



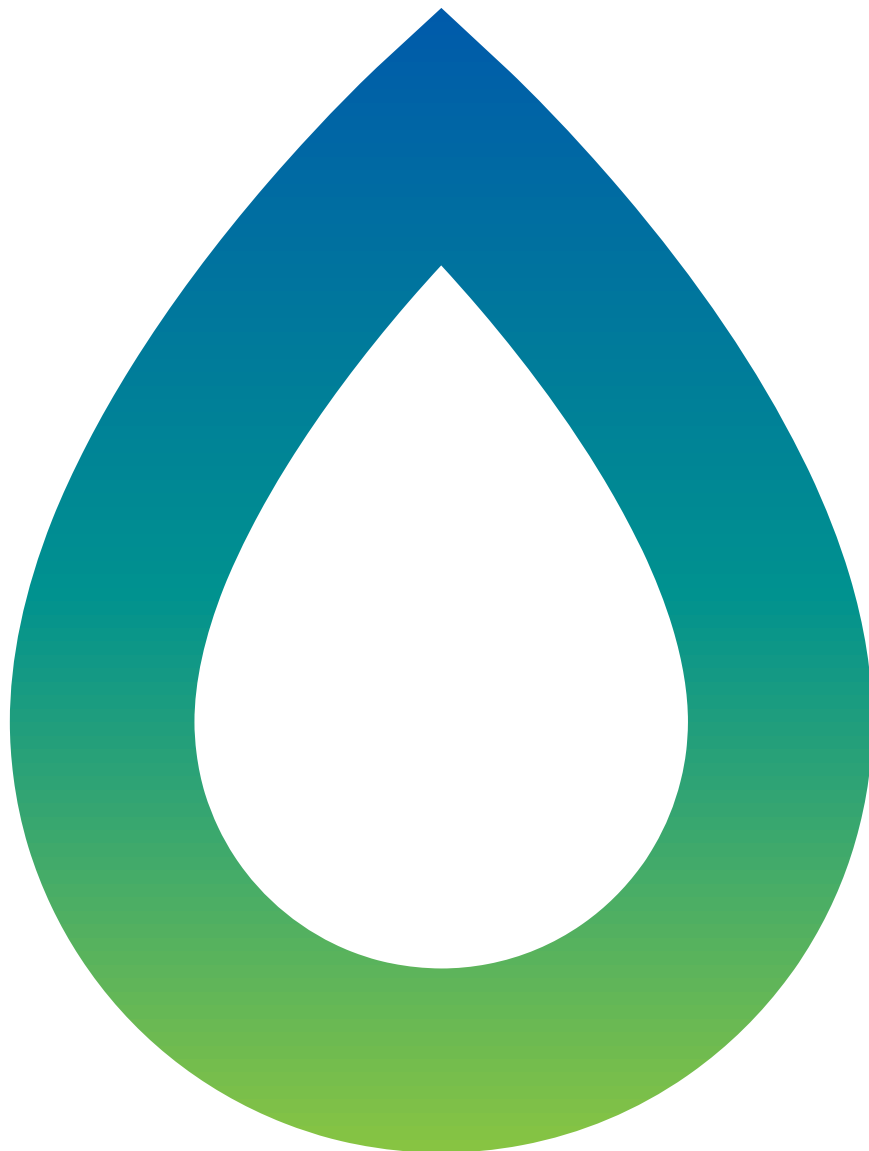
# PRCP FLOOD MODELLING DAUNIA MINE

PRCP Flood Report

Whitehaven Coal Limited

17 March 2026

1583-04-F2



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## DETAILS

<b>Report Title</b>	PRCP Flood Modelling Daunia Mine, PRCP Flood Report
<b>Client</b>	Whitehaven Coal Limited

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## THIS REVISION

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## 1 INTRODUCTION

### 1.1 BACKGROUND

WRM Water & Environment Pty Ltd (WRM) previously undertook a flood study for Daunia Mine (DNM), located approximately 24 km east-southeast of Moranbah in the upper Isaac River catchment, in the Fitzroy River basin – see Figure 1.1. The study, completed in November 2019, involved hydrologic and hydraulic modelling of the Isaac River and nearby local catchments to define baseline flood behaviour at the site.

Whitehaven Coal is progressing updates to the mine’s final landform as part of a revised Progressive Rehabilitation and Closure Plan (PRCP). WRM has been engaged to update the previous flood models and reporting to reflect current site conditions, modelling standards, and regulatory requirements.

DNM have asked WRM to update the previous (WRM, 2019) hydrologic and hydraulic modelling to:

- take advantage of updated and improved model versions;
- include updates to the Australian Rainfall and Runoff (ARR2019) (version 4.2) guidelines (Ball et al., 2019) on accounting for the effects of climate change;
- Update the Flood Frequency Analysis (FFA) to include the five (5) years of additional recorded data; and
- undertake a PRCP flood modelling assessment.

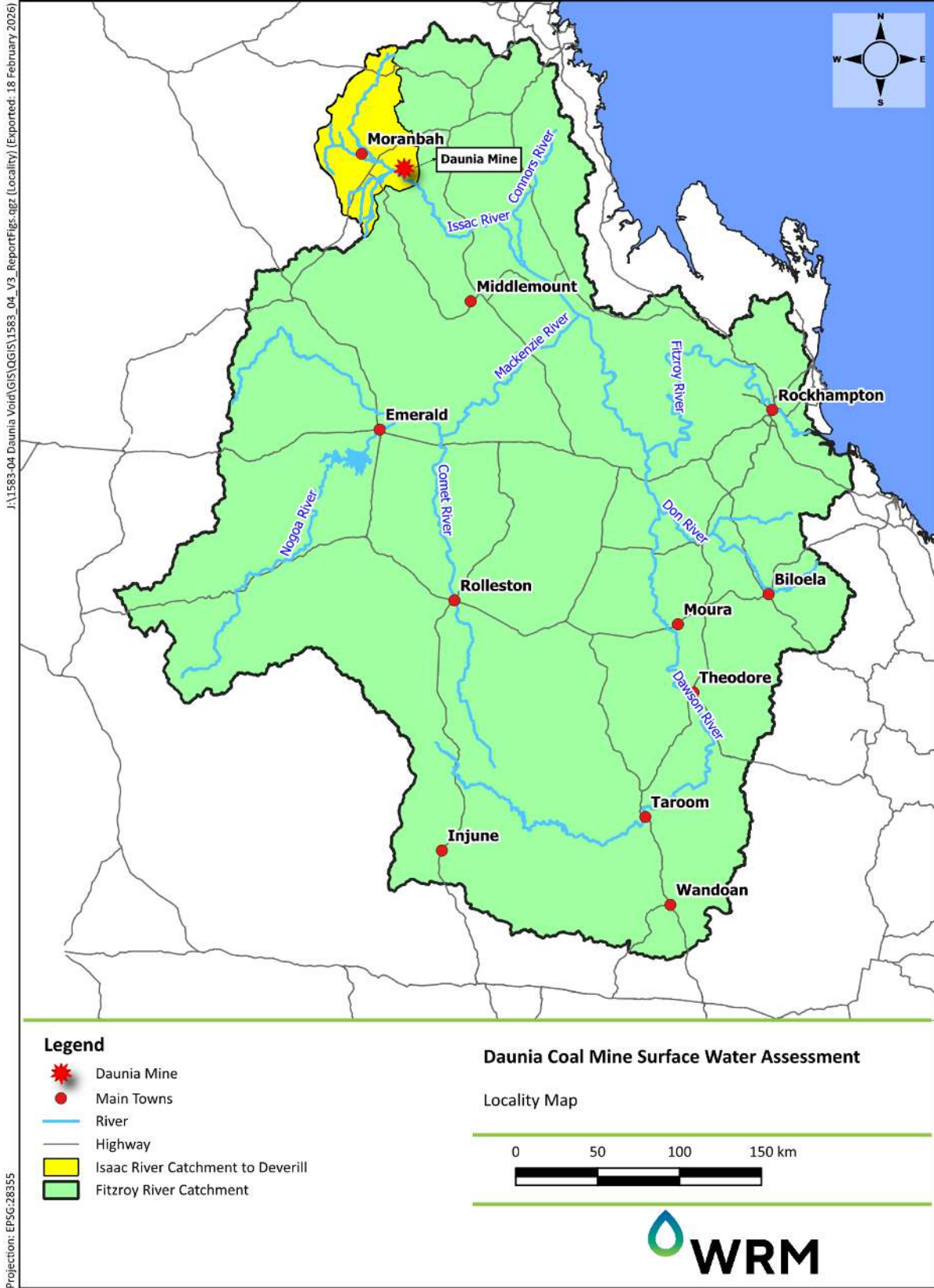
### 1.2 SCOPE OF WORKS

Key scope of work items include:

- Updated hydrologic modelling, including:
  - Converting the model from XP-RAFTS to URBS;
  - Re-calibrating the model;
  - Reconciling the model to an updated Flood Frequency Analysis (FFA) at the Deverill gauge; and
  - Applying updated ARR 2019 climate change factors to estimate design hydrology for existing and post-mining conditions.
- Updated hydraulic modelling, including:
  - Updating the TUFLOW hydraulic model to the 2025.0.0 version;
  - Recalibrating the model;
  - Using hydrologic modelling design inflows to assess peak design flooding conditions for existing, pre-mining and post-mining conditions;
- Prepare a report documenting the methodology and findings of the assessment, suitable for submission in support of the DNM PRCP submission.
- Note, for this assessment, the following hydrologic and hydraulic design scenarios are considered:
- Hydrology:
  - Validation – design hydrology suitable for validation against FFA, using design rainfalls and losses without any adjustments to account for climate change.
  - Existing – present day design hydrology, based on the ‘validation’ hydrology and adjusted for climate change which has already occurred between the design data baseline period, and the present day.

- Post-mining – predicted future conditions design hydrology for the time period after the cessation of mining and establishment of the final landform, based on the ‘validation’ hydrology and adjusted for climate change, which is predicted to occur between the design data baseline period and the planned post-mining period.
- Flooding (hydraulics):
  - Existing – present day conditions at DNM, using ‘Existing’ hydrology and current site topographic data;
  - Pre-mining – defining the floodplain for the PRCP, using ‘Existing’ hydrology and pre-mining topographic data at DNM (i.e., excluding any artificial features inside the mining tenure); and
  - Post-mining – proposed conditions after the cessation of mining and establishment of the final landform, using ‘post mining’ hydrology and the proposed final landform for DNM, as well as for any adjacent mining sites.

Note, proposed final landform version 3.1, provided by DNM, was considered for this assessment (see Section 4.2.1 for details). Proposed final landform version 3.1 includes an Out-of-Pit Dump (OOPD) located west of and adjacent to ML1781, outside the current lease boundary. A new Mining Lease Application (MLA) will be submitted for the Project.



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 Projection: EPSG:28355

Figure 1.1 Locality plan with Fitzroy River catchment

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## 2 EXISTING DRAINAGE

The following sections present an overview of the regional and local drainage in the vicinity of DNM, as well as a summary of the PRCP definitions relevant to the study.

### 2.1 REGIONAL DRAINAGE

DNM is located within the headwaters of the Isaac sub-catchment of the greater Fitzroy Basin. The Isaac River is the main watercourse in the vicinity of DNM and flows in a south-easterly direction to the south of DNM. Figure 2.1 presents the drainage characteristics of the Upper Isaac River to the Department of Natural Resources, Mining and Energy's (DNRME's) Deverill gauging station (GS130410A).

The catchment commences at the Denham Range, which is located about 69 km to the north of DNM. The Isaac River flows in a southwesterly direction through the Carborough and Kerlong Ranges before turning in a southeasterly direction near the Goonyella Riverside Mine. The Isaac River eventually flows to the Mackenzie River, about 160 km to the southeast of DNM.

The Isaac River is a seasonally flowing watercourse, typically with surface flows in the wetter months from November to April, reducing to shallow subsurface flows from about May to October. All other waterways in the vicinity of DNM are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with most channels drying out during winter to early spring when rainfall and runoff is historically low with some pools hold water for extended periods.

The catchment area of the Isaac River upstream of DNM is approximately 3,630 km<sup>2</sup> and comprises mainly scattered to medium dense bushland, grazing land and the township of Moranbah. There are several existing coal mines in the Isaac River catchment including, Burton, North Goonyella, Grosvenor, Goonyella-Riverside, Broadmeadow, Broadlea, Isaac Plains, Carborough Downs, Caval Ridge, Poitrel, Daunia, Millennium and Moranbah North.

Three storages are located in the Isaac River upper catchment: Lake Elphinstone, Teviot Dam and Burton Gorge Dam. Lake Elphinstone is a natural lake formed behind the Carborough Range, whereas Teviot Dam and Burton Gorge Dam are man-made structures that supply water to Burton and North Goonyella mines.

### 2.2 LOCAL DRAINAGE

Key local drainage features in the vicinity of DNM are shown in Figure 2.2 and include:

- Cherwell Creek
- North Creek; and
- New Chum Creek.

Cherwell Creek drains an area of about 698 km<sup>2</sup>, to the west of DNM, and meets the Isaac River about 6 km northwest (upstream) of DNM. According to Queensland Government mapping, Cherwell Creek at the confluence with the Isaac River is a fifth order watercourse. DNM does not impact on Cherwell Creek.

North Creek drains an area of about 330 km<sup>2</sup>, to the north and east of DNM. North Creek drains to the Isaac River, about 11 km southeast (downstream) of DNM. According to Queensland Government mapping, North Creek at the confluence with the Isaac River is a fourth order watercourse. DNM does not impact on North Creek.

New Chum Creek, a tributary of the Isaac River, drains in a southerly direction to the west of DNM. New Chum Creek has a catchment area of approximately 48 km<sup>2</sup> to its confluence with the Isaac

River. New Chum Creek traverses through multiple mining leases including, Mavis Downs, Millennium East, Red Mountain and Poitrel. According to Queensland Government mapping, New Chum Creek at the confluence with the Isaac River is a third order watercourse. Approximately 3.0 km of New Chum Creek between Poitrel and DNM (but within the Poitrel mining lease) has been replaced by a diversion channel. There are no permanent watercourse diversions within the DNM.

In addition to the watercourses discussed above, the Aurizon Goonyella rail line runs along the western boundary of the DNM mining lease and crosses the Isaac River immediately downstream of the Isaac River's confluence with New Chum Creek.

Figure 2.2 shows the general arrangement of the site, including the proposed OOPD layout.

The QLD Government information sheet on *Voids in flood plains* (DES, 2024) provides guidance on the floodplain definition as applicable to the PRCP process. For the PRCP, the floodplain definition is based on:

- The 0.1% (1 in 1,000) annual exceedance probability (AEP) flood event, determined in accordance with ARR2019 guidelines;
- Considering relevant watercourses only, where a relevant watercourse is classified as stream order 4 or higher under the Strahler stream order classification system; and
- Excluding any artificial features on the land subject to the PRCP.

For the purposes of this assessment, relevant watercourses include Cherwell Creek, North Creek and the Isaac River only.

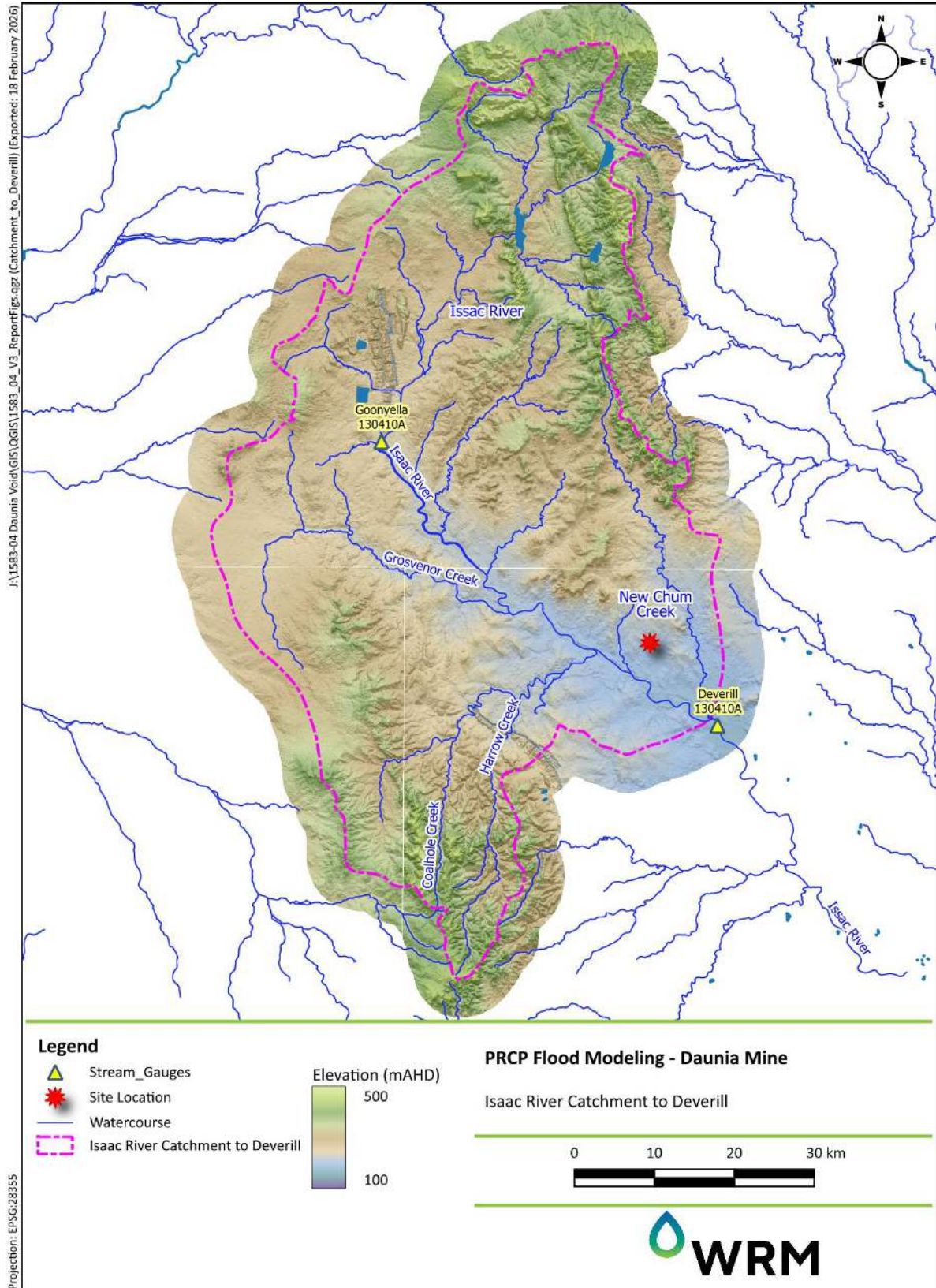


Figure 2.1 Regional drainage features

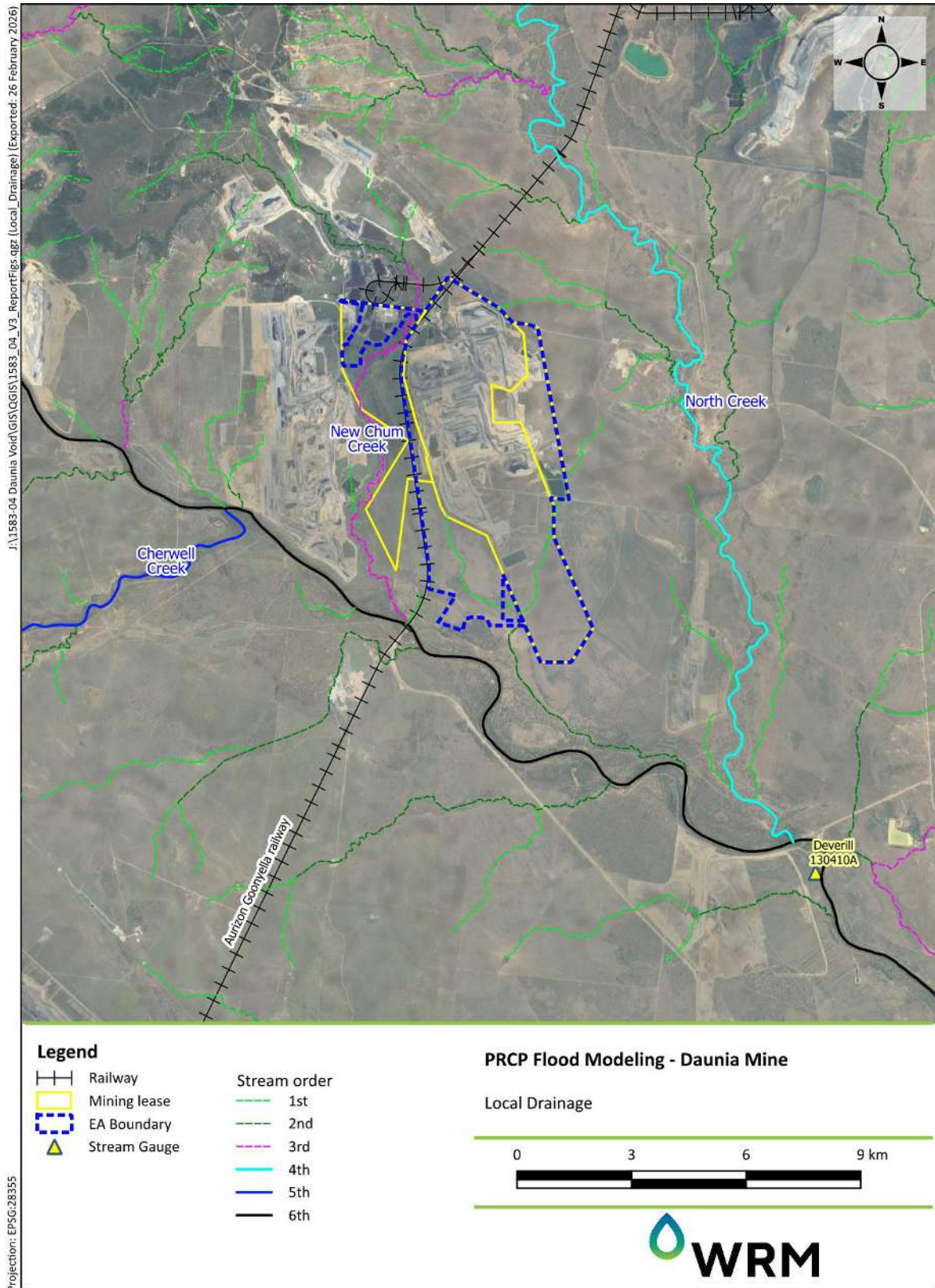


Figure 2.2 Local drainage features

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## 3 HYDROLOGIC MODELLING

### 3.1 OVERVIEW

WRM has previously undertaken modelling of the Isaac River (WRM, 2019) using the XP-RAFTS software package, which is no longer actively developed or supported. For this study, a new Isaac River hydrologic model was developed using the URBS rainfall-runoff routing software package (Carroll, 2024).

