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Technical Memorandum

To:	Steve Wilbur	**From:**	Amy L. Hudson, REM
Company:	Victoria Gold Corp.	**Date:**	July 24, 2012
Re:	Seepage and Draindown Evaluation of the 92 Million Tonne Eagle Gold Project Heap Leach Facility – Baseline Conditions	**Doc #:**	
CC:	Tracy Delaney, Ronson Chee, Troy Meyer (Tetra Tech), Erin Rainey (Knight Piesold)		

1.0 Introduction

This technical memorandum presents Tetra Tech's infiltration and seepage modeling of the proposed 92 million tonne heap leach facility at the Eagle Gold Project in the Yukon Territory, Canada. The purpose of this modeling was to assess the baseline seepage conditions that would likely exist during closure and post-closure periods and to estimate draindown rates during this period. Model results were also used to estimate the total amount of water and residual process solution that will have accumulated in the heap leach facility after rinsing and detoxification are completed and just prior to commencement of draindown. The modeling was completed using the VADOSE/W program, a variably saturated (unsaturated and saturated conditions) model from the GeoStudio 2007 software package (GEO-SLOPE, 2007). Modeling was performed on a cross-section through the central portion of the heap and the embankment (see Figure 1).

The baseline conditions modeled do not include a closure cover on the upper surface of the facility, and no recirculation of solution to manage flows to the treatment plant was considered. Modeling of these conditions will be presented in the Infiltration, Seepage, and Draindown Modeling Report being prepared for the Water Use License (WUL) application.

2.0 Model Construction

The conceptual model provided as Figure 2, shows the system water balance components of the heap. The system water balance components consist of precipitation (rain and snow which can accumulate on the surface of the facility), evaporation (from soil surface), runoff, infiltration, and seepage. Seepage includes continued drain-down of the residual heap solution, as well as any infiltration of precipitation. Modeling was performed to simulate the conditions during the closure and post closure period of the facility, so the water balance does not include the application of leaching solution or rinse water. The starting point of model is the first day after the completion of rinsing and includes the in-heap pond at its maximum operational level (elevation of 870 meters and volume of 133,000 cubic meters [m^3]). It is assumed for the purpose of simulating the draindown conditions that the system is free draining.

