

GOVERNMENT OF YUKON – ENERGY, MINES AND RESOURCES

CASE STUDY OF BREWERY CREEK



REPORT

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ACRONYMS & ABBREVIATIONS

ADR Plant	Adsorption and Desorption Recovery Plant.
Loki	Loki Gold Corporation
Viceory	Viceroy Resource Corporation
Alexco	Alexco Resource Corporation
EARP	Environmental Assessment and Review Process
WUL	Water Use Licence
DIAND	Department of Indian Affairs and Northern Development

1.0 PURPOSE

This case study reviews the engineering, environmental, and regulatory issues associated with heap leaching in northern climates, using the Brewery Creek Mine, the first open pit heap leach gold mine in the Yukon, for reference.

As part of the scope of work, EBA contacted former employees and government agencies who had worked at or with the Brewery Creek Mine. Each interviewee provided constructive feedback on the successes and opportunities for improvement of heap leach mining based on their experiences. The information presented will assist the Government of Yukon and future mine developers to avoid similar issues and emulate success from the Brewery Creek Mine.

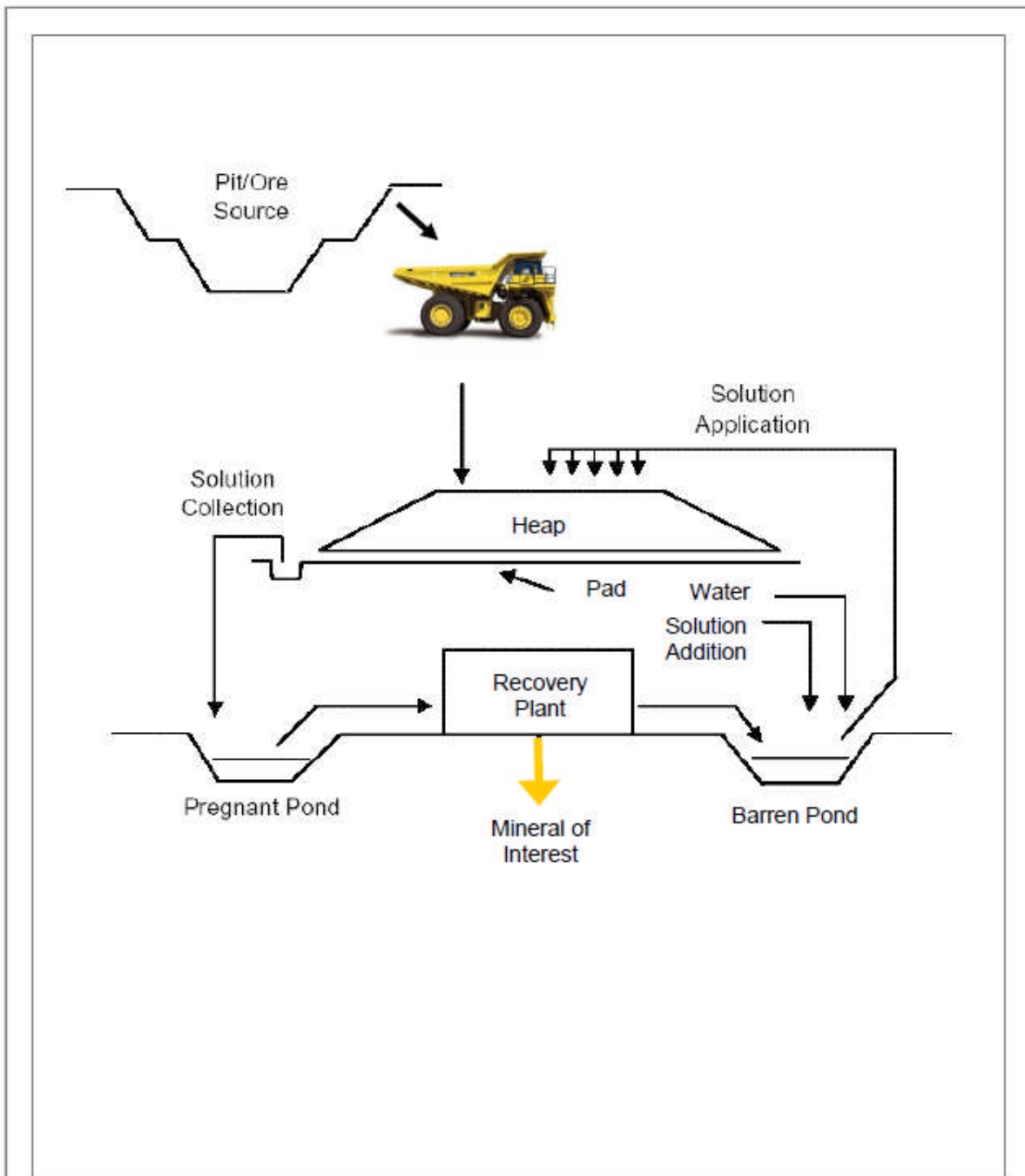
2.0 HEAP LEACHING OVERVIEW

2.1 What is Heap Leaching?

Heap leaching is a mining process that extracts precious metals from ore (rock containing valuable minerals) using a chemical solution. Heap leaching can be applied to a variety of different metals including gold, silver, copper, nickel and uranium. The solution applied depends largely on the type of mineral being extracted; copper, for example, can be leached out of ore using dilute solutions of sulphuric acid, while gold is often extracted using a cyanide-based solution. The process has been used all over the world in different environments.

The structure of a heap leach generally consists of ore that has been mounded onto some form of liner system. The liner system is often composed of several layers of natural and/or synthetic material that form an impermeable barrier between the ore and the natural ground surface and also frequently house the collection system of the heap leach.

The mineral extraction solution is sprayed or dripped onto the ore heap, and as it percolates through the heap, it dissolves the mineral of interest contained in the ore. The solution is collected at the base of the heap and transported to a processing pond. Solution is then transferred from the pond to a recovery plant where it is processed to extract the mineral from solution. Once the mineral has been extracted from the solution, the solution is released to a barren pond where it is prepared for re-application on the heap (Figure 1).



LEGEND	NOTES	CLIENT   A TETRA TECH COMPANY	CASE STUDY OF THE BREWERY CREEK MINE					
			OVERVIEW OF A TYPICAL HEAP LEACH MINING PROCESS					
STATUS ISSUE FOR USE			PROJECT NO. V15101033	DWN MO	CHK TP	APVD MO	REV 1	Figure 1
			OFFICE EBA-VANC	DATE March 17, 2011				

2.2 Why Use Heap Leaching?

There are a number of economic, environmental and engineering advantages with using a heap leach process.

