Jellinbah Group

LAKE VERMONT RESOURCES ENVIRONMENTAL IMPACT STATEMENT

CHAPTER 11 AQUATIC ECOLOGY

aarc ENVIRONMENTAL SOLUTIONS

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11 Aquatic Ecology

11.1 Environmental objectives and performance outcomes

Flora and fauna

This chapter has been prepared to assist the DES in carrying out the environmental objective assessment in respect of the following objectives detailed in the Project ToR:

> *The activity will be operated in a way that protects the environmental values of flora and fauna.*
>
> *There will be no potential or actual adverse effects on a wetland as part of carrying out the activity.*
>
> *The proposed Project will minimise serious environmental harm to areas of high conservation value and special significance and sensitive land uses at adjacent places.*
>
> *The location for the activity will be on a site that protects all environmental values relevant to adjacent sensitive use.*
>
> *The proposed project will manage the impacts on the environment by seeking to achieve ecological sustainability, including, but not limited to, protected wildlife and habitat.*
>
> *Critical habitat will receive special management considerations and protection through a management plan for the proposed Project.*
>
> *The proposed Project will avoid significant residual impacts on Matters of National Environmental Significance (MNES) and Matters of State Environmental Significance (MSES). The proposed Project will mitigate impacts when they cannot be avoided and offset any residual impacts.*
>
> *The proposed Project will provide for the conservation of the marine environment, particularly the Great Barrier Reef Marine Park.*
>
> *The construction, operation and decommissioning of the Project will be consistent with all statutory and regulatory requirements of the federal, state and local governments and be consistent with their relevant plans, strategies, policies and guidelines that relate to the terrestrial and aquatic ecological environment.*

As part of the assessment of potential impacts on aquatic ecology values, the following has been undertaken:

- an Aquatic Ecology Assessment by AARC Environmental Solutions Pty Ltd, provided in Appendix H, Aquatic Ecology Assessment;
- a Groundwater-Dependent Ecosystem (GDE) Assessment by 3D Environmental, provided as Appendix I, Groundwater Dependent Ecosystems;
- a Stygofauna Impact Assessment by Stygoecologia, provided as Appendix J, Stygofauna Assessment; and
- an aquatic ecology assessment prepared in consideration of the:
  - 'EIS Guideline–Aquatic Ecology' (DES 2021e);
  - 'EIS Guideline–Groundwater-dependent Ecosystems' (DES 2022c);
  - 'EIS Guideline–Matters of National Environmental Significance' (DES 2020g); and
  - 'EIS Guideline–Biosecurity' (DES 2020f).

Various other applicable guidelines and strategies have also been utilised and referenced throughout these studies, when appropriate.

The detailed assessment presented in this chapter and in the relevant appendices demonstrates that the Project will achieve a performance outcome for each flora and fauna objective. Specifically, the Project will achieve item 2 of the performance outcomes for each flora and fauna objective to the satisfaction of section 2(4) of Schedule 8 of the EP Regulation because the Project will be operated in a way that achieves all of the following:

- Activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land.
- Areas disturbed will be rehabilitated or restored to achieve sites:
  - that are safe and stable;
  - where no environmental harm is being caused by anything on or in the land; and
  - that are able to sustain an appropriate land use after rehabilitation or restoration.
- The Project will be managed to prevent or minimise adverse effects on the environmental values of land due to unplanned releases or discharges, including spills and leaks of contaminants.
- The application of water or waste to the land will be sustainable and will be managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.
- Areas of high conservation value and special significance likely to be affected by the Project will be identified and evaluated, any adverse effects on the areas will be minimised (including any edge effects on the areas) and critical design requirements will prevent emissions having an irreversible or widespread impact on adjacent areas.
- The Project and all its components will be carried out on the site in a way that prevents or minimises adverse effects on the use of surrounding land and will allow for effective management of the environmental impacts of the Project.

Water quality

A performance outcome will also be achieved in respect of the water quality environmental objective outlined in Schedule 8 of the EP Regulation (also prescribed in the Project ToR) relevant to flora and fauna. The objective is that the activity will be operated in a way that protects the environmental values of wetlands (including soaks and springs) and groundwater-dependent ecosystems.

The Project will achieve item 2 of the performance outcomes for that environmental objective in satisfaction of section 2(4) of Schedule 8 of the EP Regulation because the Project will be managed in a way that prevents or minimises adverse effects on wetlands.

Assessment of water quality aspects not relating to flora and fauna is provided in Chapter 8, Surface Water.

Water resources

A performance outcome will be achieved in respect of the water resource's environmental objective prescribed in the Project ToR relevant to flora and fauna. The objective is that the construction and operation of the Project will aim to maintain environmental flows, water quality, in-stream habitat diversity, and naturally occurring inputs from riparian zones (including groundwater-dependent ecosystems) to support the long-term maintenance of the ecology of aquatic biotic communities (including stygofauna).

The Project will achieve this environmental objective because the Project will be managed in a way that achieves the following:

- Any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water, a watercourse or wetland.
- The Project will be managed so that adverse effects on environmental values are prevented or minimised.

Assessment of water resources not relating to flora and fauna is provided in Chapter 8, Surface Water.

11.2 Regional and local setting

The Project is located within the Fitzroy River Basin, which covers 142,545 km^2 and contains the Comet, Dawson, Fitzroy, Isaac, Nogoa and Mackenzie River sub-catchment areas (BoM 2020a) (Figure 11.1). The Project lies within the Isaac River sub-catchment, which covers 22,364 km^2 and comprises the catchments of the Isaac and Connors Rivers. The Isaac River is approximately 5 km to the east of the Project footprint. The Isaac River flows south from north of Moranbah and converges with the Mackenzie River approximately 107 km south-east of the Project. The Mackenzie River converges with the Dawson River to form the Fitzroy River, which eventually discharges into the Coral Sea south-east of Rockhampton.

The Project is within the Brigalow Belt North Bioregion (DoEE 2016) (Figure 11.2), which is part of the Brigalow Belt Bioregion. This bioregion occupies over a fifth of Queensland, extending from Townsville in the north to near the border of New South Wales in the south. The Brigalow Belt Bioregion encompasses a broad climatic gradient and a diversity of soils and topography and is host to a high diversity of flora and fauna (DES 2018a).

The Great Dividing Range divides the Brigalow Belt Bioregion into the Brigalow Belt South Bioregion and the Brigalow Belt North Bioregion.

The Brigalow Belt North Bioregion includes woodlands characterised by:

- Ironbarks *(Eucalyptus melanophloia, E. crebra)*;
- Poplar Box *(E. populnea)*;
- Browns Box *(E. brownii)*;
- Brigalow *(Acacia harpophylla)*;
- Blackwood *(A. argyrodendron)*; and
- Gidgee *(A. cambagei)* (NRS 2000).

The Project region is classed as subtropical with a moderately dry winter (BoM's modified Köppen Climate Classification System; BoM 2021). Daily temperature records are available from the Clermont Airport (035124) and Moranbah Airport (034035) weather stations, and interpolated data is available from SILO. Recorded mean daily temperatures from 2012 to 2021 range between 14.7°C and 29.9°C at Clermont Airport, and between 15.7°C and 30.6°C at Moranbah Airport. The SILO Meadowbrook Grid calculated mean daily temperatures were approximately 16.3°C to 29.3°C during the years between 1968 and 2018. More detailed climate data is provided in Chapter 4, Climate.

The Booroondarra BoM weather station (035109) is approximately 30 km south of Dysart and approximately 45 km south of the Project. Mean monthly rainfall recorded at the Booroondarra BoM station indicates April to October are typically drier months with mean monthly rainfall usually less than 25 mm. The wet season for the region generally occurs from November to March, with rainfall during these months contributing approximately 70% to the region's total annual rainfall.

Land use within the Brigalow Belt North Bioregion is primarily beef cattle grazing, with coal mining also a major regional economic driver (DEWHA 2008a). Several resource developments (approved and pending) occur within 50 km of the study area.

Protected areas in Queensland include national parks and nature refuges and other areas established under the *NC Act 1992*. No protected areas occur within the Project area; however, 'Peak Range National Park' is approximately 50 km to the south-west. The Peak Range National Park is adjoined to the north by the 'Lords Table Mountain Nature Refuge', with the 'Norwich Park Nature Refuge' and 'Coolibah Nature Refuge' to the south of the Project (refer Chapter 3, Project Description, Figure 3.1). There are no World Heritage areas within the Project area or surrounds.

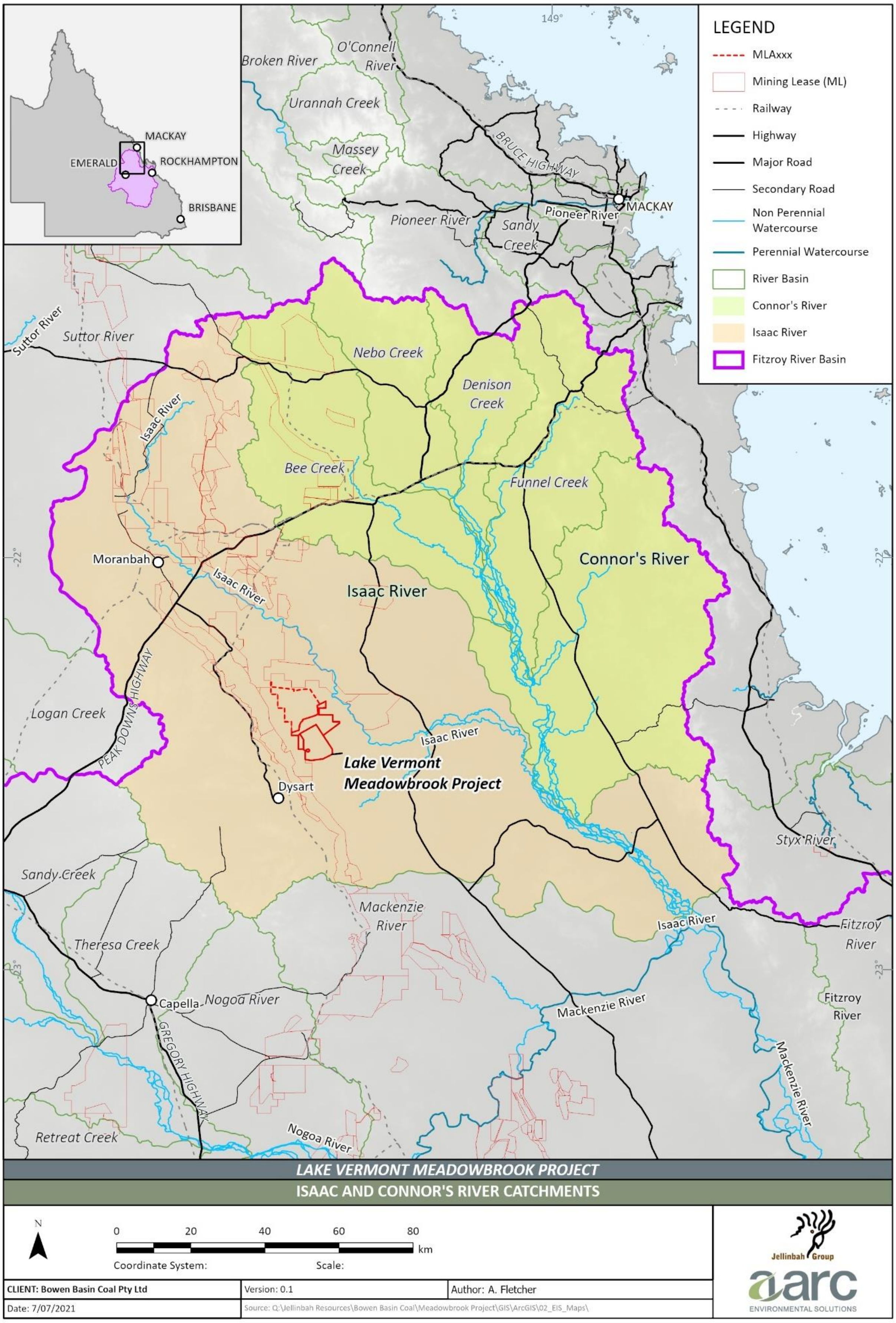

Figure 11.1: Fitzroy River Basin

Figure 11.2: Brigalow Belt Bioregion

11.3 Study area and methodology

11.3.1 Study area

The aquatic ecology study area within the Project is shown in Figure 11.3.The study area includes the waterways and wetlands within, adjacent to, upstream and downstream of the Project footprint, specifically:

- One Mile Creek, Boomerang Creek and Phillips Creek;
- a section of the Isaac River and Ripstone Creek (north of the Project footprint); and
- the wetlands within the aquatic ecology study area.

11.3.2 Desktop assessment

A desktop assessment has been undertaken to identify and present the ecological values mapped within the study area. The desktop assessment includes:

- a review of the Australian Government and Queensland Government databases and mapping;
- literature reviews;
- an analysis of aerial imagery;
- ecology assessments from the existing Lake Vermont operations; and
- ecological assessments from surrounding projects.

Searches have been undertaken with a 50 km buffer on the EPBC Act 'Protected Matters Search Tool' and the 'DES Wildlife Online' search and 'WildNet Wildlife Records'. A preliminary field survey has also been undertaken at four sites, which provide additional site-specific context. The results of the desktop assessment (described in Appendix H, Aquatic Ecology Assessment, Section 5.2) have been used in the field survey design and methodology.

11.3.3 Field survey

Aquatic ecology surveys were conducted within the study area in late wet season 2020 (20 March 2020 to 23 March 2020) and late wet season 2021 (14 April 2021 to 19 April 2021). The survey timings are considered appropriate to maximise the likelihood of detecting aquatic species of significance within the study area. It is noted that the study area streams and wetlands are ephemeral and observations made during dry and early wet season ecology surveys identified that conditions were unsuitable for aquatic ecology surveys. Conditions are only suitable for aquatic ecology assessments for a short period each year and survey effort was targeted to suitable conditions.

The aquatic ecology surveys included:

- aquatic habitat surveys (physical assessment, habitat bioassessment, and condition assessment);
- surface water and stream sediment quality assessments (physio-chemical sampling);
- aquatic macroinvertebrate sampling; and
- aquatic fauna (fish, turtles, and platypus) surveys.

The survey effort applied at aquatic ecology sites within the study area are detailed in Table 11.1 and the locations of survey sites shown in Figure 11.3.

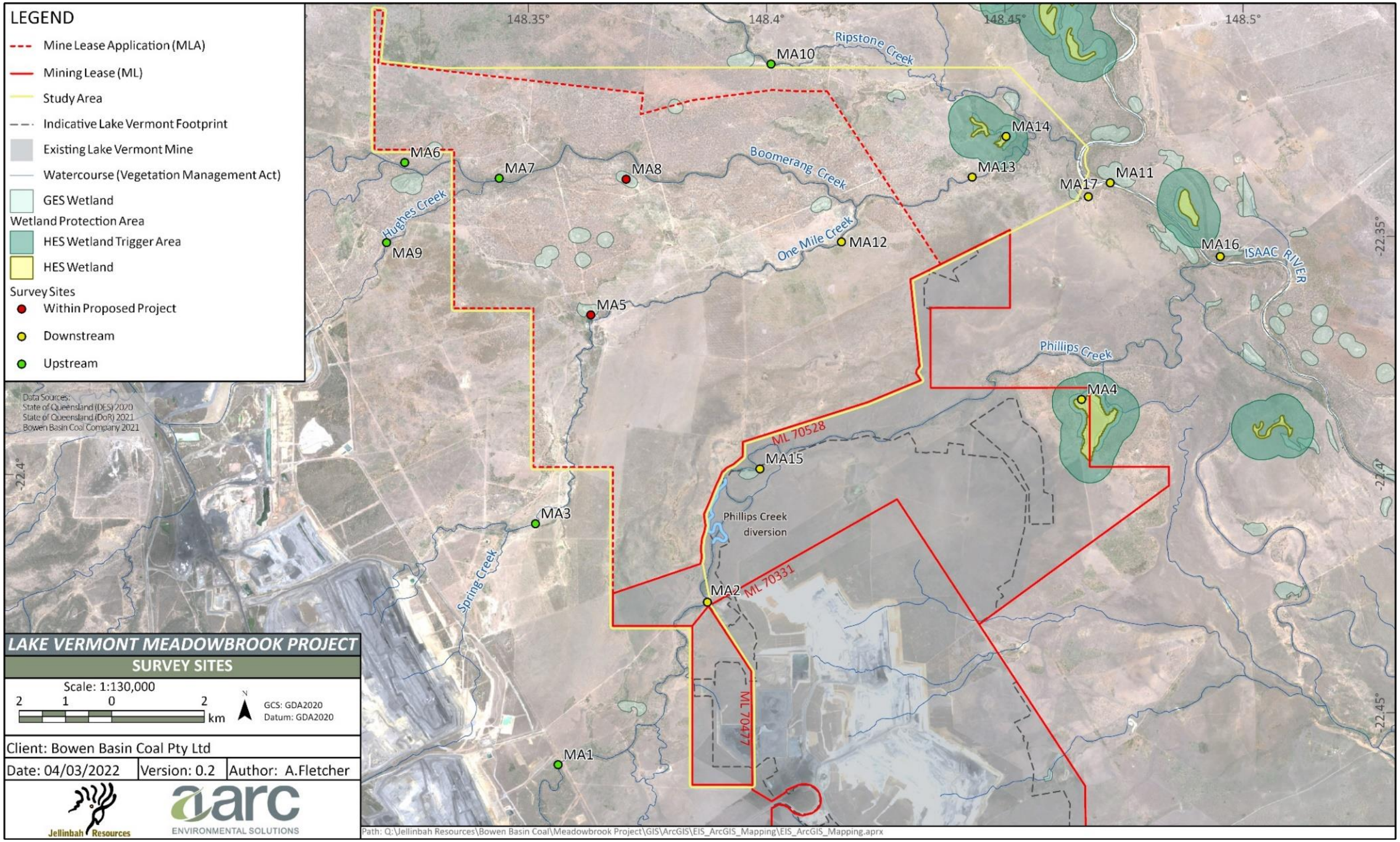

Figure 11.3: Aquatic ecology study area and survey sites

Table 11.1: Aquatic ecology survey site locations and ecological indicators assessed

