Hardrock Project – ART Working Group
Environmental Baseline

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Presentation Overview

• Introductions
• Project Overview
• Environmental Baseline:
  • Groundwater
  • Surface Water Flow
  • Surface Water Quality
  • Fish and Fish Habitat
  • Air Quality
  • Acoustics (sound)
  • Terrestrial
  • Archaeology/Cultural Heritage
• Next Steps
Project Overview

- Open pit gold mine (former mine site)
- 2 years of construction
- 15 year mine life
- 5 years of active closure and reclamation
- Estimated 340 combined direct employment opportunities
- The Project will contribute an estimated $2 billion to the local economy through operating costs during the life of mine
Groundwater (Hydrogeology)
Hydrogeology – Objectives

- Characterize background soil quality.
- Characterize seasonal groundwater variations and flow within the overburden and bedrock (shallow and deep) systems and interactions with surface water features (streams and wetlands).
- Document groundwater quality within the overburden, shallow, and deep bedrock and historic tailings.

Study Area: Defined based on anticipated drawdown associated with and model area. Generally coincides with watershed boundaries or interpreted physical flow divides.
Hydrogeology – Methods

• 35 monitoring wells (24 locations)
• 8 drive point piezometers (5 locations)
• Determine hydraulic conductivity using shallow monitoring wells (30), deep bedrock exploration holes (32), tracer profiles (11) and targeted packer testing.
• Soil quality samples collected (22 locations) and analyzed for general chemistry and metals.
• Groundwater quality samples collected (45 locations) and analyzed for general chemistry and metals
Hydrogeology – Monitoring Locations
Hydrogeology - Results

• Historic Mine Site Soils
  • Soils exceeded criteria for antimony, arsenic, boron, and molybdenum
  • Arsenic elevated in 4 of 6 (67%) samples
  • Arsenic levels ranged from 6 to 563 µg/g

• Historic Tailings Soils
  • Tailings exceeded criteria for antimony, arsenic, free cyanide, iron, and manganese
  • Average concentrations for arsenic similar for Hardrock and McLeod tailings
Hydrogeology - Results

• Groundwater
  • Overall flow towards Kenogamisis Lake.
  • Low flow systems resulting from variations in topography and with discharge to low-lying creeks (Goldfield and SW Arm Tributary) and wetlands.
  • Overburden and shallow bedrock hydraulically connected, with variable response to precipitation events.
  • Wide variations in hydraulic conductivity in overburden and similar to shallow bedrock – Average 10-6 m/s.
  • Deeper bedrock - Average 10-7 to 10-8 m/s.
Surface Water Flow (Hydrology)
Hydrology – Objectives/Methods

• Temporal and spatial water availability for various users (recreation, navigation, fishing, water supply, etc.)
• Flooding
• Environmental flows to sustain quantity and quality of freshwater ecosystem
• Source of water supply (lakes, rivers)
• Dilution and mixing potential of treated effluent
• Fish (fish passage, water level fluctuations)
Hydrology – Objectives/Methods

• Characterize flows, water levels and drainage patterns
• Review existing data on climate, regional hydrology and water balance
• Streamflow and lake water level monitoring with the installation of seven hydrometric monitoring stations
• Channel cross-section survey, bathymetry survey and watershed characteristics assessment.
Hydrology - Results

- Average precipitation is 765 mm. The driest year (1987) had 558 mm, the wettest year (2007) had 1064 mm.
- January is the coldest month with average temperature -18.6 °C. July is the warmest with average temperature of 17.2 °C. Snow cover lasts from late October to early May. Annual normal snowfall is 243 cm.
- Mean annual runoff ranges between 242 mm and 370 mm.
Hydrology - Results

Streams

Flow, m³/s

January February March April May June July August September October November December

Lake

Water Levels in Kenogamisis Lake (2005-2014)

Flows in Goldfield Creek
Hydrology - Results

- Average yearly runoff ranges from 242 mm and 370 mm
- The lowest monthly flows occurred in January and the highest during the spring melt (April and May)
- Hydrographs developed for Magnet Creek, Marron Creek and Goldfield Creek showed a similar pattern of flow
- All three creeks has a sharp peak in flow at the start of June with low flows through the summer with some minor increases in flow in September to October due to more frequent rainfall
- Water level in Kenogamisis Lake is controlled by the Dam
Surface Water Quality
Surface Water Quality – Objectives/Methods

