be an effective measure for the reduction in atmospheric CO_2, it would be necessary to artificially accelerate carbonation rates from geological time scales (e.g. complete carbonation over ~100,000 years) to time scales in the order of days to weeks. While there have been some promising results from pilot-scale studies, so far no economically viable technique has been developed.

According to Enick et al. (2001), two carbonation processes are currently being considered. The first involves the acidic (HCl) extraction of magnesium from the host material (e.g. asbestos tailings) followed by reaction with water to yield Mg(OH)Cl. This is then processed in water to yield magnesium hydroxide and magnesium chloride. The magnesium hydroxide is then carbonated in a gas-solid or aqueous system reaction. The second method - "Direct carbonation" is a more simple carbonation process, but can only be facilitated by overcoming significant reaction rate barriers. The minerals are crushed into a fine powder, and mixed with water to form a slurry which is then bought into contact with either liquid CO_2 or supercritical carbon dioxide, The subsequent formation of carbonic acid lowers the pH of the aqueous phase, which leads to the formation of poorly soluble metal carbonates. The direct carbonation technique would require reaction at high-pressure, and at benchtop scale has resulted in relatively low conversions of about 30%.

NOVEL SITE REMEDIATION APPROACHES

Martino et al. (2003) have experimented with a novel approach to reduced cancer risks from asbestos fibres in soils, based on bioremediation. This is based on the recognition that there are few viable ways of remediating large areas of soils affected by widely dispersed fibres at brownfields and abandoned mine sites. One factor that may contribute to the induction of mesenthelioma-type cancers in humans following asbestos inhalation is the presence in embedded fibres of iron, which may catalyze the production of free radicals in the surrounding lung tissue. The Italian researchers have found in laboratory experiments a high potential of fungi such as *Fusarium oxysporum*, a common cause of plant rot, *Mortierella hyalina* and *Oidiodendron maius*, a fungus that attacks trees and shrubs, to accumulate and remove iron from crocodilite asbestos fibres. An added benefit is that fungal hyphae may serve to stabilize the fibres against mobilization to the air.

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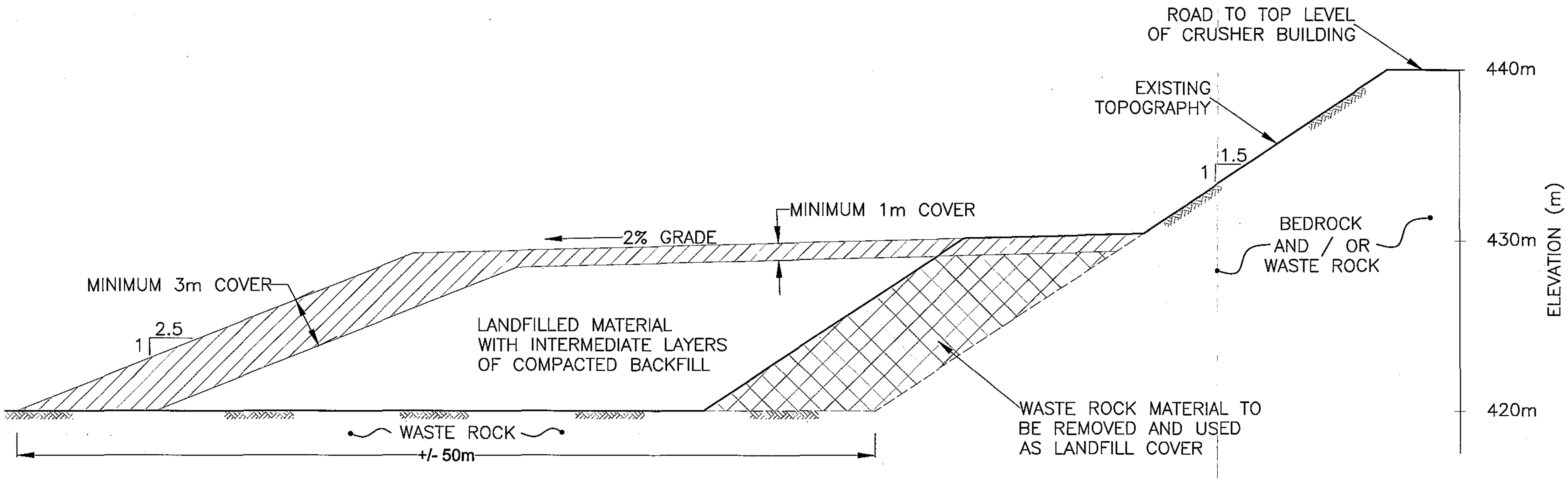
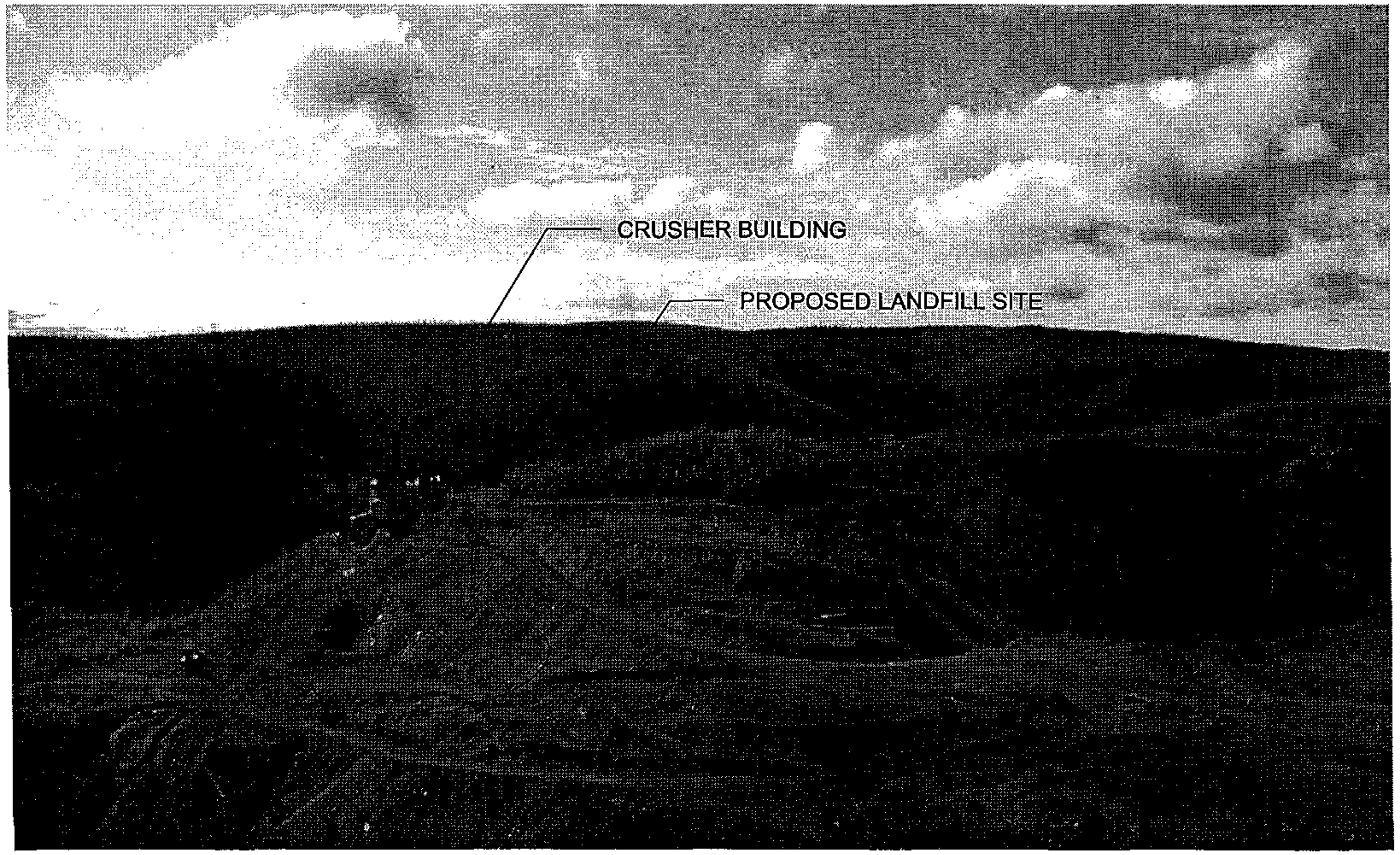
Appendix F