Site	Location	Year	Aquatic habitat	Water quality	Sediment quality	Aquatic flora	Aquatic fauna	Macro-invertebrates
Upstream of Project area								
MA1	Phillips Creek	2020	Yes	Yes	Yes	Yes	-	-
		2021	—	—	—	—	—	—
MA3	One Mile Creek	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	Yes	Yes
MA6	Boomerang Creek	2020	Yes	Yes	Yes	Yes	—	Yes
		2021	Yes	Yes	Yes	Yes	—	Yes
MA7	Hughes Creek	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	—	—
MA9	Boomerang Creek	2020	Yes	Yes	Yes	Yes	—	—
		2021	Yes	Yes	Yes	Yes	—	—
MA10	Ripstone Creek	2020	Yes	Yes	Yes	Yes	—	—
		2021	Yes	Yes	Yes	Yes	—	—
Within Project area								
MA5	One Mile Creek	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	—	—
MA8	GES Wetland	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	Yes	Yes
Downstream Project area								
MA2	Phillips Creek	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	—	—
MA4	Lake Vermont	2020	Yes	Yes	—	—	—	—
		2021	Yes	Yes	—	—	—	—
MA11	Isaac River	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	Yes	Yes
MA12	One Mile Creek	2020	Yes	Yes	Yes	Yes	Yes	Yes
		2021	Yes	Yes	Yes	Yes	Yes	Yes
MA13	Hughes Creek	2020	Yes	Yes	Yes	Yes	—	Yes

Site	Location	Year	Aquatic habitat	Water quality	Sediment quality	Aquatic flora	Aquatic fauna	Macro-invertebrates
		2021	Yes	Yes	Yes	Yes	—	—
MA14	HES Wetland	2020	Yes	—	Yes	Yes	—	—
		2021	Yes	—	Yes	Yes	—	—
MA15	Phillips Creek	2020	Yes	—	—	—	—	—
		201	Yes	—	—	—	—	—
MA 17	GES Wetland	2020	—	—	—	—	—	—
		2021	—	—	—	—	Yes	—

The field surveys were conducted in accordance with the following guidelines:

- Queensland Government Guidelines:
  - 'Monitoring and Sampling Manual: Environmental Protection (Water) Policy' (DES 2018b); and
  - 'Queensland Australian River Assessment System (AusRivAS) Sampling and Processing Manual' (DNRM 2001).
- Australian Government Guidelines:
  - 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality' (ANZECC & ARMCANZ 2000);
  - 'Survey guidelines for Australia's threatened reptiles' (DSEWPC 2011a); and
  - 'Survey guidelines for Australia's threatened fish' (DSEWPC 2011b).

Although no aquatic species listed under the EPBC Act have been considered likely to occur, or have the potential to occur, within the study area (Table 11.2) surveys have been designed and undertaken in consideration of the relevant species requirements outlined within the 'Species Profile and Threats Database' (SPRAT Database). It is noted that the threatened fish species Silver Perch and Murray Cod, although identified in desktop searches as potentially previously recorded in the area, are considered not endemic to the system.

Table 11.2: Likelihood of occurrence assessment outcomes for conservation significant species

Scientific name	Common name	Conservation status		Likelihood of occurrence
		EPBC status	NC Act status	
Reptiles				
Elseya albagula	Southern Snapping Turtle	CE	E	Unlikely
Rheodytes leukops	Fitzroy River Turtle	V	V	Unlikely
Fish				
Bidyanus bidyanus	Silver Perch	CE	—	Unlikely
Maccullochella peelii	Murray Cod	V	—	Unlikely

11.3.4 Survey methodology

11.3.4.1 Aquatic habitat

Field surveys included assessments of aquatic habitat including physical assessment according to AusRivAS Physical Assessment Protocol and Queensland AusRivAS Sampling and Processing Manual. The habitat assessment also included condition assessment of possible impacts to aquatic EVs caused by major disturbances.

11.3.4.2 Surface water quality

Surface water quality data was collected at each aquatic ecology sample site in accordance with the Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018b) methodology. Field readings of pH, dissolved oxygen, turbidity, EC and temperature were also recorded and samples were laboratory analysed for the following parameters:

- Total Suspended Solids (TSS);
- nutrients (total nitrogen [N], nitrate, nitrite, oxides of nitrogen (NOx), ammonia, Total Kjeldahl Nitrogen, reactive phosphorus and total phosphorus);
- total hardness (CaCO3);
- dissolved major cations (calcium, magnesium, sodium and potassium);
- total and dissolved metals and metalloids (aluminium, arsenic, beryllium, barium, boron, cadmium, chromium, cobalt, copper, lead, iron, manganese, mercury, molybdenum, nickel, selenium, silver, uranium, vanadium and zinc); and
- total petroleum hydrocarbons and total recoverable hydrocarbons.

11.3.4.3 Stream sediment quality

Sediment quality data was collected at aquatic ecology sample sites accordance with the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES, 2018b). Sediment samples were analysed for concentrations of total metals and metalloids, including: arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, vanadium and zinc.

11.3.4.4 Aquatic macroinvertebrates

Macroinvertebrate sampling was conducted in accordance with the AusRivAS sampling and assessment methodology as outlined by the Queensland Monitoring and Sampling Manual: Environmental Protection (Water) Policy 2009 (DES 2018b).

Macroinvertebrate community indices were calculated, and comparisons were made to relevant WQOs specified in the Isaac River Sub-basin EVs and Water Quality Objectives (DEHP 2011).

11.3.4.5 Aquatic flora

Any aquatic flora observed at each of the survey sites was recorded.

11.3.4.6 Aquatic fauna

Survey techniques used to identify the aquatic fauna species present at survey sites included the following:

- opera house trapping;
- box trapping;

- seine netting; and
- habitat searches.

The aquatic fauna survey effort undertaken during each survey event is detailed in Table 11.3 for each sampling technique.

Table 11.3: Aquatic fauna survey effort

Site Name	Start Date	End Date	Opera Houses	Box Traps	Seine Net	Habitat Search
2020						
MA2	20/03/2020	22/03/2020	Yes	Yes	-	Yes
MA5	21/03/2020	22/03/2020	Yes	Yes	-	Yes
MA8	19/03/2020	22/03/2020	Yes	-	-	Yes
MA11	22/03/2020	22/03/2020	Yes	-	-	Yes
MA12	22/03/2020	22/03/2020	Yes	Yes	-	Yes
2021						
MA3	18/04/2021	20/04/2021	Yes	Yes	-	-
MA8	18/04/2021	20/04/2021	Yes	Yes	-	-
MA11	18/04/2021	20/04/2021	Yes	Yes	-	-
MA12	18/04/2021	20/04/2021	Yes	Yes	-	-
MA 17	18/04/2021	20/04/2021	Yes	Yes	Yes	-

11.3.5 Stygofauna

11.3.5.1 Study area

The stygofauna study area comprises the Lake Vermont Meadowbrook Project area and surrounds.

11.3.5.2 Sampling

Nine bores (12 samples) have been selected as representatives of each major habitat and aquifer. Two stygofauna surveys (one autumn and one spring) were conducted on 26 May 2021 and 14 September 2021. All bores sampled had been installed at least six months prior to sampling.

The sampling and analysis undertaken for the Stygofauna assessment is described in Appendix J, Stygofauna Assessment (Section 3), and is broadly comprised of:

- sampling of the Phreatic/hypogean zone using standardised methods (Phreatobiological net and groundwater bailer);
- specimen identification to the lowest possible taxonomic level;
- collection and interpretation of supplied physio-chemical water data; and
- completion of the risk assessment in accordance with the Risk Assessment Guidelines for GDEs (Serov *et al.* 2012).

11.3.6 Groundwater-dependent ecosystems

The 'BoM GDE Atlas' mapping identifies areas of high, moderate and low potential terrestrial GDEs associated with riparian vegetation along watercourses. A GDE Assessment has been undertaken by 3D Environmental to assess and describe the GDEs within the study area (Appendix I, Groundwater-Dependent Ecosystem Assessment, Section 3.1).

11.3.6.1 Study area

The GDE assessment area comprises the MLA and surrounding potential impact areas, including the Isaac River to the east of the Project.

11.3.6.2 Desktop assessment

A desktop assessment has identified that the BoM GDE Atlas mapping shows areas of high, moderate and low potential terrestrial GDEs associated with riparian vegetation of watercourses in the Project area, as shown in Figure 11.4. The GDE mapping identified:

- 'Low Potential' for Terrestrial GDEs associated with elevated residual plains (typically RE 11.5.3); and
- 'High Potential' and 'Moderate Potential' for Terrestrial GDEs associated with floodplain alluvium (typically RE 11.3.2 and RE 11.3.3 and RE 11.3.25) vegetation and watercourses.

There are no springs mapped in proximity to the assessment area, although the Isaac River (east of MDL 439) and Phillips Creek (on the southern fringe of MDL 439) are mapped as 'High Potential' Aquatic GDEs, and larger creeks (Boomerang and Ripstone) are mapped as 'Moderate Potential' Aquatic GDEs. There are numerous floodplain wetlands, including RE 11.3.27 and RE 11.5.17, scattered across the Project area, which are mapped as 'Moderate Potential' Aquatic GDEs.

11.3.6.3 Field survey

A field survey of GDEs was completed between 15 August and 19 August 2021 by 3D Environmental (Appendix I, Groundwater-Dependent Ecosystem Assessment, Section 3).

Field assessment methodology is consistent with the 'Field Investigations of Potential Terrestrial Groundwater-Dependent Ecosystems within Australia's Great Artesian Basin' (Jones *et al.* 2020) and supplemented with additional methodologies derived from:

- 'Australian groundwater-dependent ecosystem toolbox part 1: assessment framework' (Richardson *et al.* 2011);
- 'Information Guidelines Explanatory Note—Assessing groundwater-dependent ecosystems' (IESC 2018);
- 'Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems' (Doody *et al.* 2019); and
- 'Identifying groundwater-dependent ecosystems—A guide for land and water managers' (Eamus 2009).

Eighteen sites have been selected to provide representative coverage of the major vegetation types and landform elements that are most likely to be groundwater-dependent shown in Figure 11.5. The sites have been assessed during the GDE field survey with the exception of site 12, which was inaccessible for the survey. The assessment undertaken, includes:

- one site on the Isaac River floodplain and channel;
- five sites in wetlands on alluvial floodplains or broad land surfaces;
- five sites in vegetation associated with Boomerang Creek;
- four sites in vegetation associated with Ripstone Creek;

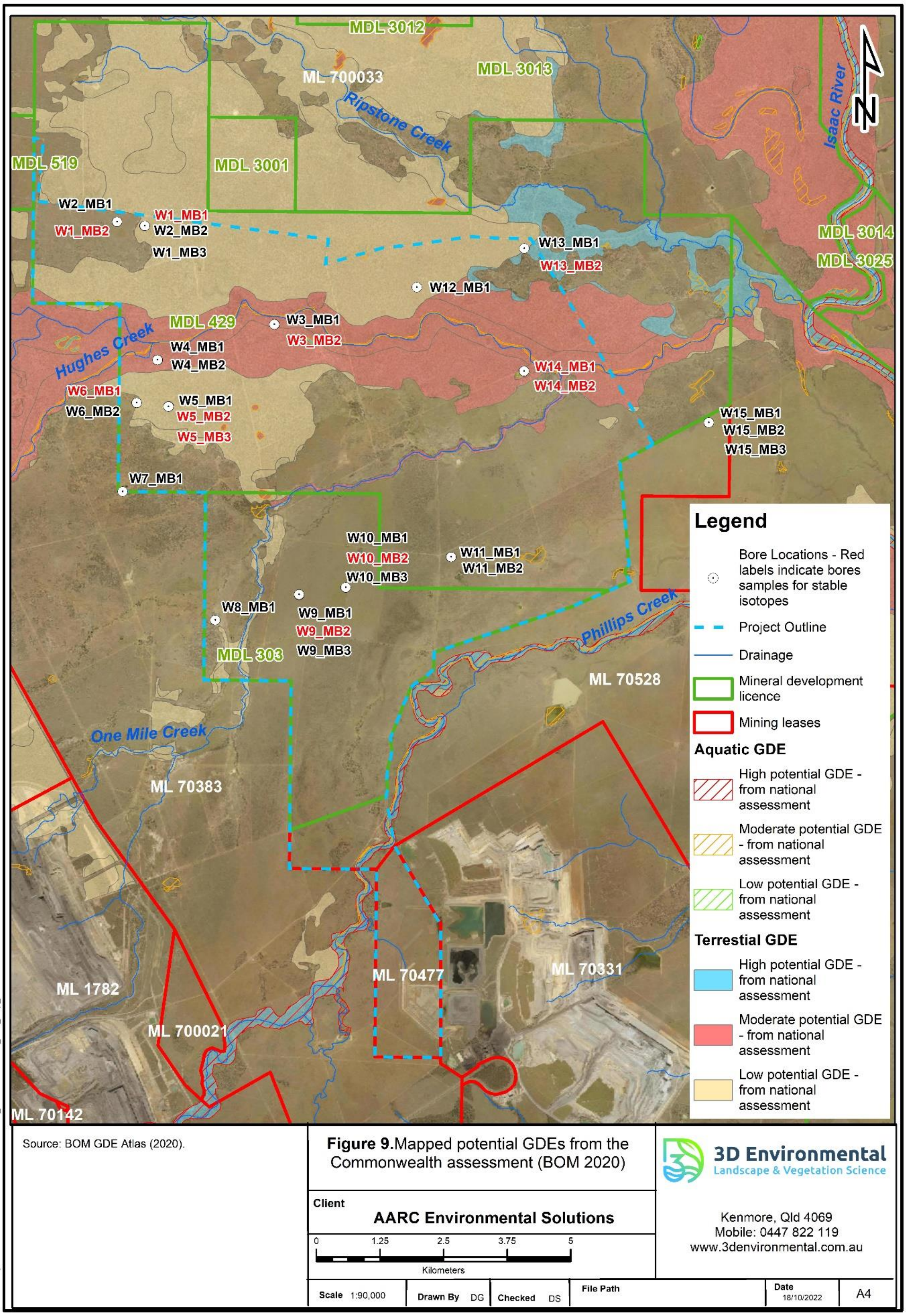

Figure 11.4: Mapped potential GDEs from Commonwealth assessment

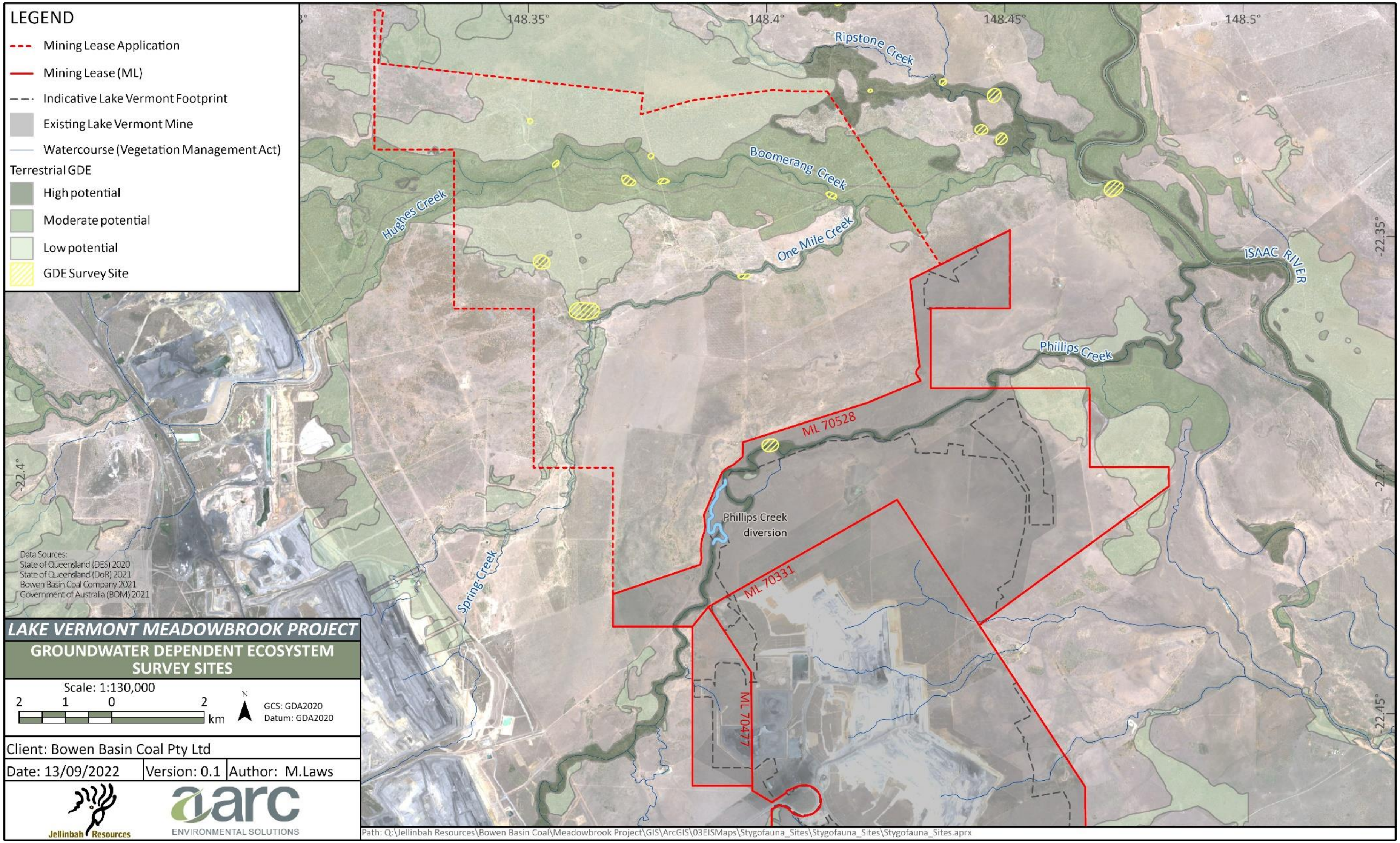

Figure 11.5: Groundwater Dependent Ecosystem survey sites

- one site in vegetation associated with One Mile Creek; and
- one site in vegetation associated with Phillips Creek.