- Determine existing water quality and to characterize and distinguish background conditions versus those affected by historical mining activities.
- Thirty three locations were sampled monthly for a comprehensive suite of parameters.
- All results were compared to the federal Canadian Water Quality Guidelines (WQG, CCME) and provincial water quality objectives (PWQO, MOECC).
- In cases where more than one guideline applied, the lowest guideline was used.
Surface Water Quality- Results

- Barton Bay is a source of arsenic, aluminum, iron, copper and phosphorus to Kenogamisis Lake.
- Primary source appears to be the McLeod Tailings and, to a lesser extent Magnet Creek and the Geraldton STP.
- Concentrations decrease between Barton Bay Basin and Central Basin and the Outlet/Northeast Arm.
- The Hardrock Tailings are also a source of arsenic in the Central Arm.
- Southwest Arm has relatively few naturally occurring exceedances of WQGs and PWQOs.
Surface Water Quality- Results

• Mosher Lake, Marron Creek and SW Arm Tributary show elevated levels of arsenic and other parameters from historical mining activities.

• SW Arm also exceeds As guideline at background.

• Seasonal trends apparent in all areas.

• Prior to 1990 cadmium (Cd), cobalt (Co), lead (Pb), copper (Cu), arsenic (As), iron (Fe) and phosphorus (P) often exceeded guidelines.

• Post 1990 and currently only As, Fe and P routinely exceed guidelines.
Surface Water Quality- Results

- Kenogamisis Lake Barton Bay, Central Basin and the Outlet Arm, as well as Mosher Lake and creeks adjacent to historical mining activities are affected by historical mining/industrial activities.
- Other sources of contamination such as Magnet Creek and the Geraldton STP are evident.
- At baseline conditions As guidelines are exceeded 8-15% of the time.
Fish and Fish Habitat
Fish and Fish Habitat – Objectives/Methods

• Characterize existing fish communities and fish habitat in the Project development area (PDA), local study area (LSA) and regional study area (RSA)

• Background data collection

• Field investigations and discussions with local residents
Fish Habitat – Results Lakes and Ponds

• Lakes within the LSA provide coolwater habitat.
• Larger lakes (Kenogamisis, Goldfield and Wildgoose Lakes) show greater diversity of aquatic vegetation, cover, substrate types and bathymetric structure.
• Lakes within the LSA provide spawning habitat for Northern Pike and Yellow Perch.
• Important spawning and feeding habitat for species like Walleye and Lake Whitefish where the Kenogamisis River and Magnet Creek flow into Kenogamisis Lake.
Fish Habitat Results - Streams

• Despite good cover, fish abundance and species diversity were generally low in streams within the LSA.

• LSA watercourses likely freeze to the bottom in winter, limiting fish use of these types of habitat.

• Highly organic substrates and ice cover may also create anoxic conditions in these areas, further limiting fish distribution in the LSA.
Fish Communities - Results

- Over 4,300 fish and 23 species were captured.
- Only fish needed for tissue sampling or identification verifications were kept.
- No species identified were listed as federal or provincial species at risk.
- Game and sustenance fish species (Walleye, Lake Whitefish, Northern Pike, Yellow Perch and Burbot) in Kenogamisis and Goldfield Lakes.
- Northern Pike and Yellow Perch were present in water > 3 m deep.
- Spottail Shiner, Trout Perch and Blacknose Shiner were found in abundance.
Fish Tissue - Results for Arsenic

• Small-bodied (forage) fish - Arsenic 4 and 2 times higher in Barton Bay and Central Arm, respectively, than in Southwest Arm - no apparent adverse effects on fish abundance

• Arsenic in Walleye muscle tissue 2 times higher in fish from Kenogamisis Lake than Wildgoose Lake

• No guideline exists for arsenic consumption but levels in Walleye were generally below international consumption guidelines for most countries
Fish Tissue - Results for Mercury

• No evidence for mercury or methyl mercury bioaccumulation related to mine activities
• Elevated in Kenogamisis Lake in general
• Some exceedences of human consumption guidelines in some fish but within normal range.
Sediment Quality - Results

• The following exceed provincial guidelines: As, Cr, Cu, Fe, Mn, Hg, Ni, and Zn.

