



12/08/2025

Ref: 2024.06002

Department of Environment, Tourism, Science and Innovation

Minerals Business Centre

PO Box 7230

CAIRNS QLD 4870

ATTENTION: Glen McMahon

Via email: ESCairns@des.qld.gov.au

Dear Glen,

**RE: ENVIRONMENTAL AUTHORITY AMENDMENT RESPONSE TO INFORMATION REQUEST
NOTICE**

AIC Copper Pty Ltd (AIC) submitted an amendment application for Environmental Authority (EA) EPML00818113 to the Department of the Environment, Tourism, Science and Innovation (DETSI) on 4 February 2025.

On 1 May 2025, the DETSI determined that additional information was required to progress the application. Wulguru Technical Services acknowledges the Information Request (IR) Notice and provides this letter in response. A response to the matters identified in the IR Notice is provided in Appendix A. We look forward to working with the DETSI through the assessment process.

Should you have any questions, please do not hesitate to contact me at madison@wulgurutechservices.com.au or 0407 491 814.

Yours sincerely,

Madison Jackson

Wulguru Technical Services

Appendix A – Response to Information Request

Appendix B – Eloise Copper Mine – TD5 Raise – Response to DETSI RFI Memo (Hydrogeologist.com.au, 2025)

Appendix C – Eloise Copper Mine TD5 – Erosion and Landform Evolution Assessment (Okane Consultants, 2025)

Appendix D – Proposed Table G2 of the EA

Appendix A – Response to IR Notice

Item	Relevant Section	Matter	Information Request	Response
1	Section 3.3.3 - Hydrogeology of the application supporting document (page 96) Section 4.5 – Boundary Conditions Appendix A – Ground water model report of Appendix K - Groundwater Assessment (Page 1367)	The groundwater is assessed to be recharged via precipitation. It is also noted that recharge occurs where the geological unit's outcrop or there is a downward seepage of recharge water from overlaying units. Section 4.5.1 of the report indicates that the historical rainfall with average of 434mm/yr was applied in the steady state model. The recharge factor was calibrated to a very low rate 1.43E-07. This assumes 52.2mm/yr recharge and equates 12% of the average historical rainfall. However, the recharge rate in both steady state and transient models were considered zero. It is understood that this may be justified by the proposed engineering of a lined tailings storage facility (TSF) which would prevent infiltration. In the absence of any real monitoring data to justify this prediction, precautionary principle would suggest the inclusion of a reduced recharge factor (e.g. due to factors such as partial failure in the lined TSF, cracks or edge infiltration, etc) as opposed to disabling the recharge in the model. Given that the historical recharge rate is also calculated as per the average rainfall, this is considered suitable for steady state conditions.	Provide: - a more robust assessment by comparing the key model outputs under both reduced recharge scenario and the disabled recharge scenario; - an updated transient model that considers the seasonal recharge over time; and - a revised calibration of the model taking into consideration the above matters, in addition to available seasonal data collected to date.	Refer to the Eloise Copper Mine – TD5 Raise – Response to DETSI RFI memo attached in Appendix B (Hydrogeologist.com.au, 2025).

Item	Relevant Section	Matter	Information Request	Response
		However, to support the transient simulations or assess a time-sensitive operation such as TSF filling, the assumption of a constant average rainfall/recharge may not adequately reflect the seasonality variability. Particularly, it is evident that strong seasonal recharges occur periodically in shallow alluvium.		
2	Section – 3.3 of Appendix C Eloise Copper Mine Tailings Dam 5 Design Report (page 515)	The report notes there is a likelihood of potential shallow flow path (less than 6m depth) for seepage offsite. This is despite current TSF conditions and the groundwater mounding beneath the TSF and while the groundwater model does not show any potential surface expression. The predicted likely flow path offsite has not been explored further.	Provide: • details (e.g. direction, distance, rate, etc) of the predicted flow path for seepage offsite; and • justification for no surface expressions despite likelihood of shallow seepage flow path.	Refer to the Eloise Copper Mine – TD5 Raise – Response to DETSI RFI memo attached in Appendix B (Hydrogeologist.com.au, 2025).
3	Section 4 – Hydrogeology Appendix K - Groundwater Assessment (Page 1320) Section 3.7.1 – Ground water levels Appendix A – Ground water model report of Appendix K -	It is noted that no local hydraulic testing has been conducted in the Gilbert River Formation. The yield information is taken from the Eloise Borefield with hydraulic conductivity of 0.6m/day. The reliability of the data from the neighbouring areas such as the Eloise Borefield without an assessment of the input/s questions the predictions of the model. For example, it is not clear how far the subject bore/s from the Eloise Borefield are compared with the TSF areas (i.e.	Provide details on: • how the hydraulic conductivity inputs across various formations in the site has been verified. • how was uncertainty in the hydraulic parameters accounted for in the model.	Refer to the Eloise Copper Mine – TD5 Raise – Response to DETSI RFI memo attached in Appendix B (Hydrogeologist.com.au, 2025).

Item	Relevant Section	Matter	Information Request	Response
	Groundwater Assessment (Page 1361)	a few kilometres assumed based on the registered bores). For a site-specific model, site-specific inputs are expected, unless there is strong evidence that the formation continuity has not changed between the site and the Eloise Borefield and there are plans for site-specific testing in the target formations. The report states that the drawdown and depressurisation within the Gilbert River Formation and Proterozoic basement were locally caused by the mining activity. Deep water levels are anticipated to be reduced due to the dewatering and water supply pumping. This suggests that the hydraulic conductivity within both formations may have been locally influenced.	- in the absence of local testing, how the range of variability considered in the model. - how this was qualified in terms of the potential impacts on the model predictions.	
4	Section 1.4.1.3.3 of the application supporting document	Table 15 of the application identifies that the proposed post mine land use (PMLU) for the tailings storage facility (TSF) is 'consistent with surrounding environments with comparable locations within 5 KM of the TSF' and Table 16 of the application states 'suitable analogue locations are present within 5 km, and directly visible from the TSF'. However, the location of the proposed analogue site for the native ecosystem PMLU, ECM6,	Provide clarification on where there are comparable locations within 5 km of the TSF and justification for not selecting a suitable analogue site within this area.	Since the original submission of the application, an alternative PMLU of 'engineered residual mineral waste facility' has been proposed within the draft transitional PRCP Schedule. The transitional PRCP Schedule is in the final stages of assessment and the proposed PMLU is expected to be approved. Notwithstanding the alternative PMLU, the proposed analogue location remains suitable

Item	Relevant Section	Matter	Information Request	Response
		provided in the application is located approximately 25 km from the site.		to compare vegetation species composition, structure and cover. The comparable regional ecosystem (RE) of the analogue location is RE1.11.3, mapped widely across the North Western Highlands. The RE is present within 5 km of the site, but the proposed analogue monitoring location is 25 km away. The reference site was chosen for the following reasons: 1. It is directly visible from the tailings dam wall and visually connected to the rehabilitation area. 2. It has topographic and catenal attributes that closely match the planned rehabilitated tailings dam embankments in slope and rock cover. 3. The direct similarity ensures that all rehabilitation monitoring requirements in the EA/PRCP will have valid comparators in a natural ecosystem including erosion, substrate stability, and fractional cover. 4. Accessibility and landholder consent for monitoring.
5	Appendix I erosion assessment summary memo	The erosion assessment summary memo included the results of a Water Erosion Prediction Project (WEPP) model that identified a ground cover of 75% or greater would produce	Provide: • further evidence to justify the proposed use of cover of rock, litter	Okane supports the notion that the 75% value includes perennial/persistent, non-erodible vegetation and organic litter coverages.

Item	Relevant Section	Matter	Information Request	Response
		acceptable erosion results (<10/t/ha/y). These results were further used for the landform evolution model (LEM) where it was recommended that a 'modified soil' consisting of 75% rock by volume is applied to a depth of 0.5 m on the embankments of the TSF to achieve a suitable erosion rate of 5 t/ha/y. Section 4.1.12.10.1 of the application supporting document identifies that a functional cover of combined rock, litter and ground cover greater than 75% is to be used on the embankments for the rehabilitation criteria which is not consistent with the recommendations from the LEM assessment. In addition, while the memo included the results of LEM and WEPP models, the input parameters were omitted from the report.	and ground cover vegetation where the LEM erosion assessment recommends 75% rock cover to a depth of 0.5 m; and the parameters used in the erosion models.	The LEM report uses the revised universal soil loss equation (RUSLE) Soil Cover (SC) Subfactor to assess the impact of rock content on the embankments, notably the evaluation indicated that a high proportion (75%) of rock was required on embankments to meet erosion targets. Although the SC factor was discussed with respect to rock content, the SC factor broadly applies to all low erodibility components of the surface matrix, the guidance specifically refers to "crop residue, rocks, cryptograms and other non-erodible material", (Predicting Soil Loss By Water: A Guide to Conservation Planning With the RUSLE, Renard et al, 1998). Importantly, these must be non-erodible, enduring components of the surface for the facility design life. The LEM report specifically limited the commentary to 'rock content' (and not vegetation & litter components) as Okane's scope did not extend to the assessment of vegetation and the ability to sustain vegetative ground cover, or to generate persistent litter. The evaluation does not rule out these components, contributing to the 75% target ground cover.

Item	Relevant Section	Matter	Information Request	Response
				The key WEPP and SIBERIA model inputs are provided as Table 4.1 and Table 5.1 (respectively) in the Eloise TD5 Erosion and LEM assessment' report (Refer to Appendix C). The model inputs were omitted from the memorandum, which is a significantly condensed version of the report, and only extends to General Approach, Results and Conclusions, for brevity.
6	Appendix E best practice options for Eloise Copper Mine tailings dam rehabilitation	Section 1.2.1.2 of Appendix E identifies that the ground cover of the analogue site, ECM6, proposed to replicate the TSF consists of 39.5% of rocks larger than 50mm and 40.5% of green vegetation. The report further recommends that the rock armour will require a planned mixture of rocks of specific size for erosion protection, to replicate visual structure and pattern of the analogue sites and provide sufficient soil matrix to support targeted vegetation. The LEM erosion assessment identifies that a rock cover of 75% is required for effective long term erosion control and further information is required to justify the suitability of the proposed analogue site where the rock cover is 39.5%.	Provide: • additional information that supports the proposed analogue site's ability to be replicated on the TSF with a 75% rock cover; or • propose an alternate PMLU that satisfies the erosion stability requirements identified in the LEM erosion modelling.	The LEM (RFI 5 referencing Appendix I) recommends rock content by volume. The proposed reference site was assessed for rock sizes at the surface by projected cover. These are not equivalent or interchangeable measures. In RFI 5, landform stability is modelled to be stable at 75% functional cover. The proposed rehabilitation reference site has a functional cover of 80% (40.5 + 39.5%). This is well within any construction tolerance and provides an independent validation of the natural stability of the Tailings Dam Cover at the proposed functional cover percentage.

Item	Relevant Section	Matter	Information Request	Response
7	Section 1.4.1.1.1 of the application supporting document	The application proposes to amend Table G2 of the environmental authority (EA) however, Table 5 of the application provided for inclusion in the EA is consistent with Table G1, final land use and rehabilitation and rehabilitation approval schedule and not Table G2 landform design.	Provide an updated table that includes changes to the landform design for inclusion into Table G2 of the EA.	Refer to Appendix D.
8	Section 1.4.1.1.1 of the application supporting document	Table 3 of the application, Amendment to EA Table D2 - TD5 Raise, proposes changes for inclusion into Table D2 Basic Details of Regulated Dams of the EA, with stage 2 identifying that the spill way level will be at 190.6 mAHD and a maximum depth of dam at spillway of 10 m. This is inconsistent with measurements provided in Table D2 of the EA where the current spillway level is lower at 186.5 mAHD however, the max depth of dam at the spillway is higher than proposed at 12 m.	Provide clarification on the depth of TD5 at the spillway and the inconsistencies in the depths proposed in the application.	The natural ground level is ~174.5mAHD. Currently, the maximum depth of the dam at the spillway is 12 m, with the spillway at 186.5 mAHD. That is correct as noted in Table D2 of the EA. The raise will increase the depth of dam at the spillway to 16 m, with the proposed spillway height at 190.6 mAHD.

**Appendix B - Eloise Copper Mine – TD5 Raise – Response to DETSI RFI Memo
(Hydrogeologist.com.au, 2025)**

To: AIC Copper Pty Ltd
Email: Matt Fallon <matt.fallon@aicmines.com.au>
Date: 1 August 2025
Subject: Eloise Copper Mine – TD5 Raise – Response to DETSI RFI

1. Introduction

A groundwater impact assessment (GIA) and associated numerical modelling appendix (the Model Report) were completed for the Eloise Copper Mine (ECM) TD5 raise by hydrogeologist.com.au in 2025. Upon review, the Queensland Department of Environment, Tourism, Science and Innovation (DETSI) have requested further information on several topics discussed in the GIA and Model Report. This memo addresses each of these requests and discusses several updates to the numerical model that were made in response to them.

2. Rainfall recharge

2.1. Matter

The groundwater is assessed to be recharged via precipitation. It is also noted that recharge occurs where the geological unit's outcrop or there is a downward seepage of recharge water from overlaying units. Section 4.5.1 of the report indicates that the historical rainfall with average of 434 mm/yr was applied in the steady state model. The recharge factor was calibrated to a very low rate $1.43\text{E-}07$. This assumes 52.2 mm/yr recharge and equates 12% of the average historical rainfall. However, the recharge rate in both steady state and transient models were considered zero. It is understood that this may be justified by the proposed engineering of a lined tailings storage facility (TSF) which would prevent infiltration. In the absence of any real monitoring data to justify this prediction, precautionary principle would suggest the inclusion of a reduced recharge factor (e.g. due to factors such as partial failure in the lined TSF, cracks or edge infiltration, etc) as opposed to disabling the recharge in the model.

Given that the historical recharge rate is also calculated as per the average rainfall, this is considered suitable for steady state conditions. However, to support the transient simulations or assess a time-sensitive operation such as TSF filling, the assumption of a constant average rainfall/recharge may not adequately reflect the seasonality variability. Particularly, it is evident that strong seasonal recharges occur periodically in shallow alluvium.

2.2. Information request

The following items have been requested:

- a more robust assessment by comparing the key model outputs under both reduced recharge scenario and the disabled recharge scenario;
- an updated transient model that considers the seasonal recharge over time; and
- a revised calibration of the model taking into consideration the above matters, in addition to available seasonal data collected to date.

2.3. Response

2.3.1. Rainfall recharge

Section 4.5.1 of the Model Report states that rainfall was applied at a single rate during the steady state stress period equivalent to the historical average rate of 434.0 mm/year (1.2 mm/day). During transient stress periods, beginning in 1996, corresponding historical rainfall rates were applied as obtained from the Queensland Government's Scientific Information for Land Owners (SILO) database in order to represent recorded seasonal rainfall rates in the model. These historical rates were used in stress periods that coincide with the availability of calibration data (i.e. groundwater levels). When the model date surpassed the current date (and hence the availability of observed data for calibration), quarterly historical rainfall averages were used to represent seasonal variability in rainfall. These quarterly historical rainfall averages were used to matching the modelled quarterly stress periods in the model predictions.

As the percentage of rainfall that infiltrates the ground surface to recharge the groundwater table is always much less than 100%, a recharge factor was calibrated to determine what proportion of rainfall recharges the groundwater table. Due to the fairly uniform nature of the surficial unconsolidated Tertiary sediments and shallow strata, this factor was applied as a single value for the whole model domain and did not use pilot points to introduce heterogeneity into its spatial distribution.

As observed water levels recorded at observation locations across the model domain show little response to rainfall events (and hence groundwater recharge), this recharge factor was previously calibrated to an extremely low value (1.43E-07), limiting the amount of rainfall recharge entering the model.

2.3.2. Recalibration

As requested by DETSI, the numerical model was recalibrated to take into account consideration the above matters, in to include all available data collected to date.

The model was recalibrated using the iterative ensemble smoothing (IES) methodology using PEST++ (an advanced version of PEST). Model parameters recalibrated include the evapotranspiration extinction depth and factor, rainfall recharge factor, TSF conductance factors, and hydraulic properties of each model layer including horizontal and vertical hydraulic conductivity, specific yield, and specific storage.