URBS is a runoff-routing computer program that uses a network of conceptual storages to represent the routing of rainfall excess through a catchment. The URBS model was used in the 'split mode', which enables the separate simulation of catchment and channel routing. Adopted rainfall losses are subtracted from the total rainfall hyetograph to obtain rainfall excess. The rainfall excess is then routed through conceptual catchment storage to determine the local runoff hydrograph for each sub-catchment of the model before being added to the creek or river channel. Routing through the creek or river system uses the non-linear Muskingum method, whose lag time is assumed proportional to the stream length.

URBS allows the user to select from several standard loss models. The initial and continuing loss model was adopted for the catchment. This model assumes that there is an initial loss (IL) in mm before any rainfall becomes runoff. After this, a continuing loss (CL) rate in mm per hour is applied to the rainfall. Full details of the URBS model and its features are given in the URBS User Manual (Carroll, 2021).

URBS models have three principal routing parameters:

- channel routing – alpha;
- catchment routing – beta; and
- non-linearity parameter - m.

### 3.2 METHODOLOGY

The Isaac River URBS model was developed in accordance with the current ARR2019 guidelines (Ball et al., 2019). The model was calibrated against recorded stream flows in the Isaac River catchment for the 2008, 2010 and 2017 floods and then design discharges were estimated using the ensemble methodology as described in ARR2019.

The FFA for the Isaac River at Deverill gauge (130410A) was updated to include the five years of additional data (2020 to 2024, inclusive) recorded since the previous study (WRM, 2019). The FFA used the latest version of FLIKE (Version 5.0.306.0).

Three different hydrology scenarios were developed to represent different conditions:

- Validation hydrology: The calibrated URBS model was reconciled with FFA results for the range of Isaac River design flood events from 10% AEP to 1% AEP, without any consideration of climate change. Design event Initial Loss (IL) and Continuing Loss (CL) values were adjusted to reconcile the peak URBS design discharge estimates with FFA estimates of peak design discharge.
- Existing conditions' hydrology: The calibrated, FFA reconciled URBS model was updated with ARR2019 climate change factors (Ball et al., 2019) for design losses and design rainfalls and used to produce existing conditions design event discharge hydrographs as inflows to the hydraulic model of the study area for the 0.1% AEP and PMF events.
- Post mining - conditions' hydrology: Similar to existing conditions, the calibrated, FFA reconciled URBS model was updated with relevant ARR2019 climate change factors to produce post-mining conditions design event discharge hydrographs for 0.1% AEP and PMF events.

Details of the adopted climate change scenarios and representative time horizons are discussed in Section 3.4.

### 3.3 FLOOD FREQUENCY ANALYSIS

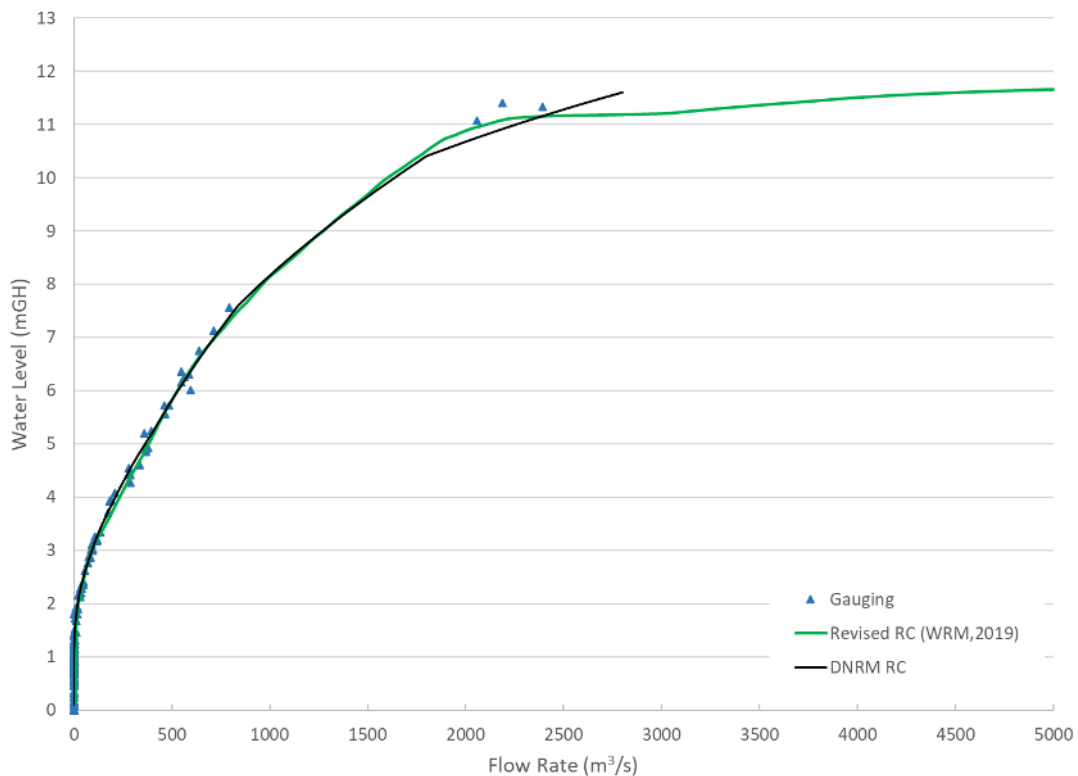
The FFA from the previous study (WRM, 2019) was updated to include additional recorded flow data available (years 2020 to 2024).

The FFA was carried out using annual peak discharges recorded at the Deverill gauge. Annual peak discharges were determined based on the water year, from October to September. FLIKE software (BMT, 2022) was used fit the data to a Log Pearson III (LP3) distribution using the Bayesian inference methodology recommended in the current ARR2019 guidelines.

#### 3.3.1 Rating curve review

The WRM study (WRM, 2019), determined that the DNRME rating curve for the Deverill gauge was not representative of the range of flow conditions at the gauge, especially for larger (out of bank) discharge. An updated rating curve was derived, based on hydraulic modelling for the study.

Figure 3.1 shows the historical gaugings, the provided DNRME rating curve, and the revised rating curve derived from TUFLOW modelling results, which was adopted for this study.



**Figure 3.1 Comparison of historical gaugings, DNRME rating curve and revised rating curve at Deverill**

Table 3.1 shows the adopted annual maximum discharge series for the Deverill gauge, from 1968 to 2024, adopted for the FFA. Annual maxima above 10 m were adjusted using the revised rating curve.

**Table 3.1 Annual maximum discharges at Isaac River at Deverill stream gauge**

Year (Oct-Sep)	Peak flow (m <sup>3</sup> /s)	Year (Oct-Sep)	Peak flow (m <sup>3</sup> /s)	Year (Oct-Sep)	Peak flow (m <sup>3</sup> /s)
1968/69	3	1987/88	2,638	2006/07	401
1969/70	511	1988/89	2,137	2007/08	2,142
1970/71	102	1989/90	235	2008/09	466
1971/72	188	1990/91	2,429	2009/10	501
1972/73	233	1991/92	110	2010/11	1,827
1973/74	1,261	1992/93	1	2011/12	1,121
1974/75	424	1993/94	753	2012/13	263
1975/76	533	1994/95	30	2013/14	1
1976/77	156	1995/96	236	2014/15	205
1977/78	1,703	1996/97	1,198	2015/16	1,791
1978/79	2,113	1997/98	1,706	2016/17	1,625
1979/80	179	1998/99	581	2017/18	25
1980/81	608	1999/00	144	2018/19	30
1981/82	83	2000/01	638	2019/20	30
1982/83	1,124	2001/02	68	2020/21	56
1983/84	307	2002/03	195	2021/22	610
1984/85	137	2003/04	350	2022/23	214
1985/86	142	2004/05	20	2023/24	353
1986/87	184	2005/06	308	2024/25	911

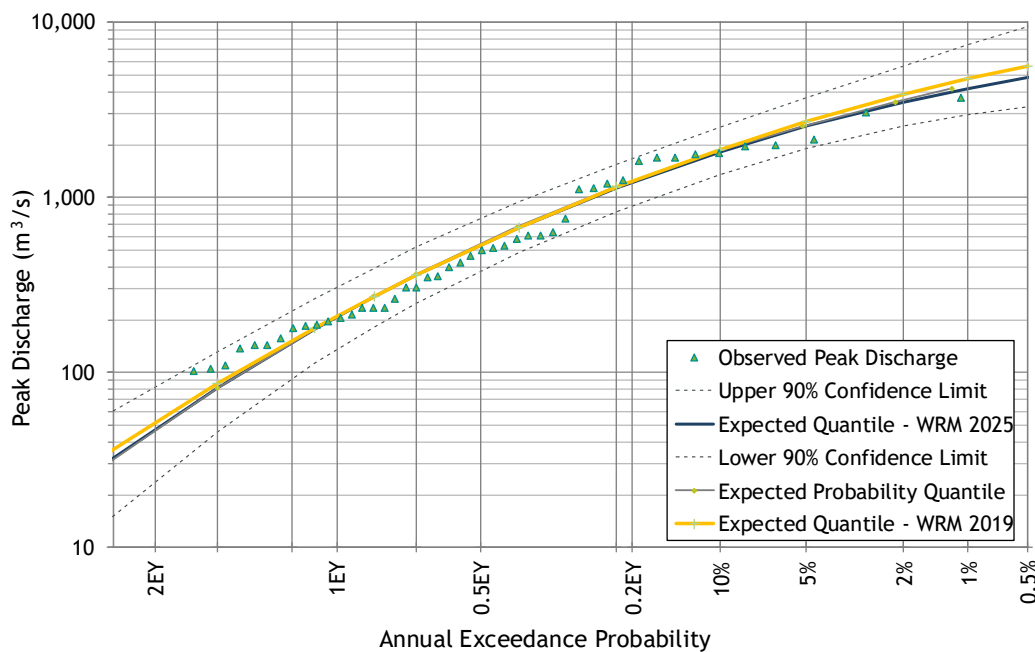
### 3.3.2 Updated FFA

Table 3.2 and Figure 3.2 compare the study FFA results with previous FFA results (WRM, 2019). The FFA results show:

- The additional years of data had annual maxima between 56 m<sup>3</sup>/s (2020/21 water year) and 911 m<sup>3</sup>/s (the 2024/25 water year);
- These values are at/below the recorded median annual maxima, and tended to reduce the FFA estimates for smaller AEP (larger magnitude) events.
- Estimated peak 10% AEP peak discharges are reduced only slightly (-3%), while 1% AEP peak discharges are reduced by -13%.

**Table 3.2 Comparison of FFA design discharges**

Design event	Peak discharge (m <sup>3</sup> /s)		
	Study FFA	Previous Study (WRM, 2019)	Difference (%)
10% AEP (10 Year ARI)	1,826	1,880	-3
5% AEP (20 Year ARI)	2,551	2,699	-6
1% AEP (100 Year ARI)	4,207	4,750	-13



**Figure 3.2 Isaac River at Deverill FFA, current study and previous (WRM, 2019) results**

### 3.4 CLIMATE CHANGE CONSIDERATIONS

#### 3.4.1 Overview

ARR2019 guidelines provide updated guidance on climate change estimates for design hydrology. Key climate change considerations include:

- The design rainfall (BoM) is centred on the period 1960 to 1990. Since that time, global average temperatures have risen by a little over 1 degree C.
- Increasing global average temperatures effect design rainfall depths, with warmer conditions increasing the atmosphere’s capacity to hold moisture and thus increasing rainfall. These

increases extend up to and include estimates of the Probable Maximum Precipitation (PMP) depths (which were previously assumed to be unaffected by warming).

- Increasing global average temperatures lead to drier antecedent conditions and thus to greater initial and continuing losses.
- Increasing global average temperatures also affect the spatial distribution of rainfall. Currently, insufficient evidence is available to assess these.
- Consequently, current design rainfall data must be adjusted to account for warming that has already occurred when estimating present-day (design) discharges and predicting future climatic conditions.

Figure 3.3 (reproduced from ARR2019) shows the latest IPCC temperature projections based on Shared Socioeconomic Pathways (SSPs). The best estimate for the mid-point of the current design rainfall data is shaded in grey. The SSPs warming scenarios comprise low (SSP1), medium (SSP2), high (SSP3) and very high (SSP5).

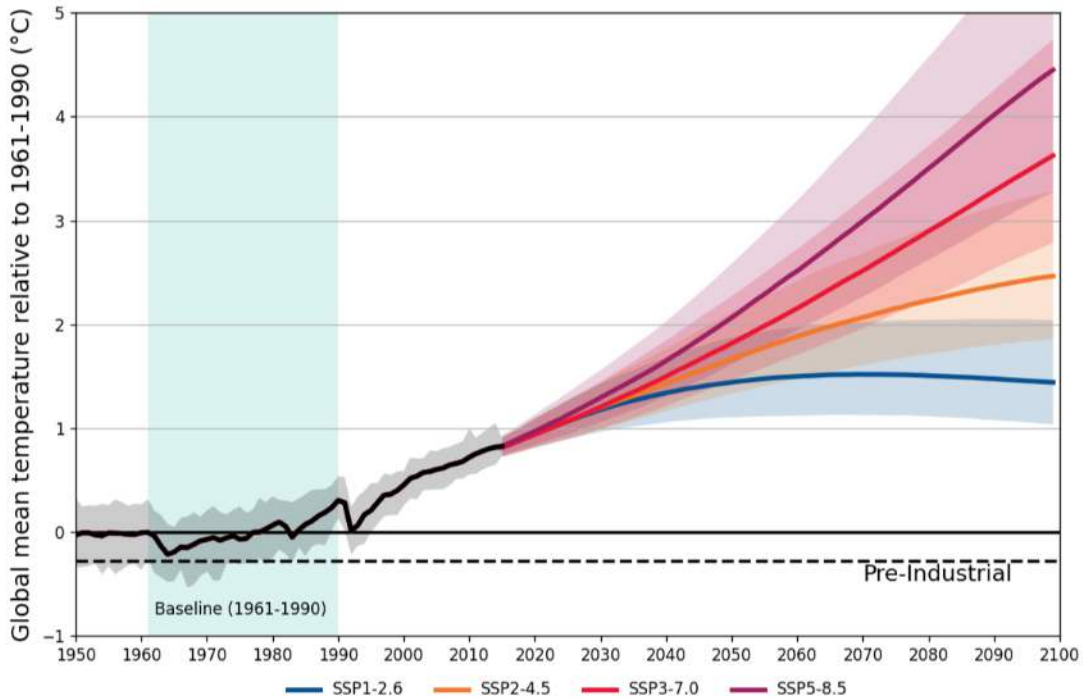
Further details of the projected impacts of increased global average temperatures on temperature and losses, as well as the basis for the guidance, are provided in ARR2019.

For this study, the following climate change scenarios were adopted:

- Existing conditions (present day) hydrology:
  - SSP5-8.5;
  - Year 2030 time horizon;
  - +1.3 degrees of warming;
- Post-mining conditions hydrology:
  - SSP2-4.5;
  - Year 2100 time horizon;
  - +2.5 degrees of warming.

Uplift factors for rainfall and losses were obtained for each scenario from the ARR Datahub portal (Geoscience Australia, 2024).

Note, given the significant overlap between the FFA data period and the rainfall data baseline period (see Figure 3.3), no rainfall or loss factors were applied to hydrologic modelling for validation against FFA results (the 'validation' hydrology conditions).



**Figure 3.3** Projected temperature increases associated with AR6 socioeconomic pathways relative to 1961-1990 (shaded vertically in grey) and their associated uncertainty.

### 3.4.2 Rainfall depth adjustment

Table 3.3 shows the adopted rainfall depth uplift factors. Note, in accordance with the updated ARR2019 guidance, rainfall uplift factors were applied to all design rainfalls, up to and including the PMP. Previous WRM modelling (WRM, 2019), showed that critical durations for the design event AEPs of interest were longer than 24 hours and factors for shorter durations are not provided here.

**Table 3.3** Adopted rainfall depth uplift factors

Duration > 24 Hours				
Scenario	Time horizon	SSP	Projected change in temperature (C)	Rainfall depth uplift factor
Existing Conditions	2030	SSP5-8.5	+1.3	1.11
Post-mining Conditions	2100	SSP2-4.5	+2.5	1.41

### 3.4.3 Loss parameters

Table 3.4 shows the adopted initial and continuing loss uplift factors. Note, in accordance with the updated ARR2019 guidance, loss uplift factors were applied to all design rainfalls, up to and including the PMP.

**Table 3.4 Adopted initial and continuing loss uplift factors**

Scenario	Time horizon	SSP	IL uplift factor	CL uplift factor
Existing Conditions	2030	SSP5-8.5	1.03	1.05
Post-mining Conditions	2100	SSP2-4.5	1.05	1.1

### 3.4.4 Temporal and spatial patterns

ARR2019 guidelines do not alter the existing guidance on the temporal and spatial distribution of rainfall. The selection of areal reduction factors and design storm temporal patterns are outlined in the following sections.

## 3.5 URBS MODEL DEVELOPMENT

### 3.5.1 Spatial configuration

The catchment configuration used in the URBS model is consistent with that of the WRM (2019) XP-RAFTS model. As shown in Figure 3.4, the model covers the Isaac River catchment upstream of the Deverill stream gauge and includes 93 sub-catchments, ranging in size from 1.9 km<sup>2</sup> to 204 km<sup>2</sup>. Mining areas (including DNM) were not excluded from model sub-catchments, even though mining operations tend to reduce catchment areas and capture of runoff.

Minor adjustments were made to sub-catchment delineation. Catchment naming was updated to meet the URBS naming requirements. Table 3.5 shows the URBS model sub-catchment areas, matched against the WRM (2019) XP-RAFTS sub-catchment IDs.

