# SUBSIDENCE MANAGEMENT PLAN

## LAKE VERMONT MEADOWBROOK PROJECT

PREPARED FOR
BOWEN BASIN COAL PTY LTD

OCTOBER 2023

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# Table of Contents

## List of Figures

## List of Tables

# 1 Introduction

## 1.1 Project Description

Bowen Basin Coal Pty Ltd (Bowen Basin Coal) proposes to develop the Lake Vermont Meadowbrook Project (the Project) as an extension of the existing Lake Vermont Mine. The Project proposes underground longwall mining and an open-cut satellite pit, to mine coal seams to the immediate north of the existing Lake Vermont Mine.

The Project is located approximately 25 km north-east of Dysart and 160 km south-west of Mackay, in the Bowen Basin region of central Queensland. The Meadowbrook Project is located within the proposed Mining Lease Application (MLA) area (refer Figure 1.1).

The Lake Vermont Meadowbrook underground mine plan incorporates underground single and dual-seam longwall mining of the Leichhardt Lower and underlying Vermont Lower seams and development of supporting infrastructure. The primary underground target seam is the Vermont Lower Seam that extends across the whole underground mining footprint. The overlying Leichhardt Lower Seam is a secondary target seam and is only present across the northern half of the underground footprint. Over the life of the Project, approximately 108.6 Mt of ROM coal is estimated to be mined by underground mining methods.

The Vermont Lower Seam occurs at depths ranging from approximately 150 m in the south-west of the underground mining footprint to approximately 500 m in the north-east. The Leichhardt Lower Seam occurs at depths ranging from approximately 250 m in the west of the underground mining footprint to approximately 500 m in the far north-east of the mining area.

Longwall extraction has been planned for the Vermont Lower Seam and the overlying Leichhardt Lower Seam. Longwalls in the Vermont Lower Seam have been designed with a solid coal face length of approximately 300 m. In the shallower area south of the main headings, the width of the gate road chain pillars will vary from between 35 m to 40 m (solid). In the deeper area north of the main headings, the solid dimension of the chain pillars will vary between 45 m to 50 m. The extraction height of the longwall will range between approximately 3 m to 4.8 m for the Vermont Lower Seam and increase from west to east.

Longwalls in the Leichhardt Lower Seam will also have face lengths of up to approximately 300 m (solid). Three panels have been narrowed to 270 m wide (solid) to maximise recovery between faults. The gate road chain pillars in the Leichhardt Lower Seam are 45 m wide (solid). The extraction height of the Leichhardt Lower Seam will be approximately 3.0 m to 4.8 m.

The following infrastructure is to be developed in the vicinity of and for purposes of supporting the underground workings:

- underground portal, drifts and shafts for underground operations;
- boreholes to support the delivery of materials to the underground operations; and
- gas drainage bores and associated surface infrastructure.

## 1.2 Subsidence assessment

A Subsidence Assessment was undertaken for the Project to provide comprehensive surface subsidence predictions (Gordon Geotechniques 2022). Subsidence refers to the movement of overburden and land surface as a result of the underground extraction of coal via longwall mining. The subsidence predictions provide an understanding of the location, extent and scale of subsidence, and its effect over time on surface landforms and hydrology.

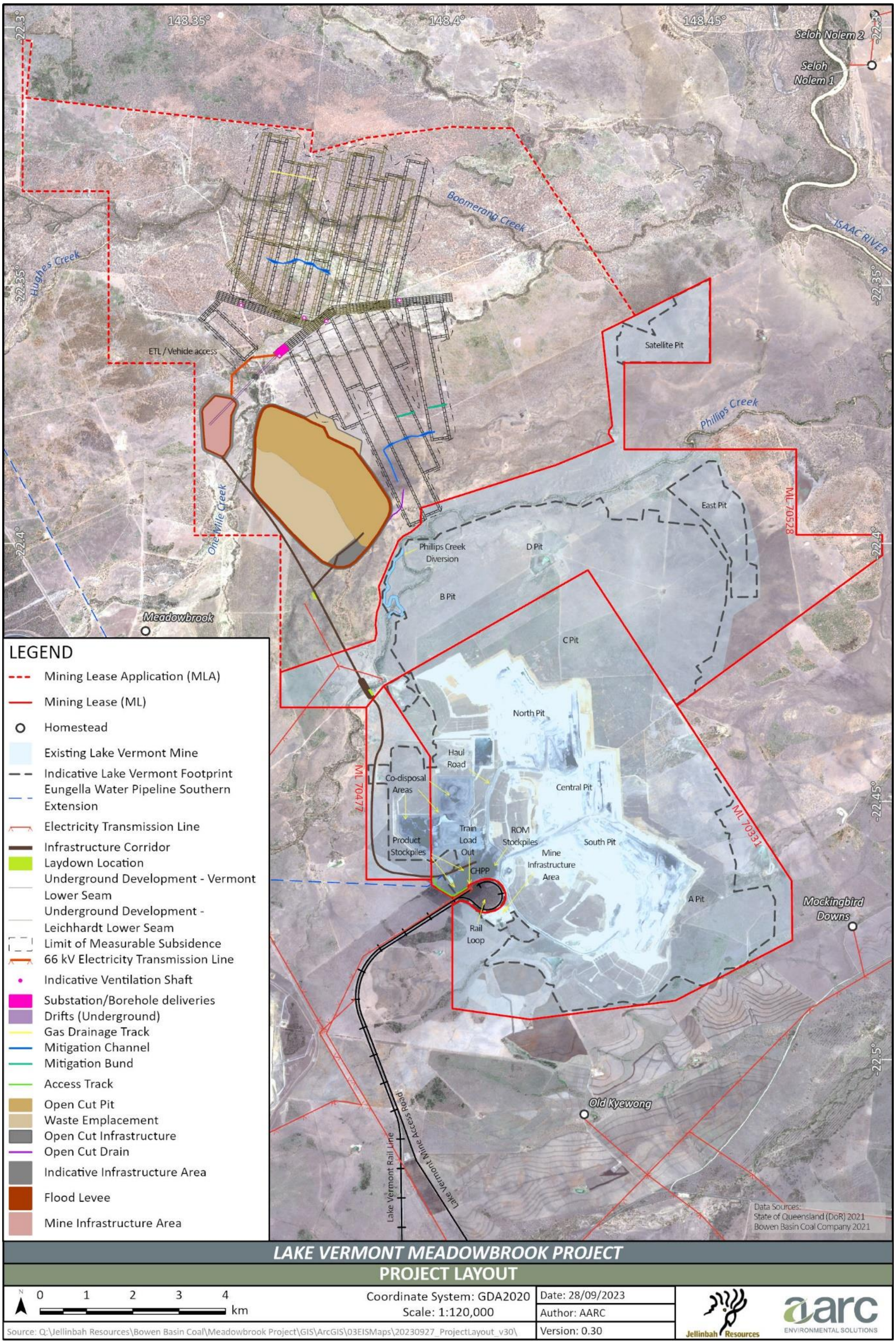


*Figure 1.1: Project layout*

Subsidence predictions resulting from the Project's underground mining operations have been determined using the influence function method (Gordon Geotechniques 2022). Modelling was conducted over two areas:

1) an area spanning the northern dual seam mining operation (where the Leichhardt Lower seam and Vermont Lower seam are both mined); and

2) the southern single seam mining area (where the Vermont Lower seam is mined).