CONCEPTUAL LANDFILL

Plot Scale: 1:1
Plot Time: Jun 16, 2004 – 11:05am
File: L:\Earth & Water\Projects\6029 Government of Yukon\6029-005-00 Clinton Creek 2003_Hazard Assessment\Drafting\2004\F1_Crusher.dwg – Tab: F-1





NOTE: AREA AVAILABLE FOR LANDFILL IS APPROXIMATELY 50m x 100m = 5,000m2.
HEIGHT OF LANDFILL CAN VARY FROM 10m TO 20m.

UMA Engineering Ltd.
• Consulting • Engineering • Construction • Management Services

GOVERNMENT OF YUKON
FORMER CLINTON CREEK ASBESTOS MINE
HAZARD ASSESSEMENT REPORT

TITLE:	CONCEPTUAL LANDFILL FOR CRUSHER DEMOLITION		
JOB No.	6029–005–00	DATE:	JUNE 2004
SCALE:	1:250	DWG. No.	F–1
CHECKED:	GR		

Appendix G

HEALTH AND SAFETY
AND
EMERGENCY RESPONSE PLAN

HEALTH AND SAFETY
AND EMERGENCY RESPONSE PLAN

CLINTON CREEK
ABANDONED ASBESTOS MINE

Prepared for:

UMA ENGINEERING LTD.

Prepared by:

SENES CONSULTANTS LIMITED
121 Granton Drive, Unit 12
Richmond Hill, Ontario L4B 3N4
CANADA

Tel:	(905) 764-9380
Fax:	(905) 764-9386
E-Mail:	senes@senes.ca
Web Page:	www.senes.ca

March 2004

33587

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LIST OF APPENDICES **AT REAR OF REPORT**

1.0 PART 1 – GENERAL

1.1 APPLICATION

This plan applies to any work performed at the Clinton Creek site, with the exception of work where air monitoring has been carried out and the results of air monitoring have indicated that potential exposures to airborne asbestos fibres are below 25% of the Yukon Occupational Exposure Level (OEL) for chrysotile asbestos. The professional judgement of a competent person may also be relied upon to determine whether potential exposures are likely to exceed 25% of the OEL. Such judgement would be based upon knowledge of site conditions and results from previous air sampling programs.

Any area at the Clinton Creek site where demolition or removal of existing structures is carried out will be classified as a "restricted area".

1.2 LOCATION

The Clinton Creek Asbestos Mine is located 100 km northwest of Dawson City in the Yukon Territory. The location is at 64^0 27' 00" N and 140^0 43' 00" W adjacent to Clinton Creek approximately 9 km upstream of its confluence with the Forty Mile River. Porcupine and Wolverine Creeks are local tributaries of Clinton Creek.