**Table 3.5 Isaac River URBS model sub-catchments**

XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )
CC1	2001	49.4	CC23	20023	23.7	IR2	1002	122.7	IR26	10026	10.7
CC2	2002	63	CG1	3001	8.8	IR3	1003	24.3	IR27	10027	18.2
CC3	2003	45.3	CG1a	31001	4.2	IR4	1004	54.2	IR28	10028	24
CC4	2004	13.3	CG1b	32001	1.9	IR5	1005	30.9	IR29	10029	15.1
CC5	2005	43.2	CG2	3002	17.1	IR6	1006	48	IR30	10030	44.3
CC6	2006	21.5	CG3	3003	12.6	IR7	1007	41.1	IR31	10031	21.2
CC7	2007	78.2	CG4	3004	7.9	IR8	1008	102.9	IR32	10032	24.7
CC8	2008	55.3	CG4a	31004	2.5	IR9	1009	110.8	IR33a	110033	20.8
CC9	2009	13.2	CG4b	32004	6.3	IR10	10010	57.8	IR33b	120033	15
CC10	20010	14.1	CG5	3005	9.7	IR11	10011	110.1	IR33c	130033	11.6
CC11	20011	50.9	GC1	4001	78.5	IR12	10012	114.4	IR34	10034	50
CC12	20012	56.9	GC2	4002	109.5	IR13	10013	184	IR35	10035	128.6
CC13	20013	9.1	GC3	4003	104.4	IR14	10014	56.7	NC1	5001	15.2
CC14	20014	29	GC4	4004	112.9	IR15	10015	166.8	NC2	5002	20.9
CC15	20015	39.5	GC5	4005	77.8	IR16	10016	204.3	NC3	5003	37.6
CC16	20016	9.1	GC6	4006	72	IR17	10017	126.5	NC4	5004	57.8
CC17	20017	14.8	GC7	4007	80	IR18	10018	19.4	NC5	5005	93.3

XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )	XPRAF TS ID	URBS ID	Area (km <sup>2</sup> )
CC18	20018	7.4	GC8	4008	37.5	IR19	10019	7.8	NC6	5006	52.3
CC19	20019	5.4	GC9	4009	22.1	IR20	10020	34.1	NC7	5007	29.4
CC20	20020	14	GC10	40010	6.7	IR21	10021	23	NC8	5008	24.9
CC21	20021	11.1	GC11	40011	3	IR22	10022	17.3	Teviot	600	40.5
CC22	20022	8.3	GC12	40012	21.5	IR23	10023	7.1			
CC22a	210022	15.5	GC13	40013	25.6	IR24	10024	36.4			
CC22b	220022	7.1	IR1	1001	82.7	IR25	10025	25.1			

### 3.5.2 Model parameters

Key URBS model sub-catchment parameters were determined from available topographic and aerial imagery, including area, degree of urbanisation, and percentage imperviousness. Global urbanization (0) and percentage imperviousness (10%) values were adopted.

URBs model loss and routing parameters were determined through the calibration process.

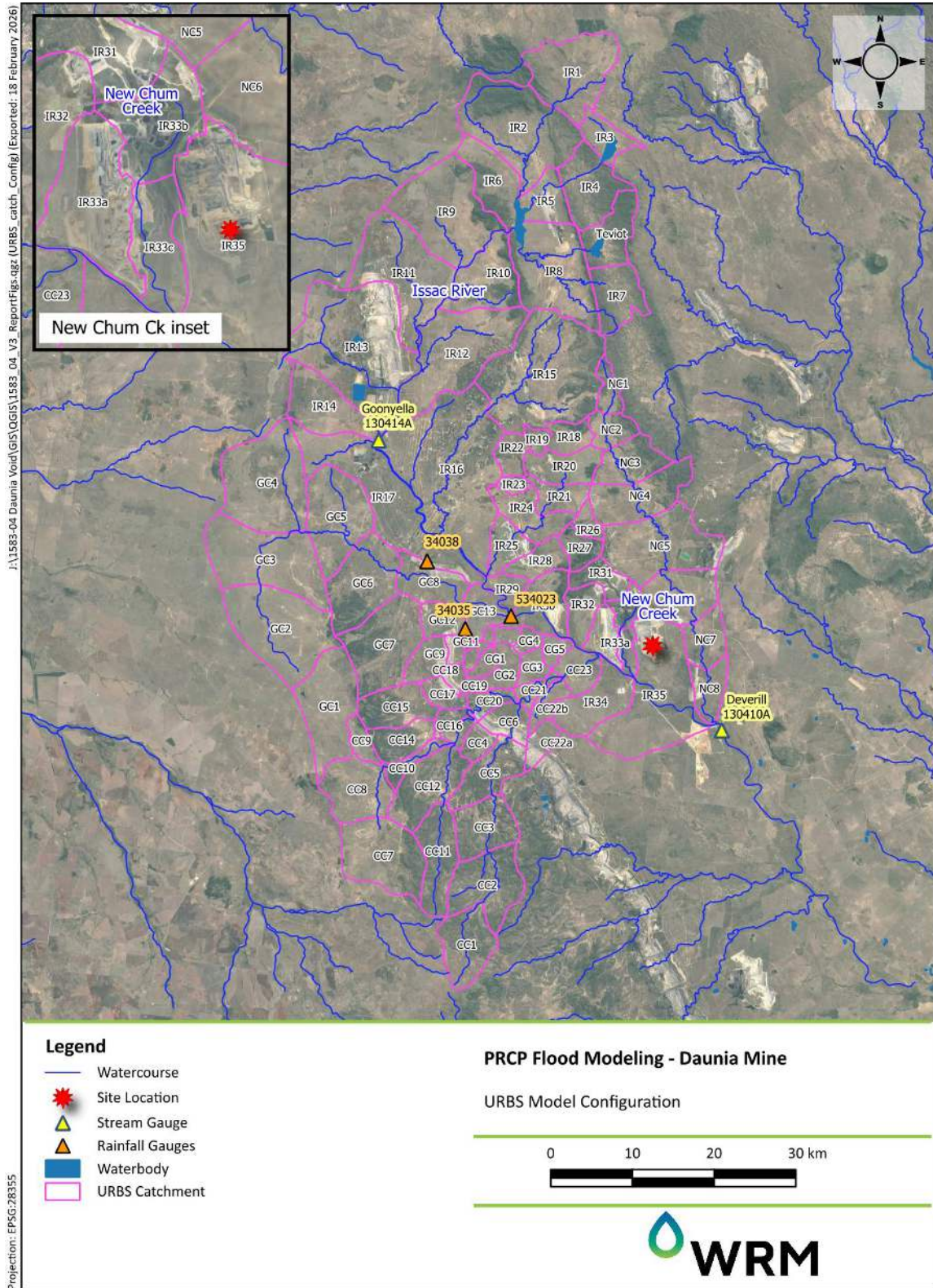


Figure 3.4 URBS Model Sub-catchments for the Isaac River to Deverill

### 3.6 URBS MODEL CALIBRATION

#### 3.6.1 Overview

The URBS model was calibrated to discharge hydrographs derived from water level data recorded at the Deverill and Goonyella stream flow stations for three flood events (2008, 2010 and 2017). The primary objective of the model calibration process was to determine a representative set of URBS model parameters (*alpha*, *beta*, *m*) providing the best possible fit between predicted and recorded discharge hydrographs at key stream gauge locations in the Isaac River catchment, for a range of historical flood events.

The quality of the calibration fit was assessed by how well the predicted discharge hydrograph matched the timing and magnitude of flood peaks, as well as the overall shape of the hydrograph.

#### 3.6.2 Available data

To calibrate the model in this study, the same data used in the previous study (WRM, 2019) was applied. This included rainfall data from both public stations and private sources, obtained through data-sharing agreements. The available rainfall and streamflow calibration data is shown in Table 3.6.

Table 3.7 shows the recorded total rainfall depths and peak discharges for each of the calibration events.

**Table 3.6 Available rainfall and streamflow data**

Station ID	Station name	Data type	Data frequency	Source	Calibration event		
					Feb-08	Dec-10	Mar-17
130410A	Isaac River at Deverill	Rainfall	Sub-daily	DNRME	✓	✓	✓
		Discharge	Sub-daily		✓	✓	✓
130414A	Isaac River at Goonyella	Discharge	Sub-daily	DNRME	✓	✓	✓
534023	Isaac River Bridge	Rainfall	Sub-daily	BOM	✓	✓	-
34038	Moranbah WTP	Rainfall	Sub-daily	BOM	✓	✓	-
34035	Moranbah Airport	Rainfall	Sub-daily	BOM	-	-	✓

**Table 3.7 Calibration event details**

Flood event	Start date	Event duration (days)	Recorded peak discharge (m <sup>3</sup> /s)		Total event rainfall (mm)	
			Goonyella	Deverill	Goonyella	Deverill
February 2008	09/02/2008	9	1,070	2,142	n/a	567
December 2010	18/01/2010	15	910	1,827	n/a	518
March 2017	27/03/2017	7	199	1,614	n/a	168

### 3.6.3 Calibration results

The calibration of the URBS model was achieved by adjusting the URBS parameters (alpha, beta, m), as well as the initial and continuing rainfall losses, to obtain the best fit between recorded and predicted discharge hydrographs.

The adopted calibration event losses and URBS parameters for the three events are given in Table 3.8. The variation in initial and continuing loss values for the calibration events reflects the differing antecedent catchment conditions during each event, as well as the selection of the simulation start time, which may coincide with the commencement of the flood producing storm burst.

Table 3.9 compares recorded and predicted peak discharges in the Isaac River at the Goonyella and Deverill gauging stations.

**Table 3.8 Adopted URBS parameters and initial and continuing loss rates, calibration events**

Flood event	IL (mm)	CL (mm)	$\alpha$	$\beta$	m
February 2008	20	4	0.2	3	0.8
December 2010	9	3	0.2	3	0.8
March 2017	50	2.7	0.2	3	0.8

**Table 3.9 Comparison of recorded and URBS modelled peak flood discharges, Isaac River at Goonyella and Deverill gauging stations**

Calibration event	Peak discharge at Goonyella (m <sup>3</sup> /s)		Difference	Peak discharge at Deverill (m <sup>3</sup> /s)		Difference
	Recorded	Modelled		Recorded	Modelled	
February 2008	1,070	1,212	11.7%	2,142	2,153	0.5%
December 2010	910	947	4%	1,827	1,895	3.5%
March 2017	199	216	7.8%	1,624	1,595	-1.1%

#### 3.6.3.1 February 2008 calibration

Figure 3.5 and Figure 3.6 show comparisons of recorded and predicted discharge hydrographs at the Goonyella and Deverill gauging stations for the February 2008 event. The model reproduced the timing and shapes of the hydrographs relatively well. However, it overestimates the peak discharge and flood volume at Goonyella and underestimates them at Deverill. This is likely due to spatial variation in rainfall that was not covered by the recorded rainfall data.

#### 3.6.3.2 December 2010 calibration

Figure 3.7 and Figure 3.8 show comparisons of recorded and predicted discharge hydrographs at the Goonyella and Deverill gauging stations for the December 2010 event. A good calibration was achieved for both gauges, with the URBS model satisfactorily reproducing the flood peaks, timing and shapes of the hydrographs.

### 3.6.3.3 March 2017 calibration

Figure 3.9 and Figure 3.10 show comparisons of recorded and predicted discharge hydrographs at the Goonyella and Deverill gauging stations for the March 2017 event. A good calibration was achieved at the Deverill station, with the URBS model satisfactorily reproducing the flood peaks, and the timing and shapes of the hydrographs. However, the model slightly underestimates the peak flows at both gauges.

The three key storages, Burton Gorge Dam, Teviot Dam, and Lake Elphinstone were also included in the model for the 2017 event. The following conditions were reported for the three storages in the WRM (2019) study, for the 2017 event:

- Lake Elphinstone is not gauged but was not observed to spill during the 2017 event. The dam did not spill in the URBS model;
- Teviot Dam did not record a spill during the 2017 event, and did not spill in the URBS model; and
- Burton Gorge Dam experienced a spill event, with a recorded peak discharge of about 235 m<sup>3</sup>/s at the Burton Gorge Dam gauging station, compared to about 167 m<sup>3</sup>/s in the URBS model.

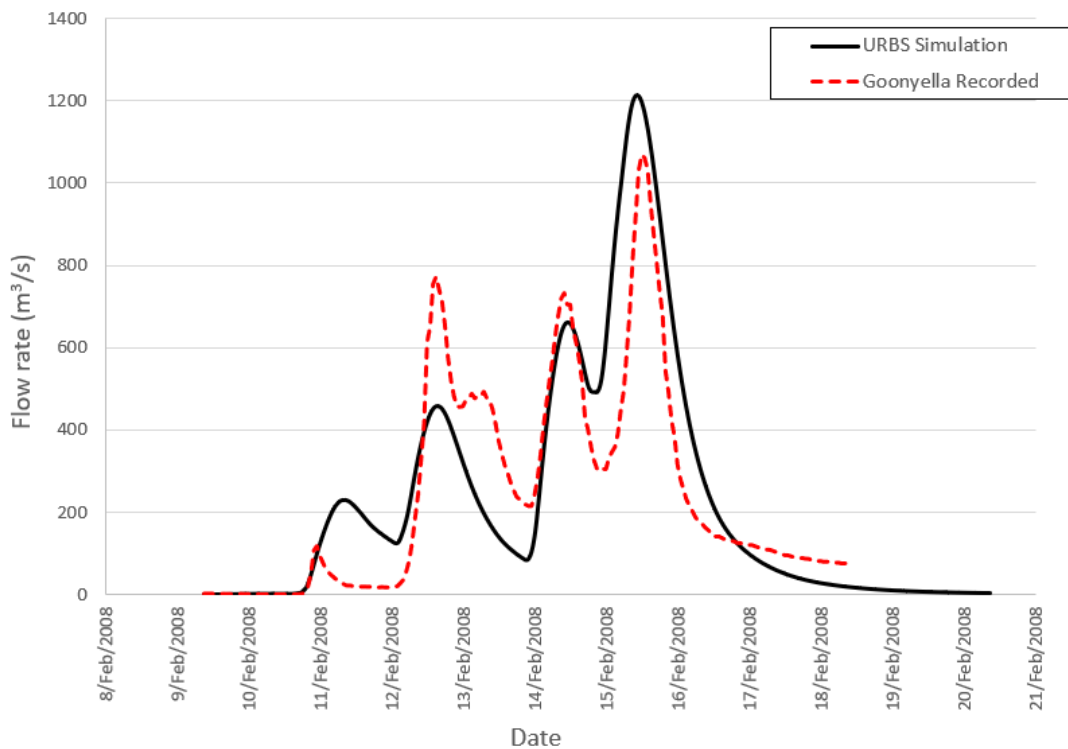
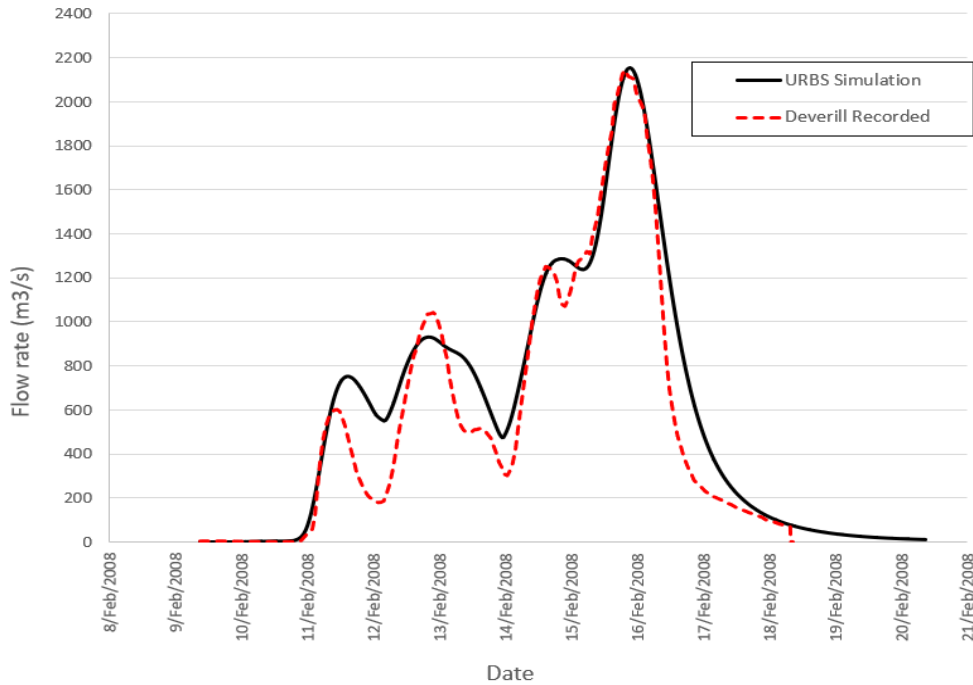
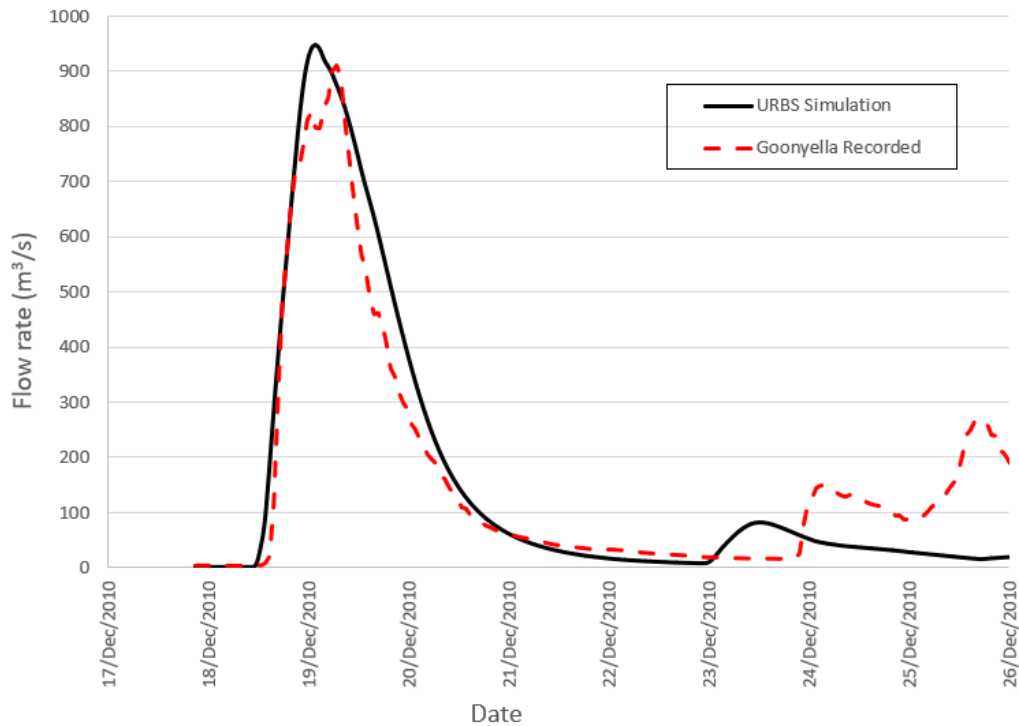


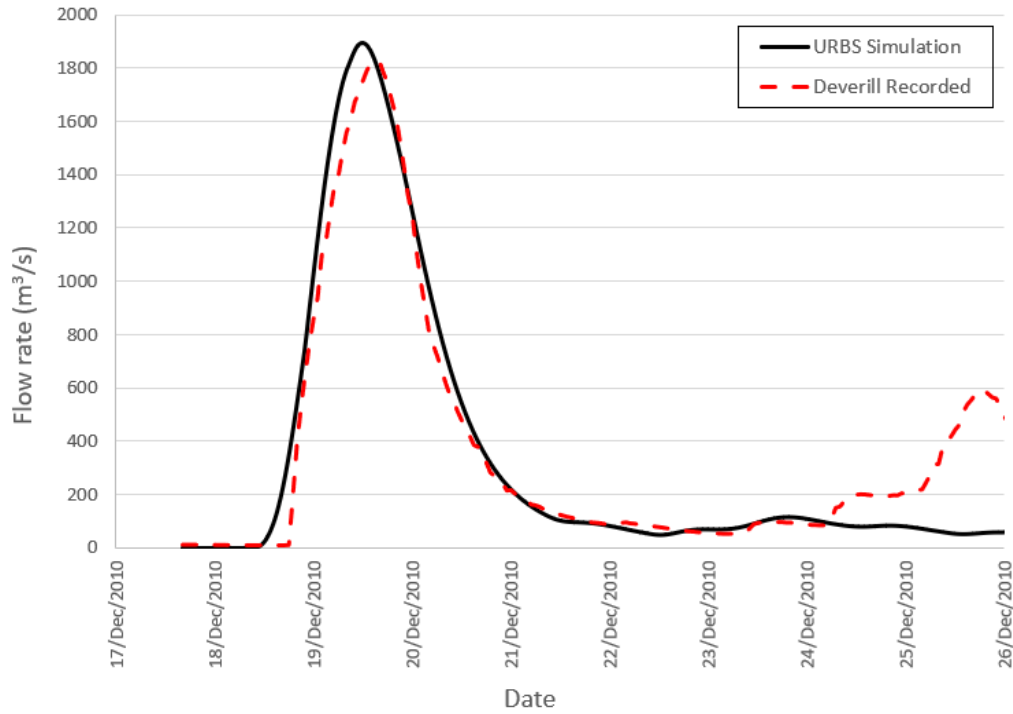
Figure 3.5 Comparison of recorded and modelled discharge hydrographs, February 2008, Isaac River at Goonyella



