TECHNICAL MEMORANDUM

TO:	A. McLellan (ERM)	**DATE:**	March 20, 2024
FROM:	L. Palmen (KCB)	**FILE NO:**	DX70088A01
SUBJECT:	Final Landform Flood Modelling Rev.1		

INTRODUCTION

KCB Australia Pty Ltd (KCB) have been commissioned by ERM to complete hydrology and flood modelling to support Anglo American's (Anglo) Progressive Rehabilitation and Closure Plan (PRCP).

The Dawson Mining Complex is located within Queensland's Bowen Basin, located approximately 175 km southwest of Gladstone. The mining complex extends over 50 km (north to south) and comprises three distinct operating areas; Dawson North, Dawson Central, and Dawson South. Anglo American are required to prepare a PRCP for submission to the Queensland Government. A PRCP is an element of the Queensland Government's Mined Land Rehabilitation Policy (State of Queensland 2021a) and the Environmental Protection Act 1994 (EP Act). The EP Act (State of Queensland 2022b) requires that all areas disturbed within the relevant mining tenure are rehabilitated to a post-mining land use (PMLU), or managed as a non-use management area (NUMA).

When mining at Dawson ceases in 2079, the site will enter a closure phase. Rehabilitation strategies for the residual voids have been considered as part of the overarching PRCP scope (completed by others), and a final landform design has been provided to KCB for the flood modelling of the site. The results of the flood modelling will provide information on the expected flood immunity of pits and general hydrologic behaviour of the final landform surface.

DESIGN BASIS

Table 1 summarises the inputs and assumptions relating to the final landform flood modelling.

Table 1 Design Basis

Item		Design Basis	Reference
1.0	**Spatial Data**		
1.1	Datum	AGD66 / AMG zone 56 (primary)	
1.2	Model Extent	▪ Hydrologic: Catchment watershed for Kianga, Lonesome, Borehole and Dawson catchments to the downstream (western) side of Dawson Mine. ▪ Hydraulic: Dawson Mining Complex (approx. 5 km wide and 58 km long).	
1.3	Topographic Survey and Surfaces	▪ DEM_Landforms_Closure_Updated_5m_20241501_R2, by others supplied by ERM. ▪ NORTH_1_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ CENTRAL_1_20220417_Dawson_Local_z56_25cm.xyz as 1m grid	 (Anglo 2022) (Anglo 2022)

Item		Design Basis	Reference
		▪ CENTRAL_2_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ CENTRAL_3_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ CENTRAL_4_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ RGTCT_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ SOUTH_1_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ SOUTH_2_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ SOUTH_3_20220417_Dawson_Local_z56_25cm.xyz as 1m grid ▪ Moura_2012_Twn_SW_1m grid ▪ Theodore_2011_Twn_SW_1m grid ▪ PRJ40001_GIBIHI_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_KIANGA_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_MOURA-NORTH_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_MOURA-SOUTH_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_NIPAN_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_NORTH_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_SOUTH_Aug21_AMG66z56.dwg as 2 m grid ▪ PRJ40001_THEODORE_Aug21_AMG66z56.dwg as 2 m grid ▪ Regional Survey ALOS World 3D V 3.2 – 30 m grid	(Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (DNRME 2011) (DNRME 2011) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (Anglo 2022) (JAXA 2021)
1.4	Aerial Photography and Features	Bing and Google sourced imagery	Bing Maps Google Maps
2.0	**Hydrology**		
2.1	Flood Events	▪ 1:20 AEP, 1:50 AEP, 1:100 AEP, 1:200 AEP, 1:500 AEP ,1:1,000 AEP, 1:2,000 AEP, 1:5,000 AEP, 1:10,000 AEP, PMPF	
2.2	Design Rainfall Guidelines	▪ Rainfall durations up to 6 hours: Generalised Short Duration Method (GSDM) ▪ Rainfall durations between 6 and 24 hours: interpolation ▪ Rainfall durations between 24 and 120 hours: Generalised Tropical Storm Method (Revised)	(BOM, 2003) (BOM 2005)
2.3	Hydrologic Model	RORB V6.45	(HARC, 2019)
2.4	Hydrologic Model Configuration	Borehole Creek ▪ Catchment Area: 57.3 km^2 ▪ k_c: 7.52 ▪ m: 0.8 ▪ Initial Loss: 47 mm (0 mm PMF) Continuing Loss: 0.7 mm/hr (1 mm PMPF) Kianga Creek ▪ Catchment Area: 307.6 km^2 ▪ k_c: 18.33 ▪ m: 0.8 ▪ Initial Loss: 41 mm (0 mm PMF) Continuing Loss: 1.1 mm/hr (1 mm PMPF) Dawson River ▪ Catchment Area: 26,477 km^2 ▪ k_c: 194.36 ▪ m: 0.8 ▪ Initial Loss: 59 mm (0 mm PMPF) Continuing Loss: 2.1 mm/hr (1 mm PMPF) Local Rainfall (adopted representative catchment) ▪ Catchment Area: 12.7 km^2	(Ball, et al., 2019)