Pilot point multipliers were also recalibrated in each model layer for each hydraulic parameter. While there is insufficient spatial data of measured hydraulic parameters to generate a representative variogram of each parameter in each layer, it is assumed that the multiplication factors of each pilot point are not statistically independent from each other. For this reason, PEST++ was provided covariance matrices for the pilot points that assists in moving their multiplication factors together, with covariance weakening over distance. This was achieved with the PEST utilities MKPPSTAT and PPCOV_SVA.

Since more groundwater level observations have been recorded in the period since the last model calibration, these more recent groundwater level observations were included in the calibration dataset. PEST++ can also calibrate to dry bores without a specific observed water level. Where a bore has been monitored as dry, the elevation of the bottom of the screened interval was assigned as the calibration target, and PEST++ was informed that the modelled water level should be anywhere beneath that calibration target.

Additionally, in order to represent the groundwater levels' lack of response to rainfall events, the differences between successive groundwater level observations at each bore were also used as calibration data. For example, where a groundwater level remains constant, the successive differences will be around 0.00 m, whereas if a response to rainfall is observed, the magnitude of the difference will be larger. This allows PEST++ to calibrate the model's hydraulic properties in a way that matches both the groundwater level elevations, and their responsiveness to modelled stresses such as rainfall events.

The recalibrated model achieved a SRMS error of 6.8% which is well below the target performance measure of 10% recommended by the Australian Groundwater Modelling Guidelines and demonstrates a very good fit to the groundwater level observations used in the calibration.

Figure 2.1 shows the scatter plot of observed vs modelled water levels. The shallow bores screened in the Tertiary sediments and upper Wallumbilla Formation show a good match, while the deeper bores with water levels below around 130 mAHD show a minor departure from the 1:1 line. The model is therefore considered to be a reliable representation of both the shallow groundwater conditions around the TSF and the deeper groundwater conditions associated with underground mining. However, the primary objective of the numerical model is to simulate shallow groundwater flow processes and impacts associated with the TSF.

As a result of the recalibration, the recharge factor, which was previously calibrated to an extremely low value of $1.43\text{E-}07$ was recalibrated to a value of $7.7\text{E-}04$ (or 0.77% of rainfall). This recalibrated recharge factor is approximately three orders of magnitude higher than the previous calibrated value.

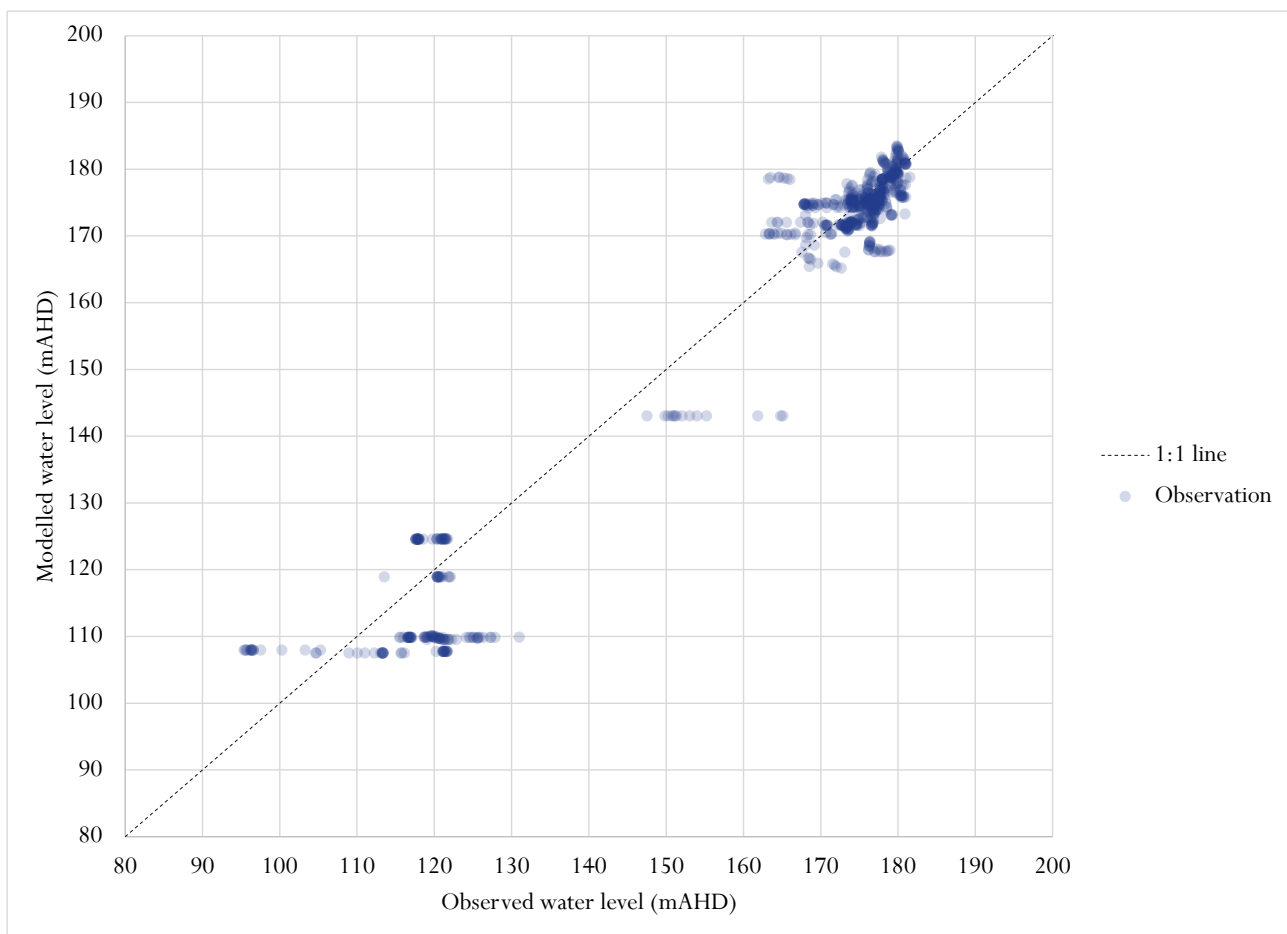


Figure 2.1 Observed vs modelled scatter plot

Water levels

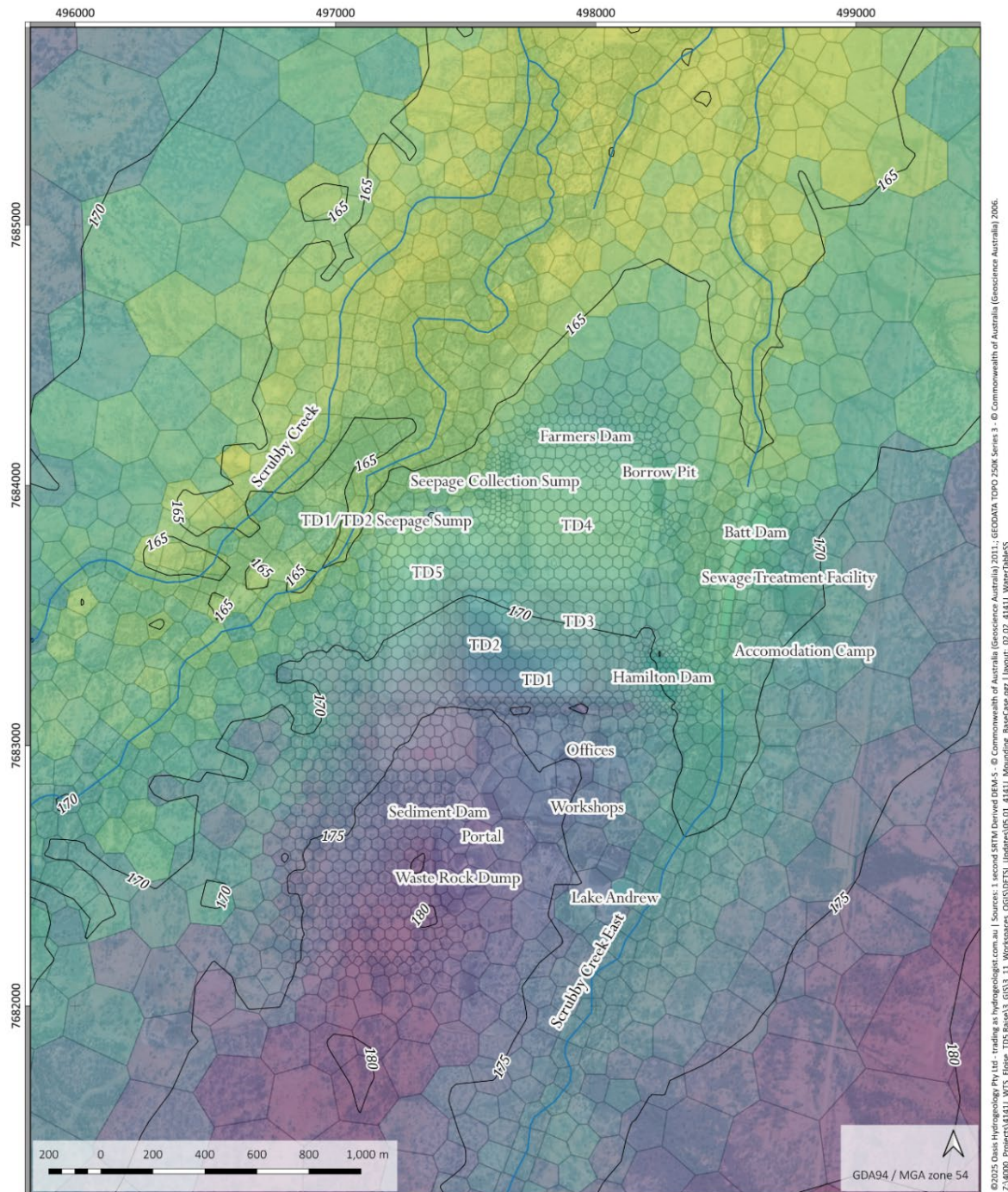
As a result of recalibrating the recharge factor, hydraulic parameters and TSF conductance factors, the water table elevation, and the predicted mounding in response to the TSF has also changed. Figure 2.2 shows the predicted water table elevation in the pre-mining steady state period.

Figure 2.3 shows the predicted mounding in layer 2 (Tertiary sediments) due to the TSF at the end of the mining period (year 2036) and after the 1,000-year recovery period. Figure 2.4 shows the predicted mounding at the same periods in layer 4 (Wallumbilla Formation), Figure 2.5 shows the predicted mounding in layer 6 (Gilbert River Formation) and Figure 2.6 shows the predicted mounding in the water table.

The extent and magnitude of mounding due to the TSF is comparable to that predicted in the GIA prior to recalibration. Predictions show that mounding is anticipated to completely dissipate by the end of the 1,000-year recovery period. The mound is predicted to appear beneath the alluvium and drainage lines of Scrubby Creek, however with the water table modelled at around 15 metres below ground level (mbgl), this mounding is not predicted to express in the bed of Scrubby Creek.

The mounding presented in the figures below is for the ‘cumulative’ case, where the modelled representation of the TSF includes both approved activities and the TD5 raise. These predictions were compared to the ‘approved’ case (i.e. where the TD5 raise was not included in the groundwater model) to represent the incremental project impact due solely to the TD5 raise.

There is no incremental project impact predicted for any of the individual model layers or the water table. Hence there are no figures presented to show this. This lack of project impact is consistent with the results presented in the GIA and is a result of the low seepage rates that occur through the base of the TSF. The combination of the clayey consolidated tailings, compacted clay liners and high density geosynthetic liners restricts the vertical movement of tailings water and its ability to migrate vertically to the groundwater table. Hence, the recalibrated model demonstrates that the TD5 raise does not itself increase or otherwise change the predicted groundwater conditions and mounding that occurs beneath the TSF from approved mining activities.



Water table (pre-mining)

4141J Eloise GIA

- Water level contour (mAH)
- Drainage line
- Model mesh



Figure 2.2

29/07/2025

Figure 2.2 Water table (pre-mining)

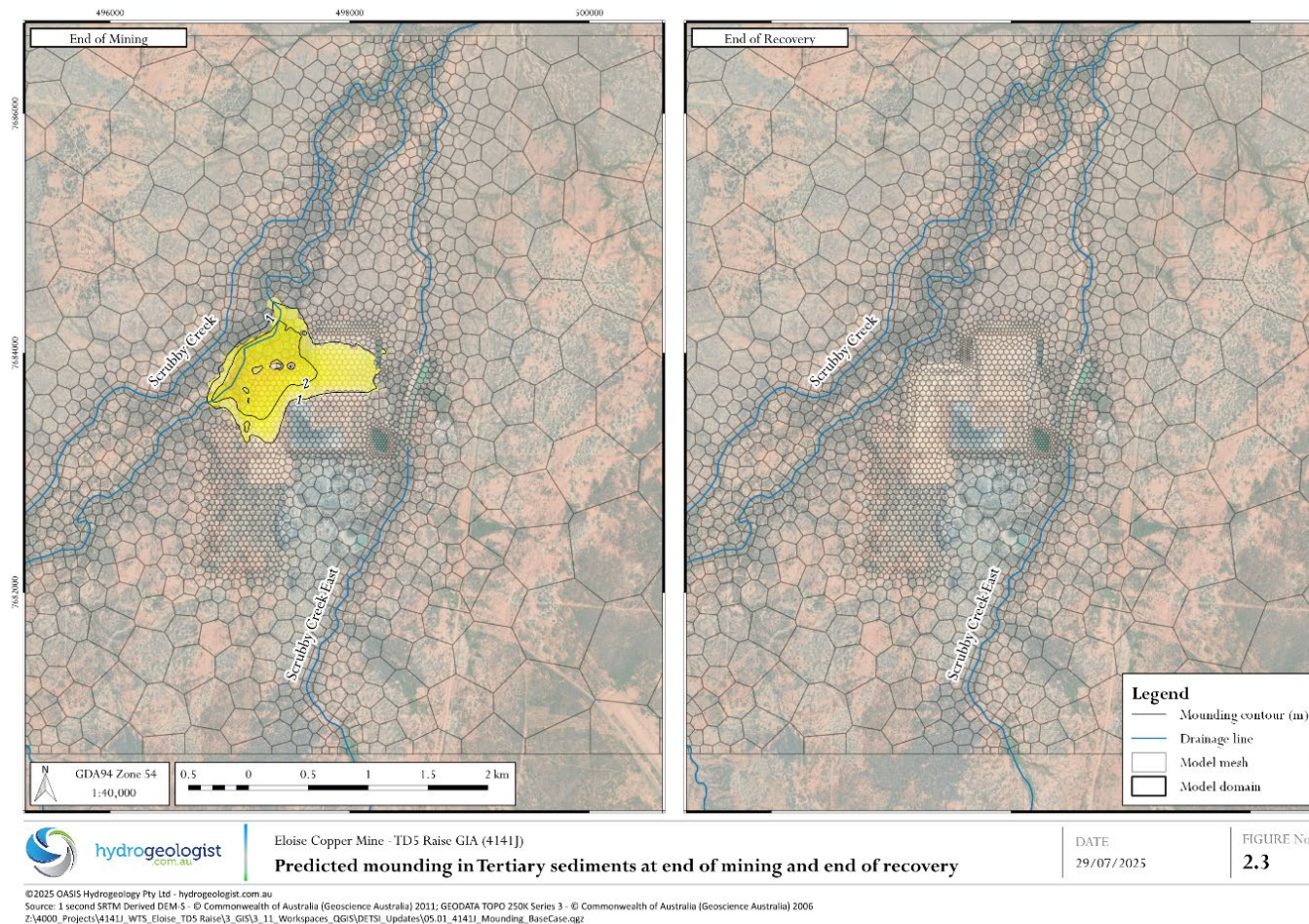


Figure 2.3 Predicted mounding in Tertiary sediments at end of mining and end of recovery