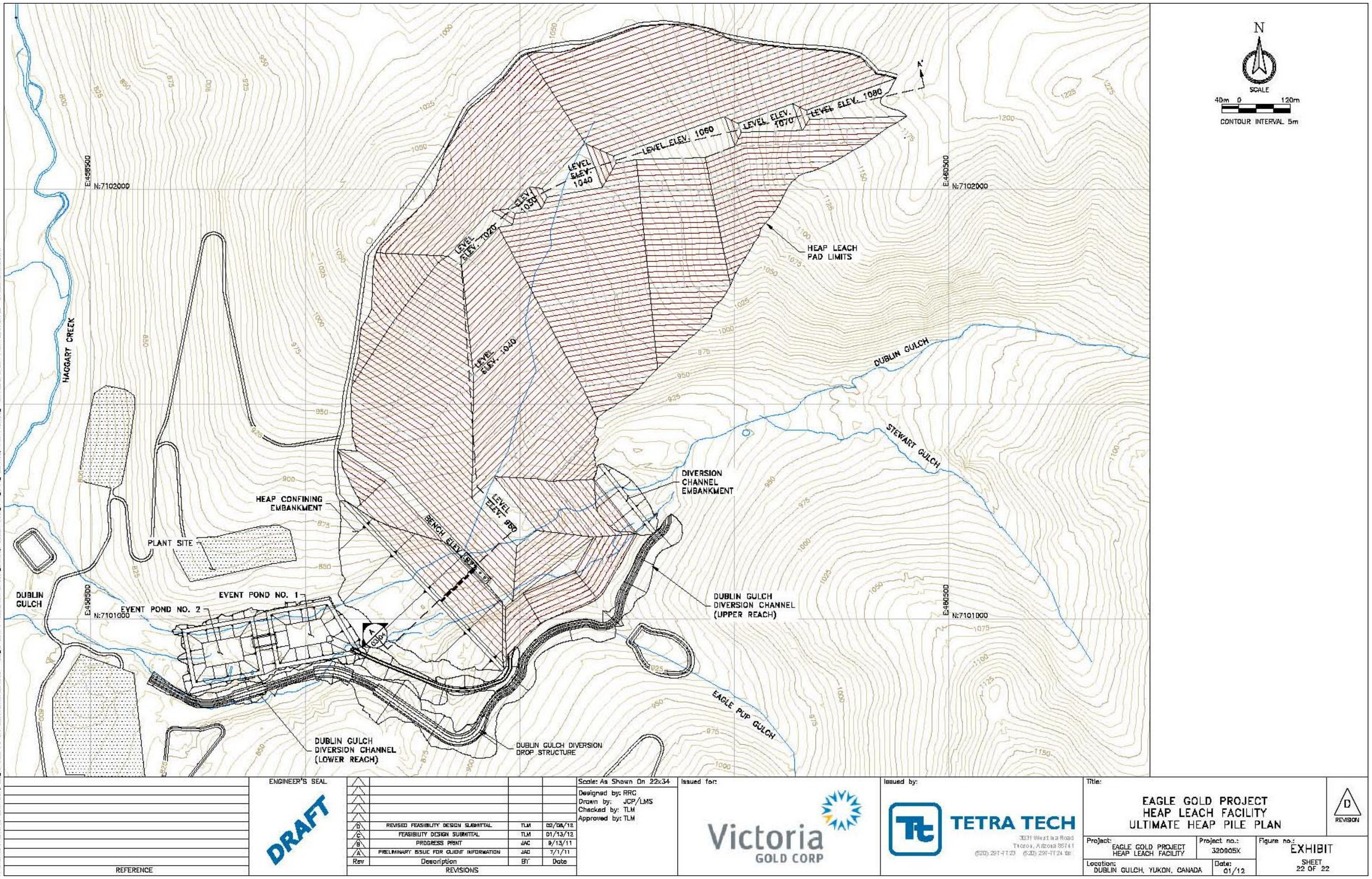


Figure 1 Heap Leach Facility Layout and Model Cross-Section

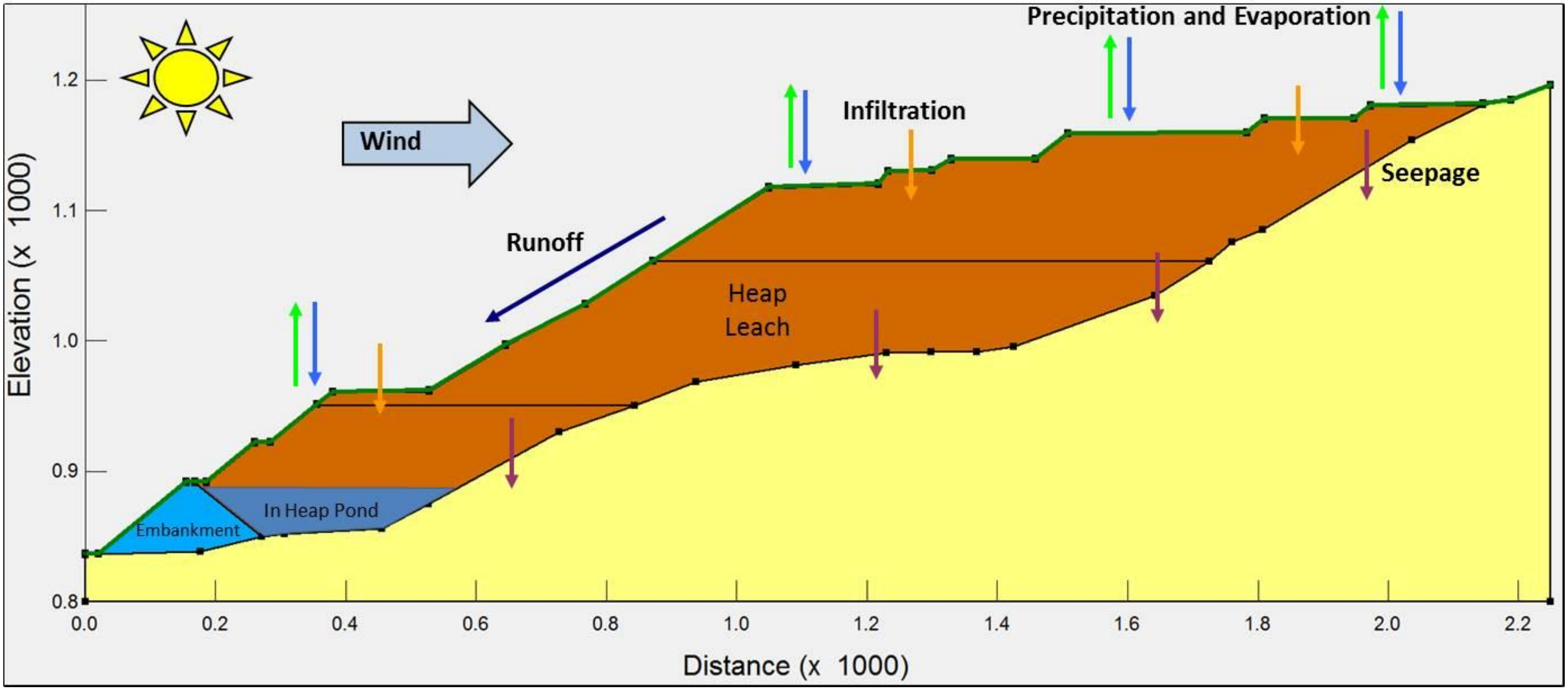


Figure 2 Heap Leach Facility Conceptual Model

2.1 Model Input Parameters

The following sections present the data that was used in the seepage assessment.

2.1.1 Climate Data

The climate data used for this modeling was obtained from the Potato Hills and the Dawson meteorological stations. The parameters in the climate data file included:

- Minimum and maximum daily temperature;
- Daily precipitation;
- Minimum and maximum daily humidity;
- Daily evaporation or net radiation; and
- Average daily wind speed.

The Potato Hills meteorological station is located approximately four kilometers from the heap. The dataset applied to the modeling utilizes the data from period of record for the meteorological station (2007 to 2011). The Dawson meteorological station is located approximately 170 kilometers from the heap and a limited amount of data was utilized to provide information to fill gaps in the precipitation record from the Potato Hills record (monthly snow measurement collection began in 2011 at this station; although spring snow survey data have been collected at Potato Hills, this type of data is not useful for input into the model). The closer Mayo meteorological station was considered but did not provide the necessary data, so the Dawson station was utilized. The climate data was used as