

Staged approach to closure of a tailings storage facility in the Kimberly, Western Australia

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Et al.

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Abstract

A nickel mine located in the Kimberley region of Western Australia is in the process of developing an amended closure plan (subject to EPA approval) for the tailings storage facility (TSF). Reference to the specific mine and location has been removed to not interfere with the approvals process. The proposed closure plan demonstrates the advantage of strategic tailings placement and long term planning while the facility is operational in order to develop a robust final landform for post closure. In addition, the proposed plan is an example of a multidisciplinary approach to post-closure planning of a mine waste facility. Part of the proposed closure plan was to develop a moisture store-and-release cover system design and a final landform for the TSF facility. Due to the valley-fill setting of the TSF, the current surface topography slopes down-gradient to a dam located at the southern-most end of the TSF. In order to mitigate the possibility of a flow-over from the entire valley catchment area during large rainfall events, the mine is proposing a staged closure approach where the large catchment is segmented into smaller catchments that drain to strategically located spillways. Developing separately contained internal sub-catchments increases the stability of the current TSF containment structures such that the erosional stability of the main tailings embankment is increased by decreasing runoff reporting to that region. Each segment, or cell, would be filled and closed incrementally once capacity of the cell is reached. This approach was developed in order to manage surface water runoff for large rainfall events that may occur post closure.

In order to develop the final landform for the TSF, detailed geotechnical testing of potential cover materials was completed. Soil-atmosphere modelling of several potential cover scenarios and erosional stability modelling of the landform was completed to determine the most stable cover system. This closure plan was designed by coupling a moisture store-and-release cover system, which captures and stores rainfall events up to a certain magnitude, with a landform engineered to carry runoff for larger storm events off the landform with acceptable erosion rates. Cover and landform designs were approached iteratively to determine the best possible predicted net percolation to ensure success of the cover system, and most ideal sloped surface to decrease erosion during large rainfall events. Surface contouring the TFS through strategic placement of discharge spigots will aid in the development of the final landform surface.

Seepage modelling of the final landform was completed to determine the post closure drain-down and seepage rates. The seepage rates and drain-down were used in regional groundwater flow and solute transport modelling to examine possible impacts on downstream receptors. The objective was to develop site-specific criteria for the cover system, in terms of required net percolation rates, which are linked to impacts to the receiving environment.

1 Introduction

Landform design for reclamation requires an expanded view of mining operations, where each operational stage and each component of the mine is part of a plan that considers the end use of the site as much as the immediate need (Environment Australia, 1998). This plan, which must be flexible to accommodate changes in methods and/or technology, is about optimising post-mining land capability, minimising the costs in achieving optimal land use, and limiting long-term maintenance liabilities. Successful reclamation provides conditions such that the landscape can *redevelop* towards an equivalent capability to that which existed prior

to mining. There are two key features of this view of reclamation. First, the specific features of the reclaimed landscape may be different than those that existed prior to mining, but they should produce an 'equivalent capability' to that which existed prior to mining. Secondly, the performance of these new landscapes will evolve over time. The goal of reclamation is to establish the basic building blocks for this new landscape and to ensure that the trajectory of evolution for this new landscape is correct, both in terms of the rate of evolution and end point (MEND, 2007).

The mine is located in the East Kimberley Region of Western Australia (Figure 1). THE MINE is an underground mine with a nickel sulphide ore body and was commissioned in 2004 with an initial mine life of 4.5 years. The operations are now projected to continue for a further 10 years.

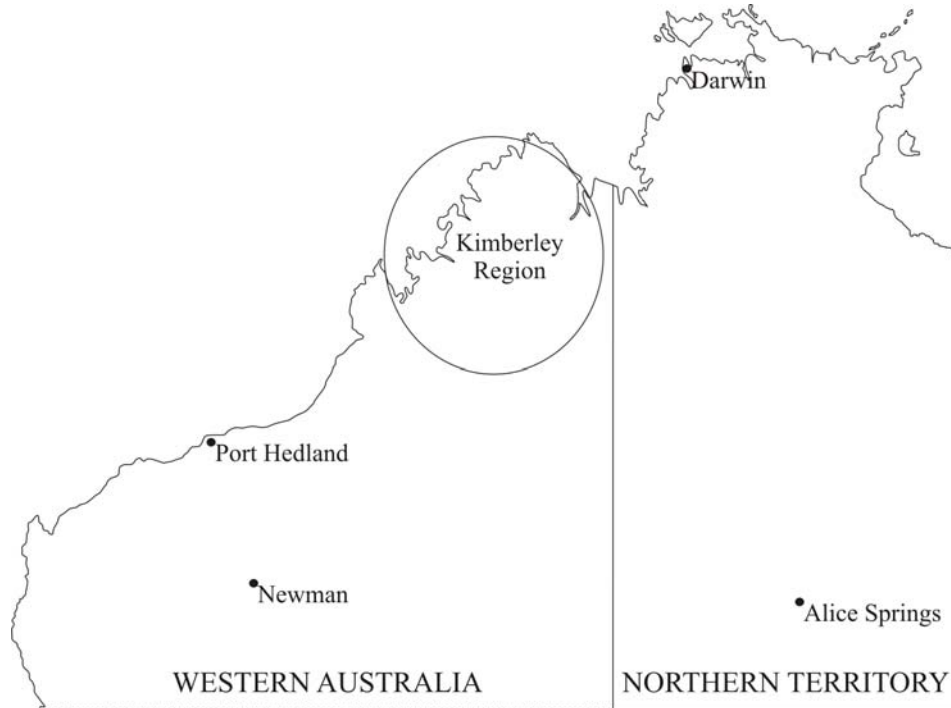


Figure 1 Map showing the region where the mine is located.

The design process for rehabilitation of the mine's TSF took a multi-phase approach with each phase a critical component for the development of a final stable landform. The proposed final landform design is based on site-specific climate and material characterisation. Numerical modelling using the site-specific data for a final cover system design provides a basis for material selection and design features required for optimal surface water management. Consolidation and seepage analysis as well as landform evolution modelling validates the final landform design.

