WARATAH COAL

Mine Development Flood Assessment

1 February 2011

M1700_002

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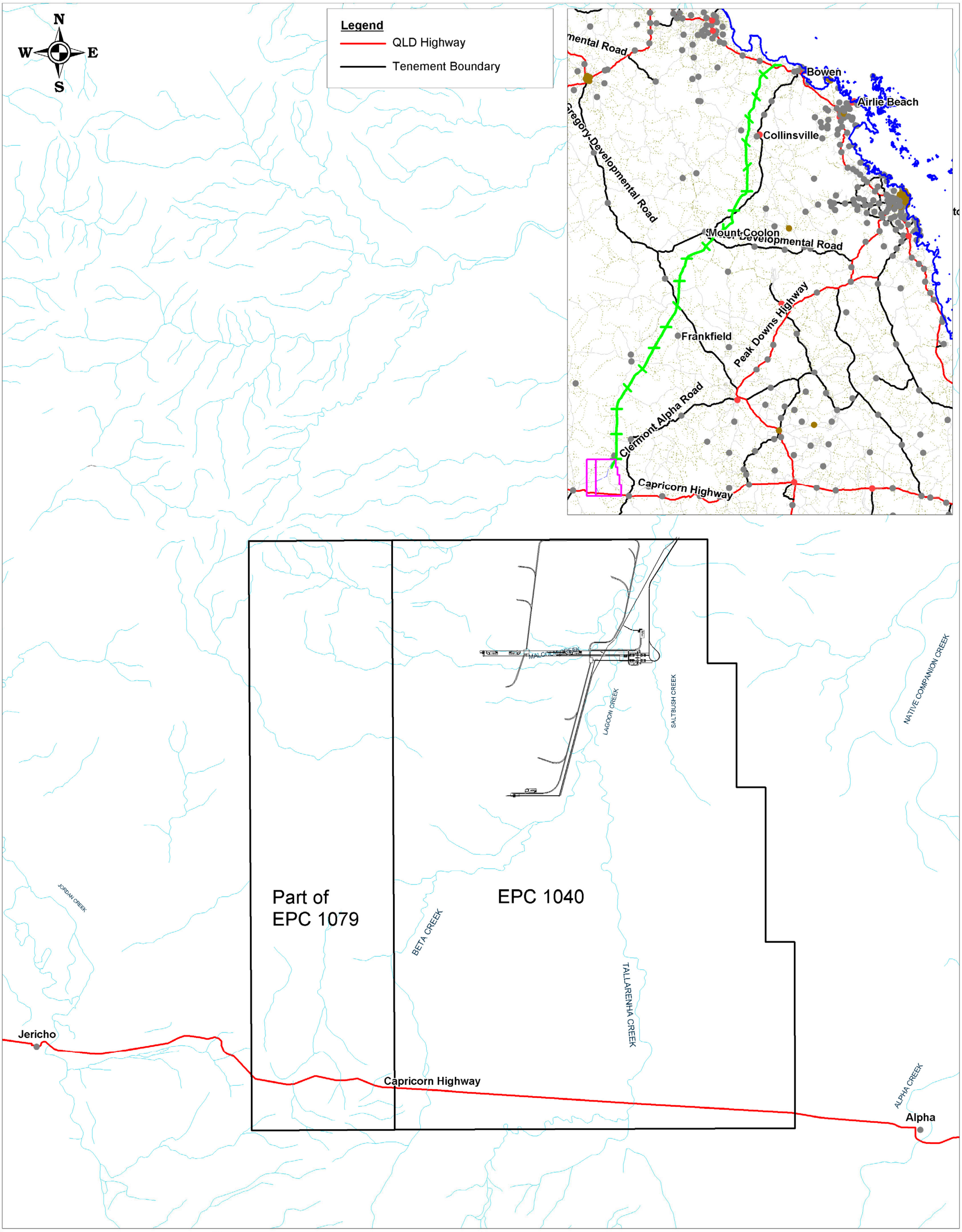
1. INTRODUCTION

Engeny has been commissioned by Waratah Coal to provide an initial flooding assessment for the proposed mine site of the China First Project. The mine site consists of tenement areas EPC 1040 & Part of EPC 1079.

The Capricorn Highway passes through the southern extent of the mine site which is located between the towns of Alpha and Jericho as shown on Figure 1-1.

The following six (6) major waterways pass through or flow adjacent to the mining lease area: Beta Creek, Tallarenha Creek, Saltbush Creek, Malcolm Creek, Lagoon Creek and Spring Creek, as well as a number of smaller contributing tributaries to these systems. The extent of these flow corridors and adjacent floodplains within the mining lease area are the subject of this flood investigation.

This study is based on data that was readily available at the time of the study. A 25m Digital Elevation Model (DEM) was provided by DERM and was used as the basis for the modelling works undertaken as part of this assessment.



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Mine Development Flood Assessment **Figure 1-1**

Mine Development Locality Plan

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2. STUDY DATA

2.1 Historical and Gauge Data

A review of the Queensland Government's Department of Environment and Resource Management (DERM) data has indicated that no direct stream gauge data is available for locations within the catchment; however data does exist for a station located within catchments contributing to waterways adjacent to the study area. This gauge is summarised in Table 2.1 and illustrated in Figure 3-1.

Table 2.1 Available Gauging Stations

Gauge ID	Name	Years of Data (Including zero's and No Records)	Years of Operation
120305A	Native Companion Creek at Violet Grove	43	1967-present

Recent flooding has occurred in the region with the most recent report being of flooding during September 2010. The Bureau of Meteorology states that for this rainfall event *"Heavy rainfall recorded in the Carnarvon region during September produced rises in Native Companion Creek and major flooding further downstream at Albro station. A Flood Warning for major flooding was issued on the 20th of September and finalised on the 27th"*.

2.2 Topographic Data

In order to construct hydrologic and hydraulic models for the study area, topographic data for the area was sourced from DERM. A 25m Digital Elevation Model (DEM) provided by DERM was used as the basis for the modelling works undertaken as part of this assessment.

The accuracy of the DERM data is noted below:

"The accuracy of this DEM depends on the accuracy of the source data and the error of ANUDEM`s interpolation. The average accuracy of AUSLIG's 1:100000 source data is + or - 25 metres in the horizontal position of well defined detail and + or - 5 metres in elevation for most mapsheets. Mapsheets 9140, 9141, 9144, 9145, 9242, 9243, 9342, 9343, 9442, and 9443 have an average accuracy in the horizontal of + or - 25 metres and + or - 10 metres in elevation and mapsheets 9244, 9245, 9344, 9345, 9444, 9445 and 9541 have accuracies of + or -50 metres and + or - 10 metres in the horizontal and vertical respectively. The data accuracy of those coastal areas with 5 or 10 metre contours (9544 and 9545 areas) is + or - 10 metres in the horizontal position of well defined detail and + or - 2.5 metres in elevation.

The average accuracy of the DEM's is a root mean square error (RMSE) of 2.5 metres with a range between 1.3 and 3.4 metres."

2.3 Land use

Land use data for the study area has been based on review of the Geoscience Australia Native Vegetation Mapping 250K Topographic Dataset and aerial imagery from Google Earth.

These datasets were used as the basis for development of catchment parameters as part of the hydrologic and hydraulic modelling works.

2.4 Aerial imagery

Aerial imagery was sourced from the widely available Google Earth internet based imagery service.

The Google Earth images were used to determine surface roughness throughout the study areas within the hydraulic model, as well as determine channel routing roughness parameters in the hydrologic model.

2.5 Rainfall

The design rainfall Intensity-Frequency Duration (IFD) data for various storm events were derived based upon the procedures outlined in Book 2 of Australian Rainfall and Runoff (AR&R) 2001 edition. Section 3.2.2 contains the adopted IFD datasets used for the catchment areas investigated in this study.

2.6 Geographic Information System (GIS) Data

Base GIS information for the study area was sourced to aid in the completion of the flooding investigation. This includes data on waterways, cadastral boundaries, roads, railways, towns, native vegetation and national parks for Queensland sourced from Geoscience Australia and DERM.

3. HYDROLOGIC MODELLING

3.1 Existing Catchment Description

The tenement areas (study area) are influenced by a number of catchments and associated waterway systems.

The study area has a significant contributing catchment area of approximately 1,316km^2. The study area and contributing catchments are located in the Barcaldine Regional Council Local Government area in Queensland, and have a number of waterway systems intersecting the subject areas, all of which lie in the Burdekin River Basin. Waterways intersecting or flowing adjacent to the tenement area include:

- Beta Creek;
- Tallarenha Creek;
- Saltbush Creek;
- Malcolm Creek;
- Lagoon Creek; and
- Spring Creek.

All the major and minor waterways influencing the tenement area are described as non-perennial and therefore flow only during intense periods of rainfall. The typical land use in these catchment areas is described as production from relatively natural environments.

The minimum elevation at the contributing catchment boundary is approximately 318mAHD with an average slope through the majority of the mid to lower catchment of approximately 0.2%. Steeper catchments located in the upper highlands are shown to have average catchment slopes of approximately 0.9%.

3.1.1 Hydrological Model

The contributing catchment to the study area has been analysed using the non-linear runoff routing program XP-RAFTS.

XP-RAFTS is a robust runoff routing model that is used extensively throughout Australia and the Asia Pacific region for hydrologic analysis of storm water drainage and conveyance systems and has been used in the analysis, design, and management of both urban and rural watersheds and flood protection and river systems for over 30 years.

