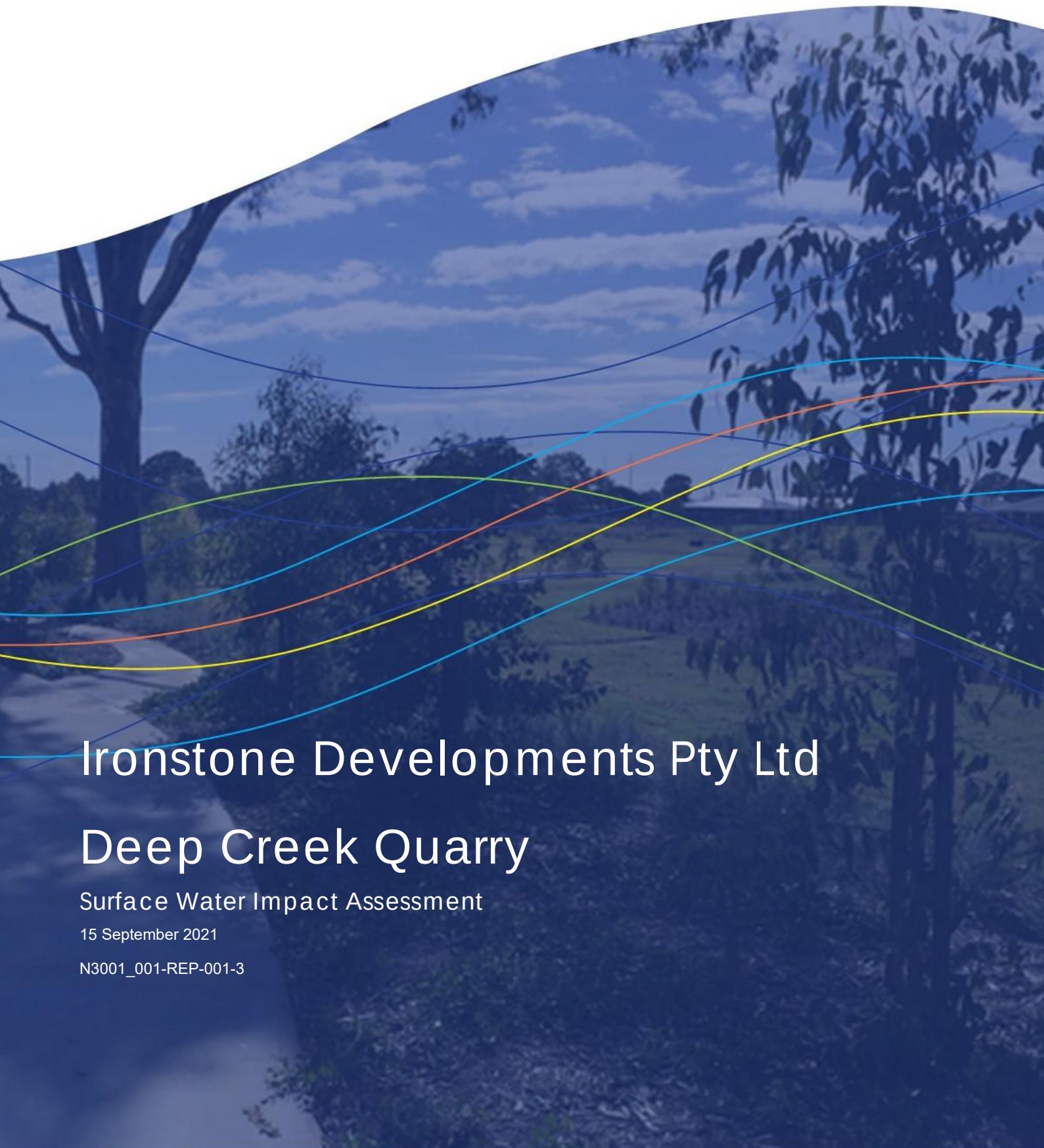
APPENDIX J: SURFACE WATER IMPACT ASSESSMENT

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Ironstone Developments Pty Ltd

Deep Creek Quarry

Surface Water Impact Assessment

15 September 2021

N3001_001-REP-001-3

Job no. and Project Name: N3001_001 DEEP CREEK QUARRY SURFACE WATER IMPACT ASSESSMENT
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
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2	18/08/2021	Client Issue	Michael Best	Adam Wyatt	Adam Wyatt	Susan Shield
3	15/09/2021	Client Issue	Adam Wyatt	Susan Shield	Adam Wyatt	Susan Shield
Signatures						

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1 INTRODUCTION

1.1 PROJECT DESCRIPTION

Ironstone Developments Pty Ltd (IDPL) proposes to develop a hard rock quarry called Deep Creek Quarry (DCQ), located off the Bucketts Way, adjacent to Deep Creek. Deep Creek flows into the Karuah River about 20 km downstream of DCQ (Figure 1-1).

DCQ will operate during daylight hours, Monday to Saturday, producing an estimated 0.5 million tonnes per annum (Mtpa) of materials, from an estimated resource of up to 12 million tonnes. The estimated production rate and resource triggers a State Significant Development. The quality of the resource, and the range of products to be produced by DCQ mean that minimal overburden is expected to be generated.

The proposed footprint of DCQ is about 33 ha, including 18 ha of quarry extraction area, within a well vegetated, rocky spur line ranging from 37 to 115 mAHD. The quarry will have a floor elevation of about 37 mAHD, allowing the final landform to be free draining to the adjacent Deep Creek (elevation of about 28 mAHD). The pit floor will also remain above the more acidic (lower pH) groundwater resources. The final landform will be grassed (floor) and vegetated (benches).

DCQ will include (Figure 1-2):

- A new intersection, access road (within an access corridor through adjacent properties), and creek crossing.
- A new power line (within the access corridor, if required).
- Workshop, weigh bridge, and office.
- Material stockpiles.
- Crushing, sizing and stockpiling on quarry floor.



Figure 1-1: Location (source: J Berry)

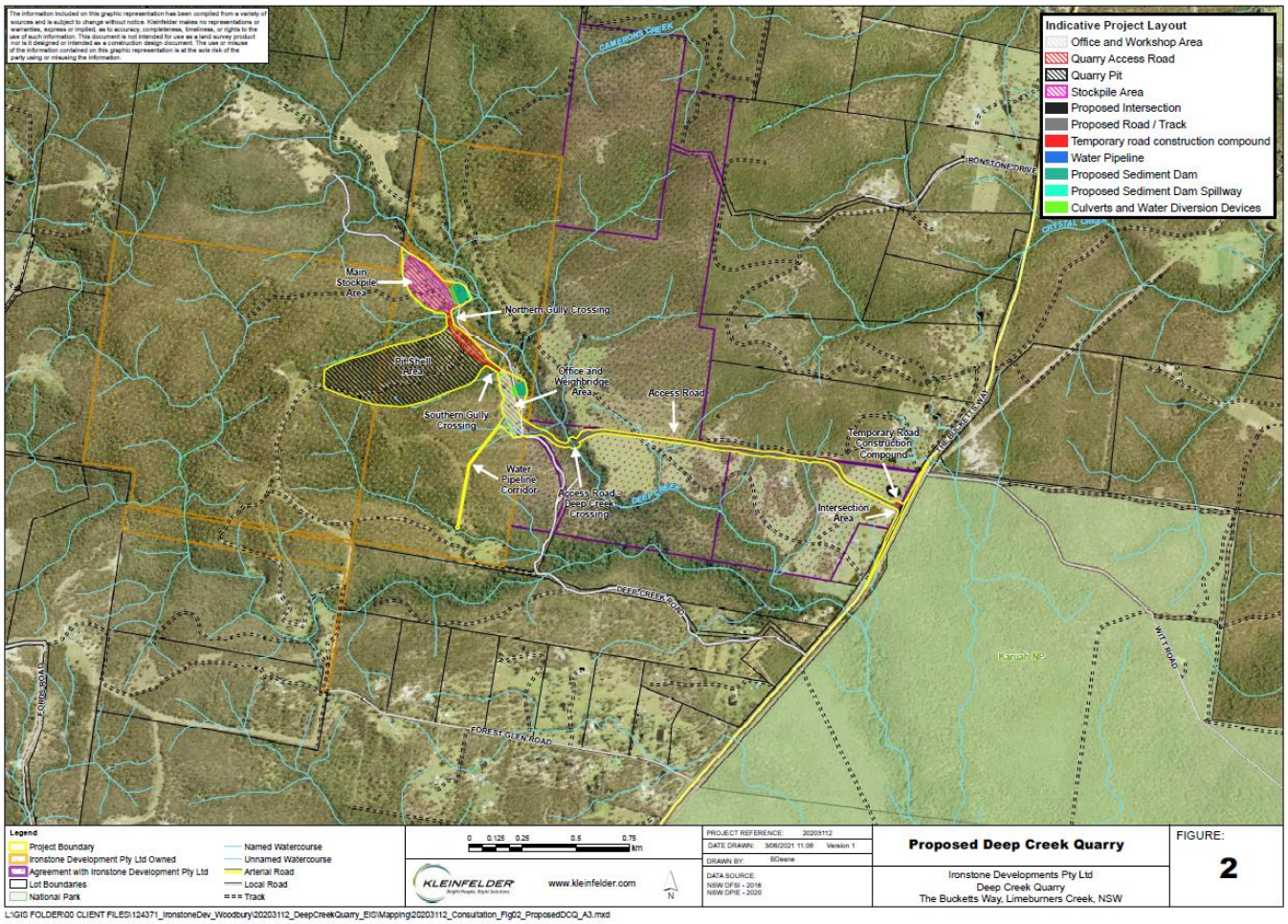


Figure 1-2: Site Layout (source: J Berry / Kleinfelder)

1.2 MEASURES TO MINIMISE OR AVOID POTENTIAL SURFACE WATER IMPACTS

Detailed environmental studies have been undertaken to inform the conceptual design for the proposed development. The consideration of the outcomes of these studies in the design of DCQ, along with a range of other key factors, minimise the potential for the proposed development to impact on surface water resources. These factors include:

- Management of water take and discharge of water within regimes established by NSW water and pollution control legislation.
- Development of a suitable water management system (WMS) to meet legislative requirements and relevant guidelines (e.g. guidelines for treatment of runoff from disturbed areas).
- Maximised water recycling within the WMS to minimise the total volume of water harvested from, and discharged to, the environment.

1.3 POTENTIAL SURFACE WATER IMPACTS

Notwithstanding the measures to minimise impacts, the following aspects of the project have the potential to impact on surface water resources:

- Landform changes as a result of the quarry operations.
- Infrastructure, including creek crossings, associated with the access road.

The following surface water aspects were reviewed as part of the Surface Water Impact Assessment:

- Catchment area and flow changes.

- Flooding, including flow rates, velocities and depths in Deep Creek.
- Water quality.

1.4 STRUCTURE OF REPORT

The Surface Water Impact Assessment Report includes the following sections:

- Surface water context, including regulatory framework, catchments and watercourses, flow regimes, water quality and water users (refer to Section 2).
- Water Management System (refer to Section 3).
- Water balance modelling (refer to Section 4).
- Surface water impacts proposed mitigation measures (refer to Section 5).
- Management, Monitoring, Licensing and Reporting (refer to Section 6).

2 SURFACE WATER CONTEXT

2.1 REGULATORY FRAMEWORK

DCQ will exist within a well-regulated system that has been designed to provide for the sustainable management of the State's water resources. This includes licensing of allowable water take with consideration of environmental flow requirements of watercourses and the needs of other water users; control of water pollution; and guidelines that govern the appropriate design of water management systems to provide for appropriate water quality in accordance with Environment Protection Licence (EPL) requirements. Further details of the NSW surface water regulatory framework and how it will be applied to DCQ is provided below.

2.1.1 NSW Regulatory Requirements – Water Use/Take

The objective of the Water Management Act 2000 (WM Act) is the sustainable and integrated management of water in NSW and is based on the concept of ecologically sustainable development. The WM Act defines water access and water sharing strategies within NSW. The WM Act supersedes the provisions of the Water Act 1912 where a Water Sharing Plan (WSP) is in place, and for works adjacent to or within watercourses.

As part of the WM Act, WSPs have been developed across NSW to protect the health of rivers, whilst at the same time securing sustainable access to water for all users. The WSPs specify maximum water extractions and allocations. By complying with the requirements of the WSPs, water take will be within the sustainable yield for the water system as determined by the NSW government. This in turn provides for sustainable environmental flows within the water systems.

The surface water within the vicinity of the site is managed by the Water Sharing Plan for the Lower North Coast Unregulated and Alluvial Water Sources 2016.

Groundwater within the vicinity of the site is managed by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (New England Fold Belt Coast Groundwater Source).

2.1.2 Licensing

All water extraction in NSW, apart from some exemptions for government authorities and basic landholder rights extractions, must be authorised by a water licence. Harvestable rights, which are a Basic Landholder Right under the WM Act, allow a landholder to capture and use up to 10 per cent of the average regional runoff from a landholding. Basic landholder rights are exempt from licensing requirements.

Each water licence, referred to under the WSP system as a Water Access Licence (WAL), specifies a share component. The share components of specific purpose licences such as local water utility, major utility and domestic and stock are expressed as a number in megalitres per year. The share components of high security, general security and supplementary WALs are expressed as a number of unit shares for the water source. The value of each unit share is subject to Available Water Determinations (AWDs) as specified by DPIE Water).

2.1.3 Works Adjacent to, or Within, Watercourses

Controlled Activity Approvals (CAA) are required under the WM Act to carry out controlled activities in, on, or under waterfront land. State Significant Development (SSD) projects approved under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) do not require controlled activity approvals as the requirements for works are assessed in detail as part of the assessment process and any specific further requirements addressed in the consent conditions.

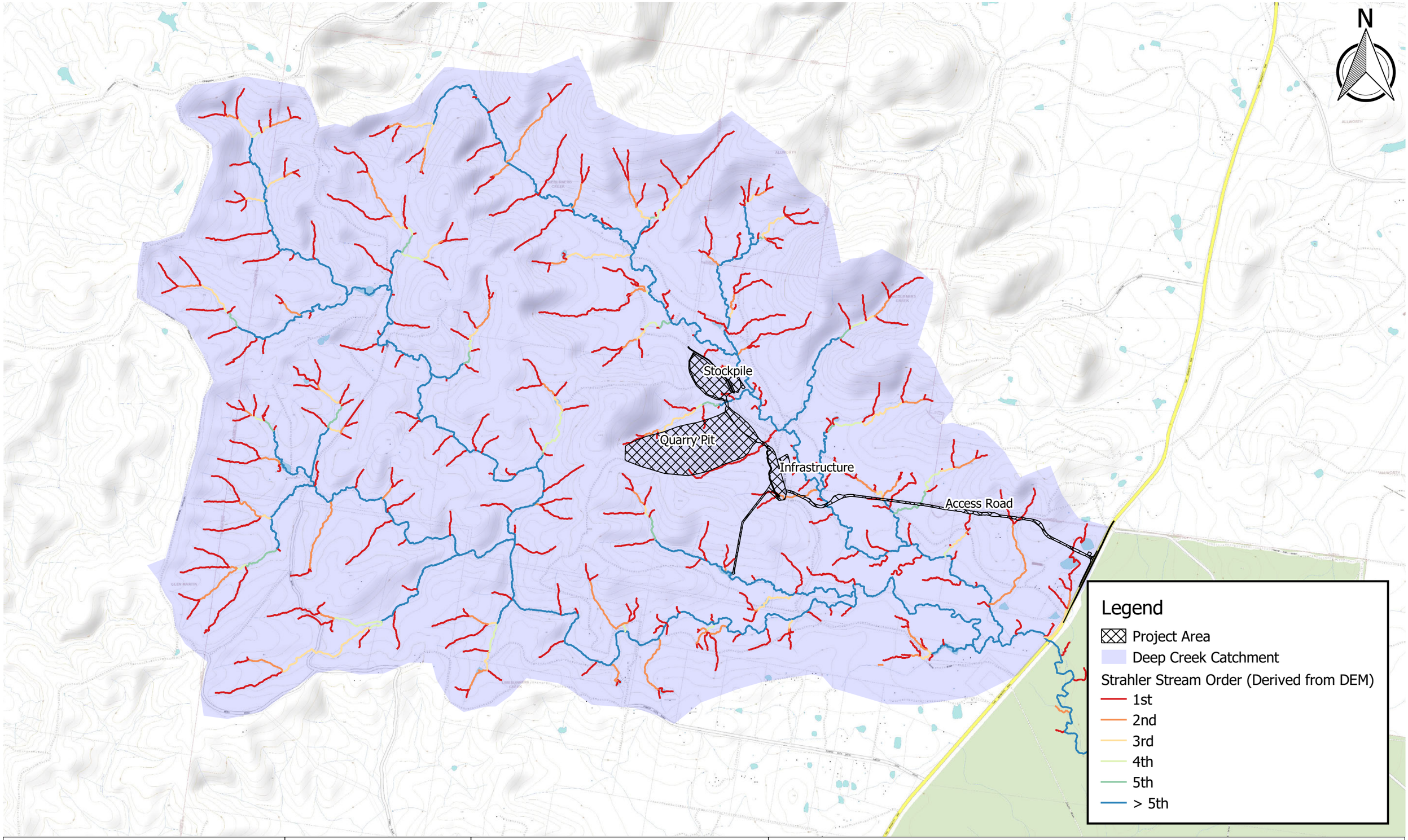
2.1.4 Environment Protection License

Activities that may lead to pollution of waters in NSW are regulated by the EPA under the Protection of the Environment and Operations Act 1997 (POEO Act). Where discharge of waters is permitted, it is controlled by licence conditions such that discharges do not result in significant impacts on water resources.

2.2 CATCHMENT AREAS AND WATERCOURSES

DCQ is located within the catchment of Deep Creek, a tributary of the Karuah River (Figure 2-1). Within the vicinity of DCQ, Deep Creek is a third order watercourse, with a catchment area of about 1,500 ha (upstream of The Bucketts Way: Figure 2-1).

The upper catchment areas of Deep Creek are generally steep and forested lands with extensive rock outcropping. The channel sections of Deep Creek are moderately sinuous, with bed and bank materials ranging from large boulders and rock, to alluvial materials that include sections of currently active head-cuts. The Creek is separated from the upper slopes by colluvium deposits that are generally cleared with sporadic tree coverage. Deep Creek extends from its headwaters located about 2 km west of DCQ to its confluence with the Karuah River about 10 km east.Land uses within and immediately surrounding DCQ is primarily agricultural. Further downstream (east of The Bucketts Way) is the Karuah National Park.



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500 0 500 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry

Figure 2.1
Surface Water Context

Job Number: N1222_001
Revision: A
Drawn: Adam Wyatt
Checked: MB
Date: 24/3/2021

2.3 FLOODING

Detailed flood modelling was undertaken to estimate the existing flood conditions within Deep Creek, as well as estimate the potential changes to the flooding in response to the proposed DCQ development (Section 5.3).

A detailed description of the flood modelling methods, assumptions, and input data is included in Appendix A and a full suite of thematic mapping, showing maximum modelled flood depths, extents, and velocities for the existing conditions in Deep Creek are included in Appendix B.

The modelling indicates that flooding is generally confined to the main channel of Deep Creek, with only a small out of bank floodplain about 100 m wide (Figure 2-2). The quarry, stockpile area, and infrastructure area are all located outside of the modelling 1% Annual Exceedance Probability (AEP) flood extent.