2 Material Characterisation

2.1 Site Investigation

A comprehensive site investigation was carried out to determine site-specific geotechnical and hydraulic properties for potential cover materials for the mine's TSF. The cover materials will be used to create a store-and-release cover system to minimise potential net percolation into the underlying tailings and to construct surface features to optimise surface water runoff management during extreme precipitation events. Potential cover materials available at site were identified as benign waste rock (from an adjacent waste rock dump), top-soil and sub-soil.

Paste electrical conductivity and pH as well as field saturated hydraulic conductivity were measured. Samples were collected to measure natural water content at time of sampling. Waste rock measured a mean

pH of 7.3 and a mean electrical conductivity of 1.5 mS/cm. The average pH of the topsoil was 7.8 and the average conductivity was 0.03 mS/cm. The mean field saturated hydraulic conductivity value measured at the surface waste rock was approximately 4×10^{-5} cm/s, which is assumed to be at the lower end for hydraulic conductivity for this material due to compaction from typical mine traffic.

2.2 Laboratory Testing Program

Samples of potential construction materials were collected from various locations and submitted for detailed laboratory analysis. A full geotechnical laboratory investigation on the materials of interest included particle size distribution, moisture retention characteristics and saturated hydraulic conductivity.

Particle size distribution tests were carried out for thirty-nine samples. The topsoil samples range from 43 to 76% gravel, 27 to 46% sand, and 15 to 26% silt / clay, falling in the intermediate to coarse textured category. The sub-soil sample texture is similar to that of the top soil at 32% gravel, 46% sand, and 22% silt / clay. The waste rock is a coarse material which shows a range of 38 to 69% gravel, 11 to 22% sand, 3 to 7% silt / clay. The specific gravity of the topsoil ranged from 2.74 t/m³ to 2.89 t/m³, with a mean of 2.81 t/m³; the subsoil sample result was 2.90 t/m³ and waste rock ranged from 2.74 to 2.95 t/m³, with a mean of 2.81 t/m³.

2.2.1 Hydraulic Characteristics

Of particular importance to the landform design program were the hydraulic properties of the materials. A sub-set of samples consisting of two topsoil, one subsoil, two waste rock, and two composite samples were submitted for moisture retention and saturated hydraulic conductivity (k_{sat}) testing. The composite samples consist of a 2:1 ratio by weight of waste rock to topsoil to represent a fine to intermediate textured material.

The laboratory k_{sat} results for the various materials are presented in Table 1. Mean laboratory k_{sat} values for topsoil, sub-soil, and waste rock were 2×10^{-3} cm/s, 3×10^{-3} cm/s, and 4×10^{-3} cm/s, respectively. The composite sample had a lower k_{sat} of 6×10^{-4} cm/s compared to the individual component values most likely due to the development of a well graded material. The laboratory values were higher than expected, however, it is typical for laboratory values to differ from field values due to small sample population and sample disturbance.

Table 1 Saturated Hydraulic Conductivity of potential cover materials

Material	k_{sat} (cm/s)
Topsoil	$1 - 2 \times 10^{-3}$
Subsoil	3×10^{-3}
Waste Rock	$2 - 6 \times 10^{-3}$
Waste Rock / Topsoil Composite	$5 - 6 \times 10^{-4}$

Figure 2 presents moisture retention curves (MRCs) representative of each material type. Composite #1 and Composite #2 produced similar results and therefore is represented by one curve in Figure 1. The moisture retention curves do not differ substantially between the different material types, consistent with the relatively similar intermediate to coarse texture of the materials. The air entry value (AEV) for the topsoil ranged from 10 to 15 kPa, and 5 to 10 for the sub-soil and waste rock. The composite top soil / waste rock sample had an AEV in the range of 10 to 15 kPa.

