Stage 3 Technical Report
Landform Design
Ensham Resources Pty Ltd
WSP
Level 3, Northbank Plaza,
69 Ann Street
Brisbane QLD 4000
GPO Box 2907
Brisbane QLD 4001

Tel: +61 7 3854 6200
Fax: +61 7 3854 6500
wsp.com

<table>
<thead>
<tr>
<th>REV</th>
<th>DATE</th>
<th>DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>19/06/2018</td>
<td>Ensham Review</td>
</tr>
<tr>
<td>B</td>
<td>11/09/2018</td>
<td>Updates for revised landform criteria</td>
</tr>
<tr>
<td>C</td>
<td>26/09/2018</td>
<td>Update standard text sections and IPR comments</td>
</tr>
<tr>
<td>D</td>
<td>21/11/2018</td>
<td>Revised groundwater rest level references</td>
</tr>
<tr>
<td>E</td>
<td>23/01/2019</td>
<td>Revised landform model for Options 1 and 2</td>
</tr>
<tr>
<td>F</td>
<td>11/02/2019</td>
<td>Revised landform areas with control boundary</td>
</tr>
<tr>
<td>G</td>
<td>28/02/2019</td>
<td>Final</td>
</tr>
</tbody>
</table>

This document may contain confidential and legally privileged information, neither of which are intended to be waived, and must be used only for its intended purpose. Any unauthorised copying, dissemination or use in any form or by any means other than by the addressee, is strictly prohibited. If you have received this document in error or by any means other than as authorised addressee, please notify us immediately and we will arrange for its return to us.
This document is protected by legal professional privilege. To ensure that the privilege is not waived please keep this document confidential and in a safe and secure place. This document should not be distributed, nor any reference to it made, to any person or organisation not directly involved in making decisions on the subject matter of this document.

<table>
<thead>
<tr>
<th>NAME</th>
<th>DATE</th>
<th>SIGNATURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepared by:</td>
<td>G.Wray</td>
<td>28/02/2019</td>
</tr>
<tr>
<td>Reviewed by:</td>
<td>C.Deaconos</td>
<td>28/02/2019</td>
</tr>
<tr>
<td>Approved by:</td>
<td>G.Wray</td>
<td>28/02/2019</td>
</tr>
</tbody>
</table>
TABLE OF CONTENTS

1 EXECUTIVE SUMMARY ...................................................... 1
2 INTRODUCTION ................................................................. 3
  2.1 PROJECT CONTEXT ......................................................... 3
  2.2 PURPOSE ........................................................................ 4
  2.3 SCOPE .......................................................................... 4
  2.4 FORMAT OF REPORT ..................................................... 4
3 PREFERRED REHABILITATION OPTIONS DESCRIPTION ......................... 6
  3.1 PREFERRED OPTION 1: LANDFORM LEVEE ............ 6
  3.2 PREFERRED OPTION 2: FLOOD MITIGATION AND BENEFICIAL USE ............................................. 7
  3.3 PREFERRED OPTION 3: BACKFILL TO PMF ............... 9
3.4 PIT EXTENTS .................................................................. 10
4 METHODOLOGY / DISCUSSION OF RESULTS ........... 12
  4.1 LANDFORM DESIGN PRINCIPLES .................................. 12
    4.1.1 NON-POLLUTING ......................................................... 12
    4.1.2 STABILITY .................................................................. 13
    4.1.3 ABLE TO SUSTAIN AGREED POST-MINING LAND USE ......................................................... 13
  4.2 METHODOLOGY ............................................................ 14
    4.2.1 COLLATION OF DESIGN CRITERIA .................................. 14
    4.2.2 LANDFORM MODELLING ........................................... 17
  4.3 SPECIFIC LANDFORM ISSUES RELEVANT TO PREFERRED OPTIONS ........................................... 18
    4.3.1 OPTION 1 - LANDFORM LEVEE ................................ 18
    4.3.2 OPTION 2 – BENEFICIAL USE .................................. 19
    4.3.3 OPTION 3 – BACKFILL TO PMF ................................. 19
  4.4 LANDFORM STABILITY OUTCOMES ............................... 19
    4.4.1 GEOTECHNICAL STABILITY ...................................... 19
    4.4.2 EROSIONAL STABILITY ............................................ 20
  4.5 FINAL LANDFORM ........................................................ 24
    4.5.1 OPTION 1 – LANDFORM LEVEE ............................. 24
    4.5.2 OPTION 2 – FLOOD MITIGATION AND BENEFICIAL USE .................................................. 24
    4.5.3 OPTION 3 – BACKFILL TO PMF ................................. 25
LIST OF APPENDICES
APPENDIX A LANDFORM SECTIONS
APPENDIX B EV IMPACT ASSESSMENT
1 EXECUTIVE SUMMARY

Ensham Mine, an open cut and underground bord and pillar coal mine is located approximately 35km east of Emerald. The mine commenced operation in 1993, with open cut mining operations currently comprised of Pits A, B, C, D, E, and F, referred to as the ‘Ensham Central Project’, and the ‘Yongala’ or Y Pit. Ensham operates the mine under environmental authority EA EPML00732813, dated 9 August 2018, under which condition G4 requires all surface areas significantly disturbed by mining activities to be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover. Condition G15 requires that Residual Voids from open-cut mining activities must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the harm constituted by the existence of the residual void itself in accordance with Appendix 4: Rehabilitation success criteria.

Three preferred rehabilitation options have been identified for assessment as part of the rehabilitation strategy for the Ensham Mine. The options are as follows:

- **Option 1: Landform Levee** - This option aims to convert the existing maintained levee structures effectively into permanent landforms capable of providing a 1:1000-year annual exceedance probability (0.1% AEP) flood immunity to residual voids in the floodplain - spoil piles and highwalls would also need to be left as long-term stable structures.

- **Option 2: Flood Mitigation and Beneficial Use** – Engineered intake structures will be constructed through the existing levee embankments to capture a small fraction of flood event flows from the Nogoa River to feed water from the river to remaining open cut voids within the floodplain. Spoil piles and highwalls would also need to be left as long-term stable structures. Existing levees will be retained as they are, and as such remain engineering structures requiring inspection and maintenance.

- **Option 3: Backfill to Probable Maximum Flood (PMF)** - Voids occupying the pre-mining floodplain would be backfilled to approximately original (pre-mining) ground levels. Parts of those pits straddling the boundary of the floodplain, would also be backfilled, whilst parts lying outside of that boundary would remain unfilled. Remaining spoil piles and highwalls would also need to be left as long-term stable structures.

This report describes the landform design development for the residual void project, identifies specific landform issues associated with each of the preferred options, discusses final outcomes, and identifies work required to further these designs in the next Stage of the project.

The findings include:

- To achieve safe and stable long-term landforms, regrading of the highwalls, lowwalls and endwalls of all residual voids will be required. Alternatively, buttressing may be adopted where regrading is not economically or spatially viable. For regrading, highwall and endwall slopes of 1V:1H for fresh Permian, 1V:2H for weathered Permian, and 1V:3H for Tertiary materials were recommended after geotechnical assessment. For the purposes of landform design all materials above the base of weathering have been regraded to 1V:3H.

- Regrading of outward facing spoils dumps should continue at 10% for Tertiary and 15% for Permian materials as stipulated in the current Ensham Rehabilitation Management Plan. This is supported by previous 500-year landscape evolution modelling undertaken for the range of topsoil types available on site. Spoil slopes reporting to the voids may be regraded at 10% for Tertiary and 15% for Permian materials like outward facing slopes, or may be regraded to a maximum slope of 25% where residual voids function as water storages and hence become inundated (Option 2), or where durable rock mulch or other suitable treatment of the slope surfaces can be shown to be effective in preventing erosion e.g. through site trials at Ensham or other similar sites.

- Based on geotechnical stability analysis undertaken, submerged lowwall spoil at an angle of repose will be stable long-term, however it is likely that stability properties of highwall materials will deteriorate over time under
saturated conditions (below groundwater recovery levels), resulting in instability at current slopes. It is therefore recommended that residual water in the pits be removed to allow for regrading or buttress stabilisation of residual voids.

— Option 1 landform levees may be constructed from spoil material provided it complies with technical requirements for levee construction materials in terms of clay content, linear shrinkage and dispersivity. Compaction of this material to an engineering standard is recommended to prevent excess settlement, and development of localised preferential drainage paths that could lead to piping failure in these embankments over time.

— Option 3 entails backfilling voids within the PMF footprint, which is likely to settle differentially over time, by way of collapse settlement when groundwater levels recover, followed by long-term creep which will occur over a log-scale period. To avoid the formation of a depression in the footprint of the backfill, it is recommended that the backfill is undertaken to a level proud of pre-mining ground levels, or that a stockpile of material be retained on site for periodic localised remedial regrading as and when required.

— Landforms have been developed that will provided safe, stable and sustainable outcomes with overall earthwork movement requirements of 151,300,000 m$^3$, 107,000,000 m$^3$, and 241,000,000 m$^3$ for Options 1, 2 and 3 respectively.

An assessment of the potential impacts of each of the three preferred options on relevant environmental values (EVs) has been undertaken based on the outcomes of the studies presented in this report. The table below provides a summary of the assessment using the adopted ranking criteria ranging from -3 (significant negative impact) to +3 (significant benefit) when compared with the current mine affected landform.

<table>
<thead>
<tr>
<th>Environment Aspect</th>
<th>Environmental Value</th>
<th>Criteria</th>
<th>Scoring Notes</th>
<th>Option 1 Landform levees</th>
<th>Option 2 FMBU$^1$</th>
<th>Option 3 Backfill to PMF$^1$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land</td>
<td>Incompatible land use</td>
<td>Land suitability class</td>
<td>Compared to the regional context</td>
<td>-1</td>
<td>2</td>
<td>-1</td>
</tr>
<tr>
<td>Agricultural potential</td>
<td>Long term available area</td>
<td></td>
<td>Compared to pre-mine available area</td>
<td>0</td>
<td>2</td>
<td>-1</td>
</tr>
</tbody>
</table>

The EV of landform aspects of the project, was assessed by considering landform stability in terms of incompatible land uses and grazing potential (included in Appendix B).

In terms of incompatible land uses, Option 3 will result in areas which are incompatible with the land suitability class and long-term availability for grazing due to the Conservation Covenant required to assist with maintenance of vegetation coverage on the backfilled rehabilitated areas exposed to the impacts of flooding (within the PMF footprint). Option 1 and 2 will have some areas of steeper terrain, which are not suitable for cross-grade vehicle traffic but remain suitable for grazing, the grazing benefits are in addition to the regional benefit provided by establishing a water resource that may be used to augment the Weemah channel regional irrigation scheme. Hence Options 1 and 3 have been ranked -1 for this criterion, and Option 2 as +2 relative to the regional landscape.