- There is a reduced requirement for grinding equipment, which subsequently reduces the need and costs associated with equipment and power generation.
- Heap leaching does not generate tailings because the ore remains on the leach pad. This reduces the environmental liability at the site.
- The heap leach is a simple design with low capital costs in comparison to other metallurgical processes.
- Heap leach mines often reuse reagents in ore processing, which minimizes reagent consumption and costs.

There are also a number of disadvantages with the use of heap leaching.

- Heap leach tends to recover less precious metal in comparison to other metallurgical processes.
- Some solutions, such as those that are cyanide-based, can cause significant harm to people or wildlife if consumed.
- The solution could be released into the environment, which could occur if the leach pad liner is damaged, improperly installed, or poorly engineered.
- There is typically a high cost associated with the reclamation of the heap. All heaps must go through a detoxification stage that removes or neutralizes the processing chemicals.

2.3 Down-stream Processing

The solution collected from the heap is transported to an adsorption/desorption recovery (ADR) plant to extract the metal of interest. The solution can go through a number of processing techniques such as Counter Current Decantation (CCD) or Carbon in Leaching (CIL) where the metal is separated from the solution. The solution is recycled and reused to extract more metal from the heap leach pad. The metal then undergoes further processing to increase its purity.

2.4 Heap Leaching in Northern Climates

A number of challenges present themselves when operating heap leach systems in colder climates.

- First, there is a limited knowledge of open pit heap leach mines in extreme cold environments. Aside from Brewery Creek Mine, there are only a handful of heap leach mines that have operated in extreme cold or high-elevations that have similar conditions such as the Fort Knox Mine in Alaska or Zortman Landusky Mine in Montana, USA.
- Second, extreme weather conditions can affect operational capabilities. Poor visibility and low temperatures can cause the mine site to shut down or damage machinery.
- Remote mine sites may be difficult to access during certain times of the year. In some remote locations, there is a limited period to transport materials necessary for year-round operations.

3.0 USE OF HEAP LEACHING IN THE YUKON – BREWERY CREEK

The Brewery Creek Mine was an open pit heap leach gold mine, located approximately 55 km east of Dawson City in the Yukon Territory (Figure 2). The Brewery Creek Mine was first staked in October 1987. Between 1994 and 1995, regulatory and environmental submissions were completed, after which mining and construction commenced in 1996. In September 2000, Brewery Creek Mine ceased active mining operation and no additional ore was added to the heap leach. Mining operations ceased primarily due to depressed gold prices. Active heap leaching continued until December 2001. Mine closure and reclamation began 2002. Environmental monitoring is ongoing.

3.1 Property History

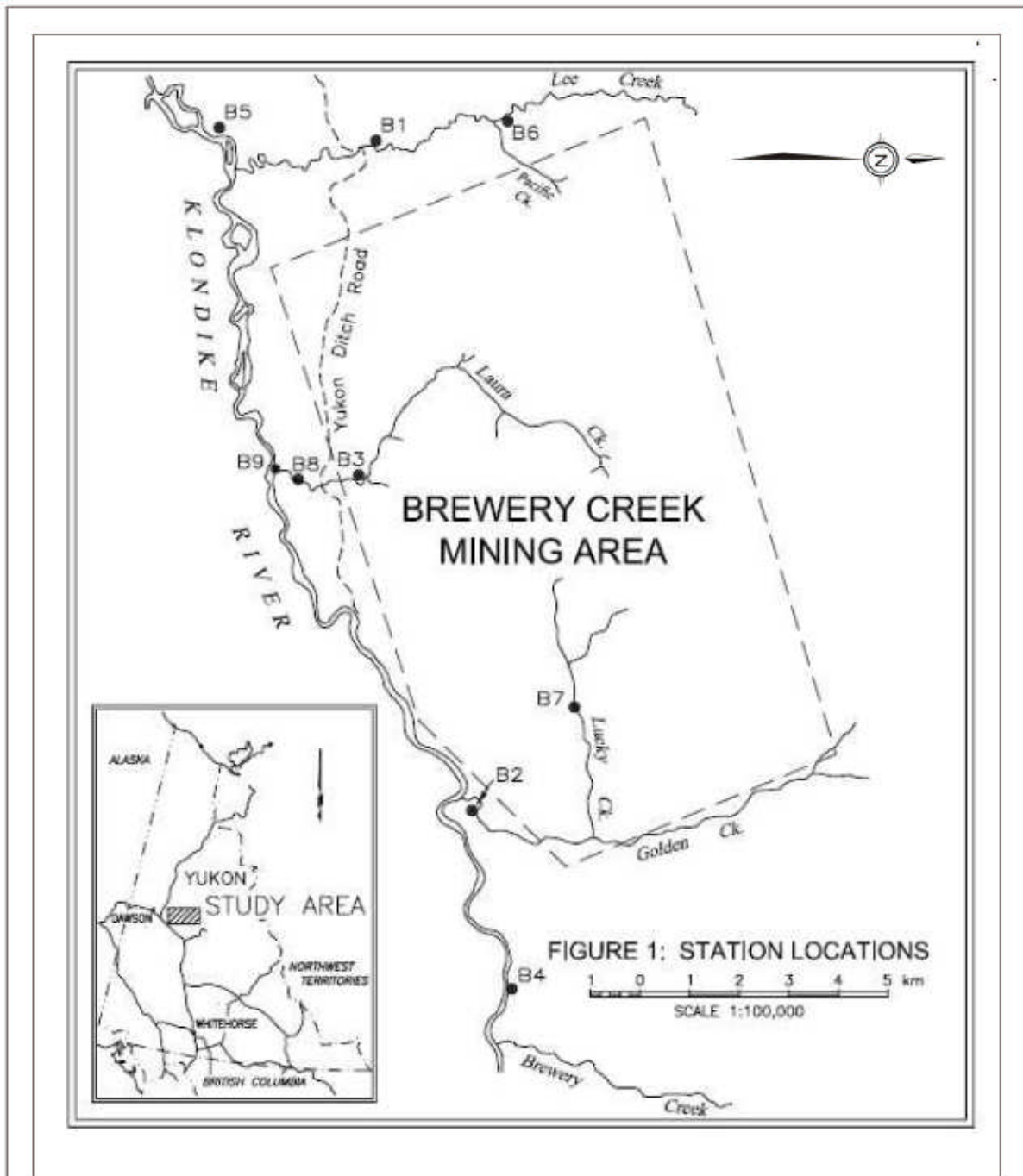
Loki Gold Corporation was the first company to submit plans to develop the Brewery Creek Mine. They submitted regulatory applications in 1994 and received the necessary approvals and permits in 1995. In 1996, Viceroy Resource Corporation (Viceroy) acquired Loki and the Brewery Creek Mine Site. Viceroy operated the mine until its closure in 2001. In 2005, all licences and permits were transferred from Viceroy to Alexco Resource Corporation (Alexco) after Alexco purchased the property.

