Ensham Mine Landform Supplementary Report

Document details and history

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1.0 Executive Summary

The Submitted Option involves partial backfilling of the existing open cut mining areas to rehabilitate these post mining areas to be safe, stable, non-polluting, and to be consistent with the regional topography. The rehabilitated open cut mining areas that were part of the Nogoa River floodplain prior to mining, and, using landform protection incorporating the current levees system, will be protected from interaction with the floodplain by permanent landforms into perpetuity.

The permanent landforms which align with and incorporate the existing levees, have been designed by Registered Professional Engineers of Queensland (RPEQ's) to exclude all flood interactions up to and including a 0.1% Annual Exceedance Probability (AEP) + 0.5 metre flood event, which is the maximum extent of a floodplain required to be modelled under Queensland legislation. The designs for these permanent landforms have been independently peer reviewed by RPEQ certified engineers.

Overburden currently placed on the A, B and C highwalls behind the existing levees will be reshaped and used in the permanent landform to provide a safe and stable landform, designed to exceed a Factor of Safety of 1.5 into perpetuity.

The design of the Submitted Option delivers a long-term safe and stable rehabilitation outcome with the following Post Mining Land Uses (PMLU's):

- Sustainable Grazing/ Water Body
- Self-Sustaining Vegetated Cover
- Native Bushland Corridor.

Rehabilitation Completion Criteria for domains 1A, 3A, 3E and 4D currently approved in the Ensham Environmental Authority remain largely unchanged.

The design of the Submitted Option means:

- water retained in the rehabilitated open cut mining areas in the longer term (including under climate change scenarios) would not reach levels that result in overflow to the environment via surface pathways. As such, there is no risk of water being exported to surrounding creeks and rivers.
- water in the rehabilitated open cut mining areas (including under climate change scenarios) remains beneath the regional groundwater levels, that is there is no flow to the regional groundwater system. The rehabilitated open cut mining areas remain groundwater sinks into perpetuity.
- water retained in the rehabilitated open cut mining areas does not pose any concern to the landform structure and function as it does not come into contact with, pond or lap against the landform.
- the permanent landforms are designed to exclude flood water from the rehabilitated open cut mining areas up to and including a 0.1% AEP + 0.5 metre flood event. By legislation a 0.1% AEP flood event is the largest flood required to be modelled to determine the extent of the floodplain.

All rehabilitated slopes are designed to exceed a Factor of Safety of 1.5 and, as such, are safe and stable into perpetuity in compliance with Condition G15 of the Ensham Mine Environmental Authority. A summary of the Design Criteria for the Submitted Option including changes discussed in Section 6 of this report are contained in Appendix A of this report. These Design Criteria are largely drawn from the Geotechnical Report (WSP, 2019) and the Landform Design Report (WSP 2019) which were completed as part of Stage 3 of the Residual Void Project and have been authored and certified by RPEQ's. The full certified Design Criteria for the

Submitted Option is listed on page 16 of the Landform Design Report (WSP, 2019). Details of the Study Teams qualifications for each report and corresponding Peer Reviews are contained in Appendix B.

Since lodgement of the Submitted Option on the 27th of March 2019, additional optimisations have been incorporated into the design of both the inward facing slopes of the low wall, and the highwall, to improve erosion control. These optimisations include the following:

a) Low walls:

- All inward facing low wall slopes with a slope gradient of 20% to 25% will have a reduced slope length, reducing from between 100m and 200m (dependent on spoil type) to approximately 75m. These 20% to 25% inward facing slopes also include additional benching to reduce the water volume and velocities at these locations. 75m slope runs have been chosen because these lengths have proven to be safe and stable and performed well from an erosion perspective on a 25% spoil slope at the Ensham Mine site.
- Additional backfilling will occur to eliminate groundwater daylighting in the A South.
- The land bridge between E and D rehabilitated areas has been removed to allow water from the former to free drain to the south to the CD rehabilitated open cut mining area and the fill placed in the floor of E rehabilitation area to eliminate groundwater daylighting.

The additional treatments for A south and E are predicted to reduce the number of visible water areas from 7 down to 5.

The fundamental design of F and Y rehabilitated open cut mining areas remain unchanged from the Submitted Option provided to DES on 27 March 2019. These additional design elements maximise the area in the final landform that can be returned to productive grazing, consistent with the regional pre-mining land use, and is the highest practical rehabilitation outcome (level no:4) based on the Hierarchy of Rehabilitation.

As previously stated in the Submitted Option Landform Report (WSP, 2019), all low wall slopes will be either topsoiled and seeded, or, ameliorated and hydro mulched to establish ground cover and minimise erosion.

b) Highwalls and End Walls

- Highwall treatments for the rehabilitated open cut mining areas will be largely the same as described in the Submitted Option, with the exception of the 30% to 100% area of A South which will be redesigned to reduce the 33% to 100% slope to less than 25% (Native Bushland Corridor) with additional backfill emplacement.
- B northern end wall buttressing fill slope angle has been reduced from 25% to 15% to further improve erosion performance.

The Self-Sustaining Vegetation domain is now restricted to D highwall and will be rehabilitated as per the Submitted Option.

The additional design elements discussed in a) and b) above have been reviewed and certified by RPEQ's (WSP and Minserve) and do not reduce the Factor of Safety of 1.5.for any slopes.

2.0 Purpose of this Report

The purpose of this report is to provide additional rehabilitation information as requested by the Department of Environment and Science (DES) in the Extension of Decision Period by Agreement Notification, dated 13th of March 2020.

Specifically, this report:

- Provides a history of the levees at Ensham
- Provides a description of the proposed permanent landforms
- Demonstrates how the Submitted Option land design component was developed having regard for the rehabilitation hierarchy, including how groundwater remaining in the rehabilitated open cut mining area presents an acceptable risk, and how the remaining risk is managed
- Confirms that the permanent landform and rehabilitated open cut mining areas are safe and stable in the long-term including RPEQ sign off, qualifications and authoring of technical studies.
- Proposes additional opportunities to optimise the design and address DES erosion concerns, including reducing groundwater daylighting in A and E rehabilitated open cut mining areas and associated impacts.
- References landform studies which demonstrate that further management of the groundwater in some pits is impracticable.
- Describes the final area and volume of water in voids for the Submitted Option.

A copy of the Extension of Decision Period by Agreement Notification, dated 13th of March 2020 discussed above is provided in Appendix C.

Note:

The Submitted Option is varied as described in this Report from that which was described in the Stage 5 Residual Void Report provided to DES on the 27 March 2019.

3.0 The history of levees at Ensham

This Report provides a history of the levees at the Ensham mine. This history is relevant in demonstrating the existing levees performance as the Submitted Option proposes permanent landforms which align with and incorporate the existing levees. The levees at the Ensham mine were subjected to flooding events in 2010 and 2011. For purposes of this Report, the performance and reconstruction of levees following the 2008 flood event was assessed by an RPEQ, Andrew Middleton, and the findings for convenience to the reader are extracted in sections 3.1, 3.2 and 3.3 below.

Andrew is a Principal and Director of Douglas Partners with over 30 years geotechnical engineering experience. As an RPEQ Andrew was:

- involved with the geotechnical design of the current levee system post the 2008 inundation event,
- responsible for oversight of geotechnical aspects during the repair and reconstruction of the current levee system, and
- has been involved with the annual inspections of this levee system under the Regulated Structures requirements since completion of reconstruction in 2010.

Andrew is a Fellow and Engineering Executive (Eng. Exec) with Engineers Australia, a Chartered Professional Engineer and a Registered Professional Engineer of Queensland (RPEQ).

Andrew's report is presented in full in Appendix D.

3.1 Levees Prior to 2008 and Reconstruction

The B Pit and C Pit mine levees prior to the breaching in early 2008 comprised a series of earth bunds ranging up to several metres in height and up to 20 m in width, with some being used as haul roads.

The existing mine flood levees were damaged and breached in floods in early 2008. The B Pit mine levee was breached where it had been constructed across Old Winton Creek, and then again where flood waters exited the mine area on the southern leg of the levee at a change of direction. It most likely failed due to a combination of height and concentrated rapid water flows in Old Winton Creek water course.

The C Pit mine levee was breached in two locations over a total length of approximately 250m immediately to the east of Red Hill. The western, upstream breach was located near a former river course (ie billabong) around the toe of Red Hill, whilst the eastern, downstream breach was located near a former bend in the main anabranch river course. There was a remaining isthmus of former riverbank between the two breach locations. It appears likely that concentrated water flows due to river channel effects led to failure of the levee.

3.2 Reconstruction of the Levees

The reconstruction and upgrade of the levees took several forms:

- *A new engineered levee was constructed for B Pit to the west of the former levee. This levee was constructed as homogenous earth fill structure with a 6m wide crest. This levee was engineered with a seepage key wide enough for the compactors to work; the seepage key varied from 1 m deep in*

clay subgrades to 3 m deep in sand subgrades (locally encountered). The levee was constructed using site won clay materials blended with some sand in the borrow area to improve the workability and compaction characteristics and reduce the cracking potential. The material was moisture conditioned in the borrow pit and then again on the levee as placed, and then spread in layers and compacted with pad foot compactors. The compaction was controlled with quality control testing to confirm compaction achieved and the results reviewed by an RPEQ to confirm conformance with requirements. The surface of the levee was capped with select granular fill to prevent drying and wetting and to provide all weather access for inspections and maintenance. The levee slopes were topsoil and grassed.

Where the new levee crossed Old Winton creek, a barrier berm approximately 3 m wide with rock protection was constructed at the toe to keep permanent water off the levee structure and provide further protection against early flood water flows.

- *The existing B Pit levee alongside the Nogoa River (central section) and also downstream (eastern section) was upgraded by raising on the outer 'upstream' face. This upgrade comprised excavation of a seepage key of the same dimensions to those described above at the downstream toe of the existing levee, followed by placement of a minimum 3m width of new engineered fill benched into the existing levee fill. The material used was won from the B Pit levee borrow pit and compacted in the same manner as described above. On completion the upper surface of most of the levee was capped with select granular fill apart from the southernmost leg of the levee which was topsoiled and grassed.*

  As above, where the levee crossed Old Winton Creek a barrier berm approximately 3 m wide with rock protection was constructed at the toe to keep any permanent water off the levee structure and to improve protection of the levee in the event of back flow.

- *The breached section of C Pit had been backfilled with mine spoil after the flooding. It was located adjoining the Nogoa River Anabranch and exposed to flooding risk during construction. The reconstruction comprised the construction of an engineered earthfill support embankment on the river side of the breach to protect the works and included coarse rock erosion protection. Following this, the mine spoil in the breach zone was excavated in a deep key trench until Permian rock was encountered; a bentonite slurry cutoff was installed at the base and the trench backfilled with engineered fill with a HDPE seepage barrier installed on the upstream face. The levee was then constructed above the backfilled trench in the same manner as the B Pit new levee.*

- *Two new sections of engineered levees were constructed upstream of Red Hill. These were constructed in a similar manner to the B Pit new levee, except that the borrow source comprised a weathered siltstone that was worked in the borrow pit to break down to a gravelly clay material suitable for construction.*

- *A new section of levee approximately 3m in height was built downstream to protect a ramp into C Pit. Again, this was engineered and constructed in a similar manner to that of the new B Pit levee. The area behind this levee was backfilled with general spoil to form a laydown pad and further protection for the mine pit ramp.*

For all levees, stability analysis was carried out to confirm the safety factor of the structures exceeded 1.5. Where a levee was located near a pit, stability analysis was also carried out to confirm setback distances to achieve a safety factor of at least 1.5 for impact from instability of the overburden in the nearby open cut pit. Instability of the weathered rock in the pit walls have been assessed by others.

Seepage analysis was also carried out to confirm seepage rates under the levee under flood conditions did not exceed those that might be associated with piping failure.

In 2014 Idemitsu Australia Resources engaged Golder Associates Pty Ltd (Golder) to conduct an independent third-party review and certification of the design of repairs to flood levees damaged in the flood of January 2008 and approved for construction. Certification was received 2 April 2014 from Golder (Mike Marley, RPEQ 1268). The certificate found that the levees were designed and constructed in accordance with the conditions in the Ensham Environmental Authority (MIM800086202). The independent third-party review and certification is attached in Appendix E.

The independent third-party review recommended an appropriate monitoring and maintenance program be implemented to ensure that the levees continued to perform in accordance with the design intent into the future. The monitoring and maintenance programme implemented by Ensham Mine is the Regulated Structures Annual Inspection required under Conditions D22 – D25 of the Ensham Mine Environmental Authority. These annual inspections have been undertaken by suitably qualified and experienced persons and each inspection report has been prepared and certification supplied in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures. All recommended actions have been undertaken by Ensham Mine.

Each Report has been forwarded to DES in compliance with the Environmental Authority.

3.3 Demonstrated Performance of the Levees

During late 2010 and early 2011, the levees (including the C Pit levee still under construction at that time) experienced two significant floods close together. The Nogoa River Duck Ponds gauging station indicated flood heights of just under 14 m and approximately 15 m in late December 2010 and early 2011 respectively (along with two other floods of approximately 9 m height in 2010), compared to the level of 14.5m in the 2008 flood. Reference to the KBR September 2013 flood study report suggests that these floods are of the order of approximately 1 in 100 year (ie 1% AEP) events.

Inspection of the levees at the time and subsequently, indicated very good performance during these events with no significant maintenance required afterwards

Further to the above, 11 annual inspections by an independent RPEQ have been carried out for the levees since 2009. Reference to these reports indicates that only minor maintenance issues have been identified, such as removal of saplings, some minor erosion scours, and a local short section of longitudinal cracking associated with drying. Generally, the grass cover has remained very good apart from the section of B Pit levee adjoining the irrigated cropping land has been unable to sustain grass cover and this is being progressively covered with rock protection.

The most recent annual inspection completed on the 30th of October 2019, performed by Douglas Partners Andrew Middleton (RPEQ 4366) and reviewed by B Egan (RPEQ 8597), confirmed that the condition and adequacy of the levees will be sufficient to meet the necessary performance requirements of the licence terms and certification was provided (protect against a 0.1% AEP flood event). The Form of Certification is shown in Appendix F.

Based on the above information, the flood levees constructed after the 2008 event were designed and constructed in accordance with the approved designs to a Factor of Safety above 1.5 and remain complaint with the Environmental Authority conditions including certification at each stage by RPEQ's. The same Factor of Safety has been included in the Design Criteria for the Landforms documented in the Submitted Option.

The levees remain complaint with the conditions of Environmental Authority EPML00732813 relevant to regulated structures, are safe and stable, and remain fit for purpose to this day.

4.0 Confirmation that the permanent landform is safe and stable in the long-term including RPEQ sign off, qualifications and authoring of technical studies

The studies submitted in support of the Environmental Authority Amendment Application dated 27 March 2019 details that the Submitted Option is safe, stable, does not cause any serious environmental harm, and able to sustain the proposed domains of:

- Grazing/ Water Area
- Native Bushland Corridor, and
- Self-Sustaining Vegetation.

These outcomes support compliance with the Ensham EA condition G15.