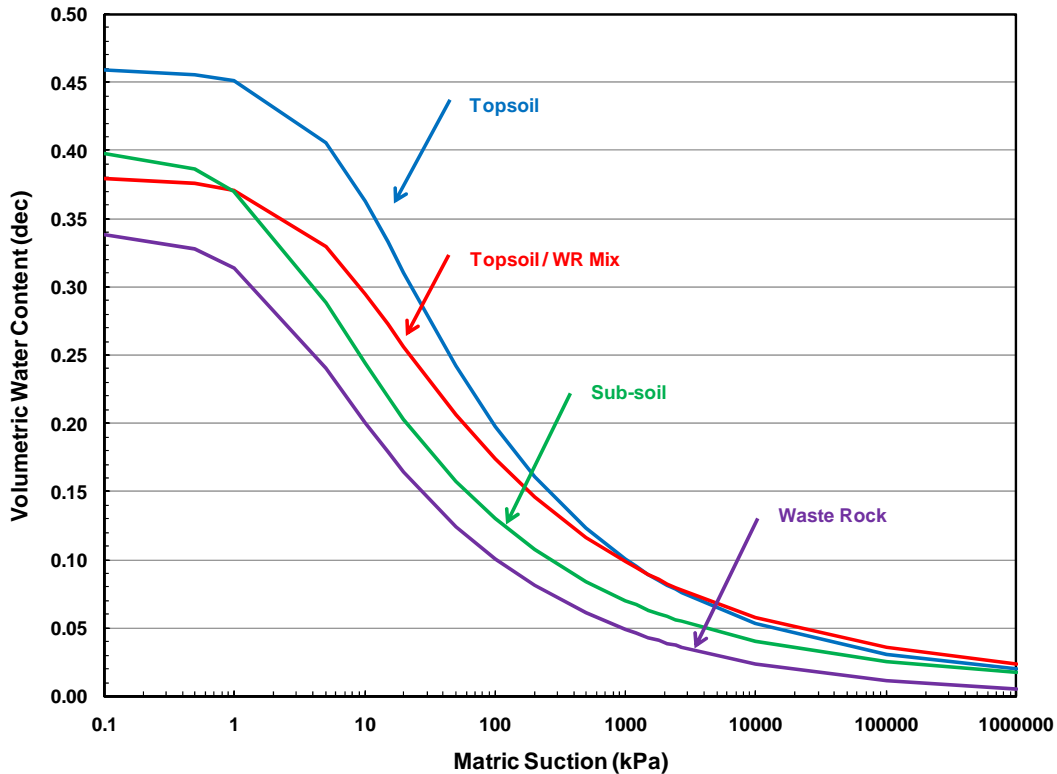


Figure 2 MRCs for potential cover materials for the mine's TSF

3 Landform Design

Climate is one of the principle factors that influence the evolution of a landform. Climate for the area is described as tropical semi-arid with hot summers and warm dry winters. The “wet” season usually occurs from December to March and is characterised by high temperatures and large sporadic rain events. The dry season is considered to be the remainder of the year. Mean annual rainfall is approximately 636 mm over an average of 60 days, although this varies considerably from year to year. It is common that very little rain be received in this area over a period of many months and in contrast during the wet season, to experience extremely large intensity events. Given the extreme variability in precipitation intensities, a ‘two-part’ method of managing water received by the TSF, which includes a store-and-release cover system and landform design was proposed. During the dry season, a store-and-release cover system is the primary method of reducing the potential solute load from the TSF area by limiting net percolation into the waste. During the wet season and periods of high intensity rainfall, the landform design and associated features will take control and become the main factor for directing surface water flows from the TSF. That is not to imply that the storage and release of moisture via evapotranspiration will not be a key component of the water balance during the wet season. However, when storage capacity is exceeded, or more typically, rainfall intensity is such that runoff occurs, the landform is designed to transmit the runoff off the landform in a safe and stable manner.

3.1 Proposed Landform Design

The final landform design consists of constructing three watershed sub-catchments on the TSF following decommissioning of the facility (i.e. final tailings elevation of 378 mRL). Based on site characterisation and soil-atmosphere cover modelling (VADOSE/W, 2007), the surface features will be constructed of available waste rock material sourced from the mine's northern waste rock dump (WRD). The bordering waste rock dump slope will be designed on the basis of landform stability and also the need to accommodate the required waste rock volumes for the TSF landform design. The watershed catchments will incorporate central, rock-armoured drainage channels that will direct collected surface water to spillways that convey

these waters from the surface of the TSF. As indicated in Figure 2, the eastern slope of the WRD will have a concave slope with no berm structures, and has been designed with a toe drain to divert runoff from the waste rock facility from the TSF. Landform evolution modelling conducted on the final designed showed that the TSF proposed final landform is stable beyond a 200-year period. Figure 3 presents a rendering of the TSF and adjacent waste dump landform.

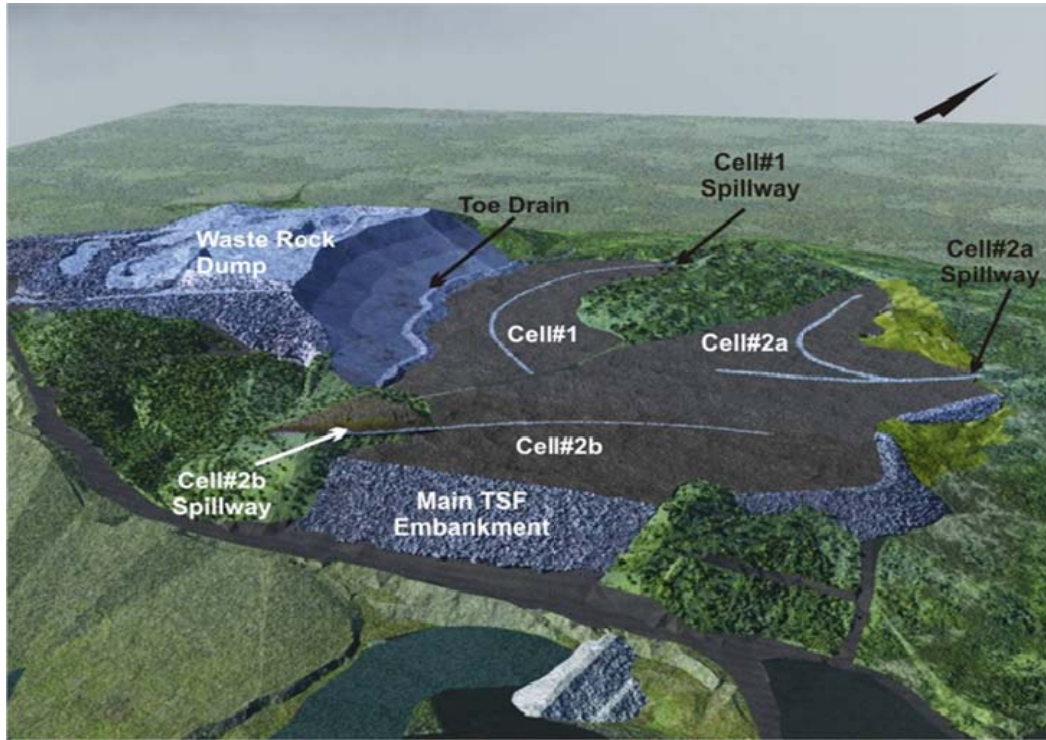


Figure 3 Rendering of final TSF and adjacent waste dump landform

For the proposed final landform design, the gradients of Cells #1, #2a, and #2b are 2% in response to results from landform evolution modelling conducted by Landloch Pty Ltd. using SIBERIA. All three cells incorporate a central drainage channel that leads to a spillway off the TSF. The Cell #1 drainage channel flow path contains a north-south divide located approximately 75 m north of the internal embankment that divides Cell #1 and Cell #2b. The northern portion remains as a rock-armoured channel and flows north to the Cell #1 spillway. The southern portion of the Cell #1 divide creates a catchment and directs flow to the Cell #2b catchment, and is directed off the TSF via the Cell #2b drainage channel and spillway located on the west side of the cell. The Cell #2a spillway is located on the east side of the cell.