The deposit was comprised of a series of shallow gold deposits along a seven kilometer belt. Mining took place in the Fosters, Blue, Canadian, Pacific, Kokanee, Moosehead, Golden and Lucky deposits (Figure 3). Additional exploration targets had been identified, however Viceroy did not consider the development of these deposits to be economically viable at the time.

3.2 Brewery Creek Operations

The Brewery Creek Mine was a conventional truck and shovel open pit mine. The typical process involves blasting rock into small fragments and transferring it using haul trucks to either the ore heaps (heap leach pads) or waste rock piles, depending on its economic value. The ore is placed directly on the heap without undergoing an initial crushing process.

Open pit mining was carried out each year on a seasonal basis from early April through early November. Seasonal mining removed the hazard of working in poor visibility and freezing conditions, however, it also meant mine operators had a limited time to complete all mining goals. Between 1.4 and 2.6 million tonnes of ore were placed on the leach pad in this timeframe. Active leaching was carried out year-round.



LEGEND <ul style="list-style-type: none"> ● Water Quality Stations 	NOTES Source: Labarge Environmental Services (2009)	 	CASE STUDY OF THE BREWERY CREEK MINE				
	STATUS ISSUE FOR USE		PROJECT LOCATION AND WATER QUALITY STATIONS				
			PROJECT NO. V15101033	DWN MO CKD TP	APVD MO 1	REV 1	Figure 2
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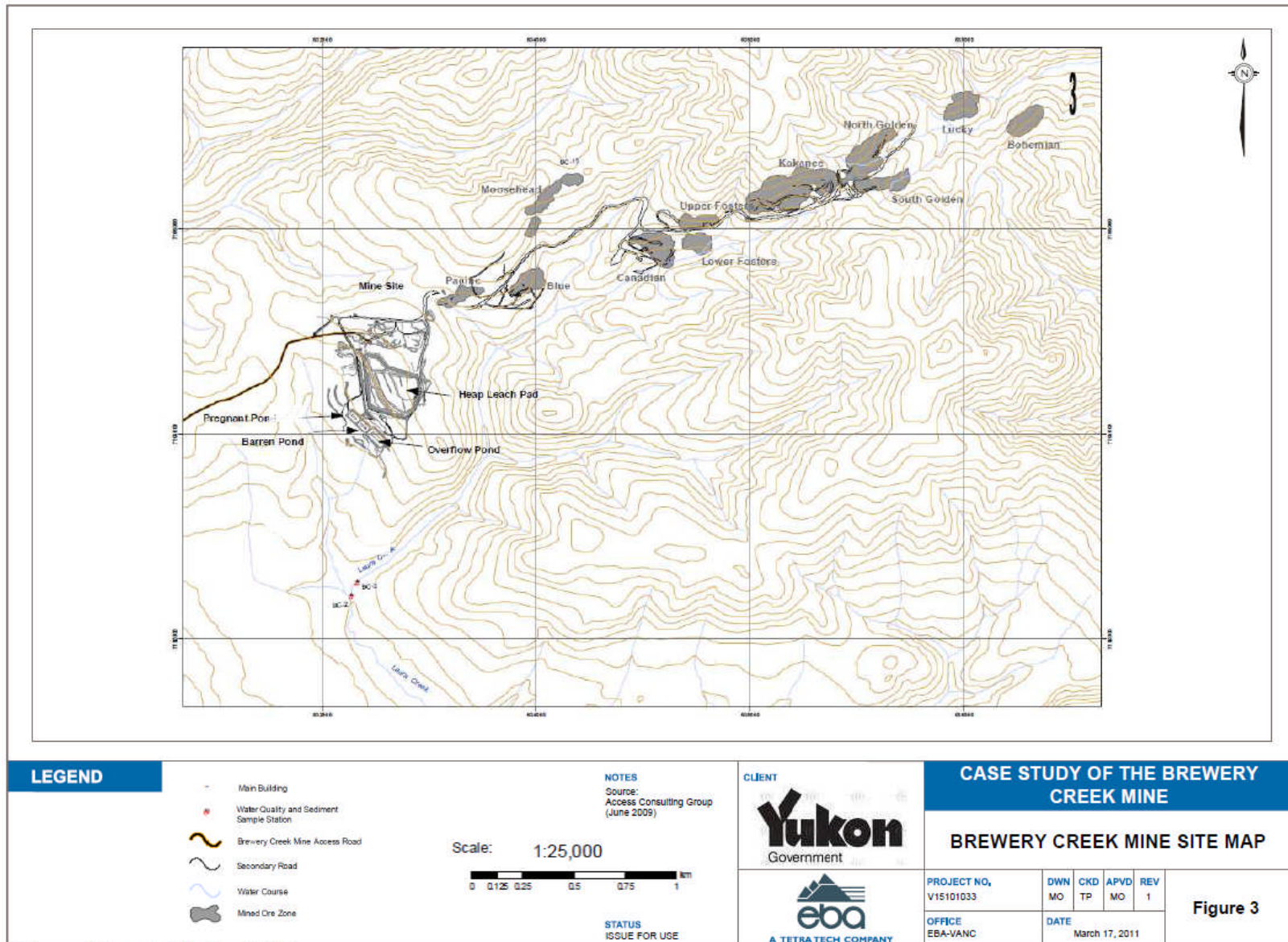




Photo 1: General Mine Site Layout (1999)
Source: Access Consulting, 2006

3.3 Brewery Creek Leach Pad and Process Design

Brewery Creek's processing facilities included a heap leach pad, adsorption/desorption recovery plant (ADR plant), two process ponds, and an overflow pond (Photographs 1 and 2). A second overflow pond was planned for but never built due to the early closure of the mine. The design of the facilities at Brewery Creek was drawn from experience gained at the Zortman Landusky Mine in northern Montana, USA, which also operated under cold climate conditions.