Hydrographs for design rainfall events are produced by routing rainfall through the storages and along channel links. This analysis involved division of the overall study area catchment into various sub-catchments, determination of physical properties of the sub-catchments and assembly of the sub-catchments by nodal network and linked together by routing links using the Muskingham-Cunge method.

3.2 Hydrologic Model Development

A single XP-RAFTS hydrologic model was developed to predict peak flow rates within study area for the 10, 50 and 100 year Average Recurrence Interval (ARI) design rainfall events.

Model input data, parameters and all assumptions for the hydrologic model created for this study are detailed below in Sections 3.2.2 to 3.2.10.

3.2.1 Catchment Delineation

The catchment and sub catchment definitions for the hydrologic model were delineated based on the DERM Burdekin Basin 25m DEM.

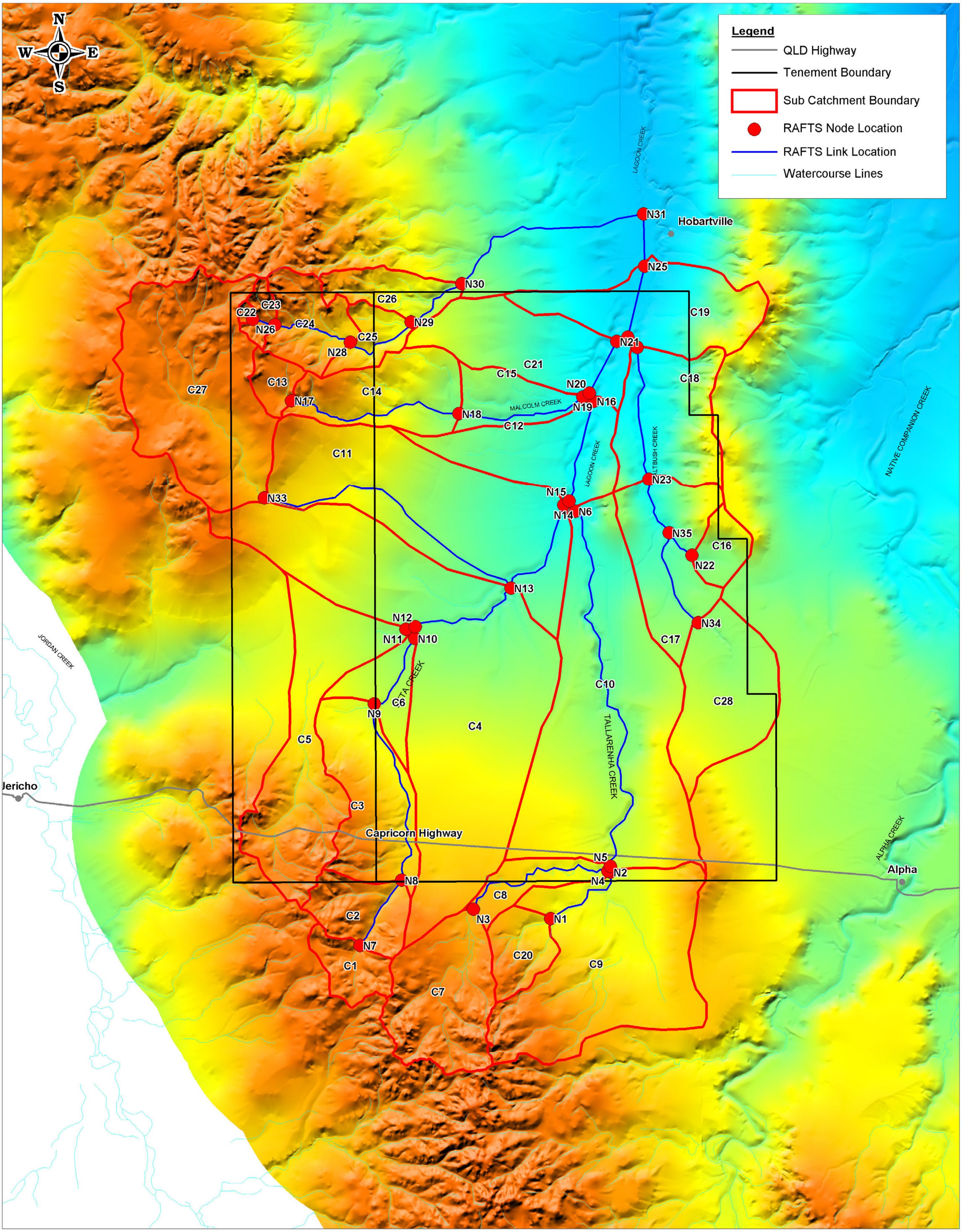
Figure 3-1 provides the sub catchment breakdowns for the hydrologic model developed as part of this study.

3.2.2 Rainfall Data

The design rainfall Intensity-Frequency Duration (IFD) data for the 10, 50 and 100 year ARI design storm events were derived based upon the procedures outlined in Book 2 of Australian Rainfall and Runoff (AR&R 2001). The design rainfall temporal pattern used in this analysis is the standard ARR Zone 3 pattern. Table 3.1 summarises the parameters used to create the IFD dataset.

Table 3.1 Adopted IFD data

Intensities (mm/hr)	Skewness and Geographical factors
${}^{2}I_{1}$ = 37.99	Skewness 'G' = 0.07 Geographical Factors F2 = 4.03 F50 = 16.20
${}^{2}I_{12}$ = 5.86	
${}^{2}I_{72}$ = 1.54	
${}^{50}I_{1}$ = 78.76	
${}^{50}I_{12}$ = 11.91	
${}^{50}I_{72}$ = 3.46	



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Mine Development Flood Assessment Sub Catchment Definition & XP-RAFTS Layout

Figure 3-1

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3.2.3 Areal Reduction Factors

The derived rainfall intensities presented in Table 3.1 from AR&R Book 2 (2001) are applicable only to a single defined location. The adopted rainfall intensity will not be maintained over the large catchment area represented in the hydrologic model for the study area and therefore needs to be adjusted by use of areal reduction factors (ARF).

Since the catchment size for the hydrologic model is greater than 1,000km^2, the ARF have been derived from the formulae for calculating ARF for large to extreme events as detailed in Page 58, AR&R Book 6 (2001). The formulae provided in Book 6 have no catchment area limitation.

Table 3.2 Areal reduction factors for catchments > 1,000km^2

ARI (years)	Storm Duration (hours)	Aerial Reduction Factor
100	24	0.824
	36	0.856
	48	0.874
	72	0.892
50	24	0.828
	36	0.861
	48	0.879
	72	0.898
10	24	0.837
	36	0.872
	48	0.891
	72	0.912

3.2.4 Rainfall Loss Model

Design loss parameters for the XP-RAFTS model were based on values described in AR&R (2001) and the Queensland Urban Drainage Manual (2nd Ed. 2007) (QUDM).

The adopted rainfall losses for the hydrologic model were a 25mm/hr initial loss and a 2.5mm/hr continuing loss.

3.2.5 Storage Coefficient Factor (ßx factor)

The ßx storage coefficient is typically used to adjust model results when calibrating model outputs to a gauged catchment.

As calibration of model results has not been undertaken as part of this investigation, it was not considered appropriate to adjust the ßx value for this analysis. As a result, a storage coefficient (ßx) factor of 1.4 was adopted for the hydrologic model developed as part of this study. This is based on the hydrologic analysis undertaken for the Belyando River as part of the Rail Alignment study (Engeny, 2011). The hydrology model for the Belyando River was calibrated using Flood Frequency Analysis and it was determined that a ßx storage coefficient of 1.4 was most appropriate for the catchment. The study area is within the Belyando catchment.

3.2.6 Catchment Land Use Parameters

Parameters based on catchment land use (including percentage impervious values and PERN values) have been based on both review of Google Earth aerial imagery and the Native Vegetation for Queensland sourced from Geoscience Australia.

Fraction impervious (percentage impervious) parameters have been based on recommendations specified in QUDM (2007) whilst all impervious areas were assigned a PERN value of 0.015.

Table 3.3 summarises the percentage impervious as well as corresponding PERN values for each land use type represented in the hydrologic model.

Table 3.3 Catchment Land Use Parameters

Description	Impervious %	Pervious Manning's 'n' (PERN)
Native / thick vegetation	0	0.075
Cleared vegetation (farmland)	2	0.055

3.2.7 Channel Routing

Routing of flow between sub catchments has been undertaken by the Muskingum-Cunge method. Existing channel roughness conditions in the main channel and flood plains were evaluated using a process of cross check of aerial imagery and site inspection notes and oblique photographic record. Roughness values range from 0.07 to 0.10 for the routing channels throughout the XP-RAFTS model and is considered appropriate based on the observations undertaken of the aerial imagery.

3.3 XP-RAFTS Model Validation

Due to the large catchments contributing to the study area (approximately 1,316km^2), using the Rational Method to validate predicted 100, 50 and 10 year ARI flows was not considered appropriate. The 'Queensland Urban Drainage Manual' (QUDM, 2007) and AR&R (1998) suggest a maximum catchment area of 2,500 hectares (25 km^2) be used for calculating flows using the Rational Method for rural catchments.

To provide verification of the adopted 100 year ARI flows, a flood frequency analysis has been undertaken at the closest gauging station on the Native Companion Creek at Violet Grove. Previous reports including *Bungil Creek Flood Study*, Final Report, (EGIS, 2002), and *Final Report for Levee Construction Investigation for Charleville and Augathella*, (EGIS, 2001) was considered for determination of appropriate magnitudes of 100 year ARI flow for the neighbouring catchment areas along with previous flood frequency analysis undertaken in *Flood Investigation and Mapping for the GLNG Upstream Development – Campsite and Hub Areas,* (Engeny, 2010) and *Australian Pacific LNG Project EIS – Volume 3, Chapter 11: Water Resources* (March 2010).