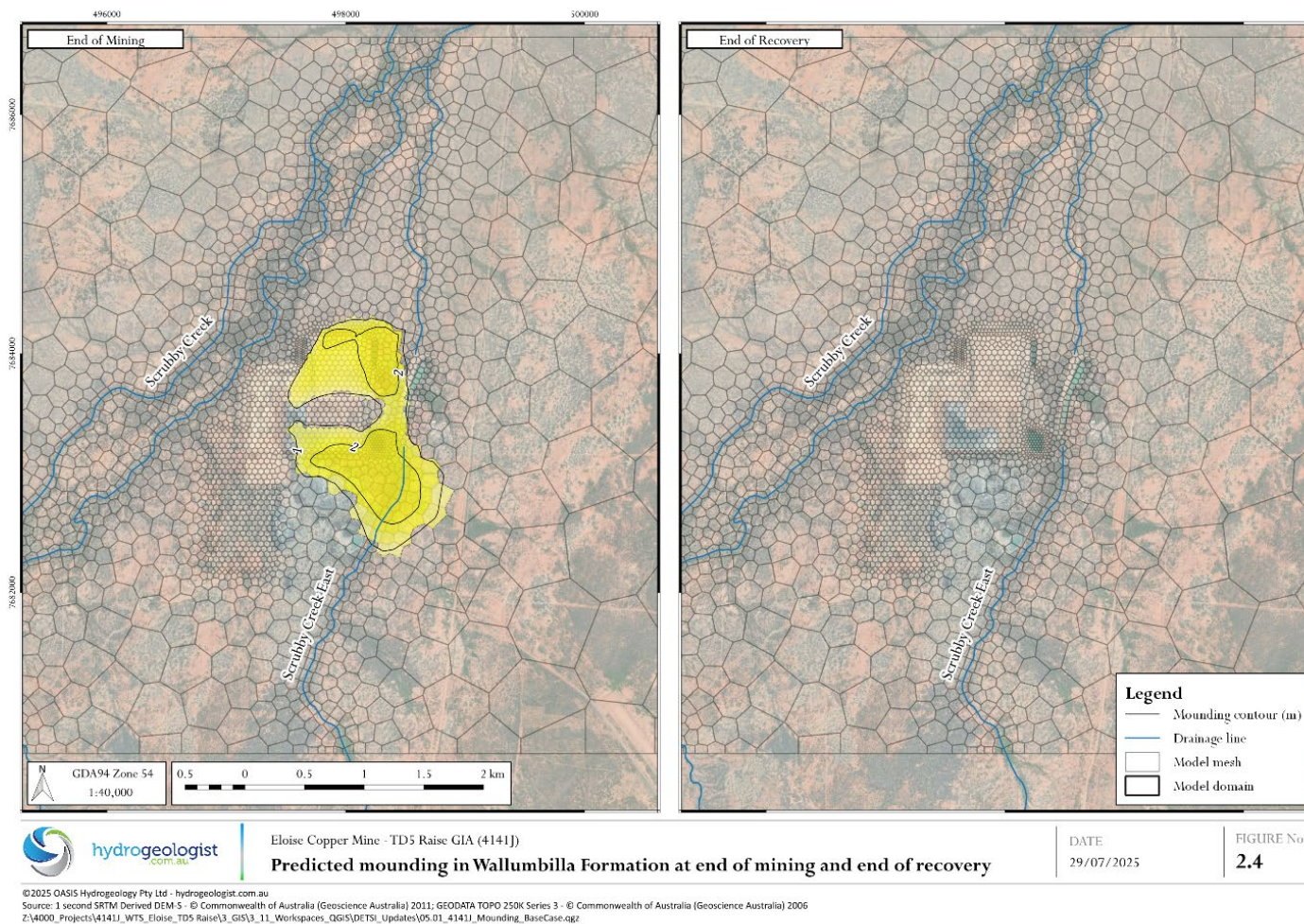


Figure 2.4 Predicted mounding in Wallumbilla Formation at end of mining and end of recovery

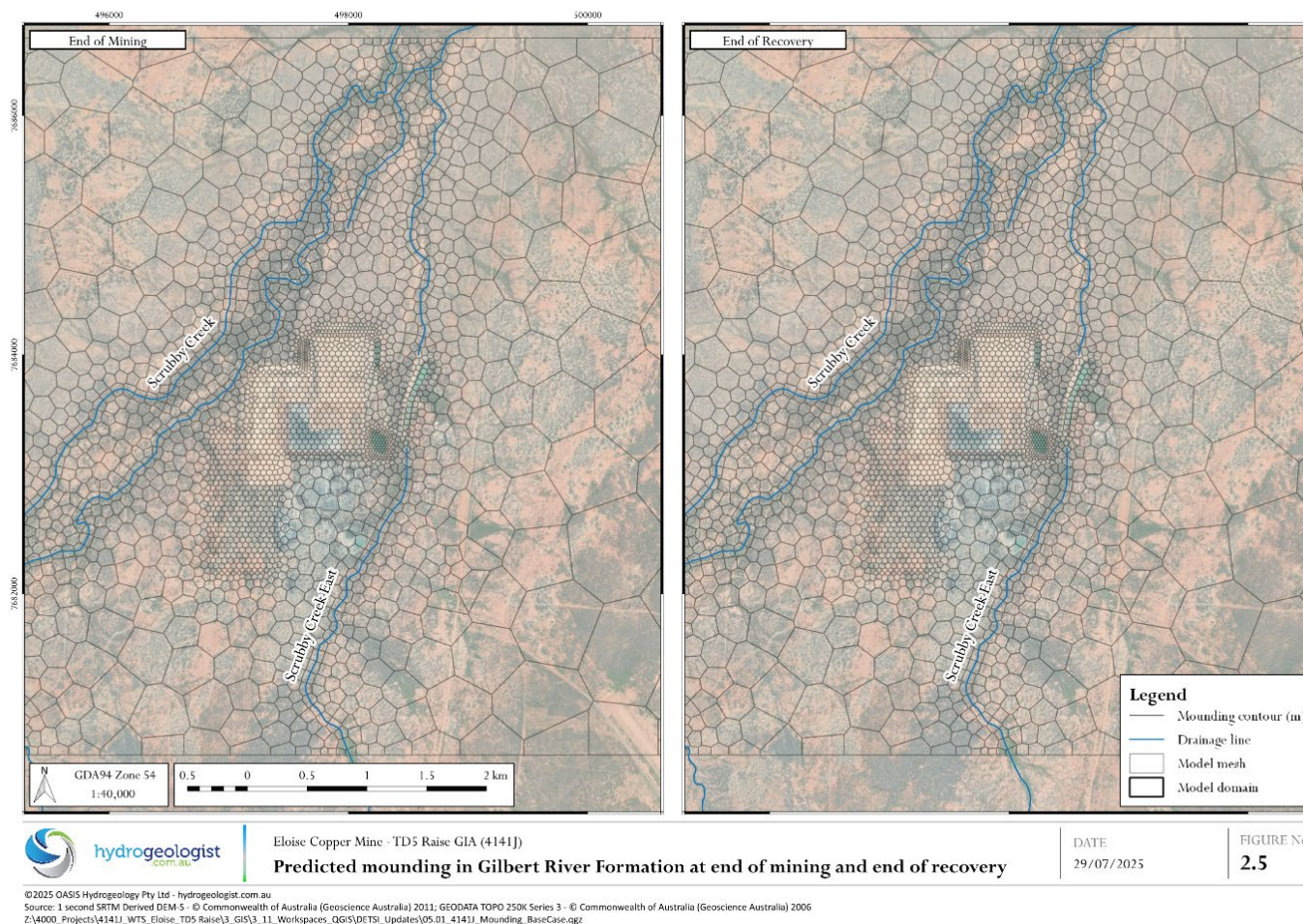


Figure 2.5 Predicted mounding in Gilbert River Formation at end of mining and end of recovery

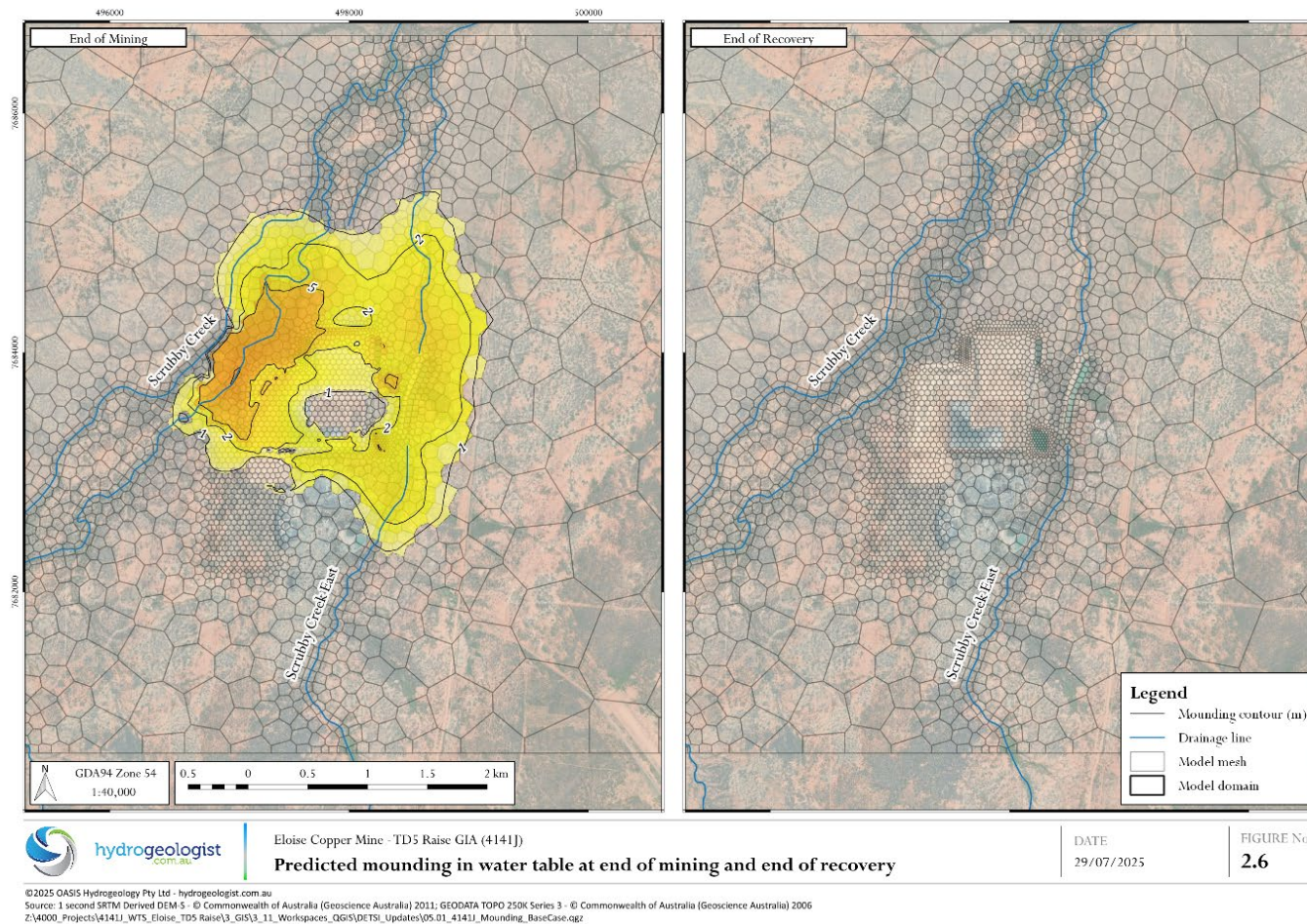


Figure 2.6 Predicted mounding in water table at end of mining and end of recovery

3. Shallow flow paths

3.1. Matter

The report notes there is a likelihood of potential shallow flow path (less than 6 m depth) for seepage offsite. This is despite current TSF conditions and the groundwater mounding beneath the TSF and while the groundwater model does not show any potential surface expression. The predicted likely flow path offsite has not been explored further.

It is noted that no local hydraulic testing has been conducted in the Gilbert River Formation. The yield information is taken from the Eloise Borefield with hydraulic conductivity of 0.6 m/day. The reliability of the data from the neighbouring areas such as the Eloise Borefield without an assessment of the input/s questions the predictions of the model. For example, it is not clear how far the subject bore/s from the Eloise Borefield are compared with the TSF areas (i.e. a few kilometres assumed based on the registered bores). For a site-specific model, site -specific inputs are expected, unless there is strong evidence that the formation continuity has not changed between the site and the Eloise Borefield and there are plans for site-specific testing in the target formations.

The report states that the drawdown and depressurisation within the Gilbert River Formation and Proterozoic basement were locally caused by the mining activity. Deep water levels are anticipated to be reduced due to the dewatering and water supply pumping. This suggests that the hydraulic conductivity within both formations may have been locally influenced.

3.2. Information request

The following items have been requested:

- details (e.g. direction, distance, rate, etc.) of the predicted flow path for seepage offsite; and
- justification for no surface expressions despite likelihood of shallow seepage flow path.

3.3. Response

Figure 3.1 shows the modelled depth to the water table in 2036, the final stress period of the model at the completion of mining. This modelled depth to the water table has been generated using the recalibrated model as discussed in Section 2 above. The depth to the water table contours are limited to those less than or equal to 20 mbgl for clarity. Note that this is calculated with the landform of the TSF included in the topographic surface, so the depth to water table appears greater beneath the elevated terrain of the TSF. This is also visible at the underground portal, which shows that constant dewatering has drawn down the water table at that location.

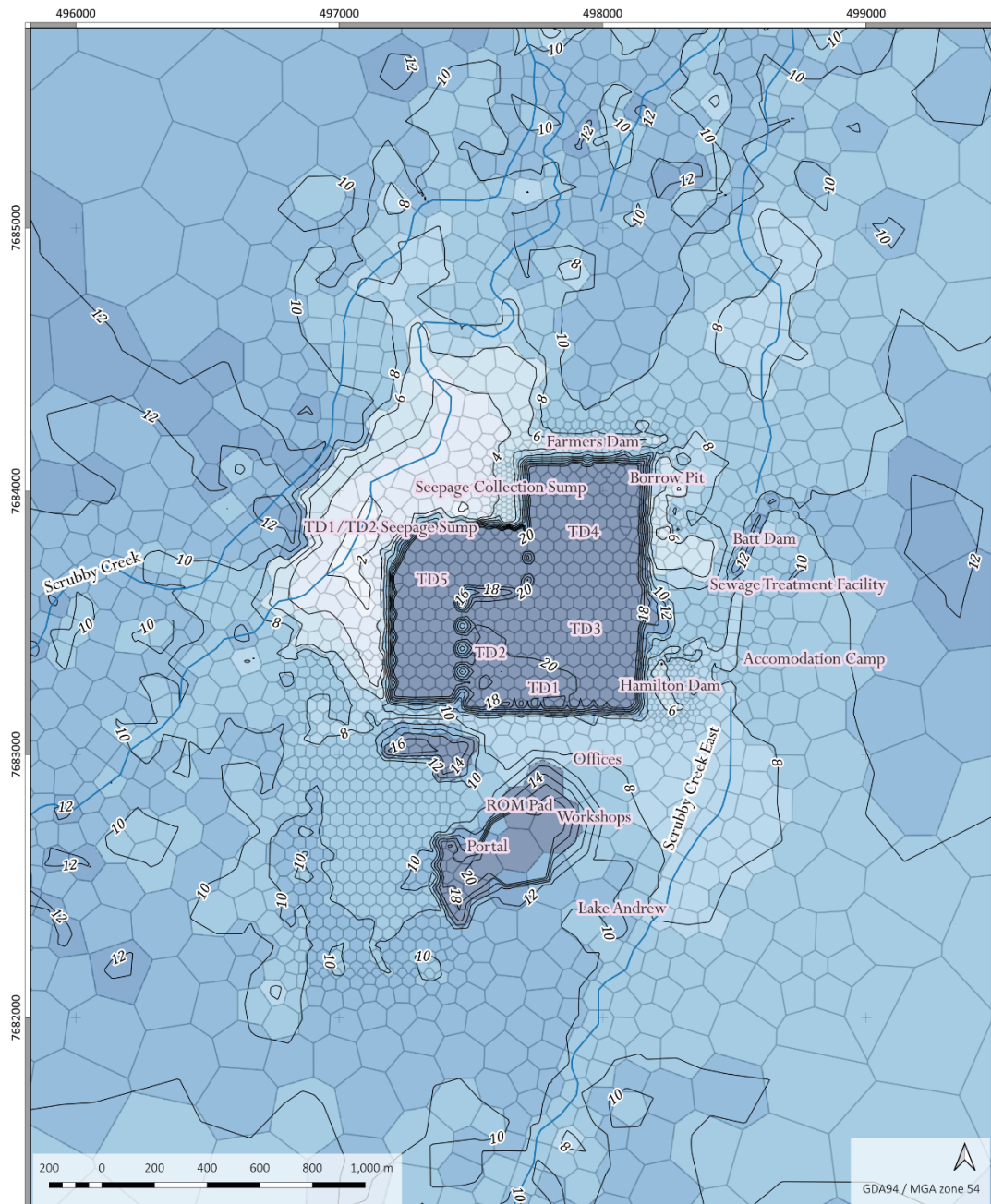
The figure shows that mounding of the water table (discussed in Section 0) can reach within 2 m of the ground surface in the north-west corner of TD5 which is around 80 m from Scrubby Creek. The potential for surface expression at this location therefore exists, however the source of the water is highly likely to be upwelling of native groundwaters as a pressure response to hydraulic loading from the TSF.