In terms of comparison of the land use potential of each option relative to pre-mining available area, Option 1 will return an area of land that is compatible for grazing use that is very like that of the pre-mining available area. All inward and outward spoil slopes are regraded to a maximum of 10 – 15%, which is sufficiently gentle for the operation of agricultural equipment. Option 1 has hence been ranked as neutral in this regard. Option 3 will incorporate similar regraded profiles as for Option 1, however the nature of the backfilled voids required for Option 3 may render this land susceptible to settlement and poor trafficability during and after rain events, and has hence been ranked as -1, as it may return less land that is suitable for grazing than was the case prior to mining. Option 2 returns less land for post mining grazing use than Option 1, due to steeper spoil regrade profiles. This option does however provide a sustainable water resource and for this reason, Option 2 has been ranked as +2 for grazing potential.
2 INTRODUCTION

2.1 PROJECT CONTEXT

Ensham Mine, an open cut and underground bord and pillar coal mine located approximately 35km east of Emerald, is operated by Ensham Resources Pty Ltd (Ensham), a wholly owned subsidiary of Idemitsu Australia Resources Pty Ltd (Idemitsu), on behalf of the Ensham Mine joint venture (JV) partners. The JV partners, and holders of the Environmental Authority, are Bligh Coal Limited, Idemitsu and Bowen Investment (Australia) Pty Ltd. EA EPML00732813 (the EA), dated 26 May 2017, is the relevant environmental authority under which Ensham operates the mine.

Condition G16 of the EA states that a Residual Void Project (RVP) must be completed and submitted to the administering authority for review and comment by 31 March 2019. The minimum content of the RVP is specified within Condition G16 of the EA as:

- Terms of Reference;
- Residual Void Study;
- Progress Reports; and
- Rehabilitation success criteria for voids.

In compliance with Condition G19 of the EA, “the Residual Void Project must be carried out in accordance with the approved Terms of Reference”. Terms of Reference (ToR) (Ensham Resources, 2017a) were approved by Queensland’s Department of Environment and Science (DES, formerly the Department of Environment and Heritage Protection, DEHP) on 21 July 2017.

Condition G20 of the EA identifies the minimum content of the RVP identified in Condition G16.

In accordance with the ToR, the project has been divided into five stages:

- Stage 1 - Project definition and options identification
- Stage 2 - Preferred options technical studies
- Stage 3 - Preferred options detail design
- Stage 4 - Most preferred option identification
- Stage 5 - Regulatory documentation.

Stage 1 - Project definition and options identification for the RVP have been completed. The Stage 1 Options Assessment report has been finalised and issued to the Department of Environment and Science (DES), the Department of Natural Resources Mines and Energy (DNRME) and the Community Reference Group (CRG). The report was independently peer reviewed and revised to address peer review comments. The final report has been delivered to DES, DNRME and the CRG.

The Options Analysis workshop held in Stage 1 of the RVP identified two options:

- Option 1: Landform Levee
- Option 2: Flood Mitigation and Beneficial Use.

DES required a third option, Backfill to Probable Maximum Flood level, be included in the study.

All three options have been advanced through Stage 2 and into Stage 3 of the RVP and are referred to as the ‘preferred options’. The preferred options are discussed in Section 3.1 to Section 3.3 of this report.
Stage 2 identified the Environmental Values (EVs) in the immediate and surrounding area of Ensham Coal Mine and determined which EVs are likely to be affected by each preferred option. Similar to Stage 1, the Stage 2 EV report and technical studies have been Independently Peer Reviewed and issued in final to DES, DNRME and the CRG.

Stage 3 builds on the technical studies completed in Stage 2 to develop feasibility level designs required to prevent or minimise the potential impacts to EVs for each preferred option. Detailed designs for each of the preferred options will inform a risk assessment of each option and includes as a minimum:

- the long-term stability of the final landform;
- safety of access to the site; and
- the short, medium and long-term risks associated with each preferred option.

The output of Stage 3, in addition to the associated technical reports, will be an Environmental Assessment report for each preferred option which identifies the design and management practices which will be implemented to minimise impacts on the identified EVs.

On completion, each preferred option report will be peer reviewed by an independent suitably qualified third party before submission to the administering authority for review and comment.

### 2.2 PURPOSE

The purpose of this document is to present the findings of the landform design elements associated with each of the 3 preferred options identified in Stage 1 of the RVP. The report will identify benefits/impacts where applicable for each option and will inform the overall Environmental Impact Assessment, the Economic Impact Assessment and the Social Impact Assessment reports.

### 2.3 SCOPE

Condition G20 of the site’s EA specifies that consideration must be given to effects of long-term erosion and weathering of the pit wall and of significant hydrological events, and the void water balance in determination of design objectives to meet Condition G15: “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”.

To address the requirements of the EA and ToR, the Stage 3 study needs to address the following:

- collation of landform design criteria;
- landform design (and optimisation for stability);
- material movement optimisation; and
- landform visualisation.

This report addresses the scope described above, including methodology, adopted landform criteria, and identification of further work required in the next Stage to advance landform design further.

### 2.4 FORMAT OF REPORT

An overview of the layout of this report is presented below:

- **Section 1** Executive Summary
— Section 2  Introduction
— Section 3  Preferred Rehabilitation Options Description
— Section 4  Methodology/Discussion on findings
— Section 5  Conclusions and Recommendations for next Stage
— Section 6  References and abbreviations used in the main body of the report.
3 PREFERRED REHABILITATION OPTIONS DESCRIPTION

3.1 PREFERRED OPTION 1: LANDFORM LEVEE

Having conceptually evolved since Stage 1, proposed Option 1 will develop permanent landforms along the existing levee alignment to provide flood immunity for the 0.1% (1 in 1,000) Annual Exceedance Probability (AEP) flood event having had consideration of the risk of a PMF level event (as proposed in the Stage 2 assessment). Figure 3-1 illustrates the current placement of the landform.

When compared to the landform levee designed at a PMF level (as considered in Stage 2) the proposed 0.1% AEP landform along the existing levee alignment:

- eliminates afflux impacts for upstream landholders in a greater than 0.1% AEP event
- eliminates any potential increased impacts on downstream landholders associated with widening the river floodplain
- eliminates the need to realign the Nogoa anabranch.

It is proposed to incorporate the existing levees into the landform design with overburden emplacement areas behind the levee being reshaped in a manner that achieves the minimum stable landform slope requirements.

Figure 3-1: Option 1 - Landform levee

In addition to any impacts associated with the existing farm levees and mining pit levees, flood levels in the vicinity of Ensham Mine are significantly affected by the confluence of flood flows from the Comet River and Nogoa River, which occurs immediately downstream of the mine. Pits would be subject to rehabilitation in accordance with the approved Ensham site Rehabilitation Management Plan and the landform design criteria.
A treed corridor will be developed along the western (highwall) side of the rehabilitated A and B pits to provide connectivity between Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3-1.

3.2 PREFERRED OPTION 2: FLOOD MITIGATION AND BENEFICIAL USE

Option 2 proposes to utilise the post-mining voids to form water storages to capture a proportion of high flow flood water and store this water for potential beneficial use as shown in Figure 3-2. Flood water harvesting is able to quickly fill the post-mining voids with minimal downstream impact, achieving improved water quality to support a range of reuse options, and/or environmental, and social values.

This option is founded on the concept of capturing a small fraction of larger magnitude flood event flows in the Nogoa River, storing this water in residual voids and releasing it back to irrigation and industrial users via a series of pipes to the Weemah Channel and Yamala Inland Port. No discharge to the Nogoa River by this option is currently envisaged, however functionality to do so is incorporated in water management infrastructure, should this be considered at some stage in the future.

The design of rehabilitation should comply with the current site Rehabilitation Management Plan and landform design criteria to optimise water capacity. Overburden emplacement areas located adjacent to the water storage voids are to be reshaped in a manner that achieves stable landform slopes without resulting in significant void backfilling. Low wall areas are to be reshaped in-pit to achieve minimum stable slope requirements to ensure safe access and stability of exposed slope surfaces.

Option 2 would utilise storage afforded by residual voids remaining in A Pit and B Pit south of the Nogoa River, and C Pit and D Pit north of the river. The quantity of water likely to be required to operate the system – or put another way, the headroom storage in the pits – is likely to be negligible when compared to overall discharges during flood events from the Nogoa River catchment into the Mackenzie River located downstream of the Ensham Coal Mine. However, in the context of irrigation usage, the headroom storage represents a significant volume and a potential economic asset.

Future assessment and optimisation of Option 2 will consider the potential for interactive operation of the voids with Fairbairn Dam to improve water use efficiency across the water supply system.

Currently Fairbairn Dam’s southern irrigation channel, known as the Weemah Channel, extends eastward to within approximately 10 km of Ensham Coal Mine. Water captured from the upper Nogoa River catchment and retained in Queensland’s second largest but relatively shallow Fairbairn Dam, is subject to significant evaporative losses. Furthermore, allocated water releases from the dam into the Weemah Channel (and the corresponding northern Channel, the Selma Channel) experience significant seepage and seasonal evaporative losses before reaching their intended customers, particularly where these customers are close to the end of the Weemah Channel. This option includes linking the residual voids located to the south of the Nogoa River to the existing Weemah Channel with large diameter pipes and pumps to transfer water to and from the voids.

Water captured in Fairbairn Dam could be released into the Weemah channel when hydrologic conditions are likely to result in minimal evaporative and seepage losses (i.e. at times when the catchment is receiving rainfall, the ground is saturated and evaporation is minimal). Whilst the water may not be required by customers at these times, the water could be transferred to the residual voids via the proposed Weemah channel(s) (refer red line on Figure 3-3) and stored in the more evaporatively-efficient residual voids at Ensham. In times of irrigation water demand at the lower reaches of the Weemah Channel (i.e. where the evaporative and seepage distribution losses are likely to be greatest), water could be returned to the Weemah Channel from the residual voids via the Weemah channel.

Because the Weemah Channel and proposed channel(s) lie on the southern side of the Nogoa River floodplain, it would be necessary to maintain a hydraulic connection between the residual voids on the northern flanks of the floodplain and those on the southern flanks. It is proposed that an upgrade of the existing water distribution main, that
runs parallel with the main haulage route between B Pit and C Pit, be undertaken along the existing orientation early in the project to provide the required hydraulic connection (refer blue line on Figure 3-3).

Option 2 proposes that pontoon-based pumping stations would be sited at each pit to transfer water as required. The Weemah channel pipeline coming into the mining lease would be configured to deliver water initially to A pit. Similarly, pumping from the mine to the Weemah Channel would be done from A Pit. An offtake from the pipe to Weemah channel would be used to meet water demand for the prospective Yamala Inland Port located to the south west of Ensham Mine.

The intakes from the Nogoa River to B and C Pits would allow temporary storage of peak flood flows during flood events. As the river rises during a flood event, it would reach the overflow level of the inlet structures constructed in the levee (the intakes) and flow into the residual voids. The water would rise in the voids to reflect the height of the flood. As flood levels recede, water would ebb back into the river floodplain through the intakes to the base level of the intakes leaving the voids at full level. The intakes on both sides of the river system have been considered as part of Stage 3.

