Technical Memorandum

To: Ed McDonald

Cc:

From: Ana Mohseni

Project No: 320614-200-40

Subject: **PWTS Pond- Stability and Seepage Analyses**

Date: May 10, 2007

1.0 Introduction

This memo presents the results of seepage and slope stability analyses of the proposed Process Water Tailings Storage (PWTS) pond at the Rosemont Mine in Arizona. The attached sections show the generalized facility geometry used for this analysis and are based on the PWTS pond maximum section. The generalized section assumes a natural ground slope of seven percent. The embankment fill is proposed to be built mainly of arkose waste rock with a 15-foot wide layer of select fill underneath the liner on the upstream face, and prepared subgrade under the liner in the impoundment area.

2.0 Design Criteria

Design of the PWTS pond is governed by the requirements of the Arizona Division of Water Resources (ADWR) Title 12, Chapter 15, and the Arizona Department of Environmental Quality (ADEQ) BADCT, adjusted for site-specific conditions. Based on these requirements, the minimum stability criteria adopted for the pond are presented in Table 1. Further information on the dam's classification as it relates to ADWR requirements can be found in a separate memorandum.

Table 1. Minimum Stability Requirements

Analysis Condition	Required Minimum Factor of Safety
Static	1.50
Pseudostatic	1.10

The site seismicity was analyzed for two levels of ground motion: the maximum probable earthquake (MPE) and the maximum credible earthquake (MCE). These values are 0.036g for the MPE and 0.326g for the MCE. Applicable regulations require that the MCE ground motion is applied to analysis of the PWTS pond.

Due to the construction of a sedimentation dam below the PWTS pond, the foundation for the dam may occasionally become saturated up to elevation 4900 feet starting in year 13 of the mine life. This saturation was taken into account in the analyses.

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3.0 Methods

The stability and seepage analyses were performed using the Slope/W and Seep/W components of GeoStudio 2004 (Version 6.20) by Geo-Slope International, Ltd. Slope/W was used to conduct limiting equilibrium analyses using the general limit equilibrium (GLE) method, which satisfies both force and moment equilibrium. This program incorporates search routines to determine the critical, lowest factor-of-safety failure surface. Slope/W was used to conduct analyses of slope stability considering global (rotational) stability of the embankment. Seep/W was used to conduct steady state analyses of the seepage through the PWTS Pond. The Seep/W results were used as the pore water pressure for the Slope/W analyses.

For the seepage analyses, the geomembrane liner was not considered. The GCL was modeled as a thin layer on the upstream side of the impoundment. A vertical flux section was drawn crossing the pond through the middle of the crest in order to estimate the total unit seepage through the dam. Infinite elements were applied to the left boundary to simulate an extended reservoir. GeoStudio sample functions for hydraulic conductivity and soil-water characteristic curves were adapted to site-specific conditions.

To evaluate the performance of the pond under seismic loading pseudo-static stability analyses were performed. The pseudo-static analyses subject the two-dimensional sliding mass to a horizontal acceleration equal to an earthquake coefficient multiplied by the acceleration of gravity. To allow for damping and attenuation of the bedrock acceleration within a slope or embankment, and to account for the rigid body pseudo-static model, the pseudo-static coefficient used in the model was a conservative estimate of horizontal ground motion of 2/3 of the MCE, or 0.217g.

Material properties for the embankment and foundation materials were determined from field and laboratory testing, published literature (for the GCL permeability), experience with similar materials, and professional judgment. Mohr-Coulomb criteria was used for the strength model of the dam materials. It should be noted that the low GCL interface strength does not affect the overall stability of the dam embankment, since the liner materials are on the surface of the upstream side of the dam and do not constitute a structural part of the dam with regards to slope stability.

Table 2. Material Properties

Material #	Description	Strength Model	Phi	Cohesion	Unit Weight	$K_{(sat)}$
			degrees	psf	pcf	ft/sec
1	Rock fill	Mohr-Coulomb	43	0	120	$3.28x10^{-4}$
2	Select fill	Mohr-Coulomb	137	2500	33	$1.64x10^{-6}$
3	GCL (interface strength for Slope analyses)	Mohr-Coulomb	11	0	95	$1.64x10^{-10}$
4	Overburden	Mohr-Coulomb	39	2000	127	$1.64x10^{-6}$
5	Weathered Bedrock	Mohr-Coulomb	40	3500	160	$4.59x10^{-8}$

4.0 Results

The seepage analysis shows a phreatic surface on top of the GCL and a unit flow of 5.56 ft^3/sec underneath the embankment at the maximum section, in the contact with the overburden material. This behavior is expected since the liner precludes any seepage through the embankment. Note that the geomembrane portion of the liner system was not included in the seepage model. Only the GCL portion of the liner was modeled.

Both the static and pseudostatic factors of safety against failure of the pond were found to be adequate for a rotational failure under both normal operating conditions and with the saturated foundation that may occasionally occur after year 13. Failure through the foundation materials does not represent a critical failure mode for the pond with the material properties used in the analysis. Table 3 shows the results of the stability analyses for the PWTS pond.

Table 3. Results of Slope Stability Analyses for the PWTS pond

Scenario	Safety Factor	
	Static	Pseudostatic (MCE)
Downstream side of Impoundment, Global Failure	2.34	1.38
Upstream side of Impoundment, Global Failure	2.95	1.78
Downstream side of Impoundment, Global Failure (with foundation saturation)	2.21	1.31
Upstream side of Impoundment, Global Failure (with foundation saturation)	2.97	1.79