INVESTIGATING LOADINGS FROM TAILINGS AND WASTE ROCK FOR CLOSURE PLANNING AT NYRSTAR MYRA FALLS

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Outline

• Contaminant load model
• Calibrated groundwater model
• Closure Plan Cover system
Myra Falls is located in Strathcona Provincial Park.

Site is located in an alluvial valley with steep terrain.
Introduction to Myra Falls

• Mine has been operating since 1966
• Producing copper, lead & zinc concentrates with silver and gold credits
• Currently owned by Nyrstar, following purchase of Breakwater Resources Limited in Aug 2011
• Site Status: closing the Tailings Disposal Facility while continuing to operate for another 10-20 years
Looking east down the valley

MAP is ~2600 mm/yr
Tailings Disposal Facility

- Tailings Disposal Facility is 44 ha
- 30 m of sub-aerially deposited conventional tailings
- 10 m of paste tailings placed on top
- The “strip” is the conventional tails
- A reclaim sand area stores coarser tails
- The TDF is supported by a stabilizing toe-berm referred to as the Seismic Upgrade Berm
Components of TDF

- Myra Creek
- RSA
- Paste Tailings
- Strip Area
- Seismic Berm
Pump House and Myra Creek

5 under drain lines connected to pump house
Summary of Under Drains

- Inner Drain – twinned drainage collection
- Outer Drains – 4 perforated lines connected
  - act as a hydraulic barrier to protect Myra Creek
- New Outer Drain system came on-line in 2008
  - Constructed with Seismic Upgrade
  - Improved seepage collection
TDF Under Drains

Five lines gravity-drain to pump house (PH4), then are pumped to water treatment
New Outer Drain
- Medium, Short, Long Drain
- Perforation in 3 segments
- Risers, Standpipes, Monitors
Waste Rock

- Waste rock has been generating acidic drainage for decades
- The under-drains collect contaminated groundwater seepage coming from waste rock
- In the 80s and 90s there were monitoring wells and active investigation of the waste rock
Waste Rock Under TDF

from Knight Piesold (1982)
Current Condition – Myra Creek

• Zinc is the main contaminant indicator for the mine

• 2010 annual average:
  – Upstream of the mine ~ 0.0006 mg/L Zn
  – Downstream of the mine ~ 0.1 mg/L Zn

• Water quality d/s varies seasonally, with higher Zn in the rainy season, Nov to Apr
Zinc at TP4, 2005 to 2012 (mg/L)

- Water quality improved in Myra Creek since 2008
Effluent is a small part of the load to Myra Creek.
Groundwater Monitoring

• MEA repaired existing wells and installed additional wells
• Paired, nested monitoring wells are located hill side and creek side of the outer drains
• Results show:
  – Outer drains are functioning to protect the creek
  – Deep groundwater is not completely captured by the drains
Active Groundwater Monitoring

Outer Drains and wells: 5 - 20 mg/L zinc
Inner Drain: 25 - 35 mg/L zinc
Tailings well: 1 – 3 mg/L zinc
U/s wells near creek: 1-2 mg/L zinc
Contaminant Loading Balance - Creek

<table>
<thead>
<tr>
<th>Component</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>0.6</td>
</tr>
<tr>
<td>Sources upstream of TDF</td>
<td>24</td>
</tr>
<tr>
<td>Treated Effluent</td>
<td>7</td>
</tr>
<tr>
<td>TDF groundwater (by difference)</td>
<td>68</td>
</tr>
<tr>
<td>TP4 total load</td>
<td>100</td>
</tr>
</tbody>
</table>

TP4: 27,000 Kg/yr Zn
**Zn Loadings - Myra Creek and PH4**

**Myra Creek**
- M1
- Other upstream
- Groundwater
- Effluent

**PH4 load is ~3 times Myra Creek**

**Pump house 4**
- New Outer Drain Total
- Area II "Old" Outer Drain
- Inner Drain

Drains are essential for protecting Myra Creek long term.
Groundwater Model

- Regional 3-D groundwater model was developed and calibrated for the TDF Closure Plan
- Developed in MODFLOW
- Objective was to help assess closure cover alternatives such as a liner on the TDF
- Groundwater model contributes information for the loading balance
Section Through TDF

- Waste rock and tailings sit on a gravel aquifer
- Conceptual groundwater model
Groundwater Model Domain

- Centred on TDF
Historical Groundwater Data

• The site has historical data back to pre-TDF period:
  • TDF Monitoring Data (2001-present)
• Model was constructed for three dates – 1982, 1990 and 2010
Versions of Model - 1982 Setting

- 1982 calibration run for foundation materials (gravel, sand, clay)
• 1990 calibration run for waste dump, Inner Drain conductance and general head conductance
Versions of Model - 2010