The Australian Pacific LNG Project EIS report undertook numerous flood frequency analyses on stream gauges on the Condamine and Dawson Rivers. Their study found that there is "significant variability between inland and coastal basins" i.e., the 100 year ARI discharge to catchment area ratio for inland basins is a lot lower than that for coastal systems.

A flood frequency analysis was undertaken on the Native Companion Creek gauge and the results are summarised in Table 3.4 below. The annual peak flows were provided by DERM and The Log Pearson Type 3 (LPIII) distribution was fitted to the data as per Book 4 of AR&R. Refer to Figure 3-1 for the location of the nearest gauging station. The Native Companion Creek gauging station had 43 years of peak flow data available. Table 3.4 below summarises the years of recorded flow data and the number of low flows omitted to obtain a better fit of the LPIII distribution at higher flows. Refer to Appendix B for a plot of the flood frequency analysis of the gauging station.

Table 3.4 LPIII Flood Frequency Summary for Available Gauging Stations

Gauge No.	Gauge Name	Year of Peak Flow Data	Number of low flows omitted	LPIII Estimated 100 Year ARI Peak Discharge (m^3/sec)		
				95% Confidence Limit	Adopted Value	5% Confidence Limit
120305A	Native Companion Creek at Violet Grove	38	5	607	1077	2375

The 100 year ARI peak flows for Bungil Creek at Roma, Warrego River at Charleville, Dawson River at Taroom, Dawson River at Utopia Downs are summarised below in

Table 3.5 along with the peak flows approximated from the flood frequency analysis undertaken in this study.

Table 3.5 100 year ARI Peak Flow Summary

Location	Catchment Area (km^2)	LPIII Estimated 100 Year ARI Peak Discharge (m^3/sec)
Bungil Creek at Roma	1,400	610
Brown River at Warrinilla	2950	688
Brown River at Lake Brown	3027	613
Dawson River at Utopia Downs	6,039	1847
Comet River at The Lake	10,188	3824
Dawson River at Taroom	15,846	3110
Warrego River at Charleville	16,000	4100
Native Companion Creek at Violet Grove	4,065	1077
Lagoon Creek (Downstream of Study Area)	1,257	715

Table 3.5 above suggests that a 100 year ARI peak flow rate in the order of 600m^3/sec would be considered a good estimate of the 100 year ARI peak flow rate on Lagoon Creek for the study area. The XP-RAFTS model was found to produce appropriate flows using a ßx =1.4 and an initial loss of 25mm and a continuing loss of 2.5mm/hr.

3.4 XP-RAFTS Results

Table 3.6 below summarises the XP-RAFTS total flows at the inflow boundaries to the TUFLOW hydraulic model. The critical duration for all inflows was 36 hours while the critical duration for the 50 year and 100 year ARI events at Spring Creek (RAFTS Nodes N27 to N30) was 12 hours.

Table 3.6 100 year ARI Peak Flow Summary

Inflow Location	10 year ARI Peak Flow (m^3/sec)	50 year ARI Peak Flow (m^3/sec)	100 year ARI Peak Flow (m^3/sec)
N13	107.97	227.31	290.38
N11	19.14	40.35	51.11
N10	38.02	74.16	92.27
N6	77.34	157.77	202.53
N14	124.92	264.83	339.44
N16	210.54	430.30	553.21
N18	21.01	39.37	48.76
N19	27.12	51.66	64.87
N22	5.74	10.32	12.75
N23	26.31	55.84	71.04
N24	37.65	79.47	100.28
N25	278.40	559.83	715.18
N21	236.73	476.53	611.24
N28	18.53	34.46	42.86
N29	24.53	46.26	58.04
N30	31.77	60.22	75.78
N5	60.76	123.91	157.52
N9	33.64	64.91	80.80
N17	5.94	10.66	13.28
N27	6.82	11.55	14.02
N33	21.14	46.25	59.60
N34	11.95	25.26	32.57

4. HYDRAULIC MODELLING

4.1 Modelling Software

Estimation of flood behaviour within the study area has been carried out using the TUFLOW software package. TUFLOW is an industry accepted software package that is highly suited to the investigation of flood behaviour in complex flow scenarios. The software can simulate unsteady hydrodynamic flow in two directions on a rectilinear grid as well as 1D unsteady hydrodynamic flow through waterway structures such as culverts. The model is based on a robust finite difference solution scheme able to compute both subcritical and supercritical flow regimes.

4.2 Model Parameters & Construction

A single TUFLOW model was constructed to predict flooding behaviour for the tenement areas. The following sections of the report summarise the various model components and parameters that have been used to estimate flooding behaviour.

4.2.1 2D Topographic Grid

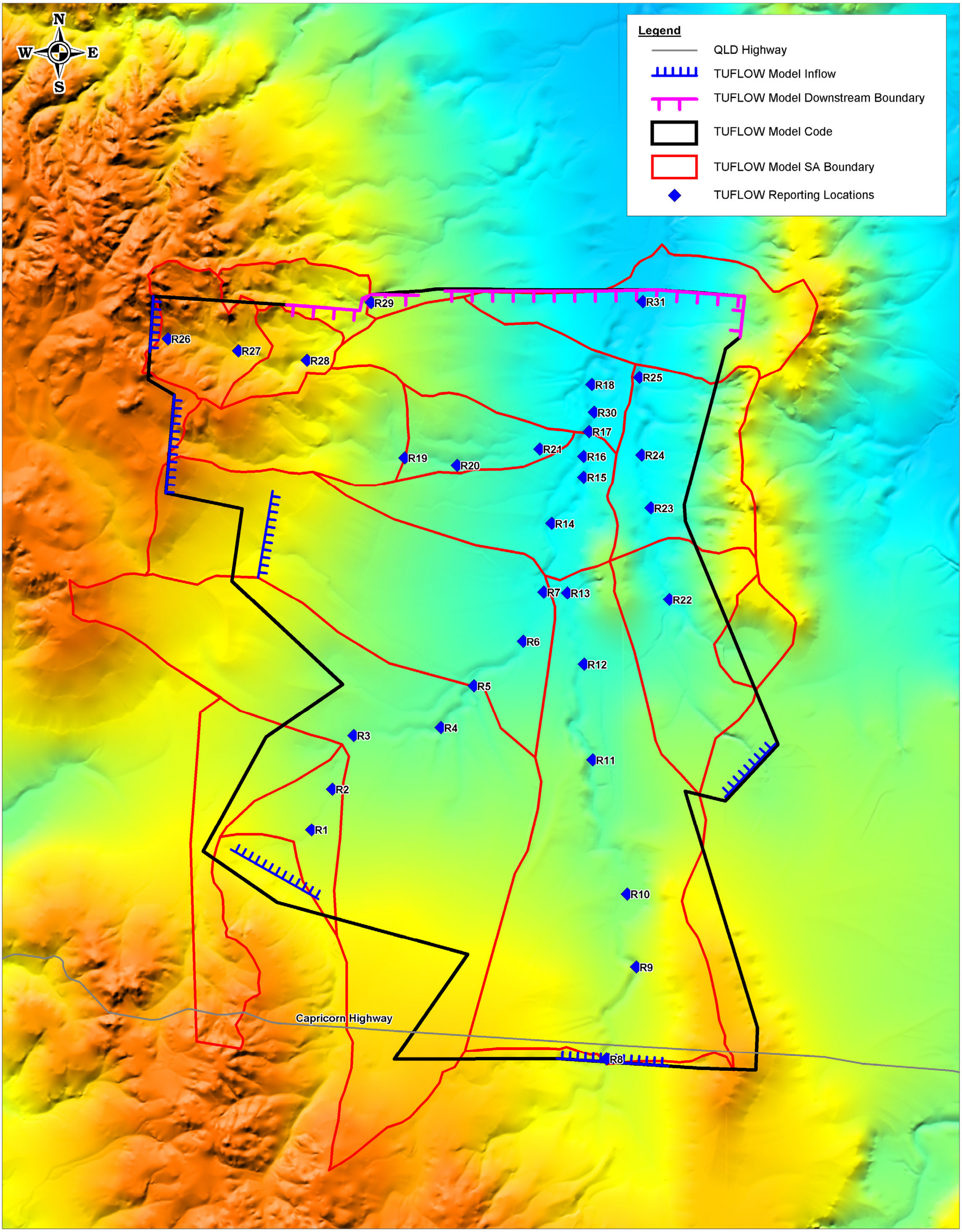
The 2D model topography has been based on the DERM supplied Burdekin Basin 25m DEM.

Review of topographic data, the size of the modelling area and model run times has been undertaken to determine the appropriate 2D grid size. It was determined that a 25m grid size was appropriate as this allows for the required level of detail to be achieved whilst maintaining realistic model run times.

The layout of the hydraulic model and the ground surface model employed is shown in Figure 4-1. Real world co-ordinate systems have been used for all modelling. The 2D hydraulic model is based on MGA94 Zone 55 horizontally and AHD vertically.

4.2.2 1D Hydraulic Structure Elements

Although the Capricorn Highway passes through the most upstream extent of the site, in order to be conservative and in the absence of structure details, the highway has not been represented in the hydraulic model. As such, no drainage structures have been included in this modelling analysis. These structures may be included in the model once details are obtained.