> *G15 Residual voids:*
> *Residual voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the environmental harm constituted by the existence of the residual void itself and subject to any other condition within this environmental authority.*

To assist with understanding the information relevant to the Landform area and individual rehabilitation domains, this chapter has been broken down into a number of sections. Section 4.1 discusses the Landform which separates the rehabilitated mining areas from the Nogoa River floodplain, and Section 4.2 discusses the rehabilitation of the open cut mining areas by domain.

Figures 1 to 5 are provided below to assist with understanding of the size and location of each of the domains within the rehabilitated open cut mining areas.

Of note, the inward facing slopes of the rehabilitated open cut mining areas with slopes between 16% - 25% were previously shown in the submitted Rehabilitation Management Plan (and area calculations) as being part of the self-sustaining vegetation domain despite the design criteria for these areas meeting the Grazing Domain treatment. Given the additional information on the 25% slope at site provided by an RPEQ (contained in Section 4.2 of this report) these slopes are now shown as Grazing Domain. This change has led to a reduction of 667ha's previously included in the Self-Sustaining Vegetation Domain.

The Self-Sustaining Vegetation Domain in the long term involves 11ha's or 0.23% of the total area rehabilitated at Ensham Mine and is located only on the D highwall area. Prior to the Water Area achieving rest levels the Self-Sustaining Vegetation Domain involves 14ha's or 0.29% of the total area rehabilitated at Ensham Mine. It is important to note that post rehabilitation, there will remain a distance of 100m – 300m between this rehabilitated highwall slope and the inward facing slope of the Landform. As such any potential for erosion in the Self-Sustaining Vegetation Domain is very unlikely to impact on the Landform. When undertaking the rehabilitation of the 11ha's, consideration will be given as to how the slope in this area can be reduced to less than 33% so as the area can be incorporated into the Native Bushland Domain.

Figures 1 to 5 identify domains for all of the rehabilitated areas at Ensham Mine. Table 1 identifies the areas (ha), percentages (%) and volume of water for each Domain. Of note, the Self-Sustaining Vegetation area is only in the D highwall. This domain has now been removed from all other areas of the rehabilitated open cut mining areas at Ensham mine.

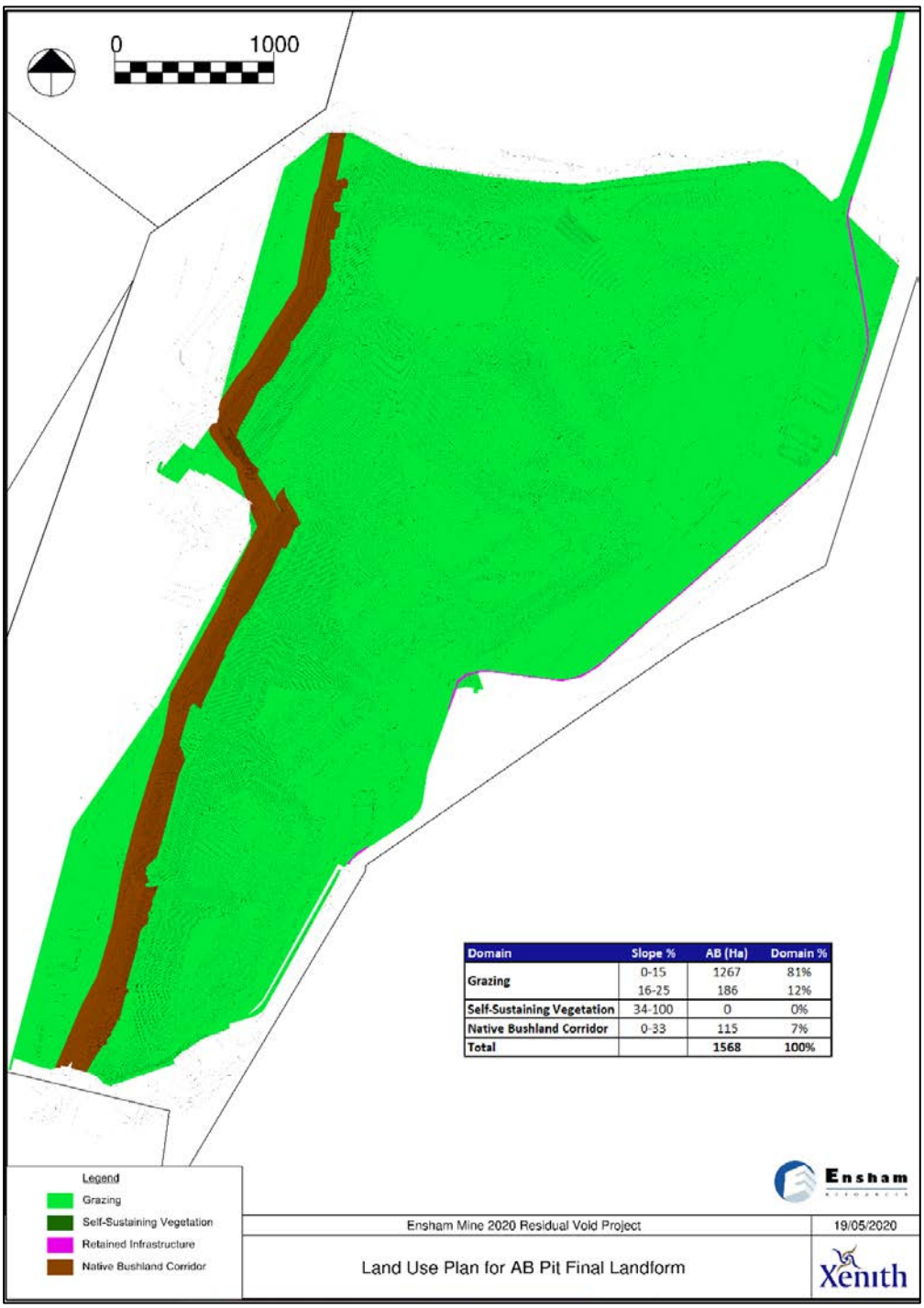

Figure 1 AB Land Use Mapping (without Water Area)

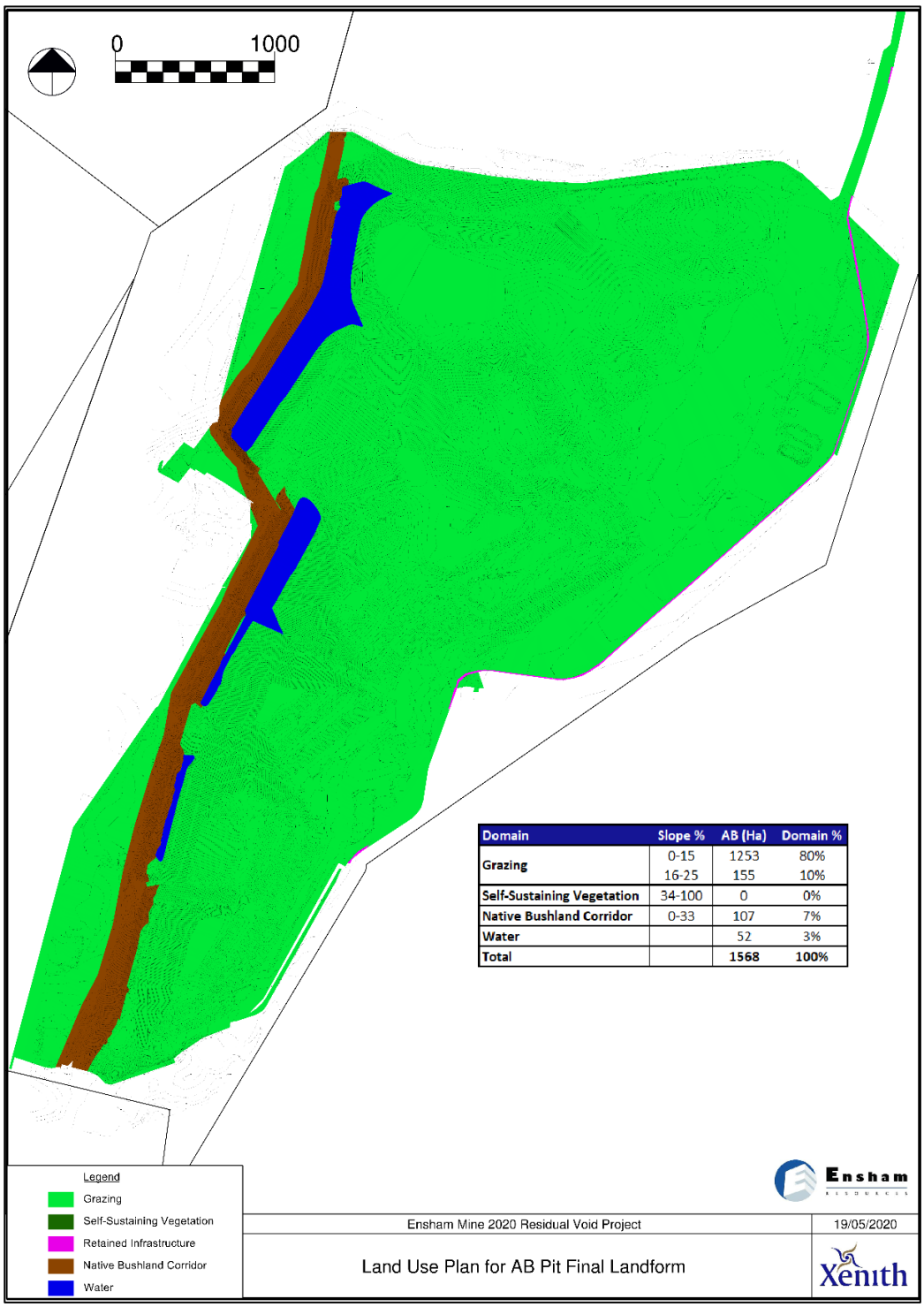

Figure 2 AB Land Use Mapping (with Water Area)

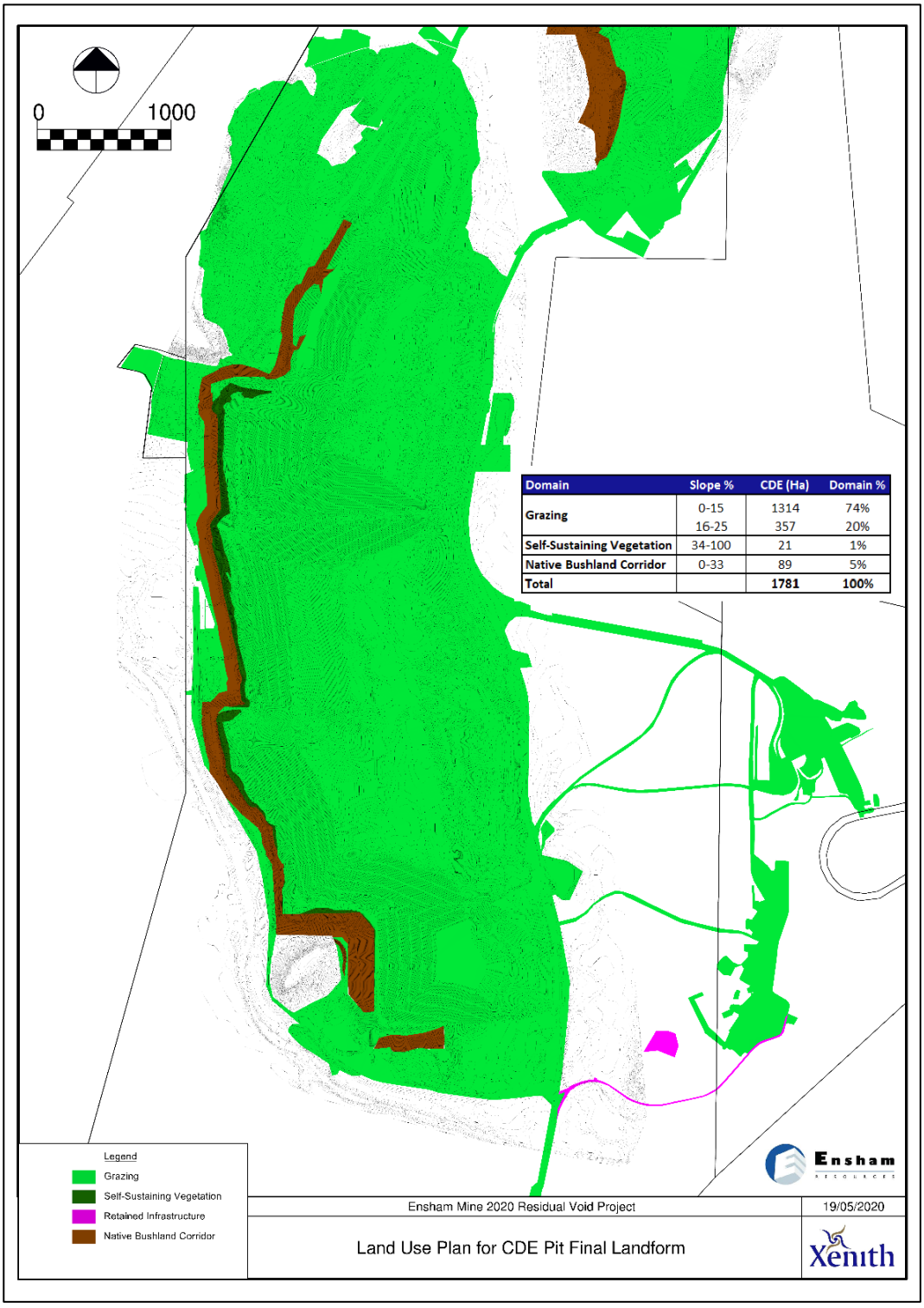

Figure 3 CDE Land Use Mapping (without Water Area)