4 Landform Design Support Studies

Cover system design, seepage, solute transport, and consolidation were examined to provide a more thorough understanding of how the design will function in the future. Cover system design used a soil-atmosphere numerical model to investigate the critical design factor in reducing potential solute load from the TSF to downstream receptors.

4.1 Cover System Design

The cover system design is a critical design factor because the cover system is a primary mechanism for reducing the potential solute load from the TSF area by limiting net percolation into the tailings waste. The recommendation of a preferred cover system alternative for the TSF was not based solely on the performance of the cover system predicted using the soil-atmosphere model. Factors such as the effect net percolation rates have on the solute flux from the base of the TSF footprint, surface erosion, vegetation sustainability,

cover construction costs and operational constraints are also considered in the selection of the preferred cover alternative.

The detailed modelling program used a 2.0 m waste rock layer, which was selected based on preliminary soil-atmosphere modelling, within the various cover system alternatives. A site-specific 100-year climate database was developed and used to compare the performance of five cover system alternatives. The initial *in situ* temperature and suction conditions used for each simulation were determined from running the initial climate year repeatedly to produce a “steady-state” set of sub-surface conditions representative of site conditions. The cover materials available consist of waste rock from the adjacent WRD, and various surface treatments including topsoil, sub-soil, and a topsoil / waste rock mix. The cover alternatives examined using soil-atmosphere modelling include the following:

1. Cover #1: 0.3 m non-compacted topsoil / waste rock mix, (Base Case) 2.0 m non-compacted waste rock.
2. Cover #2: 0.3 m non-compacted topsoil, 2.0 m non-compacted waste rock.
3. Cover #3: 0.3 m non-compacted sub-soil, 2.0 m non-compacted waste rock.
4. Cover #4: 0.3 m non-compacted topsoil / waste rock mix, 2.0 m non-compacted screened waste rock.
5. Cover #5: 2.3 m non-compacted waste rock.

4.1.1 Predicted Net Percolation Rates (Absence of Vegetation)

Table 2 summarises the average predicted net percolation rates and remaining water balance components for the 100-year continuous simulation for all cover alternatives. The average net percolation for the 100-year simulation of the base case Cover #1 was 53 mm or 8% of the average annual rainfall. The average actual evapotranspiration (AET) was 457 mm during the simulation, which is 72% of the average annual precipitation. On average, 121 mm (19%) of the wet season rainfall produced runoff during the simulation. Predicted net percolation rates are similar for Cover #2 (61 mm – 10%) and Cover #4 (51 mm – 8%), which both incorporated topsoil or a topsoil / waste rock mix as the 30 cm thick surface material. Predicted net percolation rates increased for the Cover #3 sub-soil (111 mm – 15%) and Cover #5 bare waste rock (174 mm – 27%) surface treatments.

Table 2 Summary of the average predicted net percolation and remaining water balance parameters for the cover system alternatives

Water Balance Parameter (Average Annual)	Cover #1 Topsoil / WR Mix	Cover #2 Topsoil	Cover #3 Sub-soil	Cover #4 Topsoil / WR Mix Screened WR	Cover #5 Bare Waste Rock
Rainfall	636 mm	636 mm	636 mm	636 mm	636 mm
Potential Evaporation	2,011 mm	2,011 mm	2,011 mm	2,011 mm	2,011 mm
Runoff	121 mm (19%)	110 mm (17%)	96 mm (15%)	124 mm (20%)	81 mm (13%)
Actual Evaporation	457 mm (72%)	458 mm (72%)	426 mm (67%)	457 mm (72%)	374 mm (59%)
Change in Storage	+ 5 mm	+ 7 mm	+ 3 mm	+ 4 mm	+ 8 mm
Water Balance Error	(0.8%)	(1.1%)	(0.5%)	(0.6%)	(1.2%)
Net Percolation	53 mm (8.3%)	61 mm (9.6%)	111 mm (15%)	51 mm (8.0%)	174 mm (27%)

Probability of exceedance comparisons (Figure 4) were utilised to provide a quantification of risk for annual net percolation rates. A large percentage of the 100 years simulated for the base case cover system (Cover #1) showed annual net percolation below 10 mm; however, a small percentage of years produced large net percolation (> 175 mm/yr). During these years, cyclone events produced large quantities of rainfall that overwhelmed the storage capacity of the store-and-release cover system resulting in high net percolation rates to the underlying tailings. These results are typical of store-and-release cover systems where the average annual net percolation is heavily influenced by a small number of high annual net percolation rates. The difference between the mean and median values (53 mm and 18 mm, respectively for Cover #1) highlights the influence that the small number of high net percolation years has on the mean annual net percolation.