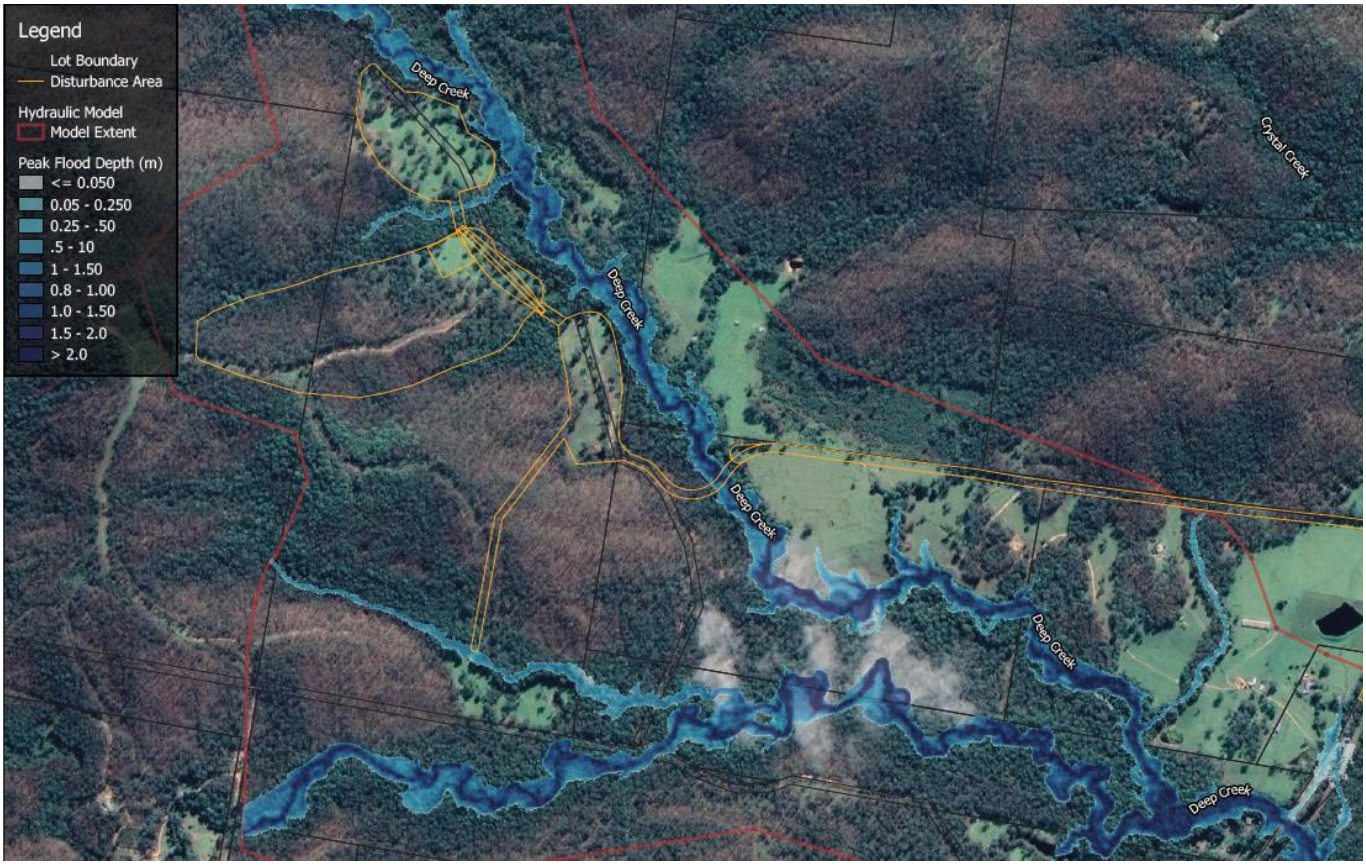


Figure 2-2: Maximum Modelling Flood Depths (1% AEP) – Existing Conditions

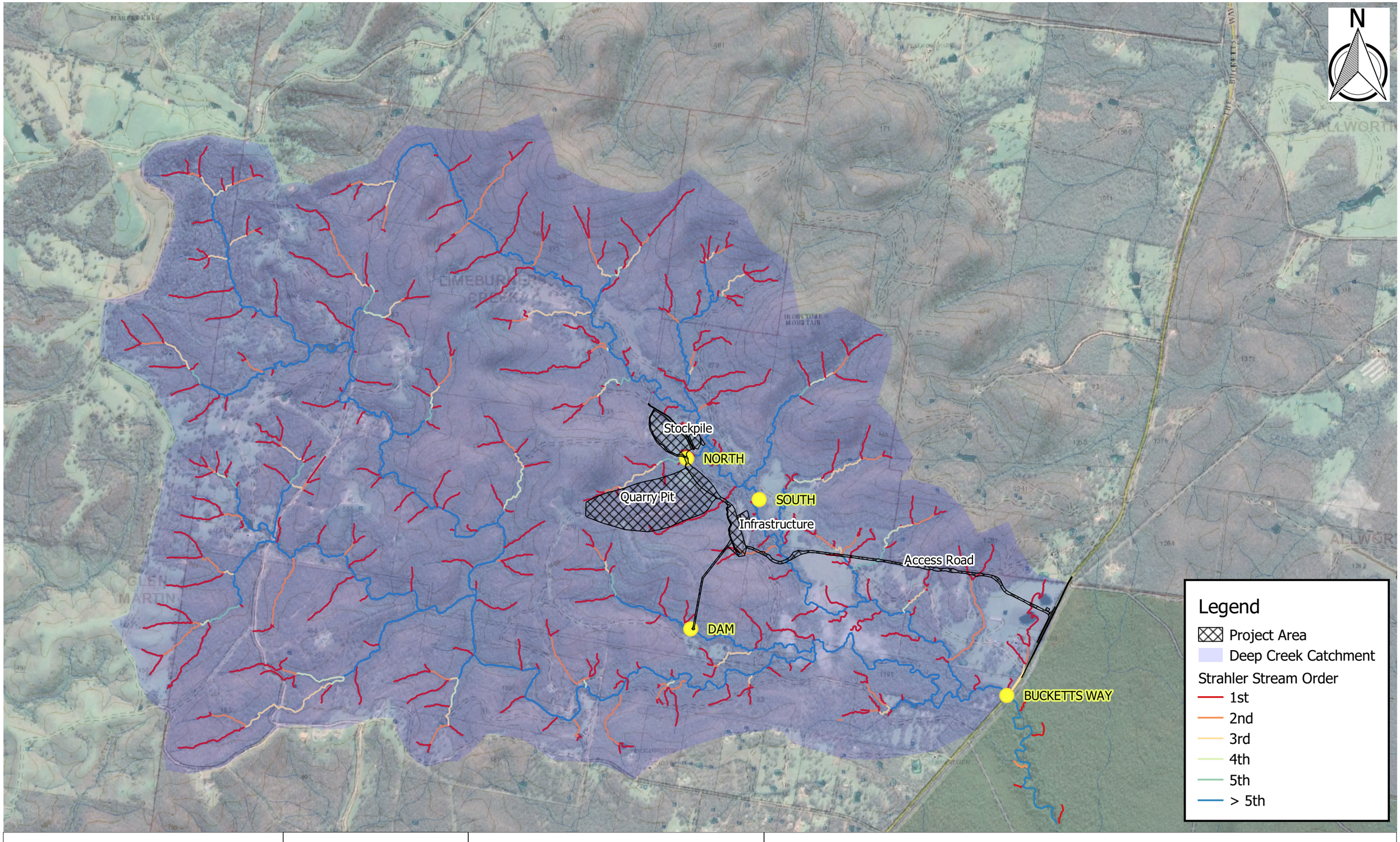
2.4 WATER QUALITY

2.4.1 Monitoring Program

Surface water quality monitoring has been undertaken at four locations (Figure 2-3):

- NORTH:
  - Located on a tributary of Deep Creek, separating the proposed quarry pit and stockpile areas.
  - Monthly field (pH and electrical conductivity (EC)) testing from July 2014 to October 2015 and January 2019 to March 2020; otherwise, sporadic.
  - Quarterly (approximately) laboratory testing from August 2014 to January 2020.
- SOUTH:
  - Located on the main channel of Deep Creek, adjacent to the proposed infrastructure area.
  - Monthly field (pH and EC) testing from July 2014 to October 2015; otherwise, quarterly (approximately).

  - Quarterly (approximately) laboratory testing from July 2014 to July 2017.
- DAM:
  - Located on an existing in-line dam, on an unnamed tributary to the south of the project.
  - Monthly field (pH and EC) testing from July 2014 to October 2015; otherwise, quarterly (approximately).
  - Quarterly (approximately) laboratory testing from July 2014 to January 2018.
- BUCKETTS WAY:
  - Located on Deep Creek at the Bucketts Way bridge, about 1.5 km downstream of the site.
  - Monthly field (pH and EC) testing from January 2019 to March 2020.
  - Quarterly (approximately) laboratory testing from January 2019 to January 2020.



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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry

Figure 2.3
Water Quality Monitoring Locations

Job Number: N1222_001
Revision: 0
Drawn: Adam Wyatt
Checked: MB
Date: 9/4/2021

2.4.2 Observations

A summary of the observed water quality data is included in Table 2.1. According to the methods outlined in the Australia and New Zealand Guidelines (ANZG 2018), 24 monthly samples are required to identify site-specific water quality trigger values. Therefore, there is insufficient data to identify site-specific water quality triggers for most analytes. However, combining the field and laboratory samples allows for the estimate of site-specific trigger values for EC and pH, which is naturally low in the Deep Creek system.

Water quality monitoring indicates occasional high background concentrations of fluoride, phosphorous and nitrogen, as well as very high levels of metals including aluminum, chromium, copper, iron, lead, and zinc (Table 2.1). Concentrations of these metals is in part governed by the background pH level.

Table 2.1: Summary of Water Quality Data

Analytes	Units	LOR	ANZG Default Trigger	DAM		NORTH		SOUTH		BUCKETTS WAY	
				#	Range	#	Range	#	Range	#	Range
Anions and Cations (Laboratory)											
Sodium	mg/L	1.0	-	10	19 to 37	12	10 to 38	9	18 to 43	-	-
Calcium	mg/L	1.0	-	10	2 to 4	12	3 to 9	9	4 to 10	-	-
Magnesium	mg/L	1.0	15 [A]	10	3 to 6	12	2 to 6	9	4 to 7	-	-
Potassium	mg/L	1.0	-	10	2 to 6	12	2 to 9	9	2 to 3	-	-
Total sulphur	mg/L	1.0	-	9	1 to 3	12	1 to 8	8	0 to 6	-	-
Sulphate	mg/L	1.0	-	10	1 to 7	10	< LOR to 22	8	< LOR to 18	-	-
Chloride	mg/L	1.0	-	10	31 to 57	12	11 to 59	9	20 to 66	-	-
Fluoride	mg/L	0.1	0.02 [A]	3	< LOR to 0.1	8	< LOR to 0.1	3	< LOR to 0.1	-	-
Total phosphorus	mg/L	0.01	0.025 [B]	3	0.02 to 0.03	5	0.02 to 0.11	4	0.01 to 0.03	-	-
Nitrite and nitrate	mg/L	0.01	-	1	0.01	2	0.01 to 0.17	2	0.01	-	-
Total nitrogen	mg/L	0.1	0.350 [B]	3	0.5 to 0.8	5	0.5 to 2.4	4	0.5 to 0.6	-	-
Total Kjeldahl nitrogen	mg/L	0.1	-	3	0.5 to 0.8	5	0.5 to 2.2	4	0.5 to 0.6	-	-
Total cations	meq/L	0.01	-	10	1.25 to 2.37	12	1.06 to 2.44	9	1.41 to 2.85	-	-
Total anions	meq/L	0.01	-	10	1.21 to 1.97	12	0.77 to 2.07	9	1.21 to 2.65	-	-
Alkalinity (Laboratory)											
Bicarbonate	mg/L $CaCO_3$	1.0	-	10	9 to 24	12	8 to 47	9	13 to 42	-	-
Carbonate	mg/L $CaCO_3$	1.0	-	2	< LOR to 1	7	< LOR to 1	3	< LOR to 1	-	-
Hydroxide	mg/L $CaCO_3$	1.0	-	2	< LOR to 1	7	< LOR to 1	3	< LOR to 1	-	-
Total	mg/L $CaCO_3$	1.0	-	10	9 to 24	12	8 to 47	9	13 to 42	-	-
Hardness	mg/L $CaCO_3$	1.0	-	10	17 to 35	12	16 to 47	9	26 to 54	-	-
Metals (Laboratory)											
Aluminium	mg/L	0.01	0.055 [C]	10	0.02 to 0.87	12	0 to 3.33	9	0 to 2.22	-	-
Arsenic	mg/L	0.001	0.013 [C]	5	< LOR to 0.002	12	< LOR to 0.006	6	< LOR to 0.003	-	-

Analytes	Units	LOR	ANZG Default Trigger	DAM		NORTH		SOUTH		BUCKETTS WAY	
				#	Range	#	Range	#	Range	#	Range
Cadmium	mg/L	0.0001	0.0002 [C]	2	< LOR to 0.0001	7	< LOR to 0.0001	4	< LOR to 0.0002	-	-
Chromium	mg/L	0.001	0.001 [C]	2	< LOR to 0.001	7	< LOR to 0.002	3	< LOR to 0.002	-	-
Copper	mg/L	0.001	0.0014 [C]	3	< LOR to 0.002	8	< LOR to 0.004	4	< LOR to 0.002	-	-
Iron	mg/L	0.01	-	10	0.18 to 1.02	11	1.1 to 2.67	8	0.39 to 1.86	-	-
Lead	mg/L	0.001	0.0034 [C]	2	< LOR to 0.001	7	< LOR to 0.001	3	< LOR to 0.002	-	-
Mercury	mg/L	0.0001	0.0006 [C]	2	< LOR to 0.0001	7	< LOR to 0.0001	3	< LOR to 0.0001	-	-
Nickel	mg/L	0.001	0.011 [C]	2	< LOR to 0.001	7	< LOR to 0.004	3	< LOR to 0.001	-	-
Selenium	mg/L	0.01	0.05 [C]	2	< LOR to 0.01	7	< LOR to 0.01	3	< LOR to 0.01	-	-
Zinc	mg/L	0.005	0.008 [C]	4	< LOR to 0.052	9	< LOR to 0.041	5	< LOR to 0.022	-	-
Physical (Laboratory)											
Electrical conductivity	µS/cm	1.0	125 to 2200 (200 to 300) [D]	10	153 to 270	12	67 to 295	9	154 to 342	-	-
Total Dissolved Solids	mg/L	1.0		10	99 to 176	12	44 to 192	9	100 to 222	-	-
Total suspended solids	mg/L	5.0	40 [E]	5	9 to 18	8	5 to 65	4	5 to 17	-	-
pH	-		6.5 to 8.0 [B]	10	6.22 to 7.04	12	6.1 to 6.93	9	6.15 to 6.92		
Physical (Field measurement)											
Electrical conductivity	µS/cm	1.0	125 to 2200 (200 to 300) [D]	24	153 to 316	24	92 to 405	22	154 to 362	12	133 to 332
pH	-		6.5 to 8.0 [B]	24	5.77 to 7.91	24	5.44 to 7.73	22	5.98 to 7.50	12	5.96 to 7.58

[A] ANZG (2018) (ANZECC (2000) Table 4.4.3 (Freshwater aquaculture))

[B] ANZG (2018) (ANZECC (2000) Table 3.3.2 (Lowland Rivers))

[C] ANZG (2018) (ANZECC (2000) Table 3.4.1 (Freshwater, 95% protection level))

[D] ANZG (2018) (ANZECC (2000) Table 3.3.3 (Lowland Rivers))

[E] ANZG (2018) (ANZECC (2000) Table 4.4.2 (Freshwater aquaculture))

LOR = Limit of Reading

The observed pH values at the NORTH, SOUTH, DAM, and BUCKETTS WAY monitoring points are included in Figure 2-4, Figure 2-5, Figure 2-6, and Figure 2-7, respectively. These figures include both the laboratory and field measured pH values, as well as providing a statistical summary (box-and-whisker plots) and the ANZG / ANZECC default trigger range. The monitoring results indicated that the pH of the local runoff is generally lower than the default ANZG / ANZECC trigger range (6.5 to 8.0). Similarly, the observed EC values for the four monitoring locations (Figure 2-8 to Figure 2-11) indicates that the local salinity levels are at the lower end of the default ANZECC trigger range for lowland rivers (125 to 2200 µS/cm), but generally consistent with the NSW Coastal Rivers (200 to 300 µS/cm). It is noted that EC levels at the SOUTH monitoring point are slightly higher than those at the NORTH monitoring point, and EC levels at the DAM monitoring point have been steadily increasing since mid-2016, likely the result of low rainfall and evapo-concentration of salts within the dam.

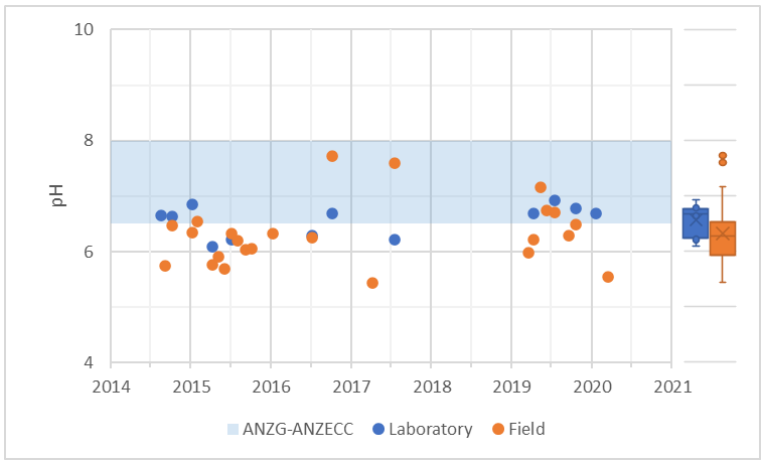


Figure 2-4: Observed pH – NORTH

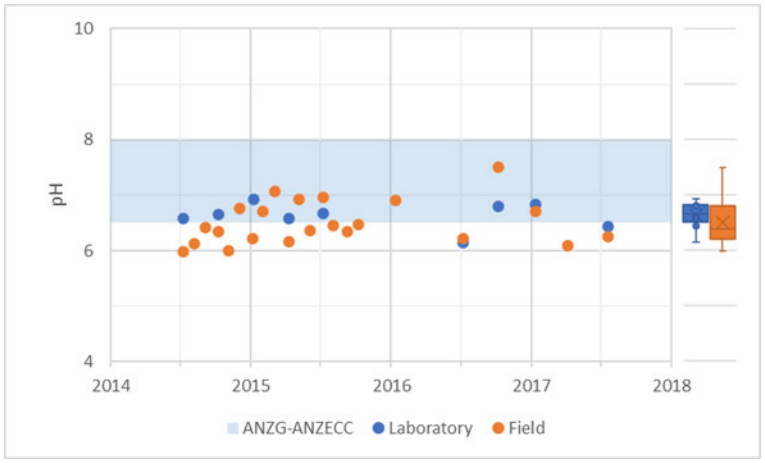


Figure 2-5: Observed pH – SOUTH

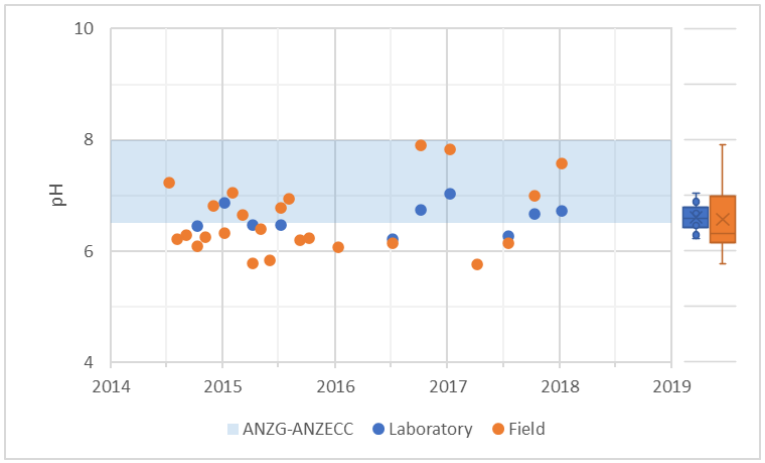


Figure 2-6: Observed pH – DAM

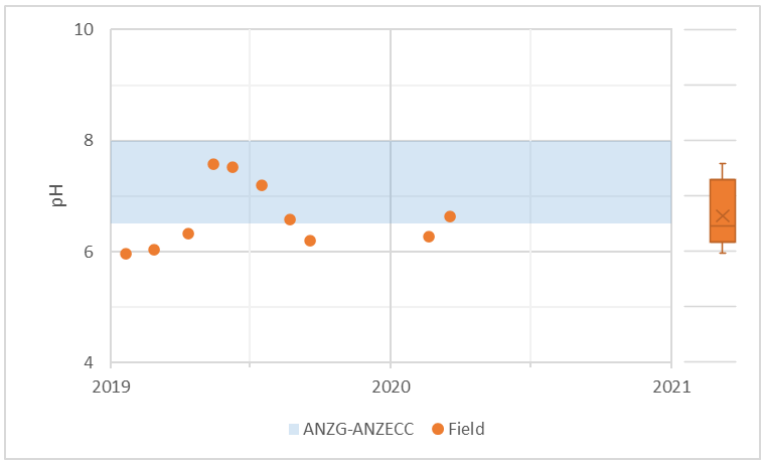


Figure 2-7: Observed pH – BUCKETTS WAY

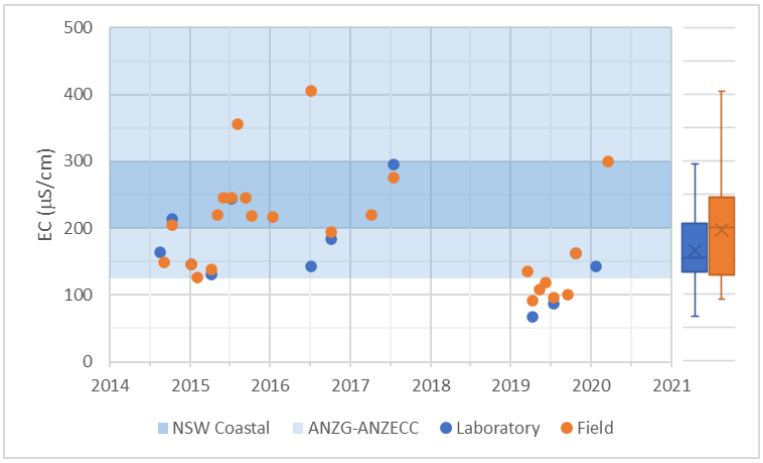


Figure 2-8: Observed EC – NORTH

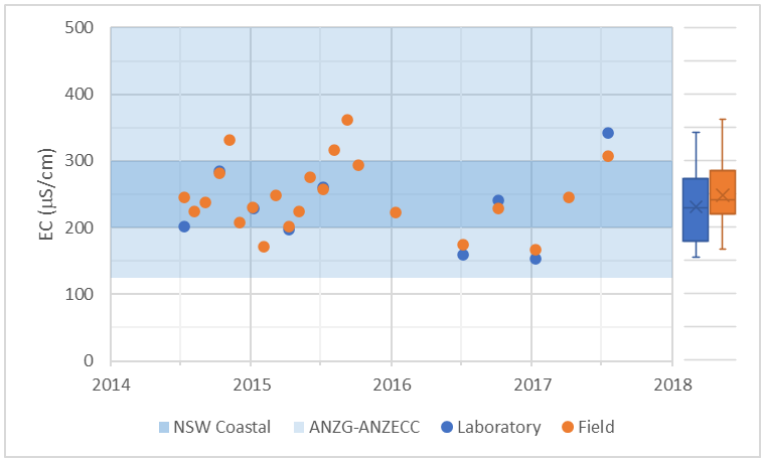


Figure 2-9: Observed EC – SOUTH

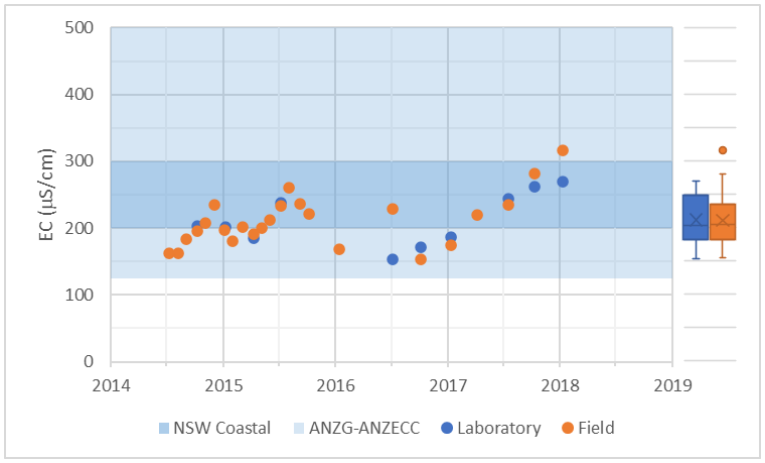


Figure 2-10: Observed EC - DAM

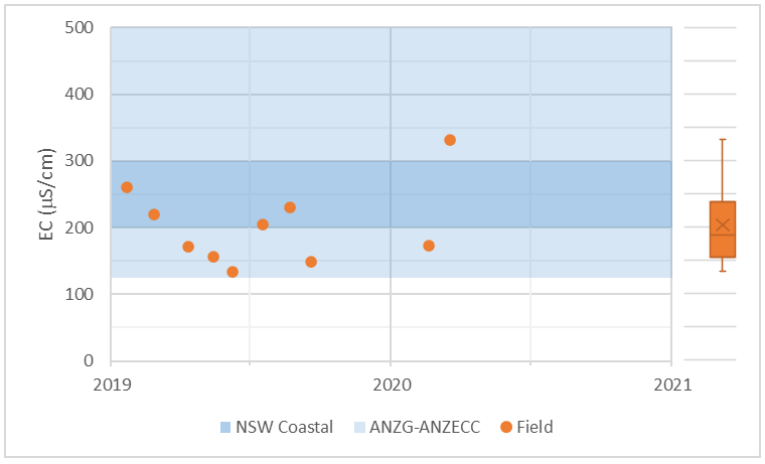


Figure 2-11: Observed EC – BUCKETTS WAY

3 WATER MANAGEMENT SYSTEM

The objectives of water management at DCQ are to:

- Minimise the capture and contamination of clean water runoff from catchment areas upslope of the operations.
- Minimise potential effects of erosion and its associated impacts as a result of quarry operations.
- Securely contain dirty water generated within the quarry pit, stockpiles, and infrastructure areas.
- Maximise the re-use of water for onsite.
- Minimising adverse effects on downstream waterways (i.e. hydraulic and water quality impacts).
- Reducing the discharge of contaminants from the quarry to the environment.
- Return runoff water from rehabilitated areas to the downstream environment.