The model required input of existing calibration data from mine geometry and local geology and considered the following:

- panel layouts;
- seam thickness;
- depth of cover;
- influence angle;
- subsidence factor; and
- strain coefficient.

The following parameters have been used for modelling the Project:

- panel adjustment factor of 0.2;
- influence angle of 70°;
- maximum subsidence factor of 65% for extraction in virgin ground and 95% for Vermont Lower seam extraction below Leichhardt Lower Seam goaf areas; and
- strain coefficient of 0.35.

## 1.3 Scope

To support the EIS for the Meadowbrook Project and satisfy the proposed Environmental Authority (EA) conditions, Bowen Basin Coal is required to develop a Subsidence Management Plan (SMP). The purpose of the SMP is to describe in detail the proposed mitigation measures for any significant impacts deemed likely to occur as a result of subsidence, including impacts on infrastructure, land, hydrology, flora and fauna.

The subsidence risk relating to the Project arises from the proposed extraction of a coal seam via conventional longwall coal mining methods resulting in the downward movement of the overlying strata and surface. This SMP is thereby relevant to all areas of land surface which share an interface with the underground mine plan as shown in Figure 1.1.

The proposed longwall mining layout involves an approximate north–south orientation which through preliminary subsidence and hydrological assessments, was found to best minimise subsidence effects and impacts on key environmental values (particularly watercourses). This general panel orientation also provides good alignment with respect to the structural geology and geotechnical characteristics. Subsidence impacts on Phillips Creek are also minimised where the longwall panels that extend to the south are offset from this watercourse.

The underground mining footprint will interface with two watercourses, known as Boomerang Creek and One Mile Creek as well as the floodplain of Phillips Creek. The Phillips Creek watercourse occurs south of the southern longwall panels and is not expected to be directly affected by subsidence. Several wetlands also occur within the northern portion of the subsidence impact area between One Mile Creek and Boomerang Creek.

Whilst the southern half of the subsidence footprint underlies large areas cleared grazing land, the northern portion underlies both grazing land and remnant ecosystems. Ecological values identified at the surface interface of the longwall mining footprint include areas of conservation significant habitat for the Brigalow

(*Acacia harpophylla* dominant and co-dominant) Threatened Ecological Community (TEC), Poplar Box (*Eucalyptus populnea)* TEC, the Ornamental Snake (*Denisonia maculata*), Squatter Pigeon (*Geophaps scripta scripta*), Australian Painted Snipe (*Rostratula australis)*, Koala (*Phascolarctos cinereus)*, Greater Glider (*Petauroides volans*), Australian Painted Snipe (*Rostratula australis*), Short-beaked Echidna (*Tachyglossus aculeatus*) and migratory species.

No significant infrastructure occurs within or is proposed to be constructed within the interface of the underground mining footprint. Existing pastoral infrastructure occurring within the potential subsidence area is limited to a blaze tree, cattle yard and loading ramp and molasses lick. Stock exclusion fencing will be constructed along pillar and header interfaces or at the limit of the subsidence footprint (if / as required) to avoid potential subsidence-induced damages.

## 1.4 Statutory Requirements

This Subsidence Management Plan (SMP) has been prepared to satisfy a set of EA conditions proposed as part of the EIS for the Meadowbrook Project.

Proposed EA conditions relevant to the development of the SMP are as follows:

**G20 - Subsidence Management Plan**

A Subsidence Management Plan must be developed by an appropriately qualified person and be implemented prior to the commencement of underground longwall mining. The Subsidence Management Plan must:

a) provide an overview of the existing environment of the proposed subsidence area;

b) provide a summary of the key impacts that may arise as a result of the proposed subsidence;

c) provide for the proper and effective monitoring and management of the actual and potential environmental impacts of the proposed subsidence; including but not limited to impacts to:

I. landform conditions;

II. surface cracking;

III. erosion;

IV. ponding;

V. watercourse channel/geomorphic conditions;

VI. ecology;

VII. an assessment of the adequacy of any completed repair works or recommended actions from the previous monitoring period.

d) provide for the development of management actions (eg. repairs or rehabilitation works) and establish a process to monitor the completion of actions.

**G21** – **Annual subsidence monitoring inspection**

An annual subsidence monitoring inspection must be undertaken (**annually, within 12 months of underground longwall mining commencing**) to identify any areas of observable or measurable impact that might be associated with subsidence or associated surface disturbance.

**G22** - Annual subsidence monitoring inspections must continue until subsidence movement in the northern subsidence area is considered to have finalised.

**G23** – **Annual Subsidence Monitoring Report**

An annual subsidence monitoring report must be prepared (**annually, within 3 months of the completion of the annual subsidence monitoring inspection**) to provide the results and analysis from each monitoring event(s) as well as detail any required repair/rehabilitation activities.

**G24** – **Subsidence Management Plan review**

A review of the Subsidence Management Plan must be conducted every 4 years, and a report made available upon request to the administering authority.

The following relevant guidelines have been consulted during the development of the SMP:

- Guideline: Application requirements for activities with impacts to land (DES 2021);
- Guideline: Application requirements for activities with impacts to water (DES 2021);
- Queensland Environmental Offsets Policy (Version 1.14) (DES 2023);
- Guideline – Progressive rehabilitation and closure plans (PRC plans) (DES 2023); and
- Monitoring and management of subsidence induced by longwall coal mining activity (Commonwealth of Australia 2015).

# 2 Existing Environment

## 2.1 Topography

The topography of the Project area is generally flat to gently undulating, with elevations ranging between 160 mAHD and 190 mAHD above sea level as shown in Figure 2.1. The topography of the Project area is representative of the surrounding region.

Ground elevations to the west of the Project are marginally higher in elevation (approximately 10 mAHD), with the Project generally draining west to east towards the Isaac River. The topography of the land between Phillips Creek and Boomerang Creek comprises a broad, flat floodplain that slopes gently to the east from approximately 180 mAHD in the west of the Project site to approximately 170 mAHD in the east.

## 2.2 Waterways and hydrology

The Project site is within the Isaac-Connors sub-catchment, an area encompassing 22,325 km2 within the greater Fitzroy Basin catchment. The Isaac River is the main watercourse in the Project region and flows in a north-west to south-east direction to the east of the Project site, eventually draining to the Coral Sea via the Mackenzie River and Fitzroy River. The Isaac River is a seasonally flowing watercourse, typically with surface flows in the wetter months from November to March, reducing to little or no flow from about April to October.

Waterways within the Meadowbrook Project area drain into the Isaac River via tributaries of Phillips Creek (to the south) and Boomerang Creek (the north) (Figure 2.1). The proposed underground mining operations underly sections of Boomerang Creek and One Mile Creek and parts of the floodplain of Phillips Creek.

All waterways and drainage lines in the vicinity of the Project area are ephemeral and experience flow only after sustained or intense rainfall in the catchment. Stream flows are highly variable, with channels drying out during winter to early spring when rainfall and runoff is historically low. Consequently, stream physical attributes, water quality and the composition of aquatic flora and fauna communities tend to be highly variable.

There are no HES wetlands within the Project area; however, there are 10 HES wetlands within the potential impact area of the Project, both to the north and east of the Project site. The subsidence management area also currently supports several wetlands classified as wetlands of General Environmental Significance (GES) and vegetation management wetlands (Figure 2.1).