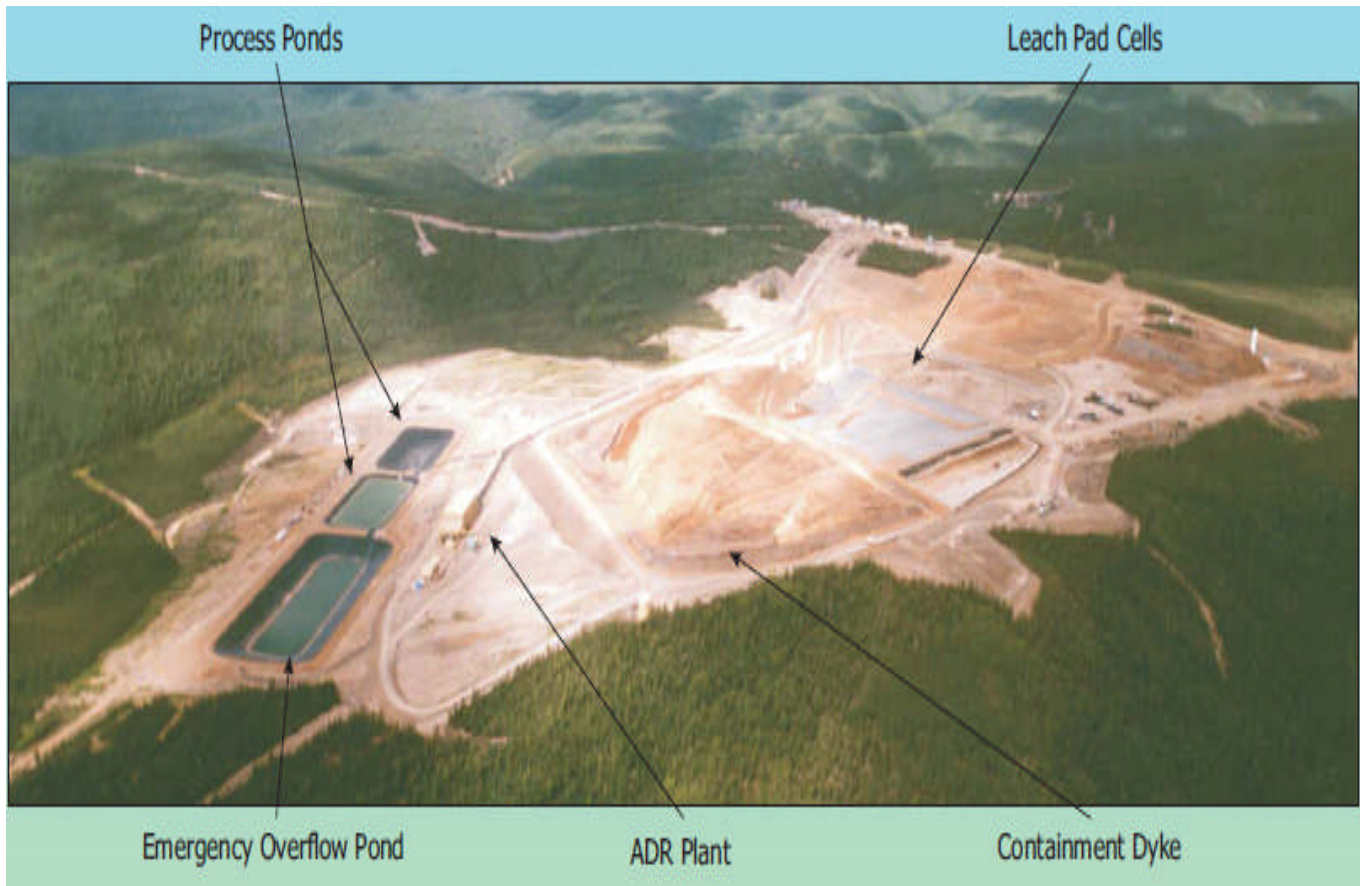
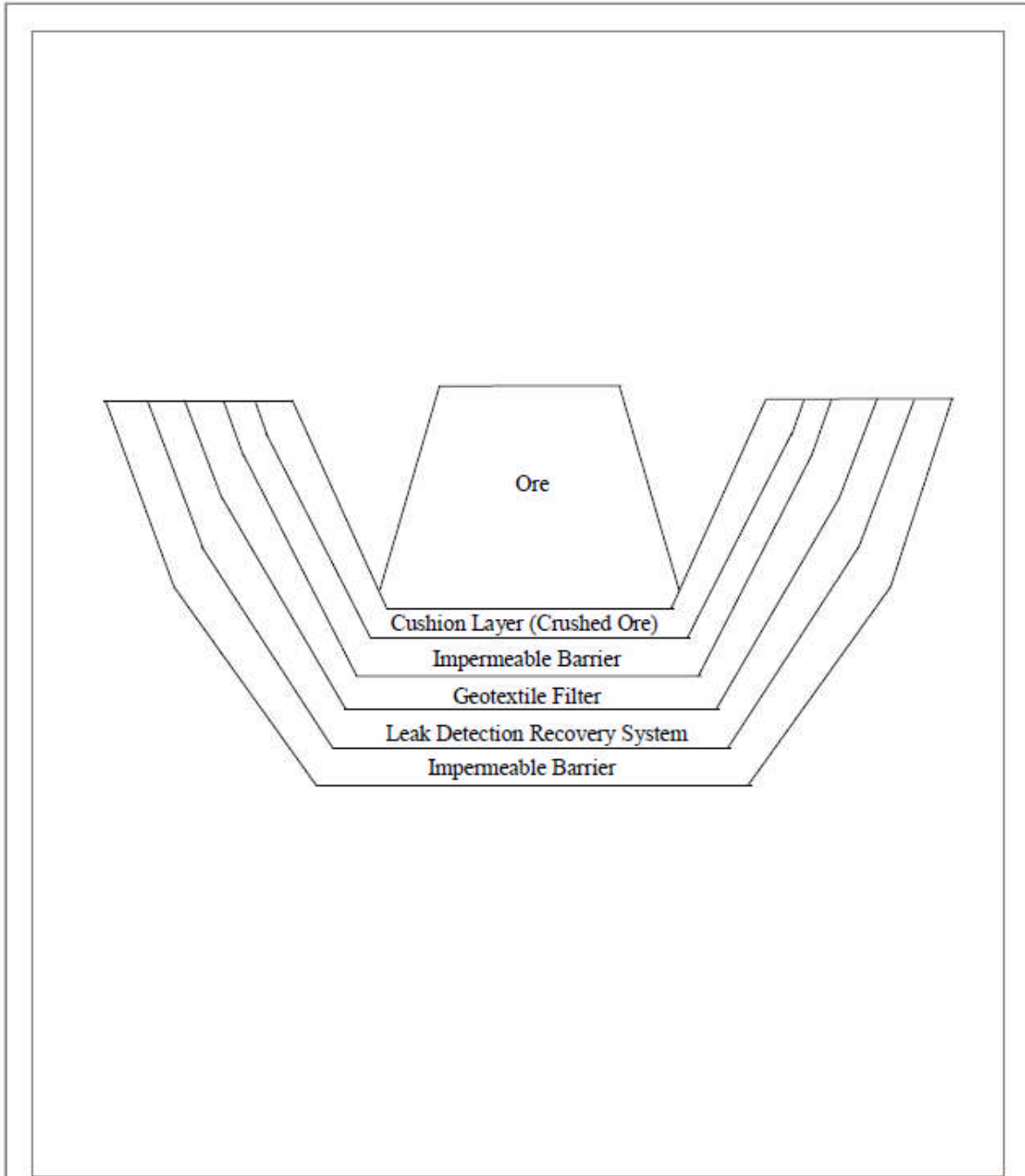