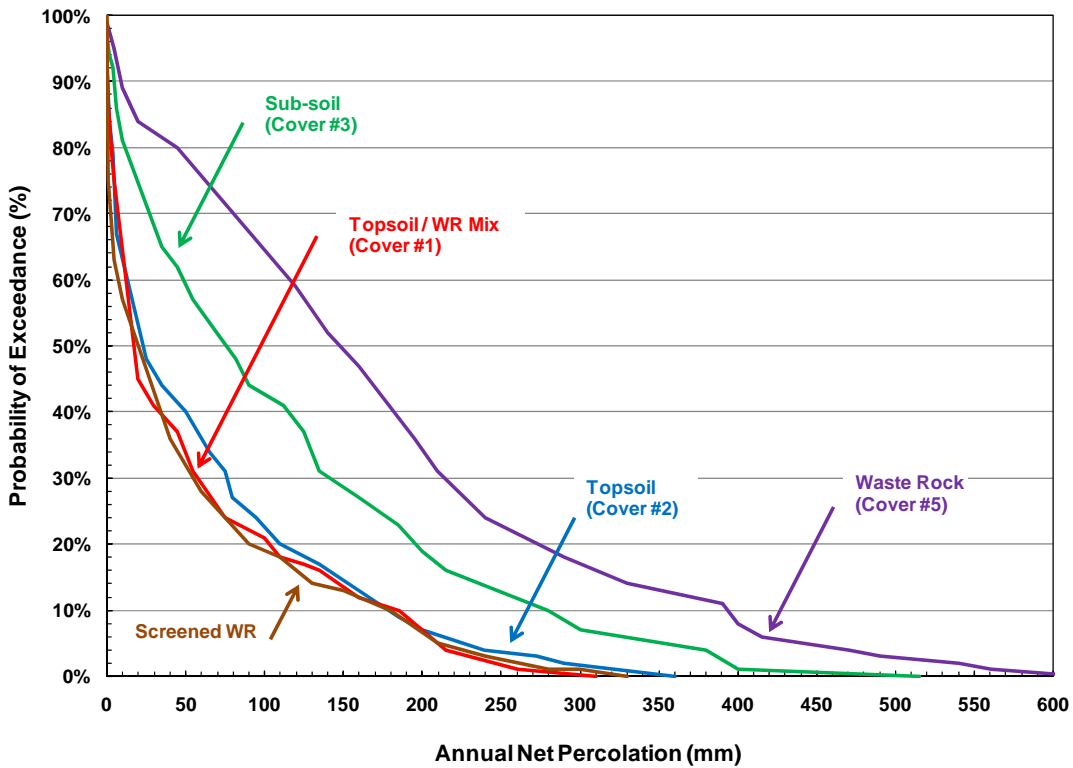


Figure 4 Probability of exceedance curves for the five cover alternatives evaluated over the 100-year climate database

4.1.2 Sustainability of Vegetation

The base case simulation (Cover #1) evaluated the topsoil / WR mix cover system *without* the benefit of vegetation. A rendering of the base case cover system profile is presented in Figure 5 showing no vegetation on the cover surface. This conservative assumption was adopted to recognise the potential adverse effects such as drought, wildfires and grazing on a vegetative stand. By using this approach, the success of the cover system was not dependent on the establishment of a specific percentage of vegetative cover. In addition, any vegetation that was subsequently established would improve the performance of the cover system by increasing evapotranspiration from the soil surface as well as improving erosion resistance and aesthetics.

A 100-year simulation was completed implementing a vegetative cover at the soil surface of Cover #1. The key vegetation parameters used were a leaf area index of 1.5 (surface coverage of 65%), a constant rooting depth of 0.4 m, and a growing season extending from October 1st to June 30th. The average annual net percolation for the 100-year simulation was 39 mm or approximately 6% of average annual rainfall.

Compared to the 53 mm net percolation from the base case, vegetation could potentially decrease the average net percolation by 26%.

The improvement in performance when vegetation was simulated is due to the vegetation's ability to "pull" moisture from lower in the cover system profile in comparison to evaporation alone, which leads to increased AET rates. The increase in evaporative front depth produces lower *in situ* water contents and increased storage capacity compared to the condition where no vegetation is assumed. When vegetation was simulated, a greater percentage of negligible net percolation years (the acceptable limit for net percolation was not established for the site therefore the limit was assumed as 5 mm for comparative purposes. The selected based on OKC's experience with similar waste materials at sites with similar climatic conditions) were predicted. For example, the probability of net percolation exceeding 5 mm was 52% and 74% with and without vegetation, respectively. In addition, the lower *in situ* water contents and increased storage capacity reduced net percolation during the high rainfall years. The probability of net percolation exceeding 200 mm was 8% without vegetation and 3% with vegetation, which represents a substantial difference in risk.

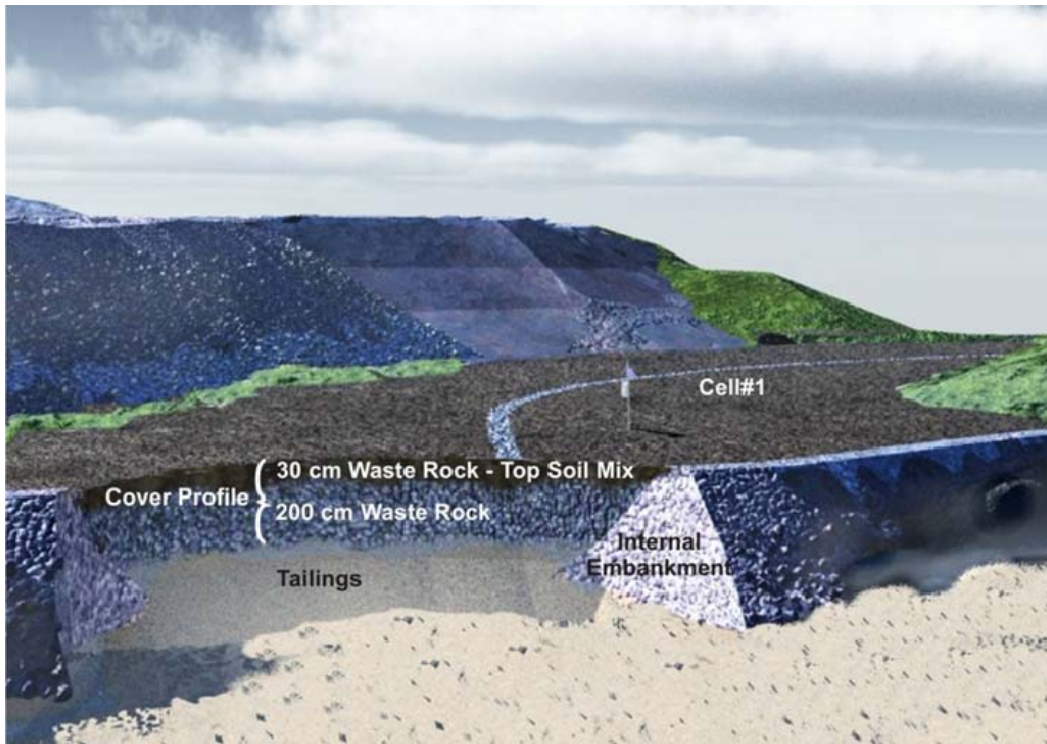


Figure 5 Rendering of TSF preferred cover design profile.