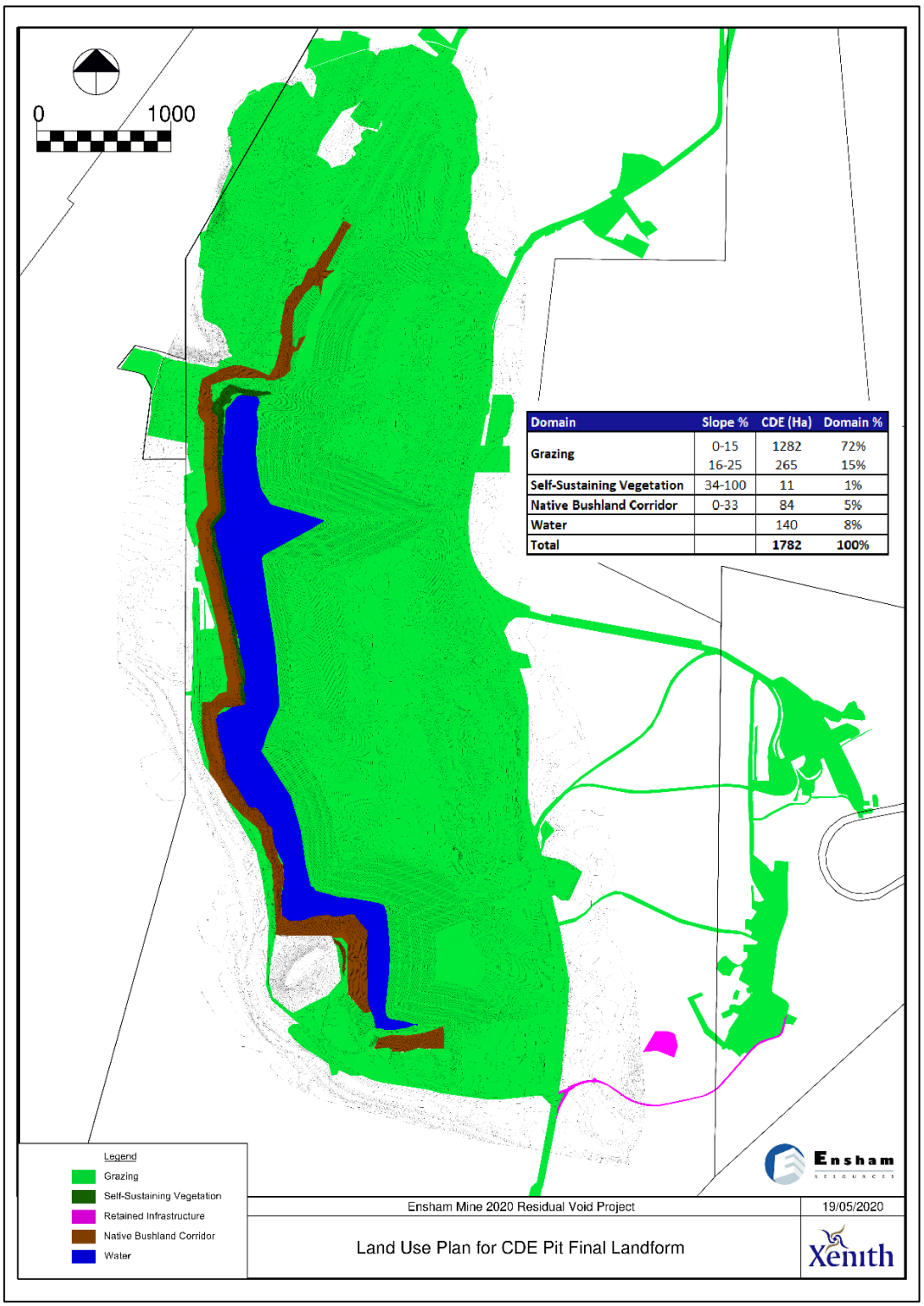

Figure 4 CDE Land Use Mapping (with Water Area)

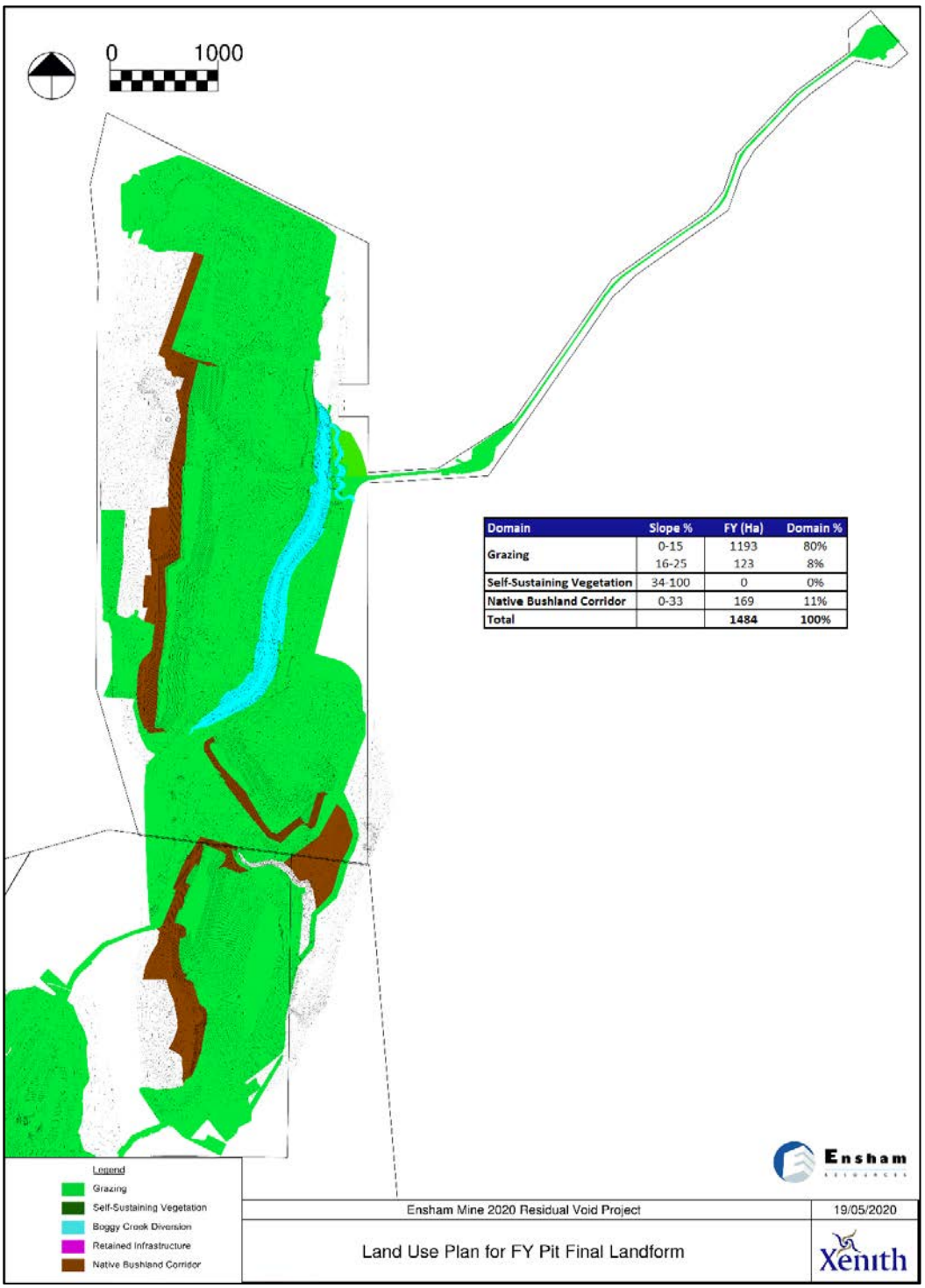

Figure 5 FY Land Use Mapping

Table 1 Predicted Final Water Areas and Volumes for each Domain

Area	Water at Rest (mAHD)	Regional Groundwater Level (mAHD)	Storage Volume (GL)	Affected Area (ha)	Total Rehabilitated Area (ha)	Percentage of Rehabilitation Area (%)	Time for Groundwater to Daylight (post mining)	Approximate year groundwater reaches equilibrium
A South	Groundwater will not daylight in this area				160	3.31%	No groundwater	
A Central	133	144	0.05	3	152	3.14%	50yrs	2140
A North	133	144	1.2	16	300	6.21%	50yrs	2140
B	123	142	3.1	33	957	19.80%	50yrs	2140
C	125	142	22.1	65	748	15.47%	55yrs	2200
D				75	531	10.98%	55yrs	2200
E	Groundwater will not daylight in this area				502	10.38%	No groundwater	
F South					346	7.16%		
F North					247	5.11%		
Y South					265	5.48%		
Y Central					362	7.49%		
Y North					264	5.46%		
Totals			**26.45**	**192**	**4834**	**100.0%**		

4.1 Landforms

The Submitted Option involves separation of the rehabilitated open cut mining areas from the Nogoa River floodplain with RPEQ designed Landforms. The main design outcomes for the Landforms were that these structures must exhibit long-term geotechnical stability, and that seepage below and through the structures during flood events should represent a very low risk of occurrence.

The Landforms have been designed on the alignment of the existing northern and southern levees, which is undisturbed by the open cut mining voids, The Landforms have been designed by RPEQ certified engineers and independently peer reviewed by RPEQ certified engineers using the design criteria listed on page 16 of the Landform Design Report (WSP, 2019). These criteria describe a free draining, safe, and stable Landform with no water ponding or damming on the inward face of the Landform.

The Design Criteria for the Landforms includes the requirement for a Factor of Safety of 1.5. Geotechnical stability modelling and analysis conducted by WSP's RPEQ and Peer Reviewed by Douglas Partners' RPEQ confirms that in all instances the Landform exceeds the FoS of 1.5 requirement. It is important to note that the geotechnical studies, which were carried out using SLOPE/W, considered ACARP Rehabilitation of Highwalls (November 2006, Pells et al; 2015; Pells et al; 2007 and Pells et al, 2005)

Pells et al confirm that exceeding a Factor of Safety of 1.5 is justifiable evidence that such slopes are safe and stable. The position that achieving a Factor of Safety greater than 1.5 is evidence of safe a stable slope has been further supported by the Independent RPEQ geotechnical Peer Reviewer (Douglas Partners, 2019). As such the Landforms will be safe and stable in the long-term.

The flood immunity provided by the Landforms is up to and including a 0.1% Annual Exceedance Probability (AEP) event plus 0.5m which means that these floodwaters are excluded from the rehabilitated open cut mining areas into perpetuity. The Stage 3 Geomorphology Report (WRM, 2019) confirms that the short and medium-term risks of accelerated morphological change in the Nogoa River for the Submitted Option are low.

The geomorphological modelling of the extreme event (1.5 x a 0.1% AEP event), which is greater than the flood event required to be modelled for a flood plain, suggests that there remains a long-term risk, albeit with very low probability of morphological change to the Nogoa River as a result of the Landforms being overtopped in flood. If such an extreme event occurred, it would appear unlikely that the course of the Nogoa River or Anabranch would be altered to drain through the rehabilitated open cut mining areas (p60 Geomorphic Impact Assessment of Options, WRM 2019). The provision of a designated overflow point in the northern Landform would reduce the likelihood of an overtopping event eroding the embankment to bed level, in the very unlikely event that an overtopping event occurred (p62 Geomorphic Impact Assessment of Options, WRM 2019). The recommended designated overtopping point has been included in the Submitted Option to reduce the long-term risk.

Additionally, the flood modelling (HEC,2019) predicts negligible change in flood levels compared with the existing conditions which has been identified in the Social Impact Assessment as an important consideration for the community (Social Impact Assessment Section 7.4.1 starting on p100).

These Landforms have been designed to be consistent with, and blend into, the regional landscape including the escarpment to the north of the Nogoa River. As such the Submitted Option is not expected to have any significant impact on the visual amenity of the area.

The names, qualification of those involved in the design of the Landform and peer review are contained in Appendix B.

4.2 Grazing/ Water Area Domain

The Grazing Domain covers 4,441 ha’s or 91.9% of the total rehabilitation to be undertaken at Ensham Mine.

Consistent with Section 2 of the submitted Rehabilitation Management Plan the design of the grazing domain with deliver a significantly better post mining land suitability for grazing than pre-mining for this area. This is supported by land mapping completed prior to mining in 1992 and undertaken as part of the Ensham Mine Environmental Management Overview Strategy (EMOS). This mapping shows significant amounts of the northern mining areas as being Land Suitability Class 5. Land Suitability Class 5 describes land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner eg grazing (Guidelines for Agricultural Land Evaluation in Queensland 2015, page 9). The Completion Criteria contained in the submitted Rehabilitation Management Plan identifies that the areas that were Class 5 areas will now be equal to or greater than Class 4 (as defined in Appendix E: Land use limitation subclass threshold limits of the submitted Rehabilitation Management Plan)

In addition, it should be noted that the Design Criteria for the Grazing Domain calls for the lowest point of the rehabilitated open cut mining Y and F areas to be raised above the groundwater recovery level. As such, groundwater can never daylight in these areas.

Once water appears in A, B, C, and D areas, then the affected area, which is approximately 3.9% of the total rehabilitated area at the Ensham Mine, will transition from a grazing PMLU to the Water Area PMLU. This is predicted to occur approximately 50 to 55 years post mining as seen in Figures 2 and 4 above. Water daylighting in the grazing domain is an outcome caused by the existence of the voids in of themselves.

The Water Area domain will be fenced either prior to relinquishment or once the water daylights (whichever is the sooner) to prevent cattle from accessing this water, Maintenance of these stock fences will be the responsibility of the landowner, which is currently the proponent.

As groundwater daylights in this 192ha, it is anticipated that aquatic bird life will reside in these Water Areas similar to current site dams and pits with water (from groundwater), that support large numbers of aquatic bird life that would not exist on site otherwise. These Water Areas will complement existing water habitats locally and regionally.

Should title transfer to another landowner, then maintenance of the fencing will become the responsibility of the new landowner and would not be expected to be any more onerous than the cost of other fencing maintenance regionally.

A smaller area of this grazing domain is made up of inward facing low wall slopes between 16% to 25%. There have been a number of discussions with DES about the expected erosional performance of these inward facing slopes, the use of rock mulch to minimise erosion, and, the ability for these slopes to support sustainable grazing. Ensham are aware that:

- spoil slopes have been certified at Norwich Park Mine at 20% (Figure 6) and Newlands Mine at 22% (Figure 7) as safe, stable and suitable for grazing without the use of rock mulching.
- There are current contemporary Environmental Authorities that allow residual void low wall slopes up to 45^{o}, and
- 25% slopes and hydro mulching have been previously approved on outward facing rehabilitation slopes.
- A recent approval was granted where the low walls are required to be stable. No angle is specified.

Figure 6 Certified 20% slope at Norwich Park Mine

Figure 7 Certified 22% slopes at Newlands Mine

There is therefore contemporary evidence supporting that slopes up to 22% can be successfully rehabilitated, and other Proponents have approval for residual void low wall slopes greater than those proposed by Ensham Mine. Ensham is then left to discuss in this report how residual void low wall slopes between 22% and 25% are able to be rehabilitated.

To demonstrate that low wall slopes of 22% to 25% can be successfully stabilised with vegetation cover, a site inspection of an existing 25% low wall spoil slope located at Ensham mine was conducted on 11th of March 2020 by an RPEQ certified civil engineer with significant mine rehabilitation experience.

The scope of the inspection was to confirm the slope angle and provide advice on how the slope was performing with regards to both stability and erosion performance. It is important to note that this slope was initially prepared by cross ripping the slope area and covering the slope with approximately 30mm to 40mm of topsoil. The slope was then fertilized and seeded.

Photos of the inspected slope include:

- Figure 8 which identifies the location of the inspected area and reference locations within the inspection area
- Figure 9 which shows the side profile of the inspected area based on Lidar and confirms the slope of approximately 25%
- Figure 10 which shows the inspected area from the base of the slope, and
- Figures 11 and 12 which shows additional pictures of the rehabilitated slope from different viewpoints.

A summary of the RPEQ site inspection report is as follows:

- Total slope length was approximately 120m
- 25% slope length was approximately 75m
- The slope has been in place at Ensham for approximately 11 years.
- No major erosion areas were identified, indicating that the 25% slope is stable and capable of sustaining vegetation cover
- Vegetation was well established with undergrowth and creeper grasses
- Ground cover was greater than 80%.