• Arsenic, Cadmium, Chromium, Copper, Lead and Nickel were naturally elevated at some sampling locations.

• Arsenic exceeded the LEL at most sampling stations throughout the study area.

• Inland lakes, creeks and the SW Arm reflected background arsenic concentrations (inland waterbodies > SW Arm).

• Concentrations of As, Cr, Cu, Fe, Mn, Hg, Ni, and Zn were highest in Barton Bay and, elevated in the Central Basin due to historical mining activities.
Benthic Invertebrates - Results

• EPT Highest in Southwest Arm of Kenogamisis Lake and creeks, suggesting these environments contained the most complex benthic habitats.

• EPT Moderate in Barton Bay.

• EPT Lowest in small lakes and the Central Basin of Kenogamisis Lake, suggesting that these environments have relatively poor habitat quality.

• EPT Absent in Mosher Lake, suggesting stressed benthic communities.
Bioavailability
Bioavailability- Objectives

- To assess whether these existing elevated metals in surface water and sediment are biologically available; and
- causing adverse effects on resident aquatic organisms
Bioavailability- Methods

• Examined Hardrock Tailings and McCloud Tailings areas and compared to reference condition (Southwest Arm and Wildgoose Lake)

• laboratory toxicity tests

• bioaccumulation studies in aquatic invertebrates

• Bioaccumulation forage fish

• Bioaccumulation sport fish

• Modelling of metal toxicity

• Bioavailability Report will be available on the Project website in the next few weeks
Air Quality
Air Quality – Objectives/Methods

- Determine existing air quality, meteorology and climate based on:
  - National Air Pollution Surveillance Program (NAPS) for northern Ontario and Manitoba.
  - Assessment of ambient air quality at two other mines in northern Ontario.
  - Conduct an ambient monitoring program for Total Suspended Particulate (TSP) and metals at one location within the Project Development Area (June-October 2014).
  - Collect meteorology and climatology from Geraldton Airport and on-site.
Air Quality – Objectives/Methods

• Review of monitoring data (2009 – 2013) for:
  • particulate matter less than 2.5 microns (PM$_{2.5}$)
  • particulate matter less than 10 microns (PM$_{10}$)
  • metals,
  • nitrogen dioxide (NO$_2$)
  • nitrogen oxides (NO$_x$),
  • sulphur dioxide (SO$_2$)
  • ozone (O$_3$)
  • carbon monoxide (CO)
  • volatile organic compound (VOC)
Air Quality – Results

• Currently influenced by the town of Geraldton, traffic on Highway 11 and potential long range transport of contaminants from other emissions sources.

• Measurements taken at five monitoring stations in residential, commercial and industrial areas which are expected to have higher background concentrations.

• Baseline levels for use in the EA are the highest from any of the data sources examined (conservative).

• Baseline air quality levels for contaminants that would be emitted from the Project are below applicable federal and provincial criteria.
Air Quality – Additional Study

• A monitoring station measuring PM$_{2.5}$, PM$_{10}$, TSP & metals, NO$_2$/NO$_x$, SO$_2$, and VOCs was installed in the Project Development Area in November 2014.

• An ambient monitoring plan for these measurements was developed and submitted for review by the MOECC prior to starting the monitoring.

• The monitoring program started operating in December 2014 and will continue into summer 2015.

• Results of this monitoring will also be used in the EA to characterize baseline air quality.
Acoustics
Acoustics – Objectives/Methods

• Identify noise sensitive land uses and Points of Reception (POR), such as residences, hotels/motels, rental residences, hospitals.

• Identify communities (e.g. Geraldton; Rosedale Point; Little Longlac; MacLeod; and Hardrock or other) and community points of interest (e.g. parks, campgrounds, and schools and places of worship)

• Establish existing sound level (ambient sound level), in the PORs, noise sensitive land uses, and communities.
Acoustics – Objectives/Methods

• Study how ambient sound level varies throughout the area – by conducting sound level measurements throughout the area.