A further key aspect of Option 2 is the depth of the residual voids. Shallow expansive voids experience greater evaporative water losses and hence potential salt concentration. Hence improved water quality outcomes are likely to be delivered with deeper inundated pits.

There remain several opportunities to manage power demands of the scheme including solar-power to generate an income to cover some or all of the overall annual operating cost of this option.

Landforms that are not within the floodplain, for example E, F and Y pits, would be rehabilitated to achieve minimum stable slope requirements and comply with currently approved site Rehabilitation Management Plan and landform design criteria, and recommendations regarding highwall rehabilitation that come out of the RVP project.

A treed corridor will be developed along the western (highwall) side of the rehabilitated A and B pits to provide connectivity between Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3-2.

---

Figure 3-2: Option 2 – Flood Mitigation and Beneficial Use
3.3 PREFERRED OPTION 3: BACKFILL TO PMF

Preferred Option 3 comprises backfilling residual mining voids located within the pre-mining floodplain up to the elevation of the original floodplain within the lateral extent of the pre-mining Probable Maximum Flood (PMF) level.

Conceptually, the residual voids lying within this PMF extent would be backfilled up to the approximate original (pre-mining) topography with an additional surcharging to accommodate settlement of the backfill. In practice, it may be necessary to extend the backfilling beyond the modelled extent of the PMF to ensure stability of the backfilled areas within the PMF extent and protect against collapse into the adjacent residual voids. Excess mining spoil that is currently present in the floodplain and that is not required for backfilling of residual mining voids, would be retained as seen in Figure 3-4.

The existing levees constructed to protect the voids from flooding would be removed once the backfilled areas are safe and stable with self-sustaining vegetation cover, with the material re-used in other rehabilitation areas. Material required to backfill residual voids would be drawn from the nearest cost-effective source e.g. low wall spoil. Any negative material balance will need to be met from adjacent low wall and high wall spoils.

Virgin rock typically exhibits an increase in volume when excavated - this is referred to as ‘bulking’. The degree of bulking will vary with the geo-mechanical properties and size distribution of the excavated rocks and the methods used in excavation and transport. Furthermore, it is likely to vary both along the linear extent of the open cut mine and within different parts of spoil tips created through the extraction of rock dominated by lithologies characterising the local stratigraphy. Re-excavation of spoil and re-emplacement within voids will again exhibit bulking. Whether subjected to dynamic compaction or allowed to settle with subsequent loading by overlying backfill, the spoil within the voids will inevitably exhibit uncontrolled settlement. This will lead to the development of low areas within the PMF extent which, though shallow, lie below the original level of the floodplain. These low areas will not necessarily

Figure 3-3: Conceptual drawing of the pipeline from Ensham to the Weemah irrigation channel and Yamala Inland Port (red), and the mine internal pump system (blue)
be connected and are likely to collect surface water runoff but be subject to intense evaporation and surface accumulation of evaporative salts which would be flushed clean by fluvial flood events.

Static surcharging of the replaced spoil material may reduce the risk of long-term settlement below original floodplain. However, this will require material to be placed above the original floodplain elevation in direct contradiction of the intent of this option.

Beyond the modelled extent of the PMF, residual voids would be rehabilitated in accordance with a combination of Option 1 and option 2 landform criteria requirements.

Replaced spoil, however comprehensively compacted, is unlikely to provide durability equal to the original virgin rock and hence during times of extreme fluvial flooding, it is likely that the Nogoa River would scour spoil within the adjacent backfilled areas subject to erosion, of particular note is B Pit. Geomorphology studies identify that downstream properties could be adversely affected by sediment eroded from the landform (WRM Water, 2018 p 5). This has the potential over time to result in sink holes and ultimately a repeat of the 2008/2010 inundation events where flood waters could enter rehabilitated landforms which remain un-backfilled. Additionally, impacts on turbidity downstream of the backfilled areas would need to be considered.

As part of the rehabilitation process, the establishment of a treed corridor along the western (highwall) side of the rehabilitated A and B pits is proposed to link Corkscrew Creek and the Nogoa River flood plain as seen in Figure 3-4.

![Figure 3-4: Backfill to PMF](image)

**3.4 PIT EXTENTS**

The extents of pits are illustrated on the plan provided in Figure 3-5.
Figure 3-5: Location of open-cut pits
4 METHODOLOGY / DISCUSSION OF RESULTS

4.1 LANDFORM DESIGN PRINCIPLES

The Ensham EA (G4) requires all surface areas significantly disturbed by mining activities to be rehabilitated to a safe, stable and non-polluting landform, with self-sustaining vegetation cover in accordance with the approved Completion Criteria. Condition G15 requires that Residual Voids must not cause any serious environmental harm to land, surface waters or any recognised groundwater aquifer, other than the harm constituted by the existence of the residual void itself.

The Ensham Rehabilitation Management Plan sets out several rehabilitation goals, which are common to those contained in the DES rehabilitation guideline EM1122, to achieve the requirements of conditions G4 and G15, which are:

— safe to humans and wildlife
— non-polluting
— stable
— able to sustain an agreed post-mining land use.

The implications of these requirements, as far as they can be managed or influenced by landform design, are described in the sections below.

4.1.1 NON-POLLUTING

For the final landform to achieve an outcome of being non-polluting, there must be no degradation of downstream surface water or groundwater quality, other than would have occurred naturally in a pre-mining landscape. Typical sources of pollutants after mine closure are: elevated levels of sediment from erosion of outward facing rehabilitated spoil dumps, overflow of residual void water with high levels of salinity into watercourses during periods of high rainfall, and leachate from spoil dumps that potentially contain acid forming (PAF) minerals. Material characterisation of spoils at Ensham have indicated that these are benign, and do not contain PAF materials, hence they can be considered non-polluting, and no special treatment of any materials will be required.

The potential for the overflow of poor quality waters from the residual voids during periods of high rainfall is dependent on the residual void hydrology, which may be influenced by final landform in terms of reporting catchments. The landform should therefore result in residual void catchments that are sufficiently small to result in a low risk of spills to the surrounding watercourses for both Options 1 and 3, while for Option 2 water quality in the residual voids will require interaction with the flood plain, and hence the design landform must support this. Rehabilitation and revegetation of outward facing spoil dumps should be prioritised to minimise erosion which could result in an increase in sediment load to receiving waters, which may be carried downstream and off-site.

For the purposes of the landform design, the rehabilitation outcomes should be:

— minimising erosion potential of outward facing landforms comprising spoil material, by adopting conservative slope gradients stipulated in the site Rehabilitation Management Plan (10% for Tertiary and 15% for Permian overburden materials), and topsoiling and revegetating slopes
— for Options 1 and 3 - residual void shaping must result in a reporting catchment, and storage capacity, that complies with void hydrology or water balance modelling outcomes in terms of creating a low risk of spillage during wet weather events
— for Option 2 - ensuring that the landform design supports the requirement for residual void / flood plain interaction, and optimises storage volumes for beneficial use.

4.1.2 STABILITY

Altering natural ground shape invariably introduces a degree of instability, with a tendency for readjustment by way of mass soil movement, either by rapid catastrophic failure such as slumping, sliding; or gradual erosion and deposition through surface processes. Catastrophic failures can represent a safety issue depending on land use of the area surrounding the failure, while erosion takes place over a significant period. Both readjustment mechanisms can hamper or cause the failure of rehabilitation efforts.

Catastrophic failure can occur in two ways: rotational failure due to oversteep slopes or soft foundation materials, or sliding wedge failure due to, for example, undercutting of softer material below more competent layers, or intersecting joints and faults. It is relatively easy to remedy the causes of catastrophic failure by way of reducing slopes or loading the toe of cuttings (buttressing). Erosional stability is dependent on several factors, including land slope, surface preparation and vegetation cover, which can be managed by landform design.

For the purposes of the landform design, the rehabilitation outcomes should be:
— batter slopes on all landform that exhibit a low risk of failure, considering long term weathering properties of exposed materials, and all possible scenarios with respect to water levels in the residual void and adjacent ground water, and fluctuations of these levels in time
— erosionaly sustainable slopes on all rehabilitated lowwall spoil areas, and final highwall profiles.

4.1.3 ABLE TO SUSTAIN AGREED POST-MINING LAND USE

The final topography or landform of the site is dependent on the pre-mining topography, mining method, and reshaping strategy. Given the nature of strip mining which results in spoil piles and a final void, a realistic key driver is to achieve a sustainable end land use that has been identified in consultation with the wider community and the regulator. Ensham has identified a reshaping strategy that returns the landform to one which will support a post-mining land use.

In terms of this reshaping strategy, commitments should relate to broad concepts that promote land capability. Slope characteristics need to be sufficiently gentle to prevent erosion of replaced soils at greater than sustainable rates. Erodibility rates depend on several factors including regional rainfall intensity and soil type. Excessively steep slopes do not promote seed retention, topsoil retention or water infiltration and hence have reduced land capability. This will result in unsustainable pastures and increased erosion due to lack of vegetation cover. It may be acceptable to incorporate areas of the final landform that are incompatible with the proposed post-mining use, such as highwall slopes that report back into the final void, which will be too steep to support agricultural use. Slopes should also be greater than a certain minimum, as deep spoil mounds will incur settlement over a long period time, which will result in localised depressions forming on flat surfaces with ponding of stormwater runoff water. It has been found that ponded rehabilitation landforms on dispersive spoil perform particularly poorly (ACARP, C12031 July 2004). Surfaces with a minimum grade will tolerate settlement without the formation of depressions, maintaining free draining conditions.

To permit the revegetation of rehabilitated areas and undertake maintenance operations of pastures, slopes should be kept below a maximum slope to permit the operation of agricultural equipment, which can generally operate up to a gradient of 1:5 or 20%. Ensham have adopted rehabilitation slopes of 10% for Tertiary material and 15% for Permian materials, so these slopes are well within those required for agricultural purposes. Inward facing spoil slopes of grades
up to 25% will be considered in some instances, with durable rock mulch or other suitable control to prevent erosion. These slopes would be considered suitable for grazing post-mining land use with relevant ongoing maintenance in the event of erosion caused by cattle activity on the slopes.

For the purposes of the landform design, the success criteria in terms of achieving a landform that is sustainable for the identified post-mining land use will be:

- maximising potential land capability and minimising erosion potential by adopting flatter than maximum batter grades wherever practically possible
- adoption of the existing site proven rehabilitation strategy where practicable, which has been successful in prevention of erosion.