- 2010 calibration run for tailings and outer drain conductance
## Key Components of Water Balance

<table>
<thead>
<tr>
<th>Component</th>
<th>Flux (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect Recharge - Mountain</td>
<td>290</td>
</tr>
<tr>
<td>Direct Recharge - TDF</td>
<td>5</td>
</tr>
<tr>
<td>Outflow to Inner Drain</td>
<td>53</td>
</tr>
<tr>
<td>Outflow to Outer Drain</td>
<td>63</td>
</tr>
</tbody>
</table>

- Largest component of flow is from indirect recharge from mountain slope
- Fluxes to Inner and Outer Drain are consistent with measured values
Predicted Pathlines - 1982

- 1982 flux to Milky Spring
- GW flows parallel to Myra Creek rather than down slope because of the high K of gravel aquifer
Predicted Pathlines - 2010

- Waste rock in red, tailings in green
- Under drains capture a large portion of Zn
- Deep groundwater plume
Contaminant Load Balance – Total

• 2\textsuperscript{nd} contaminant load model estimates the portion of loadings from waste rock and tailings sources

• Annual loadings in Myra Creek and PH4 are the total upper limit for waste rock and tailings loadings - 93,000 Kg/yr Zn

• Contaminant load model draws on groundwater model inflows and outflows
Sources of Zinc Loadings

• **Tailings**
  – Source of contamination?
  – Within tails, Zn in groundwater is low
  – At surface oxidation occurs with high Zn in runoff (decants)

• **Drainage from Waste Rock**
  – Waste Rock adjacent to and underneath tailings is a source of contamination

• **Compacted PAG waste rock included in the core of the Seismic Upgrade berm**
  – PAG used only where TDF has outer drain collection
Tailings Source Load Pathways

• Infiltration though tailings to the gravel aquifer beneath
  – The tailings are partially saturated and have a water table that changes seasonally
  – Groundwater conc. much higher for the drains and monitoring wells than the pore water in deeper tails

• Surface of the strip tails is oxidized
  – Water quality in the strip decant is poor (50 mg/L zinc)
Infiltration through waste rock increases water table fluctuations in waste rock. Mountain recharge increases water table fluctuations (Northwest Geochem, 1992). Infiltration load was estimated and remaining load was attributed to the mountain recharge mechanism.
Loadings - Waste Rock and Tailings

<table>
<thead>
<tr>
<th>Source</th>
<th>Zn (Kg/yr)</th>
<th>Flow (L/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Rock – Direct Infiltration</td>
<td>59400</td>
<td>3.8</td>
</tr>
<tr>
<td>Waste Rock - mountain recharge</td>
<td>29500</td>
<td>127</td>
</tr>
<tr>
<td>Waste Rock - PAG in seismic berm</td>
<td>2300</td>
<td>1.8</td>
</tr>
<tr>
<td>Tailings - Infiltration</td>
<td>1260</td>
<td>3.3</td>
</tr>
</tbody>
</table>

- Northwest Geochem (1992) measured *saturated* pore water at 470 mg/L zinc within waste rock
- 500 mg/L zinc assumed for *unsaturated* pore water quality contributing loadings from the waste rock (uncertain value)
- Monitoring well installed just beneath the tailings showed 3 mg/L Zinc, we assumed 12 mg/L unsaturated tails pore water
TDF Closure Design

• The final paste lift of the TDF is at capacity
• Strip, RSA and paste berm
  – Geo-synthetic liner on PAG rock platform; till
• Paste tailings
  – Waste rock & till cover
• Waste rock within the TDF footprint
  – Till cover on the re-contoured surface
• Cover design by O’Kane Consulting
• MEA modelled effect of closure plan on Myra Creek
Closure Plan Cover Design

Cover: till

Cover: till, PAG rock

Cover: till, liner, PAG rock
Post-Closure Loading Balance Model

• The proposed cover design is expected to reduce loadings in the short-term to ~80% of the current condition
  – From 93,000 Kg/yr to 76,000 Kg/yr

• This prediction does not consider long-term loadings

• The reduction is largely from reduced infiltration rates
  – Cover is expected to reduce infiltration into waste rock from 1350 mm to 600 mm
Summary

• Treated effluent is a small source of the loadings to Myra Creek
• Groundwater flowing under the TDF is the largest source of loadings to Myra Creek
• Waste rock is the primary cause of these loadings
• The under-drains and treatment system are critical for protecting Myra Creek water quality
Summary

- Conceptual model for loadings from waste rock includes two pathways.
- Seasonal variations in mountain recharge cause water table fluctuations within waste rock.
- Covering waste rock is expected to improve water quality in Myra Creek.
- A waste rock cover will not remove all loadings because of the mountain recharge.
Questions?

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