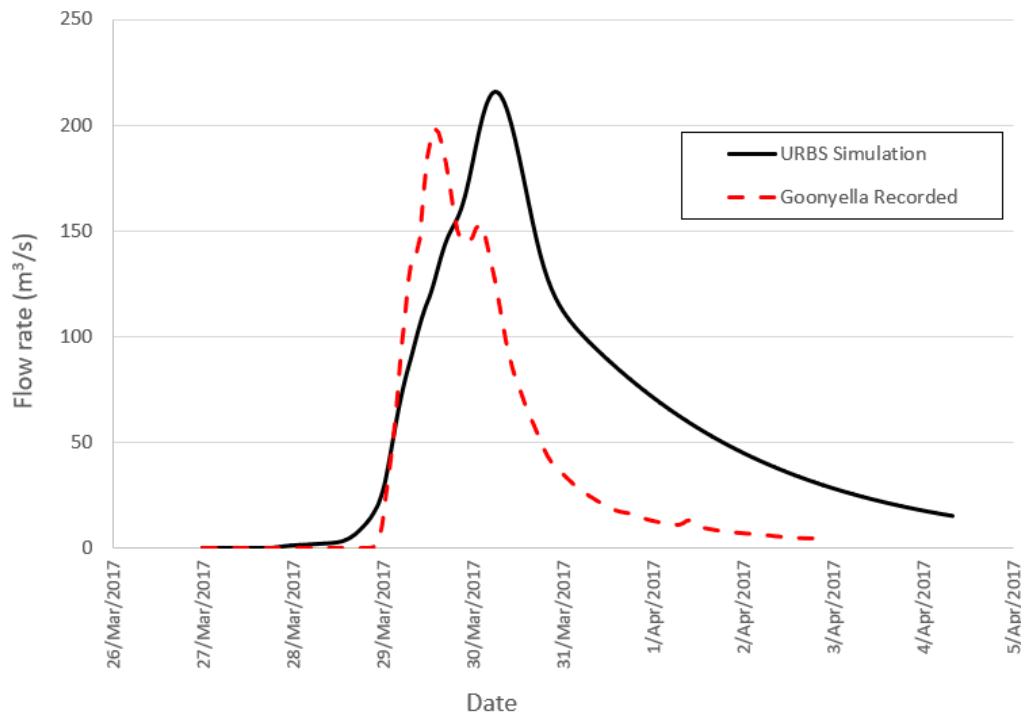
**Figure 3.6 Comparison of recorded and modelled discharge hydrographs, February 2008, Isaac River at Deverill**



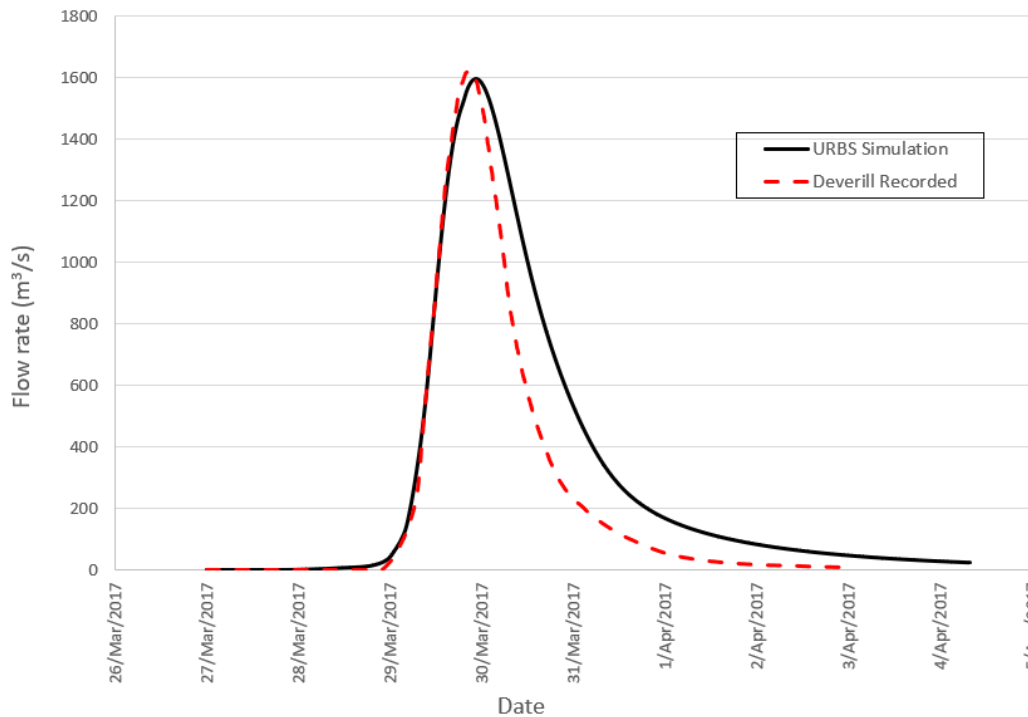
**Figure 3.7 Comparison of recorded and modelled discharge hydrographs, February 2010, Isaac River at Goonyella**



**Figure 3.8 Comparison of recorded and modelled discharge hydrographs, February 2010, Isaac River at Deverill**



**Figure 3.9 Comparison of recorded and modelled discharge hydrographs, February 2017, Isaac River at Goonyella**



**Figure 3.10 Comparison of recorded and modelled discharge hydrographs, February 2017, Isaac River at Deverill**

### 3.6.4 Summary

Overall, the calibration of the URBS hydrological model is considered acceptable. For all three calibration events, the difference between the modelled and recorded peak discharges at the Deverill gauge was less than 5%, with good agreement in both timing and magnitude of peak flow. The results were also consistent with the previous WRM (2019) study.

## 3.7 DESIGN DISCHARGE ESTIMATION

### 3.7.1 Overview

The calibrated URBS model was validated by comparing estimates of peak design discharges for a range of design events with estimates of peak design discharges derived using an alternative methodology. For this study, an FFA at the Deverill Gauge was used as the alternative design discharge estimation methodology. For the FFA validation, initial and continuing losses were varied within the range of calibration event losses, and no climate change uplift factors were applied.

The validated URBS model was then updated using the appropriate rainfall and losses uplift factors to represent both existing (present day) and post-mining hydrologic conditions. This design URBS model was then used to estimate design flood discharge hydrographs for the 0.1% AEP and PMF design event, for a range of storm durations up to 72 hours. Upstream storages in the model were assumed to start full for the design event.

### 3.7.2 Design rainfalls

Design rainfall depths for events up to and including 0.1% AEP and durations up to and including 72 hours were obtained from the Commonwealth Bureau of Meteorology (BoM, 2016) in the form of Intensity, Frequency, Duration (IFD) data<sup>1</sup>.

Estimates of Probable Maximum Precipitation (PMP) depths were previously derived by WRM (2019) for the study area. As the design guidelines for estimating PMP depths have not changed, the WRM (2019) PMP depth estimates were adopted for this study.

### 3.7.3 Spatial variability

URBS allows different IFD data to be assigned to each sub-catchment individually, improving the representation of spatial rainfall variation across the model area. A comparison of the Isaac River IFDs at the southern, northern, eastern and western catchment boundaries, and at the centroid, revealed on average more than 10% variance in rainfall for the 1% AEP event, across all durations.

Consequently, 93 individual IFD datasets were obtained for the study, each located near the centroid of its respective sub-catchment.

### 3.7.4 Temporal pattern

As the catchment area to the study area exceeds 72 km<sup>2</sup>, areal temporal patterns were applied for all events up to the 1 in 1,000 AEP, in accordance with ARR guidelines. For events with an AEP of 1 in 1,000 or greater, the PMP temporal pattern was adopted.

### 3.7.5 Climate change factors

Climate change factors were obtained from the ARR Datahub portal (Geoscience Australia, 2024) for the design scenarios described previously for existing conditions (present day) hydrology and post-mining conditions hydrology.

Table 3.10 shows the adopted rainfall and loss uplift factors for the nominated design scenarios. Note, in accordance with the updated ARR2019 guidance, uplift factors were applied to all design events, including the PMP.

**Table 3.10 Adopted climate change scenario factors**

Scenario	Projected temperature change (C)	Rainfall depth uplift factor	IL uplift factor	CL uplift factor
Existing Conditions (Yr 2030, SSP5-8.5)	+1.3	1.11	1.03	1.05
Post-mining Conditions (Yr 2100, SSP2-4.5)	+2.5	1.41	1.05	1.1

### 3.7.6 Initial and Continuing losses

A reconciliation process was undertaken using URBS and Flood Frequency Analysis (FFA) results to refine the initial and continuing loss values, and to obtain representative design initial loss (IL) and continuing loss (CL) values for events up to 1% AEP (inclusive). In accordance with ARR guidelines, IL and CL values of 1 mm and 0 mm/hr were adopted for PMF event modelling, and losses for intermediate (rare to extremely rare) design events, such as the 0.1% AEP, were interpolated. Table 3.11 shows the adopted IL and CL values. These design loss values are comparable to the losses

<sup>1</sup> <http://www.bom.gov.au/water/designRainfalls/revised-ifd/>

adopted previously by WRM (2019). Note, for events up to 1% AEP, IL values were modified based on pre burst rainfall as recommended by ARR2019. For larger events (i.e., 0.1% AEP and PMF), IL values were not modified based on pre burst.

**Table 3.11 Design event initial and continuing losses**

	Initial loss (mm)	Continuing loss (mm/hr)
Design (FFA reconciliation)	25	2.5
0.1% AEP	2	0
PMF	1	0

### 3.7.7 Design discharges

Table 3.12 shows a comparison of peak design discharge estimates for the Isaac River at Deverill from the FFA, the updated URBS model and WRM (2019).

**Table 3.12 Comparison of design discharge estimates for the Isaac River at Deverill**

Design event	FFA Design Discharge (m <sup>3</sup> /s)	URBS Design Discharge (m <sup>3</sup> /s)	WRM (2019) Design Discharge (m <sup>3</sup> /s)
10% AEP	1,826	1,870	1,936
5% AEP	2,551	2,455	2,886
1% AEP	4,207	4,576	5,067

The design URBS model was then developed by updating the FFA validated URBS model with the rainfall and losses climate change factors, and re-run for existing and post mining hydrologic conditions, for the 0.1% AEP and PMF events. Table 3.13 shows the estimated 0.1% AEP and PMF peak discharges under FFA validation (with no climate change factors), as well as existing and post mining hydrologic conditions (accounting for +1.3 degrees and +2.5 degrees of warming respectively).

**Table 3.13 Design discharge estimates for the Isaac River at Deverill, 0.1% AEP and PMF events**

	Validation (m <sup>3</sup> /s) (no climate change factors)	Existing conditions (m <sup>3</sup> /s) (+1.3 degrees warming)	Post mining conditions (m <sup>3</sup> /s) (+2.5 degrees warming)
0.1% AEP	8,719	9,928	11,121
PMF	29,131	32,580	36,013

Model results show that:

- For existing conditions, peak discharges are increased compared to the baseline FFA by +13% and +11% for the 0.1% AEP and PMF events respectively; and
- For post mining conditions, peak discharges are increased by an additional +12% and +10% for the 0.1% AEP and PMF events, respectively.

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## 4 HYDRAULIC MODELLING

### 4.1 OVERVIEW

The WRM (2019) study developed and calibrated a TUFLOW hydrodynamic model to simulate flood behaviour for the Isaac River and its floodplain in the vicinity of DNM, using the 2018-03-AD version of TUFLOW (BMT, 2018a).

For the current study, the WRM (2019) TUFLOW model was updated to version 2025.0.0 (BMT, 2025), which incorporates advancements in modelling capabilities. The model was recalibrated using the updated hydrologic inputs described in Section 3.2.

The updated hydraulic model was run for the 0.1% AEP and Probable Maximum Flood (PMF) event, for the following scenarios:

- Existing conditions:
  - Present day conditions at DNM, using ‘Existing’ hydrology and current site topographic data;
  - Used to inform final landform planning;
- Pre-mining conditions:
  - ‘Existing’ hydrology and pre-mining topographic data at DNM (i.e., excluding any artificial features inside the mining tenure), with current topographic data outside DNM;
  - Used to define the floodplain for the PRCP;
- Post-mining conditions:
  - ‘Post mining’ hydrology and the proposed final landform for DNM, as well as for any adjacent mining sites;
  - Used to assess flooding risk for the proposed final landform.
  - For each scenario and event, predicted flooding characteristics in the vicinity of DNM were assessed, including predicted peak flood extents, levels and depths.

### 4.2 TUFLOW MODEL CONFIGURATION

The Isaac River TUFLOW model covers an area of approximately 252 km<sup>2</sup>. It extends west approximately 5 km upstream of DNM to include the Aurizon rail bridge and rail embankment, Poitrel flood protection levee and New Chum Creek. The model extends 19 km to the southeast to include the Deverill stream gauge. The model outflow boundary is located 12 km south-southeast of the Deverill stream gauge.

To ensure the model accurately represents the defined scenarios, the levees and the final landforms from the surrounding mines (Moorvale, Olive down, Poitrel and Winchester mining areas) were incorporated into the model. The TUFLOW model configuration for the Pre-mining, Existing and Post-mining scenarios are shown in Figure 4.1 to Figure 4.3, respectively. Key model updates include:

- Updated TUFLOW solver from version 2018-03-AD to version 2025.0.0;
- Use of Sub Grid Sampling (SGS) functionality to enable the model to better utilise topographic data detail at a resolution below the model grid cell size; and
- Use of Quadtree (QPC) functionality to vary the model cell size, providing additional detail where required. A base model grid cell size of 10 m was adopted, consistent with the WRM (2019) modelling, reducing to 5 m (nesting level 2) for areas along key drainage features.