Photo 2: Processing Facilities Layout (1999)
Source: Access Consulting, 2006

3.3.1 Leach Pad

The Brewery Creek leach pad design involved the use of several liners to capture all liquids that entered the heap leach pad. The liners were composed of the following materials (Figure 4):

- **Crushed Ore (600 to 1,000 mm thick):** This liner was used to help cushion the weight of the ore being placed on the heap leach pad. This provided support so the liners below would not break or tear apart.
- **Primary Synthetic Liner:** This liner was the primary liner used to capture and pump the liquid to the ADR plant.
- **Geotextile Filter:** This liner was used to capture solids and separate the primary liner from the leak detection recovery system (LDRS)
- **Gravel:** This liner was permeable and was used as the main LDRS layer. Any liquid that may have bypassed the original primary synthetic liner plastic liner would flow inside the gravel and be pumped into the two process ponds.
- **Secondary Synthetic Liner:** This liner was used to capture any liquids that might have bypassed the liners above.



LEGEND	NOTES	CLIENT   A TETRA TECH COMPANY	CASE STUDY OF THE BREWERY CREEK MINE				Figure 4
			GENERAL LEACH PAD DESIGN				
STATUS ISSUE FOR USE		PROJECT NO. V15101033	DWN MO	CKD TP	APVD MO	REV 1	
		OFFICE EBA-VANC	DATE March 17, 2011				

Another design consideration that was taken into account was the potential for leach pad liners to become damaged. These concerns were addressed by creating individual heap cells for loading within the heap leach pad. Each cell was designed to segregate ore and were built adjacent to each other. If a leak was detected in the cell, the operators could load the ore on another adjacent cell. Operators could then inspect the liners and fix any damaged parts.

Initially, ten heap leach cells were planned for construction inside the heap leach pad, but only seven were built due to the early mine closure (Access, June 2009).

3.3.2 Process Ponds and Design

In a typical heap leach operation, two process ponds (known as pregnant and barren) store the processing solution (in this case a cyanide solution) and water that enter the heap leach pad. The pregnant pond stores cyanide solution containing gold and the barren pond stores cyanide solution after the gold has been removed through processing.

To minimize the risk of the cyanide solution freezing in the cold climate, mine operators collected the pregnant solution from the base of the heap leach pad and sent it directly to the ADR plant, thus bypassing the pregnant process pond. Pipes used in the collection of the cyanide solution were buried under ground to protect them from the winter climate. Once the gold was separated from the cyanide solution, the cyanide solution was recycled, mixed with new solution, and sent directly to the leach pad, bypassing the barren pond.

The pregnant and barren process ponds were constructed at Brewery Creek, but were bypassed in the processing circuit. Instead, the ponds were used as receiving points for the LDRS. An additional overflow pond was constructed to contain excess water that may have entered the heap leach pad during severe rain events.

Regulating agencies were concerned about the potential of the processing solution freezing under winter conditions; thus requiring a complete draining of the pad in the spring. One key permitting requirement was the need for sufficient solution storage capacity for both a complete draining of the pad and a 1 in 100 snowmelt event. Therefore, Viceroy submitted plans to include two overflow ponds to maintain storage capacity for this particular scenario.

3.4 Site Water Management

Site water management addresses the circulation and potential release of water and effluent, or mine water, into the surrounding environment. The heap leach process at Brewery Creek recycled nearly all of the water used in processing. Thus, no significant amount of waste water was released to the environment during the operations.

3.5 Regulatory Framework at Start-up

In 1994, Loki submitted its applications to begin mining operations. There were two main regulatory licences required at the time of start-up: the Environmental Assessment and Review Process (EARP) Guidelines Order and the Water Use Licence (WUL). Each of the applications was accepted and licences were granted.

The EARP considered all project aspects but identified the need for further assessment of solution management plans, water treatment proposals, and decommissioning plans. These plans were later developed by Viceroy, reviewed by regulatory agencies, and eventually approved.

3.6 Regulatory Changes at Brewery Creek

Over the course of the mine life, a number of events and regulatory changes occurred that affected operations. In 1995, the *Canadian Environmental Assessment Act* (CEAA) came into effect which replaced EARP. The CEAA was the primary legislation that governed changes during the mine life of Brewery Creek. The Department of Indian Affairs and Northern Development (DIAND) became the federal authority. This affected how Viceroy dealt with project design changes. Each time Viceroy needed to change different aspects of the mine, it had to notify DIAND of its plans. DIAND would then determine whether or not the design changes would have any environmental effects prior to granting approval for the changes.

In 1997, amendments to the original WUL were subject to further environmental assessment in accordance with CEAA. DIAND concluded that the modifications and additions to the water supply of Brewery Creek Mine would not likely cause significant adverse environmental effects and issued a new WUL. The WUL change was a result of operational and design changes on site. A second recovery circuit was added to the ADR plant in 1998 to help address slower than expected solution recovery in the heap leach.

Further CEAA screenings were conducted that evaluated different aspects of the operation including:

- Modification of the heap leach pad liner design
- Water Treatment Proposal
- Solution Management Plans
- Decommissioning Plans

In 1999, changes to the *Yukon Quartz Mining Act* took effect that required that all quartz mines in the Yukon be licensed. Viceroy submitted its application and shortly thereafter, DIAND accepted and subsequently issued Viceroy a licence.