1.3 REGULATORY AGENCIES

.1 Territorial requirements pertaining to asbestos are prescribed in the Yukon Occupational Health Regulations (Sections 33 – 41).

1.4 ABBREVIATIONS

The following abbreviations and definitions are used in this document:

1.	ANSI	American National Standards Institute. Publishes consensus standards on a wide variety of subjects, including safety equipment, procedures, etc.
2.	CEPA	Canadian Environmental Protection Act

3.	CSA	Canadian Standards Association, the national consensus standards association for Canada is roughly the Canadian equivalent of ANSI in the US
4.	DIAND	Department of Indian Affairs and Northern Development
5.	ERP	Emergency Response Plan
6.	GY	Government of Yukon
7.	MSDS	Material Safety Data Sheet provided by chemical manufacturers
8.	MSHA	Mine Safety and Health Administration, an agency of the US Department of Labour
9.	NIOSH	National Institute for Occupational Safety & Health. An arm of the US Centres for Disease Control, it does research and suggests guidelines for exposure control, but is not a regulatory agency
10.	OSHA	Occupational Safety & Health Administration, a part of the US Department of Labour, it regulates many job safety issues, including chemical handling and storage; also Occupational Safety & Health Act, the US Federal legislation which created OSHA (the Administration) and NIOSH
11.	RMO	Resource Management Officer
12.	TDGA	Transport of Dangerous Goods Act
13.	WHMIS	Workplace Hazardous Materials Information System. This program is legislated by the Canadian government, which requires, among other things, the creation and availability of material safety data sheets
14.	OEL	Occupational exposure limit
15.	HEPA	High Efficiency Particulate Aerosol

1.5 DEFINITIONS

"Asbestos" means chrysotile, crocidolite, amosite, tremolite, anthophyllite and actinolite when in their fibrous form.

"Asbestos Control Contractor" means an employer certified by an accredited agency as competent in asbestos control.

"HEPA filter" means high efficiency particulate aerosol filter.

"Restricted area" means an area of a work site in which there is a reasonable potential for worker exposure to airborne asbestos in an amount equal to or greater than 25% of the 8-hour Occupational Exposure Limit (OEL). (The 8-hour OEL for chrysotile asbestos is 0.5 fibres per millilitres of air (f/mℓ).

"HEPA vacuum" means a High Efficiency Particulate Aerosol (HEPA) filtered vacuum equipment acceptable to Health and Welfare Canada and meeting U.S. Military Standard 282. This vacuum equipment shall have a filtering system capable of collecting and retaining asbestos fibres to an efficiency of 99.97% for fibres of 0.3 micrometers or larger.

"Amended water" means water with a non-ionic surfactant added to reduce water tension to allow thorough wetting of asbestos fibres.

"Airlock" means a system for permitting ingress or egress without permitting air movement between a contaminated area and an uncontaminated area typically consisting of two curtained doorways at least 1.5 m apart.

"Curtained doorways" means an arrangement of closures to allow ingress and egress from one room to another while permitting minimal air movement between rooms, typically constructed by placing two overlapping sheets of polyethylene over an existing or temporarily framed doorway, securing each along the top of the doorway, securing the vertical edge of one sheet along one vertical side of the doorway and securing the vertical edge of the other sheet along the opposite vertical side of the doorway. All free edges of polyethylene shall be reinforced with duct tape and the bottom edge shall be weighted to ensure proper closing. Each polyethylene sheet shall overlap openings an additional 1/3 of the doorway width.

"Wetting agent" means 50% polyoxethylene ester and 50% polyglycol or polyoxethylene ether, or equivalent approved product, and shall be mixed with water to a concentration to provide adequate penetration and wetting of asbestos-containing material.

"Authorized person" means a representative of the Government of Yukon, the Site Engineer or the Contractor.

1.6 EXISTING CONDITIONS

"Chrysotile" is the type of asbestos present at the Clinton Creek site.

1.7 COMMUNICATIONS

A satellite phone will be available on site for communication and emergency calls.

1.8 HAZARD IDENTIFICATION

1. Asbestos Hazards - inhalation of asbestos fibres by workers involved in work at the site.
2. Chemical Hazards - fuels used on site
3. Explosion or Fire - ignition of explosive or flammable liquids
4. Physical Hazards
    - mechanical equipment, sharp objects
    - increased risk of injury to personnel when wearing protective gear (if required) that may impair agility, stamina, hearing, and vision
    - electric shock when using power equipment in wet location or using poorly grounded tools
5. Wildlife - moderate risk (bears)

1.9 GENERAL HEALTH AND SAFETY MEASURES

1. All work will be conducted, as a minimum, in strict compliance to all applicable laws, ordinances, rules, regulations and orders and general practices for the safety of persons or property. The applicable requirements include any general safety rules and regulations of Yukon Workers' Compensation Health and Safety Board, WHMIS and Occupational Health and Safety legislation.
2. If deemed necessary, the Contractor shall provide wildlife monitors, acceptable to the Engineer, equipped with firearms to protect the safety of all workers including the Engineer, and Engineer's support staff during site operations.
3. Prior to the start of the work, all team members will participate in a mandatory safety briefing session to become familiar with all aspects of the Safety Program and Emergency Response Plan. Specific instructions on actions to be taken in case of safety violations, accidents, personal injury and emergencies will be provided.
4. Prior to commencement of specific work activities, all team members will be briefed on the following safety issues:
    a. safety equipment and use
    b. work procedures

    c. contaminants on site
    d. emergency measures in case of an accident or fire

5. A "buddy system" will also be used as a protective measure in particularly hazardous situations so that team members can keep watch on one another to provide quick aid if needed.
6. Contacts for emergency will include the GY project authority, the RCMP detachment and the nursing station in Dawson City, Yukon, and the Yukon Fuel and Oil Spills Report Line.