It is important to note that the design and construction of TD5 includes excavation of the structure into low permeability strata, the installation of low permeability liners and barriers, and the installation of underdrainage and seepage interception infrastructure to minimise potential seepage. Hence, the potential for seepage at this location to be directly emanating from the TSF is extremely unlikely.

To assess the source of the mounded water around the TSF, particle tracking was performed using the MODFLOW-USG compatible software mod-PATH3DU¹. This particle tracking was carried out on the recalibrated model described in Section 2 above. Particles were ‘spawned’ in a regular grid with 200 m spacing around the perimeter of the TSF and seepage collection ponds. They were placed in model layer 2 (Tertiary sediments) halfway between the top and bottom of the model cell and were released on day one of the model (January 1996). Particles flowed on paths calculated from the MODFLOW-USG cell-by-cell flow file (CBB). Each layer of the model was assigned a porosity derived from the average specific yield (Sy) of that layer. Particles were allowed to terminate if they encountered drain cells (i.e. the underground portal and the drainage lines of Scrubby Creek and Scrubby Creek East).

Figure 3.2 shows the start and end points of each particle as well as the flow path for each particle. Most particles showed very little lateral movement, but movement can be seen in particles that were drawn into the underground portal, and there is some minor movement toward the mounding north-west of TD5. However, the path lines of those particles have insufficient length to have originated from seepage water from the TSF and are therefore considered to represent movement of waters upwelling into the Tertiary sediments from the Wallumbilla Formation due to hydraulic loading of the TSF.

¹ S.S. Papadopoulos and Associates, Inc., (SSP&A). 2020. User’s Guide for mod-PATH3DU, a Groundwater Path and Travel-Time Simulator. Available at: <http://mp3du.sspa.com/man/>



Depth to water table at end of mining

4141J Eloise GIA

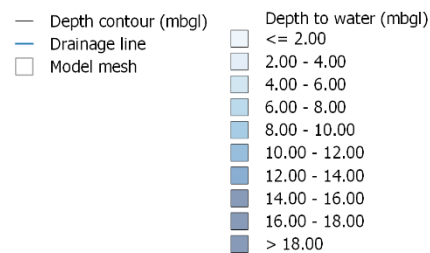
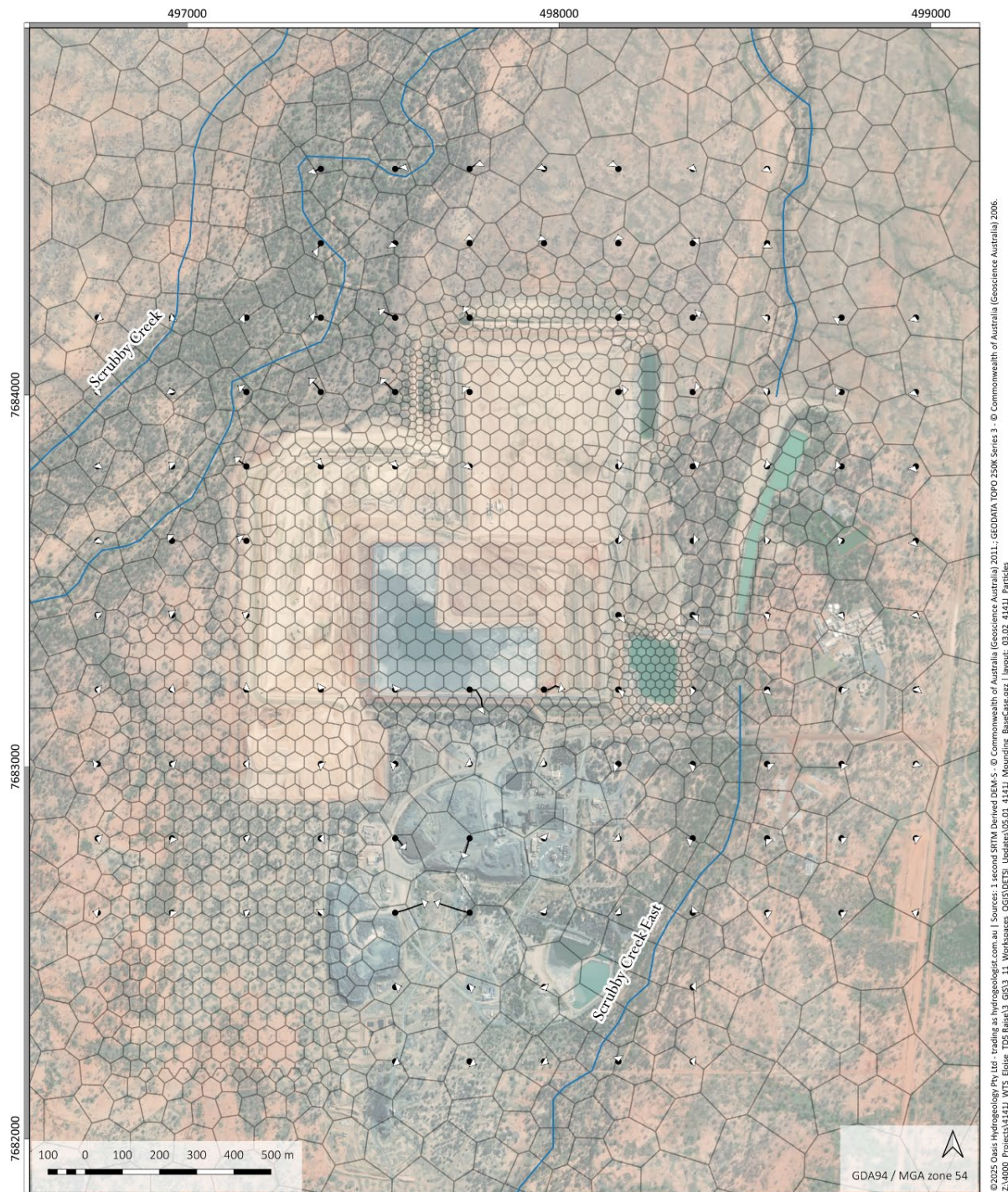


Figure 3.1

30/07/2025

Figure 3.1 Depth to water table at end of mining



© 2025 Oasis Hydrogeology Pty Ltd - trading as hydrogeologist.com.au | Sources: 1 second SRTM Derived DEM-S, © Commonwealth of Australia (Geoscience Australia) 2011; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006. Z:\4000_Projects\4141J_WTS_Eloise_TD5_Raise\3_05\3_11_Workspaces_QGIS\DETSI_Updates\05.01_4141J_Mounding_BaseCase.qgz | layout: 03.02_4141J_Particles

Tertiary sediments particle path lines until end of mining

4141J Eloise GIA

-  Particle path line
-  Drainage line
-  Model mesh

Figure 3.2

31/07/2025

Figure 3.2 Tertiary sediments particle path lines until end of mining

4. Gilbert River Formation

4.1. Matter

It is noted that no local hydraulic testing has been conducted in the Gilbert River Formation. The yield information is taken from the Eloise Borefield with hydraulic conductivity of 0.6 m/day. The reliability of the data from the neighbouring areas such as the Eloise Borefield without an assessment of the input/s questions the predictions of the model. For example, it is not clear how far the subject bore/s from the Eloise Borefield are compared with the TSF areas (i.e. a few kilometres assumed based on the registered bores). For a site-specific model, site -specific inputs are expected, unless there is strong evidence that the formation continuity has not changed between the site and the Eloise Borefield and there are plans for site-specific testing in the target formations.

The report states that the drawdown and depressurisation within the Gilbert River Formation and Proterozoic basement were locally caused by the mining activity. Deep water levels are anticipated to be reduced due to the dewatering and water supply pumping. This suggests that the hydraulic conductivity within both formations may have been locally influenced.

4.2. Information request

The following items have been requested:

- how the hydraulic conductivity inputs across various formations in the site has been verified;
- how was uncertainty in the hydraulic parameters accounted for in the model;
- in the absence of local testing, how the range of variability considered in the model; and
- how this was qualified in terms of the potential impacts on the model predictions.

4.3. Response

Model layer 6 previously represented the combined highly productive conglomerate aquifer of Gilbert River Formation and the unproductive metasediment and igneous Proterozoic basement. The decision to combine them was made due to the depth and disconnection of those deep hydrostratigraphic layers, and the primary objective of the numerical model to simulate shallow groundwater flow processes and impacts associated with the TSF. Model layer 6 has now been reduced to a constant 1 m thickness to represent the Gilbert River Formation across the whole model domain, and a new layer 7 has been added beneath to represent the Proterozoic basement.

The parameter values for the Gilbert River Formation are based on pumping test analysis from the borefield, which is only 3 km to the east of the TSF. Historically local dewatering bores have been operated within the mine area which suggests a relatively high degree of permeability would persist in the Gilbert River Formation beneath the TSF and mine area. Unfortunately, no local hydraulic parameters are available for these bores. While the thickness of the Gilbert River Formation is understood to be thinner within the model domain, no reasons are known to assume its hydraulic properties would be significantly different over that distance.

The new Gilbert River Formation model layer was included in the recalibration (see Section 2), including the use of pilot points for each parameter constrained by covariance matrices. Uncertainty in the hydraulic properties was accounted for by allowing the calibration to explore a range of layer-wide base values for each model layer and then allowing pilot points to multiply that value individually within a range of 0.1 and 10. The minimum and maximum base values used in the calibration process for the Gilbert River Formation are presented in Table 4.1 Of interest is that even though the maximum base Kh was set to 0.6 m/day, pilot points brought that value up to an average of 2.28 m/day across the model layer, meaning that a high horizontal conductivity achieved the best fit to observed water levels.

Table 4.1 **Gilbert River Formation hydraulic parameters**

	Kh (m/day)	Kv:Kh	Sy	Ss (m⁻¹)
Base value minimum	6.00E-03	1.00E-02	1.00E-04	1.00E-07
Base value maximum	6.00E-01	1.00E+01	1.00E-01	6.00E-06
Calibrated average value	2.28E+00	4.32E-01	6.06E-02	2.10E-07

Whilst variability in the model predictions themselves could be explored with a full calibration-constrained uncertainty analysis, there is no State guideline requirement to do this. Section 7 of the GIA provided sensitivity analysis for the model predictions which was justified given the lack of project related impact.

The model has been calibrated (and recalibrated) to a long groundwater level monitoring dataset (approaching 30 years of data from 1996) and on both occasions the numerical model predicts that there is no incremental impact to groundwater from the project. The groundwater level mounding that is predicted by the numerical model is entirely associated with approved mining activities. Hence, the current monitoring and mitigation strategies outlined within the current EA are suitable and appropriate.

5. Closure

We thank you for your time in reviewing the ECM GIA and Model Report and hope the information provided in response to your requests is adequate.

If you have any queries, please do not hesitate to call on mobile: **0477 744 463**.

Yours faithfully,



Daniel Barclay
Principal Hydrogeologist


**Appendix C – Eloise Copper Mine TD5 Erosion and Landform Evolution Assessment
(Okane Consultants, 2025)**

Eloise Copper Mine TD5 - Erosion and Landform Evolution Assessment

28 February 2025



Eloise Copper Mine

TD5 - Erosion and Landform Evolution Assessment

B-0761-220-011

28 February 2025

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0	Final	Feb 28, 2025	H Cunningham	M Barteaux	-

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EXECUTIVE SUMMARY

Okane Consultants Pty Ltd (Okane) was engaged by AIC Mines Limited (AIC) to evaluate the TD5 tailings storage facility (TSF) closure design at the Eloise Copper Mine (ECM) located in North Queensland. A lift to TD5 is currently being designed and assessed to support an Environmental Authority amendment application. Part of the application is to provide a revision of the existing ECM Progressive Rehabilitation and Closure Plan (PRCP).

This report includes the requirements for this application in accordance with the Department of Environment, Science and Innovation (DESI) guidelines (Queensland Government, 2023). Specifically, this report covers a 2D slope erosion assessment, erosion (flume) testing, 3D landform evolution assessment, and surface water / drainage assessment.

The numerical modelling of slopes indicated that the soils from the designated borrow area are erodible, this finding was supported by physical experimentation (flume testing). These materials are not suitable for the steep embankment slopes (33%) due to the high risk of erosion; however, the shallower plateau surface (1-2% slope) is expected to be less susceptible to erosion. To achieve desired performance targets on the slopes (less than 10 t/ha/yr), the soils will require a mix of competent rock. It is estimated that ~75% rock (by volume) is required. For the purposes of this evaluation vegetation coverage was assumed to be negligible (bare surface / 0% vegetation coverage), due to the coarse nature of the materials, steep slopes and dry climate. Over time, vegetation establishments would be expected to improve the long-term erosional stability of the embankment slopes.

A key aspect in mitigating erosion on the embankments is proper drainage of the plateau surface. A central swale is proposed along the plateau surface to collect and convey surface waters safely off the facility to the south, using the access ramp. This requires all areas of the plateau to be graded centrally and to the south. The ramp/channel structure will require robust armour to resist scour velocities in the adopted design storm event (1 in 1000 AEP, 24-hour event).

Okane recommends erosion monitoring following construction. Erosion monitoring can be linked with a trigger-action-response plan to identify any remedial actions should the monitoring identify higher than expected erosion. Remedial actions typically cover (for example) reshaping strategies, placement of armour and/or vegetation of affected areas.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Meaning
2D	Two-dimensional
3D	Three-dimensional
d50	Mean particle size
AEP	Annual exceedance probability
AIC	AIC Mines Limited
ATCW	ATC Williams Pty Ltd
Aquaterra	Aquaterra International Pty Ltd
BoM	Bureau of Meteorology
EMC	Eloise Copper Mine
LEM	Landform evolution modelling
ML	Mining Lease
Okane	Okane Consultants
PCRP	Progressive Rehabilitation and Closure Plan
SILO	Scientific Information for Land Owners
TD	Tailings dam
TSF	Tailings storage facility
WEPP	Water Erosion Prediction Project

1 INTRODUCTION

Okane Consultants Pty Ltd (Okane) was engaged by AIC Mines Limited (AIC) to evaluate the TD5 tailings storage facility (TSF) closure design at the Eloise Copper Mine (ECM) located in North Queensland. The ECM mining area is located approximately 55 km southeast of Cloncurry and 48 km northwest of McKinlay in North Queensland on Mining Lease (ML) 90064, ML 90080, ML 90086 and ML 90155. The mine is an underground operation with a conventional TSF to manage tailings and is designed with various tailings dams (TD) to separate the facility into four cells (TD1/2, TD3, TD4, and TD5).

A lift to TD5 is currently being designed and assessed to support an Environmental Authority amendment application. Part of the application is to provide a revision of the existing ECM Progressive Rehabilitation and Closure Plan (PRCP). This report includes the requirements for this application in accordance with the Department of Environment, Science and Innovation (DESI) guidelines (Queensland Government, 2023). Specifically, this report includes results from Landform evolution modelling (LEM), and erosion assessment study.