Field survey methods to assess groundwater dependence of the surveyed vegetation community include:

- leaf water potential;
- soil moisture potential; and
- stable isotope analyses of:
  - soil moisture;
  - xylem water; and
  - groundwater collected from monitoring bores.

Full details of the field methodology and laboratory analyses are provided in Appendix I, Groundwater-Dependent Ecosystem Assessment, Section 3.

11.4 Aquatic ecological values

11.4.1 Watercourses

The Isaac River is approximately 5 km east of the Project footprint. The Isaac River flows south from north of Moranbah and converges with the Mackenzie River approximately 107 km south-east of the study area. The Mackenzie River converges with the Dawson River to form the Fitzroy River, which eventually discharges into the Coral Sea south-east of Rockhampton (Hatch 2018).

A number of tributaries traverse the study area and flow in an easterly direction into the Isaac River. These tributaries include Boomerang Creek, Hughes Creek, One Mile Creek, Phillips Creek and Ripstone Creek (Figure 11.3). Boomerang Creek is an ephemeral fifth order stream that traverses the northern portion of the study area upstream of its confluence with the Isaac River (Figure 11.3). Hughes Creeks flows into Boomerang Creek near the western boundary of MDL 429. The headwaters of Boomerang Creek and Hughes Creek occur to the west of the study area and traverse the tenure of the Saraji Mine (ML 1775).

One Mile Creek, a third order stream, traverses the study area from the south-west until its confluence with Boomerang Creek towards the north-eastern boundary of the study area. Ripstone Creek, also a third order stream, occurs to the north of the study area and flows eastward before flowing into Boomerang Creek to the east of the study area. The Olive Downs Coking Coal Project has approval to divert a section of Ripstone Creek near the northern boundary of MDL 429. The surface water assessment for the Olive Downs Coking Coal Project has concluded the hydraulic properties of the Ripstone Creek diversion are within the parameters set by the relevant guidelines (Hatch 2018).

Phillips Creek is a fourth order stream that traverses a portion of the southern study area within ML 70528. The creek meanders along the northern boundary of ML 70528, outside the study area, before converging with the Isaac River (Figure 11.3).

Aerial imagery taken of areas to the west of the study area shows that the upstream reaches of all five watercourses that traverse the study area (Boomerang Creek, Hughes Creek, One Mile Creek, Phillips Creek, and Ripstone Creek) have been heavily modified by mining activities, resulting in the removal of catchment, changes in drainage pathways and modified runoff characteristics.

Boomerang Creek, Hughes Creek, One Mile Creek, Ripstone Creek, Phillips Creek and the Isaac River are defined watercourses under the Queensland *Water Act 2000.*

11.4.2 Wetlands

The mapped vegetation management wetlands (under the VM Act) within the study area and surrounds are shown in Figure 11.3 as General Ecological Significance Wetlands (GES) and High Ecological Significance Wetlands (HES).

The majority of mapped wetlands within the study area are towards the north (between One Mile Creek and Boomerang Creek) and in the east (along the Isaac River). Other palustrine wetlands are mapped along the Isaac River, both upstream and downstream of the confluence of the Isaac River with Boomerang Creek.

There are several HES wetlands to the north and east of the Project (Figure 11.3). The closest HES wetland is located approximately 2.4 km east of the Project, near the confluence of Boomerang Creek and Ripstone Creek. This HES wetland is within the aquatic ecology study area.

An additional HES wetland is approximately 7 km east of the Project at the existing Lake Vermont Mine (partially on ML 70528) and 700 m south of Phillips Creek (Figure 11.3). This waterbody is separated from the Project by the disturbance area approved for the existing Lake Vermont Mine.

Although not a MSES, there is a lacustrine wetland of very low conservation value adjacent to One Mile Creek on the western side of the Project site, which has been mapped as part of an 'Aquatic Conservation Assessment' (ACA) (DES 2018 - 2021). The landform at this location has been modified to permanently hold water through the construction of a farm dam.

11.4.3 Groundwater-dependent ecosystems

The Groundwater-Dependent Ecosystem Assessment (Appendix I, Section 6.1) has identified two types of GDEs present within the potential impact area of the Project:

1) Type 1 GDEs: Groundwater-dependent vegetation developed on drainage features and associated alluvial landforms along Boomerang Creek and Hughes Creek in the Project area and Phillips Creek and Isaac River outside the Project area; and
2) Type 2 GDEs: Groundwater-dependent wetland vegetation developed on perched groundwater lenses present to the east of the Project area (as a HES wetland).

The location of the identified GDEs is shown in Figure 10.7, Chapter 10, Terrestrial Ecology. GDEs present on alluvial landforms use groundwater seasonally recharged by surface flows and flooding. The GDEs on perched groundwater lenses use water recharged from percolating surface water captured at the alluvial unconformity. Neither GDE type uses water held in regional Tertiary aquifers or coal seams.

11.4.4 Aquatic habitat

Aquatic habitat of watercourses and wetlands within the study area is generally fair to good. The effects of erosion on the banks of the receiving waters are minimal across all surveyed sites. The leading cause of local erosion appears to be from stock access, with runoff and the influence of edge effects from historic clearing also contributing to the degradation. The habitat bioassessment scores from the aquatic sites within the sampling environment primarily fell into the fair and good categories. Condition assessment scores ranged from 39 to 49, with a mean of 45.5. Of the sites surveyed, 14 of 15 sites received condition scores above 40, indicating that the influence of activities upstream has had minimal impact. Results of the aquatic habitat assessment are detailed in Section 8.1 of Appendix H, Aquatic Ecology Assessment. Photographs and site descriptions can be found in Appendix C of Appendix H, Aquatic Ecology Assessment.

11.4.5 Aquatic flora

The aquatic flora species encountered were common emergent species, two semi-aquatic sedges, *Cyperus difformis*, and *Cyperus iria*. *Cyperus iria* and *Cyperus difformis* are considered Least Concern under the NC Act. The lack of both diversity and abundance of aquatic plants at some sites is likely indicative of harsh physical conditions, cattle grazing and trampling, or a combination of these factors.

11.4.6 Aquatic fauna

A total of 638 fish have been captured across all sites during both survey periods, representing nine species from five families. A total of 344 crustaceans have been captured across all sites during both survey periods, representing five species from four families. No listed Endangered, Vulnerable or Near-threatened (EVNT) species were noted at any of the survey sites during any of the surveys. All fish species recorded in the study area are considered common, or widespread, species in the Isaac River sub-basin. No pest fish species were noted during any of the surveys. A full list of the fish species recorded in the study area is located in Section 8.6.1 of Appendix H, Aquatic Ecology Assessment.

No turtle species listed under the EPBC Act or NC Act were noted during the surveys, and no Least Concern turtle species were noted during the 2020 or 2021 surveys. A single Krefft's River Turtle (*Emydura macquarii krefftii*) was recorded during the preliminary survey in 2019 from a site on Phillips Creek, upstream of the Project.

The ephemeral nature of the watercourses limits the suitable habitat for turtle species listed under the EPBC Act or NC Act.

11.4.7 Macroinvertebrates

Taxonomic richness of the samples is generally low to moderate, ranging from 10 to 17. None of the sites sampled during either survey exhibited a taxonomic richness that met the upper Water Quality Objective (WQO), and nine samples met or exceeded the lower WQO. A full list of the macroinvertebrates sampled within the study area can be found in Appendix H, Aquatic Ecology Assessment (within Appendix D of that report).

PET taxa richness is below the high WQO in samples from all sites collected in both surveys and is typically below the low WQO, which is representative of the habitats and the ephemeral nature of the watercourses within the study area.

The weighted SIGNAL 2 scores recorded from the samples collected are generally low, ranging from 2.6 to 4.2 and generally fall within Quadrant 4 (site conditions are likely influenced by urban industrial or agricultural pollution). The SIGNAL2 scores indicate poor habitat availability and environmental conditions, which is likely a result of the ephemeral nature of the watercourses within the study area.

11.4.8 Stygofauna

Stygofauna have been recorded at two sites along Boomerang Creek and stygophiles/stygoxenes have been recorded at four sites along Boomerang Creek (Figure 11.6). Eight families of invertebrates have been recorded, including:

- two aquatic groundwater families:
  - one family of aquatic worms (Oligochaeta); and
  - one family of Copepoda (Crustacea); and
- six terrestrial invertebrate families.

Results of the stygofauna assessment are detailed in Appendix J, Stygofauna Assessment (Section 4), with summarised details relevant to the impact assessment provided below:

- A low diversity of groundwater-dependent subterranean fauna are in the shallow, unconfined Tertiary/alluvial aquifers of the Boomerang Creek Alluvium, close to the stream but not in the floodplain.
- Stygofauna are present within the groundwater drawdown zone of the Project and the groundwater flow path of any potential contamination event downstream of the development.
- None of the subterranean fauna species recorded are currently listed as endemic, relictual, rare, endangered or threatened biota or are populations or communities listed under the NC Act or EPBC Act.

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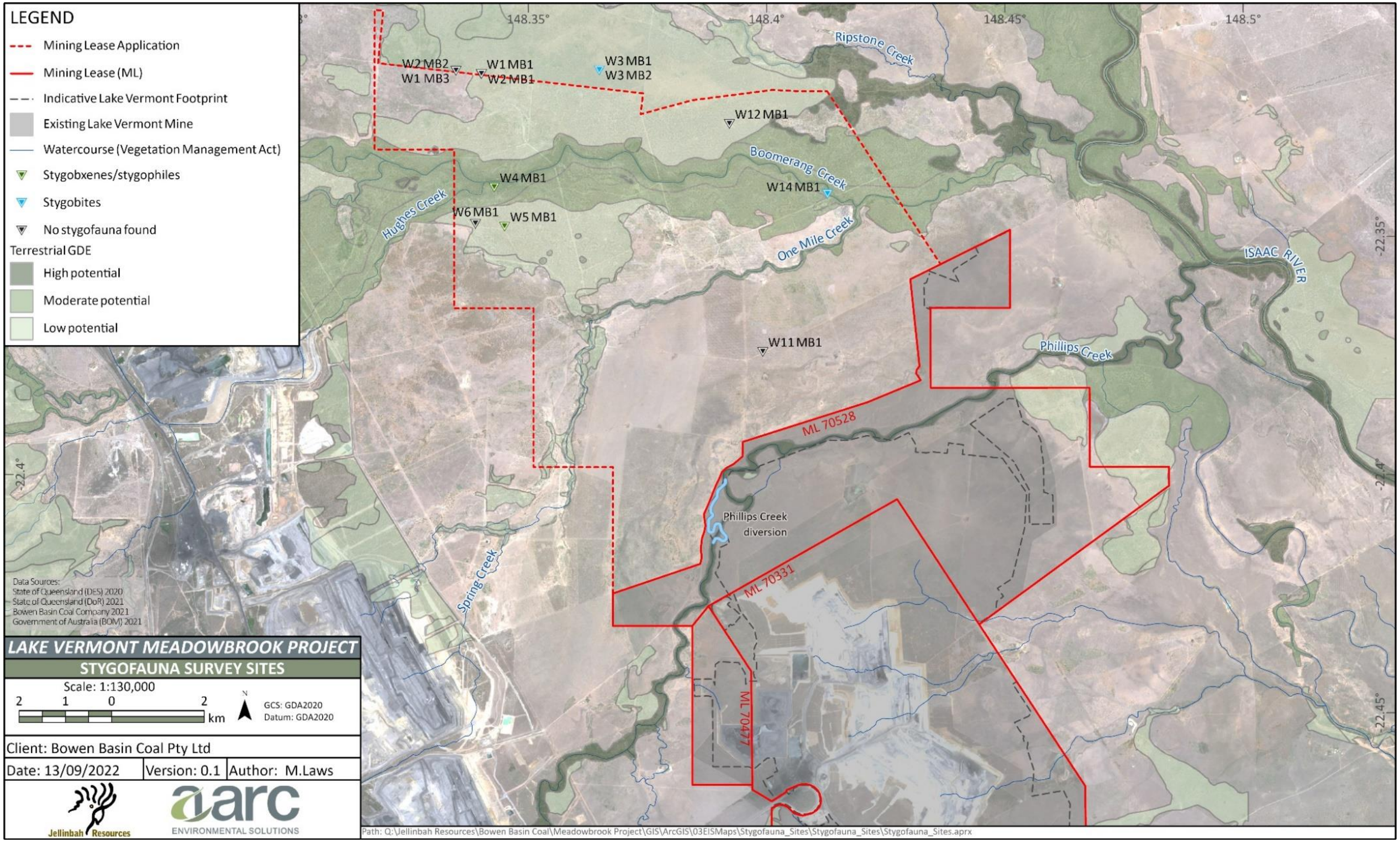

Figure 11.6: Stygofauna survey bores

- The ecological value of the two bores in which subterranean fauna are detected is considered low due to the restricted nature of the habitat and the very low number of disturbance tolerant taxa collected.
- The disjunct distribution of the fauna between the bores indicates a discontinuous connectivity between the shallow alluvial aquifers and Boomerang Creek.
- The risk of the proposed Project to these subterranean ecosystems is rated as low based on the shallow modelled depth of drawdown within the Tertiary sediments compared to the depth of the aquifer and the limited potential water quality changes to Boomerang Creek.

11.4.9 Matters of national environmental significance

Four aquatic species listed as Critically Endangered, Endangered or Vulnerable under the EPBC Act have been identified in the desktop assessment as having known records within the broader region.

Through the likelihood of occurrence assessment, it is concluded that all aquatic species of conservation significance identified by the database searches are unlikely to occur within the study area (Table 11.2).

11.4.10 Matters of state environmental significance

Threatened flora and fauna species are considered to be MSES in Queensland. No aquatic flora species listed as threatened under the NC Act were returned in the database searches.

Three listed fauna species (Table 11.2) were returned in the database searches as having records within 50 km of the study area. All three species were listed as threatened under the NC Act and the EPBC Act and, as such, these species are considered MNES and discussed in section 11.4.9.

WPAs and HES wetlands are also considered MSES in Queensland. The Map of Queensland wetland environmental values is a statewide statutory map under the 'Environmental Protection (Water and Wetland Biodiversity) Policy 2019'. The map of referable wetlands identifies:

- Wetland Protection Areas (WPAs) that comprise:
  - High Ecological Significance (HES) wetlands within the Great Barrier Reef Catchments; and
  - trigger areas that represent the area of hydrological influence of HES wetlands; and
- General Ecological Significance (GES) wetlands.

Wetland mapping indicates several WPAs associated with HES wetlands occur to the north and east of the Project (Table 11.4). These wetlands are identified in section 11.4.2.

Waterways that provide for fish passage under the *Fisheries Act 1994* are also considered MSES. These waterways include rivers, creeks, streams, watercourses and inlets of the sea. The 'Queensland waterways for waterway barrier works' mapping indicates the level of 'risk' associated with undertaking waterway barrier works within Queensland. Waterways with higher stream orders, steeper slopes, higher flow rates, greater number of fish present and fish with stronger swimming abilities obtain a higher level of risk. The risk rating of the waterways providing fish passage within the study area are shown in Figure 11.7.

Of the waterways providing fish passage within the study area:

- The Isaac River is classified as a major risk, having adverse impacts on fish movement.
- Philips Creek, Boomerang Creek and Hughes Creek are classified as major risks (purple), having adverse impacts on fish movement.
- One Mile Creek is classified as a high risk, having adverse impacts on fish movement.
- One minor waterway is classified as a low risk impact on fish movement (located on ML 70477).
- Ripstone Creek (to the north of the Project area) is classified a high risk, having adverse impacts on fish movement.

It is noted that a diversion of Ripstone Creek has been approved for the Olive Downs Coking Coal Project. The approved diversion can be seen as the relatively straight section of Ripstone Creek to the east of the study area in Figure 11.7.

The proposed infrastructure corridor crosses Phillips Creek (major risk) and One Mile Creek (high risk) as shown in Figure 11.7.

11.5 Potential impacts and avoidance, mitigation and management measures

This section describes the potential impacts resulting from the Project in relation to aquatic ecology values identified within the study area.

11.5.1 Direct impacts

The Project would remove and/or directly modify a small area of aquatic habitat; however, the watercourses in the area to be disturbed are of low to moderate ecological value. The Project will not cause any direct disturbance to wetlands. The following activities have the potential to have direct impacts on aquatic ecology values within the study area:

- loss of watercourses and wetlands due to direct disturbance; and
- creation of barriers to fish passage at infrastructure corridor watercourse crossings.

11.5.1.1 Loss of watercourses and wetlands

Construction of the infrastructure corridor (specifically the haul road) will require stream crossings of Phillips Creek and One Mile Creek.

Where the infrastructure corridor crosses these watercourses, there will be small areas of loss or modifications to the watercourses. The stream crossings will be constructed as causeways with appropriately-sized culverts to allow low flows; however, they will be inundated for approximately 19 hours per annum (Appendix Z, Flooding Assessment Report, Section 3.3.4). Construction activities will be undertaken during the dry season to minimise erosion and sediment mobilisation while also facilitating time to generate stability of works prior to wet season flows.