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Mine Development Flood Assessment Hydraulic Model Layout

Figure 4-1

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4.2.3 Model Boundary Conditions

Tailwater Boundaries

Given the location of the study area and non perennial nature of the waterway systems, it was considered appropriate to adopt a normal depth downstream boundary condition at the respective model outlets.

TUFLOW automatically generates a stage discharge curve based on the boundary cross section topography, Mannings ‘n’ value at the boundary location, and a specified water surface slope (gradient). A water surface slope of 0.001m/m was adopted at the downstream boundary of the model.

Inflow Boundaries

The hydrographs developed as part of the XP-RAFTS hydrological analyses were extracted for the 10, 50 and 100 year ARI events. Hydrographs have then been applied to the TUFLOW model by way of direct application of either the representative local or total catchment hydrograph to the associated sub catchment area or inflow boundary.

4.2.4 2D Model Roughness Parameters

Delineation of areas of different hydraulic roughness was undertaken to accurately simulate spatially varying roughness across the floodplain areas.

The roughness map was developed using Google Earth aerial photography and therefore represents the waterway roughness at the time that the imagery was captured. Table 4.1 documents roughness parameters assigned to each land use within the study area.

Table 4.1 Adopted Roughness Parameters

Land Use Type	Manning’s ‘n’ Roughness Value
Native Vegetation	0.15
Sparse Vegetation	0.06
Water body	0.02

5. TUFLOW MODEL RESULTS

5.1 Model Calibration

There are no DERM gauging stations that exist within the TUFLOW hydraulic modelling area developed as part of this investigation. The nearest gauging stations to the modelling area is located some 27km south east of the tenement area and therefore no calibration has been undertaken for the TUFLOW model.

5.2 Design Rainfall Events

The TUFLOW model was adopted for estimating flood levels and flood inundation throughout the study area for the 10, 50 and 100 year ARI design flood events.

The TUFLOW hydraulic results are included in this report and are presented below. Flood maps and digital data have been prepared from model results based upon the 25m Burdekin Basin DEM provided by DERM. As such, the flood levels provided in the following tables and in any digital data provided are inherently reliant upon the accuracy of the baseline topographic data provided for use as part of this investigation.

5.3 Flood Levels, Depths & Velocities

Flood levels, depths and velocities estimated by the TUFLOW model developed for this investigation are typically best presented using flood surface and extent maps created in a GIS environment.

However for ease of reference, a table has been developed detailing peak water surface levels at flood level reporting points shown in Figure 4-1. Peak flood levels for each location illustrated in Figure 4-1 are presented in Table 5.1. All flood maps including flood levels, depths and velocities for the study area are presented in Appendix A. It should be noted that a map cutoff depth of 0.1m has been applied to the model.

Flood maps have been prepared from the hydraulic model output and are based upon the Burdekin Basin 25m DEM provided by DERM. As such, the flood levels provided in the following tables and in any digital data provided are inherently reliant upon the accuracy of the baseline topographic data provided for use as part of this investigation.

Table 5.1 Peak Flood Levels

Reporting Location	100 year ARI (mAHD)	50 year ARI (mAHD)	10 year ARI (mAHD)
R1	367.41	367.36	367.29
R2	362.09	362.09	362.01
R3	357.22	357.19	357.05
R4	351.56	351.48	351.28
R5	347.6	347.52	347.3
R6	342.9	342.82	342.65
R7	338.75	338.71	338.6
R8	370.68	370.6	370.41
R9	364.34	364.24	363.99
R10	358.91	358.84	358.68
R11	350.51	350.4	350.15
R12	343.72	343.63	343.46
R13	339.29	339.2	338.99
R14	335.84	335.69	335.35
R15	332.82	332.67	332.3
R16	331.55	331.41	331.03
R17	330.48	330.33	329.94
R18	327.98	327.81	327.38
R19	355.23	355.17	355.08
R20	349.42	349.39	349.3
R21	340.07	340.05	339.97
R22	339.8	339.74	339.57
R23	334.26	334.2	334.03
R24	331	330.94	330.75
R25	325.84	325.76	325.56
R26	419.75	419.75	419.6
R27	398.94	398.94	398.9
R28	382.43	382.43	382.23
R29	367.73	367.74	367.42
R30	329.5	329.33	328.92
R31	320.44	320.35	320.14

5.4 Results Discussion

The TUFLOW model results show that most of the waterway systems transecting the tenement area are typically of shallow depth (less than 2.5m in the 100 year ARI event) with expansive inundation of up to 0.5km wide in most areas for the 100 year ARI event. The maximum peak depth for the 100, 50 and 10 year ARI events was found to be approximately 2.3m, 2.06m and 1.51m respectively. Maximum peak velocities in the study area was predicted to be approximately 2.76m/s, 2.54m/s and 2.04m/s during the 100, 50 and 10 year

ARI events respectively. These maximum peaks generally occurred in the Lagoon Creek reach (i.e. the mid and lower reaches of the entire waterway system).

5.5 Potential Flooding Effects

It is likely that floodplain encroachment, diversion of flows or impacts associated with drainage structures (i.e. culverts, bridges, etc) may impact on the waterway system as a result of changed flood behaviour. It is therefore crucial that the existing flow conveyance is managed and this can be achieved by incorporating appropriate creek diversion and waterway management practices into the design for the development of the mine site. This may include implementing sediment and erosion control measures and appropriately designed hydraulic structures (culverts, bridges, etc).

It is intended that Tallarenha Creek will be diverted around critical mining operations to reduce impacts to the mine site and overall environment. The creek diversion will include an appropriately engineered design to ensure that a positive outcome is achieved for the environment.

Impacts to the waterways may include but are not limited to scour and sedimentation as a result of increased velocities. It is therefore essential that appropriate scour protection measures are incorporated into the design where scour is likely to occur. Possible changes to flood levels may also occur as a result of waterway encroachment, diversion of flows or impacts associated with drainage structure design (e.g. culverts, piers, abutments etc). Waterway crossings are likely to be required for mine access roads as well as the rail connection. It is essential that mine infrastructure is located with due consideration for flooding.

5.6 Digital Data

Results from this flooding assessment have also been provided to Waratah Coal in electronic format. The supplied information includes:

- Digital copies of all reports and figures
- Digital copies of all flood mapping
- Digital GIS layers of peak flood height, depth and velocity derived from hydraulic modelling for each ARI design rainfall event.

6. CONCLUSIONS & RECOMENDATIONS

This study has been commissioned by Waratah Coal to provide an initial flooding assessment of the mine site for the China First Project. This study has been undertaken using the latest in two dimensional flood modelling software (TUFLOW).

The flood analysis results determined by the TUFLOW model have provided a prediction of flooding behaviour for the 10, 50 and 100 year ARI design storm events. Hydraulic results show that typically wide and relatively shallow inundation is likely to occur in most waterway systems within the study area, with peak depths typically no more than 2.5m, and extents of inundation up to 1.9km wide in some waterway reaches. The maximum peak velocity was determined to be approximately 2.76m/s in the 100 year ARI event.

It should be noted that the accuracy of this flooding assessment is inherently limited by the underlying baseline data used in the construction of the hydrologic and hydraulic models. To this end, further analysis will be required with more accurate topographic information to allow for the commencement of engineering design works.

Detailed GIS mapping and digital data has been provided to fully illustrate flood behaviour in the study area. This includes detailed flood level, depth and velocity maps for all of the design flood events.

Prior to the engineering design of any infrastructure, it is recommended that further refinement of the flood modelling works be undertaken, including the collection of Aerial Laser Scanning (ALS) topographic information for the entire waterway system to facilitate a more accurate determination of flooding behaviour and waterway corridor alignments.

7. QUALIFICATIONS

a. In preparing this document, including all relevant calculation and modelling, Engeny Management Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b. Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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8. REFERENCES