1.1 Project Objectives and Scope

The objective of this study is to confirm the TD5 landform design meets AIC's mine closure objectives, with respect to erosional stability, and to satisfy DESI requirements for PRCP development. The scope of work involved the following tasks:

- Conduct materials erosion testing (flume testing) to determine specific erodibility parameters for the material units expected to be used as cover system material.
- Conduct erosion modelling, to support design-related tasks.
- Conduct landform evolution modelling to assess 3D designs and performance against key erosion criteria.
- Conduct surface water modelling to support the design of the TD5 grading and channel designs.

The overarching objective of the study is to support the development of a closure design that is safe stable and non-polluting using best-practice erosion and landform evolution models.

1.2 Report Organisation

For convenient reference, this report is subdivided into the following sections:

- Section 1 – introduction
- Section 2 – provides pertinent background information for this study.
- Section 3 – describes the general approach.

- Section 4 – provides details and results of the erosion assessment
- Section 5 – provides details and results of the LEM
- Section 6 – drainage and scour assessment results
- Section 7 – provides conclusions and discussion
- Section 8 – references.

2 BACKGROUND

Okane (2024) completed a background review and gap analysis for TD5 closure in support of the overall TD5 PRCP design project. This section summarises pertinent background information, relevant to the erosion and LEM assessments presented herein.

2.1 Previous Erosion Assessments

ATC Williams Pty Ltd (ATCW) previously completed erosion modelling using the Water Erosion Prediction Project (WEPP) model (ATCW, 2024). The erosion assessment evaluated the average annual erosion rates of the cover system for a range of TD5 plateau and embankment slope configurations.

As part of that study, the acceptable annual average erosion rate was developed using CSIRO Land and Water Technical Report 13/01 (CISRO, 2001). CSIRO (2001) estimated annual soil loss rates for Australia using the RUSLE method (Renard et al., 1997). The soil loss estimates within the area of ECM were classified as 10 to 20 t/ha/yr and therefore ATCW (2024) set an average annual acceptable erosion rate of less than 20 t/ha/yr.

The WEPP modelling conducted by ATCW (2024), was based on the following:

- Climate data: Bureau of Meteorology (BoM) Scientific Information for Landowners (SILO) drill data was used to generate a 100-year synthetic climate dataset in the CLIGEN stochastic weather generator.
- Two-dimensional (2D) hillslope geometry: The model geometry for the plateau evaluated consisted of 0.5% grade for a 600 m length. The steeper embankment model geometry evaluated existing (1V:2H for approximately 55 m length) and reshaped (1V:3H for approximately 83 m length) slopes.
- Ground cover: bare (0%) to 100% vegetation coverage.
- Soil properties: Material data from test pits were used to develop soil property inputs (Table 2.1).

Table 2.1: Summary of WEPP Material Inputs from ATCW (2024)

Layer	Thickness	% Sand	% Clay	% Organics	CEC	% Rock
1	100 mm	44.8	18.8	1.0	6 meq/100g	21.5
2	900 mm	43.3	16.0	1.0	6 meq/100g	21.0

Results of the modelling indicated erosion rates for the plateau ranged from 0.5 to 1.2 t/ha/yr for vegetation cover of 0 to 40%. Whereas the existing and reshaped slopes experienced greater erosion rates of 39 to 157 t/ha/yr and 38 to 101 t/ha/yr, respectively. Shortened slope lengths were recommended in an exercise to achieve acceptable erosion rates (< 20 t/ha/yr).

2.2 Cover System and Embankment Materials

Material sampling and laboratory testing was completed to inform on design work for TD5 (ATCW, 2022). The field investigation was completed within the TD5 footprint. Laboratory testing was conducted on materials representative of those encountered within the investigation area (ATCW, 2022). Material testing of interest for this scope of work included particle size distribution by sieve and hydrometer and Emerson class.

Limited material properties are available for the topsoil and cover system materials. Generally, the particle size distribution for the borrow material and topsoil indicate the materials are similar in texture (Figure 2.1). The materials included a high proportion of sand (45 to 83%), clay and silt (6 to 48%), and gravel (0 to 41%).

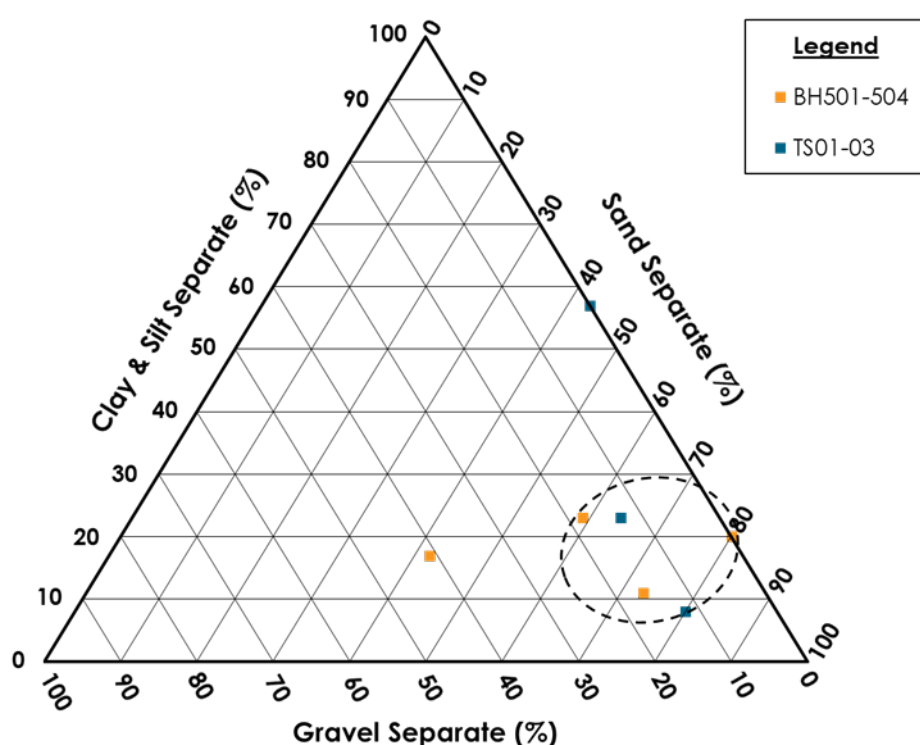


Figure 2.1: Ternary plot showing material textures of topsoil and cover system material from ATCW (2022).

Emerson class testing was completed for the topsoil and cover system material samples and ranged between 3 and 4 (Table 2.2).

Table 2.2: Summary of Emerson Class Number results for topsoil and cover system material from ATCW (2022)

Sample ID (sampling depth)	BH503 (1.00-1.45 m)	BH504 (0.0-0.3 m)	TS01 (0.0-0.3 m)	TS02 (0.0-0.3 m)	TS03 (0.0-0.3 m)
Emerson Class No.	4	4	3	4	4

2.3 Climate

The climate data required for WEPP modelling was generated from Bureau of Meteorology (BoM) weather stations using Scientific Information for Land Owners (SILO) drill data for the site location. Based on the Köppen-Geiger climate classification system (Peel et al., 2007), the region is classified as an arid hot steppe climate (BSh), with characteristic high evaporation and low rainfall.

The climate dataset generated for the soil-plant-atmosphere modelling (Okane, 2025) was used to generate the synthetic climate dataset for the WEPP modelling. The dataset ranges from January 1974 to December 2023 with average annual precipitation of 435 mm/yr and average annual potential evaporation of 2,261mm/yr.

Table 2.3: Monthly averages for the 50-year (1974 to 2023) synthetic historical climate dataset

Month	Precipitation (mm)	Air Temperature		Radiation (I/d)
		Min	Max	
January	127	24	37	586
February	104	24	36	574
March	53	22	36	548
April	11	19	33	490
May	9	14	29	420
June	10	11	26	393
July	9	9	26	419
August	3	11	28	490
September	5	15	33	558
October	17	19	36	616
November	32	22	38	632
December	56	24	39	625
Annual Average	435	18	33	529

Bureau of Meteorology (BoM) rainfall intensity-frequency-duration (IFD) charts illustrate the relationship of probability of various rainfall depths and durations associated with individual storm events. The IFD relationship for Eloise mine is indicated in Figure 2.2.

The surface water assessment described in Section 6 utilises the 1 in 1000 annual exceedance probability (AEP), 24-hr duration event. This event is identified by the yellow star on Figure 2.2.

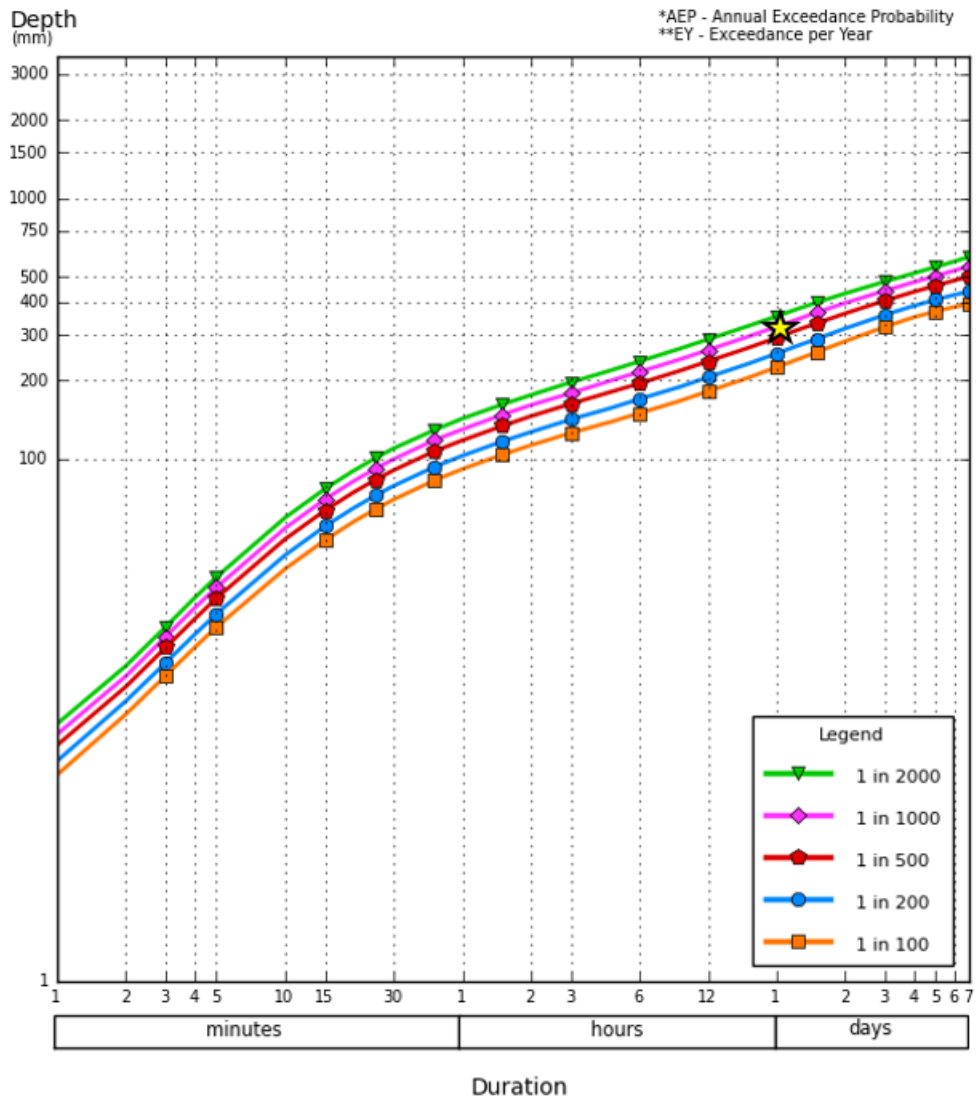


Figure 2.2: Rainfall IFD relationships for 'Rare' events – Eloise Mine.

3 ASSESSMENT METHODOLOGY

3.1 General Approach

The study was conducted in four parts to support a comprehensive, technical evaluation of erosion landform evolution and scour. The four technical assessments are summarised in the following subsections. Sections 4, 5 and 6 provide details of the slope assessment, landform evolution assessment, and scour assessment, respectively.

3.1.1 Slope Assessment

A two-dimensional (2D) slope assessment was developed using the WEPP model to predict erosion for the TD5 embankment and plateau slopes. WEPP provides the capacity to rapidly assess different combinations of slope length and gradients to provide prediction of erosion rates. The modelling integrated:

- Physical characteristics of the borrow materials,
- Slope geometry of plateau and embankment areas (2D),
- Vegetation conditions (bare surface assumed), and
- Site-specific rainfall, by applying a daily climate sequence (50-year).

Results of erosion predictions for the bare surfaces were subsequently scaled to evaluate the surface cover (rock content) required to meet erosion objectives (refer to Section 3.2). The modified materials were assumed to be created by adding competent rock (coarse gravel / cobble size fractions) to the soil.

A full description of the 2D erosion assessment is presented in Section 4.

3.1.2 Erosion (flume) testing

An erosion flume was used for the testing and development of a calibrated model. The flume tests provide an empirical approach to establish relationships relating rainfall, surface water runoff, slope gradients with erosion. Importantly, the flume testing enables the calibration of key erosion parameters used in the SIBERIA LEM (refer to Section 5).

The testing was completed on a bulk clayey soil sample from the future borrow area. The sample was collected by AIC and was independently tested by Aquaterra International Pty Ltd (Aquaterra) to determine erosion parameters for use in the SIBERIA model.

To facilitate the testing, bulk (200 L) sample of waste was collected by AIC site personnel. The material was selected to be representative of unmodified cover material. Two erosion tests were completed, one at 5% gradient and one at 35% gradient to evaluate the effect of slope gradient on erosion.

The flume testing report is provided as Appendix A. Refer to Section 5 for the key input parameters used in the SIBERIA modelling.

3.1.3 Landform Evolution Assessment

A three-dimensional (3D) landform evolution assessment was completed using the SIBERIA landform evolution model, developed from the flume testing and the WEPP modelling. The LEM was applied for a 100-year period of assessment to evaluate erosion rates and depths on the TD5 design. The LEM uses the 3D design geometry and was used iteratively to test and refine the design until a suitable design was developed.

The flume testing was used to assess the unmodified materials scenarios and the WEPP modelling was used as a basis for assessing modified materials. The LEM was then used to determine suitability of both modified and unmodified soils, based on the outcomes of the LEM.

The landform evolution assessment is presented in Section 5.

3.1.4 Drainage and Scour Assessment

A surface water model was complete to evaluate surface water runoff rates from the top surface and to provide channel specifications for the design rainfall event. A 1 in 1000-year, 24-hour event was adopted for the drainage and scour assessment.

The assessment is presented in Section 6.

3.2 Performance Framework

Okane has adopted an erosion risk classification framework (Table 3.1) to characterise and benchmark the results of the assessment. This has been used to align with the objectives for safe, stable, non-polluting landforms. The classifications use erosion rates as well as the depth of erosion (which varies across the landform) as follows:

- Erosion rates are reported separately for embankment areas and plateau areas given the distinct difference in slope and catchment characteristics of these areas.
- The eroded depth indicates how deep into the cover profile erosion develops and uses a percentile metric to describe how much of the cover is affected. The 99th percentile erosion depths are used herein for assessing the performance, this means that over 99% of the cover system erodes to a depth less or equal to the reported value.

A 'Low' erosion target erosion classification is recommended and has been adopted for the purposes of design appraisal.

Table 3.1: Proposed erosion classification matrix.

Erosion Risk Classification	Erosion Rate (t/ha/yr)	99 th Percentile Depth (m)	Description
Very Low	< 1	< 0.2	Negligible impact on TSF cover system functionality; erosionally stable.
Low	1 to 10	0.2 to <0.5	Cover systems are stable and maintain effective thickness. Erosion rates are conducive to vegetation establishment and trending towards an inherently erosionally-stable surface. Minor erosion features (rills) forming sporadically over the surface, with minor sediment-related impacts to environmental receptors. Cover systems a TSF is trending to an erosionally stable surface.
Moderate	11 to 25	0.5 to <1.0	TSF is generally stable with limited adverse effect on overall cover system functionality; some rilling and gully development, with certain areas potentially requiring minor remedial earthworks repairs to prevent worsening.
High	26 to 50	1.0 to <1.5	Material losses adversely affect the efficacy of the cover system and will appreciably limit design life of the cover system (without maintenance).
Very High	> 50	1.5 and greater	Substantial material loss from the cover system; integrity of the TSF landform is compromised in short-medium timeframes, and substantial earthworks and revegetation strategies are required for remediation, with potentially adverse impacts to receiving waters.