an actual conditions file in the modeling so the daily measured data from the station was used to make a ten year continuous data set that represents the site conditions and would provide a long term scenario to minimize the “noise” in the model results and to allow the draindown to reach a near steady state condition. Each year selected for use in the ten year file had a generally average amount of precipitation. The average site precipitation was determined from a regression equation presented in the Surface Water Balance Model Report (Stantec, 2011):

y = (0.173x + 203) site adjustment factor

Where: y = average annual precipitation (mm)

x = median basin elevation (m)

site adjustment factor = 1.4

Using the mean elevation of the heap (1027 meters), the average site precipitation is 533 millimeters (mm).

2.1.2 Material Properties

The most significant difference between saturated and unsaturated flow is the hydraulic conductivity. The hydraulic conductivity in saturated media is a function of the material type. In unsaturated flow, the hydraulic conductivity is a function of the material properties and the moisture content of the material. The equation used to calculate water flow within unsaturated media is:

$$q = -K(\theta)\nabla H$$

Where:

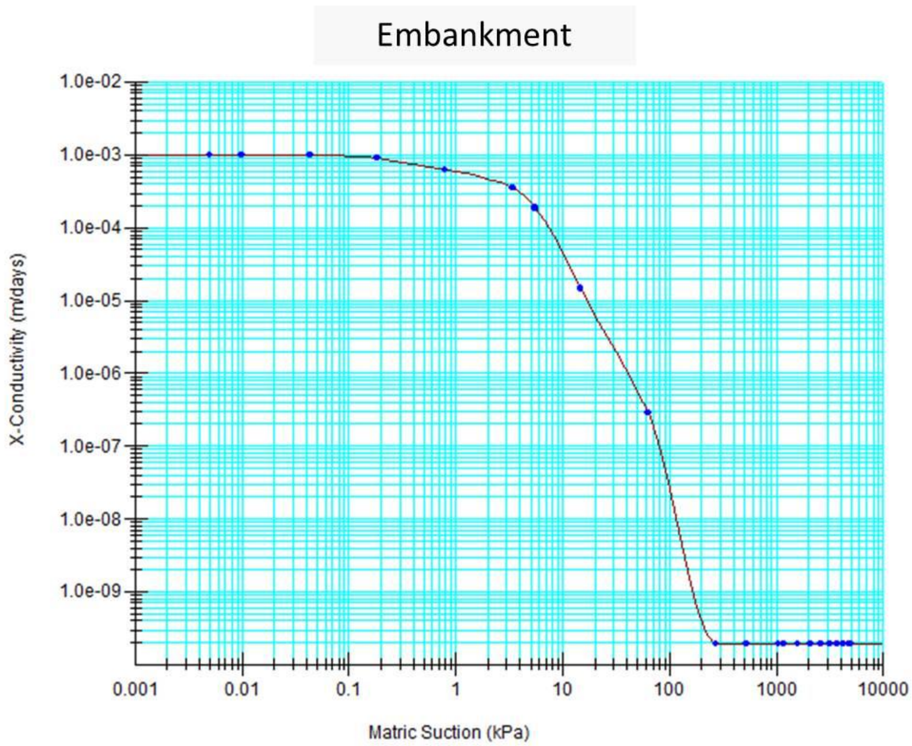
- q = water flow velocity (L^2/t)
- K(θ) = hydraulic conductivity as a function of soil (or rock) moisture content (L/t)
- ∇H = hydraulic head (L)