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2. XP Software, *"XP-RAFTS Manual v.7",* 2008;
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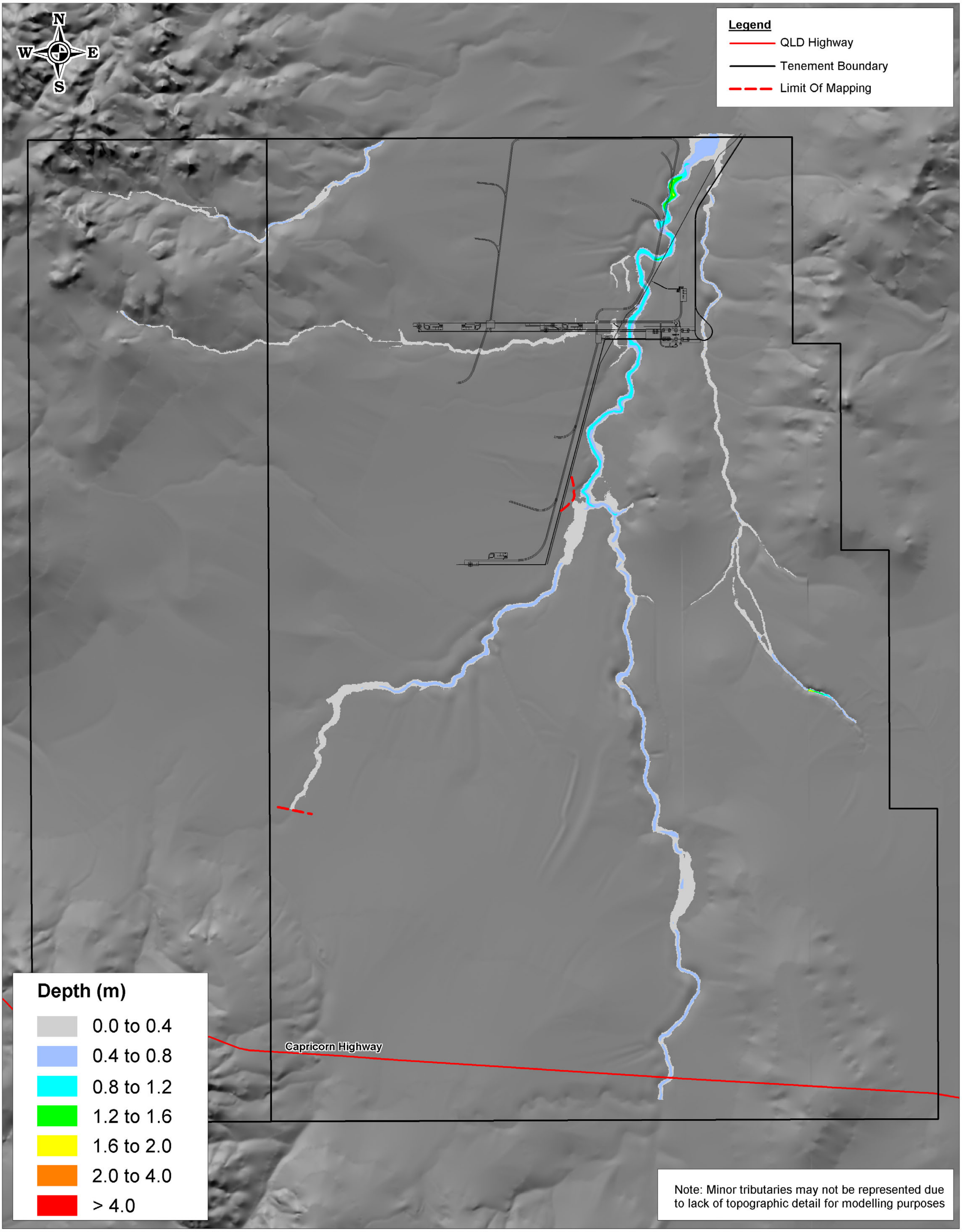
8. *Final Report for Levee Construction Investigation for Charleville and Augathella*, (EGIS, 2001); and
9. *Flood Investigation and Mapping for the GLNG Upstream Development – Campsite and Hub Areas,* (Engeny, 2010).

APPENDIX A

Flood Maps



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

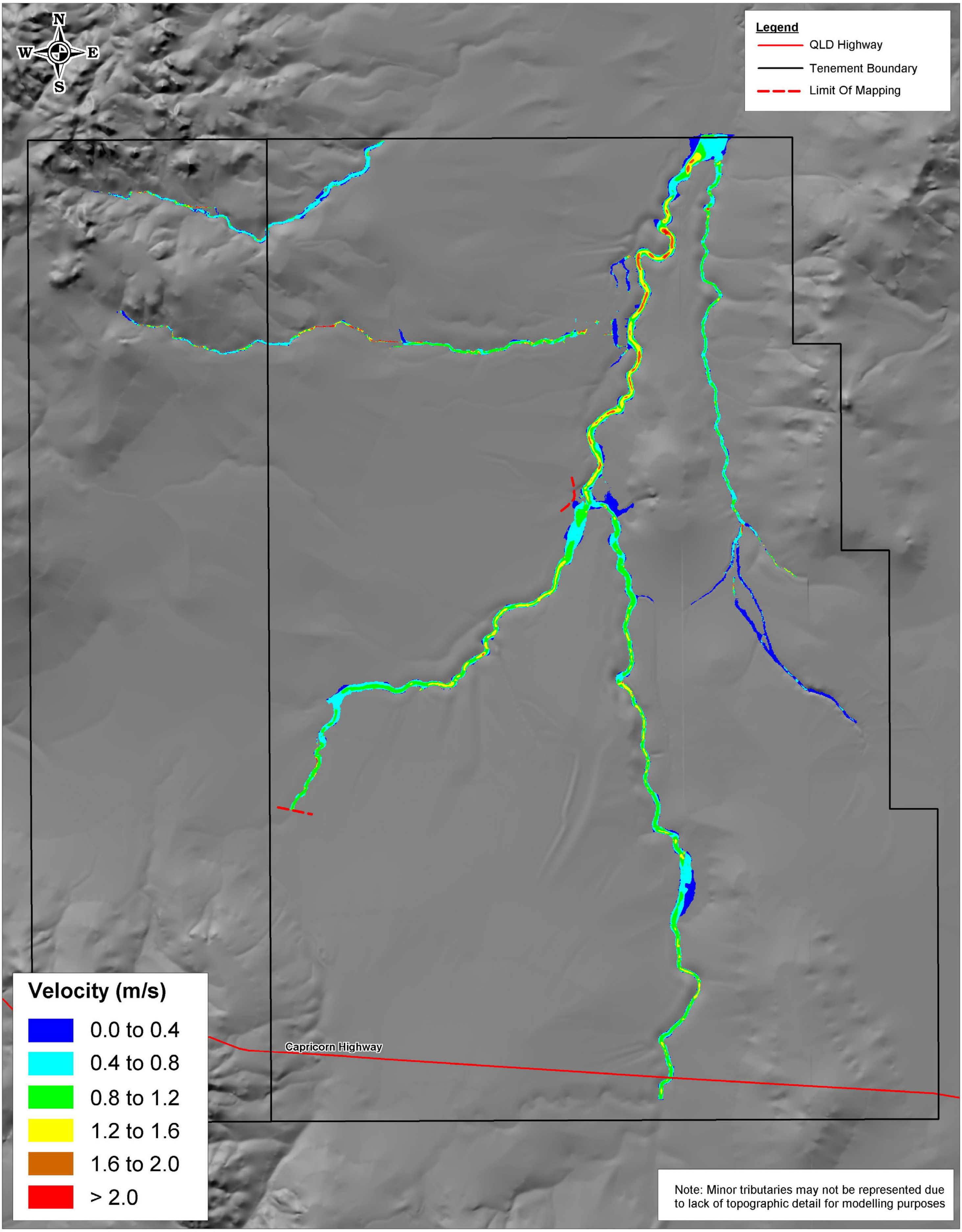
0 2.4 4.8 Kilometers

REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment
10 Year ARI Flood Depth

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8 Kilometers

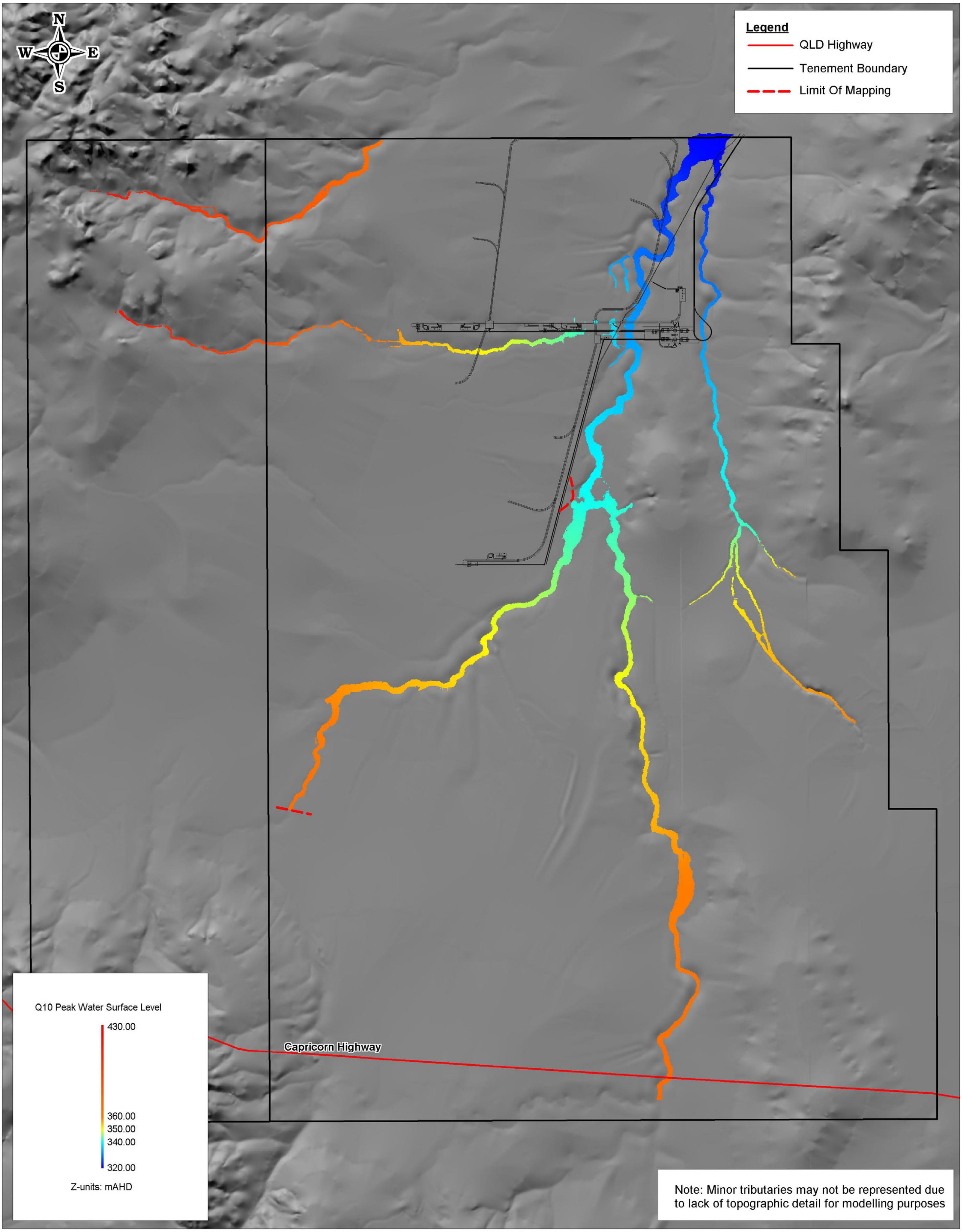
REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment

