Appendix B
Geotechnical Investigation Results and Design Calculations
for Evaporation Pond Removal Action

Design Objective

The evaporation pond removal action at the Yerington Mine Site includes the placement of vat leach tailings (VLT) as cover materials on the Thumb Pond and Sub-Area A (a small portion of the Sulfide Tailings Area). Per the SOW for the Thumb Pond and Sub-Area A is to mitigate the potential for fugitive dust. The geotechnical testing program required for the basis of design utilized the following consultant to characterize the Sub Area-A sulfide tailings materials, as described below:

Black Eagle Consulting (Appendix A):

- Measure VLT material homogeneity through gradation, plasticity index, and Modified and Standard Proctor testing;
- Estimate field moisture/density placement conditions of VLT materials; and
- Estimate tailings pond sediment strengths in the historically-saturated areas of the LEP and Sub-Area A, and conduct strength assessment of the UEP.

The Thumb Pond cover materials were not tested as this area was subject to a previous removal action which covered the area with VLT material.

Geotechnical Design Elements (Shear Strength Assessment)

The installation of cover materials on Sub-Area A requires consideration of shear strength and sediment thickness to develop the basis of design. The tailings typically exhibit the following geotechnical characteristics: low density, relatively low-to-high moisture contents and low shear strength. Pond tailings with greater than 50 percent solids content and a Torvane Shear strength greater than 5 kiloNewtons per meter kN/m^2 (0.745 psi) will exhibit a slow pore water pressure dissipation rate, but will typically behave in accordance with the theory of soil mechanics (Jakubick, 1999).

The cover designs are based on testing the moisture content, density and shear strength parameters, then implementing techniques which have been researched and historically successful in gaining access on to similar soft materials. A summary of these applicable methodologies is presented in the technical paper "Stabilisation of Tailings Deposits: International Experience" Alex. T. Jakubick, WISMUT GmbH, Chemnitz, Germany, Gord McKenna, Syncrude Canada Ltd., Fort McMurray, Canada, Andy MacG. Robertson, Robertson GeoConsultants Inc., Vancouver, Canada, Sudbury 2003." The cover placement methods described in Jakubick et. al. (2003) are discussed below.

A Torvane shear assessment program was completed for Sub Area A on the fine-grained tailings (given that the Thumb Pond was previously covered with VLT materials, no such testing was performed). Field testing of Sub-Area A used a nuclear gauge to measure in situ moisture and density, a Torvane shear instrument to measure mobilized shear strength and a probe to determine sediment thickness. The geotechnical testing program and results, provided in Appendix A, were accomplished as saturated areas within Sub-Area A became accessible due to evaporation during the summer months of 2009. Depth probing was supplemental to previous data collected from the UEP and LEP as part of the removal action characterization program. Torvane shear tests and thickness measurements were plotted on plan sheets and contoured to provide the spatial distribution of these parameters, as shown in Appendix C on Drawing Numbers: 138555-C-020 (Sub- Area A).

The field testing program determined that the order of test importance for influencing the cover designs (in descending order of relative importance) were: measured thickness, shear strength, moisture content, and density. Sub-Area A tailings thickness measurements averaged greater than 1-foot thick. Shear test results were more relevant for this area in influencing design parameters. The moisture density tests were used qualitatively to validate the shear test results (i.e. low density, high moisture should return a relatively low shear vane value).

Key design elements for cover placement from Jakubick et. al. (2003) include terminology, reclamation methods, critical bearing pressure, capping method limits and trafficability. These are presented in Figure B-1, modified from Jakubick et. al. (2003), and summarized below:

Pond Sediments or tailings may be classified into the following four categories, based on shear strength:

- *Fluid* - at or below the material's liquid limit and can not sustain any shear force, access would require floatation type equipment.
- *Very Soft* – slightly above the material liquid limit and to approximately 12 kilopascal (kPa or 1.7 pounds per square inch (psi)). This soil is marginally solid typically requiring intensive ground improvements for access with to low ground pressure tracked equipment.
- *Soft* – material with shear values above 12 kPa to 100 kPa (10.45 psi), which will permit heavier tracked equipment, light rubber-tired vehicles (pick-up trucks) and lighter rubber-tired haul trucks.
- *Hard* – material above 100 kPa that allows heavy rubber-tired haulage equipment and direct end-dumping cover materials.