A small area of a GES wetland will be disturbed by the proposed Electricity Transmission Line (ETL) and a light vehicle access road running from the MIA to the substation/borehole deliveries area (refer Figure 3.2, Chapter 3, Project Description). This wetland is a lacustrine wetland of very low conservation value adjacent to One Mile Creek. The landform at this location has been modified to permanently hold water through the construction of a farm dam. The ETL alignment has been selected to avoid and minimise clearing of remnant vegetation, habitat and aquatic ecology values as far as reasonably possible. Detailed explanation of the selection of the ETL alignment is provided in Chapter 3, Project Description. The ETL and vehicle access road would result in 0.01 ha of disturbance to the GES wetland/farm dam.

Overall, the aquatic habitats of these watercourses and wetlands are common and typical of the region, and while impacts will mean a minor loss of available aquatic habitat for aquatic communities, this is not expected to impact aquatic ecology on a regional scale.

The small area of direct disturbance to watercourses and wetlands is unlikely to impact aquatic flora on a regional scale. Impacts from direct disturbance to riparian and wetland vegetation communities is discussed in Chapter 10, Terrestrial Ecology.

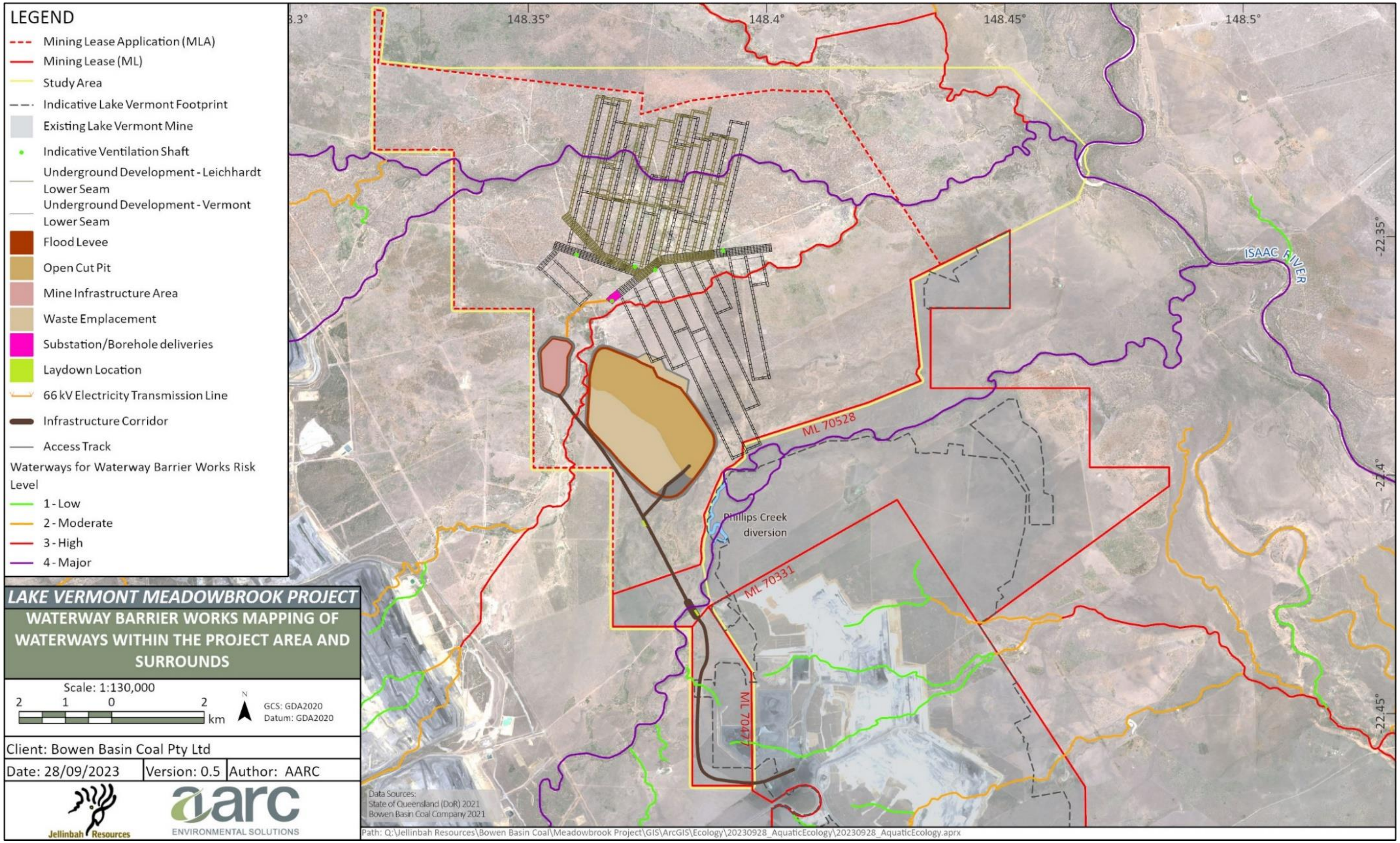

Figure 11.7: Waterway Barrier Works risk mapping of waterways within the study area

11.5.1.2 Barriers to fish passage at waterway crossings

The construction of waterway crossings along the infrastructure corridor has the potential to create barriers to fish movement along the waterways. Barriers to fish movement that could be created by the Project include waterway crossings at Phillips Creek, One Mile Creek and the minor waterway on ML 70477 (Figure 11.7).

The minor waterway is a shallow drainage line of stream order one, is highly ephemeral, and is not expected to currently provide fish passage. The disturbance associated with the infrastructure corridor will not create an impediment to fish passage.

One Mile Creek and Phillips Creek are highly ephemeral waterways that do not flow for long periods of the year, thus limiting the connectivity of waterways and wetlands within, upstream and downstream of the Project. It is considered that both waterways are likely to provide some localised fish passage for periods during which they sustain flow. Upstream of the Project, both waterways pass through the existing BMA Mine site, where they are both crossed by an existing road network (with culverts located at crossings). Additionally, the proposed Saraji East development will include a transport and infrastructure corridor that will cross One Mile Creek and Phillips Creek upstream of the Meadowbrook Project.

The watercourse crossings at Phillips Creek and One Mile Creek associated with the Project's infrastructure corridor would be constructed in consideration of fish passage and water flow. Conceptual crossing designs are provided in Chapter 3, Project Description, Section 3.3.2.1. The causeway length for the One Mile Creek crossing will be approximately 164 m with an underlying concrete box culvert 750 mm wide x 600 mm high. The causeway length for the Phillips Creek crossing will be approximately 175.5 m with two underlying box culverts 3600 mm wide x 1800 mm high.

The culvert crossing will include the following configuration:

- All instream works will commence and finish within 180 calendar days.
- The culvert aperture will span a minimum of 100% of the low flow channel width.
- The culvert will be installed at no steeper gradient than the waterway bed gradient.
- Outermost culvert cells will incorporate roughening elements on the bank side walls and upstream wingwalls to the height of the upstream obvert.
- The culvert cells will be aligned parallel to the direction of water flow.
- The width of the culvert aperture will span a minimum of 75% of the main channel width for Phillips Creek and approximately 40% for One Mile Creek where the channel width is approximately 3 m.
- The internal roof of the culvert must be 600 mm above the waterway bed level.

The proposed configuration is adequate to meet the requirements for new culvert crossings for accepted developments according to the ADR (REF). The crossings are proposed within the Project ML and therefore exempt from being assessable development requiring approval under the Planning Act. Notwithstanding, by meeting the crossing design requirements of the ADR it is considered to demonstrate the crossings are designed to minimise potential impacts to fish habitat and fish passage.

It is anticipated that the proposed culverts will maintain fish passage during periods of low flow. Due to the poor-quality fish habitat and fish passage values of the waterways, there is unlikely to be a measurable impact on fish resources beyond the Project area.

11.5.2 Indirect impacts

The Project has the potential to indirectly impact aquatic ecology values through changes to water quality and hydrology. Specifically:

- changes in timing and magnitude of flow caused by loss of catchment area;

- subsidence of the stream bed level caused by underground mining operations;
- subsidence-induced changes in ponding caused by underground mining operations;
- changes to flood regimes due to surface infrastructure and subsidence;
- erosion and sedimentation due to Project activities;
- water quality changes due to water releases;
- water quality changes due to releases from final rehabilitated pit landform;
- impacts to water quality from litter, wastes and spills; and
- impacts to aquatic ecosystems utilising groundwater due to groundwater drawdown.

Aquatic ecosystems have the potential to be impacted through changes in hydrology by:

- affecting the life cycles of aquatic species that have adapted to existing hydrological conditions (i.e. affecting cues for movement, migration and breeding);
- changing the diversity and structure of in-stream aquatic habitat, in turn, influencing the composition of aquatic communities;
- introduction and/or proliferation of aquatic weed and pest species in the Project area;
- affecting water quality through changes in the volume and timing of flows (especially flushing);
- increasing erosion of watercourses, which will affect water quality and habitat conditions; and
- altering the connectivity between aquatic habitats through changes in flows.

11.5.2.1 Impacts to downstream channel flows from ponding and mitigation measures

The Project will result in a loss of catchment area due to the construction of the open-pit mining area and the MIA, both of which will be protected by flood levees for the duration of the operations. Both flood protection levees will be removed at mine closure. Additionally, subsidence-induced changes to floodplain morphology will result in the retention of additional water during flood events. The retained water would pond and either seep into the underlying sediments or evaporate, effectively reducing the catchment area and thus the downstream flows.

Where practical, mitigation drains and mitigation bunds are proposed to drain subsided areas and prevent water ingress into subsided areas (Figure 11.8). This is not possible in all areas, and ponding of runoff captured in the floodplain between Boomerang Creek and One Mile Creek would reduce the local catchment draining into One Mile Creek by approximately 900 km^2 (6.9%). This catchment loss would impact the downstream 4 km reach of One Mile Creek before the confluence with Boomerang Creek, in minor runoff events. The stretch of One Mile Creek where flows are modelled to be reduced during regular flow events has moderate aquatic ecological values, and the reduction in flows will have a minor ecological impact on aquatic values.

Impacts on stream flows would be minimal downstream of the confluence, where loss of catchment would make up 1.8% of the 48,900 ha total catchment area. The modelled flood hydrographs downstream of the Boomerang Creek and One Mile Creek confluence for the 50% and 2% AEP events show that loss of catchment would attenuate the flood hydrograph for the 50% AEP event, reducing and delaying the flood peak, compared to existing conditions. This reduction in flow would reduce the 50% AEP flood depths in the Boomerang Creek by approximately 0.3 m to 0.5 m (Figure 11.9).

In larger floods, the effect of storage on flood flows and downstream flood levels would be minimal (Figure 11.10). There is not predicted to be any changes to downstream flow in Phillips Creek due to loss of the catchment area.

11.5.2.2 Subsidence-induced impacts

One Mile Creek and Boomerang Creek would experience subsidence of the creek bed where the creeks traverse the northern longwall panels as discussed in the section below. The channel of Phillips Creek would not be affected by subsidence.

Boomerang Creek

Predicted subsidence would result in a series of six small troughs in the channel bed of Boomerang Creek, where there would be a decrease in channel velocity, bed shear and stream power, causing reductions in sediment transport capacity in each trough. This is expected to promote aggradation of the bed (relative to the top of the bank level) in these areas. Channel velocity, bed shear and stream power are greater across each of the pillars when compared to the mine subsidence troughs. However, this increase in stream flow characteristics differs to the current conditions at four locations where the creek crosses the underlying pillar.

The bed sediments at the downstream side of the relative elevated sections (i.e. the point where the stream flows from the longwall panel into the troughs) are expected to scour, and the elevated section may erode to match the downstream bed profile. There may be marginal increases in bank erosion at these locations.

During initial flows, local incision and bank erosion can be expected over the pillars between troughs. However, given the abundant sediment supplies in Boomerang Creek, the sand bedload will infill the troughs such that the bed grade would revert over time to the pre-mining grade. The expected aggradation relative to the bank levels could accelerate the potential abandonment of the existing Boomerang Creek channel; given the number of remnant channels and abundant sediment supplies in the catchment, a new Boomerang Creek channel could form in the absence of the predicted subsidence.

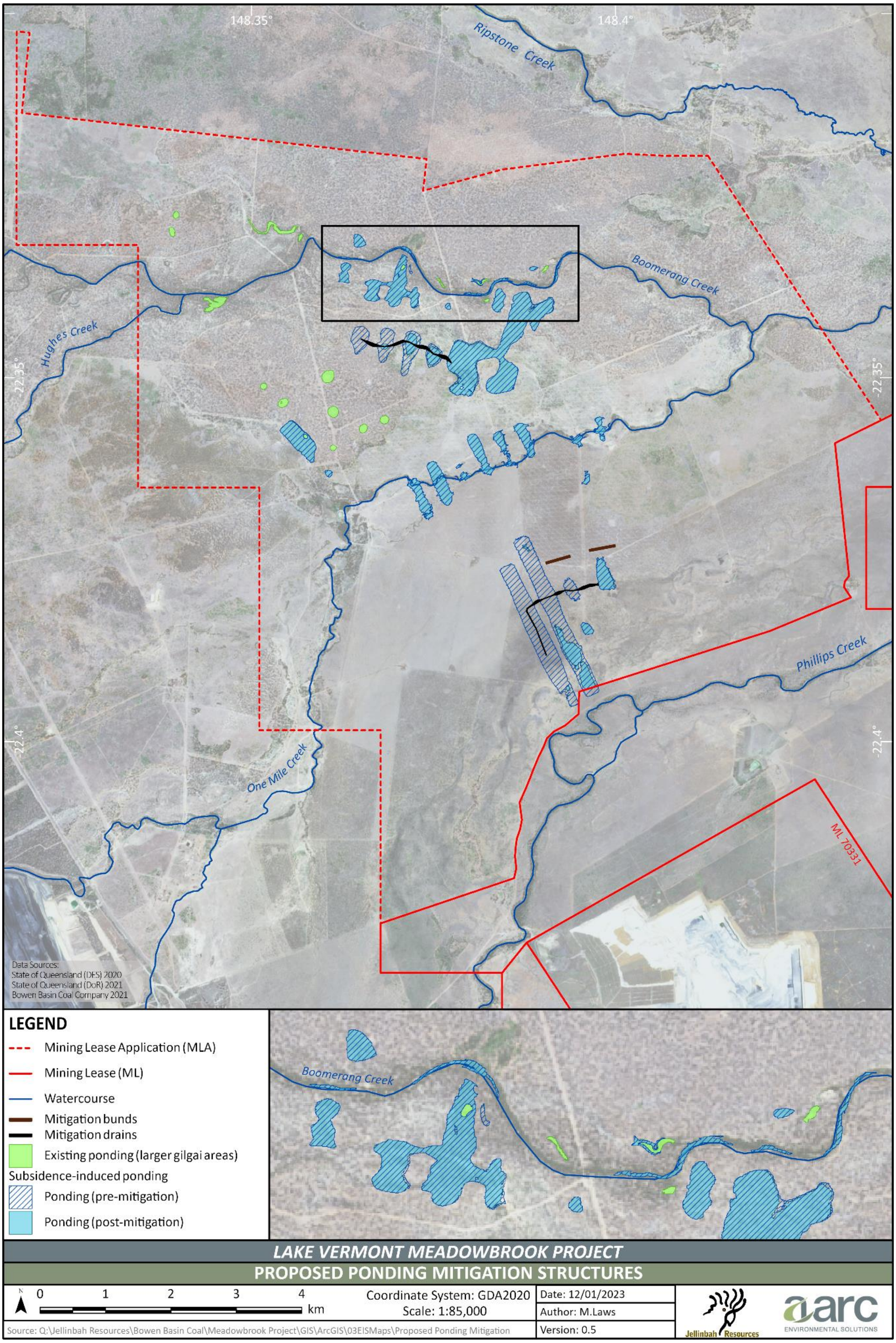

Figure 11.8: Map of mitigated subsidence-induced ponding and location of mitigation measures

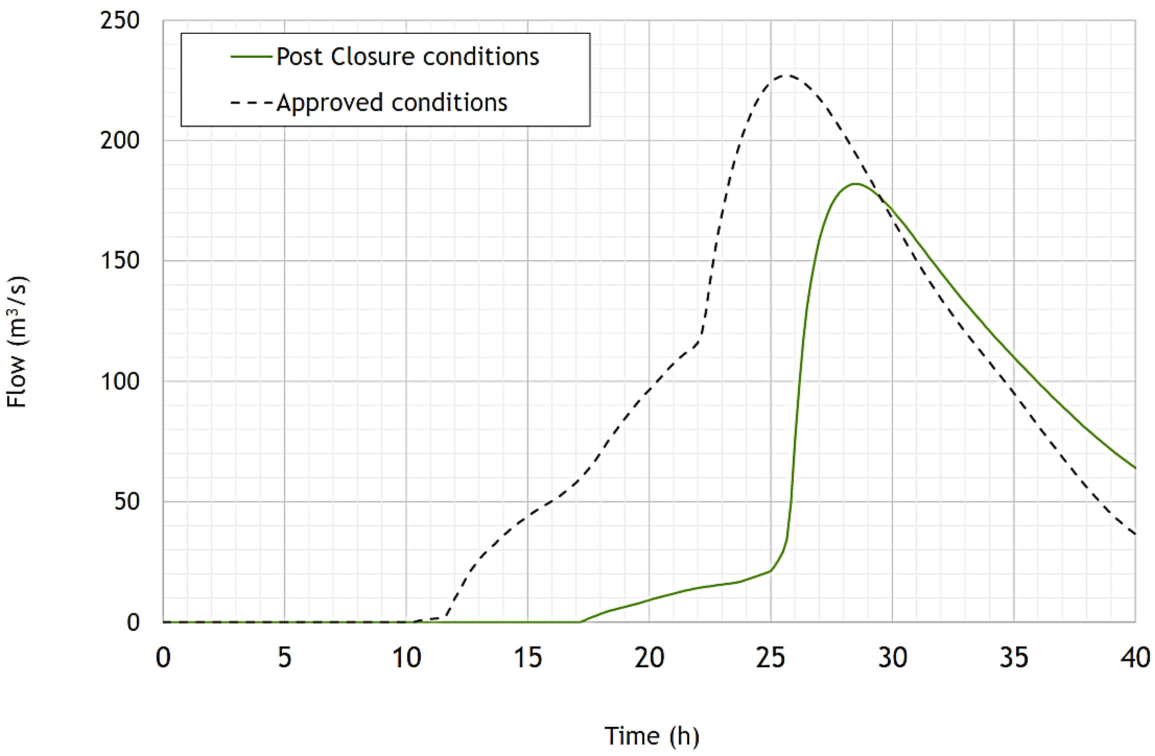

Figure 11.9: Change in downstream flood hydrograph - Boomerang/ One Mile Creek 50% AEP