In 2002, the Metal Mining Effluent Regulations (MMER) came into effect under the *Fisheries Act*. This regulation largely required the collection of baseline studies describing the fish populations and aquatic conditions of the area. At this time, however, Brewery Creek had been closed, so the regulations did not apply.

In 2003, the *Yukon Act* transferred powers to the territorial government of the Yukon. The powers transferred to the Yukon Government included control over land and natural resources. To account for the new territorial powers, the (Yukon) *Environmental Assessment Act* (EAA) was passed to replace the CEAA. In 2005, the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA) came into effect and replaced the EAA.

3.7 Mine Closure and Reclamation

In September 2000, Brewery Creek Mine ceased active mining operation and no additional ore was added to the heap leach. The end of mining operations was primarily due to depressed gold prices. Active cyanide leaching continued until December 2001. Mine reclamation began shortly after the mine closed in 2002. Approximately 300 hectares of land was disturbed during the life of the mine.

3.7.1 Mined Areas and Waste Rock Dumps

Areas affected by mining infrastructure have been progressively reclaimed by re-grading slopes, slope stabilization, and re-vegetation. Haul roads were also reclaimed. Fifty percent of the road surface was scarified and re-vegetated. Culverts were removed and replaced with a rock lined ditch (Access, October 2006). The majority of waste rock generated during mining activities was backfilled into the mined-out open pits. Additional external waste dumps were created in other areas.

Some areas were identified by Viceroy as having the potential to produce acid rock drainage (ARD). ARD is a chemical process between water and certain rock that causes water to become more acidic, causing environmental damage. Plans were to cap and seed these locations; however, the Government of Yukon expressed concern with the methodology used by Viceroy in their geochemical characterization of the site. As such, monitoring programs were initiated and are ongoing to verify environmental performance. Some indicators used to verify environmental performance includes water infiltration, geochemical stability of metals, and local ground and surface water quality. To date, monitoring has concluded that water infiltration is low, metal content remains stable and water quality meet guidelines.

3.7.2 Mine Infrastructure Decommissioning

All infrastructure evaluated as being unnecessary for mine reclamation was decommissioned and removed from site. In 2006, the main access road to site was decommissioned and turned into a minimal use trail. In 2008, the process ponds were decommissioned and the surrounding area was reclaimed. Half of the warehouse remains on site for equipment storage.

3.7.3 Heap Leach Pad Detoxification and Effluent Management

After mine closure, the heap leach must go through a detoxification process to remove the potential of toxic elements from entering the environment. During the regulatory process, the initial plans proposed included a fresh water rinsing process. Detoxification was expected to be completed in six months. The method ultimately adopted by Viceroy was a process call in-situ bacteria detoxification.

The in-situ bacteria process involves mixing nutrients such as sugars, alcohol, and fats with water that is then spread over the heap. The existing bacteria present in the heap use the nutrients to transform the cyanide and other metals into an inert state. The process was initiated in 2002 and continued until 2003, after which the heap leach was considered clean.

Heap effluent (water used in detoxifying the heap) was stored in the process ponds and overflow pond and was monitored regularly for water quality. Most suspended solids in the heap effluent settled out. By July 2003, the water quality had improved considerably with the exception of selenium. The heap effluent was released into the receiving environment through a combination of water sprinkling and groundwater releases between 2002 and 2005. The releases were in accordance with Canadian Council of Ministers of the Environment (CCME) approved guidelines, and water licence restrictions. Information of the heap effluent releases can be found in annual water licence reports reported by Viceroy and Alexco.

4.0 SUCCESSES AND OPPORTUNITIES FROM BREWERY CREEK

A number of successes and opportunities for improvement resulted from the Brewery Creek Mine, both from a mine operation and environmental stewardship perspective. These successes and opportunities are highlighted in this section.

4.1 Heap Leach Freeze Up Scenario

One major concern for regulators and owners was how the heap leach would perform during cold Yukon winters. Keeping the cyanide solution from freezing was important in maintaining production and preventing excess solution buildup. If the cyanide solution froze during the winter, operators would have to wait until spring for it to thaw. Operators would have to also deal with excess water contributions from snowmelt. This potential scenario was the main justification for requiring Viceroy to build sufficient solution storage capacity for a complete drain down and 1 and 100 snowmelt event. It had major design implications such as adding a second overflow pond in the later stages of the mining operation.

4.1.1 Issues and Lessons Learned

Operational experience at Brewery Creek demonstrated that cyanide solution temperatures can be maintained above freezing throughout the Yukon winters. Annually, solution temperatures in the heap pad ranged between 6°C and 13°C, indicating that the pad “freeze-up” scenario is less likely for potential future operations in the Yukon (Viceroy, 2000 USMP). It demonstrates that there is a reduced risk of solution circulation loss during the winter months and therefore no solution build-up would occur over winter. This could also indicate that smaller storage ponds could be used, however, the design of these features needs to be tailored to the environment in which they are to be used.

4.2 LDRS, Overflow Pond, and Leach Pad Design

One major engineering and environmental concern was the possibility of cyanide solution being accidentally released into the surrounding environment during operation. These concerns were addressed through the design of the LDRS, overflow ponds, and compartmentalization of the individual heap leach pads, as described in Section 3.3.

In general, low volumes were detected by the LDRS throughout the mine life. However, there were two incidents where higher leakage rates were observed. In 1998, high leakage rates were observed and subsequently tested for water quality. Results indicated that the water was not process water. Further investigation revealed that runoff water was entering the LDRS through a nearby ditch.

The other incident occurred in 2000 and had resulted in damage to the upper liner. A broken cable had caused a nearby pump to pierce the upper liner. Water quality testing indicated that the excess water in the LDRS was surface runoff.

In both cases, the excess water was treated as process water as a safety precaution until lab testing proved otherwise.

4.2.1 Issues and Lessons Learned

The overflow ponds were designed to provide an excess holding capacity for the leach pads in case the heap leach recovery circuit froze (described in Section 4.1) and a 1 in 100-year snowmelt event threatened to dilute the cyanide solution and release it into the surrounding environment. The second overflow pond was never constructed, because the heap leach “freeze-up” scenario was considered to be unlikely, given the operational experience gained. Additionally, early mine closure meant less liquid would be travelling through the processing circuit at any given time.

Future mine developers should take note of the importance of accurate precipitation data. Incorporating accurate data early in the mine planning and design stages ensures that the mine design is appropriate for the region, which translates to potential construction and decommissioning savings in the future.