3.1 CONCEPTUAL WATER MANAGEMENT SYSTEM

The conceptual water management system at DCQ considers three categories of water, the target design criteria for each are summarised in Table 3.1.

Table 3.1: WMS Design Criteria

Water Category	Water Description	Target Design Criteria
Clean	Runoff from undisturbed or rehabilitated areas.	Release, where practicable, to downstream environment.
Dirty	Runoff from disturbed areas, including workshop area.	Managed in line with the Blue Book (Managing Urban Stormwater: Soils and Construction Volumes 1 and 2E). Designed to manage runoff from the 5 day, 95th percentile rainfall event. Additional oil-separators will be required within the workshop area to manage oil and grease.
Effluent	Wastewater (sewage)	Pump out system.

The conceptual WMS for the DCQ includes:

- Dirty water management system, including:
  - Two sediment dams.
  - An in-pit water storage dam.
  - Catch drains to intercept sediment-laden runoff from disturbed areas, and direct it to one of the two sediment dams.
- Clean water management system, including:
  - Diversions and / or windrows to divert undisturbed up-slope catchment areas around the site.
  - Culverts and bridges to provide access over existing watercourses.

Both the dirty and clean water management systems will need to be periodically modified in line with the progression of quarrying activities. The proposed evolution of the water management system at three stages of quarry at DCQ is presented in Figure 3-1, Figure 3-2, and Figure 3-3.

Wastewater (sewage) will be managed using a contained pump-out (or similar) system, which would require minimal site infrastructure.

Stockpile Dam

Quarry Dam

Infrastructure Dam

Office and Workshop

Access Road

Legend

- Watercourse (DEM)
- 1m Contours (NSW LPI)
- Project Extent
- Access Road
- Office and Workshop
- Quarry Area
- Stockpile Area
- Water Pipeline
- Quarry Extent
- Dams
- Catch Drain
- Diversions (e.g. bunds, drains, flow paths)

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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry

Figure 3.1
Conceptual Water Management System
Stage 1

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Stockpile Dam

Quarry Dam

Infrastructure Dam

Office and Workshop

Access Road

Legend

- Watercourse (DEM)
- 1m Contours (NSW LPI)
- Project Extent
- Access Road
- Office and Workshop
- Quarry Area
- Stockpile Area
- Water Pipeline
- Quarry Extent
- Dams
- Catch Drain
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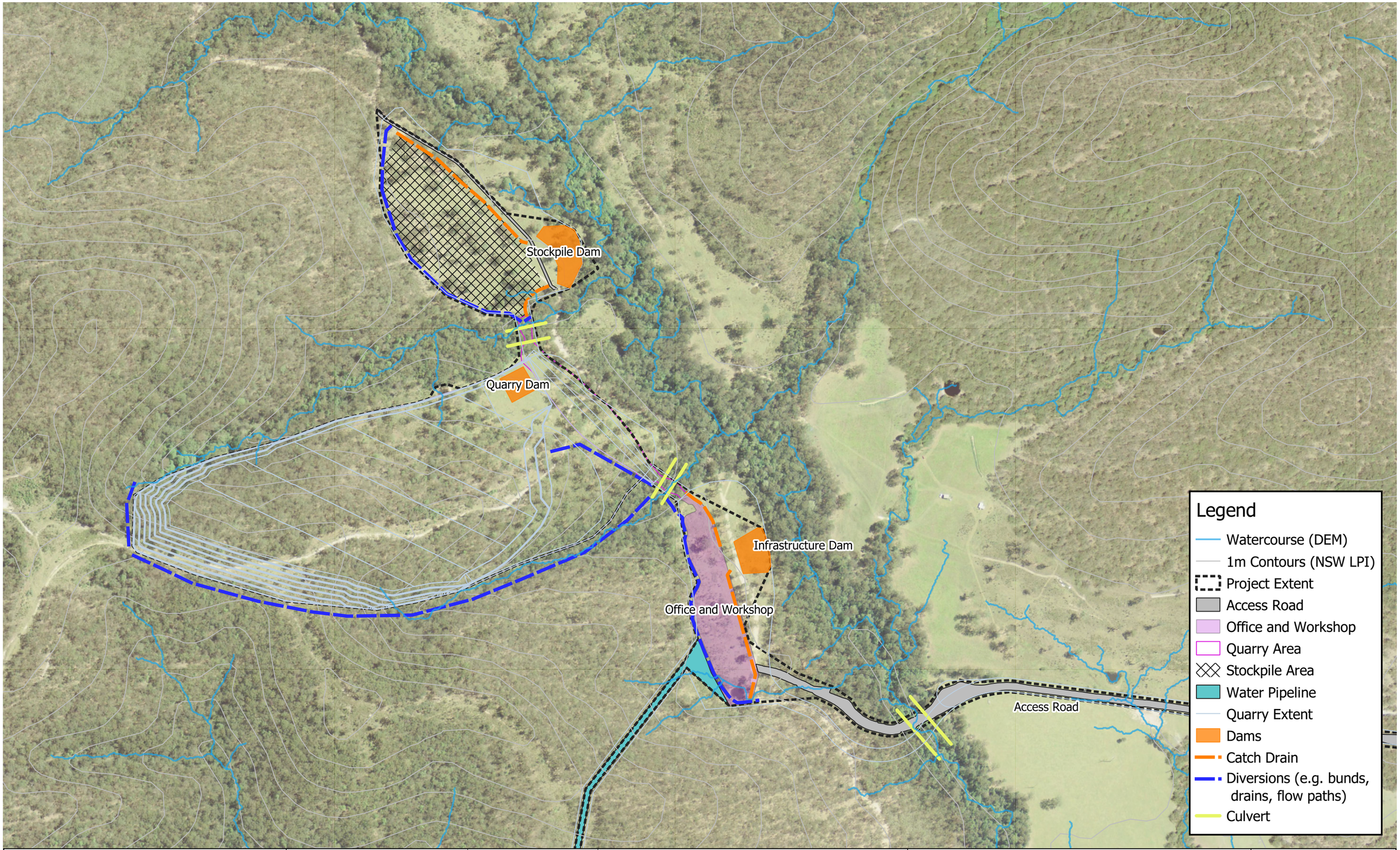
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Deep Creek Quarry

Figure 3.2
Conceptual Water Management System
Stage 2

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Scale in metres (1:5000 @ A3)

Map Projection: Tranverse Mercator
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Vertical Datum: Australia Height Datum
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Deep Creek Quarry

Figure 3.3
Conceptual Water Management System
Stage 3

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3.1.1 Dirty Water Management

The dirty water management system, including sediment dams, will be designed in accordance with *Managing Urban Stormwater: Soils and Construction* (the Blue Book), Volumes 1 and 2E - Mines and Quarries (Landcom 2004 and DECC 2008) to manage runoff from the 5 day 95th percentile rainfall event. Volume 2E of the Blue Book (DECC 2008) indicates that for the 95th percentile design storm event the indicative average annual sediment dam overflow frequency will be 1 to 2 overflows per year. The receiving waters in the event of overflows from the sediment dams during events that exceed the design criteria from the WMS is Deep Creek, and then the Karuah River. Sediment dams would be dewatered within 5 days following rainfall events, by pumping to the Quarry Dam (located within the quarry pit) for reuse.

Indicative sediment dam sizes are included in Table 3.2, based on the *Blue Book* parameters outlined in Table 3.3.

Table 3.2: Conceptual Sediment Dam Sizes

Dam	Local catchment Area (ha)	Settling Zone (ML)	Sediment Storage Zone (ML)	Design capacity (ML)	Pump Capacity (L/s) [A]
Stockpile Area	5.5 (maximum)	4.0	0.2	4.2	12.2
	2.0 (likely)	1.5	0.1	1.6	5.6
Infrastructure Area	3.5 (maximum)	2.5	0.1	2.6	7.5
	1.5 (likely)	1.0	0.1	1.1	3.2
Quarry Area (indicative)	18 (maximum)	13.0	1.2	14.2	-

[A] Assuming dewatering of the sediment dams occurs over four days (i.e. allows for up to one day delay in commencing pumping).

Table 3.3: Adopted *Blue Book* Parameters

Parameter	Value	Justification
Sediment type	D/F	Potential for dispersive and fine (rock dust) materials.
Receiving environment	Sensitive	Private landholders (highly visible), and National Park and coastal wetlands downstream
Design rainfall depth	91.5 mm	5day 95th percentile design rainfall for Nelson Bay (nearest *Blue Book* gauge point)
Soil erosivity (R-factor)	2500	Map 9, Appendix B (Landcom 2004)
Soil erodibility (K factor)	0.065	Table 13, Appendix C (Landcom 2004) for “Ten Mile Road” soil landscape “Type D” (dispersive) sediments
Erosion control practice factor (P factor)	1.3	Table A2 (Landcom 2004), hard, compacted earth
Cover factor (C-factor)	1.0	Topsoil stripped, no vegetative cover and no root mass
Volumetric runoff coefficient (Cv)	0.79	Table F2 (Landcom 2004), high runoff potential

The conceptual water management system (Figure 3-1, Figure 3-2, and Figure 3-3 above) includes two main dirty water catch drains. Indicative dimensions of these drains are presented in Table 3.4. It is assumed that during operations the quarry pit will be internally draining and not require permanent dirty water catch drains.

Table 3.4: Conceptual Catch Drain Sizes

Drain	Maximum Catchment Area (ha)	Maximum Length (m)	Average Slope (%)	Proposed Depth (m)	Proposed Width (m)	Scour Protection
Infrastructure	1.5	300	0.5%	1	4	50mm d50
Stockpile	3.5	400	0.5%	1	4	50mm d50

3.1.2 Clean Water Management

The clean water management system principally consists of diversion drains and bunds to divert flows from the undisturbed upslope areas of the catchment around disturbed areas of the site. These diversions are intended to limit the volume of water required to be managed within the dirty water system (thereby reducing the capacity requirements), as well as reduce the loss of flows into the downstream system (thereby reducing the potential environmental impacts due to reduced flows as a result of water take).

The conceptual water management system (Figure 3-1, Figure 3-2, and Figure 3-3) indicates the general location and extent of the proposed clean water management system.

Within the upper areas where the local catchment is small or where the pit generally runs perpendicular to the contours, there is little to no concentration of flow, allowing localized control measures such as mulch berms or windrows (potentially integrated into the safety bunds) to be adopted. Such measures are intended to balance the need to manage the external (clean) water runoff with the progressive development of the quarry shell, and would be constructed in advance of the quarry development, typically as part of pre-clearance works.

Moving downslope (east), where flows start to become concentrated or will be in place for an extended period of time (for example, within the vicinity of the stockpile, and office and workshop areas), small formal diversion drains are likely to be required to provide a stable, non-polluting diversion.

The location, extent, and dimensions of the clean water management system components will be refined and specified in the site water management plan that will be prepared in accordance with the requirements of the *Blue Book* and relevant approval conditions.

4 WATER BALANCE MODELLING

A water balance model was developed and used to estimate the range of water transfers, storages, demands, and discharges are likely to occur during the operational life of the project. This allows for an estimate of water security and spill risk to be made, which will inform the identification of the licensing requirements (Section 6.1.1).

4.1 OVERVIEW OF WATER BALANCE MODEL

The site water balance model was developed using the GoldSim modelling package and is based on the conceptual water management system for the site (Section 3), including the proposed progression of quarrying activities. The model includes representations of:

- Water sources:
  - Direct rainfall onto dam/water storage surfaces.
  - Runoff from natural, rehabilitated and disturbed catchment areas.
  - Groundwater inflow into the quarry pit.
  - External water supplies.
- Losses:
  - Evaporation from dams and the quarry pit.
  - Water lost to product.
  - On-site dust suppression (haul roads and stockpiles).
  - Spills.

A schematic of the water balance model is included in Figure 4-1.

4.1.1 Input Data

The following input data was used in the water balance model:

- Historical rainfall and potential evaporation data were sourced from gridded Silo Data Drill for 32.55 S 151.90 E (Figure 4-2 and Figure 4-3, respectively).
- Predicted groundwater inflows into the quarry were estimated as part of the Groundwater Impact Assessment (Hydrominex Geoscience 2021).
- Quarry staging plans (Figure 3-1, Figure 3-2, and Figure 3-3) and timing / schedule (Figure 4-5) were provided by IDPL.

4.1.2 Assumptions

- Catchment runoff in response to rainfall was modelling using the Australian Water Balance Model (AWBM: Boughton 2004) Figure 4.4).
- Model parameters typical of land usages within the catchment were adopted.
- The dam to the south of the proposed quarry was assumed to have enough storage volume and inflows to meet all external water demands, or alternate water (e.g. sourced from local reticulated network).
- Seepage losses from the sediment dams and quarry were assumed to be negligible.
- Truck washdown water will largely be recovered within sediment dams and reused. Losses will be minor.
- Potable water will be imported in bottles as required (i.e. not considered in this model).
- Material preparation (e.g. crushing) will require little water, outside of basic dust control.
- The two sediment dams are managed as per *Blue Book* requirements (i.e. dewatered to the quarry dam (Figure 4-1) within 5 days of rainfall).
- Water from sediment dams is transferred to the quarry dam, when water in the quarry dam is below 1 ML.
- Dust suppression water demands were estimated on a daily time step as the difference between rainfall and evaporation, and consider:
  - Haul road areas.
  - Stockpile areas (provided by IDPL).
  - Active quarrying areas (provided by IDPL).