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Figure 8 The inspected area relative to the C/D Pit

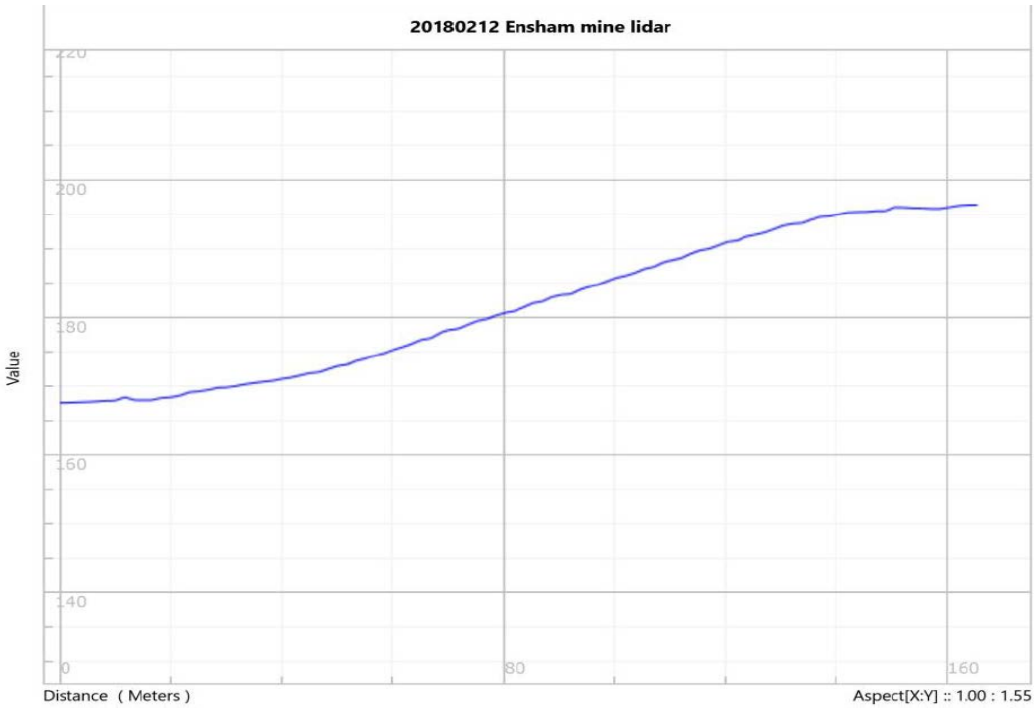


Figure 9 Side profile of the Inspected area based on Lidar

Figure 10 The inspected area looking towards location B

Figure 11 Vegetation taken from location B

Looking downslope from location B

Looking upslope from the base across the inspected area

Figure 12 Landscape photos (4) from different viewpoints

The RPEQ reported that the 25% slope is generally performing well with no visible signs of significant erosion. The vegetation was observed to be in good condition and demonstrates that slopes up to 25% can be successfully rehabilitated, including being erosionally stable, at Ensham Mine.

Conventional contouring, cross ripping, topsoiling and seeding of 25% rehabilitation areas can deliver positive outcomes at Ensham. Additionally, Figure 13 identifies that 10m benching at approximately 75m intervals reduces the base to crest slope angle of the 25% slopes in B, C and D rehabilitated areas to an effective 22% slope angle. The removal of water from each slope on bench likely means better erosion performance than a 22% 200m slope run length.

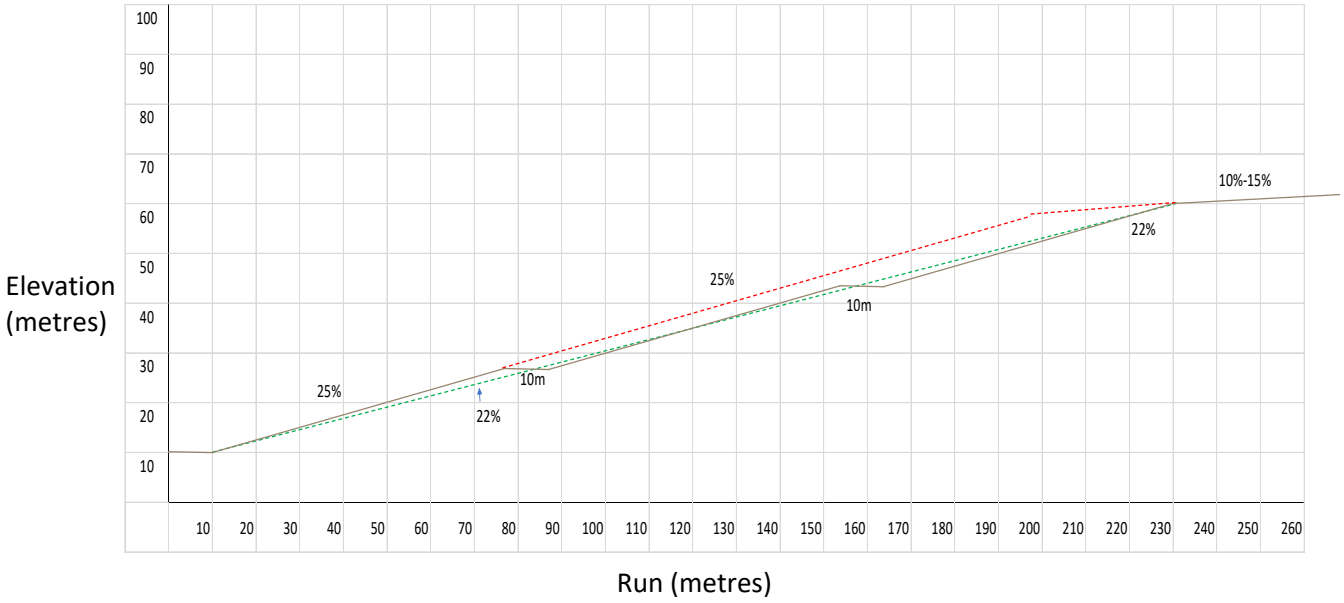


Figure 13 22% effective slope (Xenith 2020)

It is recognised that rock mulching has historically been used by industry in minimising erosion on low wall spoil slope angles greater than 15% and could be seen as a lower risk strategy for erosion management. Unfortunately, the use of rock mulching, while useful for erosion management, is undesirable for grazing post mining land uses ie: grazing where the dominant pre-mining land use. Erosion is controlled to an acceptable level however the use of rock mulch precludes grazing and, as such, delivers a lower rehabilitation hierarchy outcome.

In instances where a site is topsoil deficient or when the spoil requires additional treatments other than topsoiling and seeding, then hydro mulching has proven to be a viable treatment option.

Hydro mulching is a one-step application process that allows customised treatment to deliver faster and more sustainable vegetation growth than conventional topsoil and seed practices. When customised by soil scientists and managed by experienced rehabilitation practitioners, these treatments act to replenish the soil with nutrients and improve the soils ability to support long term growth, all while promoting erosion control and soil stabilisation.

When added with soil binding agents the composition of these mulches makes them very effective on depleted and/ or dispersive soils.

Examples of hydro mulching applied to spoil slopes at 25% in coal mining in Queensland include the Blackwater Creek Diversion which used hydro mulching and hydro seeding to treat 179 ha of land as shown in Figure 14.

Figure 14 Slope preparation and application of hydro mulching at Blackwater Creek

The use of the hydro mulching (or other similar treatment) would support an additional 667ha of grazing area. Rock mulching this 667ha will deliver a lower land use outcome than the pre mining use and is inconsistent with principle of the Hierarchy of Rehabilitation which requires that strategies listed higher in the hierarchy should be adopted in preference to those listed lower. In essence Ensham Mine are aiming to deliver a higher order strategy (grazing) whilst rock mulching would deliver a lower order strategy.

To ensure that the rehabilitated open cut mining areas meet the performance criteria prior to relinquishment of the mining lease, the following are proposed:

- Annual reviews and reporting of rehabilitated areas to confirm the condition of the rehabilitation. Recommendations of the review to be implemented;
- If the slopes are not able to achieve the completion criteria the relevant slopes will be re-profiled or given alternate treatment to achieve a stable outcome as recommended by the suitably qualified person.

The above said, the 25% inward facing low wall slopes cannot cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer as run off from these slopes does not report to the receiving environment as discussed in the Water Report (SMI, 2020).

4.3 Self-Sustaining Vegetation

The Self-Sustaining Vegetation Domain in the long term involves 11ha's or 0.23% of the total area rehabilitated at Ensham Mine and is located only on the D highwall area. Prior to the Water Area achieving rest levels the Self-Sustaining Vegetation Domain involves 14ha's or 0.29% of the total area rehabilitated at Ensham Mine.

It is important to note that post rehabilitation, there will remain a distance of 100m – 300m between this rehabilitated highwall slope and the inward facing slope of the Landform. As such any potential for erosion in the Self-Sustaining Vegetation Domain is very unlikely to impact on the Landform. When undertaking the rehabilitation of the 11ha's, consideration will be given as to how the slope in this area can be reduced to less than 33% so as the area can be incorporated into the Native Bushland Domain.

The Geotechnical Report (WSP, 2019) prepared and peer reviewed by RPEQ's for the Submitted Option demonstrates that all highwall slope angles including the 33% - 100% self-sustaining vegetation area exceed a Factor of Safety of 1.5 and would be safe, stable, and would not cause environmental harm.

Section 4.1 of the Geotechnical Report states the Methodology used for the geotechnical analysis included the use of SLOPE/W and SEEP/W software. Section 4.2 Highwall Stability of this report focusses specifically on the stability of the highway treatment (inclusive of 33%-100% slopes). It is important to note that the studies, which were carried out using SLOPE/W, considered ACARP Rehabilitation of Highwalls (November 2006, Pells et al; 2015; Pells et al; 2007 and Pells et al, 2005)

Pells et al confirm that exceeding a Factor of Safety of 1.5 is justifiable evidence that such slopes are safe and stable. The position that achieving a Factor of Safety greater than 1.5 is evidence of safe a stable slope has been further supported by the Independent RPEQ geotechnical Peer Reviewer (Douglas Partners, 2019).

In addition to the studies discussed above, Ensham have also considered successful slope treatments in environments outside of open cut mining which are intended to be employed to rehabilitate the 33% to 100% slopes at Ensham.

Figures 15 and 16 demonstrate that fresh rock slopes profiled to angles higher than 100%, which is the maximum for the self-sustaining vegetation domain, can be successfully rehabilitated without the use of rock mulch. These figures are representative of the height of the 11ha of self-sustaining vegetation slope in D rehabilitated open cut mining area.

Figure 15 **Centennial Motorway - Amelioration of fresh rock slope and two months post application**

Figure 16 **The same Centennial Motorway fresh rock slope after 3yrs**

Similar applications have been successful on the Tugan Bypass which has required stabilisation of much higher slopes runs than expected for the self-sustaining vegetation domain at Ensham Mine. Refer to Figures 17 and 18 over page.

Figure 17 **Tugan Bypass - Amelioration of fresh rock slope and post application (April 2008)**

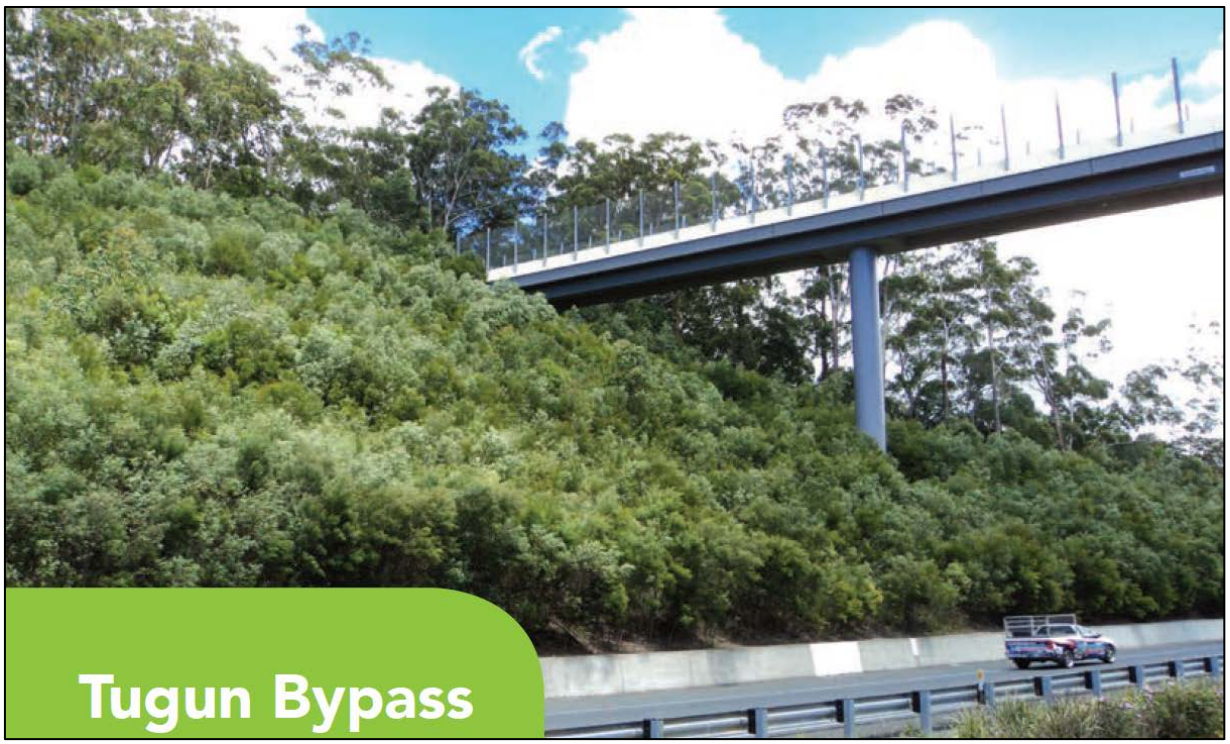


Figure 18 **Tugan Bypass slope stabilisation with hydro mulching (February 2012)**

Safe access to these higher slopes on the Tugan Bypass during the construction phase was an operational issue safely managed with the use of elevated work platforms. The slopes at Ensham mine would be constructed in multiple steps to achieve the final batter slopes safely using tracked equipment which are regularly operated on down-gradients in excess of 100%. Once profiled and treated, there would not be any need for further vehicle traffic on these slopes.

As such, slopes from 33% to 100% can be successfully rehabilitated and the self-sustaining vegetation will provide habitat for local fauna and compliment the adjacent Native Bushland Habitat domain. Plant species selection will be determined closer to time of rehabilitation and would logically require the inclusion of small trees similar to Figure 16 to assist with water infiltration and velocities.

The Submitted Option identifies the minimum vegetation cover for this domain as greater than 50% to minimise erosion. This is the minimum vegetation cover Ensham Mine believe will be required to manage erosion of this narrow slope.

It is important to note that post rehabilitation there will remain a 100m – 300m distance between the rehabilitated highwall slope and the inward facing slope of the Landform. As such any erosion in the Self-Sustaining Vegetation Domain is very unlikely to impact on the Landform.

When undertaking the rehabilitation of the 11ha's, consideration will be given as to how the slope in this area can be reduced to less than 33% so as the area can be incorporated into the Native Bushland Domain.