### 2.2.1 Surface water quality

Surface water and stream sediment quality assessments, including physico-chemical sampling, have been conducted to characterise the baseline conditions of the Project and its receiving environment. To perform these assessments, water samples have been tested regularly since January 2021 at the locations shown in Figure 2.2. Where possible, water quality monitoring data has been obtained from nearby mining operations for the purposes of establishing background water quality and developing site-specific guidelines when sufficient suitable data is available. These monitoring locations are also shown in Figure 2.2.

Characterisation of the baseline water quality revealed that water quality in the Project area is considered typical of the slightly to moderately disturbed aquatic ecosystems in the Project region. Several factors, such as direct access of cattle to the watercourses and mining activities upstream of the Project (Saraji Mine and Saraji East Project) are likely to influence water quality results and may be responsible for a number of baseline water quality samples not meeting the default guideline values.

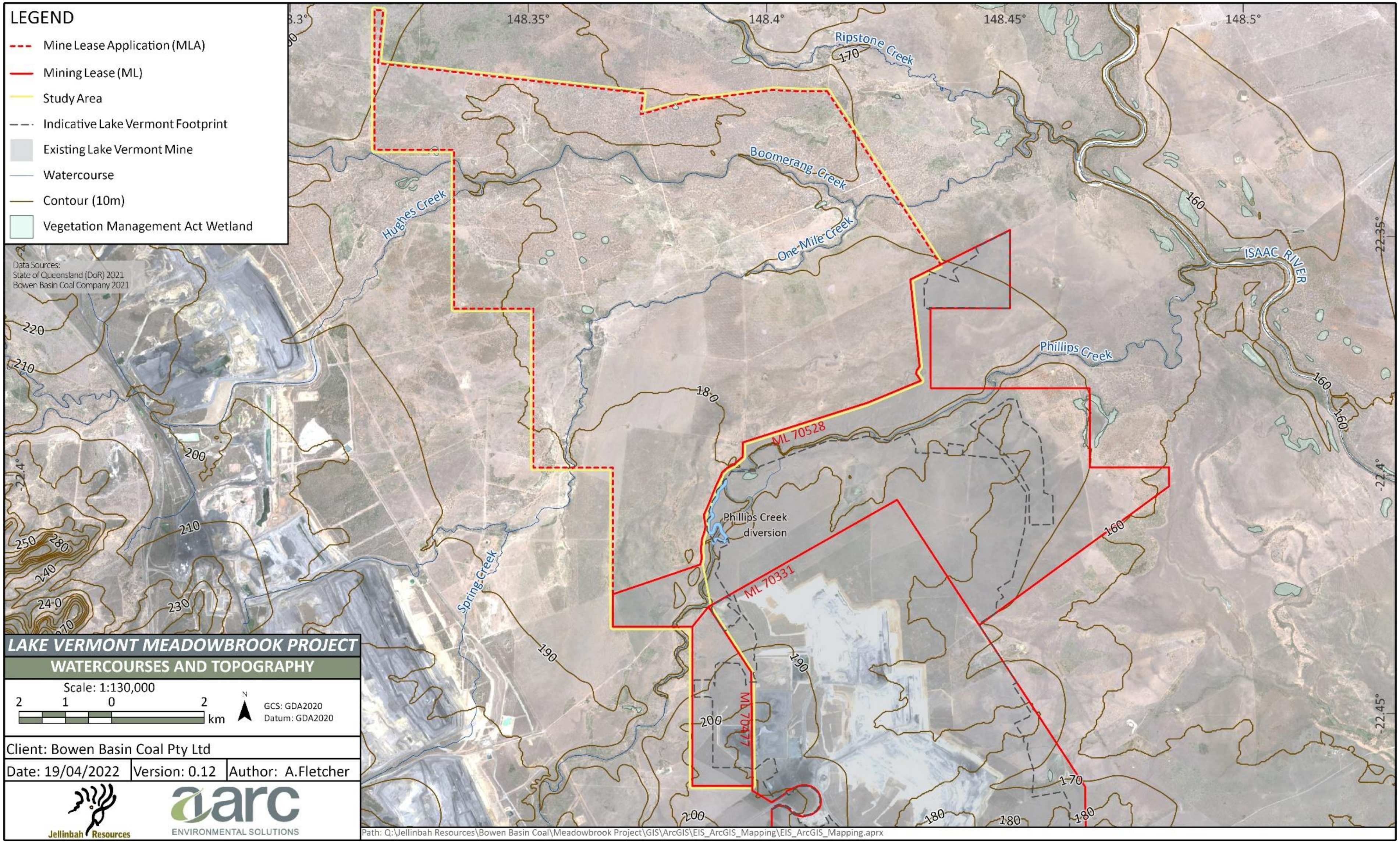


*Figure 2.1: Local topography and watercourses*

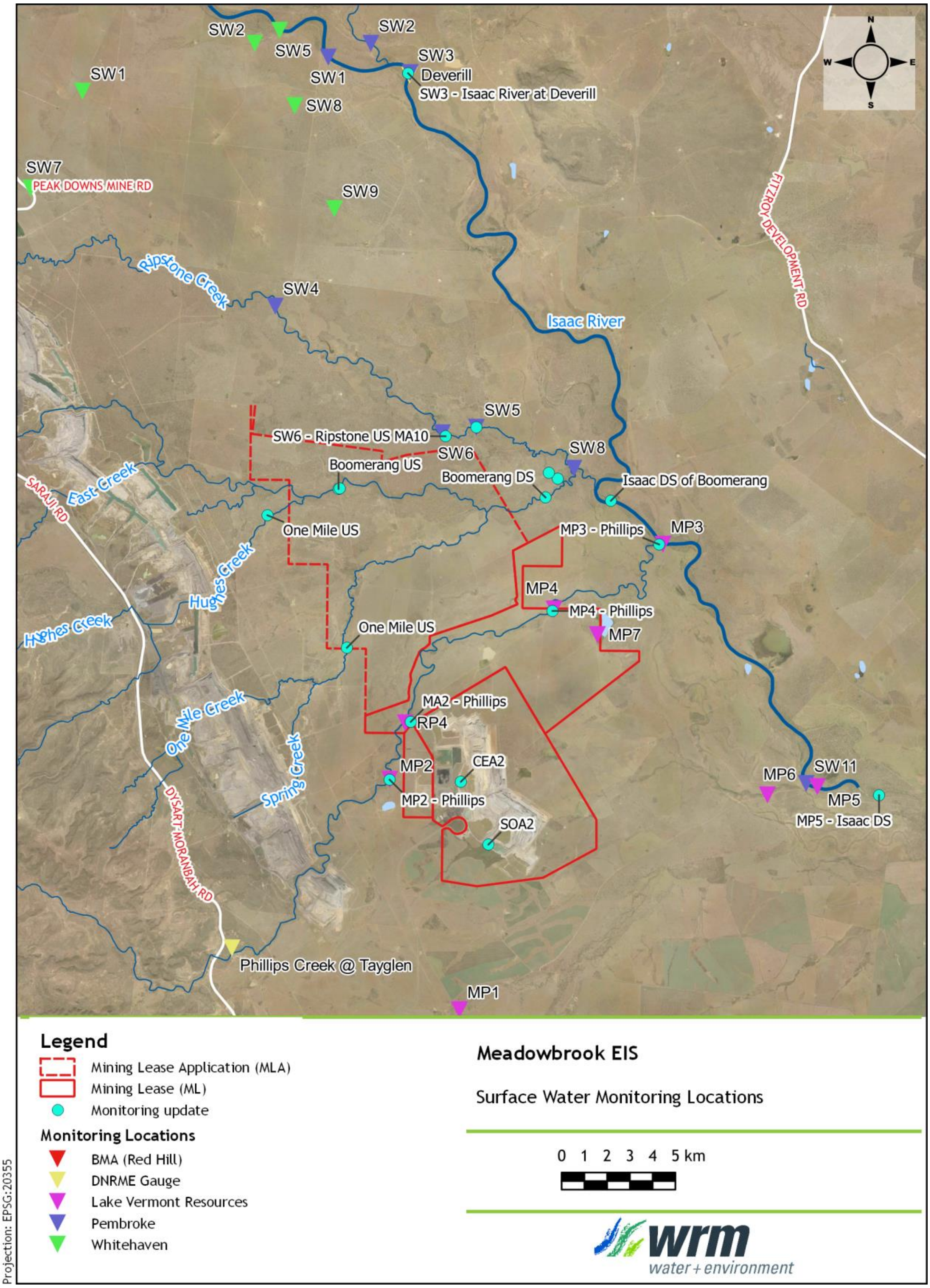


*Figure 2.2: Map of monitoring locations used in collection of baseline data*

## 2.3 Geology

The Project area comprises the Permian and Triassic-age sediments of the Bowen Basin overlain by a veneer of unconsolidated to poorly consolidated Tertiary and Quaternary sediments. The area surrounding the Project is dominated by clastic sedimentary rocks of marine and lacustrine origin, including sandstones, mudstones, siltstones and coal (Geoscience Australia 2019).

The stratigraphic sequence within the Project area comprises the following:

- Cainozoic sediments—Quaternary and Tertiary alluvial sands, clayey sands and clays, with sand and gravel basal layers in some locations;
- Rewan Group—Early to Mid-Triassic sandstone, mudstone, and conglomerate;
- Blackwater Group—Late Permian Age (Fairhill Formation/Fort Cooper Coal Measures) sandstones, conglomerates, mudstones, carbonaceous shales, coal and cherty tuff; and
- Back Creek Group—Middle Permian conglomeratic sandy siltstone, mudstone and sandstone.