### 4.2 METHODOLOGY

#### 4.2.1 COLLATION OF DESIGN CRITERIA

Landform design commenced during Stage 2 with collation of design criteria by way of a literature review of regulatory publications, best practice guidelines, ACARP guidelines, the site Rehabilitation Management Plan, guidelines relating to industry best practices, previous landform studies undertaken by consultants for the Ensham site, and Rehabilitation Management Plans from other similar mine sites (see list of references provided). In addition to this literature review process, a site visit was undertaken to inspect rehabilitation undertaken at Ensham to date. At the end of Stage 2 a preliminary set of recommended criteria were identified (WSP, 2018. PS107225-RES-REP-002 Rev3).

During Stage 3 the development of criteria was further informed by Stage 3 geotechnical stability analysis modelling (WSP, 2018. PS107225-RES-REP-004 Rev I), resulting in the adoption of the design criteria contained in Table 4-1 for final void regrading for all options, construction of landform levees for Option 1, and backfilling to PMF level for Option 3.

Table 4-1: Adopted planform design criteria

<table>
<thead>
<tr>
<th>OPTION</th>
<th>DOMAIN</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>All options</td>
<td>General criteria</td>
<td>— Final landform to be water-shedding with no ponding shapes – minimum slopes of 1% to be adopted draining to voids or to watercourses.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Final landforms to be generally free-draining other than landform regraded towards the lowest point of the rehabilitated landforms.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Regrating to provide a materials balance between cut and fill.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Minimum volumetric movement to achieve landform objectives.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— The lowest point of the rehabilitated landform for Y and F Pits to be raised above groundwater recovery level.</td>
</tr>
<tr>
<td>OPTION</td>
<td>DOMAIN</td>
<td>TREATMENT</td>
</tr>
<tr>
<td>------------</td>
<td>-------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
|            | Outward slope of spoil  | — Regrade to a slope of 10% for Tertiary spoil rehabilitation in line with current successful site practices, with slope length up to a maximum of 200m between benches  
— Regrade to a slope of 15% for Permian spoil rehabilitation in line with current successful site practices, with slope length up to a maximum of 100m between benches.  
— No permanent drainage structures to be incorporated in the landform.  
— 10 m wide non-drainage bench at the frequency described above to break runoff velocity down slopes.  
— Slopes to be topsoiled and grassed, benches to be seeded with trees.  
The selection of these regrade slopes was supported by 500-year erosion modelling undertaken in 2016 considering the range of topsoil available on the site (Landloch, 2016). |
|            | Inward slope of spoil   | — As for outward facing slopes for Options 1 and 3.  
— Maximum of 25% for all spoil with durable rock mulching or other suitable control for Option 2. |
|            | Highwalls and endwalls  | To achieve long-term stability, highwalls must be regraded as follows:  
— Tertiary material – maximum slope 1V:3H (18° or 33%)  
— Weathered Permian – maximum slope 1V:3H (18° or 33%)  
- for the purposes of landform design weathered Permian to be regarded as Tertiary material due to lack of information on the interface between these two materials, which aligns with current rehabilitation practices on site  
— Fresh Permian – maximum slope of 1V:1H (45° or 100%)  
— Minimum 5 m wide bench to be provided between weathered and fresh Permian layers  
— Buttressing of highwalls from pushed or blasted material from the highwall side to be sloped inward at a maximum slope of 25%.  
The basis for regrading of the weathered Permian is the Base of Weathering profile provided by Ensham site staff. |
<p>|            | Land bridges            | No treatment required – access to land bridges to be cut off with earth bunds. |</p>
<table>
<thead>
<tr>
<th>OPTION</th>
<th>DOMAIN</th>
<th>TREATMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ramps</td>
<td>— Ramps are to be partially infilled to create slopes that comply with spoil regrade requirements stipulated elsewhere in this table.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Ramps to be retained for Option 2 where these provide access to water pumping infrastructure.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Ramp embankments to be battered back at 10% in Tertiary material and 15% in Permian.</td>
</tr>
<tr>
<td>Option 1 only -</td>
<td>Landform</td>
<td>— Free draining landform with no water damming behind the levee.</td>
</tr>
<tr>
<td>Landform levee</td>
<td>levee</td>
<td>— All watercourse facing slopes to be 1V:6.7H (15%) and constructed from compacted cohesive clay materials, finished with topsoil and grass.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— A bench of at least 10 m will be provided separating the inward toe embankment of the levee landform and adjacent edge of void stabilisation regrade.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Level of landform - based on 0.1% AEP flood modelling surfaces provided by Hydro Engineering and Consulting, + 0.5m freeboard.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Raising of levees 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.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— River-facing batters to receive rip rap facing where flood flows exceed velocity of 1.5 m/s and at sharp changes in alignment, with durable rock of average diameter (D_{50}) in accordance with the following:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— D_{50} = 150mm for velocities up to 3.0 m/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— D_{50} = 300mm for velocities up to 4.0 m/s</td>
</tr>
<tr>
<td>Option 2 only -</td>
<td>Beneficial use</td>
<td>— Void regrade to be undertaken to optimise storage capacity, ideally achieving a minimum capacity of 110 GL to FSL in A, B, C and D Pits.</td>
</tr>
<tr>
<td>Beneficial use</td>
<td></td>
<td>— No topsoil and grassing to be undertaken for landform below FSL in voids to be used for water storage.</td>
</tr>
<tr>
<td>Option 3 only -</td>
<td>Backfill to PMF</td>
<td>— Voids within the PMF footprint to be backfilled to pre-mining levels + a 50m buffer where voids only require partial infill.</td>
</tr>
<tr>
<td>OPTION</td>
<td>DOMAIN</td>
<td>TREATMENT</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>-----------</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Landform to be developed to obtain sufficient void backfill material while not exceeding maximum lowwall and highwall regrade angles provided above.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Backfill slope into pit where partially filled – 10% batter for Tertiary fill or 15% for Permian fill, topsoiling and grassing.</td>
</tr>
</tbody>
</table>

4.2.2 LANDFORM MODELLING

Based on the criteria developed for landform design described above, and geotechnical stability assessment, void stabilisation sections were developed, indicating stabilisation measures for each pit in terms regrading of high and low walls. Landform modelling was undertaken by MEC Mining using Deswik mine planning software, which was used to identify the most cost-efficient utilisation of mining plant to perform the rehabilitation earthworks. Refinement of the MEC modelling was undertaken by Xenith. WSP have reviewed modelling undertaken by these consultants to assess compliance with the design criteria.

Sections through the final landform have been taken and superimposed on the proposed stabilisation sections to assess model compliance with lowwall and highwall regrade design requirements, these have been included in Appendix A.

In general, final landform features include:

— an elevated ridge on the lowwall side of the void, running parallel to the lowwall (approximately north-south orientated on site), shaped from spoil material

— residual voids other than those backfilled under Option 3, with partial infilling to accommodate surplus spoil generated by reducing resting angle of lowwall spoil dumps

— for all the Options, residual voids will be partially backfilled to achieve a materials balance and stability of high and low walls – for Y and F Pits the residual void floor will be higher than the predicted groundwater recovery level, while for other residual voids groundwater may present in the bottom of the void on recovery

— benched rectilinear slopes, from the elevated ridge towards the residual void or outwards, with grades of either 10 or 15% depending on spoil characteristics for Options 1 and 3

— for Option 2, inward facing spoil slopes have been regraded at a maximum slope of 25% with a durable cover of rock mulch or other suitable treatment, as the A, B, C, and D rehabilitated landforms will ultimately be inundated with water, preventing the mechanisms of erosion from occurring in the long term

— the final landform of the Boggy Creek diversion between F and Y Pits

— where possible existing rehabilitated landform areas have been retained, however the more fundamental criteria of achieving sustainable slope angles on spoil material has resulted in regrading (and hence loss) of significant areas of existing rehabilitated land for some options

— a reduction in the slopes associated with ramps that could possibly contribute to concentrated stormwater runoff pathways, other than for Option 2 where ramps are required to access water management infrastructure

— an absence of formal drainage structures, with landforms shaped to cause sheet flow runoff rather than concentration in gulleys.
4.3 SPECIFIC LANDFORM ISSUES RELEVANT TO PREFERRED OPTIONS

Landform design entails creation of stable residual voids for all the pits on site, which is a desired outcome that is common to all the Preferred Options. There are however specific requirements in terms of landform that apply to individual options. These specific requirements, and associated issues, are described in this section.

4.3.1 OPTION 1 - LANDFORM LEVEE

4.3.1.1 LANDFORM DESIGN DEVELOPMENT

In addition to stabilising residual voids, Option 1 requires that the residual voids are isolated from flood events up to a 0.1% AEP event. To achieve this outcome a landform will be created to separate the residual voids from the Nogoa River floodplain, effectively permanently isolating the residual voids from flood water. These landform levees must exhibit long-term geotechnical stability, and seepage below and through the structures during flood events should be of a magnitude that represents a very low risk of destabilisation of highwall materials adjacent to the levees. These levee landforms will be located on the alignment of the existing northern and southern levees where possible, however where highwall regrading encroaches within 10 m of the levee toe, the levee has been shifted to achieve this minimum bench separation. The landform levees will be raised slightly above existing levee crest levels to ensure 0.1% AEP flood event immunity, based on current calculation methods, is achieved.

The following philosophy has been adopted in landform design relating to these specific structures:

- landform levees will result in a free draining landform, with runoff captured behind the structures directed to residual voids
- these landforms will incorporate the existing levee structures wherever possible, and additional earthworks embankment construction required to raise the levees shall be founded on natural ground, with no part of the levee structure founded on backfill into any residual void
- the landform levees will resemble landform in nature, rather than the existing engineered levees, with embankment batters of 15% (1H:6.7V) for all embankments where space permits, void facing embankments of 1H:4V have been adopted at a few locations
- new earthworks for the landform levees will be constructed from typical levee construction materials (low permeability, low dispersivity clay materials), with full engineering compaction to eliminate preferred seepage paths and high porosity associated with uncompacted materials.

Typical sections of the landform levees are shown in Figure 4-1 and Figure 4-2 below.

![Figure 4-1: Typical levee landform profile – central raising encapsulating the existing levee](image-url)
4.3.1.2 STABILITY AND ANALYSIS

The geotechnical stability of the landform levee structures has been assessed based on information provided by Ensham, which describes geotechnical testing and design undertaken for the existing southern and northern levee structures. The levee assessment is described fully in the Geotechnical Design Report (WSP, 2018. PS107225-RES-REP-004 Rev J), which found the levee structures to be stable in the long-term, but recommended some additional inspection, testing and analysis to confirm stability modelling assumptions prior to the implementation (construction) phase of the project.

4.3.2 OPTION 2 – BENEFICIAL USE

Option 2 does not include any specific landform requirements in addition to stabilising residual voids. The existing northern and southern levees will be retained as they are wherever possible, with intake structures created to encourage flood plain interaction with the A, B, C and D-pit residual voids. Localised watercourse training works will be required to achieve this interaction; however, the scale of these works do not render them landform in nature, but are more engineering features, and hence are not addressed here.