<table>
<tr><th colspan="2">Item</th><th>Design Basis</th><th>Reference</th></tr>
<tr><td></td><td></td><td>k_c: 3.38
m: 0.8
Initial Loss: 25 mm (0 mm PMF)
Continuing Loss: 1.1 mm/hr (1 mm PMPF)</td><td></td></tr>
<tr><td>2.5</td><td>Design Rainfall Critical Event</td><td>Adopted critical events (h) and temporal pattern (TP)
<table>
<tr><th>Event (AEP)</th><th>Borehole</th><th>Kianga</th><th>Dawson</th><th>Local</th></tr>
<tr><td>1:20</td><td>12h TP25</td><td>24h TP3</td><td>48 h TP6</td><td>2h TP13</td></tr>
<tr><td>1:50</td><td>12h TP25</td><td>24h TP10</td><td>24 h TP6</td><td>2h TP28</td></tr>
<tr><td>1:100</td><td>12h TP25</td><td>24h TP5</td><td>24 h TP6</td><td>1.5h TP28</td></tr>
<tr><td>1:200</td><td>9h TP11</td><td>12h TP21</td><td>36h TP6</td><td>1.5h TP2</td></tr>
<tr><td>1:500</td><td>9h TP11</td><td>12h TP4</td><td>36h TP6</td><td>1.5h TP2</td></tr>
<tr><td>1:1,000</td><td>9h TP11</td><td>12h TP15</td><td>36h TP6</td><td>1h TP1</td></tr>
<tr><td>1:2,000</td><td>9h TP11</td><td>12h TP15</td><td>36h TP6</td><td>1h TP1</td></tr>
<tr><td>1:5,000</td><td>2.5h TP4</td><td>9h TP11</td><td>36h GTSMR</td><td>1h TP1</td></tr>
<tr><td>1:10,000</td><td>2.5h TP4</td><td>9h TP11</td><td>36h GTSMR</td><td>1.5h TP7</td></tr>
<tr><td>PMPF</td><td>3h GSDM</td><td>5h GSDM</td><td>36h GTSMR</td><td>2h TP3</td></tr>
</table></td><td></td></tr>
<tr><td>2.6</td><td>Climate Change</td><td>Long-term (2081-2100), using a climate scenario of SSP3-7.0 (2.7 - 5.0), adopting a median of median of 3.6°C. Factors to extreme rainfall depth, initial and continuing losses applied as per the draft update to the Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation.</td><td>(DCCEEW 2023)</td></tr>
<tr><td>3.0</td><td colspan="3">Hydraulic Model</td></tr>
<tr><td>3.1</td><td>Hydraulic Model</td><td>TUFLOW Single Precision 2023-03-AC (latest release at the time of modelling), heavily parallelised compute (HPC) solution scheme.</td><td></td></tr>
<tr><td>3.2</td><td>Model Time Step</td><td>Variable, automatically selected to maintain model stability.</td><td></td></tr>
<tr><td>3.3</td><td>Grid Size</td><td>6 m hydraulic computation, 3 m output resolution, sub-grid sampling to 1 m.</td><td></td></tr>
<tr><td>3.4</td><td>Boundary Conditions</td><td>Regional Upstream: QT boundaries
Regional Downstream: HQ boundaries
Local Catchment Upstream: Direct rainfall (excess)
Local Catchment Downstream: Various HQ boundaries based on normal depth at the specific location.</td><td></td></tr>
<tr><td>3.6</td><td>Hydraulic Structures</td><td>No hydraulic structures have been included in the model</td><td></td></tr>
<tr><td>3.7</td><td>Hydraulic Roughness</td><td>Varies, spatially distributed using vegetation-density relation to Manning’s ‘n’ roughness value, consistent with KCB (2022b).</td><td>(Gill, et al. 2017)</td></tr>
<tr><td>3.8</td><td>Result Mapping</td><td>Results are an envelope of modelled maximums.
Following results provided as raster data:
Inundation extent, maximum elevation, and maximum depth.
Final Landform
Dawson_20y_d_HR_Max.tif
Dawson_20y_h_HR_Max.tif
Dawson_50y_d_HR_Max.tif
Dawson_50y_h_HR_Max.tif
Dawson_100y_d_HR_Max.tif
Dawson_100y_h_HR_Max.tif
Dawson_200y_d_HR_Max.tif
Dawson_200y_h_HR_Max.tif
Dawson_500y_d_HR_Max.tif
Dawson_500y_h_HR_Max.tif
Dawson_1k_d_HR_Max.tif
Dawson_1k_h_HR_Max.tif</td><td></td></tr>
</table>