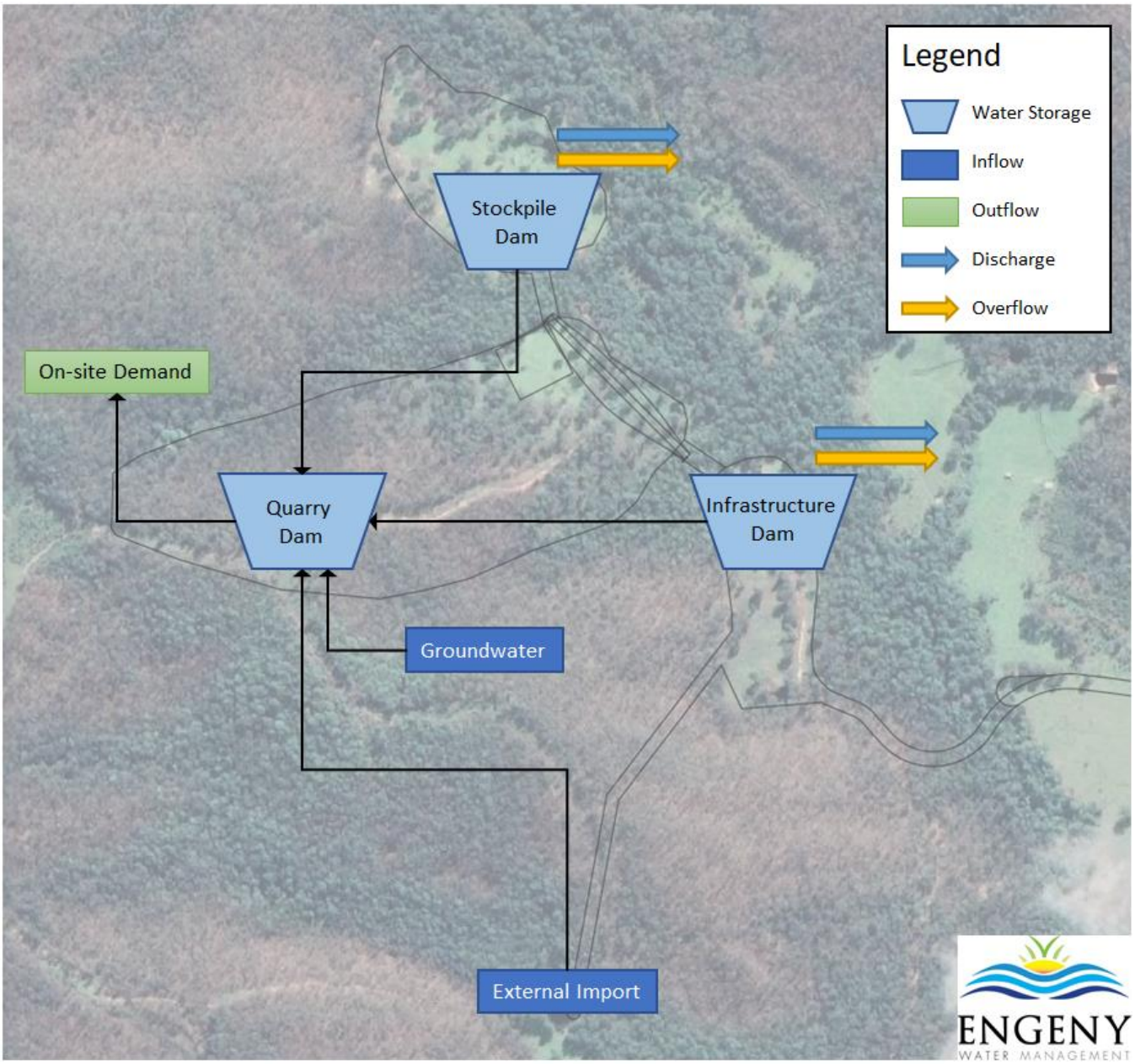


Figure 4-1: Water Balance Model Schematic

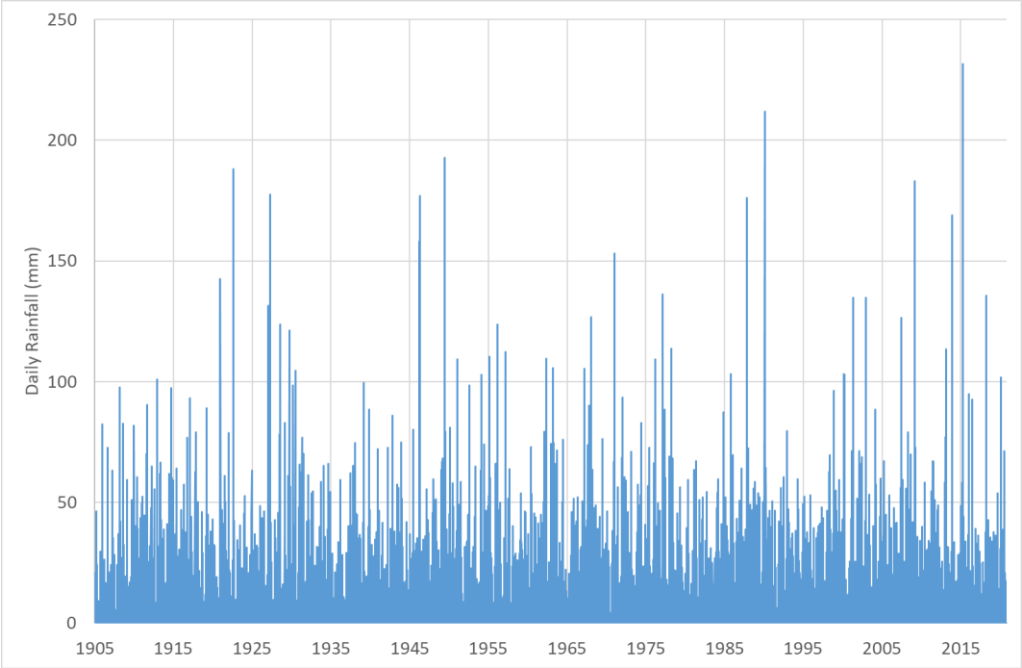


Figure 4-2: Historical SILO Rainfall Data

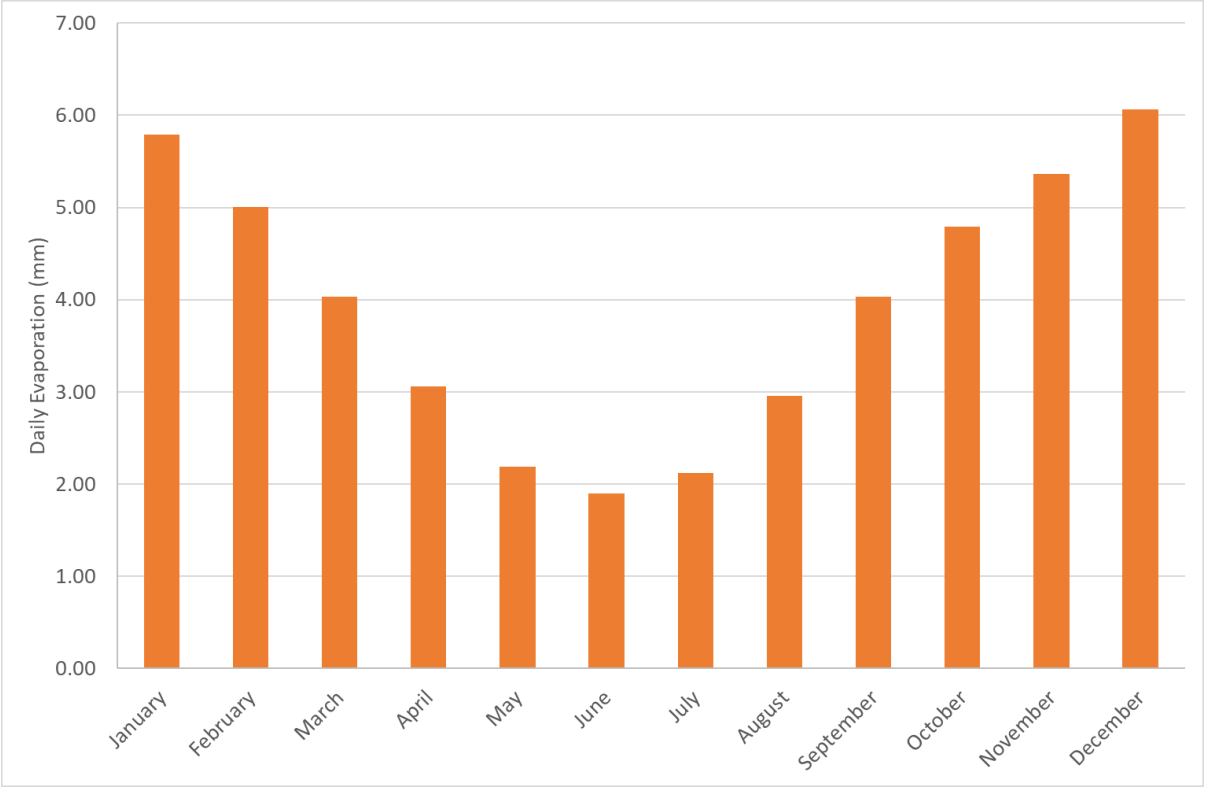


Figure 4-3: Historical SILO Evaporation Data

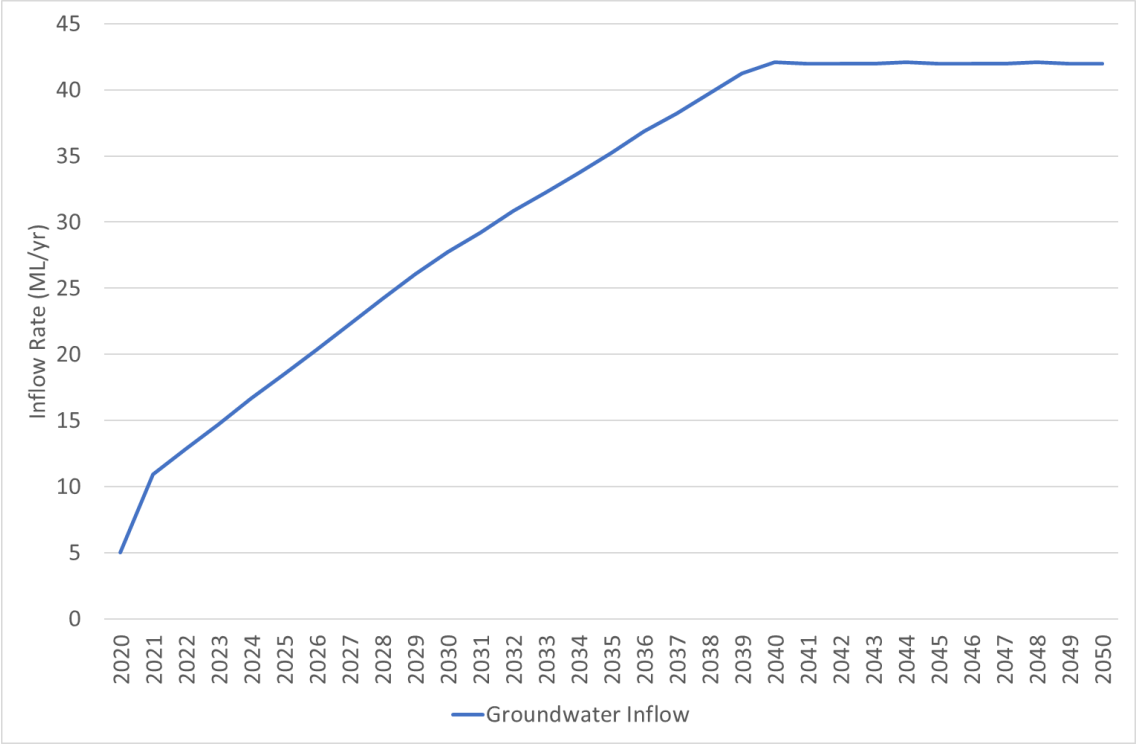


Figure 4-4: Forecast Groundwater Inflow

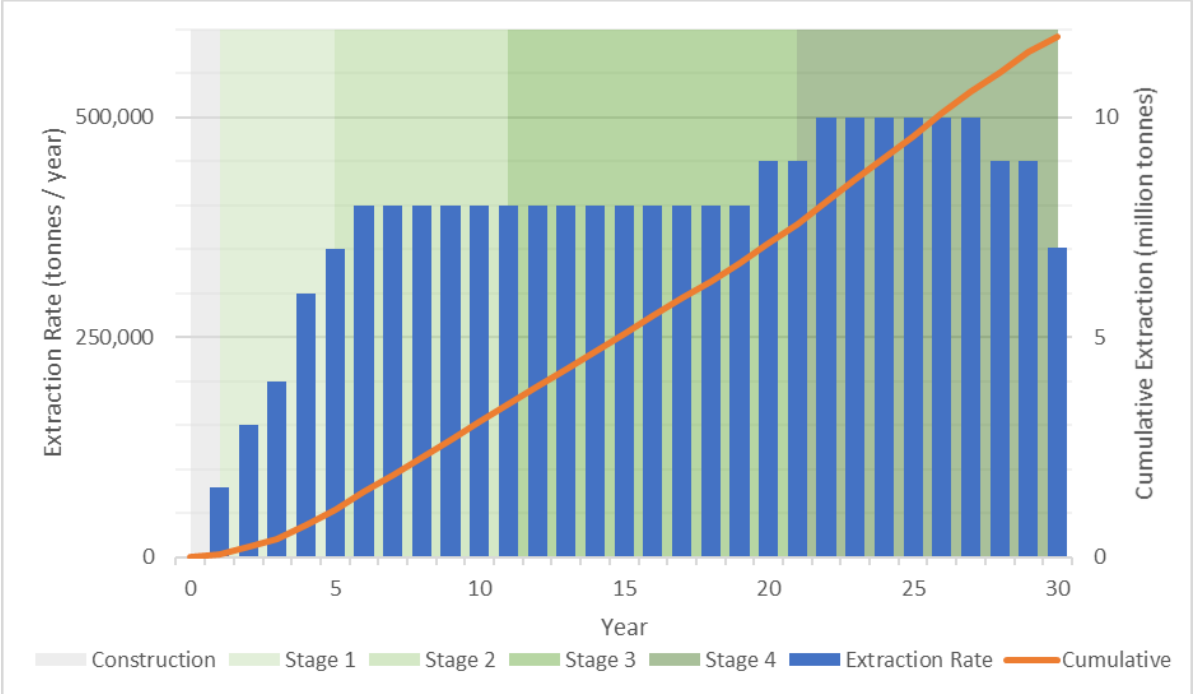


Figure 4-5: Forecast Quarry Extraction Rates

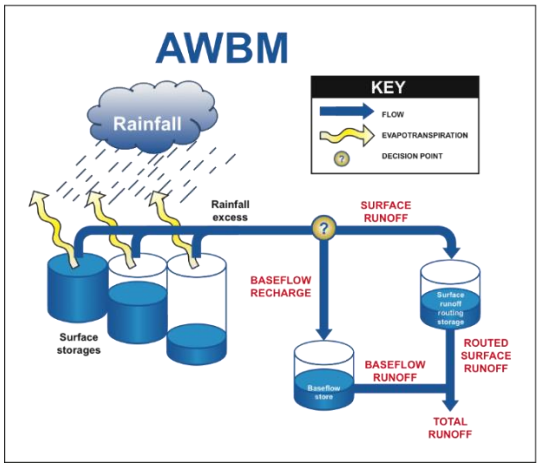


Figure 4-6: AWBM Schematic (adapted from Boughton 2004)

4.2 WATER BALANCE MODEL RESULTS

A summary of the average water balance results for stages 1, 2 and 3 of the proposed quarry is included in Table 4.1. The predicted water inventory is also shown on Figure 4.1.

The water balance modelling indicates that, provided sufficient water storage is maintained in the quarry, external water supplies can be minimal, meaning all water demands on site can be met by water harvested on site (mostly within the dirty water management system). As the quarry pit progresses, the volume of water managed within the dirty water management system will increase, as there is limited opportunity for progressive rehabilitation to be undertaken. Therefore, as quarry operations progress, the site is more likely to require regular dewatering by discharging to Deep Creek. These discharges will need to be in accordance with any water quality conditions specified within the site EPL, and will require sufficient water quality testing prior to, during and following discharges to demonstrate water quality criteria are met.

Table 4.1: Summary of Average Water Balance (ML)

Water Management Element	Stage 1	Stage 2	Stage 3	Stage 4 (Final)
Inputs				
Rainfall-runoff	70.1	102.5	143.3	143.1
Groundwater inflows	10.9	27.7	42.1	42.0
Imported water	1.8	0.0	0.0	0.0
Sub-total - inputs	82.8	130.2	185.4	185.1
Outputs				
Evaporation (dams and pit)	4.5	6.2	6.5	6.5
Dust suppression	25.6	27.4	27.5	27.4
Discharges (controlled releases)	32.1	81.0	134.3	135.9
Overflows (uncontrolled releases)	3.2	3.2	3.2	3.2
Sub-total - outputs	65.5	117.7	171.5	173.0
Change in Storage	17.4	12.5	13.9	12.1

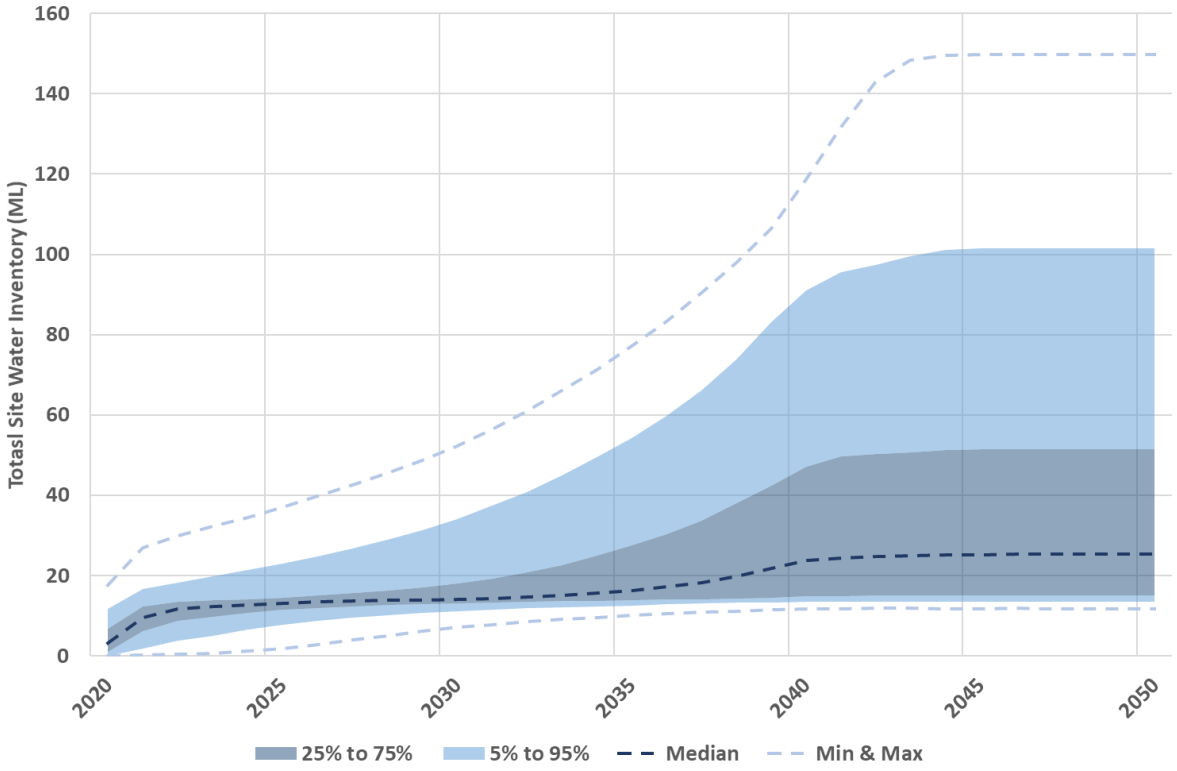


Figure 4-7: Predicted Site Water Inventory

Figure 4-7 shows the predicted water storage inventory for the quarry for a range of confidence intervals (i.e. 5%, 50% and 95%). Figure 4-7 clearly shows the steady increase in site water inventory volumes as the quarry progresses and surface water inflows into the pit increase. These volumes may need to be managed by either increasing water usage on site (subject to licensing limitations) or treated and discharged off site (subject to EPL conditions). The modelled discharges and overflows (Table 4.1) include:

- Controlled releases from the sediment dams, following rainfall events (as per *Blue Book* requirements and subject to EPL conditions).
- Uncontrolled overflows from the sediment dams during rainfall events in excess of the design capacity.
- Discharge of excess water from the quarry dam (subject to EPL conditions).

The majority of discharges are associated with the controlled releases from sediment dams. During earlier stages of the project, the sediment dams will, at times, be dewatered to the main water storage dam (Quarry Dam) for reuse on site. However, as the project progresses and site water inventories increase (Figure 4-7), the sediment dams will be increasingly dewatered via discharge into the downstream environment, as reflected in the increased discharge volumes indicated in Table 4.1. The controlled releases from the sediment dams would be subject to EPL conditions specifying water quality limits (Section 6.1.1).

Uncontrolled overflows from the sediment dams will occur during rainfall events in excess of the design capacity. These overflows are expected to occur on average about twice per year, assuming that the sediment dams are managed in accordance with the *Blue Book* requirements. As the local catchment area of the two sediment dams does not change, the average overflow volume included in Table 4.1. Whilst volume of uncontrolled discharges are not typically covered by EPL limitations, additional water quality monitoring will be required during overflow events to identify the potential environmental harm (Section 6.1).

Discharge of excess water from the quarry dam would occur only during extended wet weather, with permission of the EPA. As a result, no discharge of excess water from the Quarry Dam is considered to be required for the average conditions presented in Table 4.1.

As annual site water demands are about 30 ML, provided sufficient water inventories are maintained, the risk of water shortfall during extended dry periods is considered small.

Water Access Licences (WALs) will be required to cover the surface water runoff intercepted by the WMS, where that water is not reused for environmental purposes (e.g. dust control). Based on landholdings of about 300 ha, IDPL has a harvestable right of about 33 ML per annum.

5 SURFACE WATER IMPACTS AND MITIGATION MEASURES

5.1 CATCHMENT AREAS

During operations, the proposed DCQ is predicted to result on a small reduction in the catchment area of Deep Creek (Table 5.1). The proposed final landform for the quarry pit includes a free-draining landform, meaning the final catchment areas are expected to be comparable to the existing conditions.

Table 5.1: Impacts to Deep Creek Catchment Area (to The Bucketts Way Bridge)

Catchment	Catchment Area (ha)	Change in Catchment Area (ha) (%)
Existing conditions	1,524	-
Maximum operational footprint	1,502	- 22 ha (- 1.5%)
Final landform	1,524	0 ha

The greatest changes to the Deep Creek catchment area occurs when the pit is at the maximum operational area (Figure 3-3). At this point, the total catchment area being managed by the dirty water management system is about 22 ha. Once the site is rehabilitated however, the final quarry pit will be free draining, thereby returning catchment area to Deep Creek.

5.2 FLOW REGIMES

The Groundwater Impact Assessment (Hydrominex Geoscience 2021) indicates that quarry operations are unlikely to intercept significant groundwater resources. In addition, as the sediment dams will be managed as per *Blue Book* requirements and dewatered via discharging to the downstream environment (following suitable treatment), the potential for impacts to streamflow regimes in Deep Creek are considered to be small and is associated with the small reduction in total catchment area associated quarry footprint (< 1%).

5.3 FLOODING AND WATERCOURSE STABILITY

The proposed DCQ has the potential to influence flooding and watercourse stability in Deep Creek as a result of:

- Changes to local catchment areas associated with:
  - Diversion drains.
  - Loss of catchment to the quarry pit.
- Concentration of flows within bridges and culverts associated with the access road.

5.3.1 Flood risks and Impacts

The flood risks (to quarry operations) and impacts to the surrounding flood behaviours were assessed by updating the base flood model (Section 2.3 and Appendix A) to reflect:

- The “maximum” quarry footprint – to estimate the maximum potential flood risk associated with quarry operations.
- Final landform – to assess the long-term flood impacts as a result of the proposed DCQ.

Maximum modelled velocities and depths just upstream of the proposed crossing point of Deep Creek (downstream of the quarry) are included in Table 5.2, and Table 5.3 respectively. The change in the maximum modelled flood depths (afflux) for the 1% AEP flood event during operational stages of DCQ are included in Figure 5-1. A full suite of thematic mapping, showing maximum

modelled flood depths, extents, and velocities for the operational and final landform conditions in Deep Creek are included in Appendix C and Appendix D respectively.

The modelling indicates:

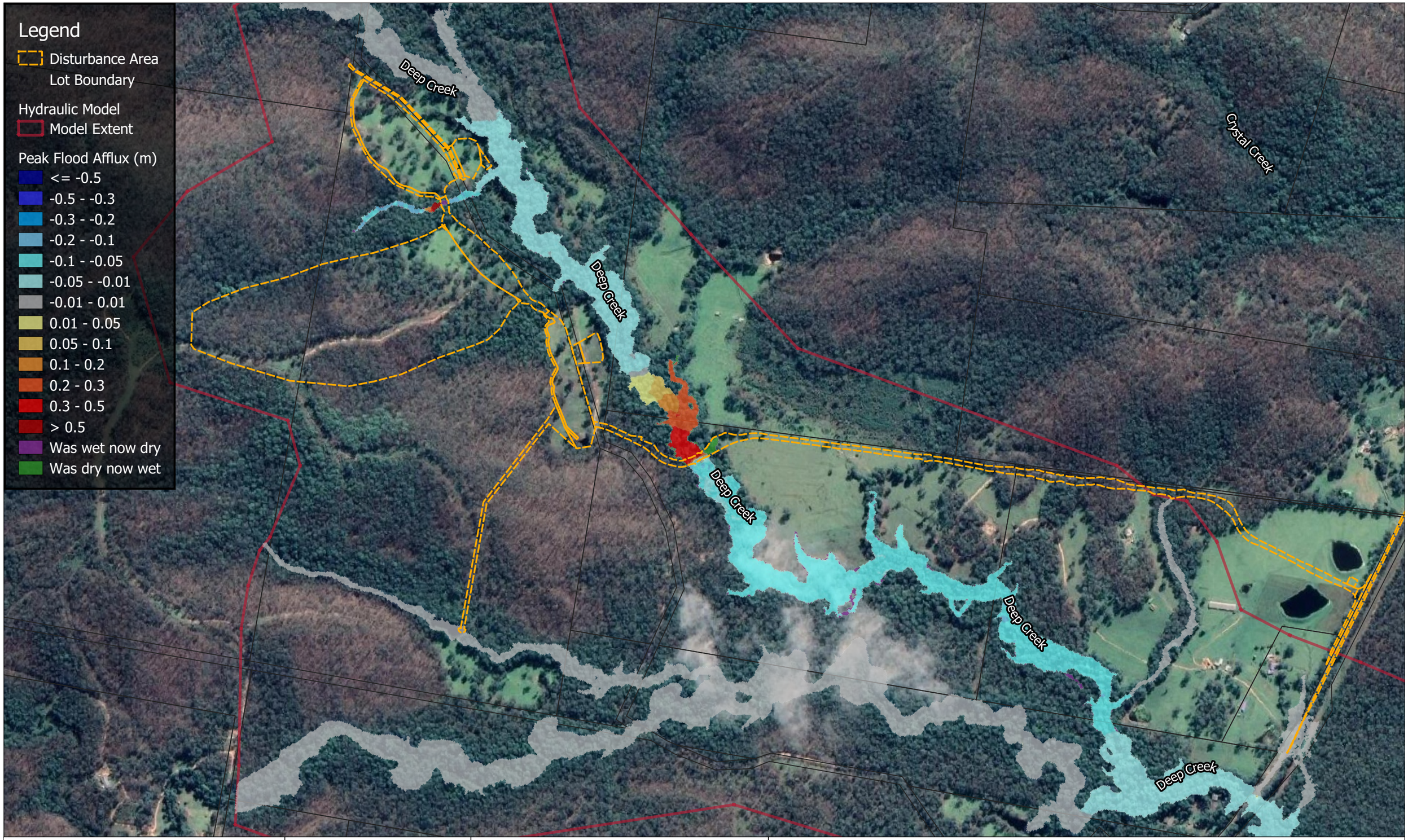
- For more frequent events (i.e. the 50% and 10% AEP events), the proposed crossing is expected to locally increase flow velocities (Table 5.2) and depths (Table 5.3). This is due to the concentration of flow required to drive the modelled flows through the proposed culvert.
- For larger events (i.e. the 1% AEP and the Probable Maximum Flood (PMF)), the proposed crossing is expected to located reduce flow velocities (Table 5.2), with continued increases in depths (Table 5.3). This is due to the routing effects of the access track, temporarily storing excess stormwater prior to overtopping the road or discharging through the proposed culvert. It is noted that the increases depths are limited to about 200 m upstream of the proposed crossing, with modelled depths downstream of the proposed crossing point expected to decrease (Figure 5-1).