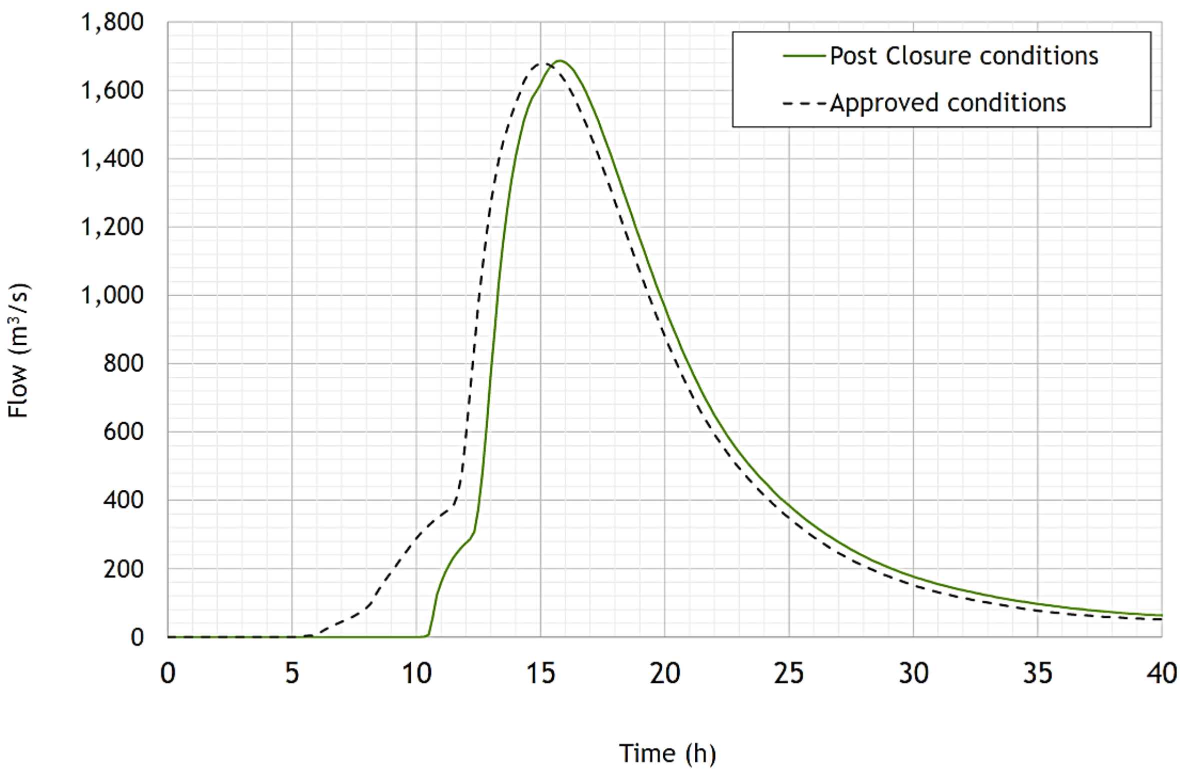

Figure 11.10: Change in downstream flood hydrograph - Boomerang/ One Mile Creek 2% AEP

The erosion and scouring of the watercourse could cause localised loss of in-stream habitat. This could have an impact on habitat availability for macroinvertebrate species and aquatic flora. However, as the erosion is predicted to be localised, it is not expected that this impact will extend off-lease. Nor will it impact habitat availability for other aquatic species, such as fish and turtles, given that there is currently limited in-stream habitat for these species.

As there is plentiful sediment supply within Boomerang Creek and the turbidity of the water typically exceeds the water quality guidelines values. It is not expected that the increased sediment load associated with the localised erosion and transport of bed sediments will impact water quality to the extent that aquatic ecology values are negatively impacted.

The post subsidence stream profile is conceptualised as following the existing stream course, with areas of deeper stream bed located at subsidence troughs, with minimal changes to flow conditions compared to pre-mining conditions. In flow events, flows in the creek are predicted to be retarded by approximately three hours as modelled downstream of the Boomerang Creek and One Mile Creek confluence for 50% AEP events and flows are predicted to be reduced by about 0.3 m to 0.5 m flood depth and approximately 20% by volume (Figure 11.9).

Impacts to flow in larger flow events are expected to be minimal. The predicted minor delay in flow event timing, change to duration and changes to flow heights are considered consistent with the existing highly ephemeral streamflow conditions. The subsidence troughs within Boomerang Creek are predicted to rapidly infill during large streamflow conditions, due to abundant sediment present within this stream. The subsidence management plan will include measures for the monitoring of stream morphology and the application of bank protection measures where demonstrable impact on channel form is identified. Given the existing ephemeral streamflow conditions, expected infilling of troughs, and the predicted minor changes to flows, the changes to stream bed morphology are considered unlikely to create a barrier to fish or turtles that may migrate along the watercourses. Project impacts are also not expected to result in entrapment of aquatic fauna within stream pools, beyond existing conditions.

One Mile Creek

The proposed subsidence would result in a series of eight main troughs in the channel bed due to the differential settlement caused by the unmined pillars resulting from the longwall panels (which are aligned approximately perpendicular to the channel).

The channel velocity, bed shear and stream power will decrease in sections where the channel flows over the subsided panels. This will cause a reduction in sediment transport capacity in each trough, promoting further aggradation of the bed (relative to the top of bank level) in these areas.

Channel velocity, bed shear and stream power are expected to increase at four locations where the watercourse drains from the underlying pillar sections into the lower subsided panel sections. Although velocities would remain below the AEP values defined in the 'Guideline: Works that interfere with water in a watercourse for a resource activity—watercourse diversions authorised under the Water Act 2000', due to the relatively fine sediment in this area and the apparent limitation in sediment supply, erosion is expected as the channel morphology changes to reflect the higher bed grade. This may also lead to an increase in bank erosion as the channel capacity increases. Further, infilling of troughs is expected to require more time than the troughs in Boomerang Creek, due to less availability of sediment within the upstream reach of this watercourse (Appendix F, Surface Water Assessment, Section 7.4.1).

The erosion and scouring of One Mile Creek could cause localised loss of in-stream habitat, which could have a localised impact on habitat availability for macroinvertebrate species and aquatic flora. However, as the erosion is predicted to be localised, it is not expected that this impact will be significant or extend off-lease. Nor will it impact habitat availability for other aquatic species, such as fish and turtles, given there is currently limited in-stream habitat for these species. Given that turbidity levels at sites on One Mile Creek (MA5 384 NTU (2020), MA12 (262.5 NTU (2020) and 574.66 NTU (2021)) have been recorded as well above WQO value (<50 NTU) under pre-mining conditions, it is also unlikely that an increase in turbidity due to localised erosion will impact aquatic flora or fauna communities.

The post subsidence stream profile is conceptualised as following the existing stream course, with areas of deeper stream bed located at subsidence troughs, with minimal changes to flow conditions compared to pre-mining conditions. In flow events, flows in the creek are predicted to be retarded by approximately three hours as modelled downstream of the Boomerang Creek and One Mile Creek confluence (for 50% AEP events) with flood levels predicted to be reduced by approximately 0.3 m to 0.5 m or approximately 20% by volume (Figure 11.9). Impacts to flow in larger flow events are expected to be minimal. The predicted minor delay in flow event timing, change to flow duration and changes to flow heights are considered consistent with the existing highly ephemeral streamflow conditions. Given the existing ephemeral streamflow conditions, and the predicted minor changes to flows, changes to stream bed morphology are considered unlikely to create a barrier to fish or turtles that may migrate along the watercourses. Project impacts are not expected to result in entrapment of aquatic fauna within stream pools beyond existing conditions.

Floodplain and flood impact mitigation measures

Subsidence of the landform due to longwall mining will create a series of depressions aligned with the underground mining panel array orientated in a north–south direction. How the local hydrological regimes will be affected by these depressions has been modelled as part of the hydrological assessment of the Project (Appendix W, Geomorphological Assessment Report, Section 3.3.2), and the results are briefly summarised here.

To minimise the extent of ponding caused by the subsided landform, the Proponent is proposing to establish two drainage channels (mitigation drains) that would be cut through the pillars separating the subsidence troughs to allow free drainage of catchment runoff through the subsidence zone (refer Figure 11.8). Additionally, two small embankments (mitigation bunds) are proposed to be constructed across the subsidence panels to restrict the flow of water from Phillips Creek towards One Mile Creek, preventing ingress into subsided ponds within the floodplain (refer Figure 11.8). These mitigation drains and mitigation bunds will significantly reduce the extent of ponding due to subsidence; however, post-mitigation ponding would still occur. Pre- and post-mitigation ponding is illustrated in Figure 11.8 and the mitigation measures are detailed further in Section 9.5, Chapter 9, Flooding and Regulated Structures.

Subsidence of panels along One Mile Creek would result in surface water flowing laterally into the subsidence areas. Following flood events (50% AEP), water is expected to persist for several months post-filling with the maximum modelled ponding extent shown in Figure 11.8. However ponding is expected to typically be of smaller extent and duration and pumping of the major ponding areas may be undertaken when depths exceed 0.5m at the deepest point (refer Appendix W, Geomorphological Assessment). The creation of these stream-connected ponds has the potential to create additional aquatic habitat locally, as water is constrained within them rather than passing downstream. Persistence of water within the local landscape for an extended period potentially creates additional habitat for macroinvertebrate assemblages and other aquatic fauna. The sustained inundation of these areas (up to 1 m in depth) may provide seasonal refugial habitat for aquatic fauna between flow events and at times across the dry season. The inundation of these areas may also provide habitat for aquatic pest species. The drying between ponding events (every few years) is expected to impede the establishment of aquatic pests in ponding areas and the Weed and Pest Management Plan will be implemented to manage the risk of pest species establishment (Appendix H, Aquatic Ecology Assessment, Section 9.2.3). Therefore, no aquatic pest species are expected to establish or increase within the Project area as a result of the Project. Impacts on vegetation through the establishment of these ponds is discussed in the terrestrial ecology assessment, Chapter 11, Terrestrial Ecology.

11.5.2.3 Changes to flood regimes

Ripstone Creek, One Mile Creek and Boomerang Creek all have relatively shallow channels that experience regular flow breakouts, even in relatively frequent floods. Through much of the Project area, the catchment boundary of One Mile Creek extends to a natural levee along the southern bank of Boomerang Creek. Minor indistinct floodplain flow paths direct runoff from the catchment boundary south-east across the proposed mining area towards One Mile Creek.

The Project is predicted to have three main components that will influence changes to local flooding regimes (depth and velocity), namely:

1) construction of flood protection levees around the open-cut pit and MIA;
2) construction of the haul road; and
3) subsidence caused by underground mining.

The Flood Impact Assessment (Appendix Z, Flood Modelling Assessment Report, Section 4) of the scenarios modelled for the Project are discussed in Chapter 9, Flooding and Regulated Structures. Expected changes to flood depths indicate that:

- Underground mine subsidence would locally reduce flood levels but increase the depth and extent of flooding.
- Subsidence would increase floodplain storage, which has the effect of reducing downstream flood flows, levels and extents for 50% and 10% AEP flood events on Phillips Creek, One Mile Creek and Boomerang Creek of between 50 and 100 mm.
- For the 10% AEP event over the subsidence panels on the Phillips Creek floodplain downstream of the open-cut mine, reductions in flood level are up to two metres in some areas. In larger events, reductions in level are smaller and within the range of 700 mm to 850 mm.
- For the subsidence areas on One Mile Creek, reductions in level range would be from one metre to 700 mm.
- Along Boomerang Creek, some flood levels have reduced by as much as three metres in the 10% AEP event to 2.5 metres in the PMF in the most affected locations.
- Afflux downstream of the mine lease area is negative for all events, ranging from a 600 mm reduction at the Isaac River in the 50% AEP to 300 mm in the 10% AEP. Reductions in the floodplain of the Isaac River in the larger events from the 2% AEP to the PMF range from 60 to 100 mm.
- In the 0.1% AEP and PMF events, there is also some positive afflux in the vicinity of the confluence of the Boomerang and Isaac Rivers of approximately 30 mm to 50 mm.
- In the 1% AEP event for regional flooding conditions, off-lease impacts are limited to the Phillips Creek northern floodplain, with reductions of up to 100 mm just to the south of the Satellite pit and small increases of 30 mm to the western side of the Satellite pit.
- In the 0.1% AEP flood event, reductions downstream in the Phillips Creek northern tributary are approximately 150 mm.

The flood protection levee around the MIA would increase flood depth around the southern and eastern section, with some of the change in flood depth being attributed to the embankment created by the establishment of the haul road. There would also be a small area over which flood depth increases at the northern extent of this flood protection levee. These changes to flooding depths will be temporary, with levee structures to be removed as part of mine closure.

Despite some increase in flood depth, flood flow velocities are only predicted to be marginally higher than currently experienced along the eastern section of the flood protection levee. Further to this:

- There are no significant changes in velocity expected downstream of the mine lease area in design flood events.
- Across the range of events, the subsidence panels would typically experience velocity reductions of up to 0.5 m/s and velocity increases between the panels of up to 0.7 m/s (with some areas experiencing increases up to 1.2 m/s).
- The Phillips Creek floodplain near the south-eastern corner of the open-cut mine is predicted to experience the greatest velocity increases. Modelled point velocity increases range from 0.8 m/s in the 10% AEP event to approximately 1.3 m/s in the 2% and 1% AEP events, and up to 1.5 m/s in the 0.1% AEP event. These velocity increases would be temporary until the operational pit protection levee has been decommissioned.

- In the 2% and 1% AEP events, increases of 0.2 m/s would occur upstream of the haul road in the channel of Phillips Creek and increases of 0.1 to 0.2 m/s along the haul road on the Phillips Creek northern floodplain.
- Minimal upstream velocity impacts are predicted for the 50% and 10% AEP floods. Minimal increases in velocity are predicted in the 0.1% AEP event.

The increase in flood velocities close to the open-cut levee could cause erosion and sediment transport into the surrounding aquatic environments. It is unlikely the increase in flood velocities and depths associated with the MIA flood protection levee would cause any significant increase in erosion and sediment transport. Both of the proposed levees are designed to ensure they can withstand the predicted velocities during operations and would be removed on decommissioning, at which time the flood velocities would return to pre-mining conditions (Appendix Z, Flood Modelling Impact Assessment, Section 3.3.3).

The construction of the haul road would cause changes in the flood regime on the floodplains of Phillips Creek and One Mile Creek. As previously acknowledged, stream crossings will be constructed as causeways, with appropriately sized culverts to allow low flows; however, they will be inundated for approximately five days per annum. In low flows, when the proposed causeways are not inundated, the afflux created by the haul road will be sufficient to extend off the mine lease area. In the 50% AEP design event, the afflux will be confined to areas within the channel, with a maximum of 60 mm at the lease boundary. Velocities associated with the changed flood patterns due to the establishment of the haul road would be minimal and not expected to cause significant erosion or scouring, provided cross-drainage structures are appropriately designed.

The effect of the change of flood regimes on aquatic ecology values is not anticipated to be significant, given the adaptation of the aquatic flora and fauna to the relatively harsh environmental conditions, which are currently experienced within the study area. Afflux impacts (resultant of the Phillips Creek haul road crossing) are predicted to cause minor increases in upstream flow velocities, however these changes are not expected to impact fish passage. Specifically, in the 2% and 1% AEP events, increases of 0.2 m/s would occur upstream of the haul road in the channel of Phillips Creek and increases of 0.1 to 0.2 m/s would occur along the haul road on the Phillips Creek northern floodplain (Appendix Z, Flood Modelling Impact Assessment, Section 3.3.3). Further, despite the change in the flood regime, the wetland areas within the study area are all still expected to receive water from flood events.

11.5.2.4 Groundwater drawdown

The aquatic habitats associated with Boomerang Creek, Phillips Creek and the Isaac River, along with the GES wetland and HES wetlands within the study area, may comprise aquatic GDEs. As watercourses and wetlands are ephemeral, any groundwater dependence of the aquatic environments would be for short periods of the year, and given the ephemerality of the aquatic environments, the aquatic species that inhabit them are adapted to wetting and drying cycles.

The groundwater model and groundwater impact assessment (Appendix E, Groundwater Impact Assessment Section 3.2 and Appendix E, Attachment A Groundwater Modelling Report, Section 8.1) have concluded that the only location where the alluvium is permanently saturated is the Isaac River alluvium and that this is consistent with available data from landowner groundwater bores. The modelled drawdown of the alluvium sediments does not extend to the Isaac River; drawdown in the alluvium is confined to a relatively small area along Boomerang Creek, which the groundwater model predicted will contain some water (Appendix E, Attachment A, Groundwater Modelling Report, Section 4.4).