Head Protection

Head protection against impact blows will be provided when required in the form of a protective hat with a liner, which will be able to resist penetration and absorb the shock of a blow. The hat will meet CSA standard Z94.1.

Foot Protection

For protection against falling or rolling objects, sharp objects, wet, slippery surfaces workers will use appropriate insulated safety shoes or boots. Safety shoes will be sturdy, have an impact-resistant toe and meet CSA Standard Z195 or ANSI standards. In case of an emergency spill, team members responding will wear protective boot covers.

Eye and Face Protection

When required, protection will be based on the kind and degree of hazard present. Available equipment will include goggles, safety glasses, and face shield. The eye protectors will meet the requirements of CSA Z94.3 or ANSI standards.

Ear Protection

To avoid exposure to high noise levels disposable phone earplugs and/or earmuffs will be made available.

Respiratory Protection

It is anticipated that exposure to harmful concentrations of air contaminants may result from temporary or emergency conditions. In such a scenario, the exposed team members will wear protective respiratory equipment to prevent breathing air contaminated with harmful dusts (including asbestos), fumes, gases and vapours. The selection of protective respirators equipment will be made according to the guidance of NIOSH or MSHA or ANSI Practices for Respiratory Protection.

Arm and Hand Protection

Absorption of chemicals, cuts and burns are examples of hazards associated with arm and hand injuries. Insulated rubber gloves and leather gloves will be provided for protection from these hazards. These gloves will conform to CSA and ANSI standards.

1.10 SITE SAFETY MEETINGS AND INSPECTIONS

To ensure that the Site Safety Plan is being followed, the contractor will conduct a safety meeting prior to initiating each site activity and at the beginning of each workday.

The purpose of the meetings is to:

- describe assigned tasks and their potential hazards;
- co-ordinate activities;
- identify methods and precautions to prevent injuries;
- plan for emergencies;
- describe any changes to the Site Safety Plan;
- get worker feedback on conditions affecting safety and health;
- get worker feedback on how well the Site Safety Plan is working.

The contractor will also conduct frequent inspections of site conditions, facilities, equipment and activities. The Site Safety Officer and personnel will be responsible for inspecting the condition of their personal protective equipment and ensuring its operational condition.

1.11 FIRST AID

First Aid will be administered on site by a qualified member of the Contractor's work force. The requirements for First Aid made available on site are to be met by an attendant with a Standard First Aid certificate, a # 2 Unit First Aid Kit (St. Johns Standard), a stretcher, and three emergency blankets. In addition to the basic requirements, a spinal board, cervical collars and a Scott Air Pack will also be on site. In case of an accident, a casualty will be transported to the nursing station at Dawson City, Yukon by ground or air transport, depending on weather conditions and the severity of the casualty. The preferred mode of air transport is via rotor wing (i.e. helicopter) although a small fixed wing air craft could likely land at the former mine air strip if required. An ambulance can be dispatched from Dawson City if weather conditions prevent air travel. Emergency phone numbers are provided in the ERP. Every incident requiring First Aid will be recorded in an accident report.

1.12 FIRES

The fire safety program includes fire prevention, fire protection and fire fighting.

1. As a preventative measure there will be no fires or burning of rubbish at the work site.
2. A person discovering a fire will report the incident to the Project Superintendent.
3. Fire extinguishers will be located on site and in each supervisor's vehicle.
4. Smoking will not be permitted in restricted areas and care will be exercised in the use of smoking materials in non-restricted areas.
5. The current National Fire Code of Canada shall govern the handling, storage and use of flammable liquids such as gasoline. Flammable liquids such as gasoline will be stored in approved safety cans.
6. Disposal of flammable liquids will be in accordance with all applicable environmental regulations.

2.0 PART 2 – WORK PRACTICES AND PROCEDURES

2.1 RESTRICTED AREAS – GENERAL REQUIREMENTS

.1 A competent worker, certified in asbestos control procedures, must remain on site at all times during the work process.

.2 Amended water shall be used to wet the ground surface or any other surfaces contaminated with asbestos prior to any disturbance of asbestos fibres and on a regular basis during the course of the work to control "dust", as required.

.3 All tools and equipment shall be thoroughly washed or cleaned with a vacuum equipped with a HEPA filter prior to being removed from a restricted area.

.4 Access to restricted areas shall be limited to authorized persons.

.5 No person shall be permitted to eat, drink or smoke in a restricted area.

.6 Any person entering a restricted area shall be attired with protective clothing and equipment.

.7 Signs shall be posted at the entrance to, or on the perimeter of a restricted area, indicating that:

- (a) asbestos is present;
- (b) access is limited to authorized personnel;
- (c) asbestos is a carcinogen; and
- (d) eating, drinking and smoking are prohibited.

.8 Any person leaving a restricted area shall be free from asbestos contamination.

.9 Compressed air shall not be used in a restricted area.

2.2 WORKER TRAINING

.1 Prior to commencing work in a "restricted area", direction and instruction shall be provided to all workers involved in the work outlining:

(a) the health hazards associated with exposure to asbestos fibres and the additional risk when combined with cigarette smoking;

(b) the requirement to wear the personal protective equipment as outlined by this plan;

(c) the use (including fit testing) and limitations of the respiratory protection being provided; and

(d) the work to be performed at the site.