4 SLOPE ASSESSMENT

4.1 WEPP Model Description

The WEPP model is a process-based, continuous simulation tool developed by the United States Department of Agriculture to predict soil erosion from hillslopes and small watersheds (Flanagan & Nearing, 1995). WEPP integrates inputs such as climate data, soil properties, topography and land management practices. It then simulates key erosion processes, such as rainfall detachment, runoff generation and sediment transport to provide temporal estimates of soil loss and deposition.

Erosion modelling was completed with the WEPP model, as a first step. It was used to estimate the rate of erosion along the benched TD5 embankment profile (maximum height section used) as well as a range of other single-slope configurations representing a range of embankment and plateau slopes.

4.2 WEPP Model Inputs

The inputs required for the WEPP model include:

- Climate data
- 2D hillslope geometry
- Soil properties
- Ground cover

Each specific input is discussed in more detail in the following sections.

4.2.1 Climate Data

A 50-year climatic sequence was developed to represent location specific climatic conditions for model input. This includes daily precipitation and details (duration, time to peak, and intensity at peak), air temperature, radiation, and wind speed and direction, etc. The 50-year synthetic sequence covers the period 1974 to 2023, developed using CLIGEN stochastic weather generator with data inputs from the BoM SILO drill data (Long: -20.95, Lat: 141.00) (CSIRO, 2001).

4.2.2 Geometry

The WEPP model was used to assess various slope configurations, to predict erosion for a range of embankment and plateau areas – enabling selection of preferred angles for design purposes.

- The plateau was modelled with slope gradients ranging from 1.0% to 2.0% with horizontal slope lengths of 100 m to 200 m.

- The embankments were modelled to align with the desired (33%) slope and height of the landform, which varies. The modelled range includes heights of 10m to 33m in height (30 m to 100 m in length, respectively).
- A benched embankment profile was also assessed, which includes the standard 33% embankment slopes and a 10m wide bench (Figure 4.1). This profile supports a second lift to facilitate surface water drainage of the plateau area. In 3D, the profile varies and the most conservative 2D section as been used for the WEPP assessment. Results of this modelling were used to facilitate calibration of the LEM (described in Section 5).

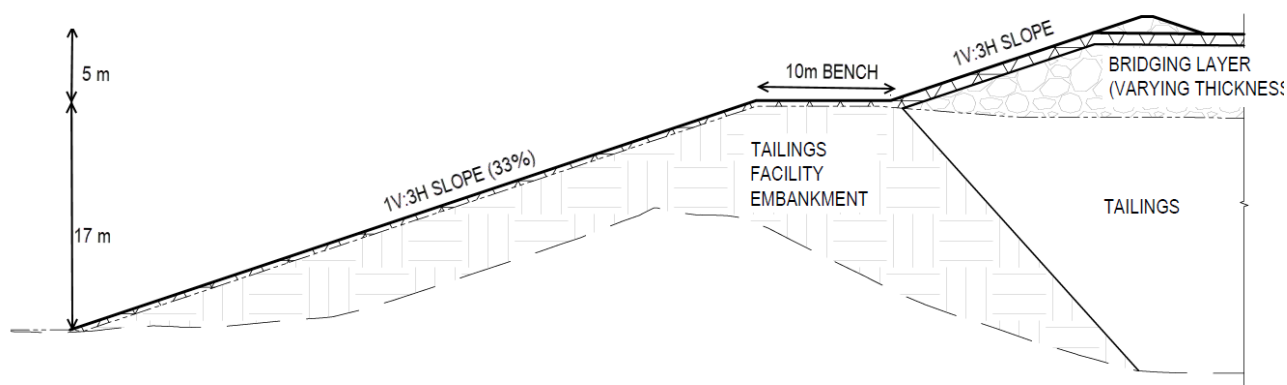


Figure 4.1: Benched profile

4.2.3 Materials

The material inputs were developed using available physical characteristics and are representative of the average borrow material texture (refer to Section 2.2). The embankment clay was also modelled (Table 4.1), for the purposes of comparison, though the borrow materials have been used as the primary material considered for use. .

Table 4.1: WEPP Material Inputs

Parameter	Description	Borrow Materials	Embankment Clay
Clay (%)	The clay content is used to estimate soil parameters such as bulk density, porosity, and the water retention characteristics.	16	17
Sand (%)	The sand content is used to estimate soil parameters such as bulk density, porosity, and the water retention characteristics.	69	73
Rock (%)	The rock fragment percentage reduces the cross-sectional area of the soil profile, reducing hydraulic conductivity, soil porosity and volumetric water content.	15	10
Organic content (%)	Organic matter affects soil porosity and reduces erosion. It is used in WEPP calculations relating to bulk density, porosity, water retention and erodibility parameters. The	1.0	1.0

Parameter	Description	Borrow Materials	Embankment Clay
	value used reflects the median recommended value in the WEPP user guidance documentation (0-5%)		
Effective hydraulic conductivity (mm/h)	Refers to the Green and Ampt effective conductivity parameter (American Society of Agricultural and Biological Engineers, 1994).	Model calculated	Model calculated
Cation Exchange Capacity (CEC) (meq ⁻¹)	CEC is the quantity of cations adsorbed on soil particles per unit of mass of the soil under chemically neutral conditions.	6.0	6.0
Interill erodibility (kg s/m ⁴)	Interill erodibility reflects the susceptibility of the soil to raindrop impact and shallow flows. This was not tested and is therefore model calculated.	Model calculated	Model calculated
Rill erodibility (s/m)	Rill erodibility reflects the susceptibility of the soil to shear detachment by water flowing in rills. This was not tested and is therefore model calculated.	Model calculated	Model calculated
Critical shear (Pa)	Threshold under which rill detachment does not occur. This was not tested and is therefore model calculated.	Model calculated	Model calculated

4.2.4 Rock Content

The study evaluates the addition of rock content (coarse gravel and cobbles), and its ability to resist erosion. The effect of adding rock was assessed using the Revised Universal Soil Loss Equation (RUSLE), (Renard et al, 1998). Specifically, the RUSLE ground cover subfactor (SC) was used to scale erosion rates, based on rock content. The RUSLE estimates the effect of erosion-resisting covers by the following equation:

$$SC = \exp(-b \times S_p \times (0.24 \div R_u)^{0.08})$$

where:

S_p = percentage cover (%).

b = surface cover effectiveness, an empirical coefficient, (adopted value = 0.05).

R_u = roughness (in), (0.5).

This relationship is illustrated by the soil loss chart (Figure 4.2). The curve shows that soil loss (expressed as a percentage of a bare baseline condition) decreases exponentially as rock content increases. As an example, a coverage of 50% (x-axis) corresponds with an approximately 90% (y-axis) reduction in erosion compared with the bare (unmodified) surface. This relationship has been applied to determine erosion rates for the 'modified' soils. The natural rock content is accounted for in the results tables and where results are presented of modified soils, the quoted rock percentage is in addition to the natural content. The assessment assumes that the rock is competent and durable.

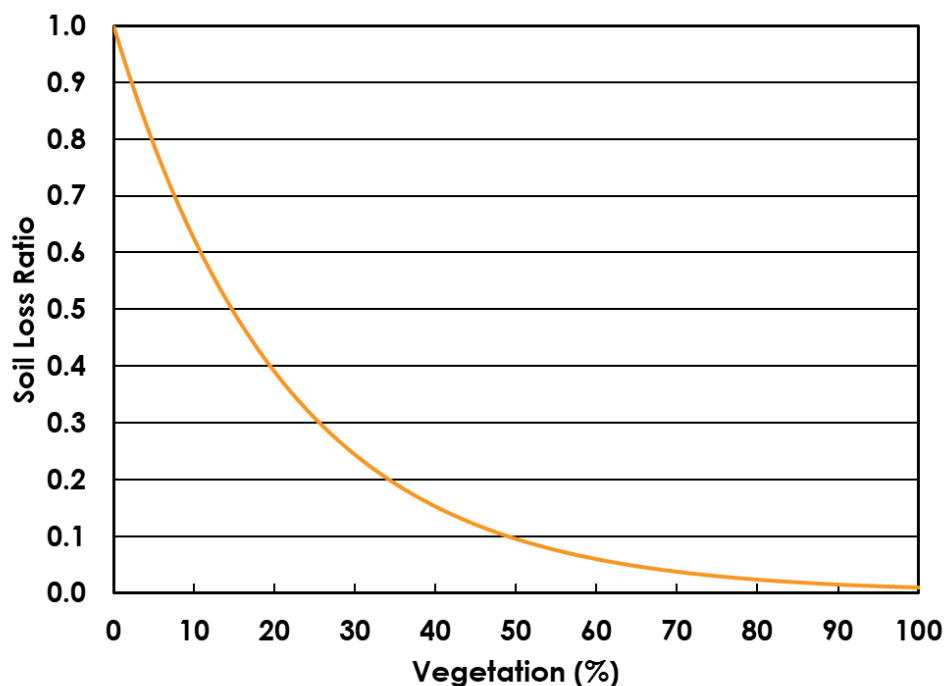


Figure 4.2: Soil loss relationship used to estimate the effects of rock content.

4.3 WEPP Model Results

The modelling results are provided in the following sections for embankment areas (Section 4.3.1) and plateau areas (Section 4.3.2). The results tables are organised to show results for a range of slope configurations and their classifications colour-coded according to the erosion risk classifications described in Section 3.1. The average and maximum predicted values along the 2D slope profile are provided for each configuration.

4.3.1 Embankment Erosion Rates

The erosion assessment for the embankments were completed for various slope lengths ranging from 10 to 33 m high slopes (30 m to 100 m in length respectively) at a gradient of 33% (3H:1V). Results of the modelling are presented in Table 4.3 and Table 4.2.

The influence of the benched slope geometry on erosion is evaluated in the landform evolution modelling.

Table 4.2: Average erosion rate for embankment with cover materials.

Material	Rock content (%)	Horizontal Slope Distance											
		30 m		40 m		50 m		60 m		80 m		100 m	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Cover material	0	43	67	51	79	58	89	64	98	75	113	85	127
	10	27	42	32	49	36	55	40	61	47	71	53	79
	20	17	26	20	31	22	35	25	38	29	44	33	49
	30	10	16	12	19	14	22	16	24	18	28	21	31
	40	6	10	8	12	9	13	10	15	11	17	13	19
	50	4	6	5	7	5	8	6	9	7	11	8	12
	60	3	4	3	5	3	5	4	6	4	7	5	7
	70	2	2	2	3	2	3	2	4	3	4	3	5

Table 4.3: Average erosion rate for embankment with embankment clay material.

Material	Rock content (%)	Horizontal Slope Distance											
		30 m		40 m		50 m		60 m		80 m		100 m	
		Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Embankment clay	0	56	87	66	102	75	115	83	126	97	147	109	164
	10	35	54	41	63	47	72	52	79	61	92	68	102
	20	22	34	26	40	29	45	32	49	38	57	43	64
	30	14	21	16	25	18	28	20	31	24	36	27	40
	40	8	13	10	15	11	17	13	19	15	22	17	25
	50	5	8	6	10	7	11	8	12	9	14	10	15
	60	3	5	4	6	4	7	5	7	6	9	6	10
	70	2	3	2	4	3	4	3	5	4	5	4	6

As anticipated, the cover material with higher rock content, the average and coarser textured cover materials, resulted in lower erosion risks. Modelling of the linear configurations indicates that borrow materials designated in the cover requires at least 50% additional rock (by volume) to achieve Low erosion classification for the range modelled.

Erosion predictions for the benched profile (Figure 4.1) indicated that an additional 75% rock by volume is required to achieve stable (low) erosion rates on the benched profile.

4.3.2 Plateau Erosion Rates

Results presented in Table 4.4 are representative of the plateau surface of the TD5 for various slope lengths ranging from 100 m to 200 m and for slope gradients ranging from 1.0% to 2.0% for the various cover system material textures.

Table 4.4: Average erosion rate for plateau with cover materials.

Material	Slope Gradient (%)	Surface Coverage (%)	Horizontal Slope Distance					
			100 m		150 m		200 m	
			Avg	Max	Avg	Max	Avg	Max
Cover material	1.0	0	<1	2	1	3	2	4
		10	<1	1	<1	2	1	2
		20	<1	<1	<1	1	<1	2
		30	DNE		<1	<1	<1	<1
		40	DNE					
	1.5	0	2	5	3	6	4	7
		10	2	3	2	4	2	5
		20	<1	2	1	2	2	3
		30	<1	1	<1	2	<1	2
		40	<1	<1	<1	<1	<1	1
	2.0	0	4	8	5	9	6	10
		10	2	5	3	6	4	6
		20	2	3	2	4	2	4
		30	<1	2	1	2	1	2
		40	<1	1	<1	1	<1	1

DNE (Did not evaluate) – assessments were not completed based on previous ground coverage erosion rates indicating erosion was <1 t/ha/yr.

The slope gradients on the plateau are substantially shallower than the embankment slopes, though the slope lengths are longer. The modelling indicates Low and Very Low erosion classifications for all slope gradients and lengths modelled, without the addition of rock.

5 LANDFORM EVOLUTION ASSESSEMENT

5.1 SIBERIA Model Description

The landform evolution assessment conducted uses the SIBERIA model, widely considered state-of-the-art in its capability to assess fluvial erosion and geomorphic evolution of mine landforms. SIBERIA provides a platform to evaluate erosion and landform morphology over short (annual) to long (commonly millennial) timeframes. The key advantage of SIBERIA is that it can process, assess, and visualise landform evolution in three dimensions.

The SIBERIA model, as applied herein, integrates the five key mechanisms driving erosion and landform evolution, including:

- Rainfall runoff and its influence on driving erosion process.
- The inherent erodibility of surface materials.
- Landform geometry, i.e. runoff-routing from local catchments and the effects of slope lengths and gradients.
- Vegetation – this project adopts a conservative, bare surface/no vegetation scenario.
- Assessment timeframes over which erosion occurs – a 100-year timeframe has been adopted for assessing the TSF against design objectives.

5.2 Model Application

The model was applied using an iterative process of design and assessment. The process allows for testing of the TD5 design by interrogating the model outputs, and enabled refinement of the design. Multiple models were completed prior to arriving at the final design, as such this report presents only the final design geometry assessed.

Two models were completed:

1. A bare soils model, representing the natural borrow materials.
2. A modified soils model, assuming the addition of 75% rock (by volume) to soils from the borrow area.

Both models were processed as monolithic landforms i.e. the first model represents only bare soils at surface and the second model only modified soils at surface. The final cover specification for plateau and embankment areas of TD5 differs, with the steeper embankment areas requiring more erosion resistance.

A 100-year period of assessment was used for both models. Key erosion metrics were calculated at the 100-year end of model to ensure the predicted erosion meets performance targets (i.e. maximum 'Low' classification, as described in 3.2).

5.3 Input Parameters

The accuracy of SIBERIA, as with any numerical model, relies on the accuracy and validity of the inputs. The key erosion parameters used in the SIBERIA modelling include the β_1 , m_1 , and n_1 parameters, that relate materials erodibility with the hydrological setting. The parameters are used in the model to generate the rate and form of the erosion as described by the empirical fluvial sediment transport formula (Equation 1).

$$q_s = \beta_1 \times q^{m_1} \times S^{n_1} \quad [1]$$

Where: β_1 is the coefficient of the fluvial sediment yield formula, m_1 is the exponent on discharge (q), n_1 is the exponent on the slope (S), and q_s is the sediment yield.

The approach to model calibration is conducted separately for the bare and modified soils models, as follows:

- The input parameters for the bare soils, were taken from the erosion testing conducted by Aquaterra (refer to Appendix A for the report). These parameters are only applicable for the plateau area where bare soils would be applied.
- For the modified soils, the SIBERIA model was calibrated to the WEPP model results for the benched embankment profile (after scaling for rock addition).

The input parameters are listed in Table 5.1 below.