The relationship between moisture content and hydraulic conductivity is non-linear, which further complicates the flow dynamics. In saturated material, the physics of flow are relatively simple and are driven by Darcy's Law where the flow is proportional to the saturated hydraulic conductivity, gravity, and pressure gradients. In simple terms, water flows downhill (downward pressure gradient) and flows faster through coarse material than fine material. However, in unsaturated flow, additional controlling forces include matric pressure, absorption, and electrostatic forces.

Matric pressure is the suction created by capillary forces and the interaction of water, air, and solid surfaces. Matric pressure can be observed by placing a thin straw into a body of water. Driven by the surface tension forces, the water rises inside the straw, defying the force of gravity. The thinner the straw, the stronger the suction force will be and the higher the column of water will rise in the tube. The same process occurs in the voids between material particles in a heap.

One of the more curious properties of unsaturated zone flow is that different materials are preferentially conductive with varying moisture contents. Under high moisture conditions, pores are saturated and their suction decreases significantly. In this case, gravity is the strongest force and water will flow downhill from pore space to pore space. At low moisture conditions, the preferential flow changes, and the suction forces become stronger than gravitational forces. In this case, the tight materials are the most conductive with small voids that literally suck water through them. Under low moisture conditions, clay is more conductive than the sandy material.

The material properties used in the VADOSE/W (GEO-SLOPE, 2007) models were based on the design properties of the heap, literature values and previous experience. The embankment material was simulated as low permeability dam material (10^{-6} cm/sec), and the heap material simulated as a generally uniform material with a saturated hydraulic conductivity of approximately 10^{-2} cm/sec (well-sorted sand and gravel [Fetter, 2000]). The ore will be conventionally ground to a P80 of 6.3 mm (fine gravel) and agglomerated with cement. Figure 3 presents the hydraulic conductivity as a function of the matric suction of the heap and embankment materials. Figure 4 presents the water content as a function of the matric suction of the same materials. The units used in these figures are those utilized by the modeling software.