Table 5.2: Maximum Modelled Velocities (at Proposed Deep Creek Crossing Point)

Flood Event (AEP)	Peak Velocity - Existing (m/s)	Peak Velocity - Final (m/s)	Change (m/s)
50%	1.2	1.3	+ 0.1
10%	1.5	1.7	+ 0.2
1%	2.0	1.8	- 0.2
PMF	3.3	2.6	- 0.7

Table 5.3: Maximum Modelled Depths (at Proposed Deep Creek Crossing Point)

Flood Event (AEP)	Peak depth - Existing (m)	Peak depth - Final (m)	Change (m)
50%	1.4	1.6	+ 0.2
10%	2.6	3.6	+ 1.0
1%	2.6	3.4	+ 0.8
PMF	3.9	4.4	+ 0.5



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Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure 5.1: Afflux - 1% AEP Flood Event, Operations vs Existing Conditions

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Date: 9/4/2021

5.3.2 Climate Change

The potential impacts of climate change on flooding within Deep Creek have been assessed using the 0.5% and 0.2% AEP events. These events are used as representative proxies for potential future changes to the 1% AEP event, in response to increased storm intensities due to climate change.

The modelling indicates that differences in the maximum modelled flood extents for the 1% and 0.2% AEP events (Figure 5-2) largely occur downstream of the proposed cross point, within a section of the creek which broadens to include a small floodplain. Elsewhere, the well-defined channel geometry and limited overbank (floodplain) area associated with Deep Creek within the assessment area limits the modelled increase in flood extent.

5.3.3 Flood Planning Information

Flood Prone Land is defined by the NSW Floodplain Development Manual (2005) (the Manual), as “Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land”.

The assessment indicates that there are regions within the proposed operational areas that are located within Flood Prone Land for Deep Creek. Modelled elevations for the peak flood levels during the PMF event are estimated to be in the order of:

- 32.8 mAHD in Deep Creek adjacent to the proposed quarry pit.
- 29.5 mAHD in Deep Creek adjacent to the proposed infrastructure area.
- 33.7 mAHD in Deep Creek adjacent to the proposed stockpile area.

The assessment also indicates that the proposed quarry will have negligible impact on flood flows or extents during the PMF and as such is not expected to impact on the extent of flood prone land in the wider Deep Creek catchment.

Legend

Disturbance Area

Lot Boundary

Hydraulic Model

Model Extent

1% AEP Flood Extent

0.5% AEP Flood Extent

0.2% AEP Flood Extent

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Figure 5.2: Flood Impacts due to Climate Change

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5.4 WATER QUALITY

The proposed WMS (Section 3.1), includes drains, diversions, and sediment basins. The proposed WMS is intended to limit the potential impacts on downstream water quality by managing water that has the potential to cause environmental harm. This would be achieved, in part, by dewatering the proposed sediment dams to the quarry dam, or discharging into the downstream environment (subject to the proposed water quality triggers included in Section 6.1.1). During large rainfall events (i.e. that exceed the design capacity of the sediment dams), discharges from sediment dams may occur (from licenced discharge points), however would occur at a time of higher flows within Deep Creek thereby reducing the potential water quality impacts to the downstream environment. Event-based water quality monitoring (Section 6.1) would allow for any potential impacts to be identified, quantified, and reported.

The proposed WMS would form the basis of a site Water Management Plan (WMP), that will outline how the WMS is to be operated to meet EPL conditions within the requirements of the POEO Act, taking account of both historical and current water qualities in the surrounding watercourses, and current and future downstream water users.

The WMP allows for the ongoing assessment of risk as quarry operations progress, and the implementation of improvements and changes to the WMS where required.

It is considered that, with the proposed WMS, the proposed quarry will have minimal impact on water quality in downstream watercourses.

5.5 GEOMORPHOLOGICAL AND HYDROLOGICAL VALUES

The proposed quarry is not expected to have a significant impact on the geomorphological and hydrological values of local surface water systems. Potential impacts on geomorphological stability and changes to potential erodibility and scour as a result of the proposed quarry have been assessed and indicate that there is minimal risk of increased erosion or scour.

During the operational phase, the modelling indicates that the proposed quarry will result in generally lower peak flows and flood levels within Deep Creek, compared to the existing scenario. Following the rehabilitation of the site, the modelling indicates that flood depths and velocities would return to levels comparable to the existing conditions.

The modelling does show localised increases in flood depths and velocities within the vicinity of the access track culvert crossings, however these structures will be designed and constructed to incorporate suitable erosion and scour protection.

Therefore, it is considered that there is minimise risk of increased scouring within Deep Creek as a consequence of the proposed quarry.

5.6 RIPARIAN AND ECOLOGICAL VALUES

The predicted changes to flow regimes within Deep Creek, both during and following the quarry operations, are expected to be negligible (Section 5.2). Therefore, the potential to impact downstream riparian and ecological values is considered minor.

5.7 WATER USERS

There are no known licensed water users on Deep Creek downstream of DCQ.

The proposed quarry will have minor impacts on the annual flow volumes in Deep Creek, due to the reduced catchment associated with the quarry operations (Table 5.1).

As such only minimal impacts are expected on basic landholder rights on Deep Creek to The Bucketts Way, downstream of which is the Karuah National Park.

5.8 SUMMARY OF PROPOSED MITIGATION MEASURES

The principal measures proposed to mitigate the potential surface water impacts of the proposed project are:

- A WMS that includes:

  - Clean water management system to minimise water take.
  - Dirty water management system to minimise uncontrolled releases of dirty water.
- Scour protection measures for the proposed watercourse crossing points associated with the proposed access route.
- Sediment dams designed with stable spillways for overflows in wet weather.
- Discharge points located within tributaries of Deep Creek with suitable scour protection controls and pumping procedures.
- Management for discharge of sediment dams to ensure water quality measures are implemented.

All water management infrastructure, and scour protection measures are to be designed, constructed, maintained, removed, and rehabilitated to:

- Fulfil the statutory conditions of the project approval.
- Meet industry standards and best practice, specially:
  - Landcom 2004. Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.
  - Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

5.9 CUMULATIVE IMPACTS

5.9.1 Flows

During operations, the proposed quarry will result in changes to the catchment area of Deep Creek. This is primarily due to the fraction of the catchment that will be managed within the site WMS.

The results of the flow analysis (Section 5.2), indicate a slight increase in the frequency of very low flows (<1 ML per day) in Deep Creek for the operational period of the proposed quarry, with negligible predicted impacts on baseflows.

The analysis of watercourse stability (Section 5.3) indicates negligible changes to velocities within Deep Creek (away from the proposed watercourse crossing structures). The proposed quarry is consequently considered likely to have limited impact on waterway stability and scour potential.

5.9.2 Water Quality

Management of potential water quality impacts throughout the life of the proposed quarry would be undertaken using the proposed WMS (Section 3). The WMS includes a series of erosion and sediment control measures that will be utilised during operation and rehabilitation phases of the operations to manage water quality.

Through management of dirty water within the WMS over the life of the operations, it is not anticipated that water quality in downstream waterways will be adversely impacted as a result of the proposed quarry.

As such the cumulative potential impacts on water quality in downstream watercourses is considered to be low.

5.9.3 Downstream Users

Deep Creek flows into the Karuah River, which has a very large catchment area. Water quantity is not anticipated to be adversely impacted by the proposed quarry on a sub-regional or regional scale.

6 MANAGEMENT, MONITORING, LICENSING, AND REPORTING

6.1 WATER MANAGEMENT PLAN AND MONITORING

Prior to commencing operations, a site WMP will be prepared that will include details of erosion and sediment controls, surface water and groundwater monitoring programs, as well as a surface and groundwater response plan. The WMP will include specific monitoring requirements for:

- Erosion and sediment control measures.
- Surface water and groundwater quality monitoring.
- Stream health and channel stability monitoring.

At a minimum, the current water quality testing schedule (Section 2.4.1) is expected to be maintained, i.e.:

- Monthly field measurements of EC, pH, and TSS at the four monitoring locations indicated in Figure 2-3.
- Quarterly full laboratory suite (as per Table 2.1) at the four monitoring locations indicated in Figure 2-3.
- Event-based monitoring at the four monitoring locations indicated in Figure 2-3, including field measurements (EC, pH, and TSS) and full laboratory suite.

In addition, during storm events, discharges from the sediment dams may occur. Monitoring of these discharges should be undertaken, including grab samples for a full laboratory suite, to assess potential impacts of these discharges. Water quality triggers (Section 6.1.1) are used in combination with the water quality sampling, in order to identify whether the discharges have impacted the downstream water quality (and therefore, potentially, caused material harm).

6.1.1 Water Quality Trigger Values

The NSW Water Quality and River Flow Objectives (as published by the Office of Environment and Heritage (OEH)) are the agreed environmental values and long-term goals for NSW surface waters. The objectives are consistent with the agreed national framework for assessing water quality as set out in the ANZG (2018).

The ANZG (2018) provide default trigger values and methods to determine site specific trigger values. The ANZG (2018) indicate the preferred use of site-specific trigger values. The trigger values are not assessment criteria however are used to characterize the water quality and estimate the ecological integrity of a water resource.

The ANZG (2018) require at least two years of monthly water quality sampling to derive site-specific trigger values. Therefore, site-specific trigger values for pH and EC have been estimated, based on the combined field and laboratory results (Section 2.4.2), and are included in Table 2.2. Table 2.2 also includes the ANZG (2018) default trigger values for other water quality analytes where insufficient data is available for the derivation of site specific trigger values.

Table 6.1: Proposed Water Quality Triggers

Analyte	Units	Trigger Value	Source
pH	-	6.0 to 6.9	20th and 80th percentiles of observed values for NORTH and SOUTH water quality data
EC	µS/cm	150 to 250	
TSS	mg/L	< 40	ANZECC (2000) Table 4.4.2 (Freshwater aquaculture)
Magnesium	mg/L	15	ANZECC (2000) Table 4.4.3 (Freshwater aquaculture)
Total phosphorus	mg/L	0.025	ANZECC (2000) Table 3.3.2 (Lowland Rivers)

Analyte	Units	Trigger Value	Source
Total nitrogen	mg/L	0.350	
Aluminium	mg/L	0.055	ANZECC (2000) Table 3.4.1 (Freshwater, 95% protection level)
Chromium	mg/L	0.001	
Copper	mg/L	0.001	
Lead	mg/L	0.001	
Zinc	mg/L	0.005	

6.2 LICENSING REQUIREMENTS

6.2.1 Protection of the Environment Operations Act 1997

The EPL, to be issued under the POEO Act, will require two discharge locations: one for each of the two sediment dams.

Water balance modelling (Section 4) indicates that discharges of up to about 140 ML per annum are likely (for median climate conditions: Table 4.1). These discharges principally consist of controlled dewatering of the dams, however also include uncontrolled overflows due to storm events with rainfall depths in excess of about 91.5 mm (based on the design rainfall depth of the sediment dams of 91.5 mm over 5 days).

Controlled discharges would be subject to water quality limits (Section 6.1.1), and will require water quality monitoring to demonstrate that any discharges are consistent with these limits.

6.2.2 Water Management Act 2000

WALs, in addition to the site harvestable right of about 33 ML, will be required to cover the water take from the dam to the south of the quarry. Water balance modelling (Section 4) indicates that by retaining and reusing surface water generated on site (primarily within the quarry footprint), external supply from the dam are expected to be small (up to 1 ML per year).

Groundwater seepages into the pit will need to be licensed under the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (New England Fold Belt Coast Groundwater Source). It is understood that the final landform will be free-draining and will therefore not represent a loss of groundwater to evaporation.

6.3 REPORTING

A summary of surface water monitoring results will be provided in the Annual Review. As a minimum, the following information will be reported in the Annual Review:

- A summary of monitoring results against impact assessment criteria, historical monitoring results.
- Annual site water balance and comparison against predictions in for the project approval.
- An identification of any trends in the monitoring results.
- Any non-compliances reported during the year.
- Actions taken to address any non-compliances.

In addition, any significant findings regarding the implementation of the WMP will be reported in the Annual Review, including:

- The effectiveness of the erosion and sediment controls.
- Changes to the site water balance.
- Any identified issues or exceedances of trigger values.

The Annual Review will also document reviews and feedback relating to the maintenance and performance of the WMS.

7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (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.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or
   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

8 REFERENCES

ANZECC, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*

ANZG, 2018. *Australian and New Zealand guidelines for fresh and marine water quality*

Boughton W.J., 2004, *The Australian Water Balance Model*, Environmental Modelling & Software, vol. 19, pp. 943-956

Hydrominex Geoscience Pty Ltd, 2021. *Groundwater Assessment, Deep Creek Quarry, Deep Creek, NSW, Report For Ironstone Developments Pty Ltd, Version 5*

Appendix A:
Flood Modelling Method

HYDROLOGIC MODEL DEVELOPMENT

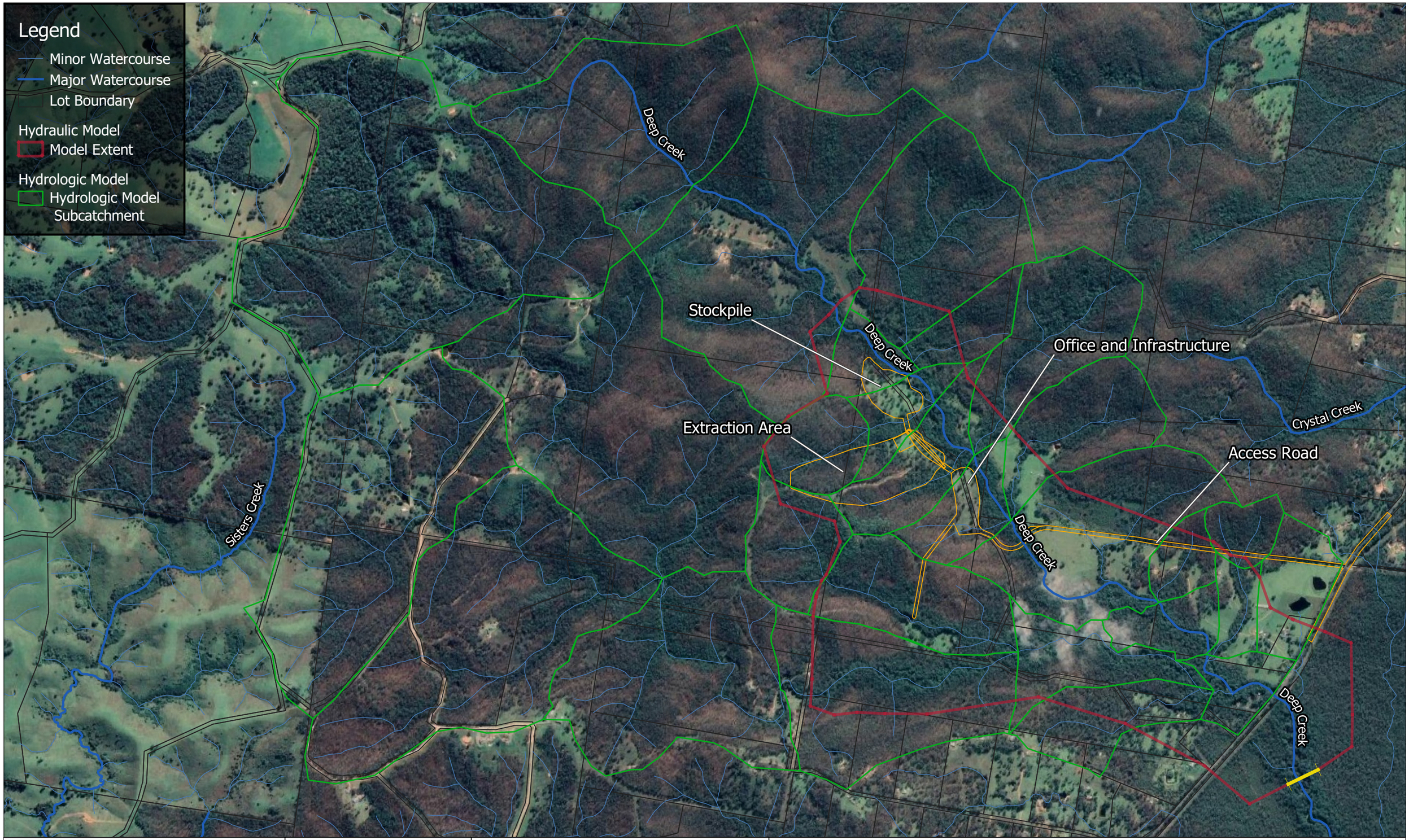
OVERVIEW

Hydrologic modelling for this study was undertaken using the XP-RAFTS software package to estimate catchment runoff for the critical duration at the 50%, 10%, and 1% Annual Exceedance Probability (AEP) and Probable Maximum Flood (PMF) events. Design storm parameters were sourced from Australian Rainfall and Runoff 2019 (ARR2019) Data Hub (data.arr-software.org).

XP-RAFTS MODEL SETUP

Sub-Catchment Delineation

Sub-catchment delineation and XP-RAFTS model schematisation was undertaken manually using GIS software (Figure A.1). 2 m DEM, derived from LiDAR data, sourced from NSW Government Spatial Services was used as the basis for sub-catchment delineation.



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400 0 400 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure A.1: Hydrologic and Hydraulic Model Overview

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Catchment Properties

The following sub catchment characteristics were incorporated into the XP-RAFTS model for the runoff routing calculation:

- Catchment area (pervious and impervious)
- Catchment slope
- Fraction impervious
- Catchment roughness (Manning's n)

Catchment area and slope were generated manually using GIS software and the topographical data. Impervious areas were delineated based on aerial photography. As the catchment is predominately rural, no consideration was given to the calculation of indirectly or directly connected impervious areas.

The catchment roughness (PERN) values adopted in the model are summarised in Table A.1.

Table A.1: XP-RAFTS PERN Values

Land Use Type	PERN
Pervious Areas	0.20
Impervious Areas	0.025

RAINFALL INPUTS

Design Intensity-Frequency-Duration (IFD) Data

Design rainfall depths used in the hydrologic modelling were sourced from the Bureau of Meteorology (BoM) ARR Design Rainfall System (bom.gov.au/water/designRainfalls/revised-ifd).

Rainfall Losses

Design event initial loss (IL) and continuing loss (CL) values were sourced from ARR2019 Data Hub. Consideration was given to the NSW Office of Environment and Heritage (OEH) recommendation for using NSW specific design losses (WMA, 2019), as recommended by ARR2019.

The adopted storm losses are summarised in Table A.2.

Table A.2: Adopted Storm Losses

Land Use Type	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious Areas	10	2.5
Impervious Areas	2	0.0

HYDRAULIC MODEL DEVELOPMENT

OVERVIEW

The TUFLOW model includes the reaches and tributaries of Deep Creek and adjacent floodplain, extending from upstream (west) of the proposed quarry to the bridge crossing at The Bucketts Way (Figure A.1)

TUFLOW MODEL SETUP

Model Topography and Extent

The NSW LPI 2 m DEM (2015) was used as the base for this model.

Three scenarios were assessed:

1. Existing landform.
2. Operational landform.
3. Final landform.

Hydraulic Roughness

The adopted hydraulic roughness (Manning's 'n') values are summarised in Table A.3.

Table A.3: Adopted Hydraulic Roughness Values

Land Use Type	Manning's 'n'
Roads and hardstand	0.020
Open fields	0.035
Moderate vegetation	0.060
Channel with low vegetation	0.035
Channel with moderate to high vegetation	0.055
Floodplain	0.035

Model Boundaries

The following boundaries were applied to the model:

- Model inflow boundaries:
  - Applied as 'flow over area' boundaries, as these typically result in a more stable hydraulic model.
  - Hydrologic model inflows locations will be representative of the sub-catchments delineated in the hydrologic model.
- A model outflow boundary:
  - Applied as normal depth boundary at The Bucketts Way bridge, using the automatically generated stage-discharge relationship generated by TUFLOW.

Structures

The proposed Deep Creek crossing structures associated with the access road were included as 1-D elements.

Grid Size and Time Step

A grid size of 3 m was adopted for the hydraulic model, as it was considered to provide a reasonable balance of model precision and run time.

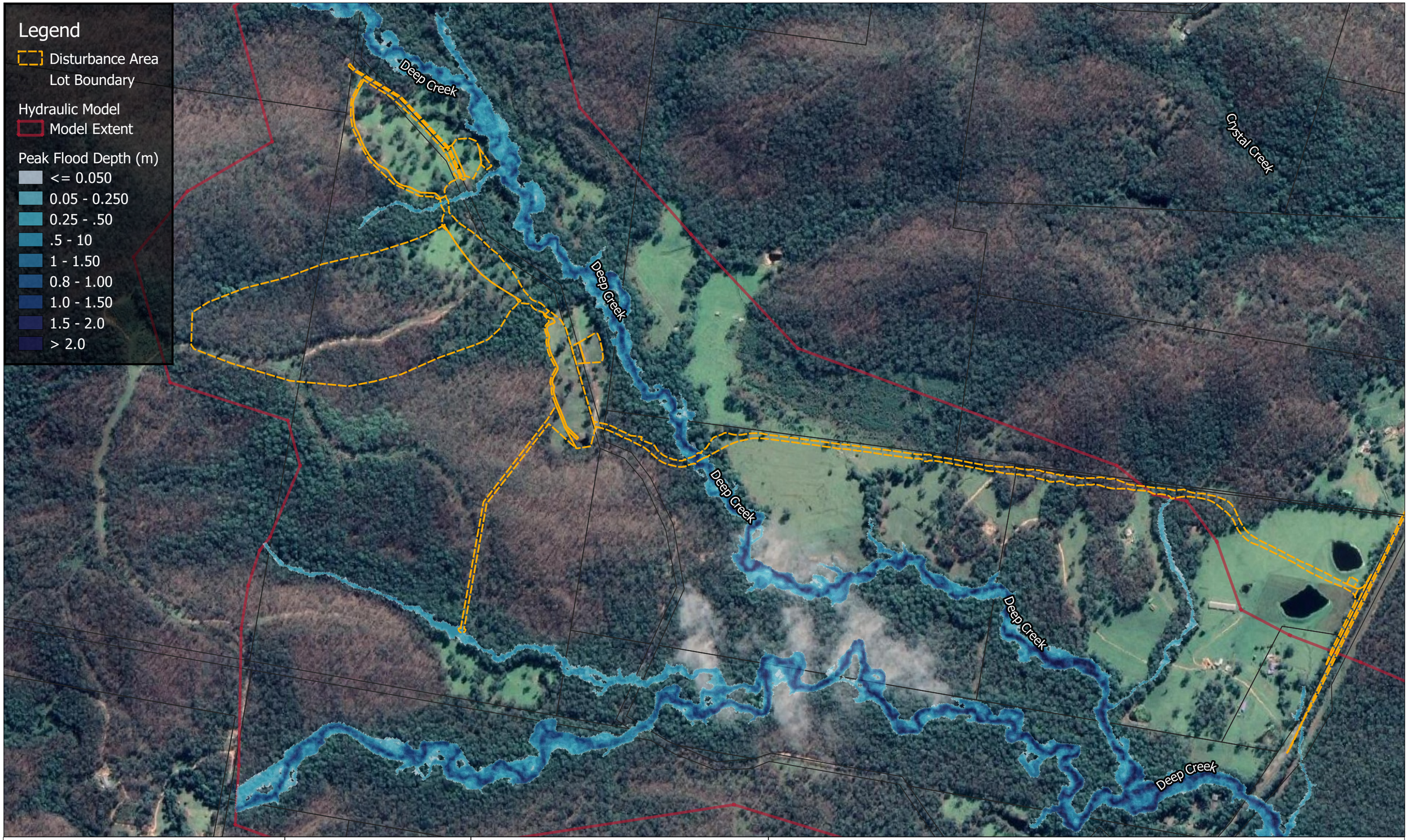
Channel Representation

All channels for >=3rd order watercourses were modelled in the TUFLOW domain.

