STATE OF NEW MEXICO
BEFORE THE WATER QUALITY CONTROL COMMISSION

In the Matter of:	)	
	)	
PROPOSED AMENDMENT TO 20.6.2 NMAC (Copper Rule)	)	**No. WQCC 12-01(R)**

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Geotechnical evaluations for tailings impoundments

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SYNOPSIS

The design, operation and reclamation of tailings impoundments require a knowledge of the geotechnical characteristics of the site and impoundment materials. This paper describes the general considerations and approaches involved in geotechnical investigations for tailings impoundments. Five case histories of geotechnical investigations for tailings impoundments are described to illustrate the approaches and methods discussed. The case histories vary from studies of tailings discharged into model ponds from a pilot plant (to predict full scale tailings behaviour) to site investigations in areas covered by alluvial clays and collapsing sands.

INTRODUCTION

Tailings impoundments are argueably the largest structures built by man. They are primarily geotechnical structures; built on soils and rocks, with soil and rock materials to contain ground-up rock that behaves essentially as a soil. The mining engineer, the mill manager and the geotechnical engineer all play a part in the safe design, economic operation and effective reclamation of a tailings impoundment. For this reason a broad understanding of the geotechnical nature and requirements of the foundations, earthworks and tailings is an essential requirement for the proper functioning of a tailings impoundment.

This paper sets out the elements of geotechnical evaluations required to design, construct, operate and reclaim tailings impoundments. Case histories are described in order to illustrate the principles discussed.

GEOTECHNICAL REQUIREMENTS

Geotechnical evaluations for tailings impoundments may be divided into the work required to characterize:

- the in situ foundation soils, rock and groundwater.
- the construction materials for embankment starter dykes and filter drains.
- the tailings.

Table 1 lists the geotechnical characteristics of the site, construction materials and tailings, which will most likely be used in the design, construction, operation and closure of a tailings impoundment. This information is required in order to perform at least those geotechnical analyses and evaluations listed in Table 2.

The tables referenced above are an attempt to define which geotechnical parameters are required and why they are used in tailings impoundment geotechnical evaluations. A general philosophy of approach might be that the designer or operater of a tailings impoundment must have a feel for the materials on which, of which, and for which the structure will be built. Quantifying the parameters in the list is only a part of the engineering synthesis that constitutes getting a feel for a tailings impoundment.

The geotechnical characteristics must be quantified in order to carry out calculations. The strength of the various materials must be defined in order to calculate the factor of safety or probability of failure of the embankment. Permeability must be measured to calculate the quantity of seepage from the impoundment, and hence to determine if this is acceptable. Consolidation properties must be known to allow an acceptable rate of rise for the impoundment to be calculated.

SITE CHARACTERISATION

In order to design a tailings impoundment, the geotechnical characteristics of the

TABLE 1 : SITE & MATERIALS GEOTECHNICAL CHARACTERIZATION

PARAMETER	USE
Site Materials	
1 Soils	
- Distribution	Impoundment Layout
Depth	Layout, Stability Analyses
In Situ Description (MCCSSO)	Identification and Evaluation
- In Situ Density	Definition of Strength
- In Situ Permeability	Seepage Analyses
- In Situ Strength	Stability and Settlement
- Moduli	Seismic Stability
- Grading Curve	Identification and Evaluation
- Plasticity	Identification and Evaluation
- Permeability	Seepage Analyses
- Strength: Undrained	Stability Analyses - Short term
- Effective Strength: c' ∅	Stability Analyses - Long term
- Consolidation	Settlement and Strength
- Chemical	Contaminant Mitigation
2 Rocks	
- Distribution	Layout Definition
- Depth	Layout Definition
- Core Descriptions	Indentification and Evaluation
- In Situ Permeability	Seepage
- Jointing and Fracturing	Seepage and Stability
- Bedrock Acceleration, Velocity, Displacement	Seismic Stability
3 Groundwater	
-Distribution	Layout Definition
- Depth	Layout Definition
- Quality	Identification and Evaluation
Construction Materials	
4 Soils	
- Grading, Plasticity	Identification and Evaluation
- Permeability	Seepage
- Compaction Characteristics	Construction Specifications
- Strength	Stability
- Durability	Long-Term Behavior
- Chemical Characteristics	Contaminant Control
5 Tailings	
- Grading	Identification and Evaluation
- Permeability	Seepage Analyses
- Strength: Static	Stability Analyses
- Strength: Dynamic	Stability Analyses
- Consolidation	Settlement and Strength Increase
- Beaching Angle	Impoundment Geometry
- Deposited Density	Impoundment Volume
- Deposited Moisture Content	Water Balance Studies
- Chemical Characteristics	Contamination Potential
6 Slurry	
- Slurry Density	Water Content, Depositional Characteristics
- Slurry Supply Rate	Impoundment Size, Rates of Rise, Distribution Facilities
7 Mill	
- Supply Rate	Impoundment Size
- Rock Type	Tailings Definition
- Grinding Process	Containment Potential
- Chemical Process	Post Deposition Behaviour