A requirement of this option is that the voids comprising the beneficial use storage be stabilised in such a way that capacity is maximised.

4.3.3 OPTION 3 – BACKFILL TO PMF

In addition to stabilising all residual voids on site, Option 3 requires that residual voids within the extent of the PMF footprint be backfilled to pre-mining landform levels. Landform that is proud of the pre-mining levels will be shaped in accordance with the landform design criteria.

To simulate the bulk earthworks requirements for backfilling of the residual voids within the extent of the PMF, Ensham have provided two sets of ground data, one representing the final void footprints of Pits A, B, C and D, and one representing the pre-mining landform. The pre-mining landform ground data has been imported into final landform model for the extent of the voids within the PMF, with trimming and regrading at the interface of the two sets of ground data to achieve free draining conditions.

4.4 LANDFORM STABILITY OUTCOMES

4.4.1 GEOTECHNICAL STABILITY

A geotechnical investigation was undertaken to identify stability requirements for final landform design in terms of residual void geometry, a summary of the recommendations arising from this investigation, and the landform design responses are included below:

— Outward facing spoil slopes – geotechnical analysis identified that slopes of 1V:4H (25%) would be considered long-term stable under all envisaged conditions, however based on experience learnt from rehabilitation practices...
on site to prevent erosion, the spoil slope criteria were set as $10\%$ (1V:10H) or $15\%$ (1V:6.7H) depending on whether the spoil is Tertiary or Permian based material, which is represented in final landform topography. These slopes are flatter than those recommended for geotechnical stability, and hence will have a low risk of failure.

- Inward facing spoil slopes – for Options 1 & 3 inward facing slopes will be sloped at 10 or 15\% as for outward facing slopes, while for Option 2 slopes of 25\% have been adopted, which are geotechnically stable.

- Highwall – the geotechnical report recommended that highwall materials be set-back at angles of 1V:1H for fresh Permian, 1V:2H for weathered Permian, and 1V:3H for Tertiary materials to allow for long-term weathering of exposed materials with associated geotechnical weakening. Final landform profiles incorporate partial backfilling of all voids to accommodate surplus spoil material generated by reducing spoil slopes, effectively buttressing fresh Permian profiles. Those surfaces not buttressed have been set back to 1V:1H to comply with geotechnical recommendations. Any material above the bottom line of weathering profile provided by Ensham, was regraded at 1V:3H, which is flatter than geotechnical recommendations for weathered Permian rock, and in compliance with that recommended for Tertiary materials.

4.4.2 EROSIONAL STABILITY

In addition to geotechnical stability against sudden, catastrophic surface failures, the landform must exhibit stability against longer term, more gradual erosion. Slope angle, length of slope, and vegetation cover are important factors in the control of erosion, and can be incorporated in landform design to manage erosion characteristics of the final landform. Best site practices for spoil rehabilitation have been developed over years considering the erosional stability of rehabilitated areas, which are incorporated in the Ensham Rehabilitation Management Plan. The site has had success rehabilitating Tertiary spoil dumps with $10\%$ slope regrades, coupled with maximum slope lengths of 200m and 10m wide benches as slope breaks. Permian spoil has been found to be erosional stable at regraded slopes of $15\%$ with 100m slope lengths. Rehabilitation practices include topsoiling, deep ripping, grass seeding, and hay mulching. Benches are not topsoiled, but are populated with tree tube stock.

A site map indicating the distribution of typical spoil material is included in Figure 4-5 below, and has been used to guide landform design in terms of adoption of appropriate spoil regrade slopes at different locations across the site. As can be seen from this figure, spoil dumps for A-pit through to E-pit have void facing slopes comprising mostly Permian material, and hence inward facing slopes have been regraded to a maximum slope of $15\%$ in these areas. Spoil dumps at the northern F and Y pits are characterised by a higher of proportion of Tertiary material, and hence for these pits a maximum spoil regrade slope of $10\%$ has been adopted. Quaternary spoil adjacent to A pit has also been regraded at $10\%$, as review of rehabilitated slopes in this area has shown that $10\%$ has been used previously and is performing well.

For Option 2 all inward facing spoil dumps have been regraded to a maximum slope of $25\%$, assuming a durable rock mulch or other suitable control will be available to dress slopes to prevent erosion. In the absence of proven success of stabilisation of $25\%$ slopes, regrading would default to $10 - 15\%$ regrade depending on the nature of the spoil material. The site has undertaken limited trials incorporating $25\%$ rehabilitation slopes, however further trials areas will be required to gain confidence in this method for all soil types and with alternative erosion control measures (refer to photographs in Figure 4-3 and Figure 4-4 below).
Figure 4-3: Rehabilitated landform at 25% (photograph 1)

Figure 4-4: Rehabilitated landform at 25% (photograph 2)
Key to achieving erosionally stable landform is the establishment of a sustainable vegetation cover, and the following revegetation measures are proposed:

- spoil regraded at no steeper than 10 - 15% will be topsoiled and or ameliorated to promote and sustain vegetation growth (Options 1 and 3)
- spoil regraded at no steeper than 25% will be rock mulched with tree seed or other suitable controls to reduce erosion potential (Option 2)
- cut slopes in tertiary materials with slopes of less than 33% will be topsoiled and or ameliorated to promote and sustain vegetation growth (all options).

4.4.2.1 LONG-TERM EROSION MODELLING

In September 2015, Landloch Pty Ltd were commissioned by Ensham to assess the stability of final void and landform shaping options, with a brief including inter alia - undertaking a site inspection to assess site materials and typical vegetation cover levels achieved on rehabilitated areas, sampling of key site materials (topsoils and wastes), chemical and physical characterisation of the materials, measurement of key erodibility parameters for topsoils, development of SIBERIA landform evolution models, and the use of SIBERIA and WEPP models to develop slope design rules for 3-D planners.

Dr Rob Loch visited the site in January 2015 and reported the following key observations (Landloch, September 2016):

- relatively low gradients of rehabilitated areas (10% rather than 17% commonly on most central Queensland coal mines)
— consistently high levels of surface vegetative cover, with revegetation targeting the establishment of pasture grasses and legumes
— absence of flow control structures
— general absence of areas of concentrated flow and incision on rehabilitated areas.

The conclusion drawn from the site visit was that “relative to most, if not all, mines in the region, rehabilitation works have been highly successful”. A site visit was undertaken by WSP staff in early 2018, during which rehabilitated areas were observed, and the same conclusions were drawn. Spoil adjacent to E-pit was being rehabilitated at the time of the visit, and the rehabilitation process was observed.

SIBERIA modelling undertaken by Landloch considered general areas of predicted erosion over 50 and 500 year periods considering two vegetation scenarios, with grazed and ungrazed pastures. Models were set up for various pits with topsoil parameters that are representative of one of three typical topsoil types encountered on site. Reporting was based on typical control areas in the landform, including steep sections of spoil reporting to the void, saddles between higher areas in the landform, and batter slopes on re-shaped landform (existing rehabilitated landform). No comment was made regarding highwall erosion.

The work undertaken by Landloch was on a different final landform to that developed under Stage 3 of this project, but is however of direct relevance, in terms of erosion resistance of proposed final landform, where these are the same or comparable to the control areas used for reporting in the Landloch model. The control area referred to as “Landform batter slopes” in the Landloch report is most relevant as it refers to slopes that are the same, or like, spoil regrade slopes adopted for the final landform (between 10 and 15%).

Results were provided for each typical control section for each pit, for grazed and ungrazed vegetation conditions, with predictions of the change in ground level (mm) due to erosion or deposition, and erosion rates (t/ha/y). The results predicted that erosion of “landform batter slopes” in the A and B pit areas where black, cracking clay is the prevalent topsoil used for rehabilitation, would be the worst, with a predicted landform erosion of 52 mm in 500 years for grazed conditions and 15 mm for ungrazed. This equated to erosion rates of 1.3 to 0.4 t/ha/y for grazed or ungrazed conditions respectively, which was commented to be “not high, being in the range of 0.3 – 1.3 t/ha/y. The rates are quite sustainable, and indicate that the batter slopes are at a gradient that is stable to erosion”.

Given the lack of visual evidence of erosion on existing areas of rehabilitated spoil during site visits conduction by Landloch and WSP staff on separate occasions, and results of the SIBERIA landform evolution modelling described above, it has been concluded that spoil landform with rehabilitated slopes of between 10 – 15%, combined with topsoiling and revegetation as is currently practiced, will yield an erosionally stable final landform.

The SIBERIA modelling did not include any areas of steeper graded, rock-mulched spoil; hence no conclusions can be made regarding to stability of the Option 2 - 25% regrade surfaces based on this SIBERIA modelling, or of the highwall. The limited site rehabilitation test slopes at this angle do however show that such slopes, prepared and treated with topsoil and revegetated, have the potential to achieve erosional stability.

### 4.4.2.2 HIGHWALL EROSIONAL STABILITY

In July 2018, ACARP (Henderson Geotech) published a document (Project C26019) – Prediction of Long Term Erosion at Pit Walls, which contained the findings of an investigation undertaken to assessed erosional stability of highwalls to assess its effect on final void stability and footprint.

The methodology and findings of the project may be very briefly summarised as follows:
— the analyses were performed using the SIBERIA program for a 200-year period
— assumptions on material properties were made, as no field work was performed
— assumption that no highwall stabilisation carried out prior to commencement modelling period
the results indicate that highwalls could retreat horizontally between 10 m for moderately weathered overburden, and 30 m for highly erodible Tertiary overburden over the 200-year period of study, and hence if no highwall stability treatment is applied, long term erosion at pit walls could impact adjoining land in most cases.

The proposed landform design incorporates high and endwall treatment by way of flattened slopes to help account for material weathering and weakening, with 1V:3H in the weathered zone, including Tertiary Clays, and 1V:1H in fresh Permian material. These measures will reduce the retreat of highwall over time.

Options incorporating levee structures near the crest of final highwall regrade embankments would be at risk of damage in the event of highwall retreat, although in these areas the catchment reporting to the highwall is limited.

4.5 FINAL LANDFORM

In this section, final landform development is presented graphically for each option. It should be noted that the areas are based on landform models and areas provided by MEC and Xenith, with defined control areas around pit groupings for all options, which are used for comparative purposes.

4.5.1 OPTION 1 – LANDFORM LEVEE

Option 1 landform is based on modelling provided by Xenith.

Option 1 includes setting back of the highwall in accordance with criteria provided earlier, and regrading of inward and outward facing spoil at a maximum of 10 to 15%, depending on the nature of spoil material adjacent to the residual void. The final land use areas for this option are provided in Table 4-2 below.

The total volume of earthworks required to achieve the Option 1 final landform amounts to 151,300,000 m$^3$, with topsoiling and revegetation of 2,859 ha. Approximately 249 ha of existing rehabilitated landform will be disturbed. The final landform results in 89.2 % of the control area at a slope of 15 % or less.