Initial Conditions

Deep Creek is an ephemeral watercourse, therefore no initial flows were applied.

Appendix B:
Flood Mapping – Existing Conditions



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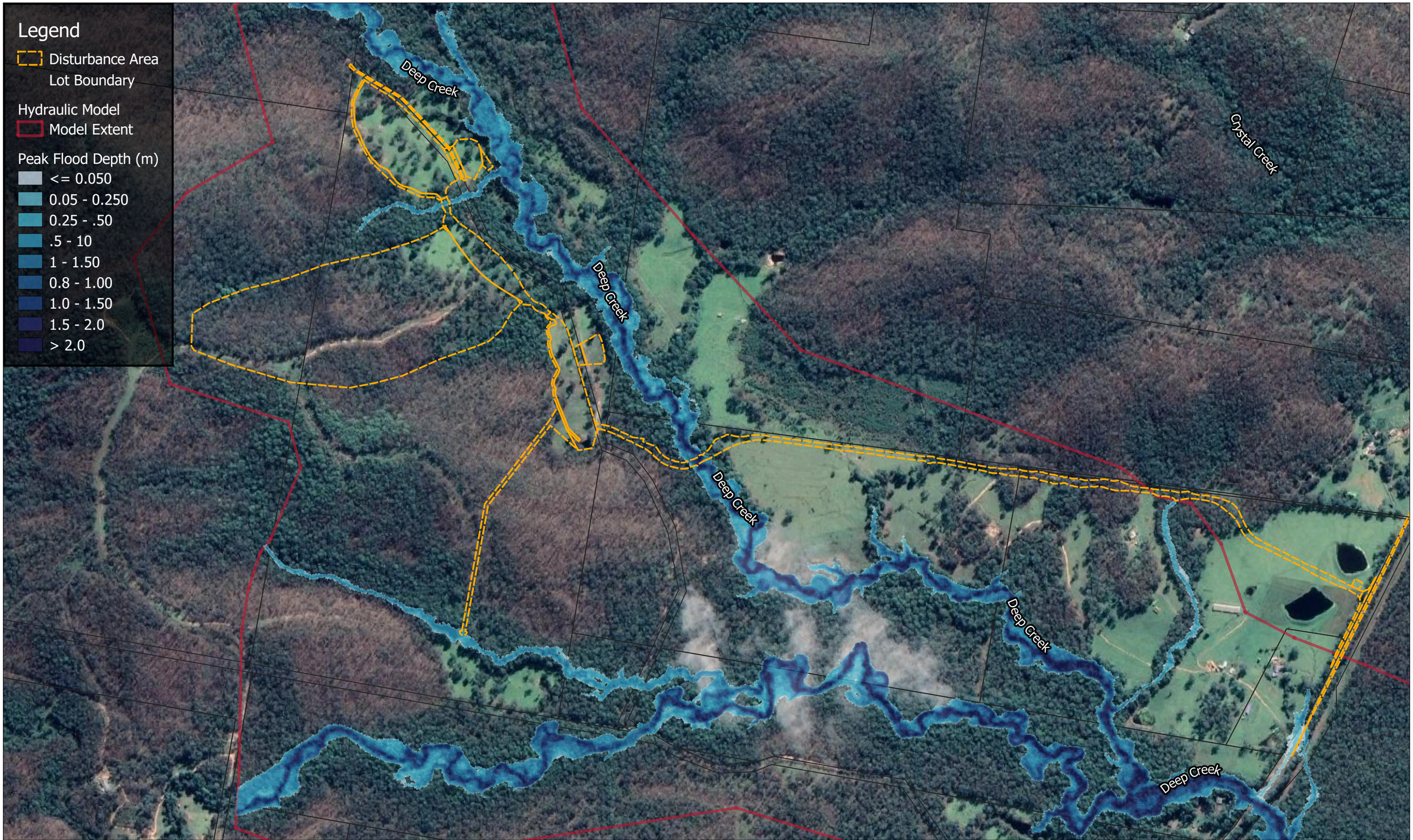
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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Deep Creek Quarry SWIA

Figure B.1: 50% AEP Maximum Modelled Flood Depths Existing Conditions

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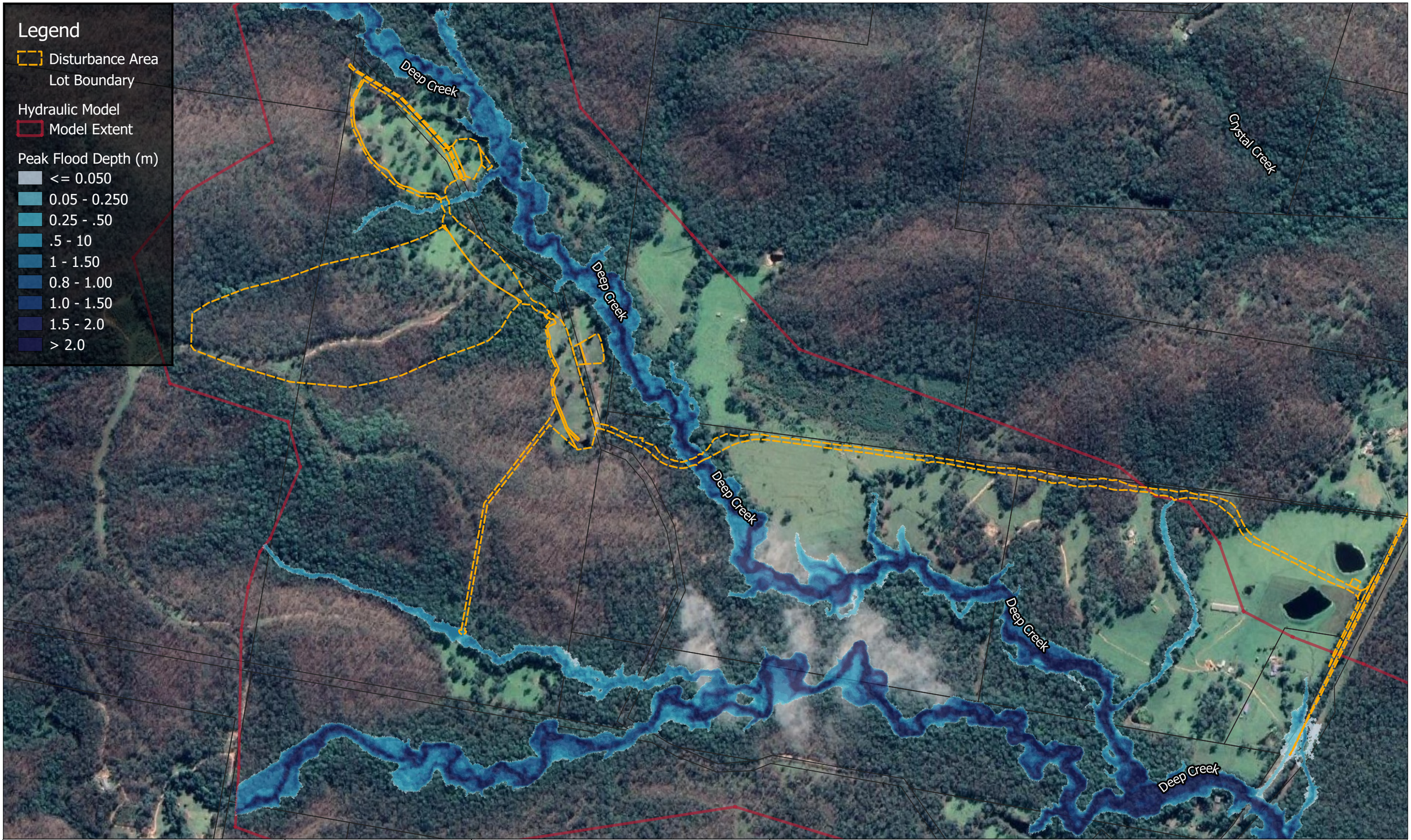
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Map Projection: Tranverse Mercator
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Deep Creek Quarry SWIA

Figure B.2: 10% AEP Maximum Modelled Flood Depths Existing Conditions

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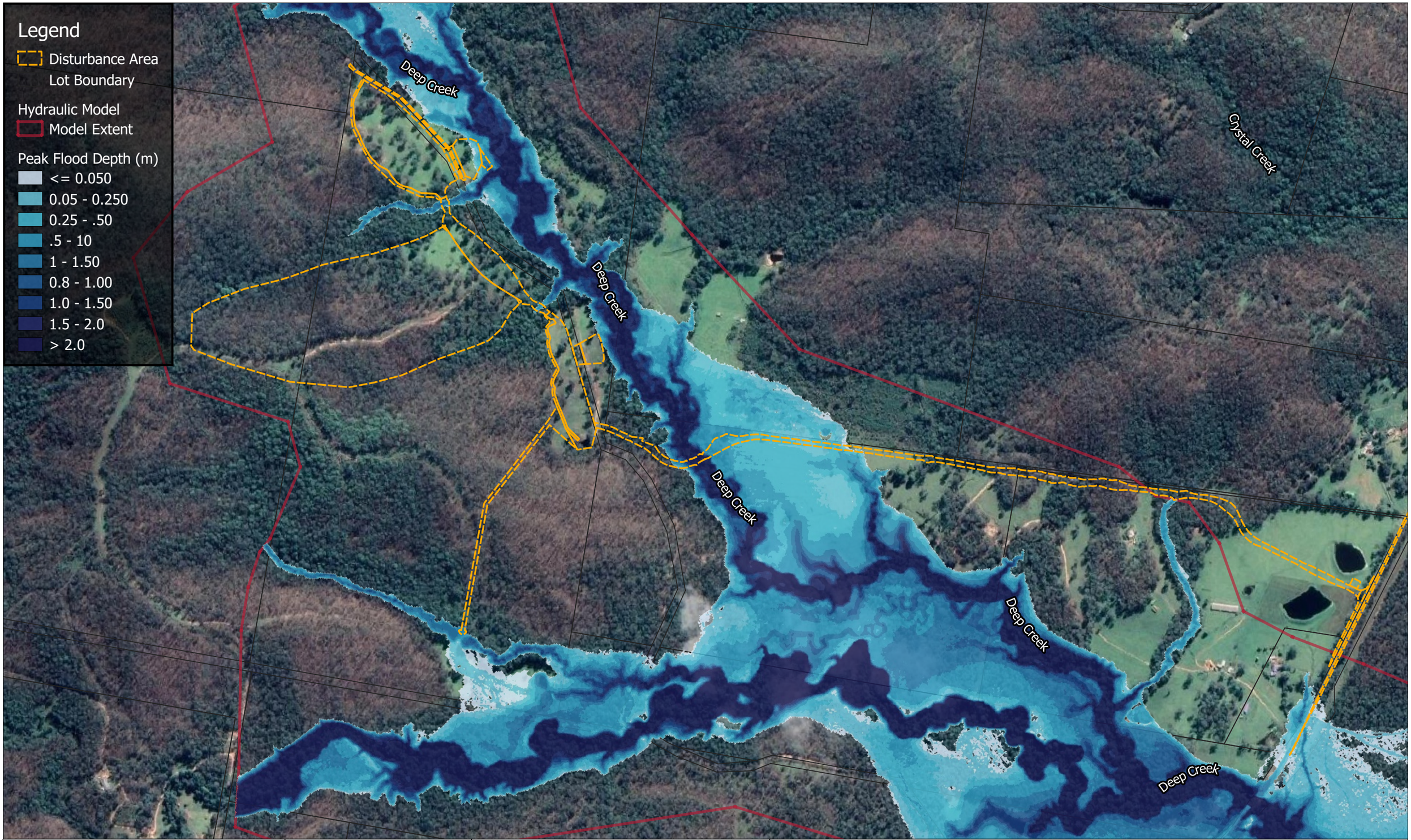
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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
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Deep Creek Quarry SWIA

Figure B.3: 1% AEP Maximum Modelled Flood Depths Existing Conditions

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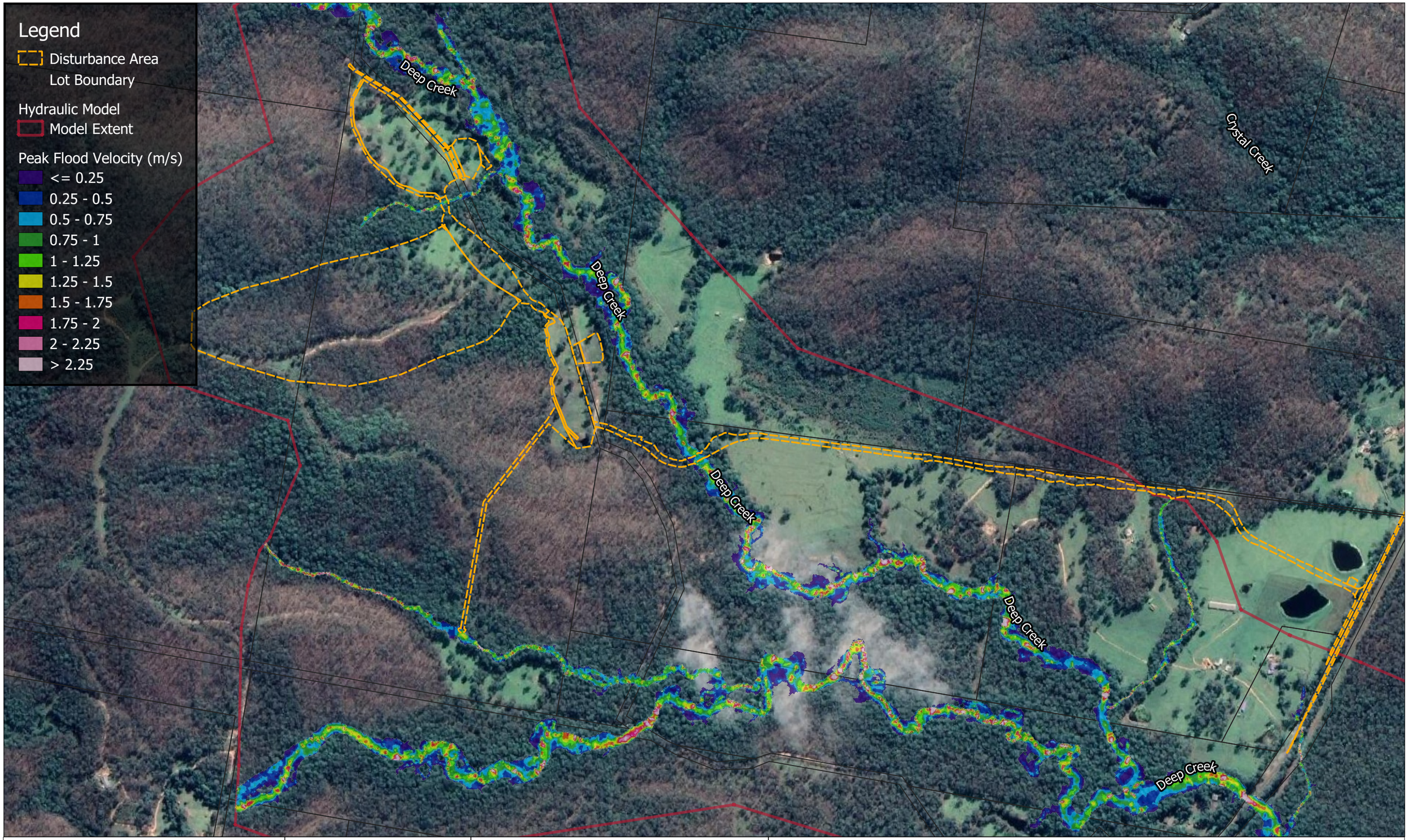
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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Deep Creek Quarry SWIA

Figure B.4: PMF Maximum Modelled Flood Depths Existing Conditions

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Deep Creek Quarry SWIA

Figure B.5: 50% AEP Maximum Modelled Flood Velocities Existing Conditions

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Legend

Disturbance Area
Lot Boundary

Hydraulic Model
Model Extent

Peak Flood Velocity (m/s)
<= 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
2 - 2.25
> 2.25

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
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Deep Creek Quarry SWIA

Figure B.6: 10% AEP Maximum Modelled Flood Velocities Existing Conditions

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Legend

Disturbance Area
Lot Boundary

Hydraulic Model
Model Extent

Peak Flood Velocity (m/s)
<= 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
2 - 2.25
> 2.25

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

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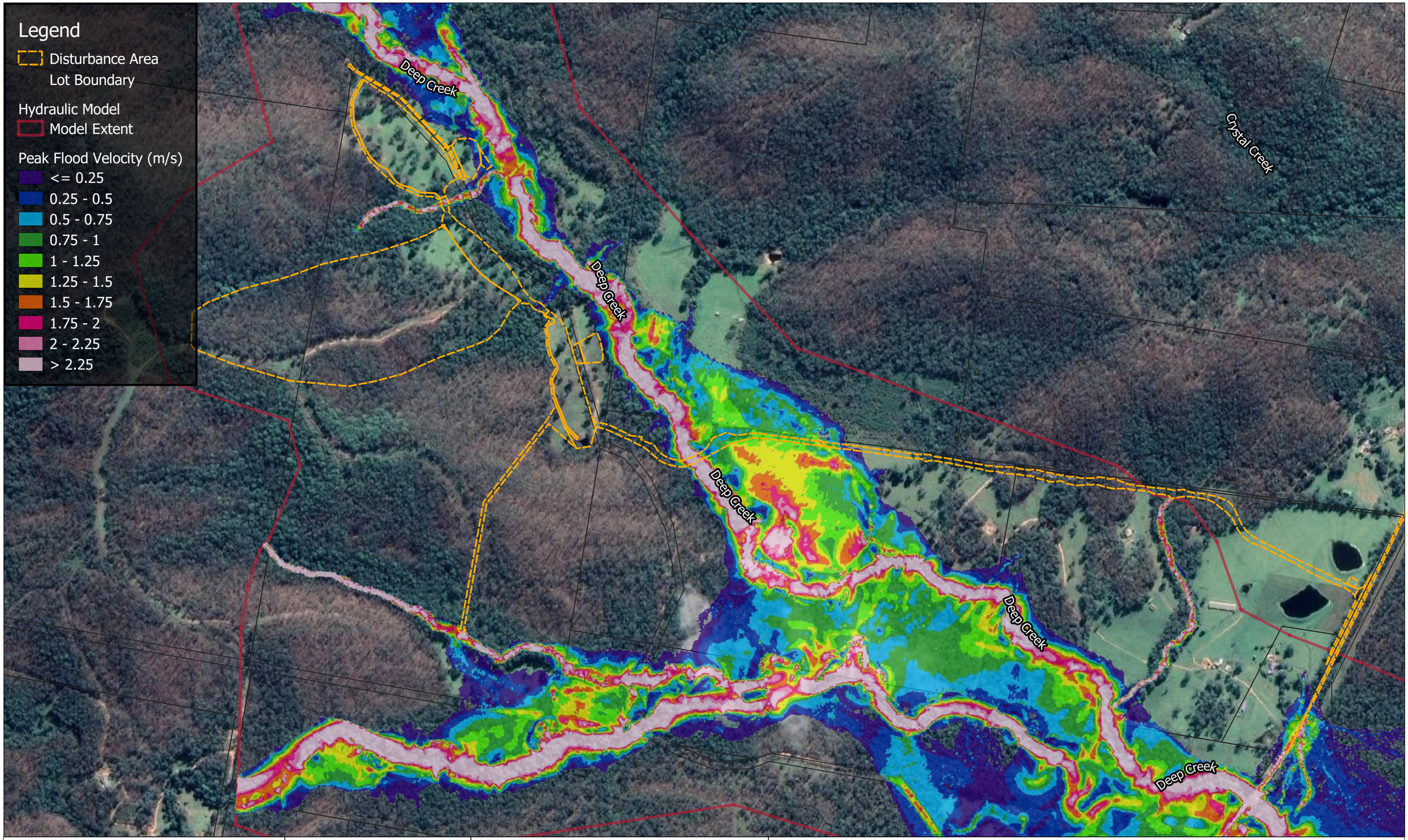
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Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
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Figure B.7: 1% AEP Maximum Modelled Flood Velocities Existing Conditions

