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CAMECO ENGINEERED TAILINGS PROGRAM: LINKING RESEARCH WITH INDUSTRIAL PROCESSES FOR IMPROVED TAILINGS PERFORMANCE

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INTRODUCTORY STATEMENT

The waste product from uranium mining and milling that generates the greatest public and regulatory concern is tailings. The tailings contain all of the mined material except uranium plus a host of processing reagents. These minerals and compounds have the potential to harm the local environment if not deposited in a fashion that is both geochemically and geotechnically stable. Environmental leadership impels Cameco Corporation to ensure that the methods used to dispose of tailings are at the forefront of best available technologies whereby tailings production results in a product with geotechnical and geochemical characteristics that minimize the environmental impact associated with long-term storage of this product.

Cameco has developed an Engineered Tailings (ET) program to ensure optimization of long-term tailings performance and minimal impacts of elements of concern (EOCs) to the receiving environment, regardless of the ore being milled. Within this program chemical and physical performance of tailings from geochemical and geotechnical investigations and baseline environmental data, integrated with regulatory requirements and corporate commitments, will be used to evaluate and set criteria for mill- and tailings management facilities-based chemical and physical tailings characteristics, identify key knowledge gaps, prioritize areas of concern and implement appropriate responses. This paper provides an overview of the Engineered Tailings program, the research being conducted as part of the ET program, and how it links with present and future Cameco operations.

OVERVIEW

Mine tailings at Cameco's operations are the by-product of milling of uranium ores having highly variable concentrations of uranium and associated EOCs including As, Cu, Co, Mo, Ni, Ra-226, U, Se, and rare-earth elements. The mine tailings slurry is disposed in engineered Tailings Management Facilities (TMF) designed to minimize the transport of tailings pore water and associated EOCs to the local groundwater. Ideally, the tailings slurry should have low hydraulic conductivity (K), minimal particle segregation, and good consolidation and low porewater concentrations of EOCs in both the short- and long- term. Within the milling environment these constraints present a significant challenge. For example, the concentrations of EOCs in uranium ore may vary by one to two orders of magnitude, while variations in grade and mineral assemblage will affect the K and consolidation behaviour.

Over the past two decades, Cameco has been pursuing a holistically-based research program to demonstrate the long-term stability of tailings produced at their northern operations. These studies encompass investigations into geochemical, geotechnical and micro-biological aspects of the tailings mass and link it to mill based processes (Figure 1). A similar approach has been taken by AREVA Canada Resource Inc through initiation of a Tailings Optimization Validation Project (TOVP) at the nearby McClean Lake Operation (COGEMA Resources, 2005).