2.3 WORKER PROTECTION

.1 Protective equipment and facilities to be provided in a "restricted area" shall include:

(a) a complete change of clothing, including coveralls, caps and rubber boots, for each worker involved in work with asbestos;

(b) respiratory protection designed to protect against exposure to asbestos fibre;

(c) sanitary facilities within or close to the restricted area;

(d) a shower facility to remove all asbestos fibres from the body; and

(e) goggles, hard hats or other Personal Protective Equipment as required by the General Safety Regulations for the work being performed.

.2 Respiratory Protection

.1 Provide workers with personally issued and marked respiratory equipment suitable for the asbestos exposure in the work area. Ensure that suitable respiratory protective equipment is worn by every worker who enters the restricted work area. A respirator provided by an employer and used by a worker:

(a) shall be fitted so that there is an effective seal between the respirator and the worker's face;

(b) shall be assigned to a worker for the worker's exclusive use;

(c) shall be used and maintained in accordance with the procedures specified by the equipment manufacturer;

(d) shall be cleaned, disinfected and inspected after use on each shift, or more often if necessary;

(e) shall have damaged or deteriorated parts replaced prior to being used by a worker; and

(f) when not in use, shall be stored in a convenient, clean and sanitary location.

.2 Half-face air purifying respirators have a protection factor of 10. The maximum average airborne fibre concentration should, therefore, not exceed 5 f/mℓ if half-face respirators are to be used. Full-face powered-air purifying respirators (PAPRs) shall be used if the airborne fibre concentration exceeds 5.0 fibres per cubic centimetre of air, as outlined in Section 2.7.4. HEPA filters are the appropriate filter type for asbestos work.

.3 Protective Clothing

.1 Provide workers with protective clothing which shall:

(a) be worn by every worker who enters the restricted work area;

(b) be made of a material which does not readily retain nor permit penetration of asbestos fibres (e.g. Tyvek);

(c) consist of full body covering including head covering with snug fitting cuffs at the wrists, ankles and neck;

(d) include suitable footwear; and

(e) be repaired or replaced if torn.

2.4 PERSONAL DECONTAMINATION

.1 At least three separate decontamination chambers shall be provided for workers to use to ensure that they and their clothing are free of asbestos contamination when they leave the work site. The decontamination chambers, except for the shower, shall be constructed of sufficient size to hold all the workers, their protective clothing and equipment, and their street clothing. A trailer may be appropriate for housing the decontamination facilities.

The Decontamination System shall comprise a serial arrangement of three separate compartments including a Clean Change Room, a Shower Room and a Transfer Room with an airlock separating each area.

.1 *Clean Change Room:* Build a clean room between the shower room and clean areas outside of enclosures, with one airlock to the shower room. Install a mirror to permit workers to fit respiratory equipment properly; provide sufficient hangers and hooks; provide a bench or chairs.

.2 *Shower Room:* Build a shower room with two airlocks: one to the Clean Change Room and one to the Transfer Room.

Provide a constant supply of hot and cold water. The Shower Room shall have individual controls inside the room to regulate water flow and temperature.

Provide piping and connect to water sources and drains. Provide soap and appropriate containers for disposal of used respirator filters. Note that workers may provide their own towels as these are not contaminated and may be removed from the site for cleaning.

.3 *Transfer Room:* Build a Transfer Room between the Shower Room and the work areas, with one airlock to the Shower Room.

.2 Every worker shall remove, store and dispose of all clothing and protective equipment, except for the respirator, while in the first chamber (or "Transfer Room").

.3 Every worker shall enter the shower with the respiratory equipment still in place.

.4 After each worker has thoroughly washed their head, face and respirator, they may remove their respirators and discard the used filters.

.5 In the third chamber (or "Clean Change Room"), workers shall dress in street clothing and store their respirators with new filters installed.

.6 Facilities shall be provided within the Clean Change Room to store street clothing and to ensure that no contamination of street clothing occurs.

.7 Reusable protective clothing worn in a restricted area shall be laundered, when necessary, and, in any event, not less frequently than every three days of use.

.8 Protective clothing to be laundered shall be transported from a restricted area in sealed containers that are clearly labelled to indicate the contents and carcinogenic hazard with a warning that dust should not be breathed.

.9 Used disposable protective clothing and discarded filters shall be treated as asbestos waste.

.10 Doors between chambers shall be constructed of triple sheets of polyethylene, opening on alternating sides to ensure as good a seal as is reasonably practical between chambers.

A typical worker decontamination facility layout is provided in Appendix A.

2.5 WASTE HANDLING

All of the used disposable personal protective equipment (e.g. HEPA filters, Tyvek suits) and material collected during clean-up of the decontamination chambers shall be secured and sealed in polyethylene bags and transported to the on-site landfill for final disposal.

2.6 MEDICAL EXAMINATIONS

Medical examinations are required for "exposed workers" as specified in Sections 40 and 41 of the Yukon Occupational Health Regulations. "Exposed worker" is defined as "a worker who, for at least 10 days in a 12-month period, will likely be exposed to airborne asbestos in an amount equal to or greater than 25% of the 8-hour Occupational Exposure Limit".

2.7 AIR MONITORING

1. Air samples may be taken from commencement of work until completion in asbestos work area(s) with NIOSH 7400 procedures, or with a Fibrous Aerosol Monitor.
2. Co-operate in collection of air samples, including requiring workers to wear sampling pumps for up to half shift periods. Workers shall exercise care not to damage air sampling equipment.
3. A portable battery-operated sampling pump is used to draw air through a 25 mm, 0.8 um pore size, cellulose ester filter at a constant flow rate for a sufficient period of time to collect a representative sample of air for personnel in the work area. The air sample(s) are then retrieved and analysed by Phase Contrast Microscopy (PCM).
4. If air monitoring shows airborne fibre levels exceed 10X the time-weighted average exposure criteria (TWAEC) of 0.5 fibres per cubic centimetre of air (f/cc) for personal

exposure, then workers will be required to use powered air purifying respirators (PAPRs) with full-face piece and HEPA filters.

