Giant Mine Remediation Project

RemTech,
Banff, AB Oct 2009
• Giant Mine History

– Several companies owned and operated Giant Mine for 55 years. 1948 - 2004

– 7.6 million ounces gold were produced by roasting arsenopyrite

– Ultimately, bankruptcy of the last two mine operators left Indian and Northern Affairs Canada (INAC) and the Government of the Northwest Territories (GNWT) responsible for the site.

– The former mine lease area is now a reserve issued to INAC by the GNWT.

– The site is currently under the care and maintenance of INAC/PWGSC
Legacy of mining activity

- Contaminated surficial materials (arsenic and hydrocarbon)
- Buildings with severe arsenic contamination, asbestos insulation
- Decaying mine infrastructure
- Tailings impoundments, sludge settling and polishing ponds
- Toxic arsenic trioxide dust in underground storage (237,000 tonnes)
Giant Mine
• NWT Commissioner’s Land
• Within Yellowknife City Limits
• Includes Town Site

Giant Mine Reserve 846ha
Ore Processing

- Refractory ore

- Arsenopyrite concentrate was roasted at high temperature (~500°C) to break down the mineral structure and liberate gold
Gold Extraction by Roasting

As 46.01%
Fe 34.3%
S 19.96%

Common Impurities
Au, Ag, Co, Sn, Ni, Sb, B, Cu, Pb
Roasting process to extract gold produced 237,000 tonnes of arsenic dust as byproduct – now in underground storage
Remediation Plan Review

- Review and ongoing involvement by expert federal departments
  - Environment Canada
  - Fisheries
  - Health Canada

- Peer Review

- The remediation project is currently undergoing an Environmental Assessment
  - The scope and terms of reference have been established by the Mackenzie Valley Environmental Impact Review Board (MVEIRB).
  - The Developer’s Assessment Report (DAR) is currently under development by INAC/PWGSC.
  - A decision on the project’s environmental effects by the MVEIRB is required before a water licence for treatment plant discharge can be granted by the Mackenzie Land and Water Board.
Remediation Plan Elements

- **Surface**
  - Pits and underground mine openings
  - Tailings impoundments, sludge settling and polishing ponds
  - Contaminated surficial materials (arsenic and hydrocarbon)
  - Decaying mine infrastructure and buildings with severe arsenic contamination, asbestos insulation
  - Junk equipment/scrap lay down areas
  - Mine roads
  - Alignment of Baker Creek
Remediation Plan Elements

- **Underground**
  - 237,000 tonnes toxic arsenic trioxide dust stored in sealed rock chambers – in situ freezing

  - Requirement for indefinite period of effluent treatment
• All existing infrastructure with no future use will be decontaminated, if necessary, and demolished prior to contaminated soils removal.
Contaminated Surface Materials

Highly contaminated soils will be removed and placed in one of the open pits for freezing.

Outside the main areas of soils contamination, there are many small deposits of contaminated soil.
B1 Pit

- Requires backfill to construct drill platform for freezing two freeze areas.
- Platform - 60,000 m$^3$ of contaminated surficial material, >340 mg/kg As to be frozen
- 330,000 m$^3$ of fill needed to fill pit
- 270,000 m$^3$ will consist of waste rock, quarry rock or clean demolition debris
Other Pits

- Some pits will remain open – bermed/fenced
- Pit floors are connected to underground workings which prohibits flooding
- No source of clean backfill without added impacts
Tailings Containment Areas - 95 hectares

NW Pond

Central Pond

North Pond

South Pond
Tailings to be graded, covered, and natural drainage established
Tailings Cover Design – 2 Layer

- Bottom layer of broken rock has 4 functions:
  1. Physical Barrier to prevent contact with the tailings by humans or animals
  2. Prevents erosion (ATV’s, Dirt Bikes)
  3. Prevent upward wicking of arsenic salts through to cover
  4. Helps prevent roots from penetrating tailings
Tailings Cover Design – 2 Layer

- Upper layer of locally available silt and silty clay will:
  1. Act as clean surface to shed runoff
  2. Allow vegetation to establish
  3. Reduce water infiltration
  4. Allow for future recreational and/or traditional use
  5. Eliminate airborne tailings fines on windy days

Note:
Minimizing infiltration is NOT a primary objective, but the two layer design will reduce infiltration
Effluent Treatment Plant and Settling Pond will be covered using design similar to tailings cover.
• Baker Creek Rehabilitation
Arsenic trioxide dust in underground storage is enclosed completely in rock – all access drifts sealed by cement bulkheads.
Underground Contamination Areas

Northwest Pond

AR-1

AR-2

AR-3

AR-4

Mill & Roaster Complex

Photo Credit: Paul Vecsei
#1 > Four Separate Arsenic Trioxide Storage Areas to be Frozen
• Creating a Frozen Block
Freezing and Water Management Sequence
AREA AR 3