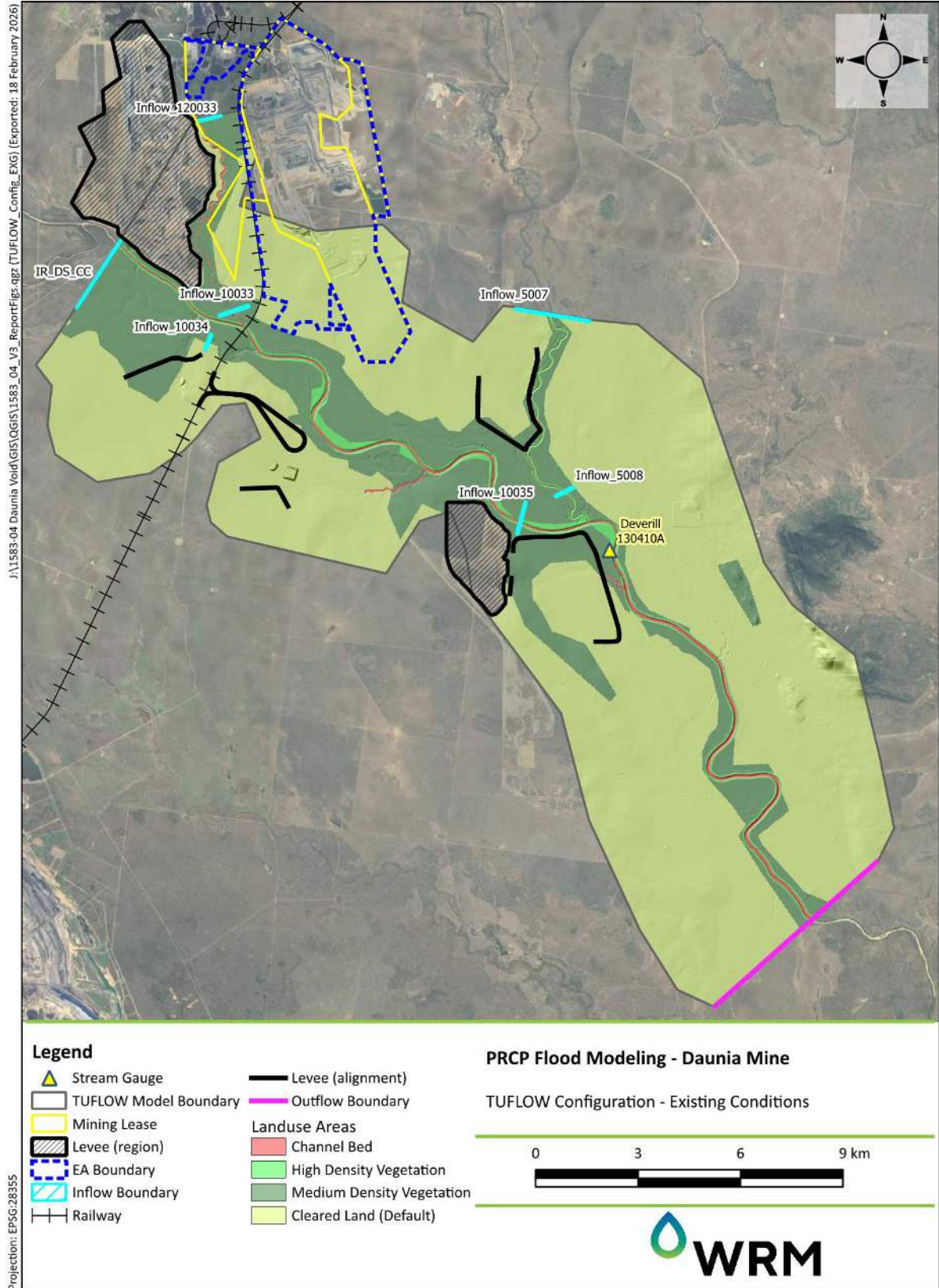


Figure 4.1 Isaac River TUFLOW model configuration- Existing conditions

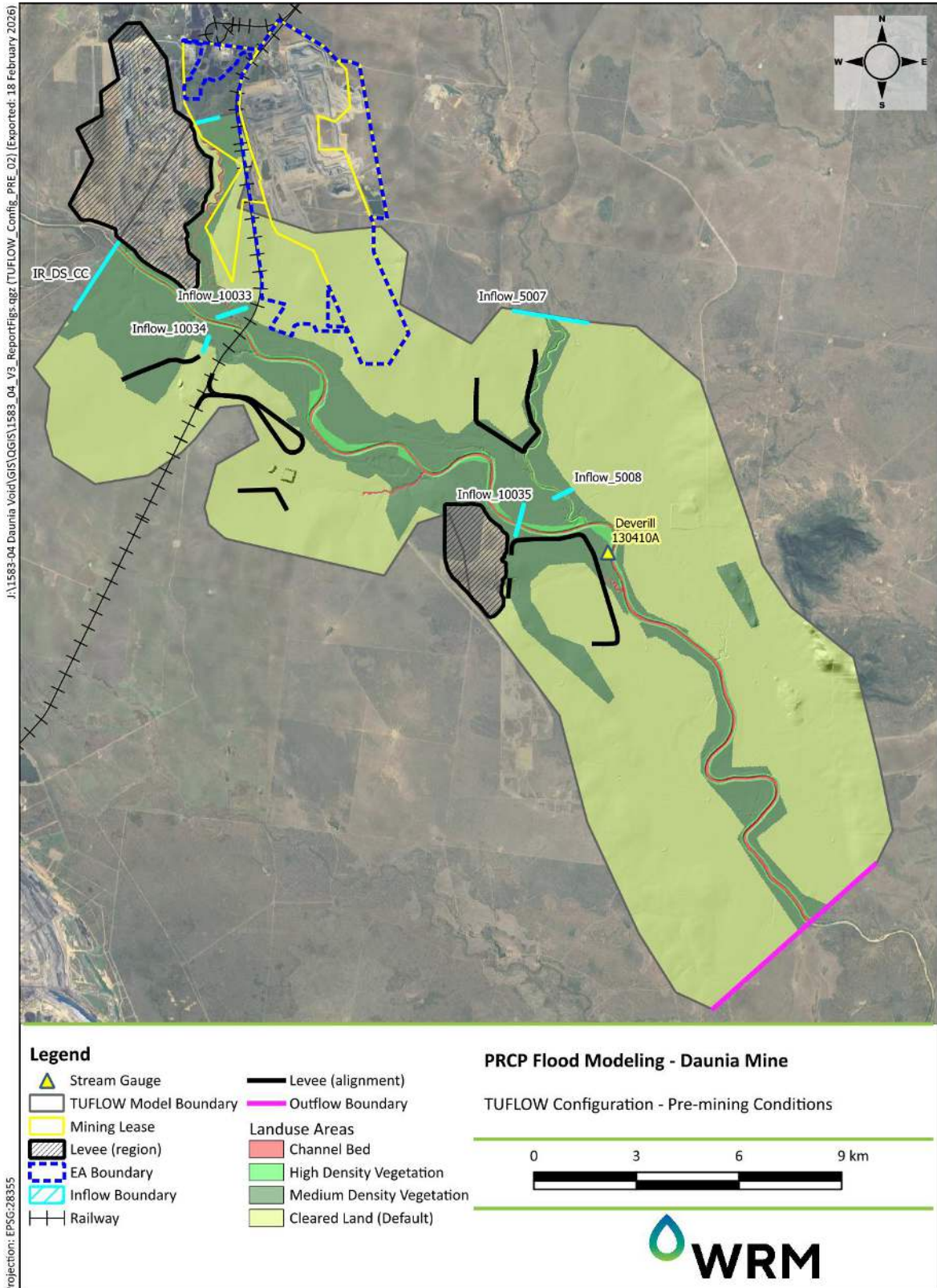


Figure 4.2 Isaac River TUFLOW model configuration- Pre-mining conditions

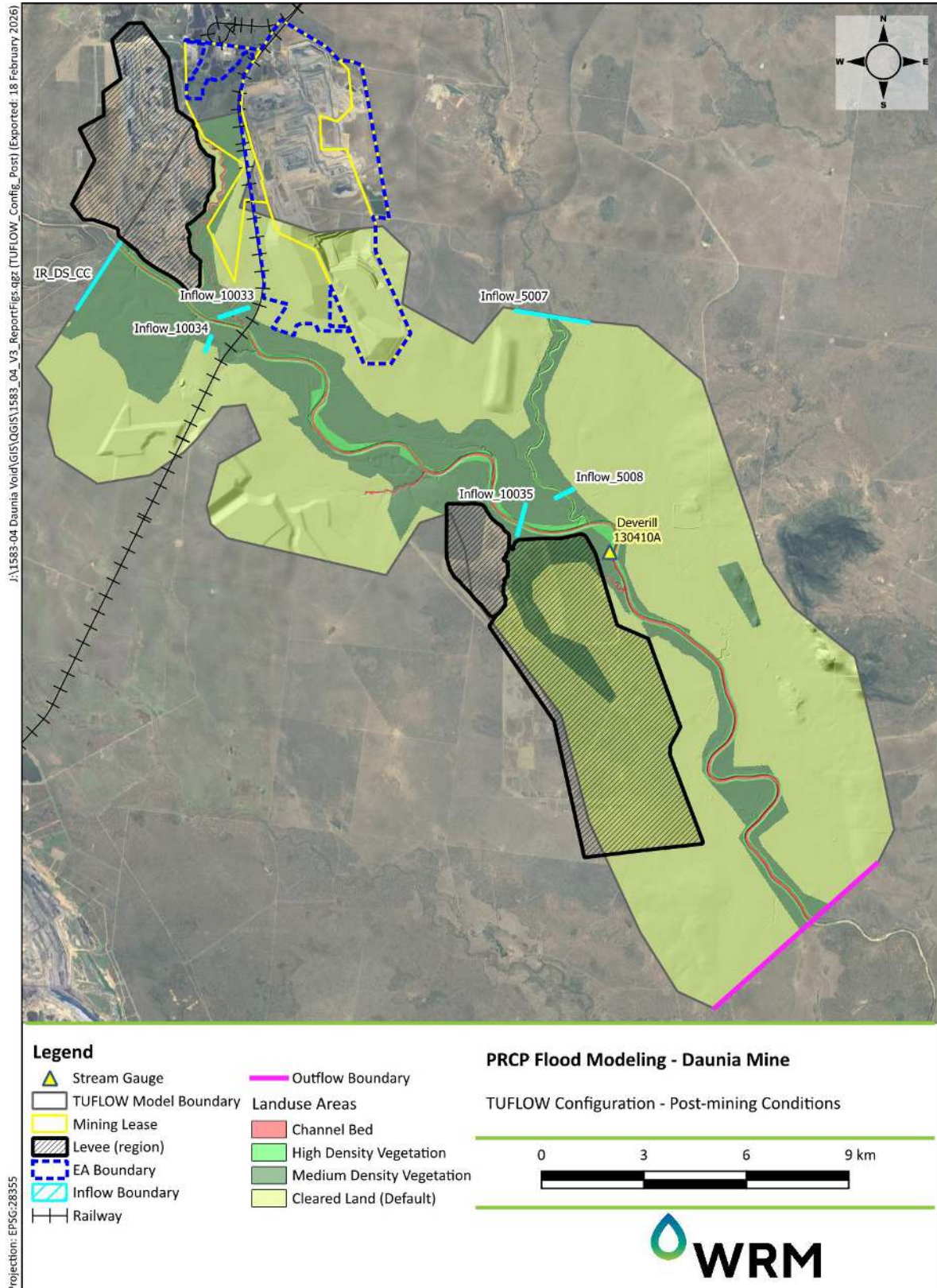


Figure 4.3 Isaac River TUFLOW model configuration- Post-mining conditions

#### 4.2.1 Topography

Base topographic data available from the WRM (2019) study includes:

- Shuttle Radar Topography Mission (SRTM) Digital Elevation Model, captured in 2000, was used to fill in a few outer edges of the flood plain. This data was normalised to the other LiDAR sources to match ground elevations.
- LiDAR data captured in 2012 (referred to as the 2012 LiDAR data). This data covers areas of the Isaac River floodplain that were not covered by LiDAR data from 2019 (see below).
- LiDAR data captured in August 2019 (referred to as the 2019 LiDAR data). This data covers most of the DNM operational areas, including most the Isaac River within and in the immediate vicinity of DNM.

In addition to the topographic data available from the WRM (2019) study, DNM provided updated LiDAR data for the DNM site, acquired on 22 January 2025. A review indicated there were no material differences between the 2019 and 2025 LiDAR data sets, within the Isaac River floodplain.

DNM provided proposed final landform topographic data (Rev3.1.1, received on 30 Jun 2025), which includes None-Use Management Areas and forms the basis for this assessment and is shown in Figure 4.4.

Information on proposed final landforms for nearby mines was obtained from the relevant PRCPs (where available) and via data sharing agreements between proponents (see Figure 4.3).

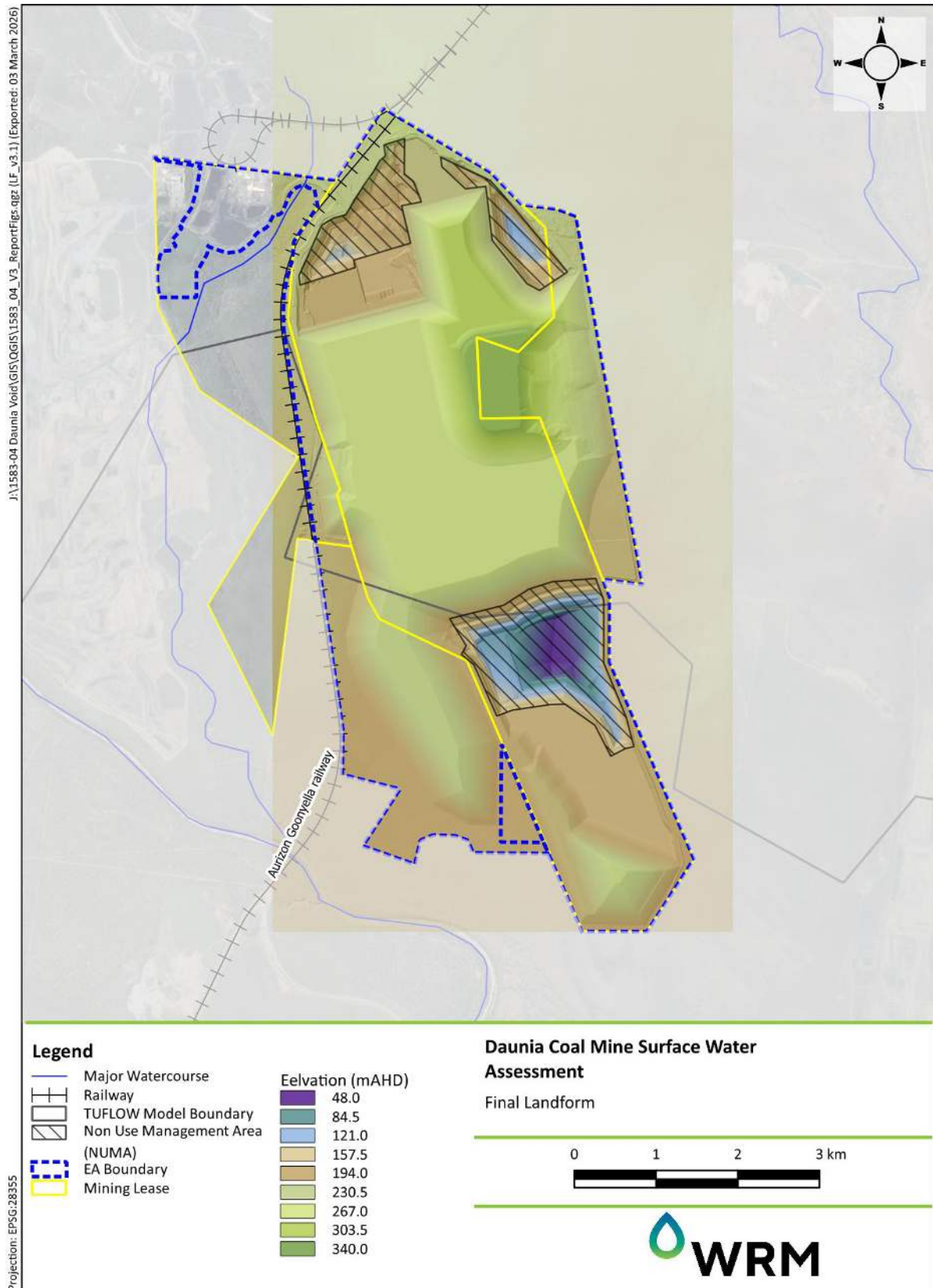


Figure 4.4 Proposed DNM final landform

#### 4.2.2 Inflow boundaries

Figure 4.1 to Figure 4.3 show the model inflow boundaries for three defined scenarios.

To show the existing conditions, inflows from the Isaac River, North Creek and New Chum Creek were incorporated into the model as shown in Figure 4.1. However, in the Pre-mining and Post-mining scenarios, New Chum Creek was excluded to meet PRCP requirements, as it is classified as a third-order stream (Figure 4.2 and Figure 4.3).

#### 4.2.3 Outflow boundaries

Figure 4.1 shows the model outflow boundary. The model boundary is a normal depth boundary across the Isaac River floodplain, about 12 km downstream of the Deverill gauge. A downstream flood slope of 0.1% was adopted.

#### 4.2.4 Adopted Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent the hydraulic resistance of different material types. Figure 4.1 shows the adopted land use mapping, and Table 4.1 shows the corresponding Manning's 'n' values.

Manning's 'n' values were adjusted during the calibration process to provide an improved match to both the historical calibration event, and the Deverill gauge rating curve.

**Table 4.1 Adopted Manning's 'n' values**

Land use	Manning's 'n'
Channel bed (sand)	0.025
Cleared land, grass areas (Default)	0.04
Medium density vegetation	0.06
High density vegetation	0.09

#### 4.2.5 Hydraulic structures and levees

Key hydraulic structures including the Aurizon Goonyella railway were included in the model.

Mine levee information in the vicinity of DNM was incorporated into the model including the addition of levees from Moorvale, Olive Downs, and Winchester mines, as well as the adjacent Poitrel Mine (see Figure 4.1 to Figure 4.3).

### 4.3 TUFLOW MODEL CALIBRATION

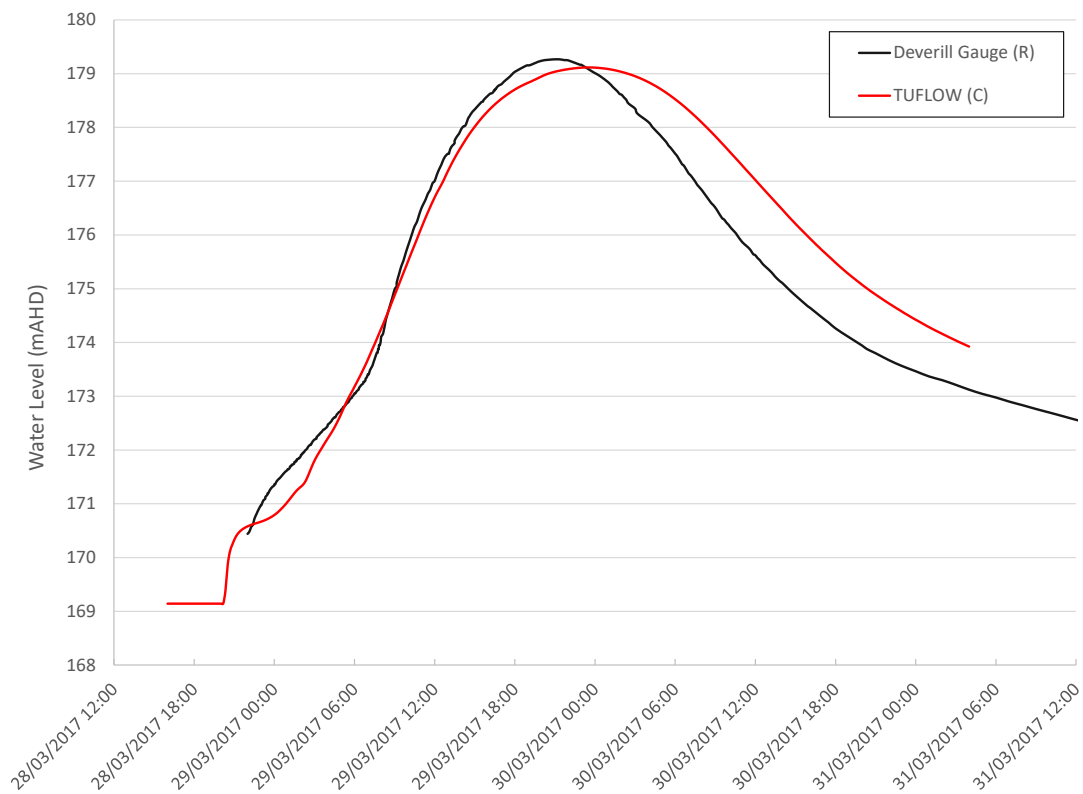
#### 4.3.1 Overview

The model was calibrated to recorded water levels and discharges in the Isaac River at the Deverill stream gauge for the March 2017 event. The discharge hydrographs obtained from the URBS model for the March 2017 event were used as inflows in the TUFLOW model. The Isaac River model was calibrated by adjusting the hydraulic model parameters (particularly Manning's 'n' values) until a satisfactory match was achieved between modelled and observed discharge rating curves at Deverill stream gauge.

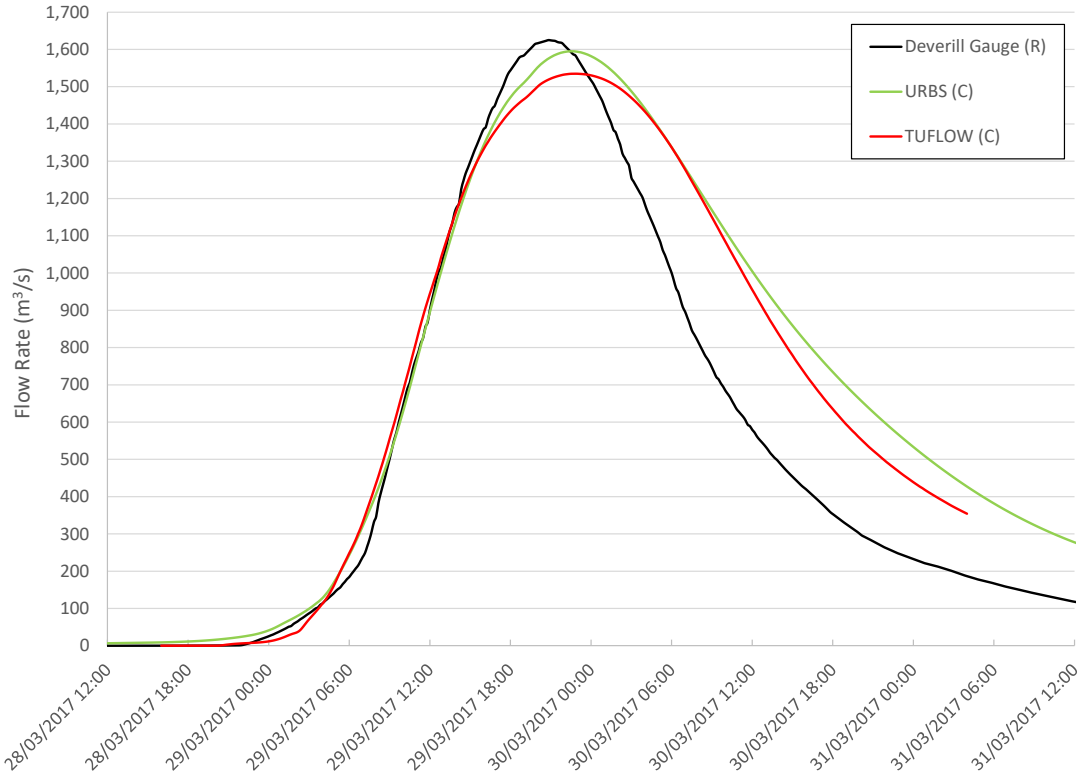
### 4.3.2 2017 event calibration

Figure 4.5 and Figure 4.6 show the recorded and predicted water levels and gauged discharges at Deverill for the March 2017 event.

The model results show that a good calibration was achieved for the TUFLOW model, with a good match to the timing and magnitude of peak flows and water levels, as well as good matches to the hydrograph shape and stage-discharge characteristics.



**Figure 4.5 Comparison of recorded and modelled water level hydrographs, March 2017, Isaac River at Deverill**



**Figure 4.6 Comparison of recorded and modelled discharge hydrographs, March 2017, Isaac River at Deverill**

## 5 DESIGN EVENT FLOOD MAPPING

### 5.1 OVERVIEW

The calibrated TUFLOW model was undertaken to simulate Existing, Pre-mining and Post-mining scenarios for the 0.1% (1 in 1,000) AEP and PMF design flood events, based on critical duration design storm hydrographs selected from the URBS model at Deverill (Table 5.1).

The results of the design events for different scenarios are presented below.

**Table 5.1 Adopted critical duration and Temporal pattern**

Scenario	Critical Duration (hr)		Critical TP	
	1in1000	PMF	1in1000	PMF
Pre-mining	24	24	TP05	TP04
Existing	24	24	TP05	TP04
Post-mining	24	24	TP05	TP04

### 5.2 EXISTING CONDITIONS FLOODING

Figure 5.1 to Figure 5.4 show predicted peak flood extents, depths and velocities for the 0.1% AEP and PMF events under existing conditions.

The model results show that in the vicinity of DNM:

- 0.1% AEP peak flood levels are about 192.6 mAHD and do not vary much along the (western) site boundary; and
- The PMF peak flood levels are about 196.3 mAHD and, like the 0.1% AEP event, do not change significantly across the DNM site area.

### 5.3 PRE-MINING CONDITIONS FLOODING

Figure 5.1 to Figure 5.4 show predicted peak flood extents, depths and velocities for the 0.1% AEP (i.e., the floodplain as defined for the PRCP) and PMF events under pre-mining conditions.

The model results show that in the vicinity of DNM:

- 0.1% AEP peak flood levels are about 192.6 mAHD and show little variation along the site boundary, similar to the existing conditions; and
- The PMF peak flood levels vary slightly across the DNM, ranging between 196.1 and 196.3 mAHD, which is consistent with the existing results.