Table 4-2: Option 1 - final landform areas by slope (provided by Xenith)

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>AB</th>
<th>CDE</th>
<th>FY</th>
<th>TOTALS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10 %</td>
<td>1,546</td>
<td>1,546</td>
<td>1,303</td>
<td>4,395</td>
<td>73.3</td>
</tr>
<tr>
<td>11 - 15%</td>
<td>225</td>
<td>474</td>
<td>252</td>
<td>951</td>
<td>15.9</td>
</tr>
<tr>
<td>16 - 25%</td>
<td>54</td>
<td>142</td>
<td>103</td>
<td>299</td>
<td>5.0</td>
</tr>
<tr>
<td>26 - 33 %</td>
<td>26</td>
<td>90</td>
<td>46</td>
<td>162</td>
<td>2.7</td>
</tr>
<tr>
<td>34 - 100%</td>
<td>44</td>
<td>81</td>
<td>65</td>
<td>190</td>
<td>3.1</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL (ha)</td>
<td>1,895</td>
<td>2,333</td>
<td>1,769</td>
<td>5,997</td>
<td>100</td>
</tr>
</tbody>
</table>

| EARTHWORKS | VOLUME (M.m$^3$) | 52.5 | 62.8 | 36 | 151.3 |

4.5.2 OPTION 2 – FLOOD MITIGATION AND BENEFICIAL USE

Option 2 landform is based on modelling provided by Xenith.

Option 2 includes setting back of the highwall in accordance with criteria provided earlier and regrading of inward facing spoil at a maximum of 25%, and outward facing spoil to a maximum slope of 10 of 15 % depending on the nature of spoil material adjacent to the residual void. The final land use areas for this Option are provided in Table 4-3 below.
The total volume of earthworks required to achieve this final landform amounts to 107,000,000 m$^3$, with topsoiling and revegetation of 2,703 ha. Approximately 130 ha of existing rehabilitated landform will be disturbed. The final landform results in 77.6 % of the control area at a slope of 15 % or less. Approximately 570 ha of land within the control area will be below the full storage water level in A, B, C and D pits. No surface treatment is proposed for these inundated areas as the mechanisms for erosion will be absent when the landform is submerged. Based on this philosophy, rock mulch would only be required for rehabilitated slopes of 25% for the E, F and Y pits. This is likely to result in a requirement of approximately 400 ha of rock mulch or other suitable control, with growth medium to promote vegetation growth.

Table 4-3: Option 2 - Final landform areas by slope (provided by Xenith)

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>AB</th>
<th>CDE</th>
<th>FY</th>
<th>TOTALS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10%</td>
<td>1,358</td>
<td>1,396</td>
<td>1,218</td>
<td>3,972</td>
<td>66.2</td>
</tr>
<tr>
<td>11 - 15%</td>
<td>212</td>
<td>280</td>
<td>194</td>
<td>686</td>
<td>11.4</td>
</tr>
<tr>
<td>16 - 25%</td>
<td>175</td>
<td>254</td>
<td>214</td>
<td>643</td>
<td>10.8</td>
</tr>
<tr>
<td>26 - 33%</td>
<td>98</td>
<td>322</td>
<td>68</td>
<td>488</td>
<td>8.2</td>
</tr>
<tr>
<td>34 - 100%</td>
<td>52</td>
<td>81</td>
<td>73</td>
<td>206</td>
<td>3.4</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL (ha)</td>
<td>1,895</td>
<td>2,333</td>
<td>1,767</td>
<td>5,995</td>
<td>100</td>
</tr>
</tbody>
</table>

**EARTHWORKS VOLUME (M.m$^3$)**

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>AB</th>
<th>CDE</th>
<th>FY</th>
<th>TOTALS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10%</td>
<td>34.2</td>
<td>47.1</td>
<td>25.7</td>
<td>107</td>
<td></td>
</tr>
</tbody>
</table>

**4.5.3 OPTION 3 – BACKFILL TO PMF**

Option 3 landform is based on modelling provided by MEC, with F and Y Pits as for Option 1.

Option 3 includes setting back of the highwall in accordance with criteria provided earlier, and backfilling residual voids within the PMF footprint to pre-mining levels. For residual voids outside the PMF footprint, void regrading will be as for Option 1. The final land use areas for this option are provided in Table 4-4 below.

The total volume of earthworks required to achieve this final landform amounts to 241,000,000 m$^3$, with topsoiling and revegetation of 3,880 ha. The final landform results in 75 % of the control area at a slope of 15 % or less. This is the highest of the three options due to the infilling of the pits within the PMF footprint to pre-mining levels.

Table 4-4: Option 3 – Final landform areas by slope (provided by Xenith)

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>AB</th>
<th>CDE</th>
<th>FY</th>
<th>TOTALS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10%</td>
<td>1,793</td>
<td>1,720</td>
<td>1,303</td>
<td>4,815</td>
<td>80.3</td>
</tr>
<tr>
<td>11 - 15%</td>
<td>70</td>
<td>401</td>
<td>252</td>
<td>723</td>
<td>12.1</td>
</tr>
<tr>
<td>16 - 25%</td>
<td>18</td>
<td>151</td>
<td>103</td>
<td>272</td>
<td>4.5</td>
</tr>
<tr>
<td>26 - 33%</td>
<td>11</td>
<td>29</td>
<td>46</td>
<td>86</td>
<td>1.4</td>
</tr>
<tr>
<td>34 - 100%</td>
<td>3</td>
<td>32</td>
<td>65</td>
<td>100</td>
<td>1.7</td>
</tr>
<tr>
<td>&gt;100%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL (ha)</td>
<td>1,895</td>
<td>2,333</td>
<td>1,769</td>
<td>5,996</td>
<td>100</td>
</tr>
</tbody>
</table>

**EARTHWORKS VOLUME (M.m$^3$)**

<table>
<thead>
<tr>
<th>SLOPE</th>
<th>AB</th>
<th>CDE</th>
<th>FY</th>
<th>TOTALS</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10%</td>
<td>79.6</td>
<td>125.4</td>
<td>36</td>
<td>241.0</td>
<td></td>
</tr>
</tbody>
</table>
5 CONCLUSIONS AND RECOMMENDATIONS FOR THE NEXT PHASE

5.1 CONCLUSIONS AND RECOMMENDATIONS

The Stage 3 Landform Design work has included the following elements:

— identification of regulatory requirements and development of key success criteria to meet these requirements
— review of technical literature concerning landform rehabilitation, local and international guidelines for rehabilitation, and previous studies undertaken for the Ensham Mine
— visiting the Ensham site to observe the current rehabilitation strategy on site and its effectiveness
— extraction of pertinent criteria identified in the literature search and site practices, and identify criteria that will be adopted for the landform design
— geotechnical stability analysis of high, end and lowwalls to determine appropriate regrading requirements to provide long-term stability
— modelling of landforms for all the Preferred Options and analysis of outcomes in terms of total earthworks movements required to achieve the landforms, the proportion of land that is suitable for the identified post-mining land use, and required volumes of surface treatment in the form of topsoiling or rock mulching.

Based on the work undertaken, the following general conclusions have been made:

— To achieve safe, stable landforms regrading of the all voids will be required, including highwalls, endwalls and spoil dumps. This stabilisation regrading will be required for all the Preferred Options. Excess spoil material generated from regrading the lowwall will be disposed of by partial infilling of adjacent residual voids, which may be used as buttress material to stabilise highwalls as an alternative to regrading.

— Option 3 results in a landform where the highest proportion of disturbed land may be restored to a similar condition as the surrounding undisturbed land and less residual voids in the landscape, while Options 1 and 2 yield a very similar but lower area. Option 3 has a lower area available for grazing due to the Conservation Covenant required to assist with vegetation management of pits backfilled to PMF.

— To achieve safe stable landforms, Option 3 requires 241,000,000 m$^3$ of earthworks, which includes the volume required to backfill pits within the PMF footprint to pre-mining levels. Options 1 and 2 require 151,300,000 and 107,000,000 m$^3$ earthworks respectively. Option 2 requires less earthworks as it adopts steeper maximum spoil regrade slopes than Option 1 (25% as opposed to 10 - 15%) and does not require full backfilling of voids on the floodplain to PMF under Option 3.

— Options 1 and 3 will provide long-term stable landforms with proven erosion stability criteria based on successful rehabilitation strategies implemented on site over many years. Option 2, with 25% maximum regrade slopes combined with rock mulching, has the potential to deliver required erosion stability outcomes but has had limited testing on site. In the absence of sufficient rock mulch or other suitable control, maximum slope regrade angles would need to default back to the 10 – 15% limits applied historically.

— Option 3 requires backfilling of residual voids to pre-mining levels within the PMF footprint, which will be subject to ongoing settlement over time. Removal of levees and roads will permit overland flood water flow across
these backfilled areas, which will result in erosion if vegetation coverage does not attain or maintain levels required to provide protection. The magnitude and locality of settlement in these backfilled areas is likely to be unpredictable and variable.

The following recommendations are made for consideration before construction commences:

— An assessment should be made of rock mulch inventories, and identify potential sources for this material for Option 2 spoil slope stabilisation. This material may be sourced from areas where highwall set back has been recommended for long-term stability reasons, or selected from overburden dumps on site.

— Trial sections should be undertaken on site to test the effectiveness of 25% maximum regrade slopes with rock mulch and other suitable options.

— Further investigation will be required to confirm material characterisation of spoil dumps, to make more accurate assessments of relevant maximum slopes for rehabilitation efforts due to variability in this material on site.

— Refinement of landform modelling to smooth profiles, removing unnecessary gulleying or concentrated drainage paths, sharp ridge lines, optimise the Option 1 landform levees to minimise encroachment on the flood plain, and review benches on both highwall and lowwall regrades.

5.2 POTENTIAL IMPACTS ON ENVIRONMENTAL VALUES

An assessment of the potential impacts of each of the three preferred options on relevant environmental values (EVs) has been undertaken based on the outcomes of this study. The EVs are described in the Ensham Residual Void Project Stage 2 Environmental Values Workshop Report (March, 2018) and the EVs relevant to each of the Stage 3 studies have been determined by Ensham.

The assessment of impacts on EVs has been undertaken by assigning a ranking for each of the preferred options to each EV. The adopted scoring criteria, definitions of impacts and summary of the EV assessment are tabulated below.