Although the alluvium is dry for much of the year, the groundwater impact assessment concluded that the groundwater drawdown contours assigned to the Tertiary sediments can be used to indicate the zone within which any water that does occur within the alluvium would have an enhanced potential for downward seepage. The Tertiary sediment drawdown contours do not extend to the Isaac River; thus, any dependence aquatic ecosystems have on groundwater would not be impacted by the Project.

The HES wetland to the east of the Project area, but within the aquatic ecology study area, has been determined to be partially groundwater-dependent (Appendix I, Groundwater-Dependent Ecosystem Assessment, Section 6.2.5). However, the conceptualisation of this potential GDE noted that it was likely to be a perched alluvial groundwater aquifer more than six metres below the base of the HES wetland but separated from the underlying Tertiary sediments and groundwater environment. This perched aquifer may provide seasonally accessible water to the riparian vegetation of the HES wetland, which would contribute to the aquatic environment of the HES wetland by providing shade and habitat structure (Figure 10.11). The perched alluvial system is conceptualised as dry for extended periods of the year (including extended drought periods), and as such, the terrestrial vegetation that may seasonally rely on the alluvial groundwater in the perched system will be adapted to long, dry periods (Figure 10.10). The groundwater modelling conducted for the Project has predicted drawdown would not interact with this HES wetland, and the surface water flows, which recharge the alluvial groundwater lens and provide a water source for terrestrial vegetation at the HES, will not be affected. As such, it is not predicted that there will be impacts on the aquatic environment at this HES wetland as a result of the Project.

The Tertiary sediment groundwater drawdown contours do extend under Phillips Creek, which is mapped as a high potential aquatic GDE. The Tertiary groundwater system drawdown impact to GDEs located on Phillips is predicted to be insignificant because the groundwater system is discontinuous along the length of the watercourse, the riparian trees have capacity to use moisture from multiple sources and the groundwater system is recharged by surface flows and flooding, which provides the dominant driver to support riparian ecological function. In addition, the alluvium under Phillips Creek is unsaturated for most of the year (apart from small pockets that may occur in the alluvium following recharge by rainfall or stream flow), and the creek is ephemeral, indicating aquatic species and communities are not reliant groundwater. Further, as the Tertiary groundwater quality is poor (high salinity) it is considered unsuitable for aquatic ecosystem support; therefore, it is unlikely to be supporting the aquatic environments within the study area.

Notwithstanding this, additional baseline data collection is proposed to continue post Project approval, to validate the seasonal ecohydrological function and baseline condition of GDEs. Collection of baseline data will be conducted in accordance with a Groundwater Dependent Ecosystem Monitoring and Management Plan developed for the Project.

The assessment of potential impacts on stygofauna is presented in Appendix J, Stygofauna Assessment (Section 5). The assessment has determined that depauperate, sporadic and highly localised stygofauna populations of low ecological value are present in the alluvial areas of the study area.

The assessment has determined that the impacts on stygofauna in the Project area is low and suggested ongoing monitoring of groundwater levels and quality to monitor potential changes to the stygofauna community.

It is considered unlikely, therefore, that groundwater drawdown associated within the Project will impact on aquatic ecology values.

11.5.2.5 Water quality impacts

Erosion and sedimentation

Excavation within a watercourse (such as for the development of a road crossing) can have impacts on aquatic ecosystems downstream. Similarly, changes in flow velocities within streams or the creation of flood protection structures against which flood water flows can increase erosion and increase sediment load within water.

Construction of the watercourse crossings will be undertaken in the dry season, thus minimising the release of sediment into the receiving waters.

The flood protection structures levee would be designed to ensure it could withstand the predicted velocities during operations.

Increases in sediment loads within aquatic environments will increase turbidity and change water conditions. This change in water conditions can affect aquatic organisms (e.g. make it more difficult for aquatic fauna to locate and capture prey items and/or decrease light penetration), which will impact aquatic flora. Pollutants and nutrients, which may have been trapped in the sediment, can also be transported with the sediment and cause contamination or eutrophication of waterways.

However, the watercourses within the study area experience high levels of sediment transport and deposition during the wet season. Watercourses are typically highly turbid, to which the aquatic organisms of the study area are adapted. The erosion and sediment impacts associated with the Project are not expected to significantly impact the aquatic ecological values on a regional scale.

Water releases

There are no releases of mine-affected water proposed as part of the Project.

Runoff from the open-cut waste rock dumps will be managed under an updated Lake Vermont Mine Water Management Plan, such that sediment generated and transported by runoff will be settled in a sediment dam. During open-cut mining operations, catchment runoff from overburden dumps will be captured in three sediment dams; namely, the:

1) Southern Sediment Dam;
2) Northern Sediment Dam 1; and
3) Northern Sediment Dam 2.

Sediment dams will be constructed to contain a 1 in 10-year ARI 24-hour event and will be operated in accordance with the 'DES Guideline - Stormwater and environmentally relevant activities' (DES 2021). Sediment dam catchment areas and proposed storage capacities are provided in Chapter 9, Flooding and Regulated Structures.

As overburden runoff quality is expected to be relatively benign (Appendix D, Geochemical Assessment, Section 4.6), sediment dams have been designed to discharge to the receiving environment (after the settlement of suspended sediment), with minimal impact on downstream water quality anticipated. Significant dilution capacity from flows in the receiving waters during overtopping events would likely result in indiscernible impacts on the receiving environment.

11.5.2.6 Drainage and seepage

The Geochemical Assessment of Mining Waste Materials Project (Appendix D, Geochemical Assessment, Section 6) indicates waste rock at the Meadowbrook Project would have:

- low sulphur content, excess acid neutralising capacity, negligible risk of acid generation and a high factor of safety with respect to potential for the generation of acidity;
- no significant metal/metalloid enrichment compared to median crustal abundance in un-mineralised soils;
- slightly alkaline to alkaline surface runoff and seepage with relatively low salinity; and
- low dissolved metal/metalloid concentrations in surface runoff and leachate.

The water extract solutions were generally dominated by ions of sodium, chloride and sulphate, with lesser concentrations of other major ions.

Runoff from the open-cut waste rock dumps will be managed under the existing Lake Vermont Mine Water Management Plan, which is to be updated to cover Project infrastructure.

The design of open-cut area final landform is premised on achieving a final elevation above the anticipated recovered groundwater level. A water balance model has been developed to assess the behaviour of the rehabilitated pit landform under various climate scenarios (Chapter 8, Surface Water and Appendix X, Rehabilitated Landform Water Balance Report, Section 3.4). Runoff from the surrounding out-of-pit waste rock emplacement areas post-closure will be directed away from the central pit area, to limit the catchment area flowing into the depression to principally that of the depression itself; an area of approximately 185 ha.

As a consequence, it is anticipated that a shallow intermittent water body will occur within the depressed landform, with its existence dependent upon antecedent rainfall and related climate conditions. The water balance model outcomes indicate that water quality will not accumulate salts over time given losses to groundwater and that water quality will remain well below the 'low-risk' trigger value (4,000 mg/L) of the applied livestock drinking water quality guideline (ANZG 2018).

11.5.2.7 Litter, waste and spills

If litter and waste from construction and operations was to enter aquatic ecosystems, it could potentially entangle aquatic fauna and contribute to the degradation of water and sediment quality. As a Waste Management Plan is in place for the Lake Vermont Project, which will be updated to capture the activities of the Project, the risk of litter and waste entering aquatic ecosystems and subsequent impact on aquatic ecology values is very low.

Provided the appropriate management of chemicals is maintained, the Project is unlikely to result in leaks or spills that would result in environmental harm. Appropriate storage of chemicals and hydrocarbons will be required as part of ongoing operations, as well as a dedicated fuel and lube facility, which will be constructed to provide adequate containment and spill response programs. An existing Chemical and Fuel Management Plan is in place for the existing Lake Vermont Mine, which will be updated to capture the activities of the Project. As such, the risk of stored chemicals entering aquatic ecosystems and impacting on aquatic ecology values is considered very low.

11.5.3 Cumulative impacts

The cumulative impacts to water resources have been assessed based on the predicted impacts of the Project, along with the existing or approved impacts of other activities in the region (Figure 3.1, Chapter 3, Project Description). Cumulative impacts have considered cumulative changes in hydrological characteristics and quality of surface water and groundwater. The cumulative impact assessments include all current and known future coal mining operations, as well as the operation of the Arrow Energy CSG borefield.

The cumulative impact assessment conducted as part of the groundwater impact assessment has concluded that there would be no cumulative drawdown in the alluvium.

Drawdown in the Tertiary sediments from Olive Downs South and Eagle Downs extends southward to coalesce with the drawdown from the Meadowbrook operation, resulting in an additional 2 m to 10 m of drawdown beneath Boomerang Creek and an additional 2 m to 15 m of drawdown beneath Ripstone Creek.

In terms of cumulative impacts from surrounding projects on regional flooding, the assessment (Appendix Z, Flood Modelling Assessment Report, Section 4) has noted the Willunga and Olive Downs South domains of the proposed Olive Downs Project, which extend onto the Isaac River floodplain downstream and upstream of the Meadowbrook Project, may have interacting flood impacts.

Both the developed conditions (Project year 2051) of the Project (with mitigation measures and other projects) and the post-closure conditions of the Project (with other projects) have been modelled in the cumulative impact assessment, with the maximum disturbance of all projects modelled to occur simultaneously (conservative assessment). The cumulative impact modelling has been undertaken for the 1 in 1,000 (0.1%) AEP regional flood event.

The cumulative flood impact outside the Project area is dominated by the relatively large disturbance impacts on the Isaac River floodplains approved for other projects. The impacts of the Meadowbrook Project on areas outside the Project are minor, and there are minimal links to impacts from other projects.

Although there will be some direct disturbance to aquatic habitat values within the Project area, the direct disturbance will be to a small area of regional aquatic habitat compared to other approved projects in the region.

11.5.4 Facilitated impacts

Facilitated impacts relate to impacts from other projects (including third parties), which are made possible (facilitated) by the Project being assessed (this Project). Facilitated impacts may be expected to occur through the development of infrastructure (e.g. a dam, road or rail line), when that development would enable the development of other projects which otherwise may not have been viable (e.g. the development of a road leads to urban development in an undeveloped area).

The Project will not develop any infrastructure that will facilitate the development of any other projects. Mining operations will not facilitate the development of any other projects that could not already be developed. Proposed electrical, water supply and telecommunications infrastructure will link to existing infrastructure at the Lake Vermont Mine and will not facilitate the development of other future projects. Any proposed infrastructure, including electrical, water supply and telecommunications, will avoid waterways where possible, and any that do not have a functional requirement to be in a waterway will not be placed within them.

Post-mining, it is expected that, the Project area will be reinstated to grazing land similar to that which existed prior to mining. It is not considered that the return of lands to an agricultural land use or alternative use that provides similar value will facilitate the development of projects which would cause additional (facilitated) impacts to those identified for the Project.

As such there is not expected to be any facilitated impacts from the Project on any aquatic ecology values.

11.6 Impact assessments

11.6.1 Matters of National Environmental Significance (MNES)

This section provides an assessment of the significance of impacts of the Project on threatened aquatic species in accordance with the Project ToR and EPBC Act Significant Impact Guidelines (DoE 2013a).

No aquatic flora or fauna are recorded as MNES within, or considered likely to occur within, the study area. Neither the Fitzroy River Turtle nor the Southern Snapping Turtle are expected to occur within the Project area based on results of surveys and habitat assessments. However, an assessment of the potential impacts on the Fitzroy River Turtle and the Southern Snapping Turtle, in accordance with the required impact assessment hierarchy for MNES, is provided in sections 11.6.1.1 and 11.6.1.2 respectively.

11.6.1.1 Fitzroy River Turtle

Description

The Fitzroy River Turtle (*Rheodytes leukops*) is a medium to dark brown freshwater turtle with an oval shell, growing up to 25 cm in length with scattered darker spots on the upper shell surface (DoE 2021). It has a pale yellow or cream underside, dull olive-grey exposed fleshy parts and a distinct narrow white ring around the eye in adults, or a silvery-blue iris in hatchlings (Cogger 2000; Hamann *et al.* 2007; DoE 2021). The Fitzroy River Turtle has relatively long forelimbs with five long claws and large cloacal bursae, which has a respiratory function (Cogger 2000; Wilson & Swan 2003).

This species is a benthic omnivore, with a diet consisting of insects, macroinvertebrates (principally larvae and pupae of Trichoptera and Lepidoptera), crustaceans, gastropods, worms, freshwater sponges, algae and aquatic plants, including Ribbonweed (*Vallisneria sp*.) (DEWHA 2008a).

The Fitzroy River Turtle is only found in the drainage system of the Fitzroy River, Queensland. It is estimated that this species occurs in a total area of less than 10 000 km² (DoE 2021). Known sites include Boolburra, Gainsford, Glenroy Crossing, Theodore, Baralaba, the Mackenzie River, the Connors River, Duaringa, Marlborough Creek and Gogango (DoE 2021). The species is largely sedentary with relatively small home ranges, and its movements have been shown to be restricted between riffle zones and adjacent pools, although large scale movements for dispersal, courtship, nesting migrations and repositioning following flood displacement may occur (Tucker *et al.* 2001).

The Fitzroy River Turtle is found in rivers with large, deep pools with rocky, gravelly or sandy substrates connected by shallow riffles. Preferred areas have high water clarity and are often associated with Ribbonweed (*Vallisneria sp.)* beds (Cogger *et al.* 1993). Common riparian vegetation associated with the Fitzroy River Turtle includes Blue Gums (*Eucalyptus tereticornis*), River Oaks (*Casuarina cunninghamiana*), Weeping Bottlebrushes (*Callistemon viminalis*) and Paperbarks (*Melaleuca linariifolia*) (Tucker *et al.* 2001).

Preferred in-stream habitat for the species is clear, fast flowing watercourses that have:

- rocky, gravelly or sandy substrates;
- large, deep pools (between 1 m and 5 m deep) that provide refuge areas and are associated with shallow riffles zones that provide favourable foraging habitat for macroinvertebrates;
- in-stream features, such as undercut banks, submerged boulders, tree roots and logs, which provide rest and refuge spots; and
- in-stream vegetation, in particular Ribbonweed (*Vallisneria sp.*), which is a preferred food source and provides favourable foraging habitat for macroinvertebrates (Cogger *et al.* 1993; Tucker *et al.* 2001; DoE 2020).

The Fitzroy River Turtle is thought to prefer well-oxygenated riffle zones and moves into deeper pools as the riffle zones cease to flow (Tucker *et al.* 2001). However, studies have captured several turtles from deep pools (Gordos *et al*. 2007) where they may associate with surface or sub-surface logs (Tucker *et al.* 2001).

Nesting habitat is restricted to areas with alluvial sand/loam banks 1 m–4 m above water level; however, nesting sites have been found 15 m from the water on flat sandbanks (DEWHA 2008a). Preferred banks include that which have a relatively steep slope, low density of ground/understorey vegetation and partial shade cover. Females have an annual reproductive potential of 46 to 59 eggs laid within three clutches, which are deposited in nesting chambers 170 mm deep (DEWHA 2008a). Nesting occurs from September to November, with hatching occurring between November and March (DoE 2021).

Desktop analysis

There are no records of the Fitzroy River Turtle close to the study area or from the Isaac River. A record of the closest known sightings has been published in the Queensland Wildnet and Atlas of Living Australia, as shown in Figure 11.11. There are no records from the Isaac River sub-catchment and only three records from the Connors River sub-catchment of the Fitzroy River Basin. Any other records are located a considerable distance downstream (i.e. greater than 100 km) and, as such, will not be impacted by the Project.

None of the other studies conducted for surrounding projects recorded the species as part of survey program. Notably, the aquatic ecology study completed for the Olive Downs Project, which included assessment sites on Risptone Creek and the Isaac River (downstream of the Meadowbrook aquatic study area), did not record the species or habitat for the species as part of the assessment.

Survey effort

Survey effort for the Fitzroy River Turtle is detailed in Table 11.1. The Fitzroy River Turtle can be difficult to survey, as they rarely enter traps. However, the highly turbid waters and ephemeral nature of the watercourses of the study area prevented the use of snorkelling (preferred survey technique). As such, a combination of trapping and habitat assessment have been relied on for the survey of the species.

Survey outcomes

No Fitzroy River Turtles were recorded in the surveys.

Habitat assessment

There is no suitable habitat for the Fitzroy River Turtle within the study area. The habitat within the study area is characterised by ephemeral watercourses that flow for relatively short periods following the cessation of considerable rainfall in the catchment. The preferred habitat of the species (rivers with large, deep pools with rocky, gravelly or sandy substrates, connected by shallow riffles with high water clarity) is not found in the study area, and the ephemeral nature, high turbidity and sandy to fine sediment substrate do not constitute habitat for the species. The Isaac River is the largest watercourse within the study area; however, the ephemeral characteristics of the river do not support year-round habitat for the species. The Project area will not directly disturb any potential habitat for the species.