Surface geology includes the following:

- Qa–QLD (Qa)—Quaternary clay, silt, sand, gravel; floodplain alluvium; and
- TQa–QLD (TQa)—Late Tertiary to Quaternary poorly consolidated sand, silt, clay, minor gravel and high-level alluvial deposits.

Economic coal seams at the Project occur within the Rangal Coal Measures, a sub-group of the Late Permian-aged Blackwater Group. These coal seams are persistent, thick coal horizons with the following descending stratigraphic sequence:

- the Leichhardt seam and Leichhardt Lower seam; and
- the Vermont seam and Vermont Lower seam.

The Vermont Lower Seam extends across the Project underground mining area, while the Leichhardt Lower seam is limited to the northern half of the underground mining area.

## 2.4 Soils and land suitability

The Soil and Land Suitability Assessment undertaken across the Project site identified five SMUs within the subsidence footprint. These include the Knockane, Norwich, Mayfair sodic variant, Moreton and Parrot SMUs. The distribution of each SMU is shown in Figure 2.3 and landform characteristics for each SMU are summarised in Table 2.1.

Soil erodibility and the dispersion potential of soils have been assessed for SMUs using key soil characteristics. Soil erodibility, the susceptibility of soil to become detached and transported by erosive agents such as wind and water, is dependent on the mechanical, chemical and physical characteristics of the soil. It is also independent of other factors influencing soil erosion, such as topography and land use (DSITI and DNRM 2015).

For each of the SMUs identified within the subsidence footprint, the topsoil stratum has been identified as non-sodic and not dispersive. Subsoils of the Moreton and Parrot SMUs are also non-sodic and not dispersive. Subsoils of the Mayfair sodic variant (0.3-0.8 m) and Norwich (0.1-0.8 m) SMUs were found to be strongly sodic and dispersive, whilst the Knockane subsoils (0.1-0.8 m) were found to be dispersive to highly dispersive. The assessment of soil erodibility and dispersivity is shown in Table 2.2.

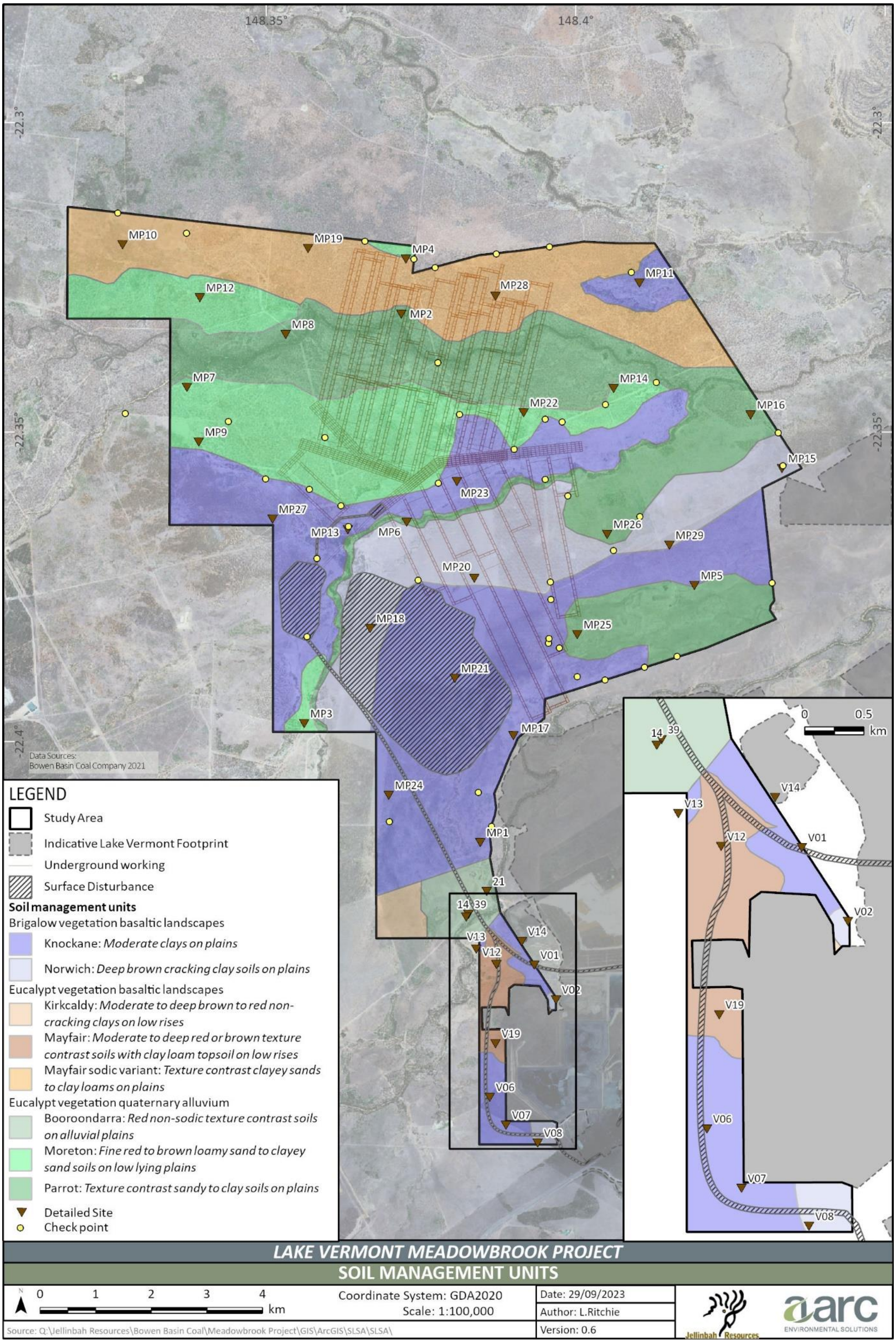


*Figure 2.3: Soil management units*

*Table 2.1: Soil management units and landform characteristics within subsidence area*