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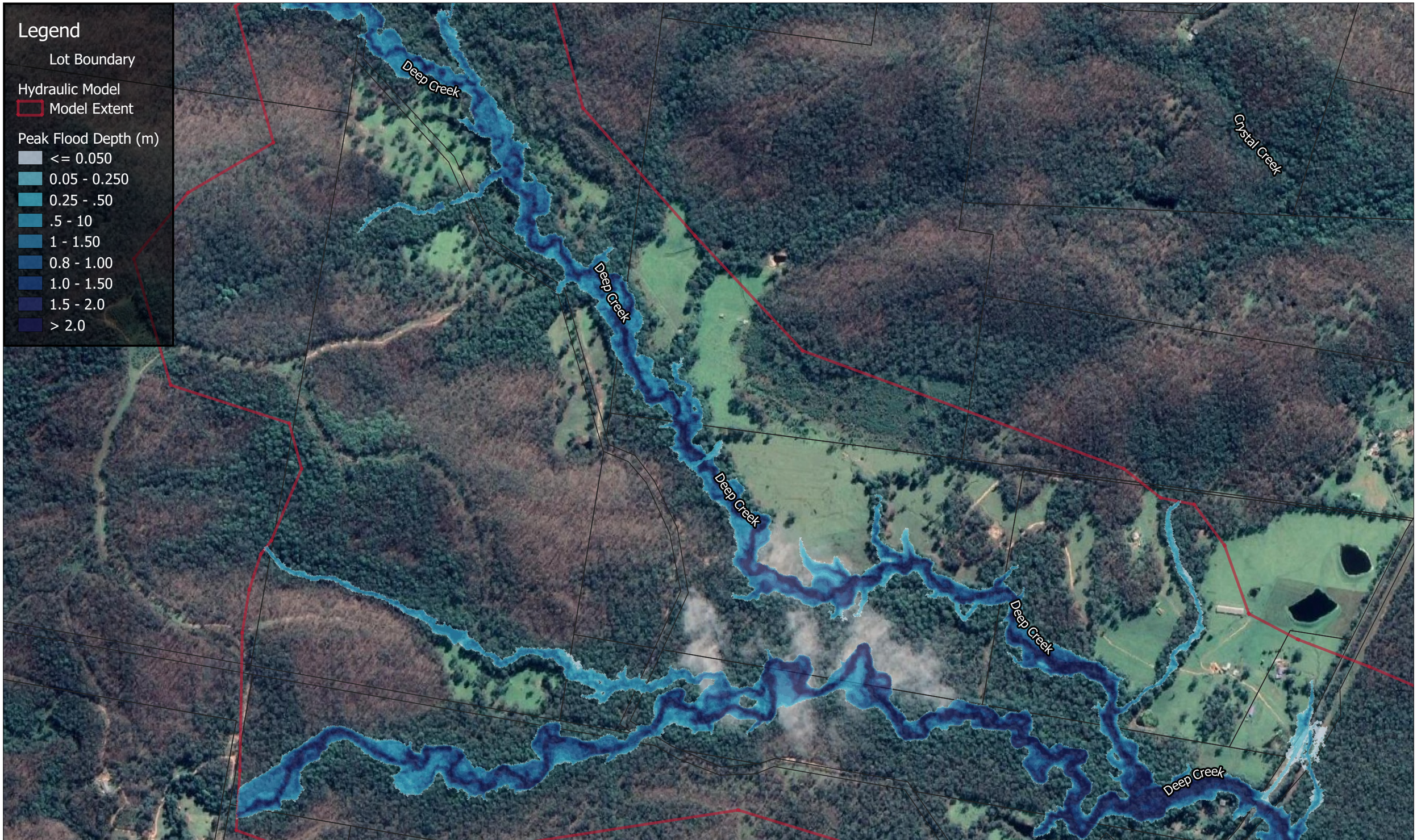
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Horizontal Datum: Geocentric Datum of Australia
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Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure B.8: PMF Maximum Modelled Flood Velocities Existing Conditions

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Appendix C:
Flood Mapping – Operational Conditions



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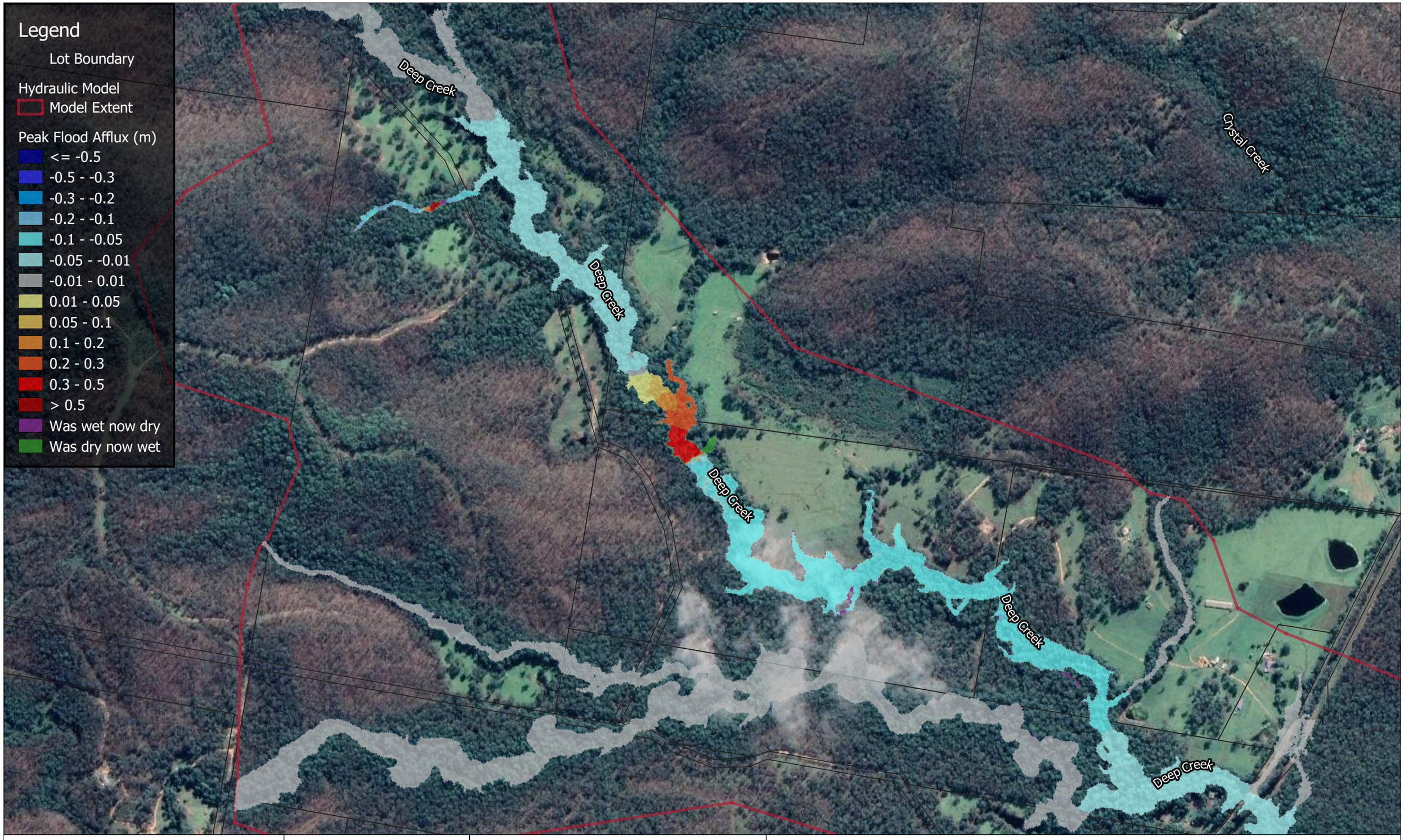
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Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure C.1: 1% AEP Maximum Modelled Flood Depths Operational Conditions

Job Number: N1222_001
Revision: 1
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Date: 24/3/2021



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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure C.2: 1% AEP Peak Flood Afflux Operational Conditions

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model
Model Extent

Peak Flood Velocity (m/s)
<= 0.25
0.25 - 0.5
0.5 - 0.75
0.75 - 1
1 - 1.25
1.25 - 1.5
1.5 - 1.75
1.75 - 2
2 - 2.25
> 2.25

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

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Figure C.3: 1% AEP Maximum Modelled Flood Velocities Operational Conditions

Job Number: N1222_001
Revision: 1
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Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model
Model Extent

Change in Velocity (m/s)
<= -0.5
-0.3 - -0.5
-0.1 - -0.3
-0.1 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Was wet now dry
Was dry now wet

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure C.4: 1% AEP Peak Velocity Afflux Operational Conditions

Job Number: N1222_001
Revision: 1
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Date: 24/3/2021

Appendix D:
Flood Mapping – Final Landform

Legend

Lot Boundary

Hydraulic Model

Model Extent

Peak Flood Depth (m)

- <= 0.050
- 0.05 - 0.250
- 0.25 - .50
- .5 - 10
- 1 - 1.50
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.1: 50% AEP Maximum Modelled Flood Depths Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model
Model Extent

Peak Flood Depth (m)
<= 0.050
0.05 - 0.250
0.25 - .50
.5 - 10
1 - 1.50
0.8 - 1.00
1.0 - 1.50
1.5 - 2.0
> 2.0

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.2: 10% AEP Maximum Modelled Flood Depths Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model

Model Extent

Peak Flood Depth (m)

- <= 0.050
- 0.05 - 0.250
- 0.25 - .50
- .5 - 10
- 1 - 1.50
- 0.8 - 1.00
- 1.0 - 1.50
- 1.5 - 2.0
- > 2.0

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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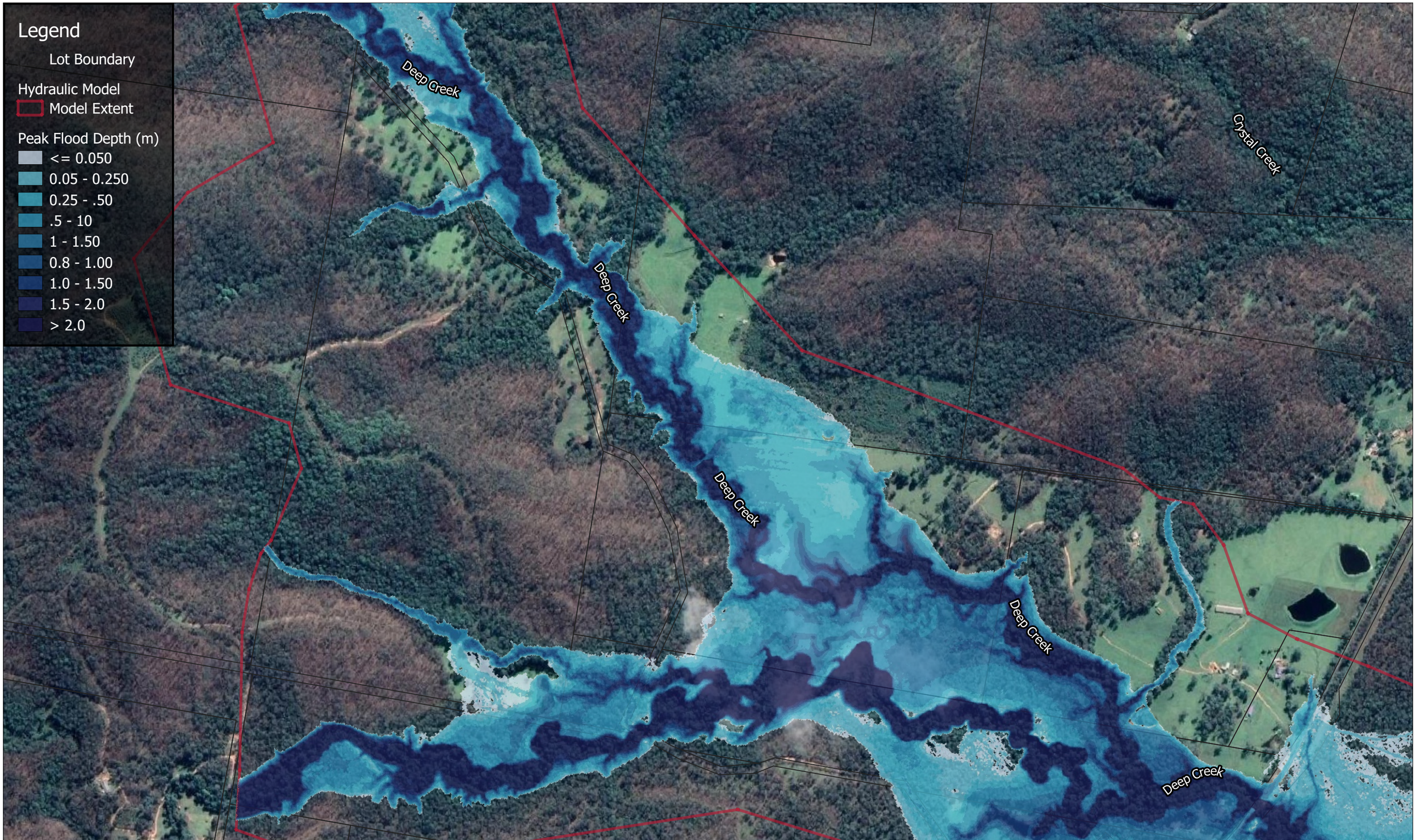
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.3: 1% AEP Maximum Modelled Flood Depths Final Landform

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Revision: 1
Drawn: MB
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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.4: PMF Maximum Modelled Flood Depths Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model

Model Extent

Peak Flood Afflux (m)

- <= -0.5
- -0.5 - -0.3
- -0.3 - -0.2
- -0.2 - -0.1
- -0.1 - -0.05
- -0.05 - -0.01
- -0.01 - 0.01
- 0.01 - 0.05
- 0.05 - 0.1
- 0.1 - 0.2
- 0.2 - 0.3
- 0.3 - 0.5
- > 0.5
- Was wet now dry
- Was dry now wet

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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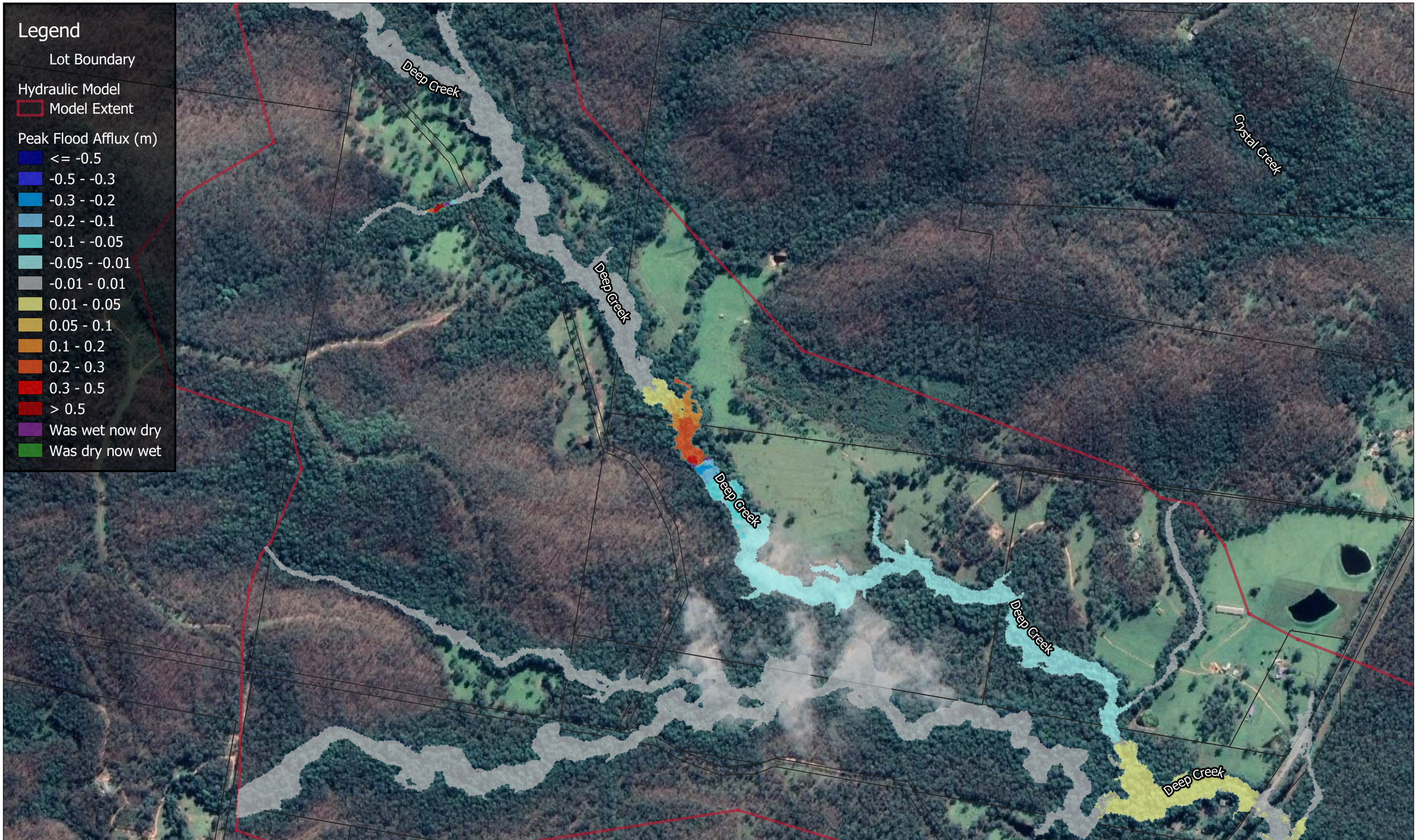
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.5: 50% AEP Peak Flood Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
Revision: 1
Drawn: MB
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Date: 24/3/2021



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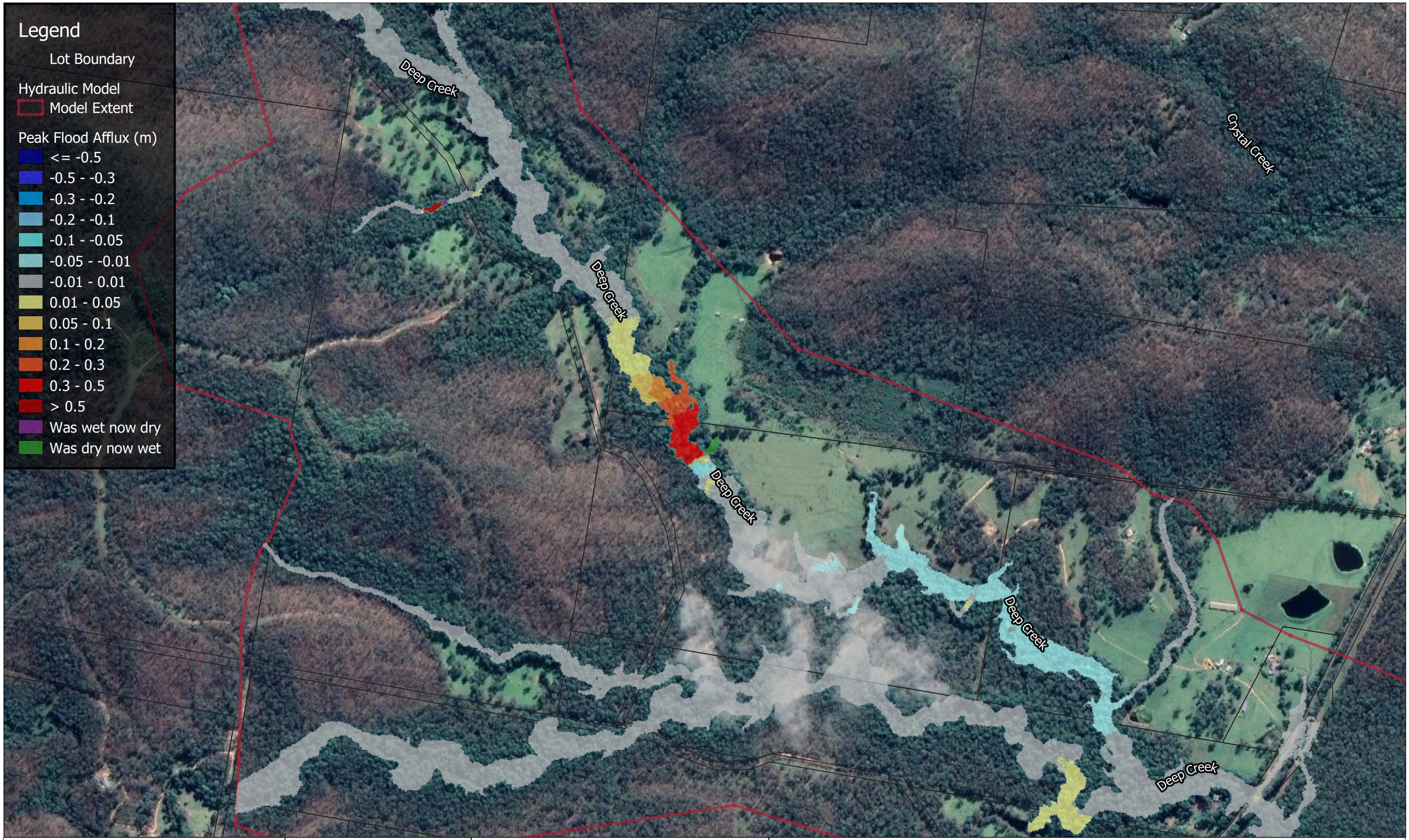
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.6: 10% AEP Peak Flood Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021