Also, from an operational view, the building of heap cells within the heap leach pad was viewed as impractical. The construction of processing cells was viewed as a waste of time during the limited operating season. Operations preferred a simpler system that would reduce the need to re-handle ore while still protecting against cyanide solution release.

4.3 Heap Leach Pad Reclamation Process

Three main heap reclamation processes needed to be addressed: Heap Detoxification, Heap Leach Soil Cover, and Effluent Management.

4.3.1 Heap Detoxification

Concerns were initially posed by regulatory agencies regarding the in-situ bacteria technology proposed for heap detoxification, its effectiveness in northern climates, and its long term stability. One primary advantage to using the in-situ bacteria process included reducing the amount of water used in the heap detoxification process. Much less water is used overall with the in-situ bacteria process. The process also reduced the length of time required to detoxify the heap by four months.

4.3.1.1 Issues and Lessons Learned

The main concerns with in-situ bacteria detoxification were whether it would work in the northern climate and determining long term effectiveness of the technology. Short term results showed metal content as stable, however, regulatory agencies had a difficult time trying to determine if metals would become unstable over the long term. Biological reduction has proven to be successful in detoxifying cyanide heap leaches and can be considered with some level of assurance for future applications (Access, June 2009). Future mine developers and regulators must continue to work together prior to mine start-up to determine benchmarks and how to evaluate reclamation performance.

4.3.2 Heap Leach Soil Cover

The construction of a soil cover followed by re-vegetation was another important step of the overall reclamation process. The purpose of the soil cover was to reduce the infiltration of precipitation runoff into the heap so that the volume of effluent was reduced. The water that infiltrated into the heap leach was tested to determine whether it could be released or treated.

The design for the soil cover estimated an annual infiltration rate of 24%. The majority of the infiltration was determined to occur in the spring and early summer months. Secondary treatment measures were estimated using a 30% infiltration factor to add conservatism in the long term management program.

4.3.2.1 Issues and Lessons Learned

Heap infiltration was calculated and it was determined that the infiltration values were above 24% but below the 30% contingency factor over the five year period (Alexco, February 2010). If infiltration rates were greater than 30%, mine owners would not have enough capacity to treat the heap effluent through secondary treatment measures. Fortunately, water quality remained good and further treatment was not required. However, future mine developers can protect themselves from uncontrollable circumstances by using conservative measures such as building excess secondary heap effluent treatment capabilities during planning stages.

4.3.3 Heap Effluent Water Quality and Discharge

In conjunction with the in-situ bacteria process, effluent water quality was a concern for regulators. Water quality tests determined that most of the metals in heap effluent were removed and deemed acceptable for release after proposals from Viceroy were approved by regulatory agencies. However, selenium in sediments was a concern because concentrations did not change after treatment.

Another issue raised in the interview process was the way heap effluent was released into the environment. Once the effluent was deemed safe for release, the chosen method of effluent release was to discharge most of the water to the groundwater zone. While groundwater discharge requires the effluent to go through natural ground filters, it will be difficult to determine how the environment will react to the effluent once it enters the surface water environment.

4.3.3.1 Issues and Lessons Learned

A number of issues were raised. One of the major issues raised with groundwater discharge was the difficulty of tracking effluent. One interviewee raised concerns that baseline ground water flows were not properly identified prior to mine commissioning. Therefore, it was difficult to determine the best locations for groundwater monitoring stations (stations that track effluent and water quality).

Concerns were also raised regarding the selenium concentration in the water over time. Selenium is one metal that was not remediated by the biological treatment cell at closure. There is also no Canadian Council of Ministers of the Environment (CCME) guidelines for selenium concentration in sediment. Regulatory agencies proposed a number of strategies for ensuring water and aquatic resource protection and these strategies were implemented by Viceroy (Government of Yukon, 2003).

A few lessons can be derived from this experience. The issue highlights the need to have accurate pre-construction information about the ground conditions. Groundwater baseline studies would provide critical information if effluent water is to be discharged through groundwater zones. The issue also highlights the need for better understanding on how selenium content affects water quality. Regulatory agencies must review the effect of metal content on water quality and determine appropriate guidelines. Likewise, future mine developers must devise reliable methods to remove metal content from heap effluent to protect water quality for future generations.

4.4 Acid Rock Drainage Management

Some areas were identified by Viceroy as having the potential to produce acid rock drainage (ARD). Plans were to construct a soil cover and seed these locations; however, the Government of Yukon expressed concern with the methodology used by Viceroy in their geochemical characterization of the site. As such, monitoring programs were initiated and are ongoing to verify environmental performance. Some indicators used to verify environmental performance include water infiltration, geochemical stability of metals, and local ground and surface water quality. From annual water licence reports, results have indicated low infiltration, good water quality and that mitigation measures have been effective.

4.4.1 Issues and Lessons Learned

Over time, freeze thaw cycles or erosion damage on soil covers may cause settling. Settling in the soil cover can reduce the effectiveness on the cover, allowing more water to infiltrate ARD rock. Monitoring the potential for ARD is critical in evaluating the environmental performance of the site. Future mine developers must devise reliable methods of eliminating or mitigating the potential for ARD.

4.5 Re-vegetation

Re-vegetation is the process of planting and rebuilding the soil over disturbed land. Between 2002 and 2003, over 180 hectares of re-contoured slopes and disturbed land was seeded and fertilized. The application of seed and fertilizer were 25 kg/ha and 300 kg/ha respectively (Access, June 2009). This was a decreased rate from the original plan in order to promote invasion of natural species to assist in the re-vegetation process.

4.5.1 Issues and Lessons Learned

Re-vegetation at the mine site posed a few challenges. First, the growing period in the north is short. This required planners to seed early in the summer months. Second, there was a shortage of native seed at the time of reseeding. A mixture of non-native seeds such as Kentucky Blue grass and Red Fescue were used to compensate for the shortage.

Laberge noted in 2009 that the soil covers appear to be self-regenerating. Many native species were colonizing most reclaimed areas. The results indicate that the re-vegetation process is a success in many flat areas. However, there are still some sparsely vegetated areas around Brewery Creek. Steep slopes and sidewalls contain little vegetation. This is primarily due to the limited soil cover applied, slope orientation and erosion forces. Natural re-vegetation is a slow process in this environment and further seeding may hinder or do little to help the process. Non-native species did not perform well in the environment and soon died off, being replaced by indigenous species of the area.

4.6 Wildlife Management

Concerns were raised during the initial regulatory process that the cyanide solution used in the heap leach process could pose a risk to wildlife, particularly if consumed. Based on recommendations, Viceroy placed netting covers around the process ponds to restrict wildlife access. Fencing around the heap leach was used to restrict access to the active heap leach areas.