Of note, the inward facing slopes of the rehabilitated open cut mining areas with slopes between 16% - 25% were previously shown in the submitted Rehabilitation Management Plan (and area calculations) as being part of the self-sustaining vegetation domain despite the design criteria for these areas meeting the Grazing Domain treatment. Given the additional information on the 25% slope at site provided by an RPEQ (contained in Section 4.2 of this report) these slopes are now shown as Grazing Domain. This change has led to a reduction of 667ha's previously included in the Self-Sustaining Vegetation Domain.

4.4 Native Bushland Corridor

The Native Bushland Corridor Domain covers 372 ha's or 7.7% of the total rehabilitation to be undertaken at Ensham Mine and is located on the western side of the rehabilitated open cut mining areas, connecting Corkscrew Creek with the Nogoa River floodplain and then up into the escarpment country.

This domain performs a dual function in that it provides connectivity for local fauna and prohibits vehicle access onto the rehabilitated highwall slopes. This sustainable control is seen as better practice than conventional practice that includes berm and fencing of the highwall.

Similar to the Self-Sustaining Vegetation domain above, the selection of the flora species will be determined closer to time of rehabilitation as per BioCondition benchmarks for regional ecosystem condition assessment, DSITI 2018.

The native species richness and ground cover proposed in the Submitted Option are seen as acceptable. Ensham understands that clarification is sought on the region relevant to the BioCondition benchmarks. Ensham propose to change the completion criteria for this domain to read "As per BioCondition benchmarks for the Central Highlands area".

5.0 How the Submitted Option design was developed having regard for the rehabilitation hierarchy

How the Submitted Option design was developed having regard for the rehabilitation hierarchy is detailed in Section 5 Landform Design Goal and Objectives of the submitted Rehabilitation Management Plan (RMP) (Ensham, 2019).

Section 5.1 talks to the rehabilitation goals of the submitted option being in accordance with the DES Guideline[1] and that that rehabilitated areas will be:

1. Safe to humans and wildlife
2. Non-polluting;
3. Stable; and
4. Able to sustain an agreed post-mining land use

Section 5.2 discusses the Rehabilitation Hierarchy and confirms that the rehabilitation was developed having regard for the Rehabilitation Hierarchy. Additional information on the application of the Rehabilitation Hierarchy is included in Section 5.1 of this report.

5.1 Application of the Rehabilitation Hierarchy

In assessing the acceptability of Rehabilitation Objectives, Indicators and Completion Criteria proposed as part for the Submitted Option, Ensham Mine have had regard to the Hierarchy for Mine Rehabilitation and adopted the Rehabilitation Goals detailed in Rehabilitation requirements for mining resource activities

With respect to the Hierarchy of Rehabilitation, strategies listed higher in the hierarchy have been adopted in preference to those listed lower, unless there are significant environmental, economic or social issues that override such a selection. The rehabilitation hierarchy applied, in order of decreasing capacity to prevent or minimise environmental harm, is:

1. avoid disturbance that will require rehabilitation,
2. reinstate a “natural” ecosystem as similar as possible to the original ecosystem,
3. develop an alternative outcome with a higher economic value than the previous land use,
4. reinstate previous land use (e.g. grazing or cropping)
5. develop lower value land use or

[1] Guideline, Resource Activities, *Rehabilitation requirements for mining resource activities*, ESR/2016/1875, Department of Environment and Science, 23 May 2014.

6. leave the site in an unusable condition or with a potential to generate future pollution or adversely

7. affect environmental values.

In summary, the rehabilitation proposed by Ensham in the Submitted Option will deliver a final landform with the following three (3) Domains:

- Grazing/ Water Area domain.
- A Native Bushland Corridor domain
- A Self-Sustaining Vegetation domain

In terms of total area rehabilitated, the following shows the domains and areas involved in order of the rehabilitation hierarchy:

No 1: Avoid disturbance: Unable to avoid the creation of the open cut, design to minimise impacts
No:2 Reinstate a "natural" ecosystem: The Native Bushland Corridor domain is 372 ha's or 7.7% of the total rehabilitation area
No:3. Higher economic value: Reservoir PMLU not advanced as part of the RVP
No 4: Reinstate previous land use:
The Grazing domain totals 4,441ha's or 91.9% of the total rehabilitated area.

- The Water Area covers an additional 192ha's or approximately 3.9% of the Grazing domain which is available for grazing until water daylights.
- Reallocation of the 16-25% low wall slopes previously in the self-sustaining vegetation cover domain to grazing has improved the rehabilitation outcome for 667ha's.

No 5 Develop lower value land use:
The Self-Sustaining Vegetation domain is 11 ha's or 0.23% of the total rehabilitated area,

Further details are provided following specific to each strategy on the Hierarchy of Rehabilitation.

In considering the Rehabilitation Hierarchy for the Residual Void Project and given the physical existence of the current mining voids, Ensham is unable to avoid the creation of the open cut mining areas. The design of the Landform for the Submitted Option did consider how to minimise impacts on the biodiversity values of the floodplain through the retention of the current alignment of the levees for the Landform which is consistent with hierarchy no:1 avoid disturbance that will require rehabilitation.

Civil works required to improve the long-term erosion performance of the outward facing slope of the Landform will result in some clearing of non-regulated regrowth/previously disturbed vegetation. A Threatened Species Survey of this area was conducted by AARC Environmental Solutions confirming that the ecological values associated with this land are limited. During the survey no species that are listed under the Environmental Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) were recorded, as such the proposed disturbance is not considered to impact upon a Matter of National Environmental Significance (MNES). As the proposed disturbance is not considered to impact upon any MNES or MSES, no environmental offsets under the Environmental Offsets Act 2014 (QLD) are required. (AARC Environmental Solutions 2019)

Ensham has given consideration as to how it could deliver hierarchy no 2. reinstate a "natural" ecosystem as similar as possible to the original ecosystem. Consistent with the TBLA outcomes, Ensham have included the Native Bushland Corridor domain in the Submitted Option. This is consistent with Hierarchy no:2 reinstate a "natural" ecosystem as similar as possible to the original ecosystem.

The Native Bushland Corridor between Corkscrew Creek and the Nogoa River floodplain provides connectivity between these areas complementing the Nogoa River Biodiversity Corridor. Similarly, the provision of the Native Bushland Corridor to the north of the Nogoa River will provide connectivity between the floodplain and the escarpment country and the Boggy Creek Diversion rehabilitation currently nearing completion.

These corridors are anticipated to be beneficial for a variety of native fauna species increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape (p77, Ecological Assessment Report, Umwelt 2019).

Consideration was also given to hierarchy no:3. Ensham Mine originally included a reservoir in Option 2 which would have developed an alternative outcome with a higher economic value than the previous land use. Following feedback received in January 2019 from DES and DNRME, Ensham Mine chose to replace the reservoir PMLU with a grazing PMLU for the inward facing low wall slopes.

The reinstatement of the grazing PMLU for the inward facing low wall slopes in the rehabilitated open cut mining areas is consistent with the pre mining land use (Hollingsworth, Dames and Moore ECP IAS 1990 p92) and aligned with Hierarchy no: 4 - reinstate previous land use (e.g. grazing or cropping). Additionally, the inclusion of the 667ha's into the grazing domain connects the grazing areas lower in the rehabilitated open cut mining areas with the grazing areas on the upper and outward facing slopes. This complements the existing approved grazing domain area currently approved in the Ensham Mine Environmental Authority, delivering additional income producing land for the landowner which would assist with maintenance and upkeep of the rehabilitated land.

Grazing has been, and continues to remain, a key industry for the Central Highlands (Central Highlands Economic Master Plan, 2017). The grazing domain in the Submitted Option will further support the Central Highlands grazing industry,

The industry practice of rock armouring of spoil slopes greater than 15% to reduce erosion has been considered in the context of the hierarchy of rehabilitation in development of the Submitted Option. It was identified that rock armouring on these inward facing low wall slopes would not support grazing, and if used, would deliver a lower value land use (No:5), based on the Rehabilitation Hierarchy. In addition, the quantities of rock required to rock armour such a large area (667ha's) would likely require additional offsite disturbance to win the rock requiring additional offsite rehabilitation.

Accordingly, consideration has been given to rehabilitation treatments which would deliver erosionally stable rehabilitation outcomes. Further information on these rehabilitation treatments is contained in Section Chapter 4.2 of this report.

Complete backfilling of the mining voids on the floodplain to the Possible Maximum Flood level was studied as an Option in the Residual Void Project (Option 3). The impact on the environmental values of this option was assessed in Stage 3. The Stage 3 and Stage 4 reports identified a number of environmental, economic and social risks, including:

- Under Option 3 rehabilitated open cut mining areas for A South, B, C, and D all drain to the receiving environment. The Environmental Assessment Report (p149) identifies that this Option has a higher likelihood of impacting water quality objectives for downstream users through increased sediment loads.
- The Landform Design Report (p26) identifies that to minimise this erosion risk for downstream users and maximise groundcover, grazing would need to be excluded on these rehabilitated areas.

- Complete backfilling of the voids was the least preferred option by the public as reflected in the results of community consultation due to the requirement to remove the existing levees resulting in additional downstream flooding and also the additional sediment likely to be released into the receiving environment (Social Impact Assessment Section 7.4.1 starting on p100).
- Deloitte Access Economics modelled the:
    - Total Net Benefit to Qld for Option 3 at $476.65M (NPV) whilst the Submitted Option Total Net Benefit to Qld is $667.44M (NPV)
    - Volume of material required for complete backfilling of the residual voids on the floodplain to PMF (Option 3) was 240 million cubic metres. The volume of material required for the Submitted Option is 107 million cubic metres.
    - Cost to Queensland of greenhouse gas emissions, largely associated with diesel burn to move material, for Option 3 were similarly higher at $2.7M (NPV), compared with the Submitted Option at $0.8M (NPV).

Based on the above information, which has been Independently Peer Reviewed, backfilling to PMF is not practicable nor reasonable having regard to the environmental risks associated with increased erosion and downstream sediment during larger flood events, the scale and volume of material required, the views of both upstream and downstream stakeholders and landholders and the economic costs and benefits when compared to the Submitted Option. As such Option 3 was not progressed to the administering authority for consideration.

Further details as to why Option 3 was the least preferred option of the 3 options studied in the Residual Void Project are contained in the Stage 4 Triple Bottom Line Assessment, supported by the Stage 3 environment studies, the Social Impact Assessment and the Supplementary Economic Impact Assessment for the Submitted Option (Deliotte, 2019).

Water daylighting in the grazing domain (the Water Areas) represents a lower value land use than grazing however this outcome is caused by the existence of the voids in of themselves.

The Water Area is discussed further in Section 4.2 of this report. There will be no export of water from the rehabilitated open cut mining areas to surface water in the receiving environment and there will be no flow from the rehabilitated open cut mining areas to the regional groundwater system (p7, Water Report UQ SMI 2020). As groundwater daylights in this 192ha, it is anticipated that aquatic bird life will reside in these Water Areas similar to current site dams and pits with water (from groundwater), that support large numbers of aquatic bird life that would not exist on site otherwise. These Water Areas will complement existing water habitats locally and regionally.

Based on the information in Section 5 there are no open cut mining areas left in an unusable condition or with a potential to generate future pollution or adversely affect environmental values.

6.0 Additional opportunities to optimise the submitted option design and address DES erosion concerns

6.1 Overview

The following optimisations to the design of the rehabilitated open cut mining areas are proposed in response to feedback from DES.

These changes do not require additional geotechnical stability analysis as confirmed by WSP (2020) (refer Appendix G). This is due to the fact that the changes represent improvements in erosion performance on the already assessed slope angles and will not affect the Factors of Safety presented in the Submitted Option. There are no increased gradients or slope lengths with the optimisations, only reductions in these nominated areas.

6.2 Details of the Additional Landform Treatments to the Submitted Option

The following section details the proposed optimisations to be applied to targeted locations on the low wall and highwall areas of the rehabilitated open cut mining areas. The Rehabilitation Hierarchy was considered when deciding to make the following modifications.

Additional backfilling to reduce/ eliminate groundwater daylighting in A, B, C, D and E rehabilitated open cut mining areas was considered in preparing the Submitted Option, in discussions with DES post submission and with Dr Noel Merrick (Principal Hydrogeologist, HydroSimulations) in developing the optimisations contained in this report. Of note, the specific issue and being considered below in this section is the flow of surface concentrated bioaccumulated water from the rehabilitated mining areas to the regional groundwater system.

Increased backfilling has been included for A South and E rehabilitated open cut mining areas, and has not been included in B, C and D rehabilitated open cut mining areas for the following reasons:

- Additional backfilling in A South and E rehabilitated areas is modelled to eliminate groundwater daylighting before the increasing height of daylighting water associated with the additional backfilling connects the daylighting water to the regional groundwater system.
- For B, C and D rehabilitated mining areas any increase in volume of backfill will increase the height of daylighting water thus increasing the risk of connectivity with the regional groundwater table (HS, 2020). Daylighting water is modelled to flow to the regional groundwater system before additional backfill can exclude the groundwater from daylighting.

  Based on the current design of the rehabilitation and associated water studies for the Submitted Option, the water in the rehabilitated open cut mining areas can never flow to regional groundwater or the receiving environment. Additional backfilling would not lead to a reduced risk of environmental harm, which could justify the additional costs. This decision not to place additional fill in B, C and D rehabilitated areas is consistent with Section H of the DES guideline in the Assessment requirements

for making a decision for an Environmental Authority for an Environmentally relevant activity (24 March 2015)

6.2.1 Low walls

Changes to the low wall rehabilitated areas have been made as listed below:

A South Rehabilitated Mining Area

- Additional backfilling will occur to eliminate groundwater daylighting in the A South.
- All inward facing low wall slopes with a slope gradient of 20% - 25% will include additional benching and have reduced slope lengths of approximately 75m to reduce the water velocities on these slopes. 75m slope runs have been chosen because these lengths have proven to be safe and stable and performed well from an erosion perspective on the 25% low wall slope discussed in Section 4.2 of this report.

B Rehabilitated Mining Area

- All inward facing low wall slopes with a slope gradient of 20% - 25% will include additional benching and have reduced slope lengths of approximately 75m to reduce the water velocities on these slopes. 75m slope runs have been chosen because these lengths have proven to be safe and stable and performed well from an erosion perspective on the 25% low wall slope discussed in Section 4.2 of this report.

C, D & E Rehabilitated Mining Area

- The land bridge between D and E rehabilitated open cut mining areas has now been removed and the E rehabilitated open cut mining area floor lifted to exclude groundwater daylighting in the rehabilitated landform. The rehabilitated floor will blend up into the as constructed rehabilitated areas to the north. The resulting north to south declining floor gradient will match the adjacent escarpment and allows this rehabilitated area to free drain to D rehabilitated open cut mining area. Water will therefore not accumulate in the E rehabilitated area.
- All inward facing low wall slopes with a slope gradient of 20% - 25% will include additional benching and have a reduced slope length of approximately 75m to reduce the water velocities on these slopes. 75m slope runs have been chosen because these lengths have proven to be safe and stable and performed well from an erosion perspective on the 25% low wall slope discussed in Section 4.2 of this report.

