Presentation Outline

• Placement data

• Stability
  - Compaction
  - Inspections

• Water level data

• Precipitation data

• Water quality at internal monitoring sites

• Snow sample results

• Sulfate Reduction Monitoring Program (SRMP) update

• ABA data

• General site management
Table 2.1 Tailings Placement Data

<table>
<thead>
<tr>
<th></th>
<th>All Materials</th>
<th>All Materials Cumulative</th>
<th>All Materials</th>
<th>All Materials Cumulative</th>
<th>Rock from Site 23</th>
<th>All Other Materials</th>
<th>Tailings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>yd³</td>
<td>yd³</td>
<td>tons</td>
<td>tons</td>
<td>tons</td>
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<tr>
<td>survey</td>
<td>survey</td>
<td>calculated</td>
<td>calculated</td>
<td>truck count</td>
<td>truck count</td>
<td>calculated</td>
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<td>2008</td>
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<td>2,850,140</td>
<td>365,344</td>
<td>5,163,598</td>
<td>25,679</td>
<td>62,395</td>
<td>277,270</td>
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<td>2009</td>
<td>227,817</td>
<td>3,078,657</td>
<td>412,736</td>
<td>5,577,603</td>
<td>16,117</td>
<td>90,584</td>
<td>306,035</td>
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Tons calculated at 134.2 pounds per cubic foot for tailings
Remaining capacity: 4 million tons
• High degree of achieving >90% compaction

• Average dry density: 141 pcf

• Average Standard Proctor dry density: 146 pcf

• Average optimum percent moisture: 11.8%

• HGCMC on-site lab 1-point Proctors
  Average dry density: 146 pcf
  Average percent moisture: 11.5%
Results of operator, engineering, environmental department and regulatory inspections revealed no signs of instability.

Agency Inspections

- USFS - 12
- ADEC - 5
Tailings Facility Water Controls
(2003 EIS)
• Maximum saturated thickness 35 feet

• Toe foundations are well drained

• Water perches approximately 12 feet above the unsaturated underdrains
Figure 2.6 Water Level Data for Piezometer 50

Top of Pile 280'

Transducer Elevation 164.9'

WATER ELEVATION (FT-MSL)

Figure 2.8  Water Level Data for Piezometer 74

- Pile Surface 168'
- Transducer Elevation 141.1' (base of pile)
<table>
<thead>
<tr>
<th>Month</th>
<th>Avg Temp (°C)</th>
<th>Precipitation (in)</th>
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<td>January</td>
<td>-3.1</td>
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<td>February</td>
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<td>March</td>
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<td>April</td>
<td>3.6</td>
<td>1.0</td>
</tr>
<tr>
<td>May</td>
<td>8.0</td>
<td>1.4</td>
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<tr>
<td>June</td>
<td>11.4</td>
<td>1.7</td>
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<tr>
<td>July</td>
<td>14.6</td>
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<td>August</td>
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<td>October</td>
<td>6.4</td>
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<td>November</td>
<td>2.2</td>
<td>3.5</td>
</tr>
<tr>
<td>December</td>
<td>-0.8</td>
<td>2.4</td>
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<tr>
<td><strong>2009</strong></td>
<td><strong>5.3</strong></td>
<td><strong>35.5</strong></td>
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</table>
• Internal site waters captured, treated and discharged per NPDES permit

• pH between 6.0 and 8.5: Alkalinity 250 to 600 mg/L

• Conductivity in wet wells and tailings completion wells ranged from 1400 to 3700 umho/cm

• Conductivity in suction lysimeters ranged from 1400 to 6600 umho/cm

• Sulfate and hardness correlate with conductivity
Tailings Facility Internal Monitoring

Sites: Water Quality Data

- Fluctuations in saturated zone thickness and associated redox conditions influence arsenic and iron concentrations.
- Zinc is considerably more mobile than other metals.
- Microbial sulfate reduction and base metal sulfide precipitation produces low metal concentrations in most saturated zone wells.
- Shallow unsaturated zone and WW3 have higher metal concentrations.
- Iron and manganese concentrations are elevated in wet wells, groundwater, and most of the suction lysimeters due to oxidation/reduction and buffering reactions.
WET WELLS

Wet Well #3

Wet Well #2
Tailings Area Internal Sites
Alkalinity - Figure 2.21a

![Graph showing alkalinity levels over time for Wet Well 2 and Wet Well 3.](image-url)
Tailings Area Internal Sites Conductivity - Figure 2.22a

The graph shows the conductivity values over time for Wet Well 2 and Wet Well 3. The y-axis represents the conductivity in microsiemens per centimeter (μS/cm), while the x-axis represents the date ranging from 1/1/98 to 1/2/10.