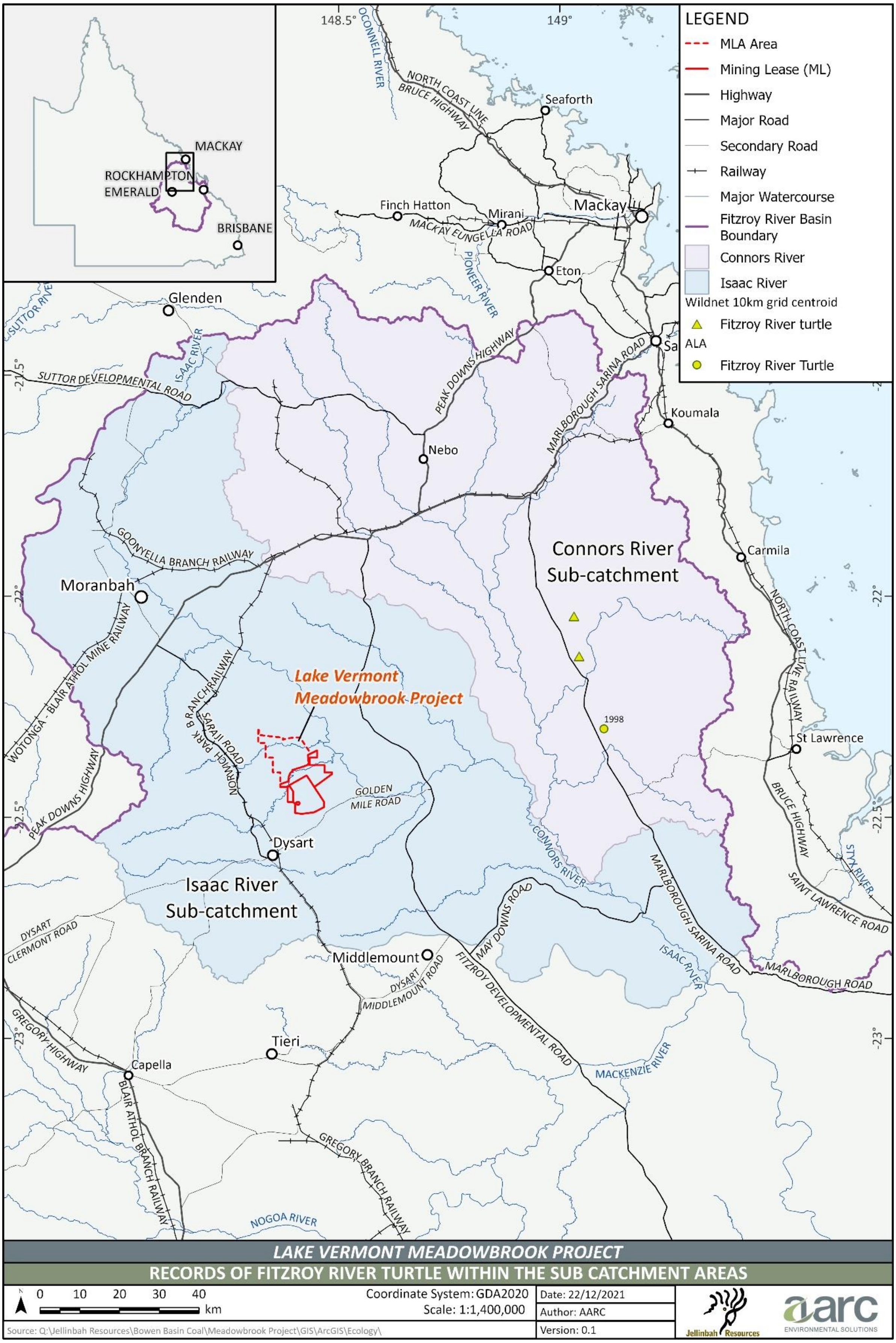

Figure 11.11: Map showing records of Fitzroy River Turtle within the Fitzroy River Basin

Direct impacts

There is no potential habitat for the Fitzroy River Turtle within the study area; thus, there will not be any direct impacts to the species from the Project.

Indirect impacts

The species could be indirectly impacted by changes in watercourse profiles through subsidence (which could change the availability of pool and riffle habitat) or changes in watercourse flow timings or volumes. The subsidence profile from underground mining does not extend to areas that are considered suitable habitat for the Fitzroy River Turtle. The flood modelling (Appendix Z, Flood modelling assessment report, Section 3.3.4) has demonstrated there would not be significant changes to regional flooding or volume or timing of flows on a regional scale. The modelled changes in flooding and surface water flows do not extend to the Isaac River; thus, they do not extend to the likely nearest population of the species. Potential soil erosion and cracking impacts are assessed in Section 5.4.1, Chapter 5, Land Resources. Given the management measures detailed in Section 5.4.3 and that no cracking or erosion is expected to extend to the Isaac River, no impacts to the Fitzroy River Turtle habitat is expected to occur. Surface water flow conditions are not expected to be impacted by groundwater drawdown (Appendix E, Groundwater Modelling and Technical Report, Section 6.3.3) and therefore it is considered unlikely that groundwater drawdown or depressurisation will impact the Fitzroy River Turtle habitat.

Given that any habitat for the Fitzroy River Turtle is only likely to be found a significant distance downstream of the Isaac River, any minor changes in water quality due to the Project are unlikely to impact habitat for the species.

The Project is not expected to result in the introduction of any new aquatic pest species to the watercourses that support habitat for the Fitzroy River Turtle. Therefore no indirect impacts on the habitat of the Fitzroy River Turtle is expected. Likewise, it is unlikely there will be any indirect impacts on individuals or habitat of the Fitzroy River Turtle.

Facilitated impacts

The Project will not result in any other actions that have the potential to impact on the Fitzroy River Turtle or their habitats. As such, no facilitated impacts to the Fitzroy River Turtle are predicted.

Cumulative impacts

The Project will not result in any impacts on the Fitzroy River Turtle and is not expected to contribute to any cumulative impacts on the species.

Avoidance, mitigation and management measures

There is no potential habitat for the Fitzroy River Turtle within the study area; thus, direct impacts to the species will be avoided. Given that there is no habitat for the species that is likely to be indirectly impacted, no species-specific management measures are proposed. However, general management measures will be implemented to minimise disturbance to aquatic habitats and minimise changes to water quality, namely:

- designing watercourse crossings to consider fish passage;
- designing flood levees to withstand increase in flood velocities;
- limiting direct impact on the identified disturbance area;
- locating areas of disturbance outside watercourses and wetlands where possible; and
- developing environmental management plans, including:
    - Water Management Plan;
    - Chemical and Fuel Management Plan; and

- Waste Management Plan

Significant impact assessment

The significance of the impacts from the Project on the Fitzroy River Turtle (after the avoidance, mitigation and management measures have been implemented) has been assessed against the significant impact criteria for vulnerable species (DoE 2013a) in Table 11.4.

11.6.1.2 Southern Snapping Turtle

The Southern Snapping Turtle is listed as critically endangered under the EPBC Act.

Description

The Southern Snapping Turtle (*Elseya albagula*) is one of the largest short-necked freshwater turtles in Australia, with females (which are larger than males) reaching up to 42 cm in length (DES 2017a). Adults of the species are heavily built, and females have white markings on their face and neck (Limpus *et al.* 2011).

The Southern Snapping Turtle is a habitat specialist and has a small home range but is thought to migrate kilometres along rivers to regular nesting sites (Limpus *et al.* 2011). It is only found in the Fitzroy, Mary and Burnett Rivers and associated smaller drainages. The species only inhabits permanent flowing streams and does not occur within farm dams, ephemeral swamplands or brackish waters (Hamann *et al.* 2007). Within the Fitzroy catchment, this species occurs throughout the permanent freshwater reaches from the Fitzroy Barrage to the uppermost spring fed pool in the McKenzie and Dawson sub-catchments. It may also occur in permanent water impoundments (Limpus *et al.* 2011).

The species prefer permanent, clear, well-oxygenated water that is flowing and contains in-stream habitat features and shelter, such as large, woody debris and undercut banks (Todd *et al.* 2013). During the day, the species inhabit areas of high shade (i.e. submerged logs, overhanging riparian vegetation), and at night, they inhabit shallow riffles. The species' preferred habitat has:

- sandy gravel substrates;
- large deep pools (between 1 m and 10 m deep), which provide refuge areas and are associated with glides;
- runs or riffle zones, which provide favourable foraging habitat;
- in-stream features, such as undercut banks, submerged boulders, tree roots and logs, which provide rest and refuge spots;
- in-stream vegetation, which provides a food source and favourable foraging habitat; and
- healthy riparian vegetation. (Limpus *et al.* 2011).

Within the permanent water bodies, the Southern Snapping Turtle is typically found in deep pools (>6 m) bordering a riffle zone (Gordos *et al.* 2007; Hamann *et al.* 2007). During the dry season, the Southern Snapping Turtle is found in remnant pools with slow flowing water.

Suitable turtle and nesting habitat preferred by these species include:

- general habitat features, such as:
  - clear, flowing and well-oxygenated water with riffle zones and deep pools;
  - sandy gravel substrate; and
  - a diversity of in-stream features, which provide shelter and refuge (e.g. submerged aquatic vegetation, submerged rock crevices, undercut banks and/or submerged logs and fallen trees); and
- nesting habitat features, including sandy or loam banks (Limpus *et al.* 2011).

Table 11.4: Significant impact assessment for the Fitzroy River Turtle

Significant impact criteria (DoE 2013)	Significant impact assessment for the Project
An action is likely to have a significant impact on a Vulnerable species if there is a real chance or possibility that it will:	
Lead to a long-term decrease in the size of an important population of a species	• An important population of the Fitzroy River Turtle has not been identified within the waters of the study area or downstream of the study area. • It is not expected that the Project will result in mortality of the species or impact on breeding success or movement of the species. • The Project will not cause any impacts on water quality or hydrological flows in an area where the species is known to occur.
Reduce the area of occupancy of an important population	• An important population of the Fitzroy River Turtle has not been identified within the water bodies of the study area. • Studies completed in areas near the Project have failed to detect the species within water upstream or downstream of the Meadowbrook Project. • The hydrological regime of the Isaac River will not be impacted by the Project.
Fragment an existing important population into two or more populations	• An important population of the Fitzroy River Turtle has not been identified within the study area or detected upstream or for a significant distance downstream of the study area. • The Project is not expected to have any direct or indirect impact on the habitat used by the species that would result in the fragmentation of an existing population.
Adversely affect habitat critical to the survival of the species	• The waters within the study area do not provide habitat critical to the survival of the Fitzroy River Turtle.
Disrupt the breeding cycle of an important population	• The waters within the study area do not provide a suitable breeding habitat for the Fitzroy River Turtle.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	• The Project will not adversely impact the habitat of the Fitzroy River Turtle and, thus, will not cause the species to decline.
Result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	• The Project will not result in the establishment of an invasive species within the Fitzroy River Turtle's habitat.
Introduce disease that may cause the species to decline	• The construction and operation of the Project is not expected to introduce diseases that may cause the Fitzroy River Turtle to decline.
Interfere substantially with the recovery of the species	• The Project will not interfere with the recovery of the Fitzroy River Turtle, as it will not directly or indirectly impact the species or its habitat.

Threats

The species is estimated to have lost more than 70% of its hatchling production and more than 70% of juveniles and sub-adults in the last 20 years (Limpus *et al*. 2011). This loss of juveniles can be attributed to loss of eggs and nests through trampling (particularly by cattle) and failure to recruit immature age classes. Additionally, direct impacts associated with the construction of barrages, dams and weirs have led to a decline in the population across its range (DAWE 2020b).

Current threats to the species are outlined in the adopted recovery plan (DAWE 2020b) and include:

- predation and trampling at nest sites;

- installation of in-stream barriers, which obstruct movement;
- degradation of habitat and water quality;
- climate change from increased temperatures and changed rainfall patterns; and
- fishing and boating activities.

Desktop analysis

There have been no sightings of the Southern Snapping Turtle close to the aquatic ecology study area or within the Isaac River Catchment. A single sighting has been recorded near the Connors River, as published in the Queensland Wildnet and the Atlas of Living Australia, with an additional recorded sighting near the Mackenzie River, well downstream of the Project as shown in Figure 11.12. Neither location where the species has been recorded will be impacted by the Project.

None of the other studies conducted in surrounding projects have recorded the species as part of survey program. Notably, the aquatic ecology study completed for the Olive Downs Project, which included assessment sites on Risptone Creek and the Isaac River (downstream of the Meadowbrook aquatic study area), did not record the species or its habitat.

The absence of records from within and around the study area are reflective of the lack of habitat for the species (i.e. permanent flowing water). It is considered likely that the nearest population of the species is at or near the confluence of the Isaac River and Connors River approximately 60 km downstream of the Project footprint and well outside the area of any expected change in surface water flows or water quality due to the Project.

Survey effort

Survey effort for the Southern Snapping Turtle is detailed in Table 11.1. The Southern Snapping Turtle can be difficult to survey as they rarely enter traps. The preferred survey technique is to observe them underwater using snorkelling equipment. However, the highly turbid waters and ephemeral nature of the watercourses of the study area prevented this survey technique from being used. As such, a combination of trapping and habitat assessment have been relied on for the survey of the species.

Survey outcomes

No Southern Snapping Turtles have been recorded in the surveys.

Habitat assessment

There is no suitable habitat for the Southern Snapping Turtle within the study area.

The habitat within the study area is characterised by ephemeral watercourses, which flow for relatively short periods following the cessation of considerable rainfall in the catchment. These ephemeral watercourses are considered unsuitable habitat for the Southern Snapping Turtle. The remnant pools retained in Phillips Creek, One Mile Creek and Boomerang Creek following flow events are comparable to the small non-flowing waterbodies in which the species is unlikely to be found.

The Isaac River is the largest watercourse within the study area; however, this watercourse is still ephemeral and does not constitute preferential habitat for the species.

Direct impacts

There is no potential habitat for the Southern Snapping Turtle within the study area, and thus there will not be any direct impacts to the species from the Project.

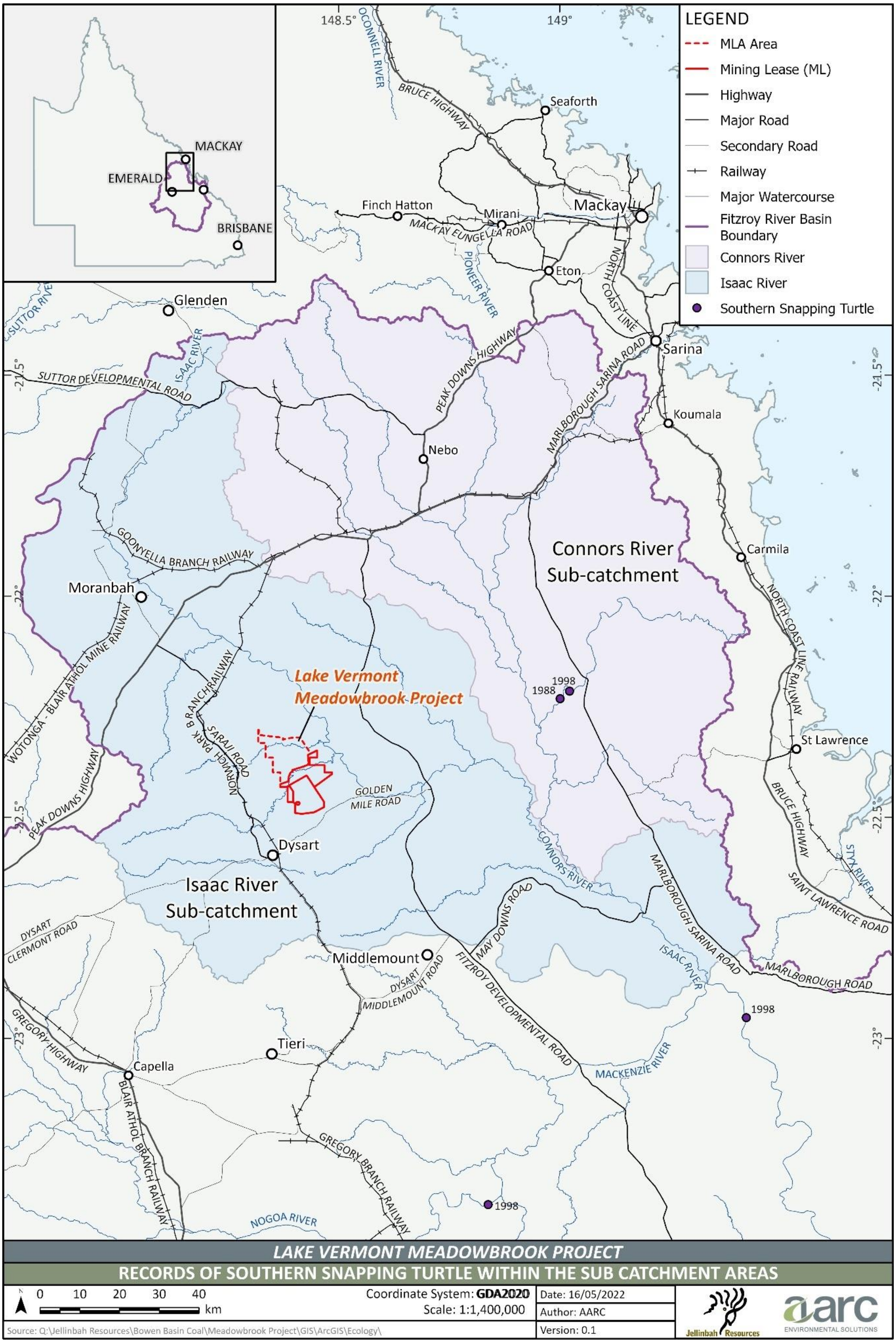

Figure 11.12: Map showing records of Southern Snapping Turtle within the Fitzroy River Basin

Indirect impacts

The species could be indirectly impacted through changes in watercourse profile through subsidence which change that availability of pool and riffle habitat for the species or through changes in watercourse flow timings or volume.

The subsidence profile from underground mining does not extend to areas that are considered suitable habitat for the species. The flood modelling (Appendix Z, Flood Modelling Assessment Report, Section 3.2.2) demonstrated there would not be significant changes to regional flooding or volume or timing of flows on a regional scale. The modelled changes in flooding and surface water flows do not extend to the Isaac River, and thus do not extend to the likely nearest population of the species. Potential soil erosion and cracking impacts are assessed, and management measures proposed in Section 5.4.1, Chapter 5, Land Resources. Given management measures detailed in Section 5.4.3, no substantial erosion or soil cracking is expected within the Project area and no resulting impacts to the Southern Snapping Turtle habitat is expected to occur. Groundwater drawdown is not predicted to impact surface water flows (Appendix E, Groundwater Assessment, Section 6.3.3), and therefore it is considered unlikely to impact the Southern Snapping Turtle habitat.