4.1.3 *Runoff on Cover Surface*

Runoff will occur when the rainfall intensity is greater than the infiltration rate at the soil surface and/or if the near surface cover materials are saturated. During the simulations, when rainfall intensity exceeded the infiltration rate, the runoff was assumed to exit the 1D model; it was not allowed to pool and infiltrate in a subsequent dry period. The average runoff coefficient ranged from 13% for the bare waste rock surface to 20% for the topsoil / WR mix with underlying screened WR.

The best-fit curve to the rainfall and runoff data is non linear; the runoff co-efficient increases with total rainfall (Figure 6). The runoff co-efficient from the best-fit line at 25 mm was 21% and increased to 27% with rainfall events of 50 mm and 31% for rainfall events of 100 mm. Due to the rarity of daily rainfall events greater than 150 mm (approximately four in 100 years), it is difficult to define an absolute runoff co-efficient. From the limited data, the runoff co-efficient is estimated at approximately 35% - 40% for these rainfall events.

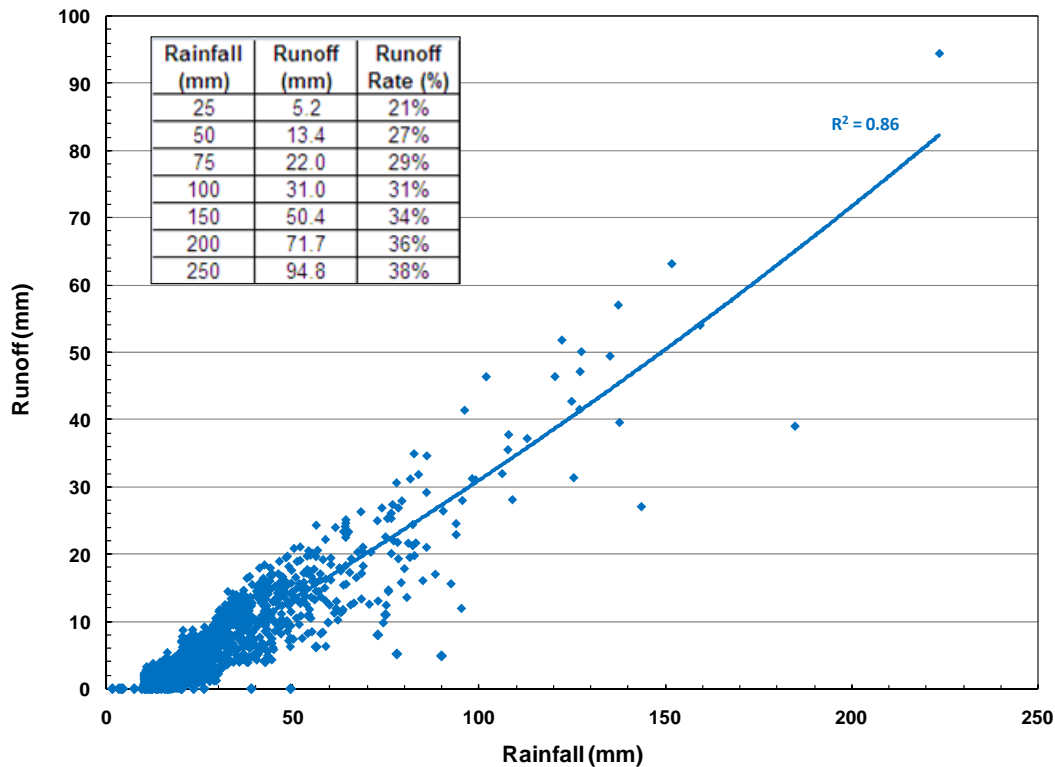


Figure 6 Comparison of total rainfall to total runoff for the rainfall events during the base case 100-year simulation

4.2 Seepage and Consolidation Analysis

Seepage and consolidation analysis highlighted the importance of the tailings characteristics on controlling seepage and pressure dissipation in the TSF. An integrated approach was used that combined inputs from the cover design analysis and numerical modelling analysis of seepage, solute transport, and consolidation. The objective of the seepage and consolidation program was to answer questions related to the long-term drain down of the TSF and the resultant location of the phreatic surface. Three different scenarios were simulated, corresponding to different locations within the TSF. Each scenario was also simulated as both a base case, and consolidated, thus providing a range of values to evaluate the results.

4.2.1 Predicted Seepage and Pressure Dissipation and Tailings Settlement

One-dimensional (1-D) seepage and pressure dissipation models indicated that the time required to reach a steady state base flux equal to the net percolation rate through the cover system was between 10 and 25 years. These results were for areas ranging from a coarse textured tailings in marginal areas of the TSF, to the thickest tailings overlying clayey alluvium in the centre of the TSF. At the extreme end of the spectrum, scenarios that simulated a consolidated tailings mass increased the time to reach steady state to up to 200 years due to the models being loaded with excess initial pressure and a lower hydraulic conductivity. Numerical analysis of consolidation settlement indicated that a 43 m base case tailings mass could be expected to settle approximately 1 m.

4.2.2 Solute Transport

A preliminary investigation into the transport of solutes (conservative) from the tailings mass was conducted to assess whether transport of solutes from the tailings into the overlying cover (from process water and/or oxidation of the tailings) would present a critical failure of the cover design. A critical flaw from a solute transport perspective would be one where concentrations of solutes in the overlying cover system were sufficiently high that performance would be negatively affected, either from a hydraulic or biological

perspective. It should be noted that only very general estimates of material properties were used, as no transport data were available for the analysis. Nevertheless, simulating the relative concentration distribution of a conservative contaminant does provide insight into the mechanisms at work.