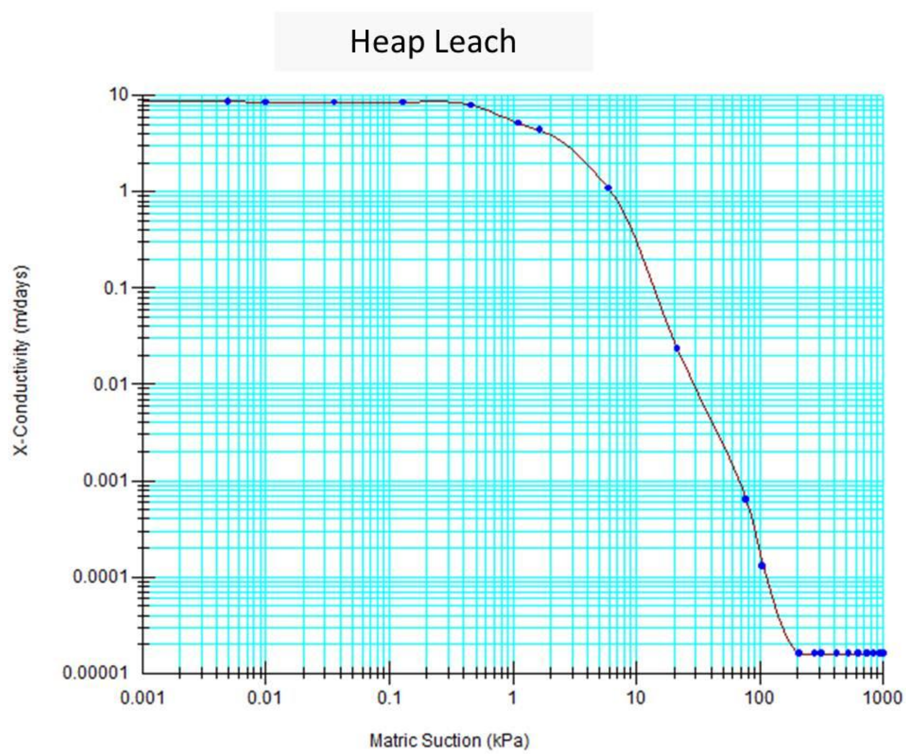
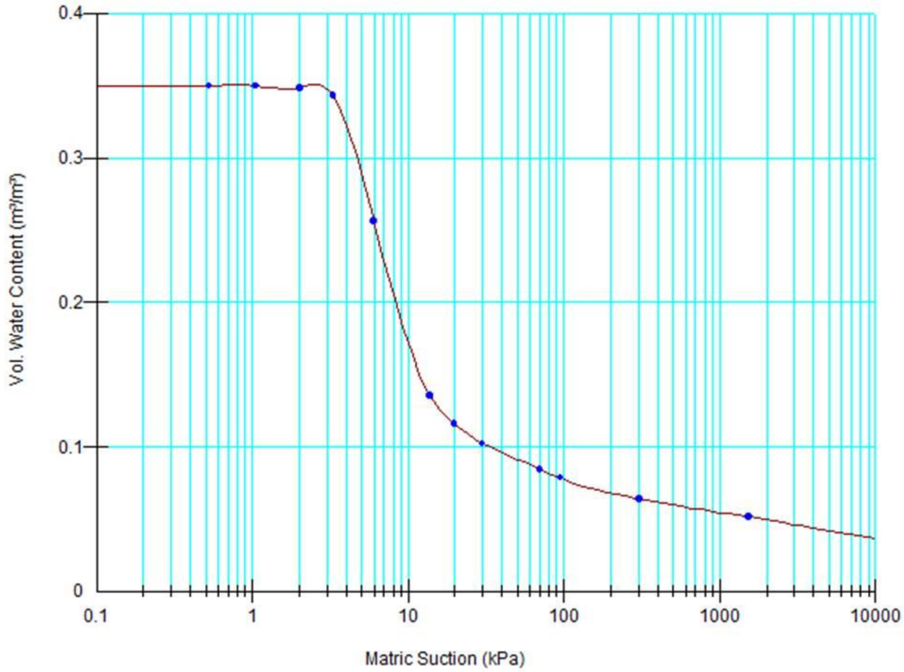