### 5.4 POST-MINING CONDITIONS FLOODING

Figure 5.9 to Figure 5.12. show predicted peak flood extents, depths and velocities, for the 0.1% AEP and PMF events, under predicted post-mining conditions.

The model results show that in the vicinity of DNM:

- 0.1% AEP peak flood levels vary along the OOPD, ranging from 192.8 mAHD to 194.2 mAHD. Along the flood protection landform, the peak level is about 192.8 mAHD.
- For the 0.1% AEP event, a freeboard of more than 7 meters is maintained above the predicted peak flood level for the flood protection landform.
- Peak velocities along the OOPD range between 1.0 m/s and 1.7 m/s for the 0.1% AEP. This represents an increase compared to existing conditions, where velocities reach up to 1.1 m/s.

Along the flood protection landform, velocities are not changed significantly compared to existing conditions, with velocities below about 0.5 m/s.

- PMF peak flood levels along the OOPD range from about 196.5 mAHD to 198.4 mAHD. Along the flood protection landform, the peak level is about 196.5 mAHD.
- For the PMF, the flood protection landform maintains more than 3.5 m of freeboard above the predicted peak level.
- The flood protection landform in the proposed DNM final landform is not inundated for either the 0.1% AEP or the PMF events.

Table 5.2 shows predicted peak flood levels and velocities along the flood protection landform and OOPD for 0.1% AEP and PMF events under predicted post-mining conditions.

**Table 5.2 Predicted peak flood levels, velocities and freeboard, 0.1% AEP and PMF events under post-mining conditions**

Event	Post-mining landform elevation <sup>1</sup> (mAHD)	Peak flood level (mAHD)	Peak flood velocity (m/s)	Freeboard <sup>2</sup> (m)
<b>Flood protection landform</b>				
0.1%	200	192.8	0.4	> 7.0
PMF	200	196.5	1.1	3.5
<b>OOPD</b>				
0.1%	240	194.2	1.7	N/A
PMF	240	198.4	3.2 <sup>3</sup>	N/A

1. Minimum proposed final landform level at locations with predicted adjacent Isaac River flooding

2. Indicative minimum available freeboard

3. A localised of high velocity, occurring near the southwestern corner of the OOPD. Elsewhere in this area, velocities generally reach between 2.1 and 2.8 m/s at peak.

Note: Peak PMF velocities on the floodplain in the vicinity of the site, vary, with areas of peak velocities exceeding 3 m/s predicted under existing conditions.

## 5.5 ALTERATION OF FLOWS

The proposed post-mining landform includes four (4) residual voids, which have a combined catchment area of 15.6 km<sup>2</sup>. Of this, 5.1 km<sup>2</sup> is excised from the New Chum Creek catchment and 2.2 km<sup>2</sup> is excised from the North Creek catchment. The total excised catchment from the Isaac River of 15.6 km<sup>2</sup>, represents 0.4% of the Isaac River catchment to the Site. This change is minor and unlikely to materially affect peak flows or flow volumes downstream of the Site.