• Study how ambient sound level varies during different time of the day - Conducted long term measurements at selected locations to study variations.
Acoustics – Sound Levels

Sound Level Equivalencies

- Jet Take-Off (100m distance): 120-130 dBA
- Average Street Traffic: 80-90 dBA
- Conversational Speech: 60 dBA
- Library: 30-40 dBA
- Woods: 10-20 dBA
- Living Room: 50 dBA
- Rock Band: 110 dBA
- North monitor (model)
- City of Edmonton Nighttime noise limit

Threshold of Hearing: 0
Acoustics – Results

- No tonal or excessive low frequency noise was encountered during field studies.
- Vehicle traffic along Highway 11 and Michael Power Boulevard were the dominant sources of noise during daytime hours.
- Sound from the natural environment dominated the nighttime hours.
- Receptor area of the Project are characteristic of a Class 2 acoustical environment which experiences “urban hum” or traffic noise during daytime hours and natural environmental sound during the night-time hours.
Terrestrial
Terrestrial – Objectives

• Characterize environmental features and functions.
• Review existing ecological data available for the area.
  • MNRF, NHIC, wildlife atlases
• Conduct field investigations for vegetation & wildlife.
Terrestrial Methods - Vegetation

Vegetation and Ecosite Mapping

- Ecosite Mapping
  - FRI data
  - Ground-truthing

- 3-season Botanical Inventory

- Wetland Identification and confirmation mapping
Terrestrial Methods - Wildlife

Breeding Amphibians
   – Targeted 3 survey windows: May, June, July

Breeding Birds
   – Targeted from June to July

Crepuscular & Nocturnal Birds
   – Specifically targeting Eastern Whip-poor-will during full moon cycle

• Waterfowl
   Nesting & migration

• Bat Maternity Roosts
   Survey plots in deciduous and mixed forests

• General Wildlife Surveys & Habitat Assessments
   Large mammals, furbearers and reptiles
Terrestrial - Results

A total of 46 ecosite community types identified in the LSA

- Wetlands, represented by non-PSW and previously unevaluated or unidentified wetlands

  - 245 species of plants (223 native, 22 exotics)
  - Five species of frogs and toads
  - One salamander species
  - One turtle species
  - One snake species
  - 129 bird species (117 of which are assumed to be breeding in the LSA)

- 15 species of migrating waterfowl
- 16 mammal species (including three species of bats)
- 6 species of dragonfly and damselfly
- 18 species of butterfly
Terrestrial – Results

Terrestrial features and associated functions identified within the PDA and LSA:

- Protected Areas:
  - Macleod Provincial Park

- Habitats of Species of Conservation Concern for:
  - Taiga Alpine (ecosite B136)

Ecological Features & Species Observations - Typical of the Boreal Region
Terrestrial – Species at Risk Results

• Provincial and Federal Species at Risk:

  • Barn Swallow nesting habitat under bridges and other human structures and buildings.

  • Breeding habitat for Canada Warbler, Common Nighthawk, Eastern Wood-pewee breeding habitat, and Olive-sided Flycatcher.

  • Little Brown Myotis and Northern Myotis habitat in deciduous and mixed forests with stand size >25 cm dbh and tree height >10 m.
Terrestrial – Wildlife Habitat Results

Seasonal Concentration Areas for Animals:
- Moose late winter cover.
- Waterfowl Stopover and Staging areas.
- Turtle wintering areas in Kenogamisis Lake.
- Snake hibernacula assumed to occur throughout the LSA.

Rare Vegetation Communities and Specialized Habitats:
- Sparse Treed Fen (unique Taiga Alpine community, Habitat of Species of Conservation Concern).
- Waterfowl Nesting Areas.
- Seeps and Springs.
- Woodland Raptor
- Nesting Habitat – assumed to occur throughout LSA
Terrestrial Additional Information

Woodland Caribou

• LSA occurs within the Lake Superior Uplands Linkage (discontinuous distribution area).

• Occupancy in the general area known pre-1980s to 2011.

• No known caribou calving or nursery areas within the LSA.