| SMU | Per cent of Project area | Landform and drainage (slope) | Surface condition | Australian soil classification | Geology | Dominant vegetation |
|---|---|---|---|---|---|---|
| Knockane | 33 | Plains with moderate drainage (0-2%) | Cracking | Epipedal Brown Vertosol | Alluvium (TQa): Stratified unit, including volcanic and metamorphic material | *Carissa spinarum, Acacia harpophylla, Apophyllum anomalum* |
| Mayfair Sodic Variant | 14 | Plains with good drainage (0-4%) | Hard setting | Brown Sodosol | Alluvium (TQa): Stratified unit, including volcanic and metamorphic material | *Acacia salicina, Cassia brewsteri, Eucalyptus populnea* |
| Moreton | 15 | Plains with good drainage (0-2%) | Soft | Brown Kandosol | Alluvium (TQa): Stratified unit, including volcanic and metamorphic material | *Corymbia tessellaris, Carissa spinarum* |
| Norwich | 12 | Plains with imperfect drainage (0-2%) | Cracking | Self-mulching Brown Vertosol | Alluvium (Tqa): Stratified unit, including volcanic and metamorphic material | *Acacia harpophylla* dominant in tree layer. Ground cover composed of various pasture grass species. |
| Parrot | 22 | Plains with moderate drainage (0-2%) | Firm and cracking | Brown Chromosol | Alluvium (Tqa): Stratified unit, including volcanic and metamorphic material | *Acacia salicina, Cassia brewsteri, Eucalyptus populnea* |

*Table 2.2: Soil sodicity and erodibility within subsidence area*

| SMU | Per cent of Project area | Depth | Erodibility and dispersion potential |
|---|---|---|---|
| Knockane | 33 | Topsoil 0–0.1 m | Non-sodic and not dispersive |
| | | Subsoil 0.1–0.3m | Dispersive |
| | | Subsoil 0.3–0.8 m | Highly dispersive |
| Mayfair Sodic Variant | 14 | Topsoil 0–0.3 m | Non-sodic and not dispersive |
| | | Subsoil 0.3–0.8 m | Strongly sodic and dispersive |
| Moreton | 15 | Topsoil | Non-sodic and not dispersive |
| | | Subsoil | Non-sodic and not dispersive |
| Norwich | 12 | Topsoil 0–0.1 m | Non-sodic and not dispersive |

| SMU | Per cent of Project area | Depth | Erodibility and dispersion potential |
|---|---|---|---|
| | | Subsoil 0.1–0.8 m | Strongly sodic and dispersive |
| Parrot | 22 | Topsoil 0–0.3 m | Non-sodic and not dispersive |
| | | Subsoil 0.3–0.8 m | Non-sodic and not dispersive |

## 2.5 Groundwater

The Project lies in the Isaac Connors Groundwater Management Area and includes the following groundwater units:

- Isaac Connors Groundwater Unit 1 (Quaternary alluvium); and
- Isaac Connors Groundwater Unit 2 (all sub-artesian aquifers other than Groundwater Unit 1).

The sequence of geological formations within the Project area and surrounds is described as follows:

- Cainozoic (Quaternary and Tertiary) sediments;
- Triassic Rewan Group;
- late Permian Blackwater Group sediments (and coal measures); and
- middle Permian.

The regional water table is generally developed in the Tertiary sediments below the base of alluvium. The alluvium is likely to be seasonally saturated following direct rainfall recharge and flow events in Boomerang Creek. The only location where the alluvium is permanently saturated is in the Isaac River.

Of the Project groundwater monitoring bores, there are two screened in Quaternary alluvium at 12 m depth, and seven screened in Tertiary sediments ranging between 20 m and 60 m in depth.

The extent of geological units underlying the Project area and locations of bores screening each unit are shown in Figure 2.4.

### 2.5.1 Groundwater levels and flows

Groundwater levels across the Meadowbrook and Lake Vermont North monitoring bore networks have been identified as consistent, with little variation that could be attributed to extraction activities, discharge to the Lake Vermont pit or recharge.

The groundwater flow direction within the Tertiary sediments and Permian coal seams is generally from west to east, following the general topography towards the Isaac River. Flows in the coal seams are truncated by faults, such as the Isaac Fault; however, groundwater flows are driven laterally at these features or over these features to continue the general flow direction.

Recharge is predominately through rainfall and downward seepage from ephemeral creeks. This occurs directly to the Tertiary and Quaternary groundwater units. The Permian coal measures are preferentially recharged where coal seams subcrop beneath Tertiary or Quaternary sediments. Recharge to the coal seams appears to be enhanced where creeks flow over the subcrop area.