10 Year ARI Flood Velocity

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8

Kilometers

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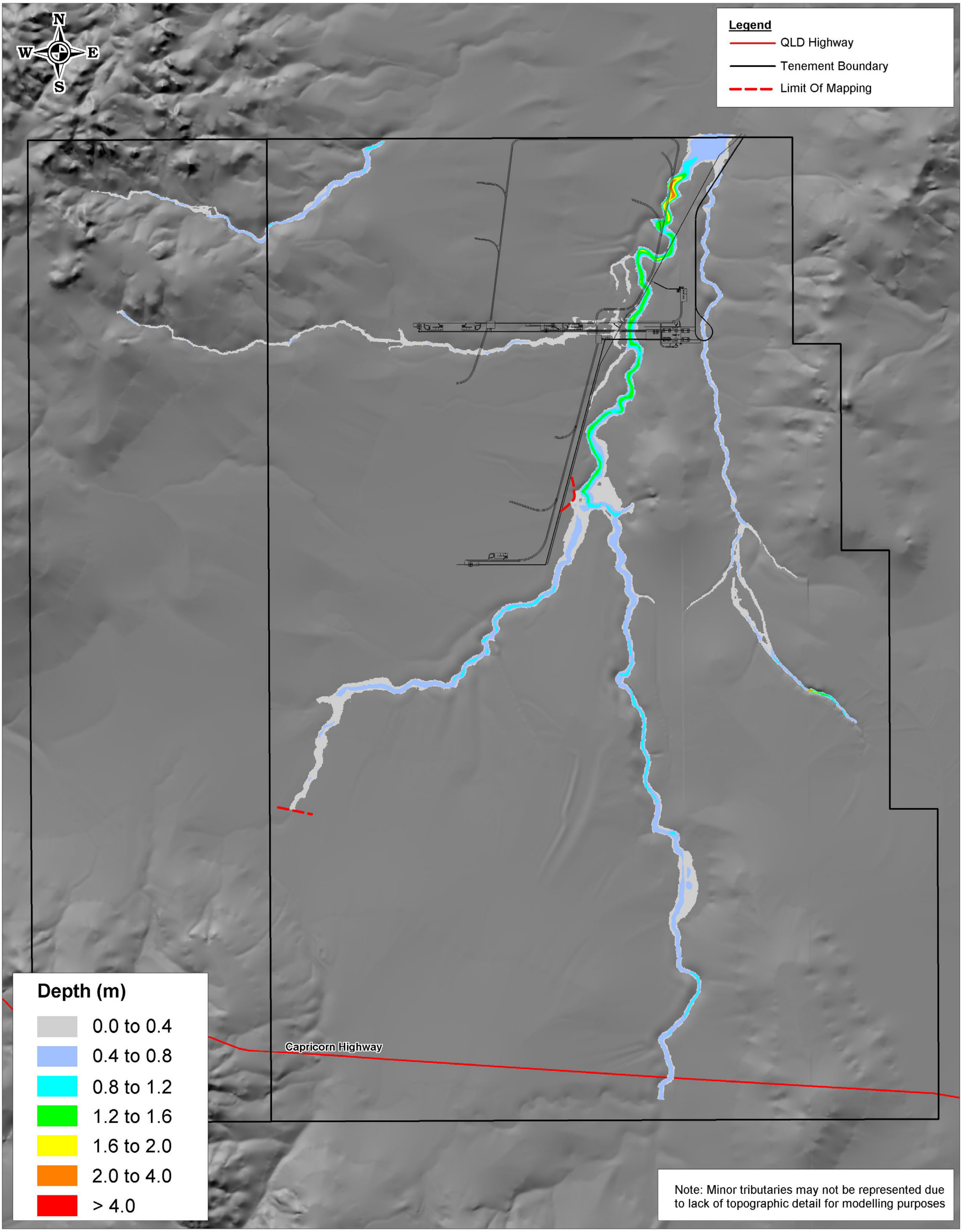
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment

10 Year ARI Water Surface Level

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8 Kilometers

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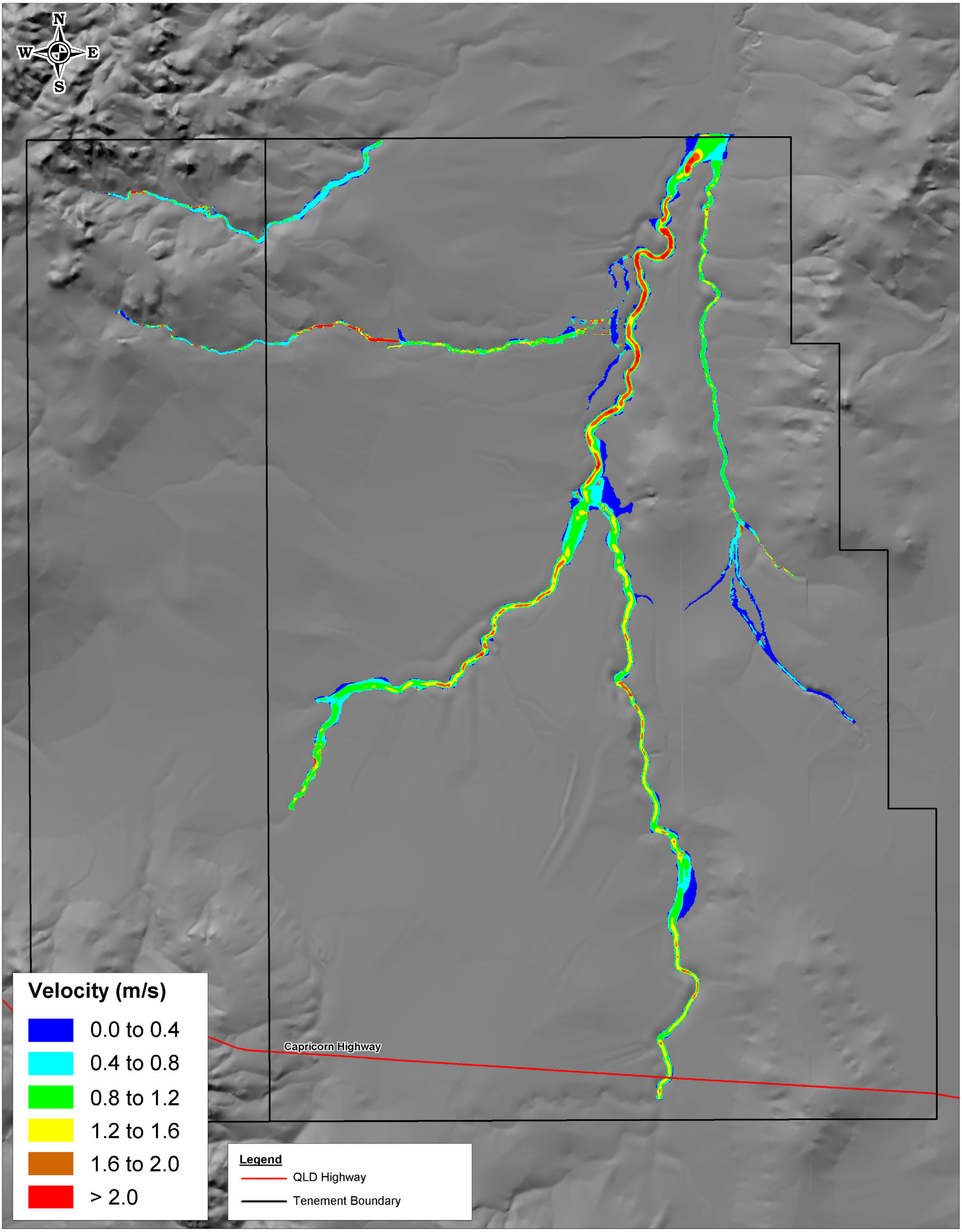
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment
50 Year ARI Flood Depth