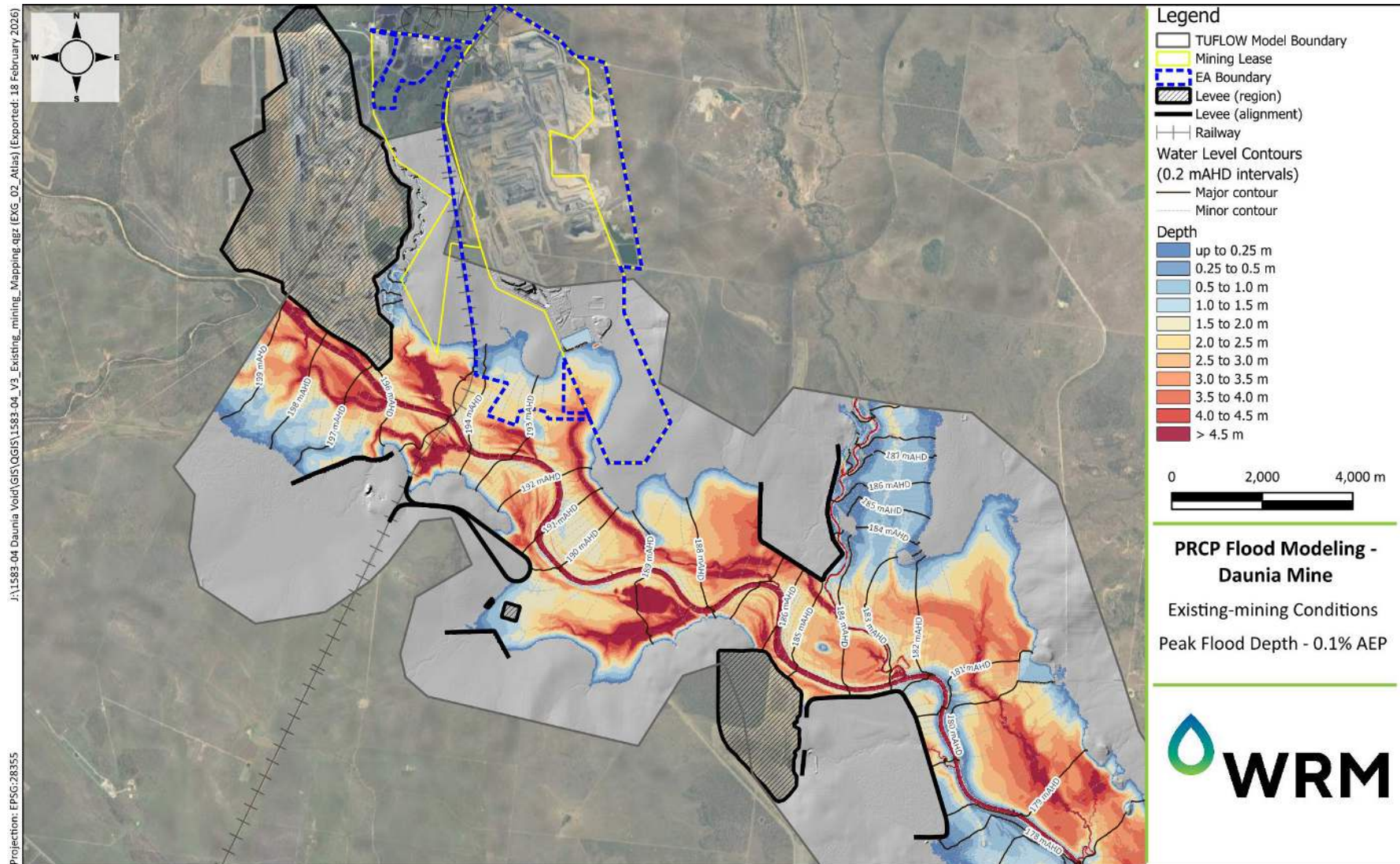


Figure 5.1 Peak flood depth – existing conditions – 0.1% AEP design event

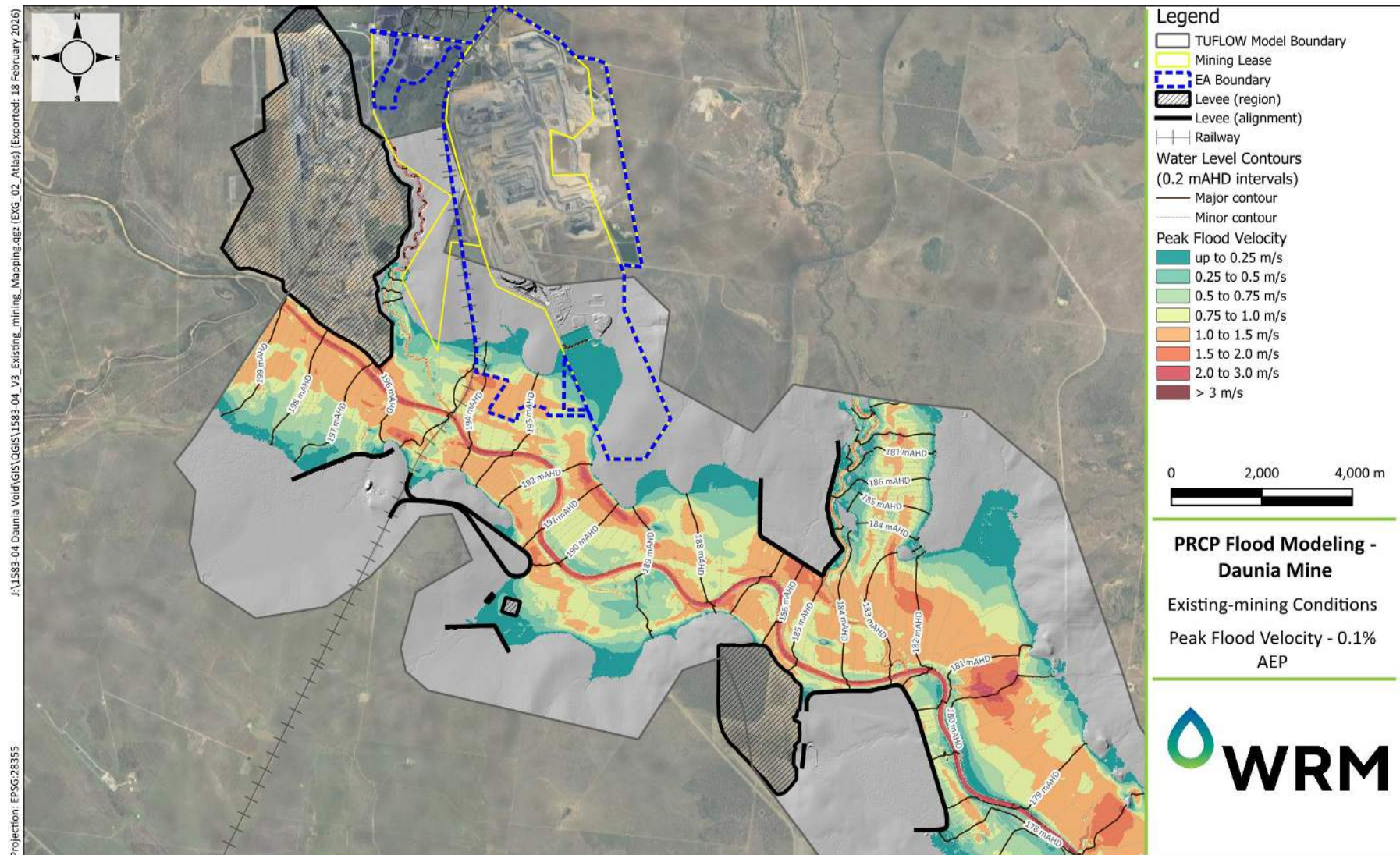


Figure 5.2 Peak flood velocity – existing conditions – 0.1% AEP design event

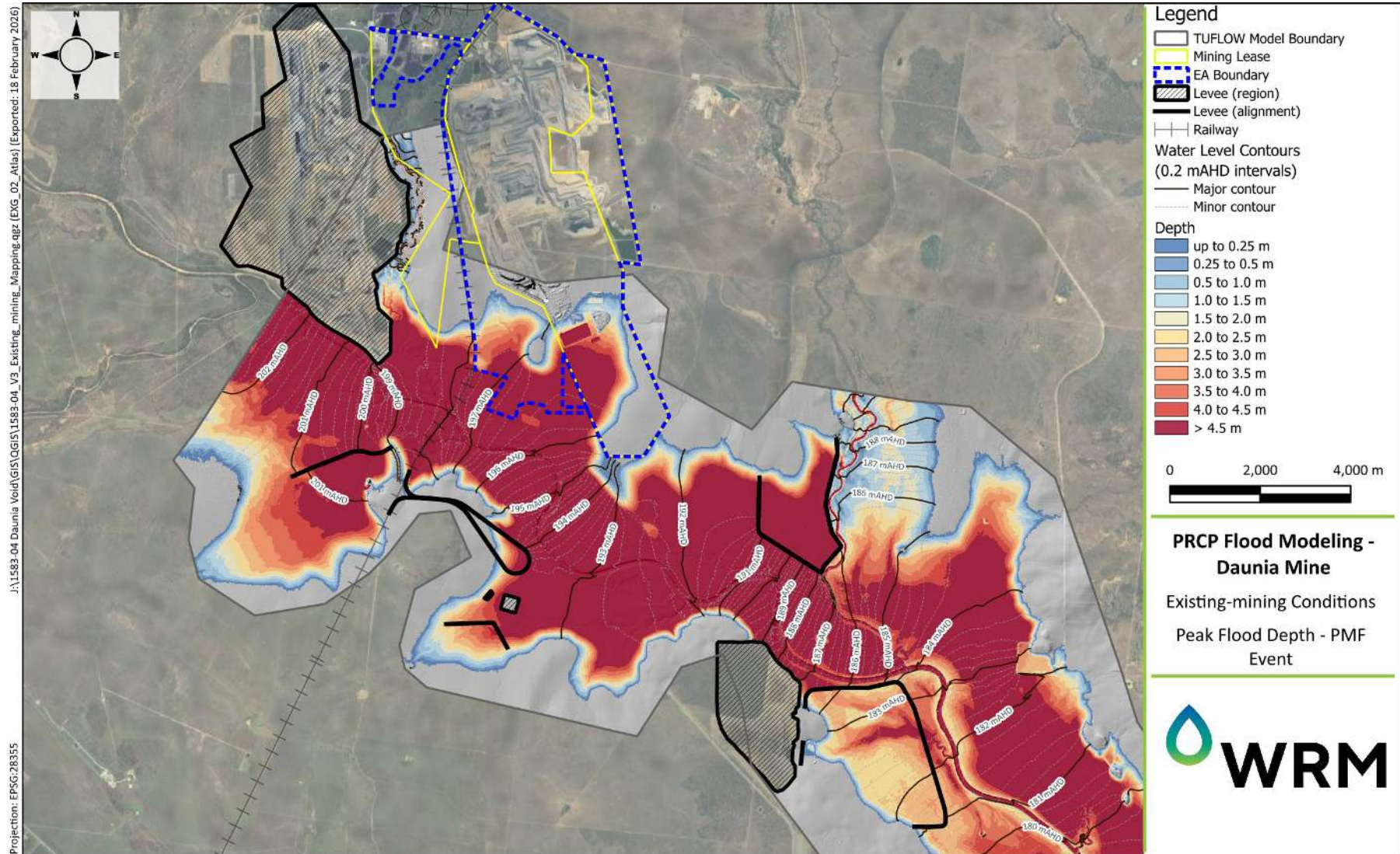


Figure 5.3 Peak flood depth – existing conditions – PMF event

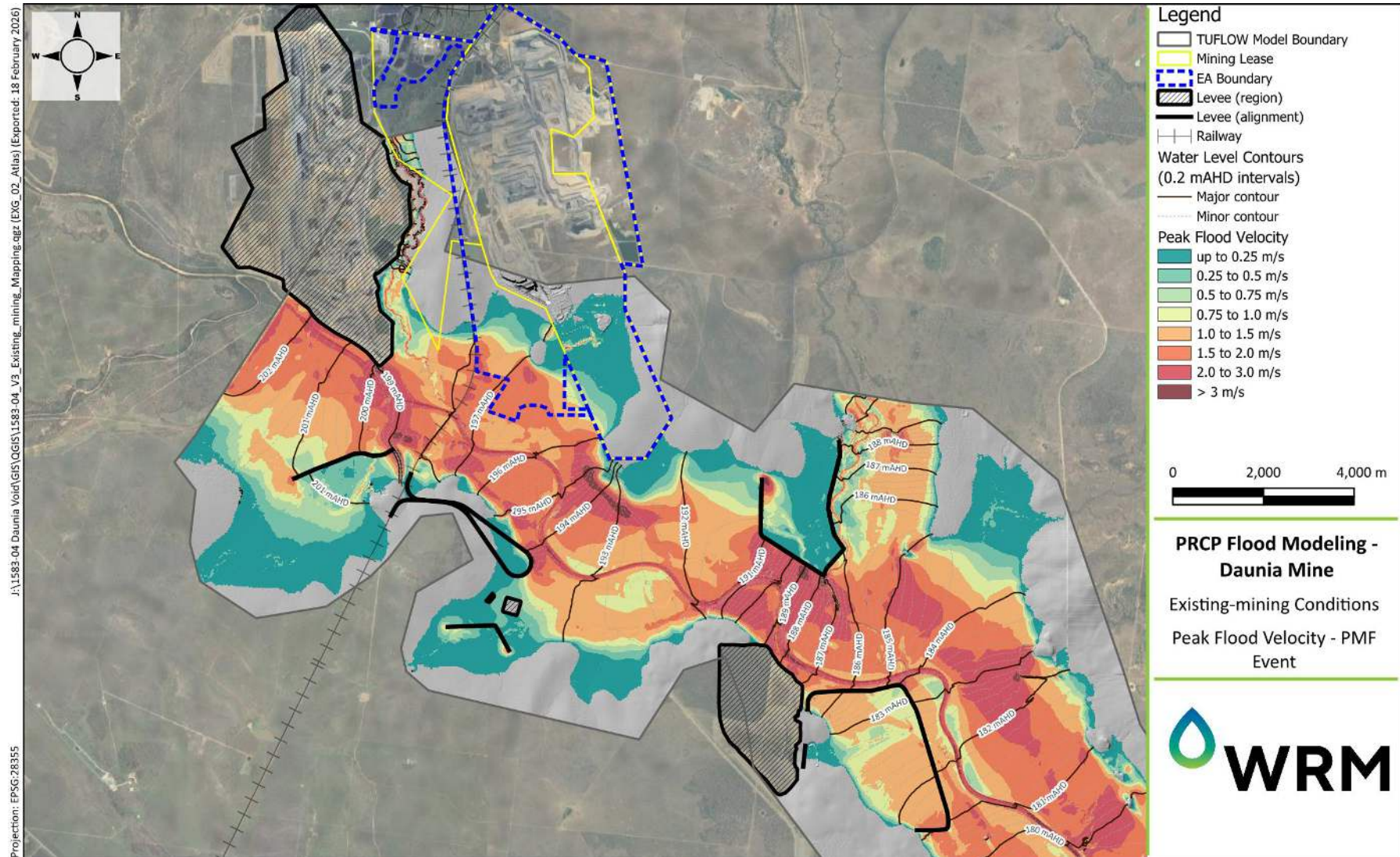


Figure 5.4 Peak flood velocity – existing conditions – PMF event

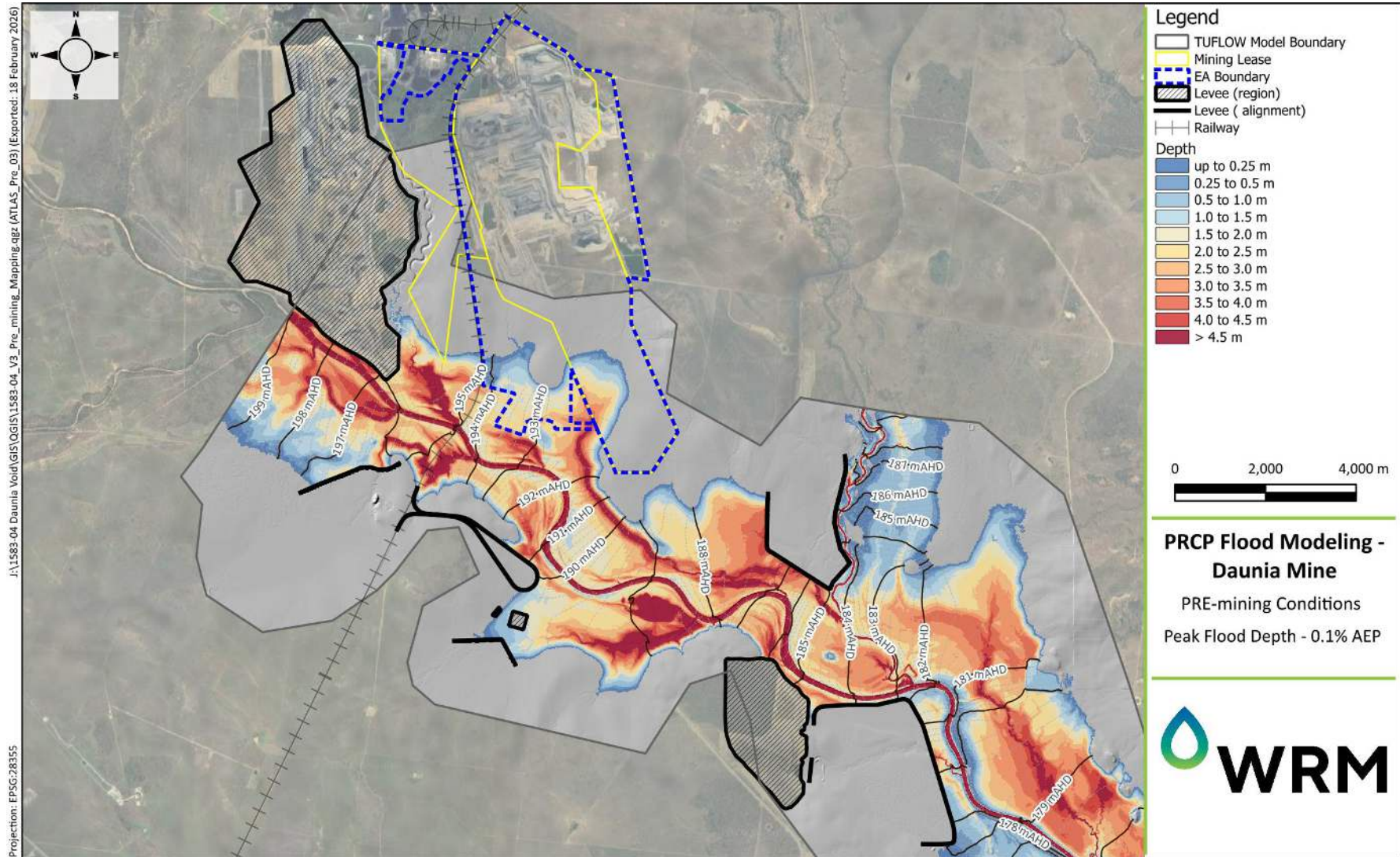


Figure 5.5 Peak flood depth – Pre-mining conditions – 0.1% AEP design event

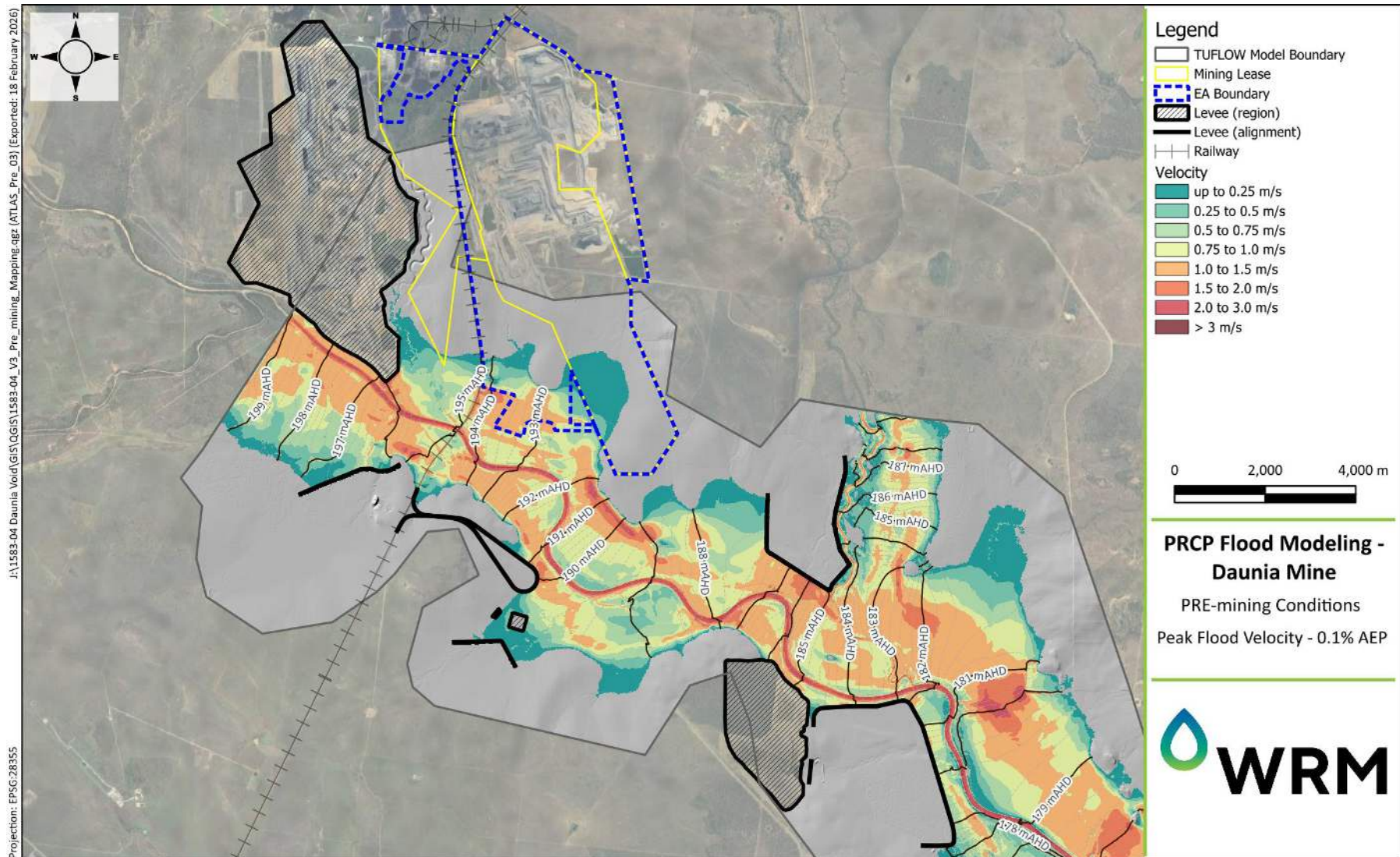


Figure 5.6 Peak flood velocity – Pre-mining conditions – 0.1% AEP design event

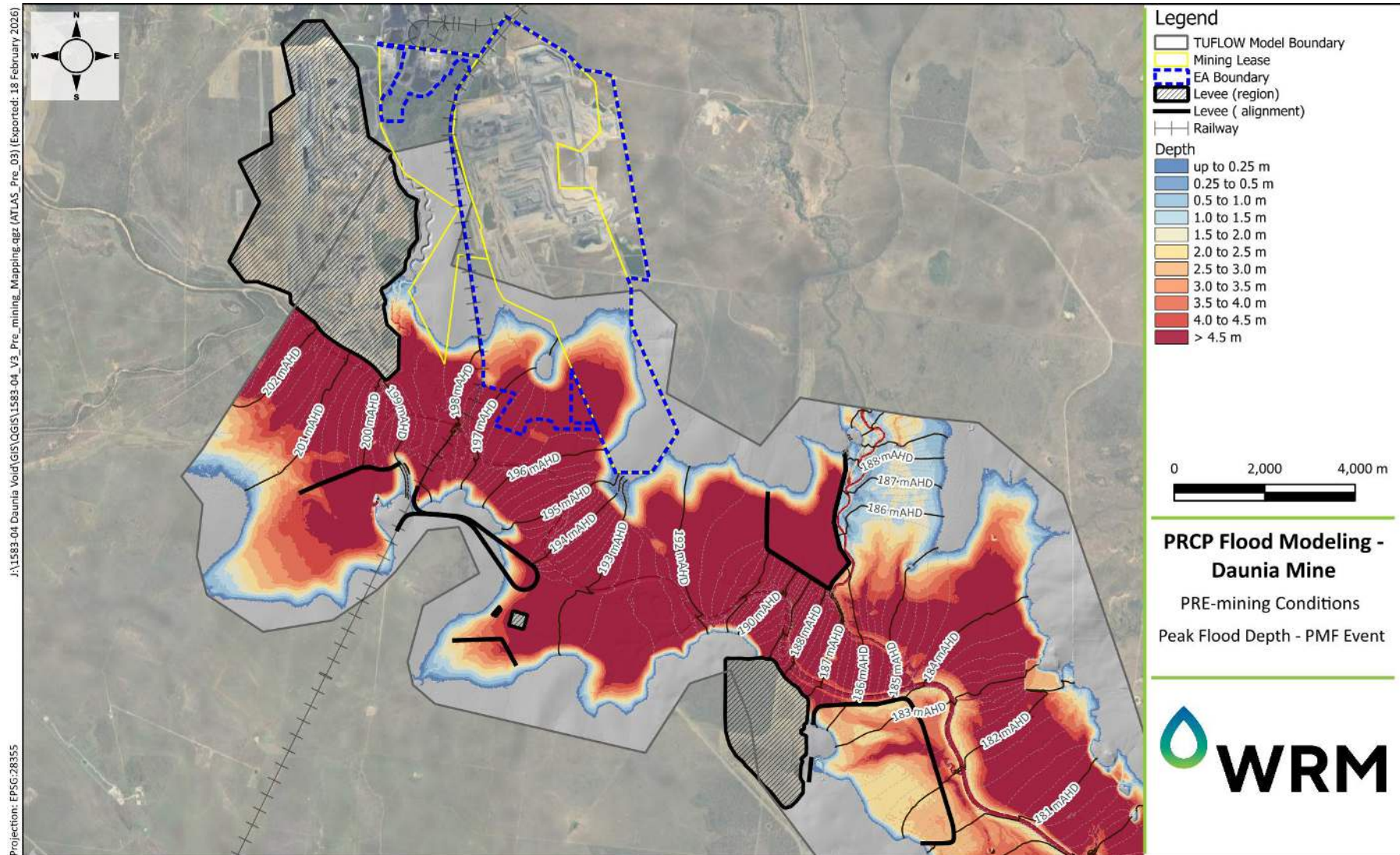


Figure 5.7 Peak flood depth – Pre-mining conditions – PMF event

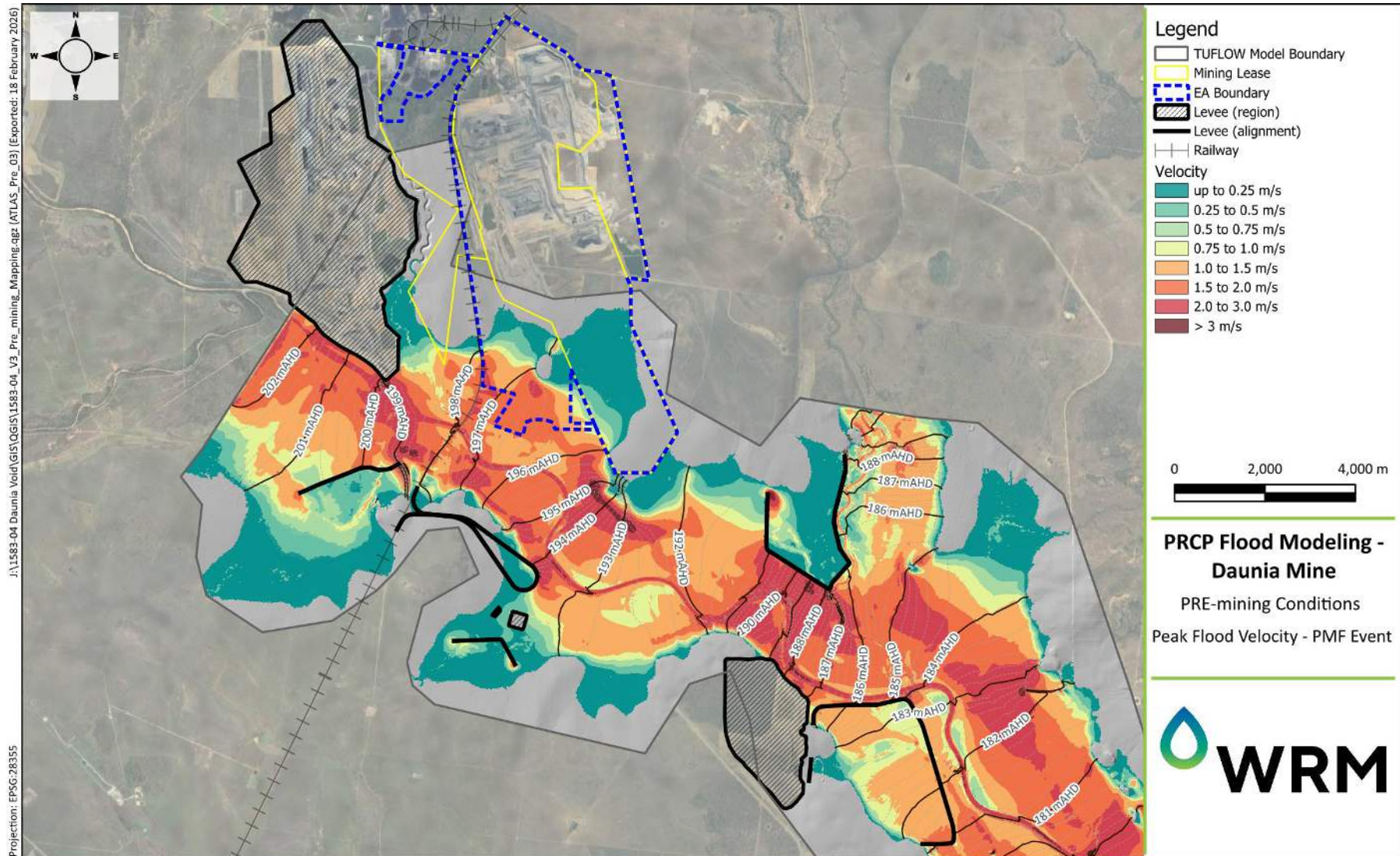


Figure 5.8 Peak flood velocity – Pre-mining conditions – PMF event

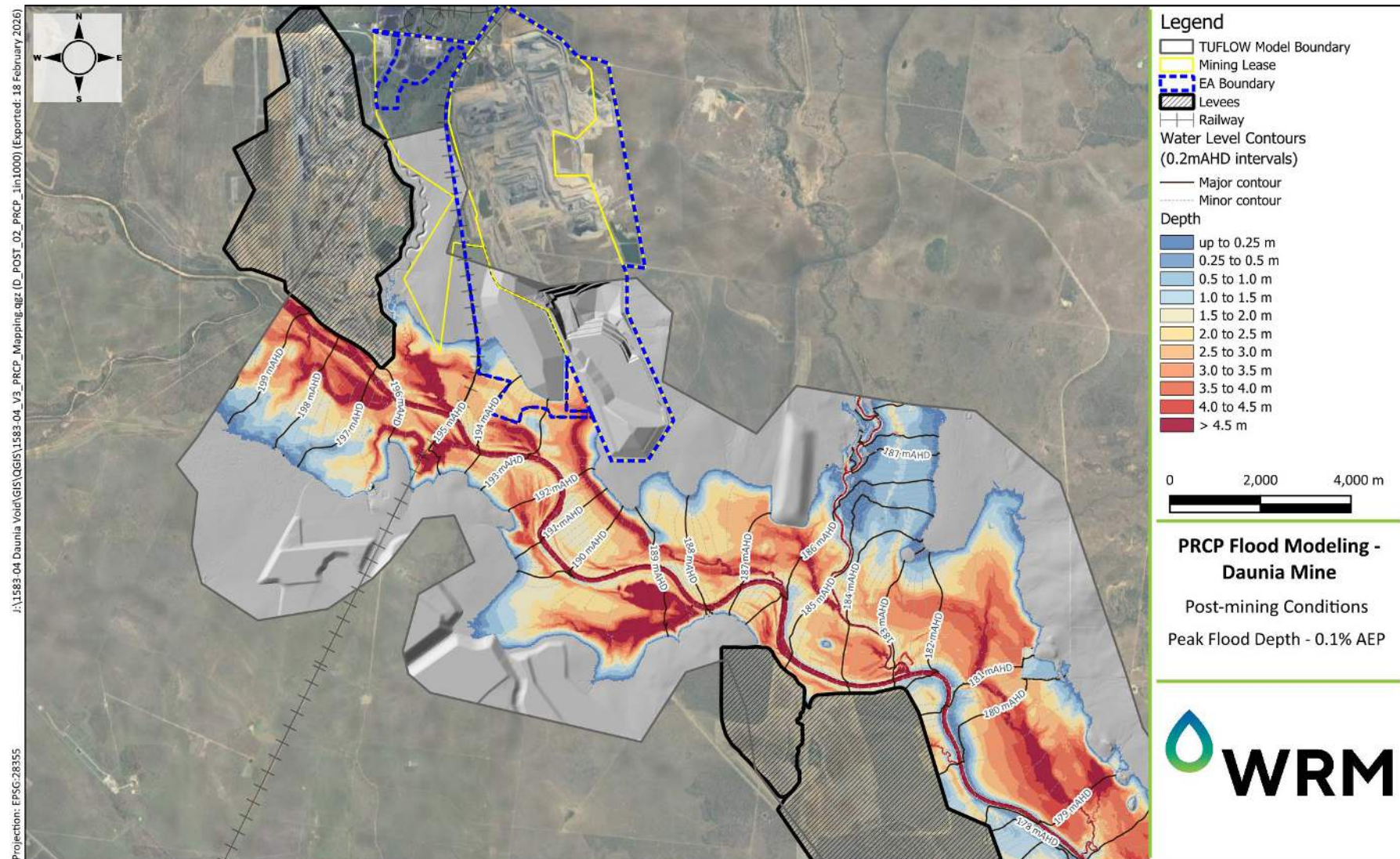


Figure 5.9 Peak flood depth – Post-mining conditions – 0.1% AEP design event

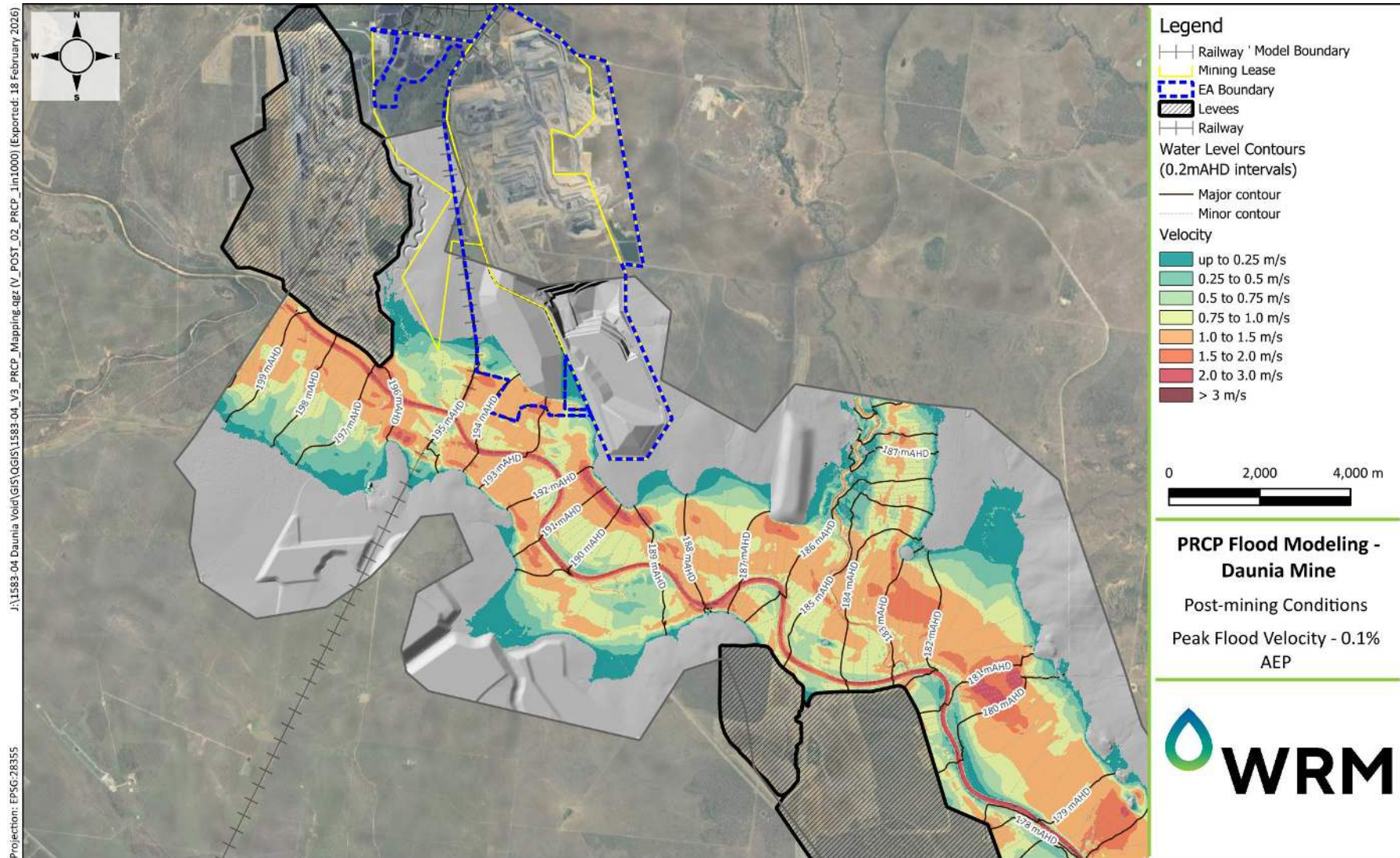


Figure 5.10 Peak flood velocity – Post-mining conditions – 0.1% AEP design event

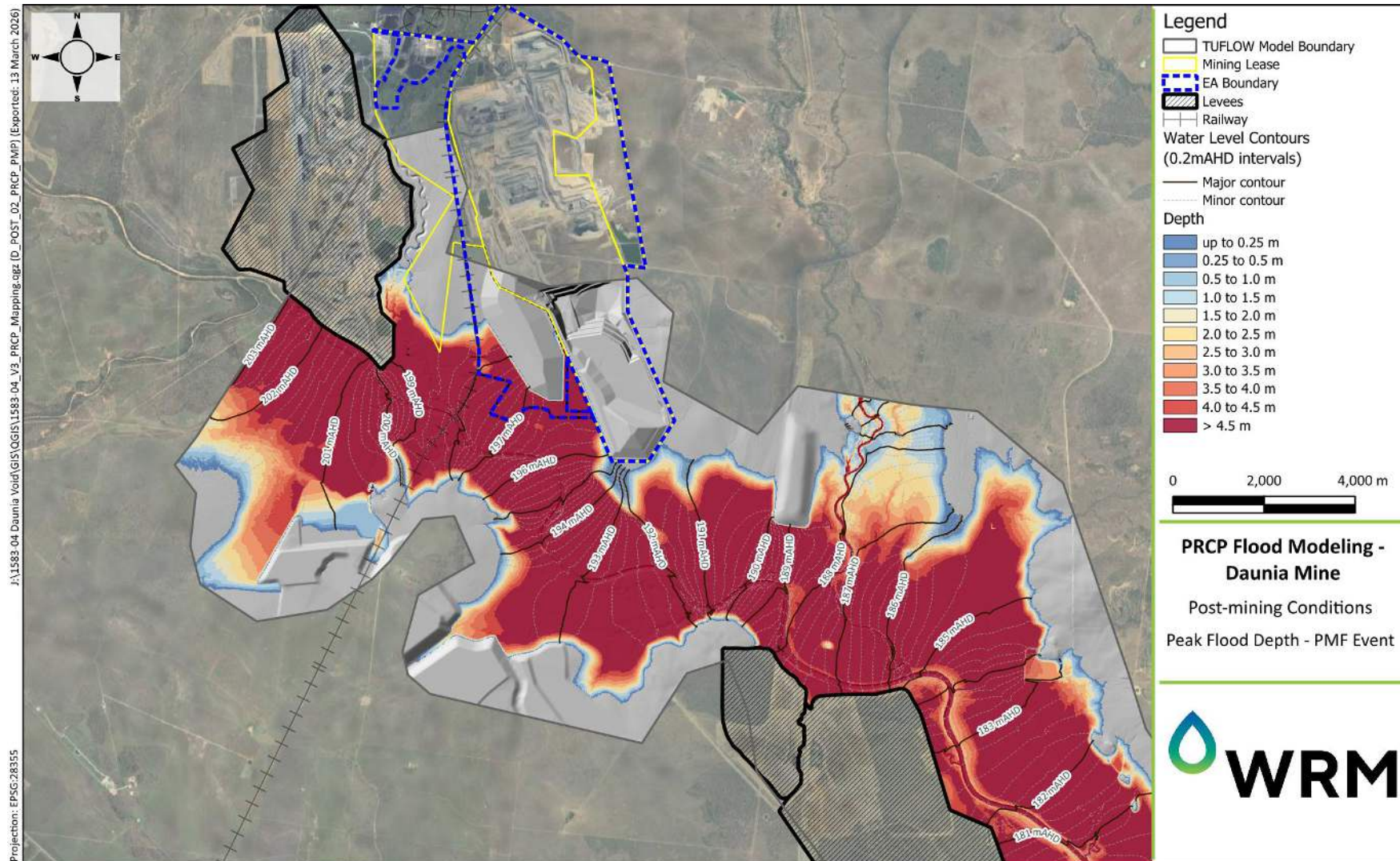


Figure 5.11 Peak flood depth – Post-mining conditions – PMF event

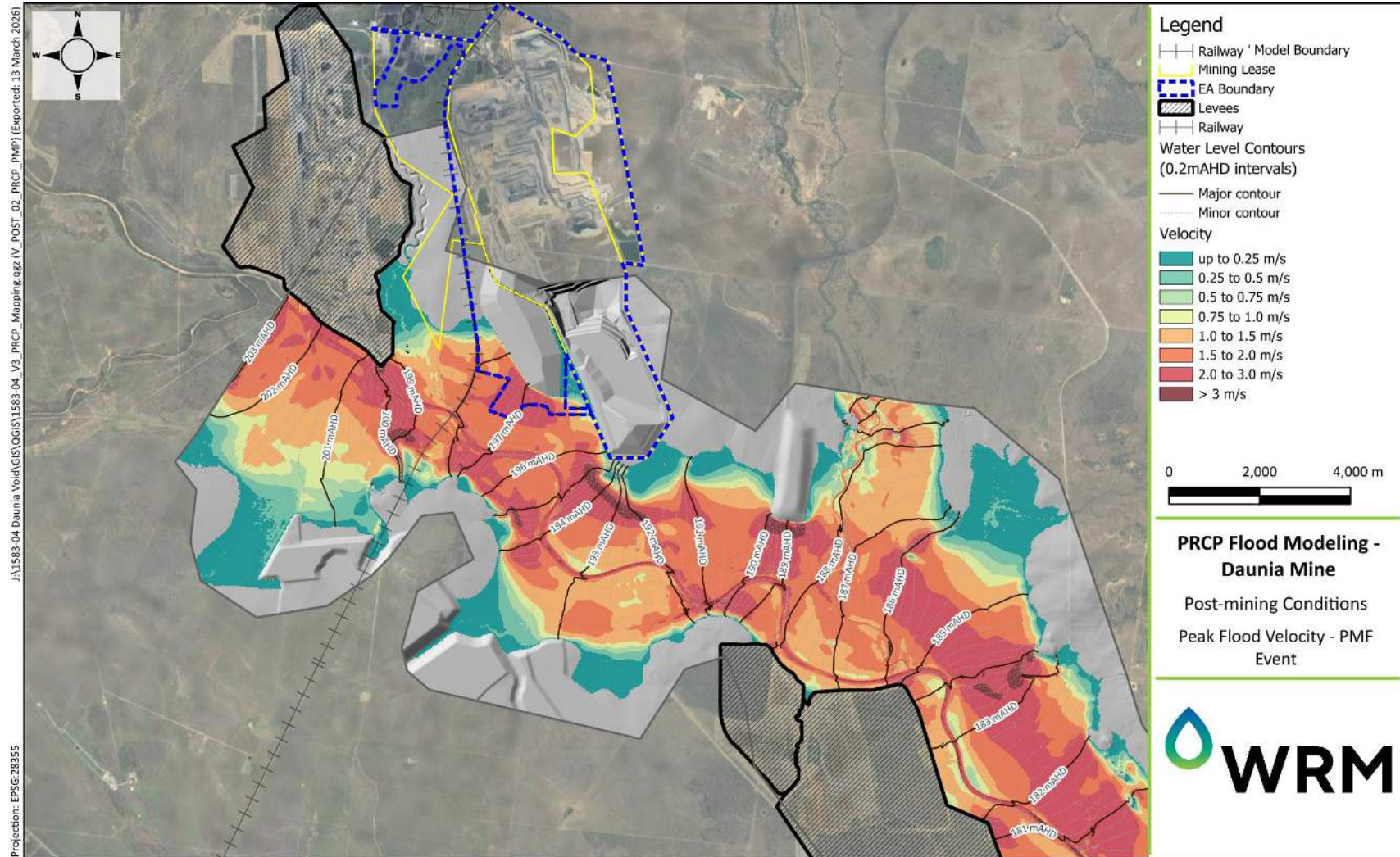


Figure 5.12 Peak flood velocity – Post-mining conditions – PMF event

## 5.6 SENSITIVITY ASSESSMENT

The sensitivity of predicted flooding characteristics at DNM to changes in key model parameters was assessed by varying key model parameters for the 0.1% AEP design event only and assessed:

- Changes in model hydraulic roughness, assessed by running additional 0.1% AEP post-mining conditions scenarios, varying model Manning’s ‘n’ parameters by +/- 20%; and
- Changes to predicted hydrologic conditions as a result of predicted future climate change, assessed by comparing 0.1% AEP design event results with existing and post mining hydrology.

Figure 5.13 shows the predicted change in peak flood levels and extents for the 0.1% AEP event, for a +20% increase in hydraulic roughness.

Figure 5.14 shows the predicted change in peak flood levels and extents for the 0.1% AEP event, for the predicted +1.2 degrees of warming between present day and post mining (year 2100) conditions. Although this comparison between Existing and Post-mining conditions includes impacts from changing landforms at DNM and adjacent sites, the primary change between the scenarios is the +12% increase in peak discharges (see Table 3.13).

Table 5.3 and Table 5.4 show the predicted change in peak flood levels and velocities respectively, at a representative location on the western boundary of DNM, for each of the sensitivity cases.

The model results show:

- Changes to hydraulic roughness (+/-20% changes to Manning’s ‘n’) could see peak flood levels vary by +0.4 m to -0.4 m, and peak velocities vary by approximately +/-0.1 m/s;
- Changes to flows (+12% increase in flows) could see peak flood levels increase by about +0.5m, and peak velocities vary by +0.2 m/s (from 1.1 m/s for existing conditions to 1.3 m/s for post-mining conditions).

The sensitivity assessment illustrates the potential range of predicted peak flooding levels under a range of potential conditions and highlights the importance of a suitable freeboard allowance in final landform design. The available freeboard (see Table 5.2) is well in excess of the potential change in peak flood levels estimated by this sensitivity analysis.