• Use of the LSA is unlikely, due to brownfield conditions, Highway 11 and other intensive human use.
Archaeology and Cultural Heritage
Archaeology – Objective/Method

• Document archaeological resources and determine if further investigations are required.

• Field investigations conducted between September and November, 2014 for all areas of archaeological potential identified in Stage 1.

• Test pit survey at intervals of 5 m conducted within 50 m of features of archaeological potential.

• From 50 to 150 m from the feature other than modern water sources (such as known transportation routes), test pit survey conducted at intervals of 10 m.

• Test pits approximately 30 cm wide 5 cm into sterile subsoil.

• Soils screened through six millimetre mesh screening to recover small artifacts.
Archaeology – Results

• No artifacts found during test pit survey
• No archaeological sites were documented during the Stage 2 archaeological assessment
Cultural Heritage – Objectives/Methods

• In order to identify the presence of cultural heritage resources, a Cultural Heritage Evaluation Report (CHER) has been completed to screen for resources of potential cultural heritage value or interest (CHVI)

• A land use history was completed to provide a cultural context for the study area and to provide a background with which to base evaluations.

• In addition, a property inspection and evaluation was completed to determine CHVI and ultimately make recommendations for further study where relevant
Cultural Heritage – Results

• Identified 47 properties containing potential built heritage resource and one property with a potential heritage landscape (Kenogamisis Golf Club).

• The built heritage resources were primarily homes built during the early mining activities.

• The MacLeod-Cockshutt Mining Headframe - only built heritage resource related directly to early mining activities. (Other resources are related to the development that arose due to the mining, but this is the only directly mine-related resource)
Next Steps

• Ongoing fieldwork in 2015 in support of permitting.
• Open house anticipated in May 2015 (present preliminary VC/criteria/indicators and alternatives for review/comment).
• EA submission anticipated in July 2015.
• Open house anticipated in July/August 2015 (present draft EA for review/comment).
• Ongoing engagement throughout Project.
Thank you

Your comments and questions about the Hardrock Project are important to us.

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Hardrock Project
ART Working Groups
Socio-Economic, Geochemistry, Bioavailability Baseline

May 27 2015
Presentation Overview

• Introductions
• Project Overview
• Socio-Economics
  • Objectives / methods
  • Results / key takeaways
  • Discussion
• Geochemistry
  • Objectives / methods
  • Results / key takeaways
  • Discussion
• Bioavailability
  • Context
  • Objectives / methods
  • Results / key takeaways
  • Discussion
• Next Steps
Project Overview

• Open pit gold mine (brownfield site)
• Two years of construction
• Fifteen year mine life
• Five years of active closure and reclamation
• Estimated 340 combined direct employment opportunities
• The Project will contribute an estimated $2 billion to the local economy through operating costs during the life of mine
Site Setting

- Long Lac Tailings
- MacLeod Tailings
- SW Arm Tributary
- Hardrock Tailings
- Goldfield Creek
- Project Development Area
Socio-Economics
Socio-Economics - Objectives

• Assess existing socio-economic conditions with respect to:
  • demographics;
  • economy, employment and business;
  • community infrastructure and services; and
  • land and resource use (LRU).

• Information will be used to inform the EA
Socio-Economics - Methods

• Data collection from Statistics Canada and, in particular, the 2011 Census of Canada and National Household Survey (NHS). Stats Canada information includes Aboriginal community data.

• Additional information was also collected from:
  • municipal corporations;
  • provincial agencies, boards and commissions;
  • planning boards and boards of trade;
  • school and health boards;
  • district social services administration boards;
  • community development corporations;
  • police and other emergency response organizations; and
  • housing agencies.
Socio-Economics - Methods

• Data collection for the LRU baseline included:
  • questionnaires
  • planning documents;
  • local and government websites;
  • government databases;
  • interactive maps (e.g., MNDM’s CLAIMaps);
  • government reports;
  • Acts and regulations; and
  • news articles.
Socio-Economics – Demographic Results

• While Ontario’s population increased by 5% the populations of Thunder Bay District and the Municipality of Greenstone decreased by approximately 2% and 4%, respectively (between 2006 to 2011).

• Available population projections indicate that the Municipality will continue to see population decline through to 2023 (with an estimated population of 4,618 residents in 2018 and 4,480 residents in 2023)
Socio-Economics – Demographic Results Cont.