Table 5-1: EV scoring criteria

<table>
<thead>
<tr>
<th>SCORING CRITERIA</th>
<th>RANKING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant negative impact for this criterion</td>
<td>-3</td>
</tr>
<tr>
<td>Medium negative impact for this criterion</td>
<td>-2</td>
</tr>
<tr>
<td>Minor negative impact for this criterion</td>
<td>-1</td>
</tr>
<tr>
<td>No impact for this criterion</td>
<td>0</td>
</tr>
<tr>
<td>Minor benefit for this criterion</td>
<td>1</td>
</tr>
<tr>
<td>Medium benefit for this criterion</td>
<td>2</td>
</tr>
<tr>
<td>Significant benefit for this criterion</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 5-2: EV definitions

<table>
<thead>
<tr>
<th>IMPACT</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant impact/benefit</td>
<td>Results in a change which is important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact the change will result in not being able to meet published standards (if there are any). For a benefit the change should meet best practice standards (if there are any published).</td>
</tr>
</tbody>
</table>
Medium impact/benefit

Results in a change which is potentially important, notable or of consequence to the EV having regard to its intensity/frequency. For an impact, the change will result in occasions where the criterion will not meet published standards (if there are any). For a benefit the change should meet good practice standards (if there are any published).

Minor impact/benefit

Results in a change which is identifiable but is not important, notable or of consequence to the EV having regard to its intensity.

Note: The definition of significant impact has been based on the Federal Government’s definition of significant impact contained within its "Matters of National Environmental Significance, Significant Impact Guidelines 1.1, Environment Protection and Biodiversity Conservation Act 1999”

The EV of landform aspects of the project, was assessed by considering landform stability in terms of incompatible land uses and agricultural potential (included in Appendix B).

In terms of incompatible land uses, Option 3 will result in areas which are incompatible with post-mining land use due to the required conservation covenant steepness of terrain, while Option 2 will have some areas of steeper terrain which is still available for grazing plus benefit provided by establishing a water resource. Hence Options 1 and 3 have been ranked -1 for this criterion, and Option 2 as +2.

In terms of comparison of the land use potential of each option relative to pre-mining available area, Option 1 will return an area of land that is compatible for grazing use that is very like that of the pre-mining available area. All inward and outward spoil slopes are regraded to a maximum of 10 – 15%, which is sufficiently gentle for the operation of agricultural equipment. Option 1 has hence been ranked as neutral in this regard. Option 3 will incorporate similar regraded profiles as for Option 1, however the nature of the backfilled voids required for Option 3 may render this land susceptible to settlement and poor trafficability during and after rain events, and has hence been ranked as -1, as it may return less land that is suitable for grazing than was the case prior to mining. Option 2 returns less land that is suitable for post mining agricultural use than for Option 1, due to steeper spoil regrade profiles. This option does however provide a sustainable water resource. For this reason, Option 2 has been ranked as +2 for agricultural potential.
6 REFERENCES

6.1 REFERENCES

The following documents have been referred to in this report:

- Department of Environment and Heritage Protection. (23 May 2014). Guideline Resources Activities – Rehabilitation Requirements for Mining Resources Activities.


- Ensham Resources. (June 2017). Rehabilitation Management Plan V2.0.


6.2 ABBREVIATIONS

The following abbreviations have been used in this report:

AEP - Annual Exceedance Probability

CRG – Community Reference Group

DEHP – Department of Environment and Heritage Protection

DES – Department of Environment and Science

DNRM – Department of Natural Resources Mines and Energy

EV – Environmental Value

PAF – Potentially Acid Forming
PMF – Probable Maximum Flood
RVP – Residual Void Project
ToR – Terms of Reference
APPENDIX A
LANDFORM SECTIONS
NOTES
1. SECTIONS ARE INDICATIVE ONLY AND MAY
   VARY DEPENDING ON LOCATIONS OF EACH
   OPTION
2. RECESS OF MOUND TO BE :
   REMOVE BOTTOM OF WESTERN LINE
   TO AVERAGE BOTTOM OF WESTERN LINE

A-PIT (NORTH)
SECTION 3800
SCALE 1:2000

GROUNDWATER REST LEVEL (GRL)
PIT PARKING OPTION 1 PARKING OPTION 2
A SHINE 1467 1863
A SHINE 1467 1863

LEGEND
FULL LENGTH OF 1:
GROUNDWATER REST LEVEL (GRL)

A-PIT (NORTH)
SECTION 3420
SCALE 1:2000

APPROVED
DRAWING No:
DESIGNED:
DRAWN:
CHECKED:
DATE:
REV:
PROJECT No:
TITLE:

PROJECT: DRAWING STATUS:

REV DATE
BY DESCRIPTION CHK APPD

SCALE


LEVEL 3, 69 ANN STREET, BRISBANE
GPO BOX 2907, QLD 4001, AUSTRALIA
TEL: +61 7 3854 6200 FAX: +61 7 3854 6500
WSP.COM

A WORK IN PROGRESS

B 26.11.18 MH GWUPDATED GROUNDWATER REST LEVEL
C 10.01.19 AB GWLANDFORM REPLACED WITH XENITH LANDFORM
C OPTION 1 REGRADING SECTIONS
SHEET 4
G. WRAY
PS107225 SK 1014
PS107225
ENSHAM RESIDUAL VOID PROJECT
M. HAMILL
PRELIMINARY ISSUE
NOT FOR CONSTRUCTION
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of manhole to be placed at end of west facing line

FULL SIZE 1:2000; HALF REDUCTION 1:4000

DESCRIPTION DRAWING NO.

APPROVED
SIGNED:
DATE:

LEVEL 3, 69 Ann Street, Brisbane
GPO Box 2907, QLD 4001, Australia
Tel: +61 7 3854 6200 Fax: +61 7 3854 6500

A WORK IN PROGRESS

© WSP Australia Pty Ltd.
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of plan to be transferred bottom of existing line torajive bottom of existing line

C-PIT
SECTION 450
SCALE 1:500

GROUNDWATER REST LEVEL (GRL)

LEGEND

FULL EXTENT OF EXISTING FENCE
FULL EXTENT OF EXISTING BOUNDARY

C-PIT
RED HILL SECTION
SCALE 1:500

PS107225-SK-1031

ENSHAM RESIDUAL VOID PROJECT
M. HAMILL
PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

© WSP Australia Pty Ltd

A WORK IN PROGRESS

File name \CORP.PBWAN.NET\ANZ\PROJECTS\PS107225_ENSHAM_RESIDUAL_V\4_WIP\BIM\DRAWINGS\PS107225-SK-1031.DWG, printed on 27 February, 2019 10:55:51 AM, by Hamill, Michael
Level 3, 69 Ann Street, Brisbane
GPO Box 2907, QLD 4001, Australia
Tel: +61 7 3854 6200 Fax: +61 7 3854 6500
wsp.com
NOTES
1. Sections are indexing only and may vary depending on objectives of each option
2. Require all work to be completed to bottom of existing line with existing bottom of existing line.

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>PIT</th>
<th>DESCRIPTION</th>
<th>CHK</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SCALE (m)

C-PIT
SECTION 1402
SCALE 1:2500

EXCESS MATERIAL TO BE WRAPPED IN BAGS

OPT1
GROUNDWATER REST LEVEL (GRL)

LEVEL 3, 69 ANN STREET, BRISBANE
GPO BOX 2907, QLD 4001, AUSTRALIA
TEL: +61 7 3854 6200 FAX: +61 7 3854 6500
wsp.com

A WORK IN PROGRESS

B 26.11.18 MH GWUPDATED GROUNDWATER REST LEVEL
C 10.01.19 AB GWLANDFORM REPLACED WITH XENITH LANDFORM

OPTION 1 REGRADING SECTIONS

PS107225-SK-1032

ENSHAM RESIDUAL VOID PROJECT

M. HAMILL
PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

50 25 0 150 100

FULL SIZE 1:2500 ; HALF REDUCTION 1:5000
NOTES
1. SECTIONS ARE INDICATIVE ONLY AND MAY VARY DEPENDING ON OBJECTIVES OF EACH OPTION.
2. REQUIRE NEW WALL TO BE TRENCHING BOTTOM OF WEATHERING LINE TO REFLECT BOTTOM OF WEATHERING LINE.
NOTES
1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of normall to be thhewn out bottom of roadway. Line to indicate bottom of roadway.

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>OPTION 1</th>
<th>OPTION 2</th>
<th>OPTION 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.2</td>
<td>11.8</td>
<td>11.5</td>
</tr>
</tbody>
</table>

LEGEND
- Option 1
- Option 2
- Option 3

SECTIONS APPLICABLE TO OPTIONS 1 & 3

FULL SIZE 1:2000 ; HALF REDUCTION 1:4000
NOTES

1. Sections are indicative only and may vary depending on objectives of each option
2. Require of Nurse to be to the yellow bottom of weathering line
   to achieve bottom of weathering line

Y-PIT
SECTION 2400
SCALE 1:4000

GROUNDBASE LEVEL (GRL)

<table>
<thead>
<tr>
<th>OPTION 1 (mGRL)</th>
<th>OPTION 2 (mGRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71.7</td>
<td>71.5</td>
</tr>
</tbody>
</table>

LEGEND

- Full options Opt 1
- Groundwater Rest Level GRL Opt 1
- Groundwater Rest Level GRL Opt 3

Options:

- Option 1: Regrading Sections

Sheet 3

PS107225-SK-1073

© WSP Australia Pty Ltd
A-PIT (SOUTH)
SECTION 803
SCALE 1:2000

NOTES
1. SLOPES ARE INDICATIVE ONLY AND MAY VARY DEPENDING ON OBJECTIVES OF EACH OPTION
2. REQUIRE OF GROUND TO BE 1.5M BELOW BOTTOM OF WEATHERING LINE
3. REQUIRE OF BOTTOM OF WEATHERING LINE

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>OPTION</th>
<th>GROUNDWATER REST LEVEL (GRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5m</td>
</tr>
<tr>
<td>2</td>
<td>1.0m</td>
</tr>
<tr>
<td>3</td>
<td>0.5m</td>
</tr>
</tbody>
</table>

LEGEND

- Full Engineering Only
- Groundwater Rest Level (GRL)
- Full Storage Level

A-PIT (SOUTH)
SECTION 650
SCALE 1:2000

NOTES
1. SLOPES ARE INDICATIVE ONLY AND MAY VARY DEPENDING ON OBJECTIVES OF EACH OPTION
2. REQUIRE OF GROUND TO BE 1.5M BELOW BOTTOM OF WEATHERING LINE
3. REQUIRE OF BOTTOM OF WEATHERING LINE

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>OPTION</th>
<th>GROUNDWATER REST LEVEL (GRL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5m</td>
</tr>
<tr>
<td>2</td>
<td>1.0m</td>
</tr>
<tr>
<td>3</td>
<td>0.5m</td>
</tr>
</tbody>
</table>

LEGEND

- Full Engineering Only
- Groundwater Rest Level (GRL)
- Full Storage Level
NOTES
1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of monohall to be within floor bottom of existing line.

GROUNDWATER REST LEVEL (GRL)

LEGEND

FULL STORAGE LEVEL
FULL EQUILIBRIUM (F1)
FULL STORAGE LEVEL

A-PIT (CENTRAL)
SECTION 1600
SCALE 1:2000

A-PIT (SOUTH)
SECTION 1200
SCALE 1:2000
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.