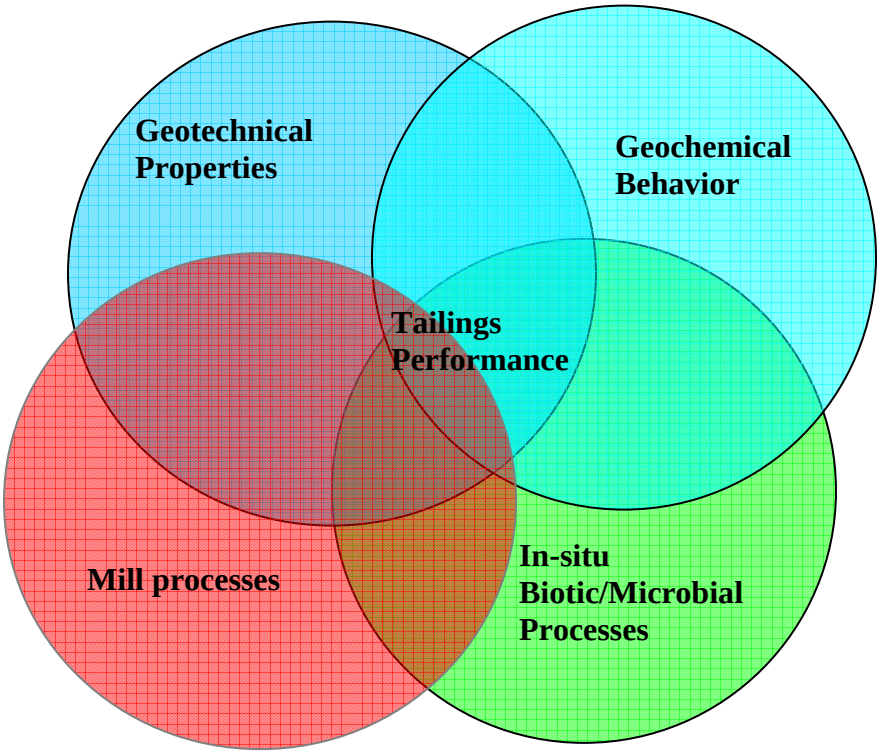

Figure 1) Graphic overview of holistic based tailings investigation program studies in the Cameco Engineered Tailings Program

Applied research on chemical and physical aspects of tailings is a cornerstone within the Cameco ET program. To date, tailings studies have primarily been linked with drilling/coring at Cameco's two TMFs, and associated bench-scale programs to investigate and understand the long-term chemical and physical stability and behaviour of tailings within the TMF and retention mechanisms for EOC, and provide initial validation of source term predictions (Table 1a). For example, the research carried out at Cameco Rabbit Lake Operations have largely demonstrated that the tailings products within the Rabbit Lake In-Pit Tailings Management Facility (RLITMF) have geochemical characteristics which ensure the long-term stability of As (V) as arsenates strongly bound to ferric oxyhydroxides. Recently, the methodologies developed from these studies have been transferred to the Cameco Key Lake Operations Deilmann Tailings Management Facility (DTMF), as well as several new methods. These methods have been used to address both short- and long-term geochemical issues within current and future tailings

operations (Table 1b). Some of the ongoing and planned geochemical research at the DTMF is identified in Table 1c.

Table 1. Summary of past, on-going and proposed research at Cameco Tailings Facilities

(a) Past Geochemistry and Microbiology at the Rabbit Lake TMF, Rabbit Lake.

Topical area	**Reference(s)**
In-pit geochemical controls on arsenic	Pichler et al. (2001), Donahue et al. (2000), Donahue and Hendry (2003), Moldovan et al. (2003, 2007)
In-mill geochemical controls on arsenic solubility	Moldovan and Hendry (2005)
In-pit microbiology	Wolfaardt et al. (2008)
Colloidal transport of elements	Hollings et al. (1999)
	Ranville et al. (2007)

(b) Past Geochemistry at the Deilmann TMF, Key Lake.

Topical area	**Reference(s)**
In-pit geochemical controls on As, Se, Mo	Shaw et al. (2010a)
Speciation of molybdenum in tailings	Essilfie-Dughan et al. (2010a)
Microscale geochemical controls on As, Ni, and Fe	Essilfie-Dughan et al. (2010c)
Arsenic and iron speciation in tailings	Essilfie-Dughan et al. (2010b)
Controls on Ra-226 in tailings	Liu et al. (2010)
Controls on crystallization of ferrrihydrite	Das et al. (2010 a and b)
	Das and Hendry (2010a)
Reductive dissolution of ferrihydrite	Shaw et al. (2010b)

(c) Current and Future Geochemistry at the Deilmann TMF, Key Lake

Topical area	**Reference(s)**
Speciation of nickel, selenium in tailings	Essilfie-Dughan et al.(2011a and b)
Controls on crystallization of ferrrihydrite	Das and Hendry (2011)
Controls of calcium-arsenic minerals on arsenic in tailings	Studies have been initiated
Impact of environmental gradients at interfaces on speciation	Studies to commence in 2011
Mineralogical controls dictated by mill processing	Studies to commence in 2011
Define alternate mill processes to optimize the geochemical stability of tailings.	Studies to commence in 2011
Evaluate geotechnical properties of current/future tailings	Studies have been initiated

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SUBJECT KEY WORDS: tailings, geochemical, geotechnical micro-biological, engineered tailings, Cameco, tailings management facilities