Table 5.1: SIBERIA Input Parameters

SIBERIA Input Parameter	Bare Soils	Modified Soils	Description
β_1	0.055	0.0002	β_1 is the SIBERIA erosion rate parameter, β_1
m_1	1.2	1.5	m_1 is the exponent on the discharge used in the sediment transport formula used in SIBERIA
n_1	1.1	1.1	n_1 is the exponent on the slope used in the sediment transport formula used in SIBERIA

5.4 SIBERIA Model Results

The model output visualisations are shown in Figure 5.1, the figures illustrate the spatial distribution of erosion across TD5, colour-coded by elevation change. In the figures, the areas of erosion are identified as positive values. Deposition is shown as a negative value. The contours shown represent the baseline (Year 0) surface and are included for illustrative purposes only.

Key metrics are listed in Table 5.2 The erosion classification adopted is provided based on Okane's experience.

Table 5.2: SIBERIA modelling results summarising erosion metrics and classification

Model / scenario	Erosion Rate (t/ha/y)	99 th Percentile Erosion Depth (m)	Erosion Classification
Clayey soil model (bare)			
Plateau area	5	0.1	Low
Embankment area	48	1.1	High
Modified (75% rock) model			
Plateau area	3	0.1	Low
Embankment area	5	0.2	Low

Figure 5.1 is arranged as follows:

- Bare soils model (left image).
- Modified soils model (middle image).
- Integrated results (right image) i.e. the figure on the right represents the application of bare soils on the plateau and modified soils on the embankments.

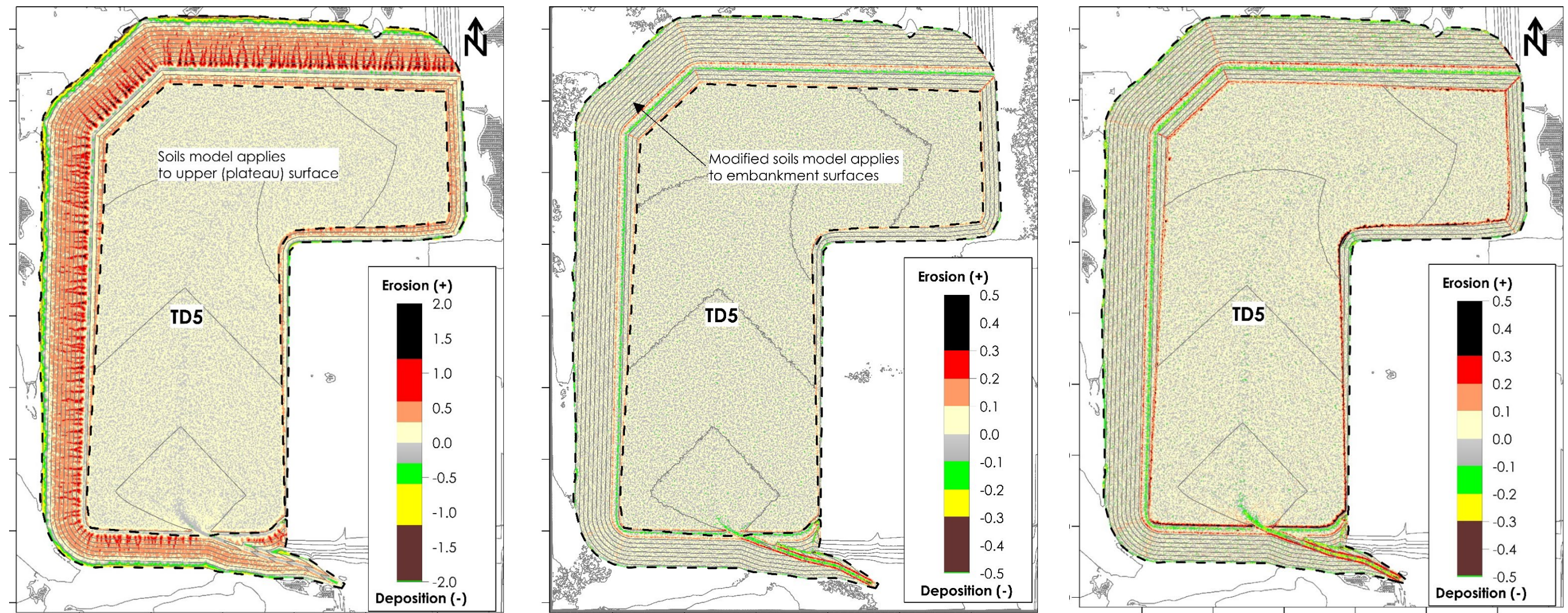


Figure 5.1: Spatial distribution of TD5 landform erosion: Bare soils model (left), Modified soils model (middle), and Combined results (right)

6 DRAINAGE & SCOUR ASSESSMENT

6.1 Model Application

The surface water model 'DRAINS was' used to assess the plateau catchment and southern ramp to support the closure design. The ramp is to be retrofitted to provide for long-term surface water drainage (referred to as the embankment drain).

The assessment includes surface water runoff predictions (peak flow rates and velocities) for the approximately 20 ha plateau catchment and drain structure. The assessment has been carried out using a 1 in 1000 AEP, 24-hour design storm, the large event has been adopted to ensure the embankment drain has sufficient capacity to manage large events in the future. Rock armour will be required and the predicted velocities associated with this event are also used to provide an armouring specification for channel surface.

6.2 DRAINS Model Description

DRAINS is an Australian surface water model, i.e., it uses location specific, Australian Rainfall and Runoff (ARR) design storm events to assess performance of stormwater networks.

The DRAINS software was used in this assessment to develop a surface water model representing:

- Event-based design rainfall temporal patterns (sourced from Bureau of Meteorology and Australian Rainfall and Runoff data hub).
- The plateau catchment area, surface gradient and properties of the cover material, i.e. surface water infiltration capacity of the cover materials.
- The geometry of the ramp corridor that traverses the southern face of TS5, to be retrofitted as a surface water drain.
- The pond sizes and key levels (such as top of wall and overflow levels). These have been adopted from topographic survey.

6.3 Input Parameters

6.3.1 Model Inputs

The catchment input parameters outlines in Table 6.1 are included in the model. Figure 6.1 illustrates the cross section details of the drainage channel.

Table 6.1: Inputs for the Drainage and Scour Assessment

Input Parameter	Value	Description
Design Storm Event	1 in 1000 AEP, 24-hour storm	Used for channel sizing and design of scour protection
Catchment area (ha)	20	
Cover System Soil Type	Type 3 (or C)	Characterised as a soil having slow infiltration rates, similar to the natural borrow materials designated for the plateau cover system.
Cover System Depression storage (mm)	5	The model allows for residual water storage present in small depressions on the surface of, that are commonly present on the surface of mining landforms. These are formed through minor subsidence and imperfect construction.
Flow path slope (%)	1	Approximate plateau grading
Maximum flow path length (m)	755	to central plateau swale
Channel cross section	Refer to Figure 6.1	Or equivalent
Catchment retardance coefficient	0.030	Value for rough soil / loam, sourced from DRAINS user manual

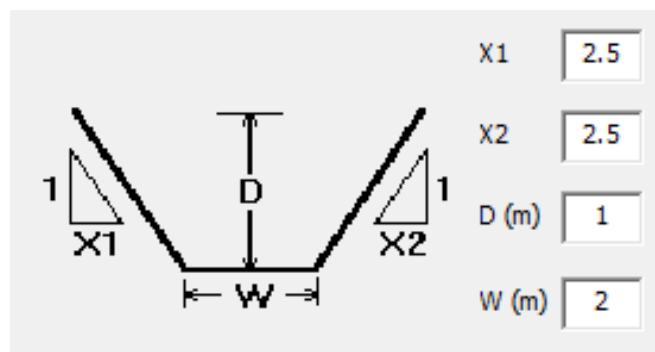


Figure 6.1 Cross section of drainage channel used

6.4 Model Results

Key results from the DRAINS analysis are provided in Table 6.2. Figure 6.2 illustrates the resulting hydrograph for the 1 in 1000 AEP, 24-hr event.

Table 6.2: Summary of DRAINS model results

Parameter	Value	Comments
Catchment peak flow rate (m ³ /s)	1.7	1 in 1000 AEP, 24-hour duration
Total surface water runoff volume (m ³)	34,376	
Channel base width (m)	2	Trapezoidal channel assumed
Channel side slopes (1 in x)	2.5	Trapezoidal channel assumed
Peak flow rate (m ³ /s)	1.7	1 in 1000 AEP, 24-hour duration
Peak flow velocity (m/s)	2.0	0.5m thick rock scour protection in channel with mean particle size (d ₅₀) = 300mm.

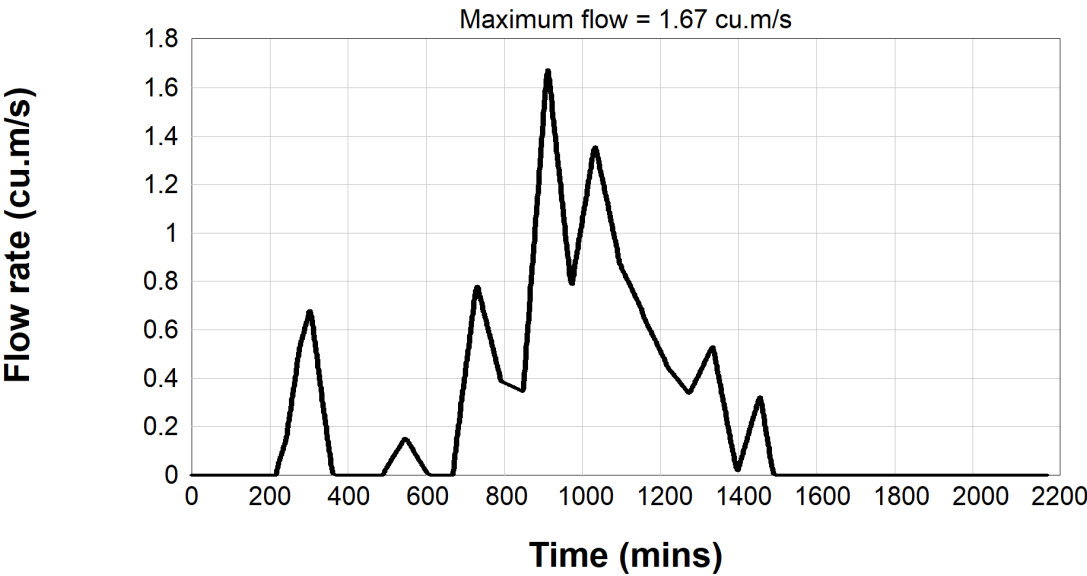


Figure 6.2: Design storm hydrograph for 1 in 1000 AEP, 24-hour event

7 CONCLUSIONS AND DISCUSSION

The key conclusions drawn from this study are outlined in the following subsections.

7.1 Cover Material Specification

With respect erosion resistance:

- Bare soils sourced from the borrow are considered unsuitable for TD5 embankments without modification. Addition of a competent, coarse rock is recommended to bolster erosion resistance and achieve target 'Low' erosion conditions. It is estimated that ~75% rock by volume is required to achieve stable the targets in the long term. The rock should extend onto the plateau area to ensure the crest is well armoured.
- The rock should be durable and resist weathering to improve longevity, approximately 50-150 mm sized rock is suitable. Okane recommends 0.5 m (minimum) thick surface layer (total) on the embankments. Presumably the rock could be dozed down from the top and tracked into the surface.
- Erosion resistance on the embankments will be enhanced with the traffic compaction from dozers, as such ripping is not recommended unless specifically required for other purposes (e.g. establishment of vegetation).
- The bare soils from the borrow are suitable for use on the upper plateau surfaces without modification. This is owing to the very shallow design gradients.

7.2 Drainage

With respect to surface water management:

- The minimum embankment drain cross section is illustrated in Figure 6.1, an equivalent cross section that provides cross fall (towards TD5) may be used. However, any steepening of the embankment slopes should be assessed for stability.
- The embankment drain that permits drainage off the plateau surface must be appropriately armoured to resist the expected flow velocities (~2 m/s). A 0.5 m thick armour layer of competent rock ($d_{50} = 0.3$ m) is recommended. A suitable bedding layer for the armour is also likely required to protect against undermining of the subgrade material. A 0.15-0.3m thick well graded bedding layer (50mm maximum size, < 10% fines) is recommended.
- Quality assurance and quality control should be undertaken to ensure a smooth transition of the plateau catchment into the channel (as per the designs) and that the entirety of the plateau area drains into the channel.

The above specifications are made for the purposes of design development and should be reviewed and signed off by the facility Engineer of Record and owners prior to any construction activities.

7.3 Monitoring

It is recommended that constructed cover systems be monitored annually and opportunistically after significant rainfall (>50 mm). Monitoring of surfaces is the best way to confirm erosion targets are being met and allow early intervention should erosion be higher than expected:

Erosion monitoring should focus on measurements and/or survey, including:

- Rainfall.
- Rill and gully measurements (if present), including location, length, width and depth.
- Vegetation coverage.
- Description of erosion mechanisms (incisive or sheet wash).
- Surface water infiltration capacity.

Erosion monitoring can be linked with a trigger-action-response plan to identify any remedial actions should the monitoring identify higher than expected erosion. Remedial actions typically cover (for example) reshaping strategies, placement of armour and/or vegetation of affected areas.

7.4 Limitations of the assessment

Even though erosion results are presented herein as values (predicted erosion rates and depth), the accuracy of the SIBERIA assessment is considered qualitative, due aspects not limited to:

- The inherently predictive nature of the study.
- Potential variability and heterogeneity in the materials tested from practice.
- Scaling considerations, such as physical scaling relationships derived from erosion flume test work to a larger scale TD5.
- Environmental extremes and climate change.

In this respect the predicted erosion rates are not intended to be definitive, rather to provide a general indication as to the ability to meet design objectives.

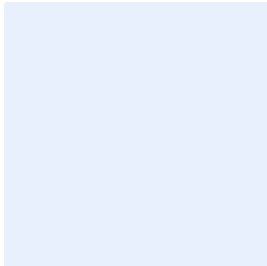
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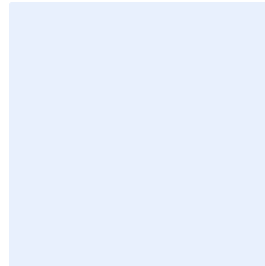
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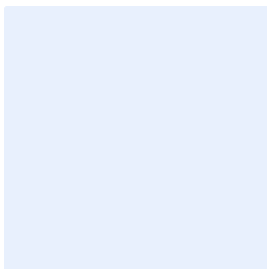
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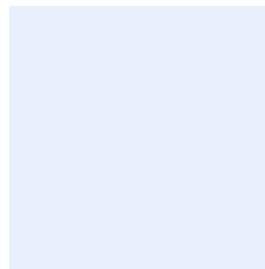
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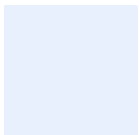


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Appendix A

Flume Testing Report

FINAL REPORT for OKane

Material analysis and SIBERIA parameter derivation
for Eloise Copper TD5 material



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Disclaimer: All care and due diligence have been exercised in testing, interpreting data and the development of recommendations presented in this report. The monitoring and testing have been undertaken in a professional manner according to accepted practices.

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Cover

Eloise TD5 material at completion of the 35% slope run

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Revision History

Revision Number	Date	Prepared by
Rev 1	9/1/2025	Greg Hancock

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1 Overview

This report presents results for a flume assessment on material erodibility and parameter derivation for potential surface materials from the Eloise Copper mine in Western Queensland. A basic material characterisation and assessment was also conducted to assist in this assessment.

The information here can be used to understand basic material properties and also used to determine input parameters for the SIBERIA Landscape Evolution Model (Willgoose et al., 1991a-c; Hancock and Willgoose, 2018).

This work was commissioned by Ian Taylor, Principal Engineer, OKane Consultants, Perth.