2. Require of groundwater to be above bottom of weathering line
   and below bottom of weathering line.

LEGEND

- Full Equivalent of 1
- Groundwater Rest Level (GRIL) of Option 2
- Full Storage Level

A-PIT (NORTH)
SECTION 2002
SCALE 1:500

A-PIT (CENTRAL)
SECTION 2002
SCALE 1:500
NOTES
1. SECTIONS ARE INDICATIVE ONLY AND MAY VARY DEPENDING ON OBJECTIVES OF EACH OPTION
2. REQUIRE TO MEET ALL TO BE WITHIN BOTTOM OF WEATHERING LINE
   TO INCLINE BOTTOM OF WEATHERING LINE

GROUNDWATER REST LEVEL (GRL)

LEGEND

- Full Level Ground (FT 2)
- Groundwater Rest Level (GRL) OPT 1
- Groundwater Rest Level (GRL) OPT 2
- Full Storage Level

Four sections are shown on this drawing, each with different groundwater levels and weathering lines. The sections are noted as A-PIT (NORTH) and A-PIT (SOUTH), with varying section numbers and details. The sections show the extent of existing piling and the groundwater levels at different depths. The drawing includes scales and legends for different levels and features, indicating the level of detail and the conditions at various points in the project.
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of main all to be:
   - fill below bottom of regrading line
   - remove bottom of regrading line

GROUNDBASE REST LEVEL (GRL)

LEGEND

- Main Line Option 1
- Groundwater Rest Level (GRL) Option 2
- Final Storage Level

C-PIT
SECTION 101
SCALE 1:2500

C-PIT
RED HILL SECTION
SCALE 1:2500
NOTES
1. Sections are indicating only and may vary depending on objectives of each option.
2. Require of Norwall to be trimmed to bottom of heaving line to achieve bottom of heaving line.

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>PIT</th>
<th>OPTION 2 (HAND)</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>1238</td>
</tr>
</tbody>
</table>

LEGEND
- Full Embankment of Option 2
- Groundwater Rest Level (GRL) of Option 2
- Full Storage Level

C-PIT
SECTION 14.05
SCALE 1:2500

EXCESS MATERIAL TO BE KEPT OUTSIDE OF BOUNDARY

C-PIT OPTION 2 REGRAving SECTIONS SHEET 2
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.

2. Required of mounding to be trimmed below bottom of weathering line to provide design of weathering line.

D-PIT

SECTION 602

SCALE 1:5000

GROUNDWATER REST LEVEL (GRL)

LEGEND

FULL LEVEL
OPTION2
D-PIT

APPROVED

SIGNED

DATE

© WSP Australia Pty Ltd
NOTES
1. SEDIMENTARY AREAS MAY VARY DEPENDING ON OBJECTIVES OF EACH METHOD
2. REQUIRE DRAINAGE TO BE TREATED PRIOR TO BEGINNING OF DRAINAGE LINE

---

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>OPTION 1</th>
<th>OPTION 2 (MINI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIT 1</td>
<td>PIT 2</td>
</tr>
</tbody>
</table>

SCALE (m)

D-PIT

SECTION 2200

SCALE 1:2000
NOTES
1. Sections are indicative only and may vary depending on objectives of each option
2. Require detailed design to be undertaken for Option 2

- Horizontal Datum: Survey Datum
- Vertical Datum: Groundwater Rest Level (GWL)

LEGEND
- Option 2
- Groundwater Rest Level (GWL)
- Fall Storage Level

GRID
- Option 2: Regrading Sections

Full Size: 1:2500; Half Reduction: 1:5000

SCALE (m)
NOTES
1. SLOPES ARE INDICATED ONLY AND MAY VARY DEPENDING ON OBJECTIVES OF EACH OPTION
2. REQUIRE URPOOL TO BE ABOVE THE ELEVATION OF REFERENCE LEVEL

LEGEND
- POOL LEVELS OPT 1
- GROUNDWATER REST LEVEL (GRL) OPT 2

SECTION 2400
SCALE 1:2000

SECTION 2000
SCALE 1:2000
NOTES
1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of muckall to be:
   - Three feet bottom of existing line
   - Observe bottom of existing line

GROUNDWATER REST LEVEL (GRL)

LEGEND

PS107225-SK-2063
Y-PIT
SECTION 402
SCALE: 1:2000

NOTES
1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of horizontal to be within yellow dotted line to achieve bottom of weathering line.

LEGEND
--- EARTH LEVEL ---
--- GROUNDWATER REST LEVEL (GRL) ---
--- OPTION 1 (BCD) ---
--- OPTION 2 (XRT) ---

GROUNDWATER REST LEVEL (GRL)

FULL SIZE 1:2000; HALF REDUCTION 1:4000
SCALE (m)
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.

2. REQUIRE OF MOWALL TO BE:
   ± 100MM BOTTOM OF RESTING LINE
   ± 100MM BOTTOM OF RESTING LINE

GROUNDWATER REST LEVEL (GRL)

LEGEND

1. OPTION 2 REGRADING SECTIONS

SHEET 2
NOTES
1. Sections are indicative only and may vary depending on objectives of each option.
2. Profile should be to the right side of the sheet.

GROUNDDRAIN REST LEVEL (GRL)

LEGEND

- Profile Line of Option 2
- Groundwater Rest Level (GRL Opt. 2)

PS107225-SK-2073

ENSHAM RESIDUAL VOID PROJECT

PRELIMINARY ISSUE

NOT FOR CONSTRUCTION

40 20 0 12080

Full Size 1:2000; Half Reduction 1:4000

SCALE (m)
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.
2. Refer to option manual for full details of each option.

Y-PIT
SECTION 2000
SCALE 1:2000

LEGEND

GROUNDWATER REST LEVEL (GWL)

OPTION 2 (GWL)

LEGEND

PALE ESPONMENT (GWL)
GROUNDWATER REST LEVEL (GWL)
OPTION 2 – BENTON DESIGN RECEIVED
IN FILE "\PC\CROPS\opt_2\benton.dwg"

NOTES
1. Sections are indicative only and vary depending on objectives of each option.
2. Require of main all to be:
   * Approx. bottom of weathering line
   * Approx. bottom of weathering line

Y-PIT
SECTION: 3420
SCALE: 1:2000

GROUNDWATER REST LEVEL (GWL)
LEGEND

<table>
<thead>
<tr>
<th>OPTION</th>
<th>NAME</th>
<th>SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>P2</td>
<td></td>
<td>1:2000</td>
</tr>
<tr>
<td>P3</td>
<td></td>
<td>1:4000</td>
</tr>
</tbody>
</table>

G.WRAY

PRELIMINARY ISSUE
NOT FOR CONSTRUCTION

Full Size 1:2000; Half Reduction 1:4000
SCALE (m)
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.
2. Require of HML to be treated as bottom of sea-floor line.
3. Refer to existing borehole L2-261118 MH GW.

A-PIT (NORTH)

SECTION 2002

SCALE 1:2000

GROUNDWATER REST LEVEL (GRL)

LEGEND

PIT OPTION 3 (REGRADING)

A-PIT (CENTRAL)

SECTION 2002

SCALE 1:2000

GROUNDWATER REST LEVEL (GRL)
NOTES
1. Sections are indicative only and may vary depending on objectives of each option
2. Require of manual to be
   - Using bottom of existing pipe
   - Using bottom of existing line

FULL SIZE 1:2000 ; HALF REDUCTION 1:4000
SCALE (m)

PS107225 - SK - 3014
NOTES

1. Sections are indicative only and may vary depending on objectives of each option.

2. Requirement: Northall to be.
   - Remove/excavate to GSNL of existing surface
   - Northall to be partially depicked by returning to existing level
   - Excess material to be used to fill in gaps.

GROUNDWATER REST LEVEL (GRL)

<table>
<thead>
<tr>
<th>Remarks</th>
<th>Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPTION 3 REGRADING SECTIONS</td>
<td>1:2000</td>
</tr>
</tbody>
</table>

PS107225 SK 3021

ENSHAM RESIDUAL VOID PROJECT

PRELIMINARY ISSUE

NOT FOR CONSTRUCTION

Full Size 1:2000; Half Reduction 1:4000
NOTES

1. Sections are indicative only and may vary depending on objectives of each option

2. Require all soil to be
   • finished bottom of existing line
   • finished bottom of existing line

• GROUNDWATER REST LEVEL (GRL)

---

GROUNDBORNE FAULTS

PREMATURELY DELAYED OR BY
RESHAPED LEVEL

EXCESS MATERIAL TO BE
USED TO FILL HOLLOW

---

B-PIT

SECTION 5600
SCALE 1:2000
NOTES
1. Sections are indicative only and may vary depending on objectives of each option
2. Require of non-all to be shown
   highest bottom of existing line
   highest bottom of existing line

E-PIT
SECTION 2400
SCALE 1:2500

GROUNDWATER REST LEVEL (GRL)

LEGEND

E-PIT
SECTION 2000
SCALE 1:2500

G. WRAY
E-PIT
PS107225 SK 3052
ENSHAM RESIDUAL VOID PROJECT

M. HAMILL
PRELIMINARY ISSUE

NOT FOR CONSTRUCTION

Full Size 1:2500 ; Half Reduction 1:5000
SCALE (m)

© WSP Australia Pty Ltd
APPENDIX B
EV IMPACT ASSESSMENT
<table>
<thead>
<tr>
<th>Environment Aspect</th>
<th>Environmental Value</th>
<th>Criteria</th>
<th>Scoring Notes</th>
<th>Option 1 Landform Levee</th>
<th>Option 1 Evidence</th>
<th>Option 2 FMBG</th>
<th>Option 2 Evidence</th>
<th>Option 3 Backfill to PMF</th>
<th>Option 3 Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Incompatible land uses</td>
<td>Land suitability class</td>
<td>Compared to the regional context</td>
<td>-1</td>
<td>Some areas around the residual voids will be too steep for post-mining landuse.</td>
<td>2</td>
<td>Residual void will become a water storage, which can be regarded as an improvement to and suitability class when compared to surrounding regional land.</td>
<td>-1</td>
<td>Some areas around the residual voids will be too steep for post-mining landuse.</td>
</tr>
<tr>
<td></td>
<td>Agricultural potential</td>
<td>Long term available area</td>
<td>Compared to pre-mine available area</td>
<td>0</td>
<td>Residual voids and spoil dumps regraded at 10 - 15%, topsoiled and revegetated - land suitable for pasture development.</td>
<td>2</td>
<td>Creation of sustainable water resource for augmentation of existing irrigation scheme. Residual voids and spoil dumps regraded partially to 10-15%, topsoiled and revegetated - land suitable for pasture development.</td>
<td>-1</td>
<td>Residual voids and spoil dumps regraded at 10 - 15%, topsoiled and revegetated - land suitable for pasture development. Area of backfill to voids in the PMF footprint may not be suitable for agriculture due to differential settlement and lack of trafficability when wet.</td>
</tr>
</tbody>
</table>