5. All air sampling test results will be kept on site and made available to workers for their review.

3.0 EMERGENCY RESPONSE PLAN

This Emergency Response Plan (ERP) includes actions to be taken to reduce the impact of any "emergency" situation which arises during the course of work at the site. A list of emergency contacts, including those for medical emergencies and emergency reporting are given below.

Project Management:

Hugh Copland (GY)	(867) 667-3208
Brett Hartshorne (INAC)	(867) 667-3268
Site Engineer (UMA Engineering)	on-site
Yukon Fuel and oil Spills Report Line:	(867) 667-7244
Dawson City, Community Nursing Station:	(867) 993-4444
Ambulance: Dawson City, Yukon	(867) 993-4444 or 1-800-661-0408
Trans North Helicopters	(867) 993-5494 or 668-2177
Fireweed Helicopters	(867) 993-5700
Resource Management Officer (RMO):	
Todd Pilgrim	(867) 993-5468
RCMP Dawson City, Yukon:	(867) 993-5555 or 667-5555

Incident: Hazardous Material or Nonaqueous Phase Liquid Spill

The response measures include:

1. Contain spill source and prevent from spreading.
2. Air monitor for explosive or toxic gases. If a hazardous condition is found, the appropriate protective equipment will be used.
3. Mobilize spill control kit. The kit will include:
    - Personal protective equipment
    - Recovery drum
    - Absorbent material

    - Hand shovel
    - Small pail for scooping up liquid
    - Plastic sheeting
4. Recover spill and contaminated material and place in recovery drum.
5. Ensure spill is secure.
6. Implement a decontamination procedure before any employee or equipment leaves the area of potential hazardous exposure.
7. Transport recovery drum to temporary storage area. A polyethylene drop sheet will be secured to the ground at the temporary storage area
8. The sorting, packaging, transportation and disposal of all hazardous materials and waste encountered will be in accordance to all applicable regulations including the TDGA and CEPA.
9. Prepare spill report.
10. Call the Yukon Fuel and Oil Spill Report Line.

Incident: Serious Injury

1. Call for help.
2. Assess hazards at the site; if necessary make area safe.
3. Initial First Aid.
4. Evacuate casualty to the nursing station in Dawson City, Yukon
5. Prepare report.

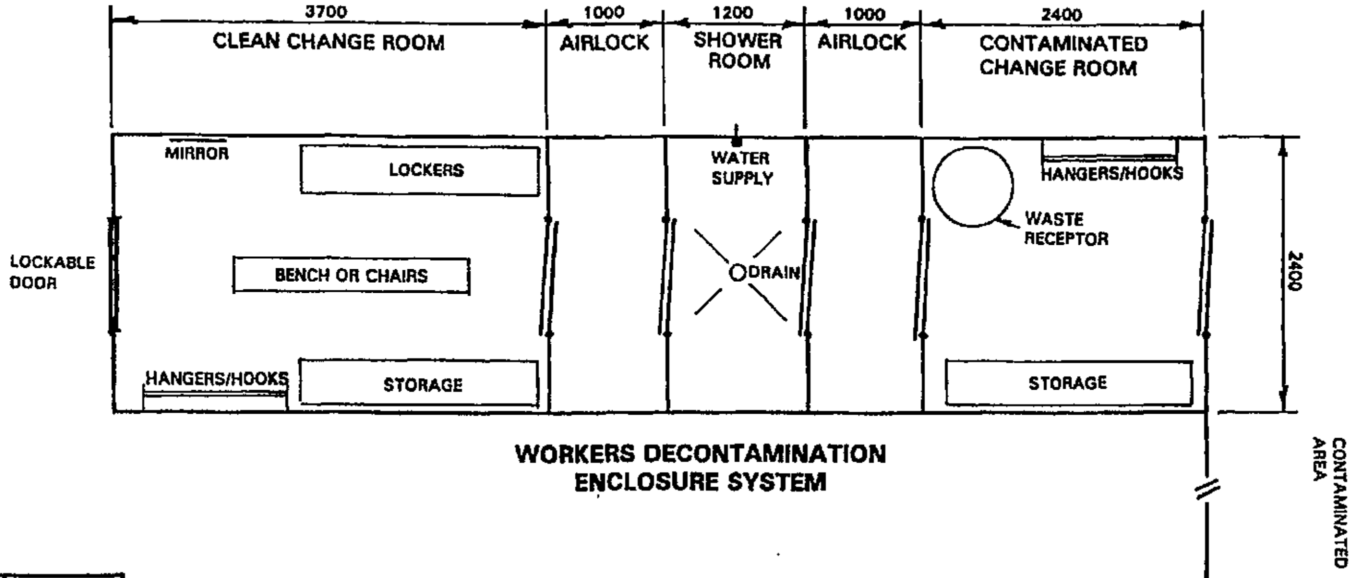
Incident: Fires

1. A person discovering a fire will report the incident to the Project Manger.
2. Fire suppression equipment will be made available. If a fire is not promptly extinguished, the RMO in Dawson City, Yukon will be notified immediately.