Item		Design Basis	Reference
		Dawson_2k_d_HR_Max.tif Dawson_2k_h_HR_Max.tif Dawson_5k_d_HR_Max.tif Dawson_5k_h_HR_Max.tif Dawson_10k_d_HR_Max.tif Dawson_10k_h_HR_Max.tif Dawson_PMF_d_HR_Max.tif Dawson_PMF_h_HR_Max.tif Final Landform with Climate Change SSP3-7.0 at 2100 Dawson_FLCC_1k_d_HR_Max.tif Dawson_FLCC_1k_h_HR_Max.tif Following results provided as pdf layout data: MAXIMUM DEPTH - 1_1K AEP FINAL LANDFORM.pdf MAXIMUM DEPTH - 1_1K AEP FINAL LANDFORM CLIMATE CHANGE SSP3-7.0 2100.pdf	

HYDROLOGY

The hydrologic assessment has used four separate hydrologic models to estimate the critical rainfall events across the site. The arrangement allows the major regional waterways (Borehole Creek, Kianga Creek and the Dawson River) to be estimated separately from the local site rainfall. The local rainfall was estimated by adopting a representative catchment within the runoff routing model. The critical rainfall duration and temporal pattern for each and annual exceedance probability (AEP) was selected based on the hydrologic model results (refer Table 1). The respective flows and rainfall events were adopted for using within the hydraulic model.

Consideration of Climate Change

The recently released draft update to the Climate Change Considerations chapter in Australian Rainfall and Runoff: A Guide to Flood Estimation (DCCEEW 2023) provides updated guidance in relation to the estimated impact of climate change upon extreme rainfall and flood risk. While it is acknowledged that the guidance is in draft, it is considered suitable for estimation of future flooding impact given it is based on recent climatic science, projections and observations.

The assessment has adopted the SSP3-7.0 (high) socioeconomic pathway with the long-term projected date of 2100. The median of published estimates has been used to factor event depths and losses.

HYDRAULICS

The assessment has used the two-dimensional Tuflow hydrodynamic model to simulate the flood flows using the final landform surface. Details of the topographical arrangement and simulation are provided in Table 1. The regional hydrologic model inputs are based on the runoff routing flows from the respective hydrologic models. The local rainfall was simulated using a direct rainfall method, utilising the rainfall excess hyetograph from the hydrologic assessment. This approach provides a detailed estimate of the inundation locations and flow paths across the final landform.

The hydraulic outputs for the multiple hydraulic models were combined to present the estimated maximum flood depths and extents across the site.

RESULTS

The results of the flood modelling are provided in raster format for the AEPs considered, for both the current and climate change scenarios. The 1:1,000 AEP, maximum depth results for the existing and climate change scenarios are also provided as layouts in Attachment I.

SUMMARY

This memorandum provides a comparative assessment of flood behaviour based on the final landform design surface developed as part of the wider PRCP project. The results of the assessment may be used to assess the hydrologic behaviour of the design surface, including the expected flood immunity of pits and conveyance of regional waterways through the site.

CLOSING

This memorandum is an instrument of service of Klohn Crippen Berger (KCB). The memorandum has been prepared for the use of ERM (Client) for the specific application to the Dawson Central and North GW PRCP, and may be published or disclosed by the Client to Anglo American.

KCB has prepared this memorandum in a manner consistent with the level of care, skill and diligence ordinarily provided by members of the same profession for projects of a similar nature at the time and place the services were rendered; however, the use of this memorandum will be at the user's sole risk absolutely and in all respects, and KCB makes no warranty, express or implied. This memorandum may not be relied upon by any person other than the Client or Anglo American without KCB's written consent.

Use of or reliance upon this instrument of service by the Client is subject to the following conditions:

1. The memorandum is to be read in full, with sections or parts of the memorandum relied upon in the context of the whole memorandum.

2. The observations, findings and conclusions in this memorandum are based on observed factual data and conditions that existed at the time of the work and should not be relied upon to precisely represent conditions at any other time.

3. The memorandum is based on information provided to KCB by the Client or by other parties on behalf of the client (Client-supplied information). KCB has not verified the correctness or accuracy of such information and makes no representations regarding its correctness or accuracy. KCB shall not be responsible to the Client for the consequences of any error or omission contained in Client-supplied information.

4. KCB should be consulted regarding the interpretation or application of the findings and recommendations in the memorandum.

5. This memorandum is electronically signed and sealed and its electronic form is considered the original. A printed version of the original can be relied upon as a true copy when supplied by the author or when printed from its original electronic file.

Yours truly,

KCB AUSTRALIA PTY LTD.

Luke Palmen CPEng RPEQ
Senior Civil Engineer

LP:lp

ATTACHMENT I

Maximum Depth Layouts

1:1,000 AEP Maximum Depth
1:1,000 AEP Maximum Depth Climate Change