Net percolations of 1, 5, 10, and 20% of precipitation were simulated to assess cover water dynamics and the subsequent effect on solute transport. After 100 years of simulated drainage, a net percolation rate of 20% led to a peak concentration that was below the tailings mass (20 m). The highest percolation rate also exhibited the lowest concentrations within the overlying cover. Conversely, the 1% net percolation simulation demonstrated that the system was advection dominated, and low percolation rates allowed for greater diffusion of solutes into the overlying cover system.

The solute transport analysis highlighted the need to approach closure design from an integrated perspective. Strictly from a seepage perspective, the lowest net percolation that a cover will allow is desirable. However, from a perspective of the potential for salts to be transported from the tailings material into the overlying cover material, the numerical analysis showed that higher net percolation rates will flush solutes from the system faster, and will also result in a lower concentration within the cover system.

4.2.3 2-D Seepage Predictions

The primary aim of the 2-D seepage analysis was to assess post-closure seepage rates and the eventual location of the phreatic surface recession within the TSF. Modelled cross-sections incorporated both base case and consolidated tailings, underlying geology of weathered bedrock, fresh bedrock, and clayey alluvium, as well as the main and internal embankments. The 2-D models included a transient flux boundary equivalent to net percolation rates of 1, 5, 10, and 20% of precipitation. The initial conditions of the TSF 2D model simulated Cell 1 post-closure, and Cell 2b immediately following cessation of tailings deposition. The TSF was then allowed to drain for 1 year, followed by 100 years of the simulated transient cover flux condition.

An example of the long-term seepage rate from the base of the TSF under 5% net percolation is given in Figure 7. Cell 1 is situated from 200 m to 650 m, and it is clear that at the beginning of the simulation, the tailings were close to steady-state. Cell 2b, from 650 m to 1025 m, had an initially high seepage rate owing to the increased pore-water pressures generated by a saturated tailings mass that is undergoing consolidation. The seepage rate declines as the gradients within the TSF are reduced, and eventually reaches steady-state between 10 and 50 years. This result is corroborated by the results of the 1-D seepage models that indicated that the time to reach steady state would be 25 years for Scenario 1. The location of the phreatic surface within the middle of Cell 2b is shown in Figure 8. The pressure profile in Figure 8 complements Figure 7, and indicates that after a period of drain down, the phreatic surface reaches a steady-state between 10 and 50 years.

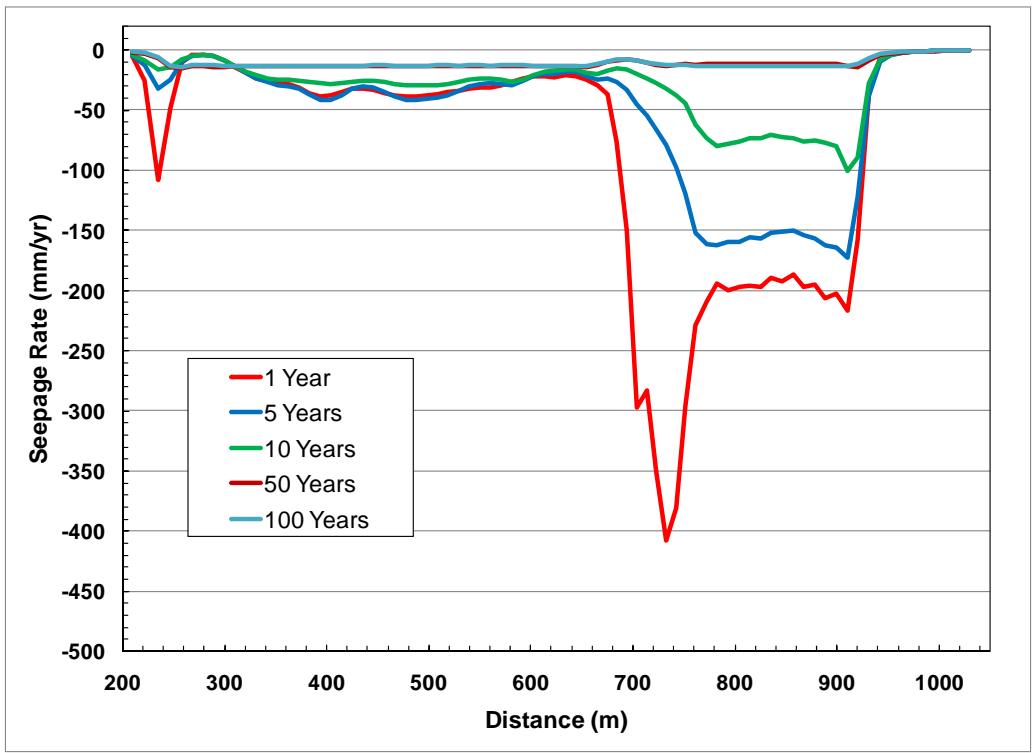


Figure 7 Long-term seepage rates from the base of the 2-D TSF model using an input equal to the 5% net percolation rate