Figure 3 Hydraulic Conductivity Functions

Embankment



Heap Leach

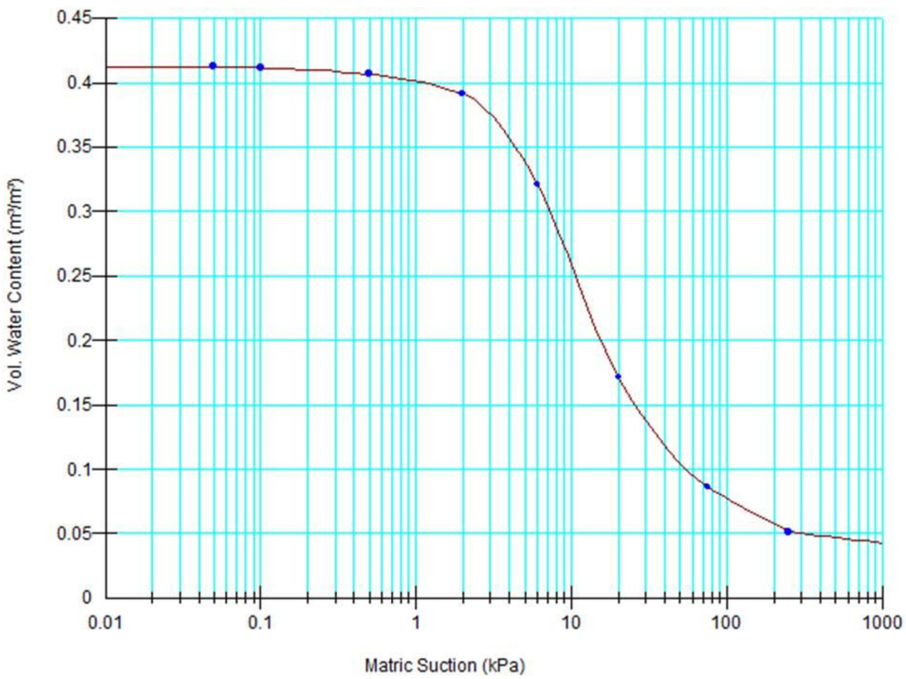


Figure 4 Soil Water Characteristic Curves

2.1.3 Boundary Conditions

The boundary conditions used in this modeling were limited to a zero pressure boundary at the base of the model to ensure the system is free draining, a unit gradient at the base of the heap to represent the drains, initial moisture addition to simulate moisture applied to the system by the emitters during the operational and rinsing phases of the heap, and the climate file. The initial moisture content of the heap leach material that had just finished leaching was defined by applying a very small source of water at the top surface of the model and allowing the model to reach a steady state condition that is representative of the operational moisture content (13.3%) of the heap material, including the in-heap pond. This is representative of one quarter of the heap at the beginning of closure. Three quarters of the heap will have completed rinsing between 150 and 450 days prior and will have an average moisture content between 5% and 10%. A climate file was used in this modeling to ensure an evaluation of the long term behavior of the heap leach material under actual climatic conditions.

2.2 Modeling Technique

2.2.1 Steady State Modeling

Steady state modeling is challenging when analyzing mining sites because the facilities change quickly. Therefore, the objective of the steady state model was to offer non-zero starting values for the subsequent transient modeling scenario and establish the water level of the in-heap pond at an elevation of 870 meters (volume of 133,000 m^3). The maximum volume of the in-heap pond is 459,349 m^3, at an elevation of 889 meters.

2.2.2 Transient Modeling

Transient modeling provides a reasonable simulation of flow conditions within the heap material. The uppermost layer of the model is a surface region representing the top surface layer of the facility. It is in this part of the model that atmospheric conditions and heap come in contact, driving the water balance. The water within the facility then moves according to the rules of unsaturated flow physics through the heap material. Finally, and if applicable, the water reaches the base of the modeled region, where it moves to the model discharge point.

2.2.2.1 Surface Layer

VADOSE/W (Geo-Slope, 2007) simulates the dynamics of the facility surface by considering climate and soil interactions. VADOSE/W (Geo-Slope, 2007) simulates precipitation using time increments with a maximum size of two (2) hours. The daily precipitation data is distributed according to a sinusoidal function that peaks at noon (normal distribution). This distribution pattern was compared with the constant averaged and the sloped averaged distribution patterns, and it was determined that the sinusoidal pattern resulted in the most stable calculation of the results. Potential evaporation or net radiation measurements are used to calculate the actual evaporation that is possible based on the conditions provided in the surface layer of the model. Evaporation is calculated from the following climate and soil parameters:

- Air temperature;
- Soil temperature;
- Relative humidity;
- Solar intensity (from latitude);

- Soil temperature;
- Soil moisture content;
- Wind speed; and
- Measured pan/modeled actual evaporation.

The combination of the factors listed above provides a reasonable estimate of water evaporation from the system. Infiltration is based on the unsaturated hydraulic conductivity of the material at a given time. Excess rain that has not evaporated or infiltrated is tabulated as runoff. Excess snow is allowed to accumulate on the surface of the heap, and snow that does not sublimate becomes snow melt and can infiltrate into the heap material.

2.2.2.2 Transient Flow within the Facilities

The transient flow dynamics within the heap material are simulated over time and space. The models account for transitions between material types and produces the following data sets:

- Water flux within the model domain;
- Moisture content;
- Water flow velocity; and
- Seepage discharge, if applicable (out of the model domain).

The following sections present the infiltration and seepage model results.

3.0 Model Results

After leaching and rinsing are complete, the spent ore will be allowed to drain freely. For this modeling effort, it was assumed that all of the draindown flow would be removed from the heap to provide a baseline draindown curve. No optimization scenarios (e.g. recirculation of fluid) were considered in this modeling. This assumption results in a faster draindown of the heap than would be realized if solution is recirculated back to the top of the heap to continue the process. This optimization condition will be considered in future modeling efforts in support of the Water Use License application. Additionally, this modeling assumed that the heap would remain uncovered (no closure/reclamation cover placed over heap material) for the period of modeling. This assumption results in a conservative estimation of the total volume to be drained. The simulated flow rate of the draindown curve for the heap is presented in Figure 5. Note that there are periodic spikes in the curve that represent modeled snowmelt or rain events that provide a short term increased flux of water into the system.