Construction (i.e., reclamation) methods consider the geotechnical properties of the material with respect to shear strength (e.g., water capping applicable for materials under their liquid limits, soft ground strategies for material between the liquid limit and 100 kPa (10.45 psi), and normal terrestrial reclamation for shear strength above 100 kPa). Applicable parameters for the evaporation ponds and Sub-Area A are soft ground and normal terrestrial strategies. The soft ground strategies include thin layer placement, geosynthetic reinforcement and conveying or pushing material over the tailings. Normal ground strategies are conventional rubber tired earth moving equipment. Water capping is not applicable to the evaporation ponds removal action.

The critical bearing pressure is the approximate pressure that would result in failure and displacement of pond sediments or tailings resulting from cover placement and/or construction surcharge loads. This pressure provides guidance for the type of equipment, cover thickness, and rate of placement (i.e., end-dumping versus dozer conveyance). For example, the placement of the removal action cover over pond sediments or tailings with a 100 kPa (14.5 psi) shear value could use heavier equipment and faster placement rates compared to pond sediments or tailings with a 10 kPa (1.45 psi) shear value.

Capping (i.e., cover) method limits for the removal action will be based on shear strength. This parameter indicates limits where intensive ground improvements are required to gain access (e.g., geosynthetic reinforcement, thin lifts, pre-consolidation and fluid management). 'Conveying' is pushing cover material out over the pond sediments or tailings at a controlled thickness and rate. 'End-dumping' can be used in areas where the tailings materials are strong enough to withstand cover material being vertically dropped without displacing or failing.

Trafficability is a design element defined by the shear testing (e.g., what type of construction equipment can be used on the range of Pond sediment and tailings). The most important values for trafficability include the following approximate values:

- below 9 kPa (1.3 psi) is inaccessible to light ground pressure (LGP) tracked equipment e.g. D-3 dozer);
- above 5 kPa (5.1 psi) access possible with light rubber-tired equipment (e.g. pick-up truck, 35 psi tire pressure); and
- above 75 kPa (10.9 psi) lower limit of potential access with heavy rubber-tired equipment (e.g. 618 scraper, 80 psi tire pressure).

The trafficability values listed above represent approximate lower limits. During the cover placement, the contractor will be required to verify these limits and will need to be aware of locally changing conditions during construction. Figure B-1 provides the basis for applying these design elements to Sub-Area A, as described below.

Sub Area A: The Torvane shear test results for the shaded area of Figure B-2 indicate the sediments are very soft and average approximately one-foot thick. This area will require intensive ground improvements including bi-axial geo-grid in conjunction with locally thicker cover sections (i.e., 18 to 30 inches, respectively, depending on whether tracked or rubber-tired equipment is used) to build a stable base for equipment access. The construction effort for Sub-Area A should begin after sufficient natural evaporation to allow for the development of a dried surface and to avoid potential de-watering activities.

An area of geo grid would be used to create an initial siding for rubber-tired equipment off loading. Subsequently, tracked equipment would push the cover materials out over unreinforced sediments in 18-inch or greater lifts. Compaction performance criteria would be confined to the geo grid-reinforced areas and the top 3 to 6 inches of the cover. Compaction of the cover below this depth is undesirable, due to lack of a dense subgrade and the potential to displace the underlying saturated tailings.

Thumb Pond: No testing was completed in this area since it has previously been stabilized, and covered with VLT material using rubber-tired construction equipment.

References

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