F and Y Rehabilitated Mining Area

The fundamental design of F and Y rehabilitated landscapes remain unchanged from the Submitted Option provided to Des on 27 March 2019. It should be noted that the Design Criteria for the Grazing Domain calls the lowest point of the rehabilitated open cut mining landform for Y and F areas to be raised above groundwater recovery level. As such, groundwater can never daylight in these areas (p13 Void Water Quantity and Quality Balance Modelling 2019).

- All inward facing low wall slopes with a slope gradient of 20% - 25% will include additional benching and have a reduced slope length of approximately 75m to reduce the water velocities on these slopes.

- 75m slope runs have been chosen because these lengths have proven to be safe and stable and performed well from an erosion perspective on the 25% low wall slope discussed in Section 4.2 of this report.

Consistent with Section 2 of the submitted Rehabilitation Management Plan, the design of the grazing domain for the F and Y areas with deliver a significantly better post mining land suitability for grazing than pre-mining for this area. This is supported by land mapping completed prior to mining in 1992, undertaken as part of the Ensham Mine Environmental Management Overview Strategy (EMOS) which shows significant amounts of the northern mining areas as Land Class 5. These areas are proposed to be rehabilitated to equal to or greater than Class 4 in the Submitted Option.

6.2.2 Highwalls and Endwalls

Highwall and endwall rehabilitation treatments, including the selection and cover of vegetation to reduce erosion, have been assessed in the Stage 3 Geotechnical and Landform studies and determined to be safe and stable. As discussed in Section 4 of this report these studies were conducted by RPEQ engineers and peer reviewed by RPEQ engineers. As such the design of these slopes will be essentially the same as described in the Submitted Option previously submitted to DES with the following exceptions:

A South Rehabilitated Mining Area

- The additional backfill discussed in the low wall section (above) will mean a reduction in the highwall angle from 33% to 100% down to 20% to 25%. As there are existing 20% to 25% highwall slopes in the Native Bushland Corridor domain of the Submitted Option then there is no requirement to conduct additional stability or erosion modelling of this revised slope angle. Effectively the Native Bushland Corridor will go from the top of the existing highwall down to the floor of this rehabilitated open cut mining area.

B Rehabilitated Mining Area

- The northern end wall buttressing fill slope angle has been reduced from 25% to 15%. This area will be rehabilitated using conventional topsoil and seed, or, hydro mulch processes. Previously, the Submitted Option had this design slope at 25% with rock armouring. A review of this slope was conducted, including the use of the Hierarchy of Rehabilitation, and it was identified that this treatment would have delivered a lower value land use. Reducing the slope angle to 15% with vegetation cover means that this area will now be available for grazing purpose consistent with the pre-mining land use as opposed to being sterilized with the use of rock mulch.

7.0 Conclusions

The following conclusions are drawn from this report.

1. The Hierarchy of Rehabilitation has been used in the development of the Submitted Option and optimisations in Section 5 of this report to deliver the best practicable outcomes for rehabilitation at Ensham Mine.
    a. The Native Bushland Corridor corridors are anticipated to be beneficial for a variety of native fauna species increasing the available vegetation cover and associated foraging opportunities in the locality, as well as increasing fauna movement opportunities in this landscape.
    b. The movement of 667ha's from the self-sustaining vegetation domain has reduced this domain down to 11ha on D highwall rehabilitated area only.
        i. Ensham Mine would look to incorporate this 11ha in the construction phase into the Native Bushland Corridor domain.
    c. 4441ha's of land will be returned to grazing.
2. Low wall slopes of 22% to 25% can be successfully stabilised with adequate vegetation cover and can be returned to productive grazing, consistent with the regional pre-mining land use, and is the highest practical rehabilitation outcome (No. 4) based on the Hierarchy of Rehabilitation.
    a. These inward facing low wall slopes cannot cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer as run off from these slopes does not report to the receiving environment.
    b. 10m benching at approximately 75m intervals reduces the base to crest slope angle of the 25% slopes in B, C, D rehabilitated areas to an effective 22% slope angle.
3. All proposed rehabilitated slopes exceed a Factor of Safety of 1.5 and are therefore safe and stable.
    a. All geotechnical and landform designs and stability assessments have been certified by RPEQ's.
4. Waterbodies daylighting in the long term in the rehabilitated open cut mining areas have been reduced from 7 to 5 water bodies.

8.0 References

Central Highlands Economic Master Plan, 2017

Deloittes Access Economics. 2019. Supplementary Deloitte Economic Impact Assessment Report

Ensham Resources. 2018. Ensham Coal Mine Residual Void Project. Stage 3: Environmental Assessment Report.

Ensham. Resources 2019. Triple Bottom Line Assessment Report.

Ensham. Resources 2018. Grazing Land Management Plan.

HEC - Hydro Engineering & Consulting Pty Ltd. 2020. Ensham Coal Mine Residual Void Project: Stage 3. Void Water Quantity and Quality Balance Modelling.

Hydrosimulations. 2020. Residual Void Project: Groundwater Assessment Stage 3.

RGS. 2018. Material Characterisation and source term development for the Ensham Coal Mine Final Void Plan. Technical Report.

Umwelt. 2019. Social Impact Assessment Report.

WRM, Water + Environment. 2019. Ensham Mine Residual Void Study: Geomorphic Impact Assessment of Options – Stage 3.

WSP. 2019a. Ensham Mine Residual Void Study: Landform Design, Stage 3 Technical Report.

WSP. 2019b. Ensham Mine Residual Void Study: Geotechnical Assessment, Stage 3 Technical Report.

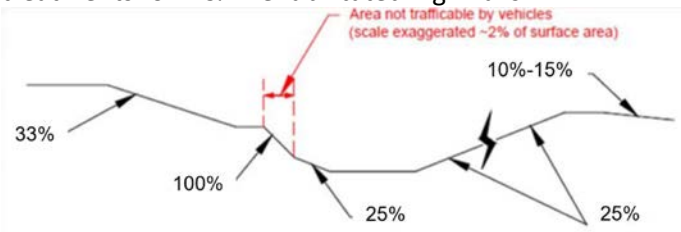
AARC Environmental Solutions 2019. Threatened Species Survey of Regrowth Vegetation at the Ensham Mine.

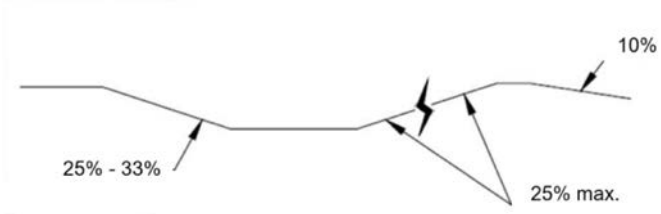
Appendix A Summary of Optimised Landform Design Criteria

SUMMARY LANDFORM DESIGN CRITERIA FOR THE RVP (Version 9)		
Option	**Domain/ Area**	**Treatment**
Submitted Option	All Submitted Option Areas (Native Bushland Corridor, Self-Sustaining Vegetation and inward faces of the Grazing/ Water Area)	• Inward facing slopes of rehabilitated open cut mining areas to be free draining to approved water areas. • A South, E, F South, F North, Y South, Y Central and Y North are to be partially backfilled such that no groundwater will daylight. • All slope designs must exceed a Factor of Safety of 1.5
	Outward facing slopes	• Regrade to a slope of 10% for Tertiary spoil rehabilitation in line with current successful site practices. • Regrade to a slope of 15% for Permian spoil rehabilitation in line with current successful site practices.

<table>
<tr><th colspan="3">SUMMARY LANDFORM DESIGN CRITERIA FOR THE RVP (Version 9)</th></tr>
<tr><th>Option</th><th>Domain/ Area</th><th>Treatment</th></tr>
<tr><td></td><td>Highwalls and Endwalls</td><td>

Highwall - Tertiary material – maximum slope 1V:3H (18° or 33%)
Highwall - Weathered Permian material – maximum slope of 1V:3H (18° or 33%)
Highwall - Fresh Permian material – maximum slope of 1V:1H (45° or 100%)
Highwall - minimum of 5m bench at interface between Weathered and Fresh Permian
Endwalls are to be treated the same as highwalls. The exception is B Pit Northern endwall which will be filled at a 15% slope.

Of note there is a difference between highwall treatments for F & Y rehabilitated highwalls.


Diagrammatic Cross Section of A, B, C, D and E Landforms


Diagrammatic Cross Section of F and Y Landforms

The difference in landform design between ABCD and E and F and Y has come about following extensive discussions between Ensham Mine and the landowners of the Yongala area where F and Y rehabilitated open cut mining areas are located.
</td></tr>
<tr><td></td><td>Inward facing low wall slopes</td><td>

25% slopes.
Incorporate a 10m bench at approximately every 75m of 25% slope length.

</td></tr>
</table>

SUMMARY LANDFORM DESIGN CRITERIA FOR THE RVP (Version 9)		
Option	**Domain/ Area**	**Treatment**
	Land Bridges/ Ramps	• E land bridge dozed down, partially backfilling E to the point that E will drain into D. • Ramp batters are to be treated the same as the inner facing low wall slopes.
	Landform	• Free draining landform with no water damming behind the landform toe. • All watercourse facing slopes to be 1V:6.7H (15%) and constructed from suitable compacted levee-building material, finished with topsoil and grass. • Void facing embankments to be 1V:6.7H (15%) where space permits, where constrained by the proximity of void regrade extents, batter slopes to be reduced to 1V:4H. • A bench of at least 10 m will be provided separating the inward toe embankment of the landform and adjacent edge of void stabilisation regrade. • Landform - based on 0.1%AEP flood modelling surfaces provided by Hydro Engineering and Consulting, + 0.5m freeboard. • Raising of Landform to be undertaken based on a central raising where space permits, where constrained by proximity of a residual void, raising to be undertaken from the watercourse side. • River-facing batters to receive rip rap facing where flood flows exceed velocity of 1.5 m/s with durable rock of average diameter (D50) in accordance with the following: o D50 = 150mm for velocities up to 3.0 m/s o D50 = 300mm for velocities up to 4.0 m/s

Appendix B RVP Study Team Credentials

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
1	**Options Assessment**			
		Idemitsu Australia	Brian Cox	Mining Engineer - IAR Development & Technical
			Dan Yates	Group Manager – IAR Health, Safety & Environment
			Dr Paul Martinkus	Mining Engineer Project Studies
		Ensham Resources	Ben Hopwood	Mine Manager – Ensham Open Cut
			Dave Meyers Manager	Health, Safety, Environment & Training Systems
			Neil Dale	Environmental Superintendent - Ensham Open Cut
		Hansen Bailey	Peter Hansen	Environmental Professional
		Rowan & Associates	Greg Rowan	Facilitator - First Class Coal Mine Managers Certificate. Queensland
2	**Conceptual Design**			
	Environmental Values Workshop	Ensham Resources	Dr Paul Martinkus	Mining Engineer Project Studies Manager – Project Studies, IAR Development
			Dave Meyers	Manager – Ensham, Health, Safety, Environment & Training Systems (OC/UG)
			Neil Dale	Environmental Superintendent – Ensham Open-cut

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
			Thomas Neame Ensham	RVP Study Manager
	Environmental Values Workshop (Independent Peer Reviewer)	KCB	Chris Strachotta	Geoscientist Registered Professional #10151
	Landform Design Report	WSP	Gavin Wray	Civil Engineer/ RPEQ 12931
	Landform Design Report (Independent Peer Review)	Minserve	Hayden Jones	Mining Engineer/ MAusIMM
	Geotechnical Design Report	WSP	Gavin Wray	Civil Engineer/ RPEQ 12931
	Geotechnical Design Report (Independent Peer Review)	Douglas Partners	Andrew Middleton	Civil Engineer/ RPEQ 4366
	Civil Design	WSP	Gavin Wray	Civil Engineer/ RPEQ 12931
	Civil Design (Independent Peer Review)	Engeny	Andrew Vitale	Civil Engineer/ RPEQ 9341
	Water Solute & Balance Report	Hydro Engineering & Consulting	Tony Marszalek	Civil Engineer/ RPEQ
	Water Solute & Balance Report (Independent Peer Review)	SRK	John Chapman	P Eng.
	Groundwater Report	Hydrosimulat-ions	Dr Noel Merrick	Hydrogeologist

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
	Groundwater Report (Independent Peer Review)	DHI	Dr Giovanni Firmani	Engineer/Groundwater modeller
	Ecological Report	Umwelt	Richard Floyd	Ecologist
	Ecological Report (Independent Peer Review)	Hydrobiology	Dustin Hobbs	Ecotoxicologist
3	**Preferred Options Detail Design**			
	Landform Design Report	WSP	Gavin Wray	Civil Engineer/ RPEQ #12931
	Landform Design Report (Independent Peer Review)	Minserve	Hayden Jones	Mining Engineer/ MAusIMM
	Geotechnical Design Report	WSP	Gavin Wray	Civil Engineer/ RPEQ 12931
	Geotechnical Design Report (Independent Peer Review)	Douglas Partners	Andrew Middleton	Civil Engineer/ RPEQ 4366
	Geomorphology Report	WRM	Greg Roads	Civil Engineer / RPEQ 06413
	Geomorphology Report (Independent Peer Review)	Alluvium	Rowan Lucas	Environmental Engineer/ RPEQ 8111
	Civil Design	WSP	Gavin Wray	Civil Engineer/ RPEQ 12931

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
	Civil Design (Independent Peer Review)	Engeny	Andrew Vitale	Civil Engineer/ RPEQ 9341
	Hydrology Report	Hydro Engineering & Consulting	Tony Marszalek	Civil Engineer/ RPEQ 3189
	Hydrology Report	BMT	Garry Lambourne	Civil Engineer/ RPEQ 7708
	Water Solute & Balance Report	Hydro Engineering & Consulting	Tony Marszalek	Civil Engineer/RPEQ 3189
	Water Solute & Balance Report (Independent Peer Review)	SRK	John Chapman	P Eng.
	Groundwater Report	Hydrosimulations	Dr Noel Merrick	Hydrogeologist
	Geochemistry Report	SRK Consulting	John Chapman	Chemical Engineer / P Eng.
	Environment Assessment Report	SPS	Garry Gough	Chemical Engineer / M EngSt
4	**Most Preferred Option Identification**			
	Risk Assessment	Rowan & Associates	Greg Rowan	First Class Coal Mine Managers Certificate, Queensland
	Economic Assessment	Deloitte Access Economics	Kathryn Mathews	Economist & Partner (Deloittes)
	Economic Assessment (Independent Peer Review)	Centre for International Economics	Laura Cassar	Economist

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
	Social Impact Assessment	Umwelt	Dr Sheridan Coakes	PhD Psychology
	Social Impact Assessment (Independent Peer Review)	Community Insights Group	Dr Ana Maria Esteves	Social Impact Assessment Practitioner
	Triple Bottom Line Assessment	SPS	Stephen Downs	Engineer
	Triple Bottom Line Assessment (Independent Peer Review)	SMI	Glen Corder	Chemical Engineer, Associate Professor, University of Qld
5	**Regulatory Documentation**			
	Economic Assessment	Deloitte Access Economics	Kathryn Mathews	Economist & Partner (Deloittes)
6	**Additional Studies for Extension of Decision Notice**			
	Landform Report	Xenith Consulting	John Cawte	Mining Engineer
		Minserve	Hayden Jones	Mining Engineer, MAusIMM
		WSP	Gavin Wray	Civil Engineer / RPEQ 12931
		Infrastruct	Ben Jack	Civil Engineer / RPEQ 15850
	Landform Report (Peer review)	Douglas Partners	Andrew Middleton	Civil Engineer/ RPEQ 4366
	Summary of Levee Landform Report	Douglas Partners	Andrew Middleton	Civil Engineer/RPEQ #4366

Stage	Study	Company	Lead Person (s)	Role/Qualification/Certification
	Water Report	Sustainable Minerals Institute University of Queensland	Claire Cote	Associate Professor & Director, Centre for Water in the Minerals Industry
	Floodplain Report	Sustainable Minerals Institute University of Queensland	Claire Cote	Associate Professor & Director, Centre for Water in the Minerals Industry
	Water Balance & Solute Report	Hydro Engineering & Consulting	Tony Marszalek	RPEQ 3189
	Groundwater Report	SLR	Dr Noel Merrick	Hydrogeologist
	Risk Assessment	Rowan &Associates	Greg Rowan	First Class Coal Mine Managers Certificate. Queensland

Appendix C Extension of Decision Period by Agreement Notification

Notice

Environmental Protection Act 1994

Extension of decision period by agreement

This statutory notice is issued by the administering authority[1] *to advise you that the decision period for your major amendment application has been extended by agreement under section 168(4) as applied by section 232(1) of the* Environmental Protection Act 1994.