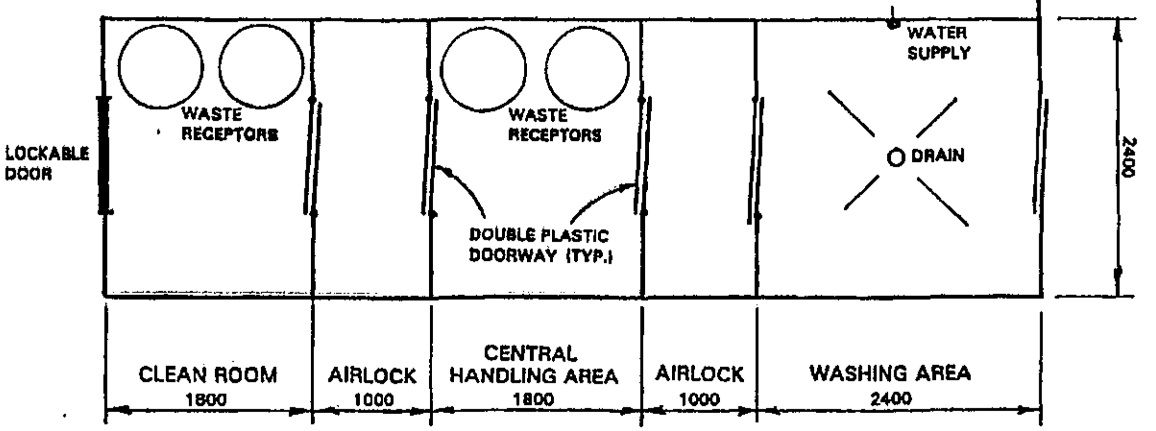
APPENDIX A

TYPICAL WORKER DECONTAMINATION FACILITY LAYOUT

DIMENSIONS PROVIDED ARE FOR TYPICAL INSTALLATIONS AND MAY VARY SUBJECT TO THE PROJECT SIZE AND AVAILABLE SPACE WITH THE APPROVAL OF THE INSPECTOR



WORKERS DECONTAMINATION ENCLOSURE SYSTEM



WASTE AND EQUIPMENT DECONTAMINATION ENCLOSURE SYSTEM

DCS
DECOMMISSIONING CONSULTING SERVICES LIMITED

TYPICAL DECONTAMINATION ENCLOSURES

Appendix H

METEOROLOGICAL STATION -
PRICE QUOTE

CAMPBELLSCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655

PRICE
QUOTATION

SALES QUOTATION # **30018721**
PAGE # 1
DATE APRIL 06, 2004

Quote To:
UMA ENGINEERING LTD
1479 BUFFALO PLACE
WINNIPEG, MB.
R3T 1L7
ATTENTION: GIL ROBINSON

THIS QUOTE VALID FOR	DELIVERY	FOB POINT	TERMS
60 DAYS	60 DAYS ARO	EDMONTON	NET 30 DAYS

ITEM	QUANTITY	DESCRIPTION	PRICE	PER	AMOUNT
001	1	METRANGER I METRANGER I Portable Weather Station w/Mobile Case including Datalogger, Power Supply, ENC, Sensors & 2M Tripod	10,950.00	EA	10,950.00
002	1	LOGGERNET SOFTWARE Datalogger Support Software LOGGERNET 2.1c (Compact Disk)	600.00	EA	600.00
003	2	SRM-5A MODEM RAD Short Haul (2 required)	155.00	EA	310.00
004	1	SC932C RAD Modem to RS232 Interface (includes SC12 cable)	250.00	EA	250.00
005	1	QDP RAD MIL-L QUICK DISCONNECTOR RAD COMMS CABLE (QDP WATER RESISTANT) FOR METRANGER I (custom lead length) 100.0000 FT OF L9720 PER EA	240.00	EA	240.00
006	100	L9720 WIRE CABLE Multiconductor 22-AWG 2-Pair Shielded Polypropelene(I) Santoprene(J) Black (Grade 121-80)	1.00	FT	100.00
007	1	L7026 INTERFACE CABLE Lap Top 9 Pin Serial Port Female to 25 Pin Male (for SC32A, SC532)	12.00	EA	12.00
008	1	CS500 Relative Humidity (0 to 100%) & Air Temperature Probe (6 Ft Lead)	630.00	EA	630.00
009	1	QDP5MIL QUICK DISCONNECTOR 5-PIN METAL ENVIRONMENTAL MILITARY CONNECTORS FOR METRANGER I	200.00	EA	200.00

THIS QUOTATION IS CONTINUED ON PAGE 2

CAMPBELLSCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655

PRICE
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PAGE # 2
DATE APRIL 06, 2004

Quote To:
UMA ENGINEERING LTD
1479 BUFFALO PLACE
WINNIPEG, MB
R3T 1L7
ATTENTION: GIL ROBINSON

THIS QUOTE VALID FOR	DELIVERY	FOB POINT	TERMS
60 DAYS	60 DAYS ARO	EDMONTON	NET 30 DAYS

ITEM	QUANTITY	DESCRIPTION	PRICE	PER	AMOUNT
010	1	41303 RM YOUNG RADIATION SHIELD 6 Plate Non-Removeable Universal Clamp 10mm max	160.00	EA	160.00
011	2	C1491 HARDWARE KNOB THUMB 1/4"-20 x 1-1/4" 4-Prong Black Plastic with Brass Insert (for Quick Deploy Stations)	12.00	EA	24.00
012	1	TE525 TEXAS ELECTRONICS Tipping Bucket Rain Gauge - 6" (25 Ft Lead)	475.00	EA	475.00
013	1	QDP3MIL QUICK DISCONNECTOR 3-PIN METAL ENVIRONMENTAL MILITARY CONNECTORS FOR METRANGER I	200.00	EA	200.00
014	1	C1643 HARDWARE MOUNT KIT for securing TE525/TE525m to Ground (METRANGER I)	90.00	EA	90.00
015	1	61205V RM YOUNG Barometric Pressure Sensor 0-2.5VDC (600-1100mb) (2.5' lead)	925.00	EA	925.00
016	1	QDP HYDRO VENT QUICK DISCONNECTOR HYDROPHOBIC FILTER AND ENTRY SEAL	25.00	EA	25.00