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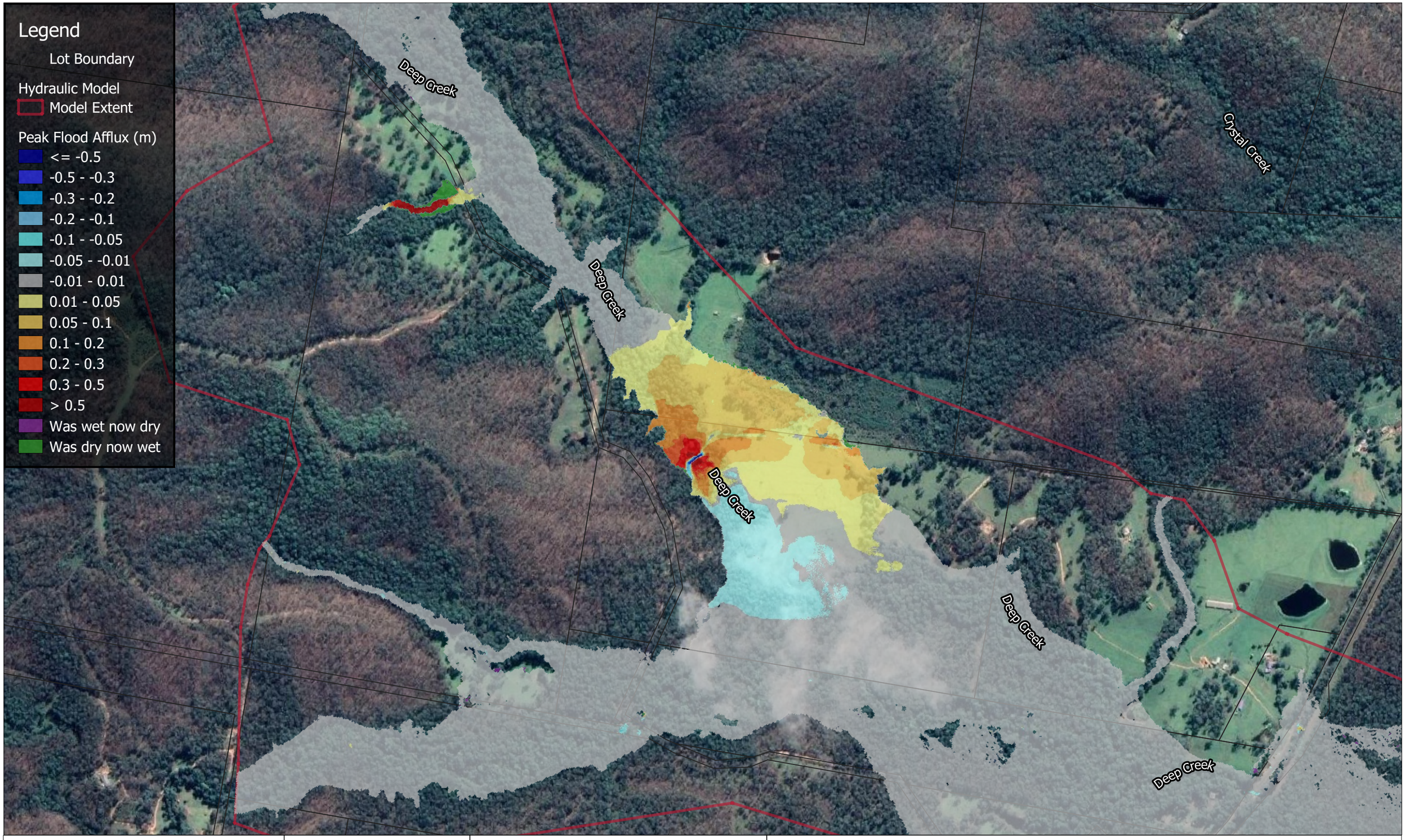
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.7: 1% AEP Peak Flood Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021



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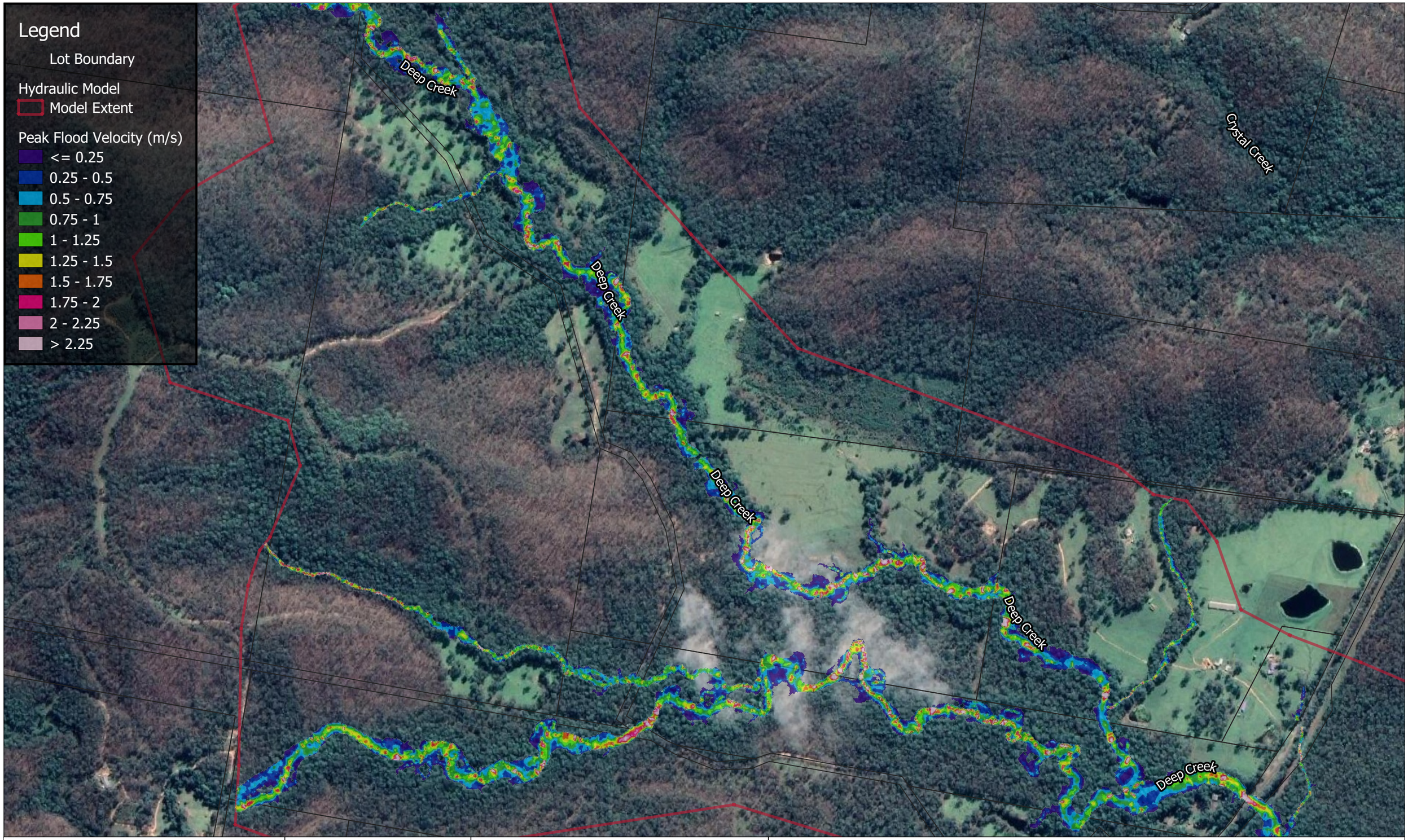
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.8: PMF Peak Flood Afflux Final Landform vs Existing Conditions

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Date: 24/3/2021



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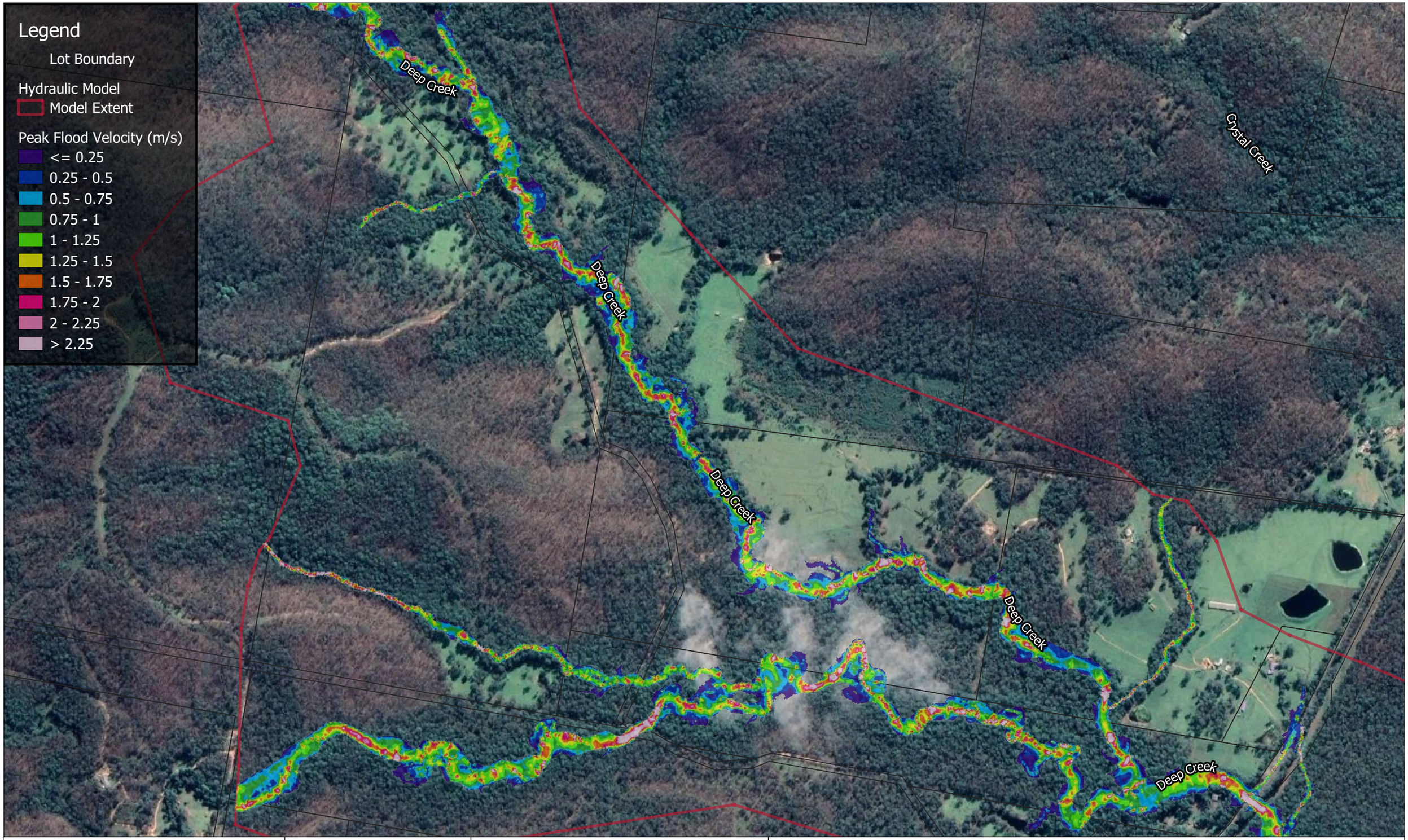
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.9: 50% AEP Maximum Modelled Flood Velocities Final Landform

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Date: 24/3/2021



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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.10: 10% AEP Maximum Modelled Flood Velocities Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model

Model Extent

Peak Flood Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2 - 2.25
- > 2.25

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.11: 1% AEP Maximum Modelled Flood Velocities Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model

Model Extent

Peak Flood Velocity (m/s)

- <= 0.25
- 0.25 - 0.5
- 0.5 - 0.75
- 0.75 - 1
- 1 - 1.25
- 1.25 - 1.5
- 1.5 - 1.75
- 1.75 - 2
- 2 - 2.25
- > 2.25

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.12: PMF Maximum Modelled Flood Velocities Final Landform

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model

Model Extent

Change in Velocity (m/s)

- <= -0.5
- -0.3 - -0.5
- -0.1 - -0.3
- -0.1 - 0.1
- 0.1 - 0.3
- 0.3 - 0.5
- > 0.5
- Was wet now dry
- Was dry now wet

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Deep Creek

Crystal Creek

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.13: 50% AEP Peak Velocity Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
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Date: 24/3/2021



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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.14: 10% AEP Peak Velocity Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
Revision: 1
Drawn: MB
Checked: AW
Date: 24/3/2021

Legend

Lot Boundary

Hydraulic Model
Model Extent

Change in Velocity (m/s)
<= -0.5
-0.3 - -0.5
-0.1 - -0.3
-0.1 - 0.1
0.1 - 0.3
0.3 - 0.5
> 0.5
Was wet now dry
Was dry now wet

Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Deep Creek
Crystal Creek

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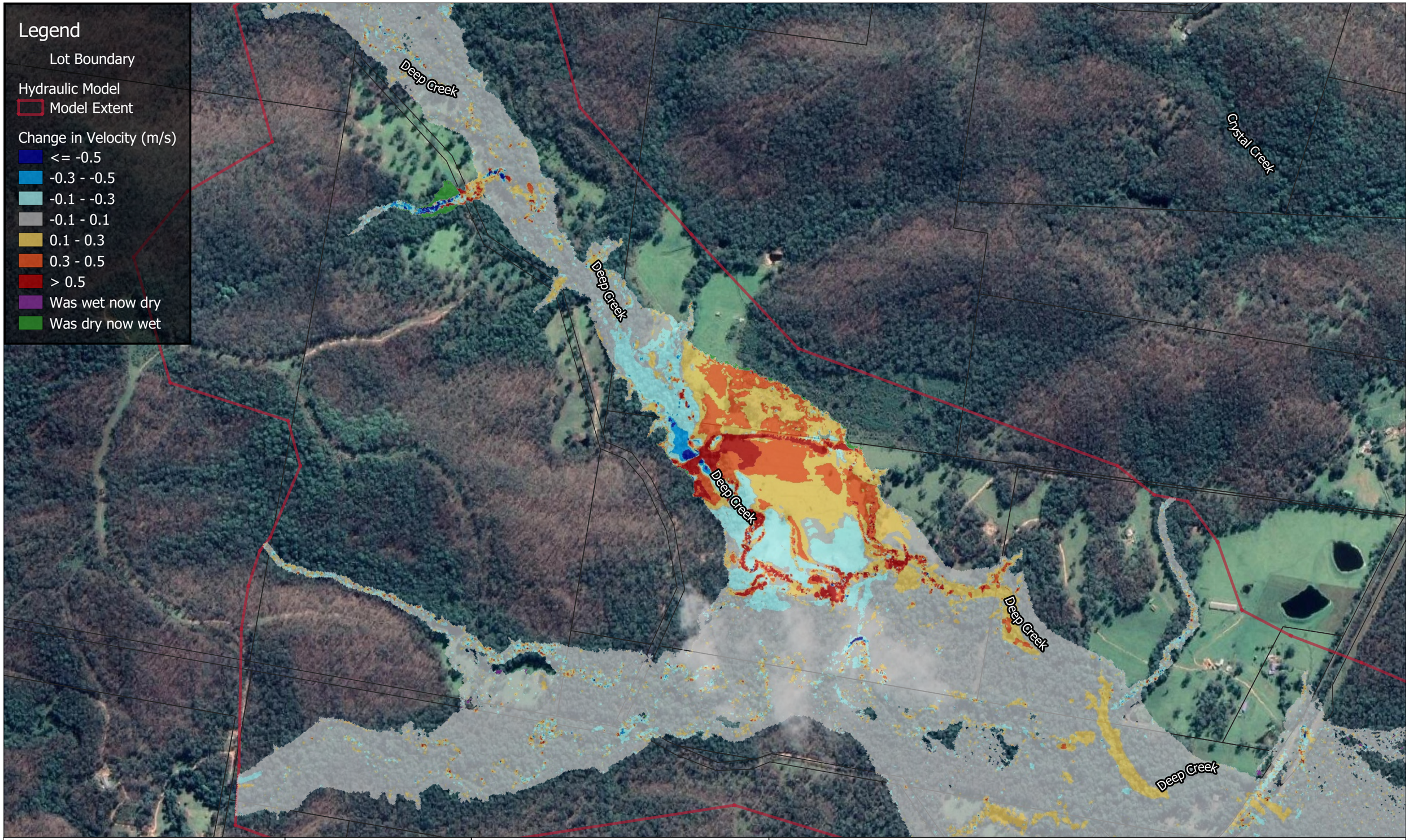
200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.15: 1% AEP Peak Velocity Afflux Final Landform vs Existing Conditions

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200 0 200 m

Map Projection: Tranverse Mercator
Horizontal Datum: Geocentric Datum of Australia
Vertical Datum: Australia Height Datum
Grid: Map Grid of Australia, Zone 56

Deep Creek Quarry SWIA

Figure D.16: PMF Peak Velocity Afflux Final Landform vs Existing Conditions

Job Number: N1222_001
Revision: 1
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Appendix E:
Secretary's Environmental Assessment Requirements

Table E-1 Planning Secretary's Environmental Assessment Requirements

Requirement		Where Addressed
General Requirements	The Environmental Impact Statement (EIS) for the development must comply with the requirements in Clauses 6 and 7 of Schedule 2 of the Environmental Planning and Assessment Regulation 2000. In particular, the EIS must include:	
	A water management strategy	Section 3
Key Issues	The EIS must address the following key issues:	
	- A detailed site water balance, including a description of site water demands, water disposal method (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;	Section 4
	- Identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;	Section 6.1.1
	- Demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	Section 6.1.1
	- A description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Section 6.1.1
	- An assessment of any likely flooding impacts of the development;	Section 5.3.1
	- An assessment of the likely impacts on the quality and quantity of existing surface and ground water resources, including a detailed assessment of proposed water discharge quantities and quality against receiving water quality and flow objectives;	Section 5.4
	- An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users;	Section 5
	- A detailed description of the proposed water management system (including sewage, wastewater, and stormwater), water monitoring program, erosion and sediment control measures, and other measures to mitigate surface and groundwater impacts; and	Section 3
	- Include a detailed consideration of any potential impacts on sensitive downstream receiving environments, including the Karuah River.	Section 5.7

Table E-2 NSW DPIE Standard Environmental Assessment Requirements

Requirement	Where Addressed
5. The EIS must map the following features relevant to water and soils including:	
a. Acid sulfate soils (Class 1, 2, 3 or 4 on the Acid Sulfate Soil Planning Map).	Addressed as part of other specialist assessment(s)
b. Rivers, streams, wetlands, estuaries (as described in s4.2 of the Biodiversity Assessment Method).	Figure 2-1 (Rivers, Streams)
c. Wetlands as described in s4.2 of the Biodiversity Assessment Method.	Addressed as part of other specialist assessment(s)
d. Groundwater.	Addressed as part of other specialist assessment(s)
e. Groundwater dependent ecosystems.	Addressed as part of other specialist assessment(s)
f. Proposed intake and discharge locations.	Figure 3-1, Figure 3-2, and Figure 3-3
6. The EIS must describe background conditions for any water resource likely to be affected by the development, including:	
a. Existing surface and groundwater.	Section 2.2
b. Hydrology, including volume, frequency, and quality of discharges at proposed intake and discharge locations.	Section 4
c. Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters.	Section Chapter 18
d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 2.4.3
7. The EIS must assess the impacts of the development on water quality, including:	
a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction.	Section 5.4 (surface water quality)
b. Identification of proposed monitoring of water quality.	Section 6.1
8. The EIS must assess the impact of the development on hydrology, including:	
a. Water balance including quantity, quality, and source.	Section 4
b. Effects to downstream rivers, wetlands, estuaries, marine waters, and floodplain areas.	Section 5
c. Effects to downstream water-dependent fauna and flora including groundwater dependent ecosystems.	Section 5.6
d. Impacts to natural processes and functions within rivers, wetlands, estuaries and floodplains that affect river system and landscape health such as nutrient flow, aquatic connectivity and access to habitat for spawning and refuge (e.g. river benches).	Section 5
e. Changes to environmental water availability, both regulated/licensed and unregulated/rules-based sources of such water.	Section 5.7

Requirement	Where Addressed
f. Mitigating effects of proposed stormwater and wastewater management during and after construction on hydrological attributes such as volumes, flow rates, management methods and re-use options.	Section 5.3.1
g. Identification of proposed monitoring of hydrological attributes.	Section 6.1
9. The EIS must map the following features relevant to flooding as described in the Floodplain Development Manual 2005 (NSW Government 2005) including:	Section 5.3.3
a. Flood prone land	
b. Flood planning area, the area below the flood planning level	
c. Hydraulic categorisation (floodways and flood storage areas).	
10. The EIS must describe flood assessment and modelling undertaken in determining the design flood levels for events, including a minimum of the 1 in 10-year, 1 in 100-year flood levels and the probable maximum flood, or an equivalent extreme event.	Sections 2.3 and 5.3.1
11. The EIS must model the effect of the proposed development (including fill) on the flood behaviour under the following scenarios:	
a. Current flood behaviour for a range of design events as identified in 11 above. This includes the 1 in 200 and 1 in 500-year flood events as proxies for assessing sensitivity to an increase in rainfall intensity of flood producing rainfall events due to climate change.	Section 5.3.2
12. Modelling in the EIS must consider and document:	
a. The impact on existing flood behaviour for a full range of flood events including up to the probable maximum flood.	Section 5.3.1
b. Impacts of the development on flood behaviour resulting in detrimental changes in potential flood affection of other developments or land. This may include redirection of flow, flow velocities, flood levels, hazards, and hydraulic categories.	Section 5.3
c. Relevant provisions of the NSW Floodplain Development Manual 2005	Section 5.3.3
13. The EIS must assess the impacts on the proposed development on flood behaviour, including:	
a. Whether there will be detrimental increases in the potential flood affectation of other properties, assets, and infrastructure.	Section 5.3.1
b. Consistency with Council floodplain risk management plans.	Section 5.3.3
c. Compatibility with the flood hazard of the land.	Section 5.3
d. Compatibility with the hydraulic functions of flow conveyance in floodways and storage in flood storage areas of the land.	Section 5.3
e. Whether there will be adverse effect to beneficial inundation of the floodplain environment, on, adjacent to or downstream of the site.	Section 5.3
f. Whether there will be direct or indirect increase in erosion, siltation, destruction of riparian vegetation or a reduction in the stability of riverbanks or watercourses.	Section 5.3
g. Any impacts the development may have upon existing community emergency management arrangements for flooding. These matters are to be discussed with the SES and Council.	Section 5.3.3
h. Whether the proposal incorporates specific measures to manage risk to life from flood. These matters are to be discussed with the SES and Council.	N/A
i. Emergency management, evacuation and access, and contingency measures for the development considering the full range or flood risk (based upon the probable maximum flood or an equivalent	N/A

Requirement	Where Addressed
extreme flood event). These matters are to be discussed with and have the support of Council and the SES.	
j. Any impacts the development may have on the social and economic costs to the community as consequence of flooding.	Section 5.3
14. The [EIS/EA] must describe the potential effects of coastal processes and hazards (within the meaning of the Coastal Management Act 2016), including sea level rise and climate change:	Addressed as part of other specialist assessment(s)
a. On the proposed development	
b. Arising from the proposed development	
15. The [EIS/EA] must consider have regard to any certified Coastal Management Program (or Coastal Zone Management Plan) and be consistent with the management objectives described in the Coastal Management Act 2016 and development controls for coastal management areas mapped under the State Environmental Planning Policy (Coastal Management) 2018.	Addressed as part of other specialist assessment(s)

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