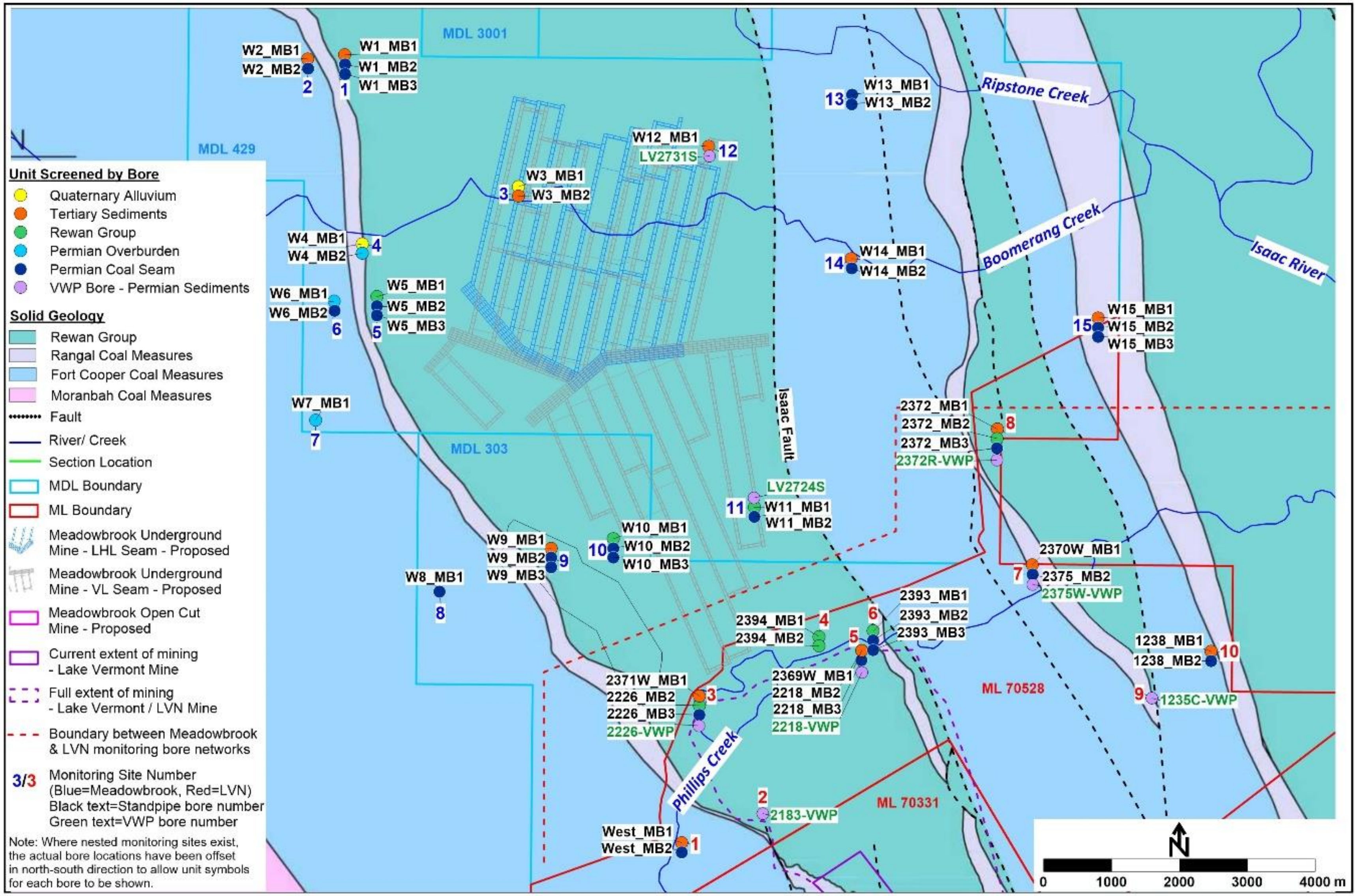


*Figure 2.4: Project Groundwater Monitoring Bores*

### 2.5.2 Groundwater quality

Groundwater quality is generally poor, in particular the Permian groundwater unit. The majority of monitoring bores recorded groundwater electrical conductivity greater than 10,000 µS/cm and often greater than 20,000 µS/cm. Lower electrical conductivity is recorded near features such as Phillips Creek and Boomerang Creek, indicating areas of potential groundwater recharge.

Mean major ion data shows bicarbonate anion water chemistry is present in some locations and is associated with low electrical conductivity water quality. The bicarbonate anion groundwater chemistry indicates high carbonate content of recharge waters. High sulphate anion groundwater has also been recorded in some Tertiary bores, likely caused by oxidation of sulphide minerals in shallow groundwater and indicative of groundwater recharge.

Groundwater in the Project area is generally neutral to very slightly acidic across all units. Metal concentrations are generally below the limit of reporting.

### 2.5.3 Groundwater dependent assets

Primary groundwater uses within the region include livestock watering and domestic use. However, no domestic use of groundwater has been identified to occur within the Project area (JBT Consulting 2023).

Other groundwater uses considered relevant to the Project include groundwater-dependent ecosystems, stygofauna and wetlands. GDE and stygofauna values are discussed in the sub-sections below whilst wetland values are discussed in section 2.6.4.

#### 2.5.3.1 GDEs

The Groundwater dependent ecosystems assessment (3D Environmental 2022) identified two types of GDEs present within the potential impact area of the Project:

1) Groundwater dependent vegetation developed on drainage features and associated alluvial landforms present along Boomerang Creek and Hughes Creek in the Project area (and Phillips Creek and the Isaac River outside the Project area) (GDE type 1); and

2) Groundwater dependent wetland vegetation developed on a perched groundwater lens to the east of the Project area (GDE type 2).

The identified GDEs are shown in Figure 2.5.

Type 1 GDEs present on alluvial landforms use groundwater that is seasonally recharged by surface flows and flooding. Type 2 GDE on a perched groundwater lens uses water that is recharged from percolating surface water captured at an alluvial unconformity. This GDE is mapped as a HES wetland under the Environmental Protection Regulation 2008 (Qld). Neither identified GDE type uses water held in regional Tertiary aquifers or coal seams.

#### 2.5.3.2 Stygofauna

Stygofauna have been recorded at two sites along Boomerang Creek and stygophiles/stygoxenes have been recorded at four sites along Boomerang Creek. Eight families of invertebrates have been recorded.

The findings of the stygofauna assessment are summarised as follows:

- A low diversity of groundwater-dependent subterranean fauna occurs 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.

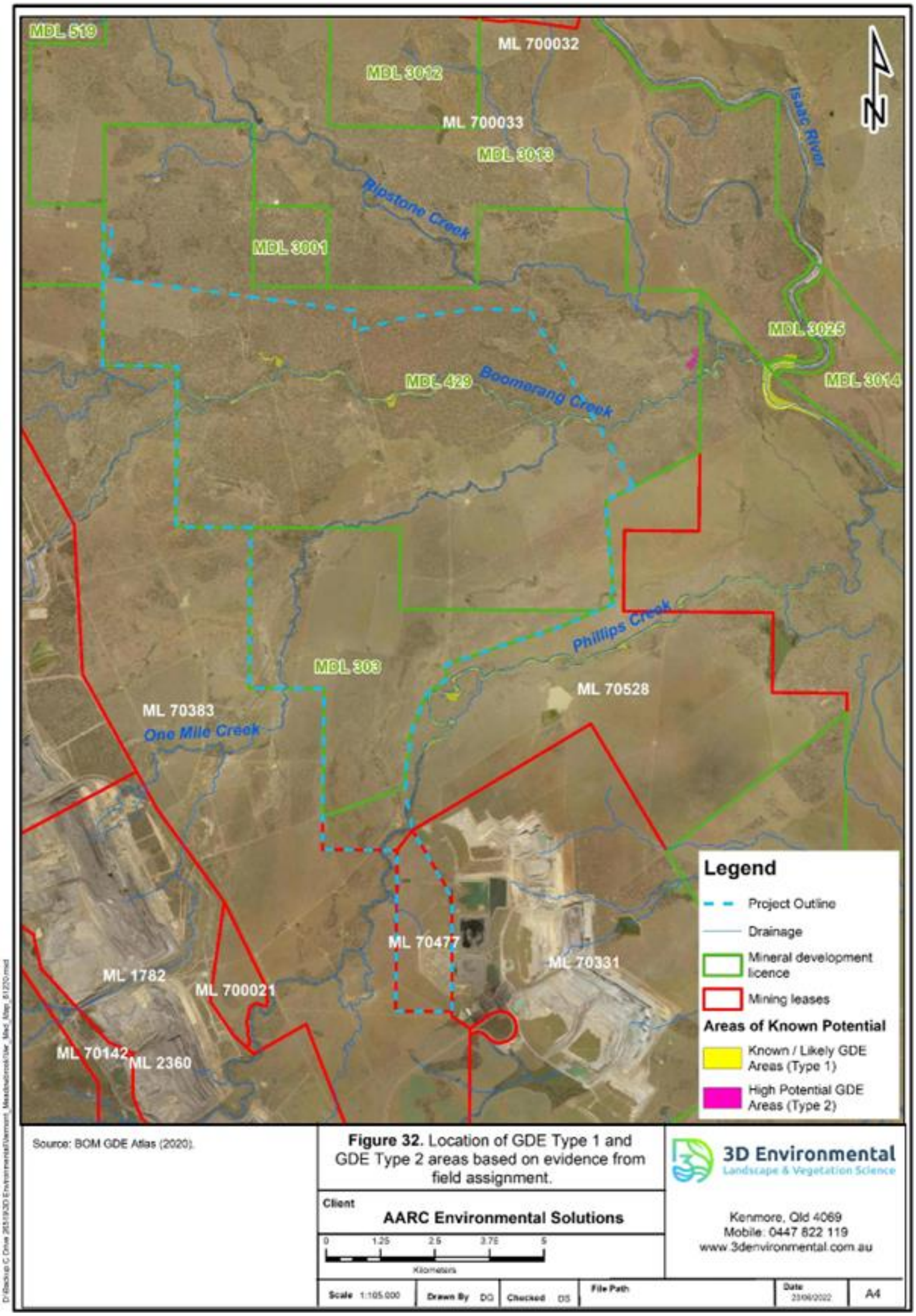


*Figure 2.5: Location of GDE Type 1 and GDE Type 2 areas*

- 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 Queensland *Nature Conservation Act 1992* (NC Act) or the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

## 2.6 Ecology

### 2.6.1 Flora

Eleven vegetation communities associated with remnant or high-value regrowth vegetation have been identified across the subsidence footprint. These communities comprise three 'Endangered' REs, two 'Of Concern' REs and five 'Least Concern' REs under the *Vegetation Management Act 1999* (VM Act) and a high-value regrowth Brigalow community.