The potential impacts to water quality through either sediment chemical release are expected to be minor. Given that any habitat for the Southern Snapping Turtle is only likely to be found a significant distance downstream of the Isaac River, any minor changes in water quality due to the Project are unlikely to impact habitat for the Southern Snapping Turtle.

The Project is not expected to result in the introduction of any new aquatic pest species to the watercourses which support habitat for the Southern Snapping Turtle, and as such, no indirect impacts to the habitat of the Southern Snapping Turtle are expected. As such it is unlikely there will be any indirect impacts to individuals or habitat of the Southern Snapping Turtle.

Facilitated impacts

The Project will not result in any other actions that have the potential to impact on Southern Snapping Turtles or their habitats. As such, no facilitated impacts on the Southern Snapping Turtle are predicted.

Cumulative impacts

The Project will not result in any impacts to the species and is not expected to contribute to any cumulative impacts to the species.

Avoidance, mitigation and management measures

There is no potential habitat for the Southern Snapping Turtle within the study area, and thus direct impacts to the species will be avoided. Given that there is no habitat for the species that is likely to be indirectly impacted, no species-specific management measures are proposed. However, general management measures will be implemented to both minimise disturbance to aquatic habitats and minimise changes to water quality, namely:

- designing watercourse crossings to consider fish passage;
- building flood levees, which are designed to withstand increase in flood velocities;
- limiting the extent of direct impact on the identified disturbance area;
- locating areas of disturbance outside of watercourses and wetlands where possible; and
- developing environmental management plans, including:
    - Water Management Plan;
    - Chemical and Fuel Management Plan; and
    - Waste Management Plan

Significant impact assessment

The significance of the impacts from the Project on the Southern Snapping Turtle, after the avoidance, mitigation and management measures have been implemented, has been assessed against the significant impact criteria for critically endangered species (DoE 2013a) in Table 11.5.

11.6.1.3 Wetlands and watercourses

The Project will not result in any direct disturbance to the HES wetlands or HES wetland protection areas; however, they could be impacted indirectly by changes to hydrogeological or hydrological flows.

There are two HES wetlands and associated wetland protection areas mapped within the study area, referred to as HES wetland 8 and HES wetland 9 in the GDE assessment (3d Environmental 2022) and groundwater impact assessment (JBT 2022). These HES wetlands are east of the Project footprint near the confluence of Ripstone and Boomerang Creeks (Figure 11.3). HES wetland 9 has been assessed to be a surface feature perched on a clay aquitard that will not be influenced by groundwater drawdown-related impacts. A conceptual model has been developed for HES wetland 8, which indicates the presence of a perched lens of fresh groundwater lying at depth below the wetland pan.

Although the two HES wetlands are utilising freshwater held in a perched groundwater lens below the wetland, the majority of the alluvium within the study area is dry. The groundwater modelling has determined the HES wetland is outside the predicted groundwater drawdown in the alluvial sediments. However, groundwater drawdown into the Tertiary sediments has been used to infer where the water level impacts on the Quaternary alluvium could occur *via* an enhanced potential for downward drainage from the Quaternary alluvium to the underlying Tertiary sediments (i.e. water from the perched groundwater lens could be drawn to the underlying Tertiary sediments). The HES wetland is within the modelled groundwater drawdown of the Tertiary sediments. No permanent Tertiary sediments drawdown is predicted to occur and the post-mining equilibrium is predicted to be equivalent to baseline conditions in the vicinity of HES wetlands. Groundwater recovery to 80% of the final equilibrium level is predicted to occur after approximately 120 years for the southern longwall panels and 200 years for the northern longwall panels.

Table 11.5: Significant impact assessment for the Southern Snapping Turtle

Significant impact criteria (DoE 2013a)	Significant impact assessment for the Project
An action is likely to have a significant impact on a Critically Endangered species if there is a real chance or possibility that is will:	
lead to a long-term decrease in the size of a population	• A population of the Southern Snapping Turtle has not been identified within the waters of the study area nor downstream of the study area. • It is not expected that the Project will result in mortality of the species, nor impacts to breeding success or movement of the species. • The Project will not cause any impacts to water quality or hydrological flows in an area where the species is known to occur.
reduce the area of occupancy of the species	• The Southern Snapping Turtle has not been found to occupy the area within the study area not any area affected by an altered hydrological regime, as such the Project will impact habitat such that the area of occupancy of the species is reduced.

Significant impact criteria (DoE 2013a)	Significant impact assessment for the Project
fragment an existing population into two or more populations	• No populations of Southern Snapping Turtle within the study area, and no populations of the species have been detected upstream of the Project. • The Project is not expected to have any direct or indirect impact on habitat used by the Southern Snapping Turtle. • The Project would not result in modifications to the aquatic environment such that the passage of the Southern Snapping Turtle would be restricted through the Project area (if the aquatic environment was used for such purpose).
adversely affect habitat critical to the survival of the species	• The waters within the study area have not been determined to provide habitat critical to the survival of the species. It is not expected that the waters provide suitable habitat.
disrupt the breeding cycle of an important population	• The waters within the study area do not provide suitable breeding habitat for the species.
modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	• The Project will not adversely impact habitat for the Southern Snapping Turtle and thus will not cause the species to decline.
result in invasive species that are harmful to a Vulnerable species becoming established in the Vulnerable species' habitat	• The Project will not result in the establishment of an invasive species within the southern snapping turtle's habitat.
introduce disease that may cause the species to decline	• There are no diseases known to impact the species. • Disease is not identified as a threat to the species. • The construction and operation of the Project is not expected to introduce diseases that may cause the species to decline.
interfere substantially with the recovery of the species	• A recovery plan has been adopted for the species. • The Project will not interfere with the recovery of the Southern Snapping Turtle, as it will not directly or indirectly impact this species or its habitat.

The HES wetlands would be reliant on surface water flows to recharge and support the associated aquatic environment. Thus, changes to the surface water flows due to the Project could impact the HES wetlands. The surface water assessment (Appendix F, Section 4.5) has assessed the changes in flood regimes and channel flows, which can be used to determine changes to water availability at the HES wetlands. The results show that for the post Project closure conditions, the increased flood storage introduced by the subsidence would attenuate the flood hydrograph for the 50% AEP event, reducing and delaying the flood peak compared to existing conditions. This reduction in flow would reduce the 50% AEP flood depths in Boomerang Creek by approximately 0.3 m to 0.5 m. In larger floods, the effect of storage on flood flows and downstream flood levels will be minimal.

There are no other HES wetlands or wetland protection areas within the study area. There is a wetland protection area and HES wetlands to the north of Ripstone Creek, which is within the footprint of the Olive Downs Project. However, the Olive Downs Coking Coal Project will remove this wetland to develop the Olive Downs South Domain (DPM Envirosciences 2018). Lake Vermont, to the south-east of the Project and within the existing Lake Vermont mining lease, is also mapped as an HES wetland with associated wetland protection area.

Table 11.6 provides an assessment of the likelihood of significant impacts on prescribed wetlands in accordance with the 'Significant Residual Impact Guideline'.

Table 11.6: Prescribed wetlands significant impact assessment

Significance criteria	**Assessment of significance**
An action is likely to have a significant residual impact on prescribed wetlands or watercourses if it is likely that the action will result in environmental values being affected in any of the following ways:	
Areas of the wetland or watercourse being destroyed or artificially modified	• The HES wetlands that occur to the east of the study area will not be directly impacted by the Project. No areas of the wetlands will be destroyed or artificially modified.
A measurable change in water quality of the wetland or watercourse—for example, a change in the level of the physical and/or chemical characteristics of the water (including salinity, pollutants or nutrients in the wetland or watercourse) to a level that exceeds the water quality guidelines for the waters	• There will not be any releases of mine-affected water from the Project. The subsidence may cause some changes to sediment transport across-sections of Boomerang and One Mile Creeks upstream of the HES wetland. The majority of any eroded sediments are likely to be trapped in the subsided sections of the watercourses due to reduced flow velocity. If eroded stream bed sediments from the subsided section of the watercourses do reach the HES wetland, there is no indication from the sediment quality analysis that these sediments would negatively affect the water or sediment quality at the HES wetland.
The habitat or lifecycle of native species, including invertebrate fauna and fish species, dependent on the wetland being seriously affected	• The wetland will not be directly impacted by the Project, and as such, no habitat for aquatic species will be seriously affected. The wetland is ephemeral and provides only moderate aquatic ecological value and minimal aquatic habitat to fauna, except during wet periods. The hydrological regime (see below) is not expected to significantly change; thus, the habitat and lifecycle of aquatic fauna species is not expected to be impacted.
A substantial and measurable change in the hydrological regime or recharge zones of the wetland (e.g. a substantial change to the volume, timing, duration and frequency of ground and surface water flows to and within the wetland)	• The flood hydrograph for the confluence of Boomerang and One Mile Creeks has indicated there would be a delay and attenuation of the flood peak at this location during a 50% AEP flow event. However, there would be no significant change in timing or volume of flow during a 1% AEP flow event (Appendix F, Surface Water Impact Assessment, Section 4.7). • The delay an attenuation of the flow event is attributed to the additional volume of flood storage due to the subsidence of the landform. However, the hydrograph assessment was performed well upstream of the HES wetland where the attenuation of the flood event would be expected to be reduced. The flood modelling for 50% AEP flow events indicates there will be a reduction in flood height at the HES wetland (between 0.25 m and 0.1 m), with no reduction in flood height during 1% AEP flow events. • The hydrological modelling indicates that, although there may be changes to the hydrological regime at the HES wetland, the wetland will still be inundated (1.0 m to 1.5 m) during regular flood events (50% AEP), and as such, the changes in hydrological regimes are not expected to be significant. • The HES wetland is determined to be a Type 2 GDE, which periodically utilises a perched freshwater alluvial aquifer. The alluvial groundwater drawdown due to mining activities will not impact this perched aquifer. • The HES wetland 9 has been assessed to be a surface feature perched on a clay aquitard that will not be influenced by groundwater drawdown-related impacts. • A conceptual model has been developed for the HES wetland 8, which indicates the presence of a perched lens of fresh groundwater lying at depth below the wetland pan. • Drawdown of the underlying Tertiary sediments, which could increase infiltration from the alluvium, would only just reach

Significance criteria	Assessment of significance
	the edge of the HES wetland, which is likely to cause minimal to no loss of groundwater in the perched system. • Although the large Eucalypts at the wetland may utilise this groundwater (all other species are obligatory reliant on surface water), their adaptation to wet/dry periods (including frequent periods of extended dry periods) indicates their use of the groundwater at the HES wetland is minimal.
An invasive species that is harmful to the environmental values of the wetland being established (or an existing invasive species being spread) in the wetland.	• The study area is within a modified rural landscape used for cattle grazing, where introduced species such as Buffel Grass and Feral Pigs are present. The Project is unlikely to increase the spread of established invasive species or result in an invasive species becoming established. • A Weed and Pest Management Plan will be implemented for the Project to manage weeds and pests.
Conclusion	• The Project will not result in a significant impact on prescribed wetlands.

11.6.1.4 Waterways providing fish passage

An environmental offset may be required for a part of a waterway that provides for fish passage if the Project includes the construction, installation and/or modification of a waterway barrier that will limit fish passage along that waterway. Waterway barriers to fish passage can:

- fragment populations of fish;
- decrease habitat availability for fish populations by preventing movement to habitat areas;
- cause direct mortality of fish through entrapment in areas of unsuitable water volume, flow and/or quality;
- decrease habitat quality areas necessary for fish survival and/or breeding; and
- increase predation due to entrapment of fish at watercourse barriers.

Within the study area, the Isaac River, Philips Creek, Boomerang Creek and Hughes Creek are classified as being major risks to fish movement. One Mile Creek is classified as being a high risk to fish movement, and a minor waterway on ML 70477 is classified as being a low risk to fish movement.

Barriers to fish movement that could be created by the Project include waterway crossings at Phillips Creek, One Mile Creek and the minor waterway (green) on ML 70477 by the infrastructure corridor. Additionally, the subsidence of the watercourses providing fish passage could change sufficiently to affect the ability of fish to navigate passage upstream by acting as a dam or barrier.

The watercourse crossings at Phillips Creek, One Mile Creek and the minor waterway would be constructed in consideration of the 'Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works' (DAF 2018) by using box culverts to permit navigation of fish during low flow events and maintaining fish passage across the Project area.

Given ephemeral streamflow conditions, expected in-filling of subsidence troughs, use of bank protection measures (if required) and the predicted minor changes to flows, changes to stream bed morphology are considered unlikely to create a barrier to fish or turtles that may migrate along the watercourses. Project impacts are also not expected to result in entrapment of aquatic fauna within stream pools beyond existing conditions.

The subsidence profile of Boomerang Creek and One Mile Creek is conceptualised as following the existing stream courses, with deeper subsidence troughs located above subsided longwall panels. Hydrological modelling predicts minor changes to stream flows in these watercourses and therefore Project impacts are not expected to result in conditions which could cause entrapment of aquatic fauna within stream pools (refer section 11.5.2.2).

The subsidence profile of Boomerang Creek and One Mile Creek will result in a series of deeper sections of the channel. These sections will experience reduced flow velocity and will hold water for extended periods, while the adjacent reaches of the watercourse may be dry. This is not expected to change the ability of fish or other aquatic species to navigate the watercourse and may provide refugial aquatic habitat for species to utilise during extended dry periods.

During the development of the Project, areas subject to subsidence will be monitored to identify where the potential impacts occur. An adaptive management approach will be pursued with proactive measures to predict, mitigate, report and improve areas affected by subsidence. A Subsidence Management Plan (SMP) will be prepared for the Project. The SMP will include monitoring, management and mitigation measures for potential subsidence impacts of the Project and, relevant to fish passage, will include mitigation measures to reprofile subsided channels.

A significant residual impact assessment on the waterways providing fish passage in accordance with the 'Queensland Environmental Offset Policy Significant Residual Impact Guideline' (DEHP 2014) is detailed in Table 11.7.

It is concluded that the Project is unlikely to have a significant impact on waterways providing fish passage.

Table 11.7: Significant residual impact assessment for waterways providing fish passage

Criteria	Assessment
An action is likely to have a significant impact on a waterway providing for fish passage if there is a real possibility that it will:	
Result in the mortality or injury of fish	The Project is unlikely to create barriers that result in the mortality of fish, as: • Waterway crossings would be constructed in consideration of the 'Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works'. • Subsidence is unlikely to sufficiently impact the watercourses such that barriers to fish passage are created.
Result in conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage, such as through the depletion of fish energy reserves, stranding, increased predation risks, entrapment or confined schooling behaviour in fish	The Project is unlikely to create conditions that substantially increase risks to the health, wellbeing and productivity of fish seeking passage because: • Waterways are ephemeral and provide limited fish passage for most of the year. Remnant ponds are small and create environments for entrapment and predation. • Waterway crossings for the infrastructure corridor would be constructed so as not to impede fish movement and, thus, not impact health or wellbeing of. • Although subsidence will cause subsidence of the stream bed, the remnant pools resulting from this will be larger than those currently experienced and are not expected to create additional barriers to fish passage. As aggradation occurs, the stream bed profile is expected to equalise.
Reduce the extent, frequency or duration of fish passage previously found at a site	The Project is unlikely to create conditions that reduce the extent, frequency or duration of fish passage, as: • Waterways are ephemeral and provide limited fish passage for most of the year. • Waterway crossings for the infrastructure corridor would be constructed so as not to impede fish movement and, thus ,not impact health or wellbeing of fish.
Substantially modify, destroy or fragment areas of fish habitat (including, but not limited to, in-stream vegetation, snags and woody debris, substrate, bank or	The Project is unlikely to create conditions that substantially modify, destroy or fragment areas of fish habitat, as: • Aquatic habitat within the study area predominately consists of discrete, isolated pools separated by significant lengths of dry stream bed for most of the year. All the species within the study area are common in the region and adapted to ephemeral systems and poor habitat quality.

Criteria	Assessment
riffle formations) necessary for the breeding and/or survival of fish	• Only small areas of aquatic habitat will be disturbed as a result of the infrastructure corridor waterway crossings. • Subsidence of watercourses is not expected to significantly alter in-stream habitat characteristics; however, subsidence is predicted to create additional areas of intermittent ponding connected to watercourses. • Erosion is likely to occur as watercourses enter subsided panel areas. This may reduce in-stream habitat for fish locally; however, the minimal in-stream fish habitat that exists indicates this is unlikely to be a significant impact on fish migration or habitat availability.
Result in a substantial and measurable change in the hydrological regime of the waterway; for example, a substantial change to the volume, depth, timing, duration and frequency of flows	The Project is unlikely to create conditions that result in a substantial and measurable change in the hydrological regime of the waterway, as: • All aquatic species recorded in the study area are tolerant of ephemeral flows. • The volume, timing, duration, frequency and depth of flows are not predicted to change such that it would significantly impact fish habitat. The conditions would still reflect the current ephemeral conditions. • Subsidence-induced ponding would intermittently and temporarily increase ponded water within the study area and, thus, water availability. • There are no planned water releases as part of the Project.
Lead to significant changes in water quality parameters, such as temperature, dissolved oxygen, pH and conductivity, that provide cues for movement in local fish species	The Project is unlikely to create conditions that lead to significant changes in water quality parameters, as: • All aquatic species recorded in the study area are tolerant of variable water quality. • There are no planned water releases as part of the Project. • Water quality is not expected to suddenly or significantly change and act as cues for fish species.