- **Wet Well 2**: The conductivity values fluctuate significantly over the years, with peaks and troughs. The values generally range between 0 and 4000 μS/cm.
- **Wet Well 3**: The conductivity values also show a varying pattern, with similar peaks and troughs as Wet Well 2. The values range between 0 and 4000 μS/cm.

The graph provides a visual representation of the conductivity changes over time, which can be useful for monitoring and managing water quality in the tailings area.
TAILINGS COMPLETION WELLS

PZ-T-00-02
PZ-T-00-01
PZ-T-00-03
MW-T-02-05
MW-T-02-06
FIGURE 2.20b  GREENS CREEK TAILINGS INTERNAL MONITORING SITES:
TAILINGS COMPLETIONS - pH DATA
Tailings Area Internal Sites
Alkalinity - Figure 2.21b
Tailings Area Internal Sites Conductivity - Figure 2.22b
Tailings Area Internal Sites
Zinc - Figure 2.26b

(6/5/03, 2520)
SUCTION LYSIMETERS

SL-02-04
SL-02-05
SL-02-06
SL-02-07
Tailings Area Internal Sites

pH - Figure 2.20c
Tailings Area Internal Sites
Alkalinity - Figure 2.21c

The graph shows the Alkalinity levels (mg/L CaCO₃) for different sites (SL-T-02-04, SL-T-02-05, SL-T-02-06, SL-T-02-07) with data points from 1/1/01 to 1/1/10.
Tailings Area Internal Sites
Conductivity - Figure 2.22c

![Graph showing conductivity over time for different sites.](image-url)
• Most perimeter wells exhibit chemistry comparable to background waters

• Pyritic rock used locally for access roads produced acidic drainage in two areas (The pyritic rock was removed from both locations)

  - Water quality shows improvement in response to remediation efforts

• Residual sulfate and metal concentrations are very low relative to contact waters but higher than background levels in localized areas

Tailings Facility Additional Monitoring

- A complex history of disturbance poses challenges to identifying potential leakage from the facility.

- Zinc in the drainage is an order of magnitude or more lower than contact water, suggesting that effects from seepage, if any, from the tailings pile are minimal.

- Zinc at sites 610 and 611 increased with construction activity but subsequently decreased.

- Further Creek drainage is expected to improve. Some element concentrations may temporarily increase as the drainage returns to its naturally acidic, dilute condition.
Tailings Facility Additional Monitoring

• Quarrying of Pond 7 influenced Althea Creek chemistry and collection of foundation drainage caused a return toward pre-construction conditions

• Comparison of zinc concentrations above and below the liner suggests that the liner is intact and functioning as designed

• Background conditions typical of muskeg drainages preclude compliance with AWQS for pH, alkalinity, aluminum and iron at sites 60 and 609

• Pb, Zn, Cd, Hg, Mn are expected to exceed background levels and may not meet AWQS as pH and hardness decrease to background levels. The magnitude of exceedance is expected to be small and temporary
Tails Snow Dust Sampling
Tails Snow Dust Sampling

- Mitigation
  - Snow Fences
  - Eco Blocks
  - Snow removal only in active placement area

- Lead levels in water do not directly correlate to lead loading values

- Observable up to approximately 1700 feet away

- Significant decrease in lead load over the past three years
Snow Sample Sites

1007
1008
1009
1007
1008
1009
Figure 2.35 Snow Survey Analysis

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<th></th>
<th>Dec-06</th>
<th>Dec-07</th>
<th>Dec-08</th>
<th>Dec-09</th>
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<tbody>
<tr>
<td>Lead Loading (mg/m²)</td>
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<tr>
<td>1015 MW-T-00-04A</td>
<td></td>
<td></td>
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<tr>
<td>1014 MW-T-02-07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1013 Main Embmknt Toe</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1012 Lease Line South</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>1009 Wet Well 1 75' S</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>1007 MW 3S, Site 29</td>
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<td></td>
<td></td>
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<tr>
<td>1010 MW 1S, Site 25</td>
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<td>1011 MW 2S, Site 27</td>
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<tr>
<td>1008 MW 5, Site 32</td>
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</table>