• Compared to the province as a whole, the Thunder Bay District and Greenstone had a smaller proportion of university graduates in 2011 (23.4%, 16.1 % and 9.6% respectively).

• The median age of the population was 43.1 years, (an increase of 3.3 years since 2006). The median age for Greenstone was comparable to that recorded for the Thunder Bay District (43.8 years), but notably higher than the median age of the province as a whole (40.4 years) in 2011.
Socio-Economics – Economy Results

• Mineral exploration and mining has been identified by the Greenstone Economic Development Corporation (GEDC) as a key component of anticipated economic growth in Greenstone.

• Mining is a key component of the economy in northwestern Ontario with over 80 exploration projects during 2012 (decreased in 2013/2014).

• As of 2014, there were 4 active mines and a quarry operation in the northwest Ontario region (located outside of Greenstone). - Closest active mine is Hemlo Gold Mine (approx 132 km from proposed Hardrock Project).
Socio-Economics – Economy Results Cont.

• A shortage of skilled workers for mining projects expected in Thunder Bay District, due to a lack of younger people with appropriate skills coming into the regional labour market.

• The unemployment rate for Greenstone was 13 % in 2011.

• The Aboriginal workforce in Greenstone, which totaled 505 people, had lower participation (59.4 percent compared to 64.2 percent for the total municipal labour force) and higher unemployment (21.8 percent compared to 13.0 percent).
Socio-Economics – Community Services and Infrastructure Results

• Some municipal services and infrastructure have been reported to be at or near capacity, (such as the solid waste facilities).

• Greenstone is designated as an underserviced area by the Ministry of Health and Long-term Care.

• Surplus of housing identified in some communities in Greenstone (in Longlac, it was estimated that roughly 150 of the 500 homes were vacant).
Socio-Economics – Community Services and Infrastructure Results Cont.

• Some underdeveloped, designated residential areas, which may accommodate larger-scale future growth in the Project vicinity, including in Beardmore, Longlac, Nakina, and Geraldton (Municipality of Greenstone Official Plan, pending approval)

• The proposed Project is located relatively close to existing municipal and provincial services: water/wastewater, transportation network, power, emergency services
Socio-Economics – Land and Resource Use Results

• The PDA is located in the Ward of Geraldton. Key land and resource use features in the PDA include:
  • Kenogamisis Golf Club;
  • Headframe;
  • Interpretive Center;
  • Highway 11 and Michael Power Boulevard;
  • Gas station
  • Barton Bay Wildlife Trail;
  • snowmobile trails; and
  • powerlines and a transformer substation owned by Hydro One Networks Inc.
Socio-Economics – Land and Resource Use Results

• Land and resource use areas near the PDA include:
  • MacLeod Provincial Park:
  • OPP station;
  • crown land campsite;
  • snowmobile trails;
  • canoe routes;
  • planned forest harvest areas and forest access roads; and
  • trapline, bear management and bait harvesting areas.
Next Steps

• Environmental Assessment:
  • Assess potential effects on labour and economy, capacity of community services and infrastructure, land and resource use and traditional land and resource use.
Geochemistry
Geochemistry - Objectives

- Evaluate the acid rock drainage (ARD) and metal leaching (ML) potential of ore, waste rock, overburden and tailings materials that will be generated by the Project.
- Determine parameters that may potentially exceed environmental thresholds.
- To provide data for use in the EA
Geochemistry - Methods

• Over 500 samples of ore, waste rock, overburden and tailings collected and tested for:
  • Acid-Base Accounting (ABA); Shake Flask Extraction (SFE); and Total Metals.
• An additional ~8,000 samples were analyzed for total sulphur, total carbon and trace element concentrations for material classification in the block model
• Metallurgical testing was completed on composite samples of ore for process optimization and tailings characterization.
• Metallurgical testing of historic tailings.
Historic Tailings and Monitoring Locations
Overburden – Results

• Classified as non-Potentially Acid Generating (non-PAG) material.

• Leachate quality from the kinetic tests is compliant with Metal Mining Effluent Regulations (MMER) limits.