Bligh Coal Limited, Idemitsu Australia Resources Pty Ltd
and Bowen Investment (Australia) Pty Ltd
C/- Bligh Coal Limited
Level 1, 60 Albert Street
BRISBANE QLD 4000

Your reference: EPML00732813
Our reference: APP0034828

Attention: Daniel Yates
Email: Daniel.Yates@idemitsu.com.au

Extension of decision period by agreement

1. Application details

The application to amend environmental authority number EPML00732813 was received by the administering authority on 27 March 2019.

The application reference number is APP0034828.

Land description: Mining Lease (ML) 7459, ML7460, ML70049, ML70326, ML70365, ML70366 and ML70367.

2. Agreement made to extend the decision period

On 13 March 2020, the administering authority of the *Environmental Protection Act 1994* sought written agreement from the applicant to extend the decision period to 5 June 2020, for the above-mentioned amendment application.

On 13 March 2020, Chris Walsh on behalf of the applicant provided written agreement to extend the decision period to 5 June 2020.

The decision period has now been extended and the end date of the period is now 5 June 2020.

3. Additional information to be provided

The extension has been agreed to allow for the following additional information to be provided to support the application:

[1] The Department of Environment and Science is the administering authority under the *Environmental Protection Act 1994*.

- **Floodplain Report**

  Report demonstrating how Ensham has assessed floodplain environmental values for the submitted option with respect to the area within the rehabilitated mining areas, and any upstream and downstream impacts.

- **Water Report**

  Report to confirm that:

  - all pits remain groundwater sinks into perpetuity (including under climate change scenarios);
  - the interaction between the surface water and the underground mine;
  - the accumulation modelling for the Water Habitat Domain;
  - the final area and volume of water in voids for the submitted option;
  - that some groundwater remaining in pits presents an acceptable risk and how any remaining risk is managed by the landform, including the history of the levees and proposed landform at Ensham;
  - reference to landform studies which demonstrate that further management of the groundwater in some pits is impracticable; and
  - assessment of opportunities to reduce groundwater daylighting in A and E pits and associated impacts.

- **Landform Report** for entire rehabilited area

  Report to:

  - demonstrate how the submitted option land design was developed having regard for the rehabilitation hierarchy;
  - propose opportunities to optimise the landform and address erosion concerns;
  - confirm that the landform and levee is safe and stable in the long-term including RPEQ sign off, qualifications and authoring of technical studies.

- **Risk Assessment**

  Report demonstrating that the material hazards for the submitted option have been comprehensively risk assessed.

Should you have any questions in relation to this notice, please contact Business Centre Coal on telephone (07) 4987 9320.

	13 March 2020
Signature	Date

Gillian Naylor
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Business Centre Coal
Department of Environment and Science
99 Hospital Road, EMERALD QLD 4720
Phone: (07) 4987 9320
Email: CRMining@des.qld.gov.au

Appendix D History of Ensham Levees

Douglas Partners Pty Ltd
ABN 75 053 980 117
www.douglaspartners.com.au

Ensham Resources Pty Ltd
PO Box 15136
City East, QLD 4002

BNE200335
20 May 2020
47793.20.R.001
AM:CRB

Email: Garry.Gough@idemitsu.com.au

Attention: Garry Gough

Summary Comments on Levee Landform
Ensham Mine Residual Void Project
Duckponds Road, Emerald

As requested, Douglas Partners Pty Ltd (DP) has reviewed the available information in the various DP reports to provide these summary comments on levee landform for the Ensham Mine Residual Void Project at Duckponds Road, Emerald. This work has been carried out for Ensham Resources Pty Ltd in accordance with DP's Proposal BNE200335 dated 24 March 2020.

The scope of work required includes comments on the following in terms of geotechnical aspects:

a) the design parameters used for the B & C levee prior to the 2008 flood;
b) the failure mechanism by design parameter for the 2008 flood;
c) what the design parameters used for the B & C levee were post the 2008 flood;
d) the repairs undertaken to the anabranch and B & C levees;
e) performance of the new levees in the 2010 flood – how big was this flood relative to 2008 flood; and
f) the proposed landform is safe, stable and non-polluting. It is understood that this landform comprises placing fill against the levee (with topsoiling and grassing) to form permanent slopes not exceeding 1V:6H.

These comments are addressed below.

Levees Prior to Failure and Reconstruction

Prior to the 2008 breach, the B Pit and C Pit mine levees comprised a series of earth bunds ranging up to several metres high and up to 20 m wide, with some being used as haul roads. These bunds were subsequently investigated for the levee upgrade works and were found to comprise clayey mine overburden that appeared moderately well compacted. It is thought the compaction was likely achieved through placement in layers and passage of heavy equipment (ie dozers and mine trucks, but not compactors).

The existing mine flood levees were damaged and breached by floods in early 2008. The B Pit mine levee was breached where it had been constructed across Old Winton Creek, and then again where

flood waters exited the mine area on the southern leg of the levee at a change of direction. It is understood that the levee across Old Winton Creek most likely failed due to a combination of overtopping and concentrated rapid water flows in the Old Winton Creek water course.

The C Pit mine levee was breached in two locations over a total length of approximately 250 m immediately to the east of Red Hill. The western, upstream breach was located near a former river course (ie billabong) around the toe of Red Hill, whilst the eastern, downstream breach was located near a former bend in the main anabranch river course. There was a remaining isthmus of former river bank between the two breach locations. The height of the levees at the time of the flood is also unknown. It appears likely that concentrated water flows due to river channel effects led to failure of the levee.

Reconstruction of the Levees

The reconstruction and upgrade of the levees took several forms:

- a new engineered levee was constructed for B Pit to the west of the former levee. This levee was constructed as homogenous earth fill structure with a 6 m wide crest. This levee was engineered with a seepage key wide enough for the compactors to work; the seepage key varied from 1 m deep in clay subgrades, to 3 m deep in sand subgrades (locally encountered). The levee was constructed using site won clay materials blended with some sand in the borrow area to improve the workability and compaction characteristics, and to reduce the cracking potential. The material was moisture conditioned in the borrow pit and then again on the levee as placed, and then spread and in layers and compacted with pad foot compactors. The compaction was controlled with quality control testing to confirm that compaction had been achieved and the results reviewed by an RPEQ to confirm conformance with requirements. The surface of the levee was capped with select granular fill to prevent drying and wetting, and to provide all weather access for inspections and maintenance. The levee slopes were topsoiled and grassed.

  Where the new levee crossed Old Winton Creek, a barrier berm approximately 3 m wide with rock protection, was constructed at the levee toe to keep permanent water off the levee structure, and to provide further protection against early flood water flows.

- the existing B Pit levee alongside the Nogoa River (central section) and also downstream (eastern section) was upgraded by raising the levee on the outer 'upstream' face. This upgrade comprised excavation of a seepage key of the same dimensions to those described above at the downstream toe of the existing levee, followed by placement of a minimum 3 m width of new engineered fill benched into the existing levee fill. The material used was won from the B Pit levee borrow pit and compacted in the same manner as described above. On completion the upper surface, most of the levee was capped with select granular fill, apart from the southernmost leg of the levee which was topsoiled and grassed.

  As above, where the levee crossed over Old Winton Creek, an approximately 3 m wide barrier berm with rock protection was constructed at the toe of the levee to keep any permanent water off the levee structure, and to improve protection of the levee in the event of back flow.

- the breached section of C Pit levee had been backfilled with mine spoil after the flooding. It was located adjoining the Nogoa River anabranch and exposed to flood risk during construction. The reconstruction comprised the construction of an engineered earthfill support embankment on the

river side of the breach to protect the works and included coarse rock erosion protection. Following this, the mine spoil in the breach zone was excavated in a deep key trench until Permian rock was encountered; a bentonite slurry cutoff was installed at the base and the trench was then backfilled with engineered fill with a HDPE seepage barrier installed on the upstream face. The levee was then constructed above the backfilled trench in the same manner as the B Pit new levee.

- two new sections of engineered levees were constructed upstream of Red Hill. These were constructed in a similar manner to the new B Pit levee, except that the borrow source comprised a weathered siltstone that was worked in the borrow pit to break it down to a gravelly clay material suitable for construction.
- a new section of levee, approximately 3 m high, was built downstream to protect a ramp into C Pit. Again, this was engineered and constructed in a similar manner to that of the new B Pit levee. The area behind this levee was backfilled with general spoil to form a laydown pad and further protection for the mine pit ramp.

For all levees, global stability analysis was carried out to confirm the safety factor of the structures exceeded 1.5 as is acceptable for permanent works. Where a levee was located near a pit, stability analysis was also carried out to confirm the minimum setback distances required to achieve a minimum safety factor of 1.5 against instability of the overburden in the nearby open cut pit. Instability of the weathered rock in the pit walls has been assessed by others.

Seepage analysis was also carried out to confirm seepage rates under the levee under flood conditions did not exceed those that might be associated with piping failure.

These levee reconstruction and upgrade works were carried under the oversight of qualified RPEQ engineers and certified upon completion.

Demonstrated Performance of the Levees

During late 2010 and early 2011, the levees (including the C Pit levee still under construction at that time) experienced two significant flood events close together. The Nogoa River Duck Ponds gauging station indicated flood heights of just under 14 m and approximately 15 m in late December 2010 and early 2011 respectively (along with two other floods of approximately 9 m height in 2010), compared to the level of 14.5 m in the 2008 flood. Reference to the KBR September 2013 flood study report suggests that these floods are of the order of approximately 1 in 100 year (ie AEP 1%) events.

Inspection of the levees at the time of the floods and subsequent inspections indicated the levees performed well during these events with no significant maintenance required afterwards.

Further to the above, 11 annual inspections by an independent RPEQ have been carried out for the levees since 2009. Reference to these reports indicates that only minor maintenance requirements have been identified such as: removal of saplings; minor surface drainage improvements; some minor erosion scours; and a local short section of longitudinal cracking associated with drying. Generally, the grass cover has remained very good apart from a section of the B Pit levee adjoining irrigated cropping

land, which has been unable to sustain grass cover, and consequently this is being progressively covered with rock protection.

Conclusion

As indicated above, the levee system has been engineered and constructed to a good standard under the oversight of qualified RPEQ engineers and would be expected to have significant lifespan with relatively low maintenance requirements. The performance of the levee has been demonstrably good, with only minor issues requiring maintenance from time to time. It is considered therefore that with continued care and maintenance, and subject to satisfactory stability of any nearby open cut pit walls, in respect of geotechnical aspects the proposed levee landform is likely to be safe, stable and non-polluting.

We trust this information meets your requirements in this case. Please contact us if you have any queries or need further information.

Yours faithfully

Douglas Partners Pty Ltd

Andrew Middleton
Principal

Reviewed by

Chris Bell
Principal

Attachments: Limitations, Notes About this Report

Limitations

Douglas Partners Pty Ltd has prepared this summary report for the Residual Void Project at Ensham Mine at Duckponds Road, Emerald in accordance with DP's Proposal BNE200335.P.001 dated 24th March 2020 under DP's Conditions of Engagement. This report is provided for the exclusive use of Ensham Resources Pty Ltd for the specific purpose as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party.

In preparing this summary report DP has necessarily relied upon information provided by the client and/or their agents. DP's advice may be based on observations, measurements, tests or derived interpretations. The accuracy of the comments provided by DP in this report is limited by unobserved features and variations in ground conditions across the site in areas between inspection locations and beyond the site boundaries or by variations with time. The advice may be limited by the amount of data that could be collected given the project and site constraints.

This report must be read in conjunction with the attached notes "About This Report" and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions from review by others of this report which are not otherwise supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Appendix E **2014 Levee Certification**

Douglas Partners
Geotechnics / Environment / Groundwater

Form of Certification (Inspection Report)

Name of Registered Professional Engineer providing certification:
Andrew Robert Middleton of Douglas Partners Pty Ltd

Address of Registered Professional Engineer providing certification:
439 Montague Road, West End QLD 4101

Statement of relevant experience
I hereby state that I am a Registered Professional Engineer of Queensland (No. 4366) and meet the requirements of the definition of 'suitably qualified and experienced person'.

Statement of certification
All relevant material relied upon by me, including subsidiary certifications of specialist components, where required by the environmental authority, is provided in the attached report "*Regulated Levee Structures 2019 Annual Inspection, Ensham Mine, Duckponds Road, Emerald*" dated 13 December 2019.

I hereby certify the inspection report entitled "*Regulated Levee Structures 2019 Annual Inspection, Ensham Mine, Duckponds Road, Emerald*" dated 13 December 2019 for the Ensham Mine Regulated Levee Structures indicates that at the time of inspection, the structures were visually assessed to be generally in good condition with respect to structural and geotechnical adequacy with a number of minor maintenance issues requiring attention. Based on the results of the inspection, once the recommended actions have been satisfactorily completed and adequate maintenance is carried out, it is considered that the structural and geotechnical adequacy of the structures will be sufficient to meet the necessary performance requirements of the licence terms until the next annual inspection due on or before 1 November 2020.

This certification relies upon and is necessarily limited by the information prepared by others and provided to myself as listed in the attached inspection report and as verified by site inspections by myself in October 2019.

I, Andrew Robert Middleton, declare that the information provided as part of this certification is true to the best of my knowledge. I acknowledge that it is an offence under section 480 of the *Environmental Protection Act 1994* to give the administering authority a document containing information that I know is false, misleading or incomplete in a material particular.