Dec-06 to Dec-09
Figure 2.35 Snow Survey Analysis

Distance from Pile Center (feet)

Lead Loading (mg/m^2)
Figure 2.35 Snow Survey Analysis

Distance from Pile Center (feet)

Lead Loading (mg/m²)

1049 MW-T-01-03B
1014 MW-T-02-07
1044 MW-T-00-03B
1007 MW 3S, Site 29
1009 Wet Well 1.75' S
1015 MW-T-00-04A
1008 MW 5, Site 32
1010 MW 1S, Site 25
1011 MW 2S, Site 27
1012 Lease Line South
1047 MW-T-95-5B
1046 MW-T-00-01B
1048 MW-T-05-04
• Tailings Expansion EIS ROD required a study to determine if long term sulfate reduction is achievable and will meet closure needs; evaluate existing and additional carbon sources and application methods

• Seven field test plots (5 carbon amendments; 2 controls) constructed, instrumented (suction lysimeters, tensiometers, moisture access probes) and sampled

• Laboratory batch and column test were performed to support field tests and constrain reaction rates

• Analyses of enzymes related to cellulose degradation were performed in support of field and laboratory testing
## Sulfate Reduction Monitoring Program

### Field Test Cell Amendment Mixtures

<table>
<thead>
<tr>
<th>Cell</th>
<th>Tailings (vol %)</th>
<th>Peat (vol %)</th>
<th>Brewery Grain (vol %)</th>
<th>Bio-Solids (vol %)</th>
<th>Condition</th>
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<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>Unexcavated</td>
</tr>
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<td>2</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>3</td>
<td>95</td>
<td>5</td>
<td>0</td>
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<tr>
<td>4</td>
<td>95</td>
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<td>0</td>
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<td>5</td>
<td>95</td>
<td>2.5</td>
<td>0</td>
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<tr>
<td>6</td>
<td>95</td>
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<td>1.25</td>
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<td>7</td>
<td>90</td>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
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</table>
Sulfate Reduction Monitoring Program

- Lysimeter
- Moisture Probe Access
- Tensiometer
- Pore Gas Tube

Diagram details:
- RPP Liner
- Organic Carbon Amended Tailings
- Unamended Tailings

Dimensions:
- 3.05 m
- 3.50 m
- 0.50 m
Sulfate Reduction Monitoring Program (SRMP) Update

- Key findings 2004-2010
  - Microbially mediated sulfate reduction in cells 4-7
  - No significant sulfate reduction in control cells or peat-amended cell
  - Precipitation of metal sulfides contributes to a decrease in sulfate and metal concentrations
  - Increase in iron reducers, elevated dissolved Fe and As
  - Organic carbon from biosolids is rapidly consumed
  - Cells containing spent brewing grain show best performance
  - Laboratory batch and column test results support field results
  - Carbon amendment to oxidized tailings is not recommended
  - High concentrations of DOC should be avoided to minimize iron reduction and arsenic mobility
  - Laboratory analysis of enzymes related to cellulose degradation supports water chemistry and microbiology results
Sulfate Reduction Monitoring Program (SRMP) Update

• Future work planned
  – Ongoing performance sampling
  – Final reports from University of Waterloo
  – Geotechnical evaluation
  – Logistical considerations
  – Program completion and final report
Tailings Facility Acid Base Accounting Analyses

• Tailings have the potential to generate acidic drainage if the buffering capacity of the tailings is consumed

• High carbonate content supports a long lag time for depletion of buffering capacity

• Long lag time (decades) allows time for construction and closure of the facility, including construction of an oxygen-inhibiting composite soil cover
Figure 2.32 Monthly Tailings Acid Base Accounting Data

Tails Monthly Composite ABA (tons CaCO₃/kton)
• Operations per GPO Appendix 3 and Waste Management Permit

• Most placement occurred in northwest expansion area

• Tailings facility activities in 2009
  – Commissioned Pond 6 area for tailings placement
  – Began co-disposal of Site E rock and tailings
  – Constructed settling basins near Pond 7
  – Began characterization of East Ridge (test pits)
2010 Planned Tailings and Closure Planning Activities

- Clearing of East Ridge area
- Geotechnical and environmental drilling program
- Continue Site E removal and co-disposal
- SRMP field program continues
- Stage III tailings preparation
- Cover monitoring and vegetation study continues
- Underground hydrology study continues