Modelling results show that the DNM proposed final landform is not predicted to be inundated for either the 0.1% AEP or the PMF events, under predicted future climate change conditions (up to +2.5 degrees warming by year 2100).

**Table 5.3 Sensitivity assessment results, change in peak flood level, 0.1% AEP design event (OOPD)**

	Design level (mAHD)	Sensitivity level (mAHD)	Change (m)
Decreased Mannings’ ‘n’	194.1	193.7	-0.4
Increased Manning’s ‘n’	194.1	194.5	+0.4
Increased flows	193.6	194.1	+0.5

**Table 5.4 Sensitivity assessment results, change in peak velocity, 0.1% AEP design event**

	Design velocity (m/s)	Sensitivity velocity (m/s)	Change (m/s)
Decreased Mannings’ ‘n’	1.3	1.4	+0.1
Increased Manning’s ‘n’	1.3	1.2	-0.1
Increased flows	1.1	1.3	+0.2

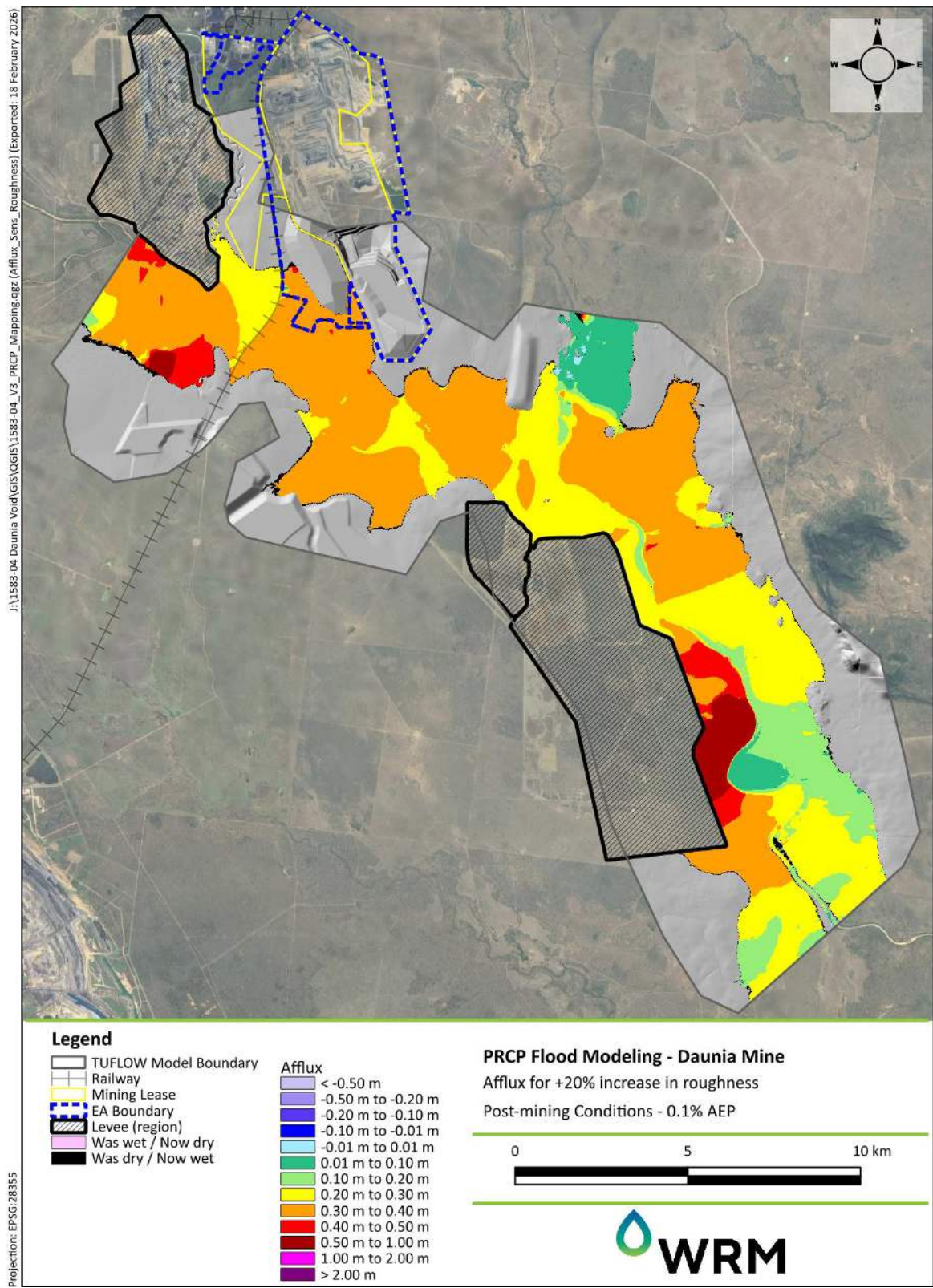


Figure 5.13 Sensitivity impacts, increased hydraulic roughness

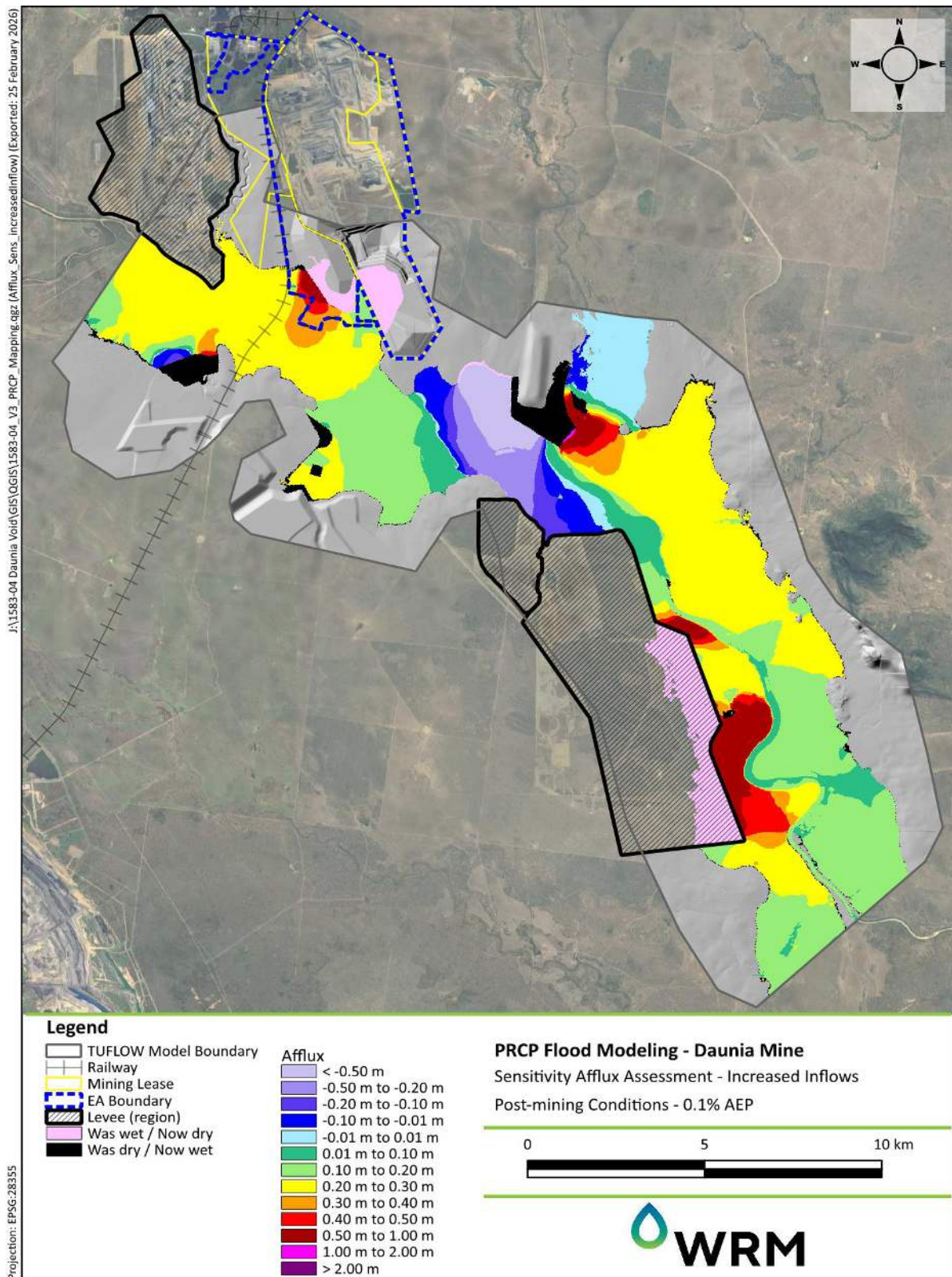


Figure 5.14 Sensitivity impacts, increased discharges

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## 6 CONCLUSION

The Isaac River hydrologic and hydraulic models developed by WRM (2019) were updated to take advantage of updated and improved model versions. The FFA at Deverill was updated to include the five (5) years of additional recorded data. The hydrologic and hydraulic models were updated to incorporate updated ARR2019 guidelines on accounting for the effects of climate change on design discharges both in the present day and for projected future conditions.

The updated models were re-calibrated, and validated against FFA results, before being used to predict peak existing conditions design flood extents, depths and velocities in the vicinity of DNM for the 0.1% AEP and PMF events.

The Isaac River hydrologic and hydraulic models developed by WRM (2019) were updated to take advantage of improved modelling tools and data. The flood frequency analysis (FFA) at Deverill was updated to include five (5) additional years of recorded streamflow data. The hydrologic and hydraulic models were also updated to incorporate the latest ARR2019 guidelines, accounting for the impacts of climate change under both present-day and future (post mining) conditions.

The updated models were recalibrated and validated against the revised FFA results before being used to predict flood behaviour for the 0.1% AEP and PMF events. Peak flood extents, depths, and velocities were predicted for each of the three scenarios (existing, pre-mining and post-mining).

Results show that Isaac River floodwaters do not overtop the flood protection landform, for events up to and including the PMF, under post mining (+2.5 degrees warming at year 2100) conditions.

Model results also show that predicted peak velocities for the 0.1% AEP design event are up to about 1.7 m/s along the proposed final landform, which is consistent with predicted peak velocities under existing and pre-mining conditions.

Sensitivity model results also show that the available freeboard for the proposed DNM flood protection landform is more than the predicted potential change in peak flood levels estimated by the sensitivity analysis, and the predicted potential change in peak velocities under sensitivity analysis are minor.

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