4 m pipe spacing
Frozen Block Events
Maintaining the Frozen Block
Ambient cold air

Condensation

Heat released

Warm ground

Heat absorbed (cooling)

Liquid CO₂

Evaporation

Passive Freezing

Cold Liquid

Heat absorbed (cooling)
Hybrid thermosyphon conceptual design

(a) Summer Operation
- Radiators Inactive
- Heat Exchangers
- CO₂ gas condenses where Thermosyphon meets heat exchanger
- Energy in

(b) Winter Operation
- Cold Winter Air
- Heat Exchangers Inactive
- Heat removed from ground
- Heat Exchangers Inactive
- Refrigeration unit Active
- No Energy required
- Normal Thermosyphon operation
Hybrid Thermosyphons
Diavik Diamond Mine
Groundwater Monitoring
#1 > Chamber Freezing & U/G Works
#2 > Pits, Baker Crk & Tailings Covers
#3 > Infrastructure Demo & HazMat
#4 > Long Term Water Treatment
Giant Mine – Recent Risk Mitigation Works
Rechanneling Reach 4 of Baker Creek
Baker Creek – Bitumen Liner
75 ton bridge installation over new creek alignment
Baker Creek Reach 4 - Complete
B2 Dam Reconstruction
B2 Dam – All clay excavations had to ripped
B2 Dam – Clay had to be heated for shaping
B2 Dam – Heating Clay at -35C
B2 Dam – Field Engineering & Challenging Geometry
Completed Baker Creek & B2 Dam
GIANT MINE 2009/10 Emerging Issues
Effluent Treatment Plant
ARSENIC CHAMBER BULKHEAD STABILIZATION
Stabilization of Bulkheads #47,48 & 49
Chamber C212
Freeze Optimization Study
FREEZE OPTIMIZATION STUDY Chamber 10

- Forty freeze holes
- Forty instrumentation holes
- The optimization study will produce the 10 meter containment, sides and bottom as planned for all the freeze zones.
- Three types of drilling types being evaluated:
  - Rotary Mud
  - Down Hole Hammer and
  - Diamond Core

LEGEND
- Mud Rotary Hole in progress
- Down Hole Hammer Hole in progress
- Diamond Core Hole in progress
- Completed Borehole
- Abandoned Holes
- Freeze Hole by Mud Rotary
- Freeze Hole by DHH
- Freeze Hole by Coring
- Freeze Hole - Method to be Determined
- Instrumentation - Mud Rotary
- Instrumentation - DHH
- Instrumentation - Core
- Core Recovery Required (outlined marker)
Chamber 10 – Freeze Study
Project: Freeze Optimization Study
Drill Type: Mud Rotary

Drillhole Summary

Hole ID: P20A
Drilled by: Calibre Drilling

<table>
<thead>
<tr>
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<th>Planned</th>
<th>Actual</th>
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<tbody>
<tr>
<td>J55 Casing Length (m):</td>
<td>94.0</td>
<td>94.0</td>
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<tr>
<td>J55 Casing Diameter (mm):</td>
<td>171</td>
<td>114 OD</td>
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<tr>
<td>Top Elev. (m):</td>
<td>166.0</td>
<td>166.6</td>
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<tr>
<td>Bottom Elev. (m):</td>
<td>72.0</td>
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Notes:
1. Planned datum is design post-site preparation ground surface; actual datum is the top of conductor pipe.
2. Planned bottom elevation of drill-hole includes 1m sub-drilling allowance.

Progress

<table>
<thead>
<tr>
<th>Date</th>
<th>Notes</th>
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<tbody>
<tr>
<td>09/04/20</td>
<td>• Drill to 22.5 m (2.4 m/hr drill rate)</td>
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<tr>
<td>09/05/20</td>
<td>• Drill to 84.5 m (2.3 m/hr drill rate)</td>
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<tr>
<td>09/06/20</td>
<td>• Drill to 95.5 m (2.9 m/hr drill rate)</td>
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<tr>
<td>09/04/20</td>
<td>• Moved to borehole P20A at 12:00</td>
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<tr>
<td>09/05/20</td>
<td>• Started drilling P20A at 13:30</td>
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<tr>
<td>09/05/20</td>
<td>• Thermistor string to be installed to the freeze pipe inside the J55 casing to prevent damaging the thermistor cable</td>
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<tr>
<td>09/05/20</td>
<td>• Loss of circulation at 84.5 m</td>
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<tr>
<td>09/06/20</td>
<td>• Complete borehole and install J55 casing</td>
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Note: Drawing not to scale
Freeze Optimization Study