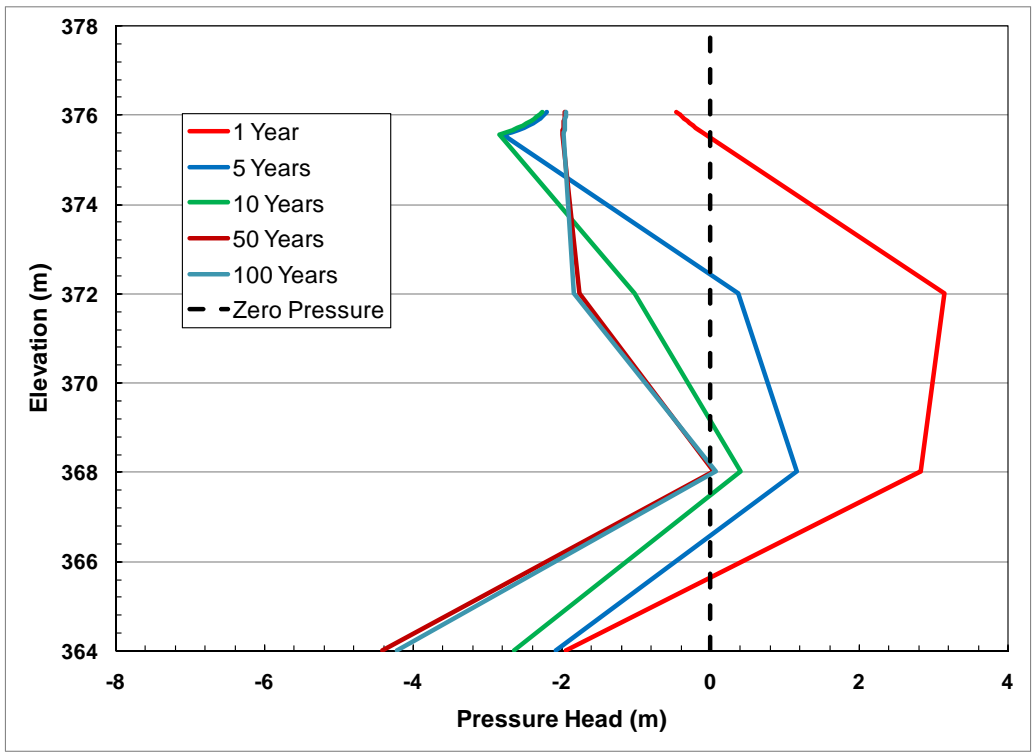


Figure 8 Long-term Cell 2b pore-water pressure profile for a 5% net percolation rate

5 Sustainability of Preferred Landform and Cover System Design

The behaviour of a cover system, and thus the final landform, will change with time as a result of physical, chemical, and biological processes. These changes may influence long-term performance, as shown in Figure 9. In general, state-of-the-art models are limited to providing quantitative predictions based on some of the physical processes listed in Figure 6 that affect long-term performance. Consideration of the effects of long-term changes in biological and chemical processes on performance has been generally dealt with in a qualitative manner, if addressed at all (MEND, 2007). This leads to difficulty in developing a defensible closure plan using cover systems because of the subjectivity involved with qualitatively evaluating these processes. However, it is essential that the cover system design account for these processes to reduce the uncertainty associated with long-term performance to an acceptable and defensible level. The key issue is that the design should account for the key site-specific processes, as opposed to allowing these processes to lead to a failure of the cover system.

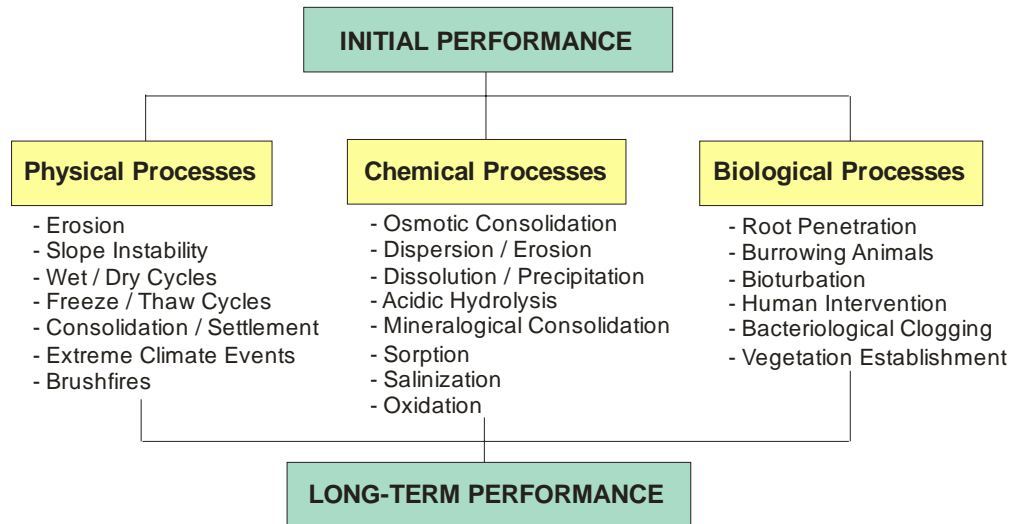


Figure 9 Processes that could impact the sustainable performance of mine waste cover systems (from INAP, 2003)

INAP (2003) conducted an examination of the processes shown in Figure 9 and discovered that their effects could be related to the change in three key cover performance properties; namely, the saturated hydraulic conductivity, the moisture retention characteristics of the cover materials, and the physical integrity of the cover system. The saturated hydraulic conductivity and moisture retention are key hydraulic properties of a cover system layer. Tests can be completed to assess the likely changes in these properties (if any) over time; however, laboratory measurements more than likely illustrate a range of values for a certain material. INAP (2003) states that developing field-based measurements of the key hydraulic properties is essential for properly designing a cover system.

6 Summary

A nickel mine located in the Kimberly region of Western Australia is engaged in developing a plan for the closure of the TSF using a multidisciplinary approach. The following summarises the key aspects of the development of a TSF closure plan:

- Division of the TSF into cells to complete progressive rehabilitation and evaluate performance prior to full scale implementation;
- An iterative multi-phase approach was used to develop a stable landform and a preferred cover design;

- The cover design includes an enhanced store and release cover that captures, stores and releases incidental rainfall to the atmosphere while excess rainfall that occurs during the largest events runs off the landform;,
- The landform design was assessed using seepage analysis to determine the length and rate of draindown following closure; and
- Establishing large field trial to assess cover performance.

References

- Environment Australia. 1998. Landform design for rehabilitation. In Best practice environmental management in mining, ISBN 0 642 54546 4. Available from <http://www.ea.gov.au/industry/sustainable/mining/booklets/landform/index.html>.
- INAP (International Network for Acid Prevention). 2003. Evaluation of the long-term performance of dry cover systems, final report. Prepared by O'Kane Consultants Inc., Report No. 684-02, March.
- MEND 2.21.5. 2007. Macro-scale cover design and performance monitoring manual. July 2007.