Vegetation communities present within the subsidence area are described in Table 2.3 and their distributions are shown in Figure 2.6.

*Table 2.3: Vegetation communities within the subsidence footprint*

| Map unit | Vegetation community | Associated RE | VM Act Status | Extent within subsidence footprint (ha) |
|---|---|---|---|---|
| **1: Brigalow Woodlands** | | | | |
| VC 1a | Remnant Brigalow woodland on alluvial plains | 11.3.1 | Endangered | 33.2 |
| VC 1b | Remnant Dawson Gum woodland with Brigalow on undulating Cainozoic clay plains | 11.4.8 | Endangered | 7.2 |
| VC 1d | High value regrowth Brigalow | — | — | 6.7 |
| **2: Eucalypt Woodlands** | | | | |
| VC 2a | Remnant Poplar Box woodland on alluvial plains | 11.3.2 | Of Concern | 371.5 |
| VC 2c | Remnant Eucalypt and Bloodwood spp. Woodland on alluvial plains | 11.3.4 | Of Concern | 65.9 |
| VC 2d | Remnant Poplar Gum and Clarkson's Bloodwood woodland on floodplains | 11.3.9 | Least Concern | 10.2 |
| VC 2e | Remnant Poplar Box with occasional Clarkson's Bloodwood and Silver-leaved Ironbark woodland on sand plains | 11.5.3 | Least Concern | 514.4 |
| VC 2f | Remnant Poplar Gum woodland on Cainozoic sand plains | 11.5.8c | Least Concern | 32.2 |
| **3: Riparian Woodlands** | | | | |
| VC 3a | Remnant River Red Gum or Blue Gum woodland fringing drainage lines | 11.3.25 | Least Concern | 40.2 |

| Map unit | Vegetation community | Associated RE | VM Act Status | Extent within subsidence footprint (ha) |
|---|---|---|---|---|
| **4: Vegetation Associated with Wetlands** | | | | |
| VC 4a | Remnant River Red Gum, Poplar Gum and/or Blue Gum fringing lacustrine wetlands | 11.3.27b | Least Concern | <2.5 |
| VC 4c | Palustrine swamp with fringing Blue Gum woodland in depressions on Cainozoic sand plains and remnant surfaces | 11.5.17 | Endangered | 4.5 |

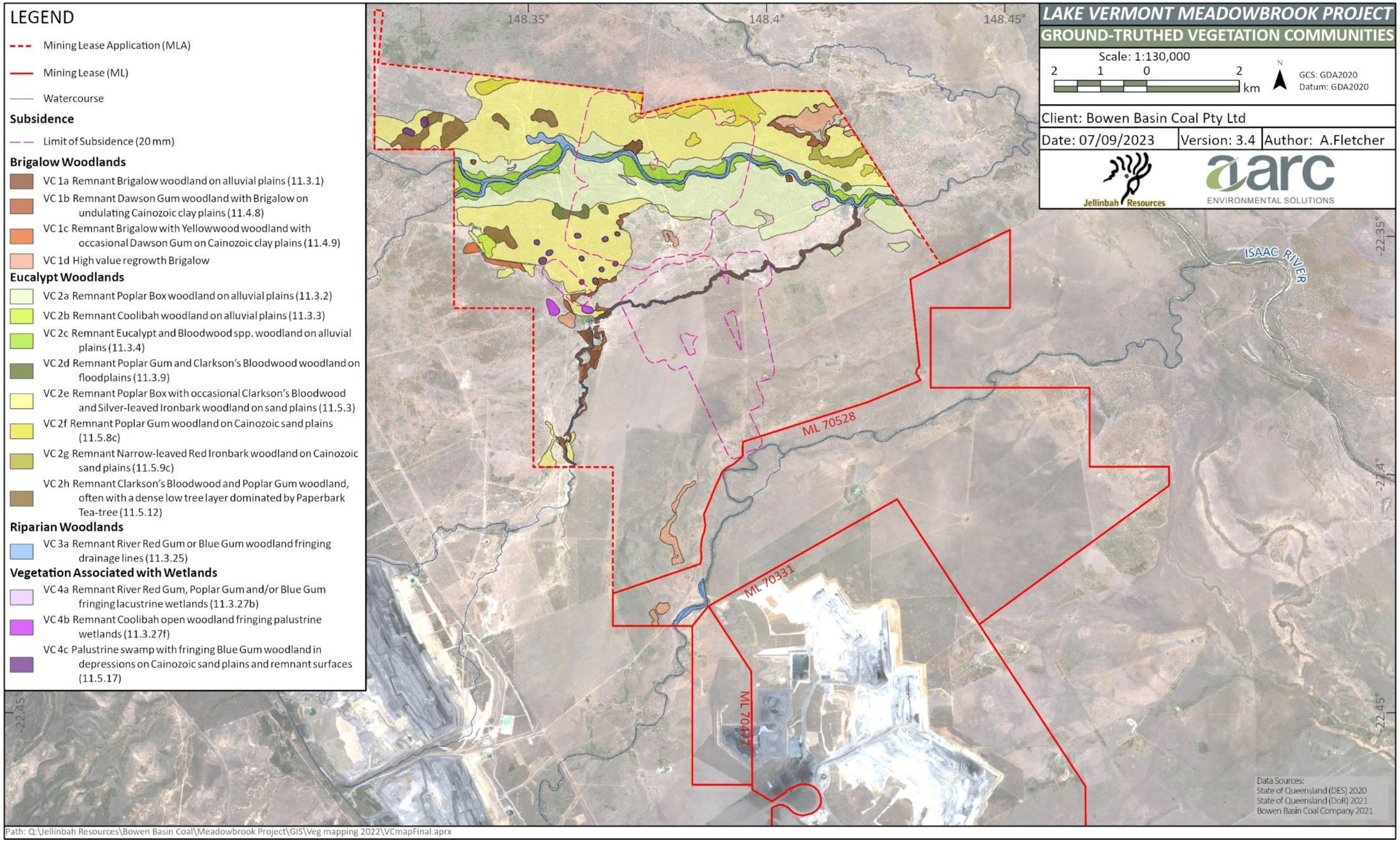


*Figure 2.6: Ground-truthed vegetation communities*

The remainder of the subsidence footprint is not associated with remnant or high-value regrowth vegetation but is best described as cleared agricultural areas. These cleared areas consist of a sparse, shrubby layer of Brigalow (< 1 m) and a ground layer of introduced pasture species (predominantly Buffel Grass).