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8

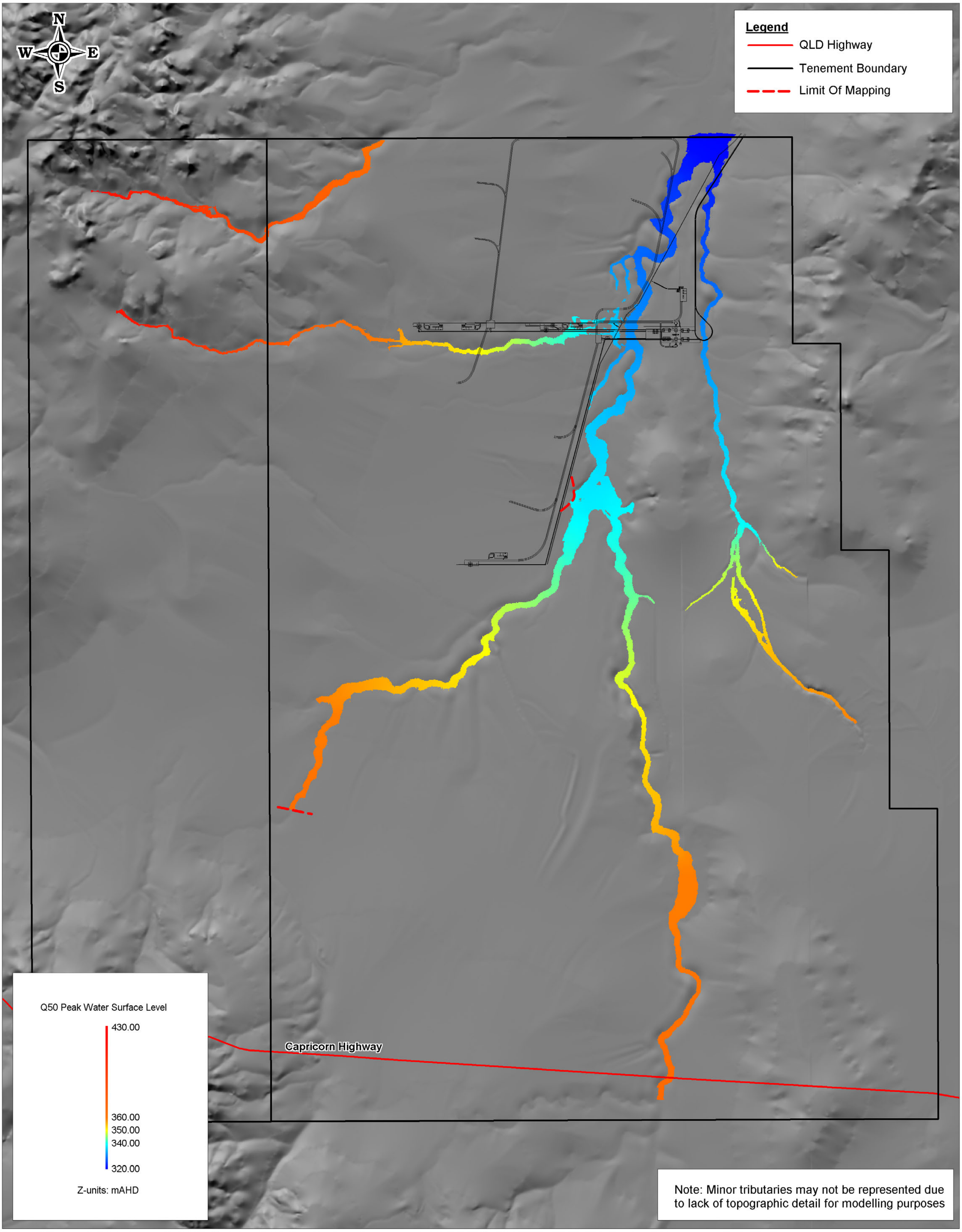
Kilometers

REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment 50 Year ARI Flood Velocity

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8 Kilometers

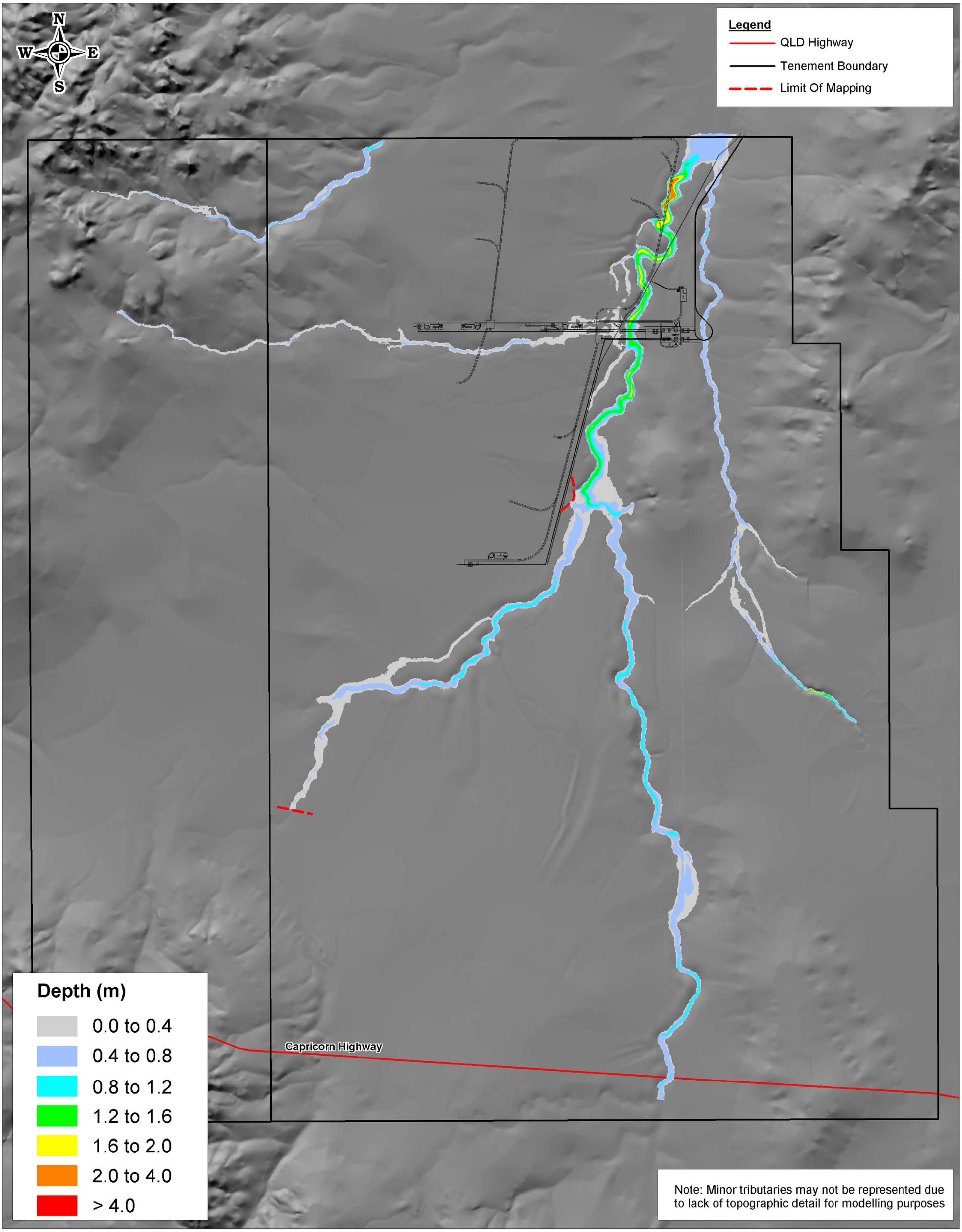
REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment

50 Year ARI Water Surface Level

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

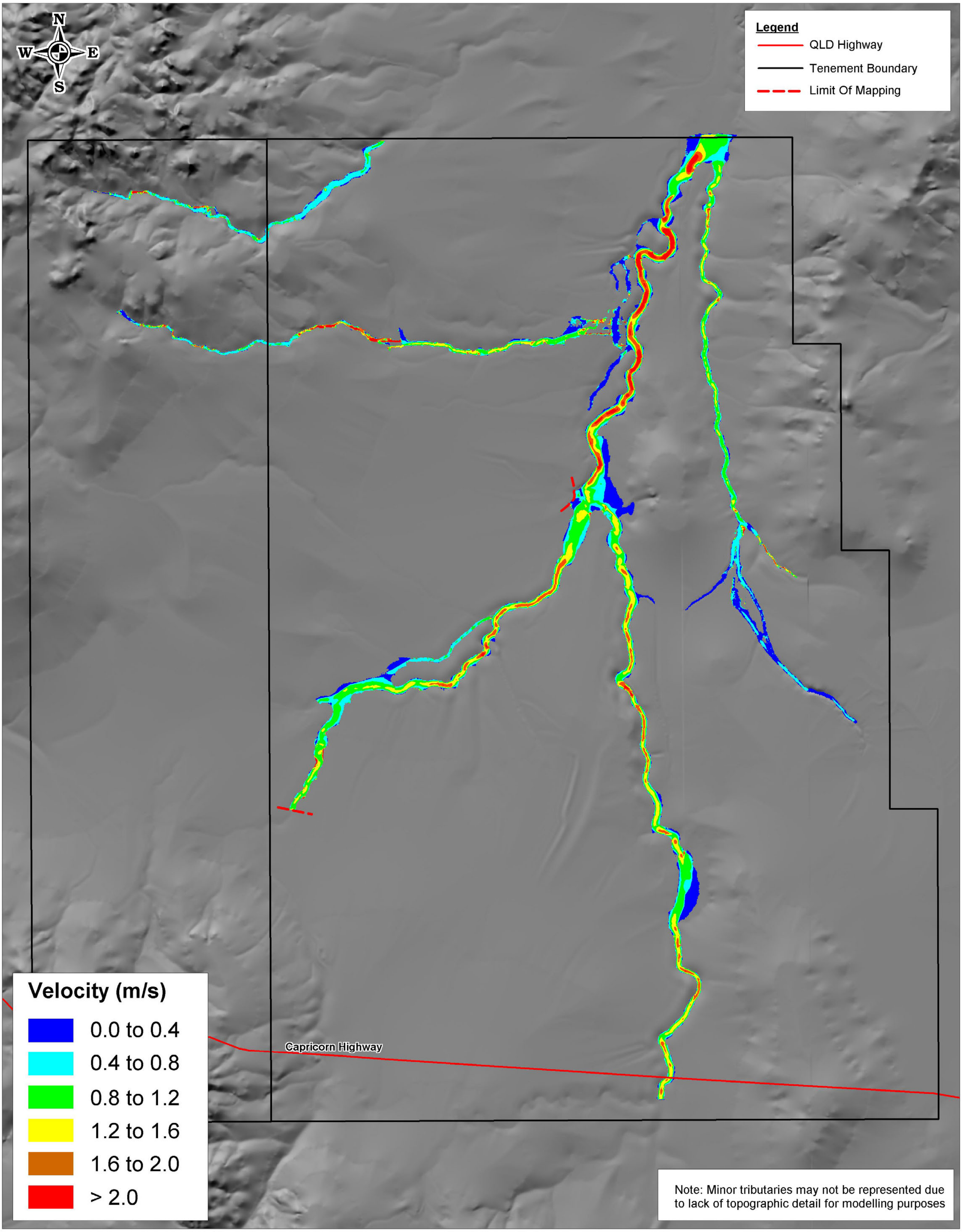
0 2.4 4.8
Kilometers

REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment
100 Year ARI Flood Depth