As shown in Figure 5, the baseline rate of draindown decreases quickly to approximately 11 m^3/hr (~2.8 L/s) after one year, 6.6 m^3/hr (1.8 L/s) after two years and approximately 5 m^3/hr (~1.4 L/s) by the end of Year 10. For an uncovered heap, the draindown rate will not trend toward zero but instead will become asymptotic with the drainage rate due to net infiltration through the top of the heap (approximately 5 m^3/hr for this heap). Infiltration during the ten year simulation period is approximately 10% of annual precipitation, with the balance of the water being lost through evaporation/sublimation and runoff.

It is assumed that the draindown rate after the ten year period (5 m^3/hr) will be representative of the long term drainage conditions of the heap. Assuming that the most recently rinse zone (one quarter of the heap) will be at a moisture content of 13.3% and the remainder of the heap will be between 5% and 10%, it was calculated that there would be approximately 1,700,000 m^3 of water and residual solution (after rinsing and detoxification) left in the heap.

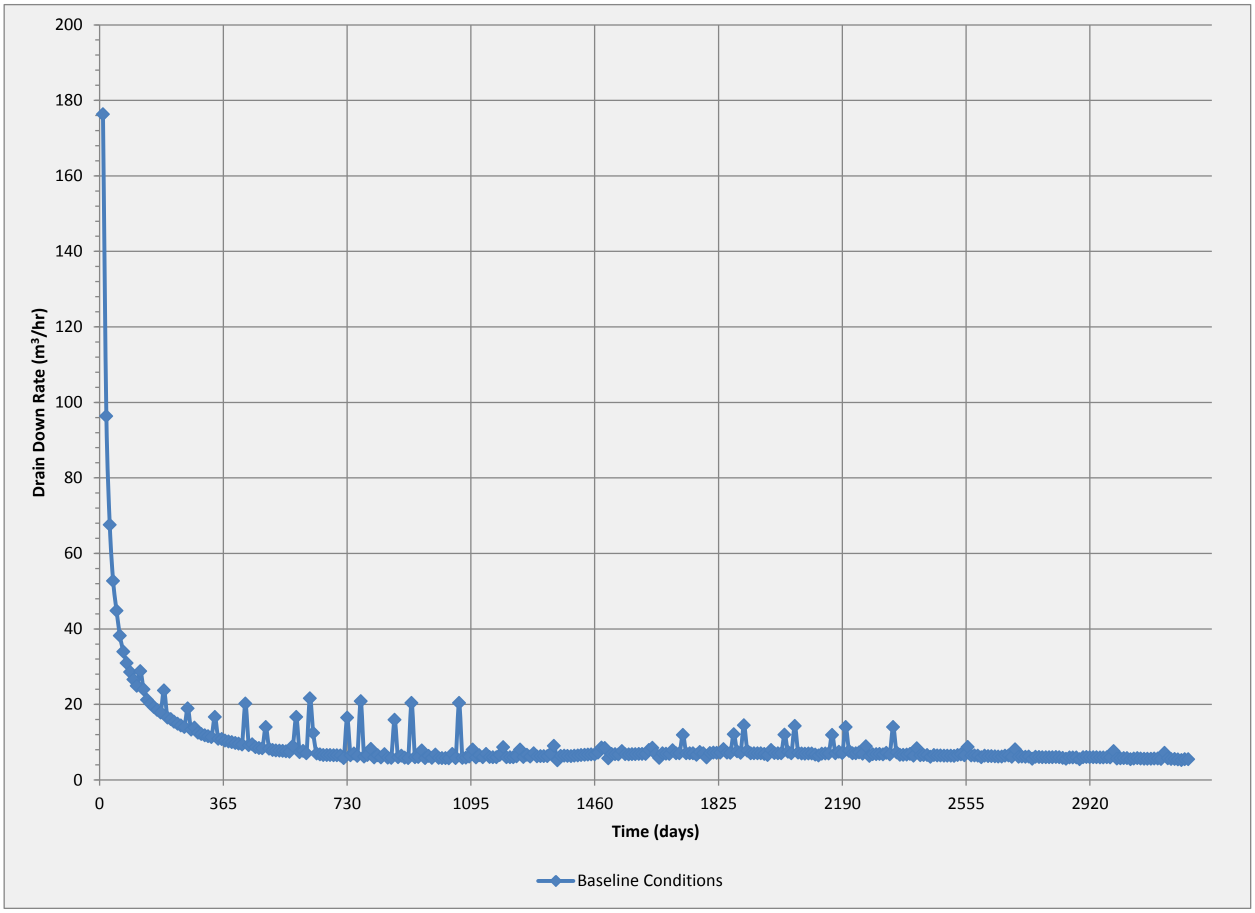


Figure 5 Draindown Curve for Heap Leach Facility

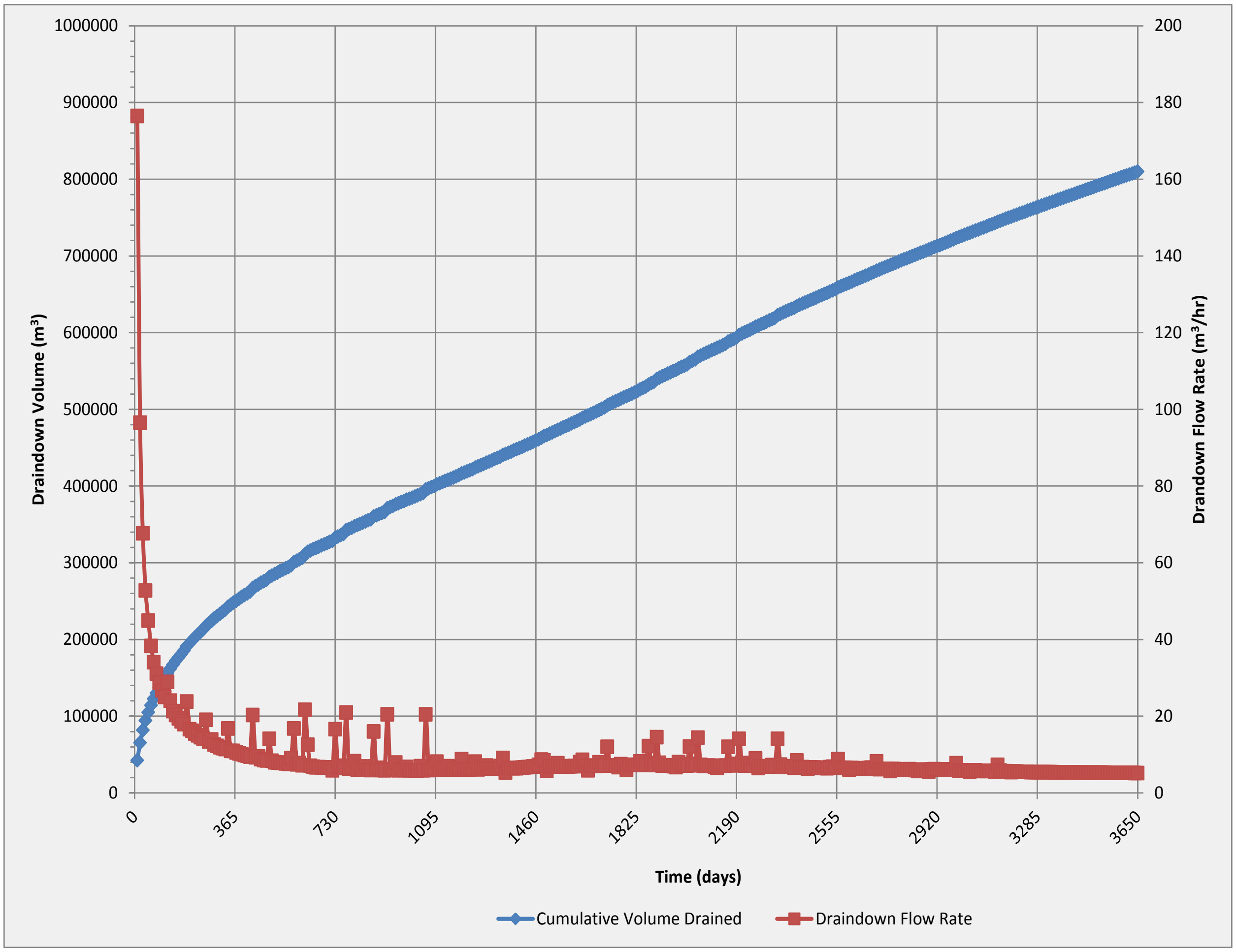


Figure 6 Cumulative Draindown Volume for Heap Leach Facility

4.0 References

Fetter, C.W., 2000. *Applied Hydrogeology*. Prentice Hall: New Jersey.

GEO-SLOPE International, Ltd. (GEO-SLOPE), 2007. *Vadose Zone Modeling with VADOSE/W 2007: An Engineering Methodology*. GEO-SLOPE International Ltd.: Calgary, Alberta, Canada.

Stantec, 2011. Surface Water Balance Model Report