Signed: _____ RPEQ 4366

Date: _____13 December 2019_____

Appendix F **Current (2019) Levee Certification**

Douglas Partners
Geotechnics | Environment | Groundwater

Form of Certification (Inspection Report)

Name of Registered Professional Engineer providing certification:
Andrew Robert Middleton of Douglas Partners Pty Ltd

Address of Registered Professional Engineer providing certification:
439 Montague Road, West End QLD 4101

Statement of relevant experience
I hereby state that I am a Registered Professional Engineer of Queensland (No. 4366) and meet the requirements of the definition of 'suitably qualified and experienced person'.

Statement of certification
All relevant material relied upon by me, including subsidiary certifications of specialist components, where required by the environmental authority, is provided in the attached report "*Regulated Levee Structures 2019 Annual Inspection, Ensham Mine, Duckponds Road, Emerald*" dated 13 December 2019.

I hereby certify the inspection report entitled "*Regulated Levee Structures 2019 Annual Inspection, Ensham Mine, Duckponds Road, Emerald*" dated 13 December 2019 for the Ensham Mine Regulated Levee Structures indicates that at the time of inspection, the structures were visually assessed to be generally in good condition with respect to structural and geotechnical adequacy with a number of minor maintenance issues requiring attention. Based on the results of the inspection, once the recommended actions have been satisfactorily completed and adequate maintenance is carried out, it is considered that the structural and geotechnical adequacy of the structures will be sufficient to meet the necessary performance requirements of the licence terms until the next annual inspection due on or before 1 November 2020.

This certification relies upon and is necessarily limited by the information prepared by others and provided to myself as listed in the attached inspection report and as verified by site inspections by myself in October 2019.

I, Andrew Robert Middleton, declare that the information provided as part of this certification is true to the best of my knowledge. I acknowledge that it is an offence under section 480 of the *Environmental Protection Act 1994* to give the administering authority a document containing information that I know is false, misleading or incomplete in a material particular.

Signed: _____ RPEQ 4366

Date: _____13 December 2019_____

Appendix G WSP Review of Optimised Submitted Option

Our ref: PS119715-RES-LTR-001-D Submitted Option.docx

By email
ben.jack@idemitsu.com.au

20 May 2020

Ben Jack
Civil / Landform / Geotechnical Project Manager
Ensham RVP
Ensham

Dear Ben

Ensham RVP - Review of Xenith Landforms for Submitted Option

1. BACKGROUND

WSP was commissioned by Ensham Resources (Ensham) in December 2017 to perform geotechnical, landform design and civil engineering for the Ensham Residual Void Project (RVP). The objective of the project was to assess three mine closure rehabilitated open cut mining area options identified by Ensham, in order to determine if they are able to achieve the desired outcomes of the project, being the identification of a preferred final landform option that is safe, non-polluting, stable, and able to sustain the agreed post-mining land use. Each option was developed with a sufficient level of engineering design to enable assessment against project objectives, preparation of realistic cost estimates, and to enable identification and assessment of associated risks.

The three options considered as final mining rehabilitated open cut mining area solutions were:

- Option 1 – Landform Levee (incorporating a landform levee to prevent flood water entering pits within the 0.1% AEP floodplain of the Nogoa River).
- Option 2 – Flood Mitigation and Beneficial Use (final landform incorporating water storages in A and B-Pits south of the Nogoa River, and C and D-Pits north of the Nogoa River).
- Option 3 – Backfill to PMF (incorporating backfilling of pits within the 0.1% AEP floodplain of the Nogoa River).

Stage 3 final WSP technical reports were completed and submitted to Ensham in February of 2019. Reports included recommended landform design criteria to achieve the desired outcomes of the project, with long-term geotechnical stability assessment of key landform elements to confirm the suitability of the criteria. Erosional stability criteria were also developed referencing tried and tested site rehabilitation methods, the site Rehabilitation Management Plan, and industry practices and guidelines.

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2. SCOPE OF SERVICES

Subsequent to submission of the Stage 3 reports, Ensham has undertaken further refinement of landform design criteria and landform modelling, arriving at a preferred final landform option referred to as the Submitted Option, that incorporates elements of the Stage 3 Options 1 and 2. Xenith Consulting have revised landform ground models, resulting in a landform with the following changed characteristics / refinements since completion of the Stage 3 landform design:

- Incorporation of landform encapsulating existing levees as developed for Option 1.
- Inward facing spoil (slope reporting to the residual void depression) sloping at a maximum of 25% (1V:4H), with 10m wide benches between 75m long slope lengths.
- Amended ramp landform into A, B, C and D rehabilitated open cut mining areas, which were retained in the original Option 2 design as ramps to convey water into the pits or provide access to pump facilities.
- The residual floor to the A rehabilitated open cut mining area has been raised with backfill to above groundwater rest levels and to buttress the highwall.
- The northern endwall of the B rehabilitated open cut mining area, adjacent to the Nogoa River, has been buttressed to reduce the slope into the residual void from 25% to 15%.
- The land-bridge that separated the D and E-Pits has been removed, with material used to raise the floor level of E rehabilitated open cut mining area to exclude groundwater daylighting.

WSP has been commissioned by Ensham to review the Xenith model of the Submitted Option described above, as well as a revised landform design criteria document developed by Ensham, and to comment on changes to the Stage 3 landform design models (described above) and adopted criteria.

3. REVIEW METHODOLOGY

Xenith have provided three ground models for review, in electronic 3D DWG format, representing the Submitted Option, which are listed below:

- Submitted Option with Selected Treatments 24 Apr 2020 /ab pit may 2020.dwg.
- Submitted Option with Selected Treatments 24 Apr 2020 / cde may 2020.dwg.
- Submitted Option with Selected Treatments 24 Apr 2020 / fy pit may 2020.dwg.

The methodology adopted for the review of the models may be summarised as follows:

- Conversion of models to 1m DEM ground models and import into QGIS open-source GIS software for processing.
- Produce 2m contours to overlay over the DEM file, to identify general topographic features of the landform, such as slope length between benching, free drainage, presence of land-bridges, and generally interrogate landform slopes.
- Undertake DEM slope analysis and produce colour coded mapping with colour gradations of 0-10%, 11-15%, 16-25%, 26-33%, and greater than 33% to review compliance with design criteria.
- Generate sections were taken at critical locations to review landform shape and presence of buttressing and measure slope lengths between benches on inward and outward facing final spoil landform.
- Verify design amendments described by Ensham are reflected in the electronic ground models.

— Provide commentary on findings and identify any adverse changes.

Ensham have provided an amended Landform Design Criteria document specifically for the Submitted Option – Version 9, 2020 for review. This has been compared to the Stage 3 landform design criteria. This Ensham document has been included as an enclosure for reference.

4. FINDINGS AND COMMENTARY

A review has been undertaken of the electronic Submitted Option landform design ground models provided by Xenith, and the revised landform design criteria provided by Ensham, with findings set out in the sections below.

4.1 SUBMITTED OPTION XENITH CONSULTING MODELS

— All 100% (1V:1H) sloping high walls (fresh Permian rock) in A and B rehabilitated open cut mining area have been removed, with weathered rock battered at a maximum of 33% (1V:3H). The elimination of the 1H:1V high wall slopes represents an improvement in landform outcomes in terms of safety, geotechnical stability, and long-term erosion stability.

— Inward facing final spoil landform for all rehabilitated open cut mining areas is sloped at a maximum of 25% (1V:4H) with maximum slope length between 10m wide benches of 75m. This represents an improvement on the previous Option 2 inward facing slopes, with more frequent benching acting to reduce the velocity of overland sheet-flow during rainfall events. The more frequent benching also reduces the overall effective slope of the inward facing spoil, which will increase the long-term geotechnical stability of the inward facing landform.

— Outward facing spoil landform complies with landform design criteria adopted for the Submitted Option (10% for Tertiary and 15% for Permian materials).

— Rehabilitated open cut mining area ramps remain a feature of the final landform, with embankments reporting to the ramp "gullies" at a maximum slope of 25% and maximum slope lengths of 75m. These gullies will serve to concentrate stormwater run-off, and it is therefore recommended that consideration should be given to lining these gully areas with durable hard rock to reduce erosion potential

— The review verifies that landform flattening of the buttress to 15% from 25% has been incorporated into the model at the northern end-wall of B North rehabilitated open cut mining area, which is adjacent to the Nogoa River landform and was flagged as a critical location during the Stage 3 works due to the proximity of the landform to the buttress into the B rehabilitated open cut mining area. While geotechnical stability analysis undertaken in this area for the Stage 3 works indicated the slope would be long-term stable for a 25% buttress, decreasing it to 15% will increase the long-term geotechnical stability factor of safety for this slope.

— The land-bridge separating E and D-Pits in the previous final landform design has been removed, resulting in a connected final landform for the C, D and E rehabilitated open cut mining areas. This change has eliminated steep end-walls on either side of the land-bridge and represents an improvement in landform outcomes in terms of safety, geotechnical stability, and long-term erosion stability

— The floor level of the E rehabilitated open cut mining area has been raised with backfill from the land-bridge to above groundwater rest levels such that groundwater will no longer daylight.

— No additional geotechnical stability analysis for the amended landform design for the Submitted Option is considered necessary as none of the changes to the final landform are adverse in terms of long-term stability.

4.2 REVISED DESIGN CRITERIA

The following amendments to the Stage 3 Landform Design Report have been made in the Submitted Option Design Criteria.

- General criteria:
  - Inclusion of a criterion that A South rehabilitated mining area and E rehabilitated mining area, be raised with backfill to above the groundwater rest level.
- Outward slope of spoil – no amendments.
- High-walls and end-walls:
  - Inclusion of criterion that B rehabilitated mining area end wall to be buttressed with 15% slope into the residual void as opposed to 25% in Stage 3 criteria.
- Land-bridges:
  - Inclusion of a criterion for the removal of the land-bridge between E and D rehabilitated mining area by way of dozer push, with material used to raise the pit floor of E rehabilitated mining area, creating a sloped drainage path into D rehabilitated mining area.
- Ramps:
  - Inclusion of a requirement that ramp batters to be treated as for inner facing spoil with maximum slopes of 25%, slope lengths of 75m with 10m wide benches
  - Outward facing ramp batters to be battered back at 10% for Tertiary and 15% for Permian materials.
- Landform – general criteria – no amendments.
- Inward slope of spoil:
  - All inward facing slopes to have maximum slope of 25% with 10m wide benches for every 75m of slope lengths with Permian cover, subject to site trials. This is an amendment to the Stage 3 Option 2 criteria, resulting in shorter slope lengths and more frequent batters.

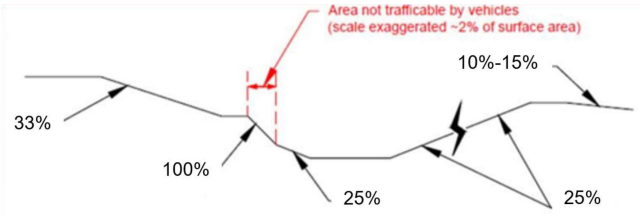
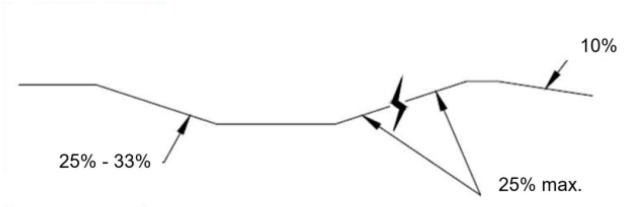
The review of Xenith Consulting ground models has identified that criteria adopted for the Submitted Option have been implemented in the landform design and are in accordance with previously developed Stage 3 landform criteria. Specific changes described are likely to improve the outcomes of the design. Landform design criteria developed by Ensham for the Submitted Option are based on those developed by WSP for Stage 3, with minor changes which are likely to result in improved landform outcomes.

Adopting 25% slopes on inward facing spoil landform has not been widely tested on site and will require trials to assess erosional performance. Landform shaping around ramps into residual voids will create paths for concentrated flow of stormwater run-off, and it is recommended that these features be treated with durable rock rip rap to reduce erosion potential.

Yours sincerely

Gavin Wray
Principal Civil Engineer
Resources Group

Encl: Landform Design Criteria - Ensham - Ver 9

LANDFORM DESIGN CRITERIA FOR THE RVP – Version 9		
Option	**Domain/ Area**	**Treatment**
Submitted Option	All Submitted Option Areas (Native Bushland Corridor, Self-Sustaining Vegetation and inward faces of the Grazing/ Water Area)	• Inward facing slopes of rehabilitated open cut mining areas to be free draining to approved water areas. • A South, E, F South, F North, Y South, Y Central and Y North are to be partially backfilled such that no groundwater will daylight. • All slope designs must exceed a Factor of Safety of 1.5
	Outward facing slopes	• Regrade to a slope of 10% for Tertiary spoil rehabilitation in line with current successful site practices. • Regrade to a slope of 15% for Permian spoil rehabilitation in line with current successful site practices.
	Highwalls and Endwalls	• Highwall - Tertiary material – maximum slope 1V:3H (18° or 33%) • Highwall - Weathered Permian material – maximum slope of 1V:3H (18° or 33%) • Highwall - Fresh Permian material – maximum slope of 1V:1H (45° or 100%) • Highwall - minimum of 5m bench at interface between Weathered and Fresh Permian • Endwalls are to be treated the same as highwalls. The exception is B Pit Northern endwall which will be filled at a 15% slope. Of note there is a difference between highwall treatments for F & Y rehabilitated highwalls.  Diagrammatic Cross Section of A, B, C, D and E Landforms  Diagrammatic Cross Section of F and Y Landforms The difference in landform design between ABCD and E and F and Y has come about following extensive discussions

		between Ensham Mine and the land owners of the Yongala area where F and Y rehabilitated open cut mining areas are.
	Inward facing low wall slopes	• 25% slopes. • Incorporate a 10m bench at approximately every 75m of 25% slope length.
	Land Bridges/ Ramps	• E land bridge dozed down, partially backfilling E to the point that E will drain into D. • Ramp batters are to be treated the same as the inner facing low wall slopes.

	Landform	• Free draining landform with no water damming behind the landform toe.
		• All watercourse facing slopes to be 1V:6.7H (15%) and constructed from suitable compacted levee-building material, finished with topsoil and grass.
		• Void facing embankments to be 1V:6.7H (15%) where space permits, where constrained by the proximity of void regrade extents, batter slopes to be reduced to 1V:4H.
		• A bench of at least 10 m will be provided separating the inward toe embankment of the landform and adjacent edge of void stabilisation regrade.
		• Landform - based on 0.1%AEP flood modelling surfaces provided by Hydro Engineering and Consulting, + 0.5m freeboard.
		• Raising of Landform to be undertaken based on a central raising where space permits, where constrained by proximity of a residual void, raising to be undertaken from the watercourse side.
		• River-facing batters to receive rip rap facing where flood flows exceed velocity of 1.5 m/s with durable rock of average diameter (D50) in accordance with the following:
		  ○ D50 = 150mm for velocities up to 3.0 m/s
		  ○ D50 = 300mm for velocities up to 4.0 m/s