2 Material

2.1 Material description

One material was supplied in a Bulka Bag (Figure 1). The bag was labelled TD5. The material (Figure 2) had the following characteristics

- 1) Tan/brown soil like material texture with minimal rock content. Material had the appearance of a natural soil with a range of ped sizes from small to large.
- 2) Peds dispersive when an air dried ped was placed in a beaker of rainwater
- 3) Fine roots present when peds broken
- 4) Small amount of rock content – angular block shape with some rounded pebbles.
- 5) By hand analysis, the material has is a silty loam

2.2 Material preparation

- 1) The material was removed from the bulka bag, placed on a clean plastic sheet on the laboratory floor and mixed (Figure 2)
- 2) A representative sample was randomly selected for laboratory material analysis
- 3) The material was passed through a 32mm screen
- 4) Material <32mm was placed in the flume (refer Section 3.2 Material Placement)

2.3 Laboratory material analysis

Laboratory material analysis conducted included the following:

- 1) Electrical Conductivity
- 2) pH
- 3) Sieve analysis (<2mm and >2mm size fraction)



Figure 1: TD5 Material as received



Figure 2: TD5 Material removed from the bulka bag and mixed

2.4 Material properties

Table 1: TD5 material properties

Property	Material TD5
Colour	Brown Hue 7.5YR 4/4
EC (μS)	107
pH	8.3
Moisture (%)	4
Particle Size Distribution	
<2mm (%)	34
>2mm (%)	66
Infiltration (mm hr^{-1})*	3

*calculated from groundwater exiting the flume

Table 2: TD5 material particle size distribution

Material TD5		
Size (mm)	% by mass	Cumulative %
>63	-	100
>32	-	100
>16	6	100
>11.2	3	94
>8	5	91
>5.6	5	85
>4	11	80
>2	35	69
<2mm	34	34

It should be noted that the particle size was obtained from oven dried material which resulted in the stabilisation of clay peds. These were not broken up before sieve analysis. The majority of these clay peds which comprised the rock fraction of the particle size distribution disaggregated upon wetting in the flume. Hence, the particle size distribution should be considered indicative only.

The EC, pH and particle size distribution suggest no plant growth limitations.

3 Flume

3.1 Flume description

The flume is constructed of a box 3m long, 0.3m wide and 0.4m deep. In the base a galvanised mesh frame is placed 0.05m above the base which is covered in geotextile material. 50mm of river sand is placed on top of this base which is then covered in geotextile material. This provides a free-flowing porous base which does not impede the infiltration of soil water and through which any groundwater could exit. At the base of the box at the lower end a 20mm diameter pipe allows any groundwater to exit.

A header tank at the top of the box supplies runoff across the width of the flume (0.3m) at a constant rate. Runoff is based on 1:2 year storm IFD (Intensity Frequency Duration) data for the site obtained from the Bureau of Meteorology (www.bom.gov.au).

The design of the flume is such that a specified discharge can be applied at the top of the slope and all water and sediment can be measured including groundwater (collected) at the outlet. Water is also free to infiltrate through the material and be collected and quantified.

The flume is mounted in a steel frame. Slope of the flume may be adjusted to any angle between 0 and 40%.

Water to the flume is provided by a header tank which provided an even distribution of water across the full width. Flow is adjusted by a valve which allows discharge to be regulated from 0 to 20 l/min. Flow is quantified (checked) twice. Firstly by checking the flow entering the header tank (pre-test) and secondly by measuring flow that exits the flume both by surface water and groundwater flow at the outlet. Infiltration is measured by collecting the water exiting the base of the flume. This measurement regime allows a full water balance assessment.

For flume operation, local rainwater is used.

3.2 Material processing & placement

The material was packed in the flume in a series of layers, wet, and compacted and smoothed with a flat plate with particular emphasis along the edges so that there were no preferential flow paths or unevenness. Maximum depth of material was approximately 150mm.

Once the material was placed in the flume, the surface was smoothed with a straight edge to provide a uniform surface (Figures 3 and 4).

The surface of the material was wet until it was saturated but not generating runoff. This was done several times and took several days before the material was fully packed and was at field capacity.

Once settled and at field capacity, the material was allowed to sit for several days. This ensured that the material was fully settled as well as providing a consistent soil moisture and starting conditions for all flume runs.

3.3 Flume operation

The flume runs were conducted at 5% and 35% slope as requested by OKane.

Each flume run was commenced with a low flow (low intensity, long duration storm) to allow the material to slowly wet up and runoff to commence. This was continued until a constant runoff and groundwater discharge occurred. Water flows were increased to represent different rainfall/runoff rates. An adjustment period of approximately 5 minutes for each new flow allowed runoff and groundwater to equilibrate for the new input flow.

Water and sediment samples were collected with both time of sample collected and the number of seconds to fill the container recorded. Surface flow and groundwater exiting the flume were independently measured for each flow rate.

Each water/sediment sample was captured in pre-weighed containers which were also weighed when full (~2000ml in volume).

The samples were then placed in an oven (for approximately 7 days) at 90°C to drive off all water. The bottles containing the dried sediment were then cooled to room temperature & reweighed.

Using the gravimetric method, both volume of runoff and mass of sediment were calculated. This data was then used to determine SIBERIA model parameters.

4 Parameters

4.1 Erosion processes

5% slope

Sediment loads for the material as observed in the collection jars were high. Both solid and suspended load was present. Sediment was mobilised and transported at low flow.

Erosion process at 5% slope was sheetwash. The sediment loads suggest that this material will require vegetation for stabilisation and should only be used at low slopes (Figure 3).

35% slope

Erosion occurred immediately at low runoff, with sheetwash and slumping occurring leading to minor rilling. With increased flow, further rilling occurred – with a rill developing the full length of the flume.

Sediment delivery was chaotic with surges in sediment output.

Material loads as observed in the collection jars were high, with both solid load and suspended load.

The erosion process for the TD5 material at 35% slope was sheetwash and rilling with the strong potential to gully at field scale (Figure 4). This material should not be used at steep slopes and if used will be totally reliant on vegetation for stability.

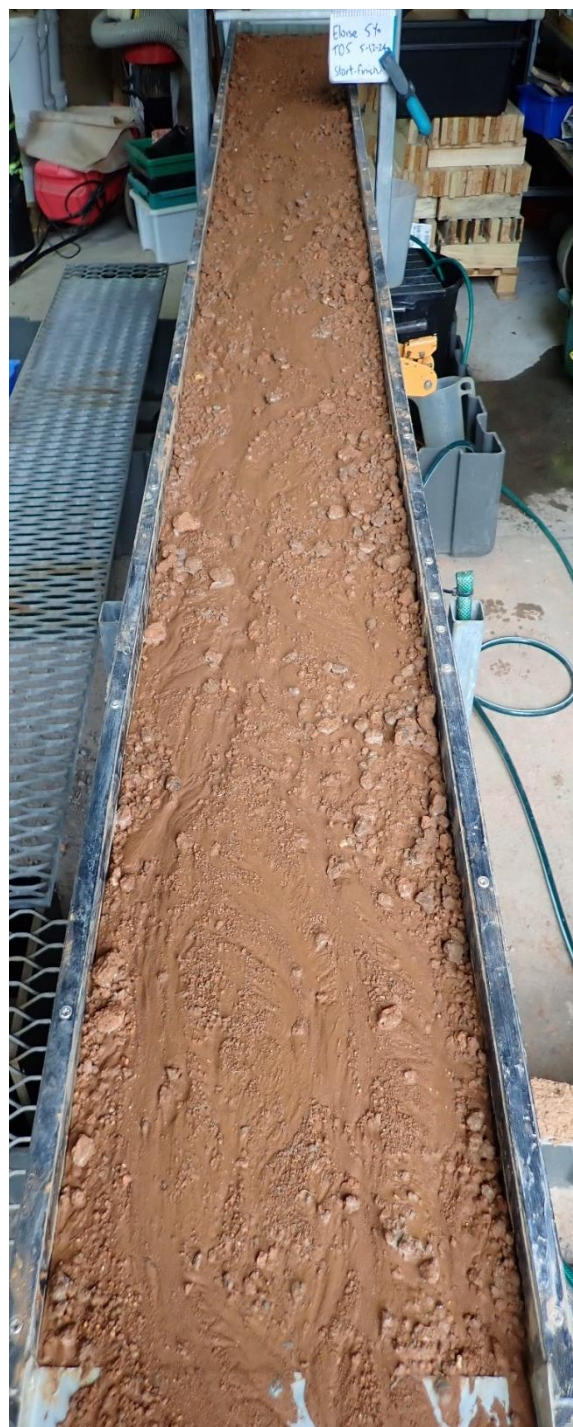


Figure 3: Eloise TD5 Material at (a) start (left) and (b) completion (right) of 5% slope flume run



Figure 4: Eloise TD5 Material at (a) start (left) and (b) completion (right) of 35% slope flume run

4.2 SIBERIA LEM

SIBERIA is a Landscape Evolution Model (LEM) that has been used extensively by the mining industry. Initial work on mining landscapes was pioneered by Willgoose and Riley (1998) and Evans et al. (2000) with later work by Hancock et al. (2008). They demonstrated that the model can be run at annual time steps for periods of 10,000 years and longer (Hancock et al., 2016).

The model has become the industry standard for landscape design and erosion assessment on both existing and proposed post-mining landscapes.

SIBERIA provides:

- 1) Visualisation of type of erosion and where it occurs (i.e. gullies, rills)
- 2) Erosion rate - both in $\text{t ha}^{-1} \text{yr}^{-1}$ and average denudation (mm yr^{-1})

For mine sites there is a dearth of long-term parameter data with several short-term studies available (Evans et al., 1999, 2000; Evans and Willgoose, 2000). Ideally, a series of field plots or small catchments should be instrumented with a pluviograph, recording flume, suspended sediment probes and bedload traps. However, this apparatus is costly to obtain and install. It is also not possible at many sites as they are still in construction. Even if constructed, data collection is weather dependent and therefore takes time to collect particularly in areas with low and infrequent rainfall.

Flumes have been demonstrated to provide a reliable method for SIBERIA parameter determination (Hancock et al., 2019; Hancock and Wells, 2020).

Below, the determination of parameters from the flume data is described.

4.3 Parameter derivation

The SIBERIA parameter derivation is a multiple regression for the β_1 , m_1 and n_1 for runoff, sediment load and each slope until the parameter combination is optimised.

The SIBERIA fluvial sediment transport equation (q_{sf}) is:

$$q_{sf} = \beta_1 Q^{m_1} S^{n_1} \quad (\text{Equation 1})$$

where Q represents the discharge per unit width ($\text{m}^3/\text{s}/\text{m}$ width), S is the slope in the steepest downslope direction (m/m) while m_1 , β_1 (soil erodibility) and n_1 are calibrated parameters which in combination will represent sheetwash, rilling or gullyng.

4.4 Eloise TD5 material SIBERIA parameters

The SIBERIA parameters for the Eloise TD5 materials are listed in Table 3.

Flume sediment output and SIBERIA predicted outputs for the materials are displayed in Figure 5.

A general guide to interpreting the parameters, particularly the influence of m_1 and n_1 can be found in Kirkby (1971) and Willgoose (2018).

For the Eloise TD5 material. It was not possible to employ a single set of parameters.

The sediment load data and observation of the erosion process together with the multiple regression of runoff and sediment loads demonstrated that the material erodes via sheetwash at 5% and via sheetwash, rilling and gullyng at 35%.

Hence 2 sets of parameters are provided.

Table 3: SIBERIA parameters for the Eloise TD5 material from the flume at 5% and 35% slopes

Slope	β_1	m_1	n_1	β_3	m_3
Eloise TD5 5% slope	0.055	1.2	1.1	1.0	1.0
Eloise TD5 35% slope	0.055	1.5	1.1	1.0	1.0

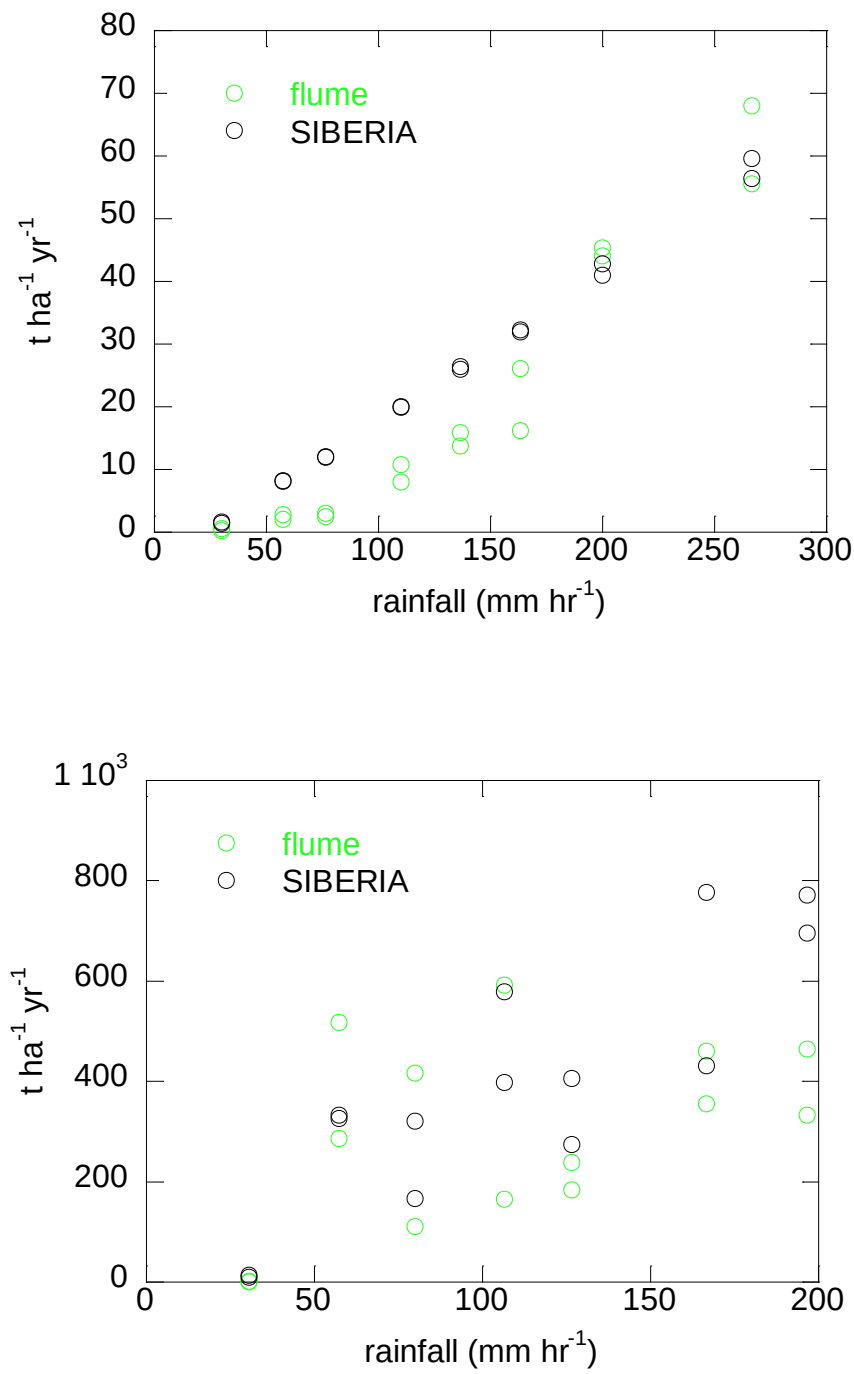


Figure 5: Flume sediment output and SIBERIA predicted sediment output for the Eloise TD5 Material at 5% (top) and 35% (bottom)

5 Limitations

- 1) All material was supplied by Eloise and OKane Consulting.
- 2) The erosion parameters obtained represent bare materials with no vegetation or long-term environmental exposure. It is not possible to guarantee that the parameters will or will not change if the material is exposed for longer periods.
- 3) The compaction and surface roughness of the materials in the flume may be very different to that of the mine site. There is no guarantee that the erosion parameters will be the same or different under mine site conditions.
- 4) The flume was run at 5% and 35% slopes as suggested by OKane. How the material performs at alternate slopes is unknown.

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Appendix D - Proposed Table G2 of the EA

Disturbance Type	Slope Range	Projective Surface Area
ROM Pad slopes	33% – 44%	1.5 ha
Temporary excavated materials stockpile slopes	33% – 40%	1.0 ha
Tailings Dam Wall slopes	≤ 33%	34 ha
Tailing Dam plateau	≤ 2%	53 ha