• Concentrations of arsenic and potentially cobalt and copper may potentially exceed Provincial Water Quality Objectives (PWQO) due to natural background soil and rock properties and/or historical mining impacts.
Waste Rock – Results

- Waste rock is predominantly non-PAG with less than 4.0 wt.% identified as PAG.
- For PAG waste rock, on-set time for generation of acidic conditions is greater than 15 years.
- Relatively low percentage of PAG rock and the long ARD on-set time provide management flexibility.
- Kinetic tests indicate that leachate will be compliant with MMER limits.
- Concentrations of arsenic, antimony, aluminum, iron, cobalt, uranium, chromium, and lead may potentially exceed the PWQO.
Ore and Future Tailings – Results

• Ore and tailings may contain 9.7% of PAG material.
• Cyanide destruction results were evaluated and considered cyanide objectives, ammonia generation, and metal concentrations. Optimization is on-going.
• Concentrations of metals and total cyanide in the Tailings Management Facility (TMF) pond are expected to comply with MMER limits.
• Ammonia, cobalt, copper, arsenic, antimony, silver, and free cyanide were identified as parameters that may potentially exceeding the PWQO from cyanide destruction testing.
• Leachate from tailings humidity cells exceeded the PWQO for arsenic
Historic Tailings – Results

• MacLeod and Hardrock historical tailings have low ARD potential
• Groundwater within historic tailings exceeds MMER limits for arsenic, nickel, and zinc, with the highest values in the PAG material associated with the Hardrock Tailings.
• Improvements in runoff and groundwater quality are expected following partial removal of historic tailings in open pit footprint.
Next Steps

• The leaching potential of waste rock will be quantified with the water quality model to inform water management planning.

• Modeling of TMF water quality will indicate if any mitigation is required at closure.

• The effects of the remaining historical tailings will be considered going forward in the water quality modeling for the EA.

• Field kinetic testing will continue through 2015 (Year 2).

• Monitoring program will be developed to verify model results.
Metal Bioavailability
Bioavailability - Context

• Runoff and seepage from historical tailings enter Barton Bay (McLeod and Long Lac Tailings) and the Central Basin (Hardrock Tailings) of Kenogamisis Lake.

• Elevated metal levels in water and sediment (arsenic, copper, and iron).

• Arsenic does not exceed the provincial objective (100 µg/L) but it exceeded the federal and Interim provincial guideline (5 µg/L) in Barton Bay (100%, 5.9 to 93.2 µg/L) and Central Basin (86%, 3.3 to 41.8 µg/L), Southwest Arm (8%, 0.5 to 6.4 µg/L)

• Arsenic is above the federal probable (PEL) and provincial severe effect level (SEL) in sediments in Barton Bay and Central Basin.
Bioavailability - Objectives

• Assess whether existing elevated metals in surface water and sediment are biologically available.

• Determine whether or not metals are causing adverse effects on resident aquatic organisms.

• Provide site specific inputs for the human and ecological risk assessments, as well as providing additional information for the aquatic effects assessment.
Bioavailability Study – Sampling Areas

• The study focuses on two “exposure” areas and two reference or unaffected areas, which were selected based on water and sediment quality information.

• Exposure areas in Kenogamisis Lake:
  - Barton Bay adjacent to McLeod High Tailings
  - Central Basin, adjacent to the Hardrock Tailings

• Reference or unaffected areas:
  - Southwest Arm of Kenogamisis Lake near proposed discharge location
  - Wildgoose Lake, outside of project influence
Bioavailability Sampling Locations
Methods – Sediment Quality Triad

**ENHANCED SEDIMENT QUALITY TRIAD**

**BENTHOS**
- Benthic Invertebrate Community Assessment
- Chronic Toxicity (algae, *Hyalella, Chironomus*)
- BLM results (LC50s)
- MEAN modeling

**CHEMISTRY**
- Water chemistry
- Sediment chemistry
- Speciation modeling

**BIOACCUMULATION**
- Fish Tissue
- Wild and Lab Exposed Benthos

**TOXICITY**

*Laboratory Testing*
Bioavailability Study - Methods

Comprehensive and innovative approach including lab and field based lines of evidence.