THIS QUOTATION IS CONTINUED ON PAGE 3

CAMPBELLSCIENTIFIC
CANADA CORP.
11564 - 149 street - edmonton - alberta - T5M 1W7
tel 780.454.2505 fax 780.454.2655

PRICE
QUOTATION

SALES QUOTATION # **30018721**
PAGE # 3
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ITEM	QUANTITY	DESCRIPTION	PRICE	PER	AMOUNT

SUB-TOTAL---------------->	15,191.00
GOODS AND SERVICES TAX	1,063.37
TOTAL $	16,254.37

For further information please contact your
Edmonton representative by dialing
(780) 454-2505

Signature

JAN HALL
Name

CSCC GST # R100748672

Ordering Information and Warranty Policy

PRICES: Prices are subject to change without notice.

WARRANTY POLICY: Campbell Scientific (Canada) Corp. (CSC) warrants its products to be free from defects in materials and workmanship under normal use and service for twelve (12) months from date of shipment unless otherwise specified on the Price List and subject to the following conditions:

> CSC's obligation under this warranty is limited to repairing or replacing (at CSC's option) products which have been returned prepaid to CSC. CSC will return warranted equipment by surface carrier prepaid. This warranty shall not apply to any CSC products which have been subjected to misuse, neglect, accidents of nature or shipping damage. Batteries are not warranted. Under no circumstances will CSC reimburse the claimant for costs incurred in removing and/or reinstalling equipment at a test site. This warranty and CSC's obligation thereunder, is in lieu of all other warranties, expressed or implied, including warranties of suitability and fitness for a particular purpose. CSC is not liable for consequential damages.

EQUIPMENT REPAIR: Products may not be returned without a purchase order and prior authorization (RMA) by our office. The RMA number must clearly appear on the shipping container, all documentation and the returned equipment. In order to accelerate the turn around time and reduce the service charges, a detailed description of the problem should accompany the item to be repaired. Repair charges: $90.00/hour (minimum labour charge $90.00).

QUANTITY DISCOUNTS: Quantity discounts are listed below. Cable quantities on all "-L" models are subject to a 7% discount on total lengths of 1000 feet or more per line item.

Quantity (units)	Discount
10 - 24	7%
25 - 99	10%

EDUCATIONAL REBATE: A 5% educational rebate for products on this list is available to universities, colleges and school boards ordering in quantities of 1 - 9 units only. Campbell Scientific (Canada) Corp. will rebate in the form of a cheque or credit invoice to the educational institution upon payment of the order within our Payment Terms of net 30 days. When 10 or more units are ordered, only the quantity discount will be allowed. The educational rebate is not available for parts and labour including installation, training, consulting, or cable.

PAYMENT TERMS: Net 30 days on approved credit, Visa or Master Card. Applications for credit are required for non-university institutions and non-government agencies. If application for credit is made, please supply one Bank Reference and two Trade References. Approved credit requires 30 days to arrange.

SHIPPING POLICY: All shipments are F.O.B. Edmonton, AB. with freight and insurance prepaid and added to the invoice as a separate item. Orders can be shipped collect upon request.

DELIVERY: Standard delivery is 60 days A.R.P.O. (After Receipt of Purchase Order). When possible, a two week delivery can often be accommodated based on order size and product selection. Under special circumstances, CSC reserves the right to apply an expediting charge to meet delivery requirements shorter than 60 days. The Expediting Fee may be applied up to a minimum rate of 15% in the total amount invoiced with a minimum charge of $50.00.

SALES TAX: The Goods and Services Tax (**GST**) or the Harmonized Sales Tax (**HST**) is indicated as a separate item on all invoices. Agencies who are GST or HST Exempt must provide an appropriate valid exemption number, stamp or certificate at the time of ordering.

RESHELVING FEE: Under some circumstances, CSC may approve the return of unused products for exchange or credit. CSC is under no obligation to the customer to accept the return of any product. Specialty items such as custom cable length sensors or any non-standard products that are not included on this Price List may not be returned. A Reshelving Fee will be applied at a minimum rate of 15% of the invoiced price of the item(s) with a minimum charge of $50.00. CSC must issue an RMA number prior to the return of any product. All shipping charges are the responsibility of the customer and are in addition to the Reshelving Fee.

CANCELLATION OF PURCHASE ORDER: Campbell Scientific (Canada) Corp. reserves the right to assess a 15% surcharge for cancellation of any purchase order in whole or in part for standard products listed on this published Price List. Specialty items such as custom cable length sensors or any non standard products that are not included on this Price List, may not be cancelled once the purchase order is received.

ORDERING LOCATION:

11564 - 149 Street
Edmonton, Alberta
T5M 1W7

Phone: (780) 454-2505
Fax: (780) 454-2655

General Email: dataloggers@campbellsci.ca

Web Site: www.campbellsci.ca

Shipment of Manuals Policy

To reduce paper consumption without inconveniencing our customers, we have developed the following policies for shipment of instruction manuals:

All User Manuals: - (1) Qty unit ordered = (1) manual; (2-5) Qty units ordered = (1) additional manual; each additional (5) Qty units ordered = (1) additional manual. If you want additional copies (up to the number of units ordered), state on your purchase order "INCLUDE ALL MANUALS" or "INCLUDE X MANUALS" where "X" is the number of manuals requested. (Datalogger, Peripheral, and Sensor Manuals fall in this category.)