Appendix A

Waratah Coal



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WATER MANAGEMENT

Waratah Coal
THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

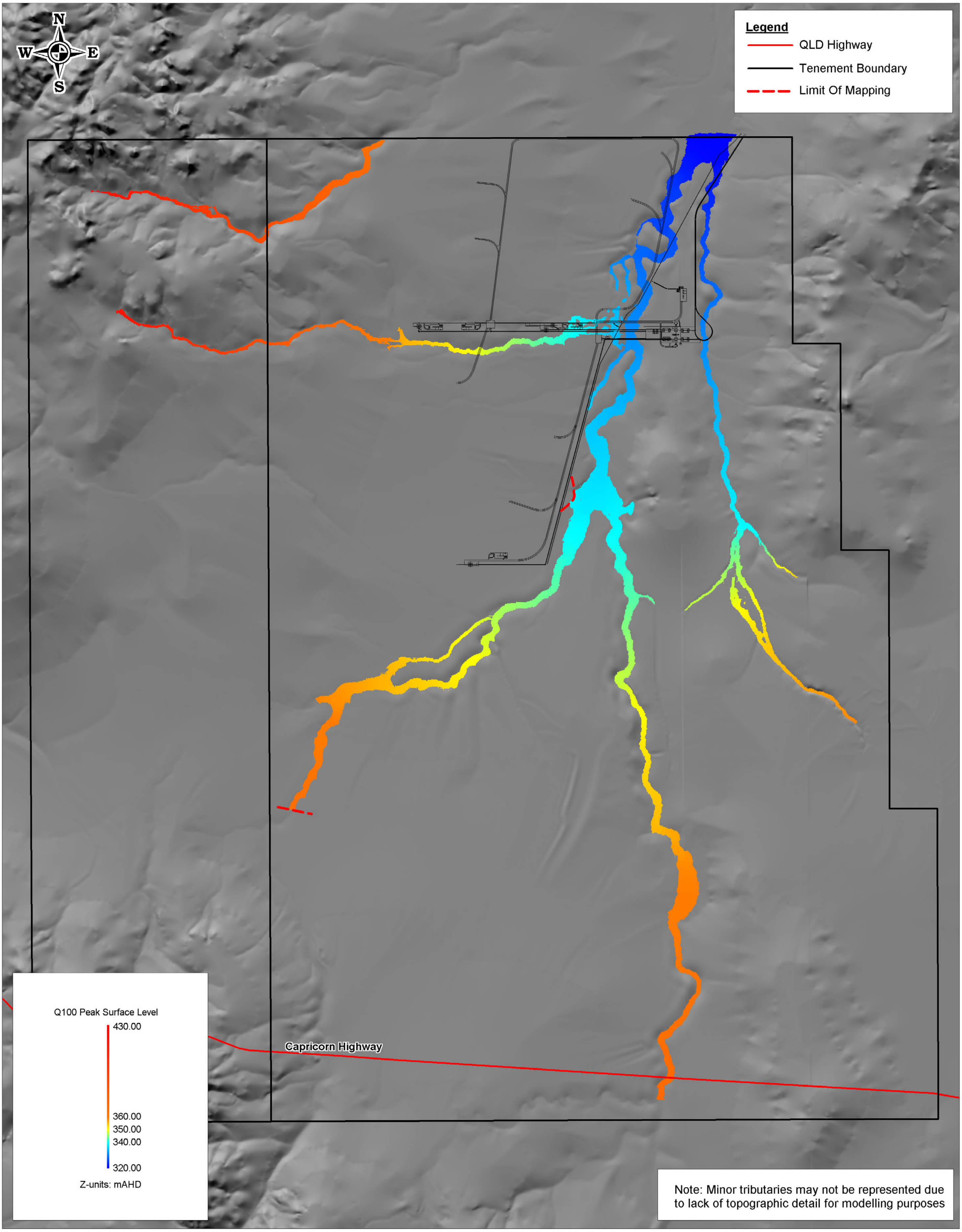
0   2.4   4.8
Kilometers

REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development
Flood Assessment
100 Year ARI Flood Velocity

Appendix A

Waratah Coal



ENGENY WATER MANAGEMENT

Waratah Coal THE NEW ENERGY IN COAL

Scale 1:120,000 (A3)

0 2.4 4.8
Kilometers

REV	DATE	REVISION DESCRIPTION	ORIG	CKD
A	25/01/11	Client Issue	MH	MP

Mine Development Flood Assessment
100 Year ARI Water Surface Level

Appendix A

Waratah Coal

APPENDIX B

Flood Frequency Analysis – Native Companion Creek

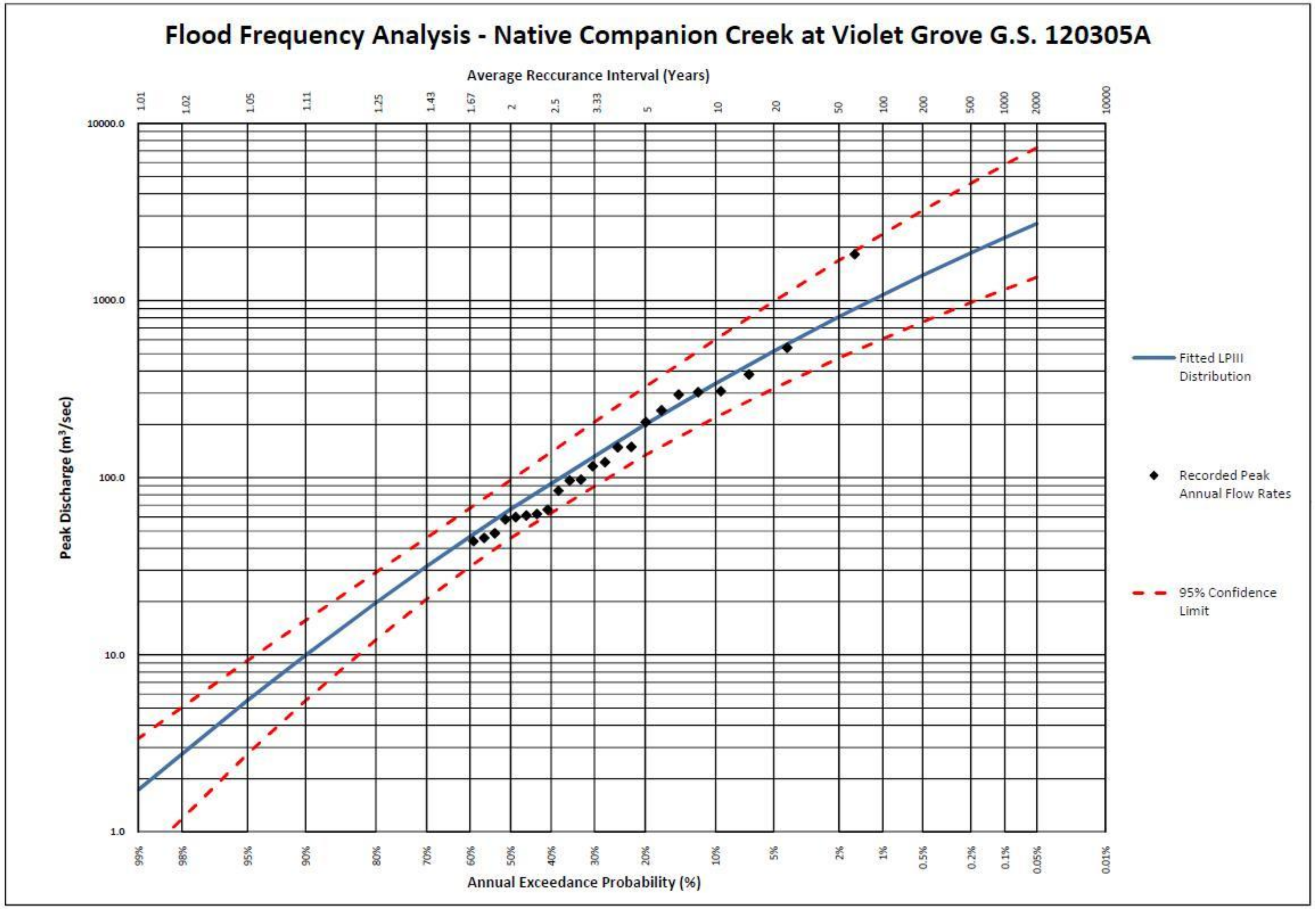


Figure B1 **Flood Frequency Analysis at Native Companion Creek at Violet Grove**