Field studies:
• Phytoplankton chlorophyll *a* assessment
• Benthic invertebrate community assessment
• Bioaccumulation of metals in fish and wild invertebrates (*Hyalella*)
• Water quality modeling (toxicity and speciation)

Lab studies:
• Sediment toxicity testing using *Hyalella* and Chironomus.
• Water only toxicity testing using *Hyalella* and algae (the most sensitive species to arsenic)
Field Collections

Wild *Hyalella* Collections

Walleye Collections

Spottail Shiner
Bioavailability Study – Fish Methods

• Spottail Shiners collected from all bioavailability assessment areas. Whole fish analyzed for metals, mercury and methyl mercury. Small bodied fish are more representative of localized conditions and available all areas.

• Analysis of 20 Walleye from Kenogamisis Lake and 20 from Wildgoose Lake reference for:
  • Morphometrics (size, weight, age relationships)
  • total metals, mercury, methyl mercury (gonads, muscle, liver);
  • arsenic speciation in muscle tissue (subset of 12 fish/area); and
  • contaminant uptake history in 10 Walleye otoliths (8 exposure, 3 reference).

Walleye are an important sport fish and abundant, integrate the whole lake.
Chemistry Results

- Arsenic is the main metal present at levels higher than the water and sediment quality guidelines
- Some copper and iron levels also exceed water quality guidelines
- Biotic ligand modeling show extremely low levels of free copper, therefore very low potential for toxicity
- Arsenic in sediment exceeds provincial severe effects level and federal probable effects level in Barton Bay and Central Basin
- Iron also exceeds severe effect level in Barton Bay
Toxicity Results

No toxicity or adverse effects were evident based on laboratory toxicity tests or field based studies.

• No evidence of effect on phytoplankton (chlorophyll a)
• No evidence of adverse effects on benthic communities
• No evidence of chronic toxicity (growth or survival) with alga (*Pseudokirchneriella subcapitata*) based on lab tests with site water from each area
• No evidence of chronic toxicity (growth or survival) to water (*Hyalella azteca*) or sediment dwelling (*Chironomus dilutus*) invertebrates, 14 day tests using site water and sediment
Bioaccumulation Results - Invertebrates

- Wild *Hyalella azteca* – arsenic accumulates above the lethal body concentration at 25% mortality (LBC25) but organisms are still common in the wild
- Sediment Toxicity Tests with *Hyalella azteca* – arsenic above LBC25 but no toxicity observed
- Water Only Toxicity Tests with *Hyalella azteca* - no exceedence of LBC25 or toxicity, hence metals taken up primarily from the sediment
- For *Hyalella* in the wild and in toxicity tests, the actual survival was always better than predicted survival
- Metals accumulate to predicted lethal levels but no impaired survival or growth observed
Arsenic Bioaccumulation Results - Fish

- Arsenic in tissue of small bodied fish (Spottail Shiner) significantly higher (p<0.05) in Barton Bay and Central Basin
- Arsenic in muscle of large bodied sportfish (Walleye) significantly higher in Kenogamisis Lake
- Most arsenic in Walleye muscle is not in a toxicologically active form (presented as arsenobetaine)
- No significant effects on abundance, condition or growth of Walleye
- Analysis of arsenic in otoliths did not show trend of increasing arsenic over time
Mercury Bioaccumulation Results - Fish

• No significant differences in mercury or methylmercury in Spottail Shiners between all areas sampled - mercury accumulation does not relate to historical tailings

• Some exceedences of human consumption guidelines but at concentrations typical of northern Ontario

[MOECC, 2012 - partial restriction guideline (0.26 mg/kg) or the total restriction guideline for women of childbearing age and children under 15 (0.52 mg/kg)].
Bioavailability Study - Conclusion

• Elevated arsenic and other metals led to bioaccumulation but no observed adverse effects on phytoplankton, benthic invertebrates or fish studied.

• Results indicate that water and sediment guideline exceedances alone are not sufficient to indicate adverse effects, likely due to the conservatism incorporated into guideline development.
Next Steps

• The data generated as part of this study will be used in the assessment of effects on fish due to changes in water quality.

• Toxicity and bioaccumulation data will be used to provide site specific data for the human and ecological risk assessments.