4.6.1 Issues and Lessons Learned

Several wildlife fatalities were documented in the annual reports, submitted as part of the WUL. Nearly all incidents were the result of wildlife not being able to escape from the leach pad area, due to the covering of synthetic plastic. A fox ladder was later constructed, however, no surveillance was carried out, so its success was difficult to determine. No records could be found on whether any wildlife fatalities occurred after the construction of the fox ladder. Consumption of cyanide solution by birds had also occurred once (Access, June 2009).

A permanent exit for trapped wildlife in lined ponds and routine inspection of fencing may reduce wildlife fatalities in future operations. Future mines in the vicinity of dense avian habitat or migratory routes need to consider potential issues of bird fatalities due to consumption of cyanide solution. Methods of scaring birds could be a potential solution and should be investigated.

4.7 Security Bond

During the regulatory process, regulators took a conservative approach to the Brewery Creek project because the heap leach process was unproven in northern climates. The technology had been tested in cold climate regions like northern Montana but never in operations north of the 60th parallel.

One of the regulatory requirements is the payment of a security deposit to the government by mine operators. The security deposit is a tool used by the government to ensure a mining company fulfills its commitments of mine closure and reclamation. Government regulators required an \$8.7 million bond; relatively high compared to other mines in the region. By comparison, the Mt Nansen mine, another gold mine which did not use heap leach technology, required a \$974,000 bond. The Mt Nansen mine was later abandoned.

While bonding plays a role in ensuring mining companies carry out effective reclamation, the approaches to reclamation must be made clear by mine owners. Mine owners seeking new approaches to reclamation must provide evidence that new alternatives will still meet reclamation objectives of the Yukon Government. Daily operations at Brewery Creek reflected a real effort to respect the regulatory processes that support the decommissioning and reclamation phases of the project (Access, June 2009).

4.7.1 Issues and Lessons Learned

One issue that arose at Brewery Creek was confusion over the repayment of the reclamation security deposit and how it would be staged. This was due in part to the actual effective remediation being completed at closed mines. Operators had been required to demonstrate the effectiveness of their reclamation works which resulted in disagreement with the regulatory agencies as to what is demonstrable effectiveness.

Clear benchmarks and expectations for reclamation need to be established prior to the calculation and posting of a reclamation bond, as well as during the evaluation of reclamation treatments. Clearly defining methods and benchmarks for assessing effectiveness will aid the Yukon government and mining proponents alike.

5.0 UPDATE OF ENVIRONMENTAL PERFORMANCE

In the latest environmental update, Alexco has released data that it has collected throughout the year. The following is a summary of their 2009 annual report. Additional information has been taken from the 2009 and 2010 Laberge Environmental Services reports and the June 2009 Access Consulting report.

In general the environmental performance can be summarized as follows:

- Half of the warehouse is all that remains of the Brewery Creek Mine infrastructure,
- The main road has been decommissioned and transformed into a minimal use access road,
- Final reclamation of the process ponds was completed in 2008. Liners have been removed, the area has been re-sloped and additional maintenance, seeding and erosion control has been completed,
- Water from the heap effluent meets water licence criteria and infiltrates into the ground within the reclaimed ponds,
- No surface discharge or water accumulated in the 6 reclaimed pits in 2009,
- Soil covers appear to be effective and self-regenerating (Laberge 2009),
- Water is relatively clear throughout mine site (Laberge 2010),
- Overall water samples at sites indicate good water quality for support of aquatic life (Laberge 2010),
- Water quality results mostly show downtrends in metal content with the exception of selenium.

6.0 CONCLUSION AND RECOMMENDATIONS

The Brewery Creek Mine is a good example of how regulatory agencies and mine owners can work together and be responsible stewards of the environment. Some lessons learned from Brewery Creek are:

- The value of accurate baseline studies. Having accurate climate data would have provided mine developers and regulators with better estimates of heap effluent storage capacity. In addition, appropriate definition of groundwater flows would have provided a better understanding of the groundwater flow regime and thus the best locations for groundwater monitoring stations. Baseline studies provide mine developers and regulators critical information about the pre-construction state of the area. It also helps define future monitoring benchmarks and environmental performance evaluation.
- The value of well-defined mine closure plans. In conjunction with accurate baseline data, regulators can clearly establish benchmarks and schedules for reclamation activities. This will assist mine developers in planning for closure and reclamation. It can also eliminate confusion over security bond repayments
- Process design considerations for future heap leach mines. Brewery Creek Mine has proven that the heap leach freeze scenario is unlikely in arctic conditions. Taking this into thought, smaller overflow pond sizes can be taken into consideration as long as the best operational practices are used to prevent the heap leach “freeze-up”.

- The importance of wildlife control measures. This entails mine developers to identify ecosystems, wildlife usage of the region and migratory patterns of wildlife. By identifying wildlife tendencies, mine developers and regulators will be able to determine the methods of sharing the land and protecting wildlife from human activity.
- The importance of being adaptable to response of regulatory and design changes. A number of changes were critical during the Brewery Creek mine life such as the second recovery circuit and in-situ bacteria processing. Being highly receptive and adaptive to changing circumstances is critical to overall operational effectiveness.
- The significance of using native plant species for reclamation activities and natural regeneration. Re-vegetation in arctic conditions is a slow process that can take years to complete. Application of seeds and fertilizer assist in the reclamation process, but over time, may hinder the natural invasion of indigenous species.

7.0 CLOSURE

We trust this report meets your present requirements. Should you have any questions or comments, please contact the undersigned at your convenience.

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APPENDIX A

APPENDIX A EBA'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

1.0 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's Client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's Client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

2.0 ALTERNATE REPORT FORMAT

Where EBA submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed EBA's instruments of professional service), only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by EBA shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of EBA's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except EBA. EBA's instruments of professional service will be used only and exactly as submitted by EBA.

Electronic files submitted by EBA have been prepared and submitted using specific software and hardware systems. EBA makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

3.0 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

4.0 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

5.0 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

6.0 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

7.0 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

8.0 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

9.0 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

10.0 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

11.0 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

12.0 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

13.0 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

14.0 INFORMATION PROVIDED TO EBA BY OTHERS

During the performance of the work and the preparation of the report, EBA may rely on information provided by persons other than the Client. While EBA endeavours to verify the accuracy of such information when instructed to do so by the Client, EBA accepts no responsibility for the accuracy or the reliability of such information which may affect the report.