### *Environmentally Sensitive Areas*

Three REs occurring in the subsidence area are listed as 'Endangered' REs under the VM Act and are also considered category B, Environmentally Sensitive Areas (Schedule 19, EP Regulation).

### *Threatened Ecological Communities*

Two Threatened Ecological Communities (TECs) defined under the EPBC Act are also known to occur within the subsidence area (Figure 2.7). These TECs are listed as endangered under the EPBC Act and are described as:

- Brigalow (*Acacia harpophylla* dominant and co-dominant) TEC (Brigalow TEC); and
- Poplar Box Grassy Woodland on Alluvial Plains TEC (Poplar Box TEC).

### *Flora species of conservation significance*

No conservation significant flora species have been observed at the Project site.

### *Weed species*

Thirty-five introduced flora species have been identified within the study area. Of these, seven are listed as restricted matters under the Queensland *Biosecurity Act 2014* (Biosecurity Act).

No flora pest species identified are listed as Biosecurity Act prohibited matters. However, five of the introduced flora species are identified as Weeds of National Significance.

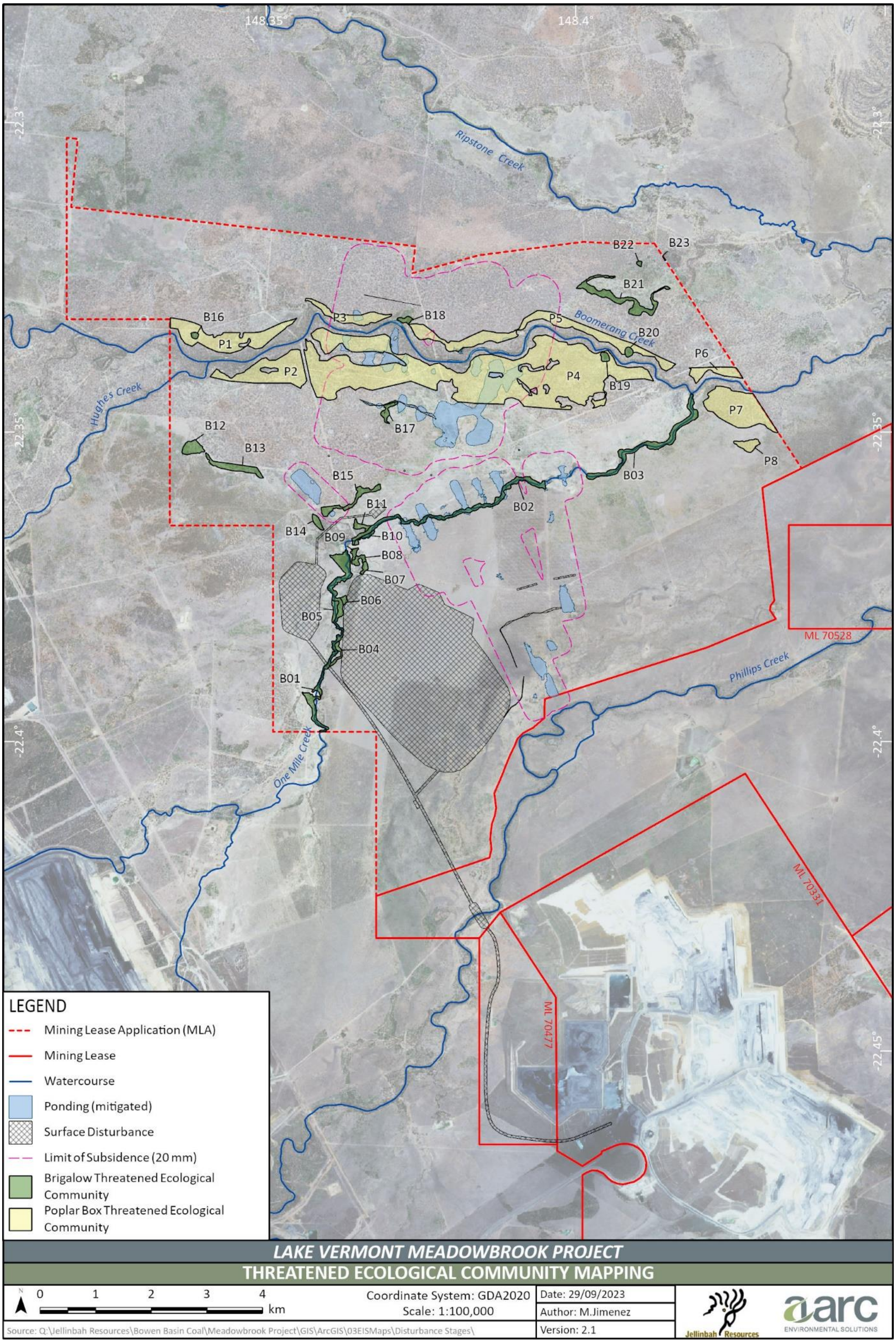


*Figure 2.7: Map of Threatened Ecological Communities within the subsidence area*

### 2.6.2 Fauna

#### 2.6.2.1 Major habitat types

Vegetation communities within the subsidence management area provide terrestrial fauna with opportunities for foraging, breeding, nesting, predator avoidance and movement between areas, facilitates dispersal/migration and promotes genetic diversity. Areas of periodic ponding induced by subsidence are expected to create additional (seasonal) water sources for fauna not completely dissimilar to the functionality of local gilgai habitat.

Major habitat types occurring within the subsidence management area include:

- Brigalow woodlands;
- Eucalypt dry woodlands;
- Eucalypt open forest to woodlands on floodplains;
- Freshwater wetlands; and
- Cleared agricultural areas.

#### 2.6.2.2 Native fauna species

A total of 167 native vertebrate species have been identified within the subsidence footprint and surrounding Project area including:

- 11 amphibians;
- 20 reptiles;
- 109 birds; and
- 27 mammals.

#### 2.6.2.3 Fauna species of conservation significance

Five fauna species listed as Endangered or Vulnerable under the NC Act have been identified within the Meadowbrook Project area:

1) Ornamental Snake.
2) Squatter Pigeon (Southern).
3) White-throated Needletail.
4) Koala.
5) Greater Glider.

The surface interface of the subsidence footprint has been found to support habitat for the following species which are listed as threatened under the EPBC Act and NC Act:

- Ornamental Snake (*Denisonia maculata*);
- Squatter Pigeon (*Geophaps scripta scripta*);
- White-throated needletail (*Hirundapus caudacutus);*
- Australian Painted Snipe (*Rostratula australis*);
- Koala (*Phascolarctos cinereus*); and

- Greater Glider (*Petauroides volans*).

With the exception of the Australian Painted Snipe which is listed as Endangered under the EPBC Act and NC Act, all of the above threatened species were listed as Vulnerable under the EPBC Act and NC Act at the time of the controlled action decision (and Terms of Reference determination) for the Project. In 2022, the EPBC Act and NC Act listing status for the Koala and the Greater Glider was upgraded from Vulnerable to Endangered.

Whilst the Australian Painted Snipe has not been recorded within the Project site, the species is considered to have a moderate likelihood of occurring within the subsidence area.

The Short-beaked Echidna, listed as a non-migratory Special Least Concern species under the Qld NC Act, has been observed within the footprint of the subsidence area.

#### 2.6.2.4 EPBC Act listed migratory species

Two species listed as migratory under the EPBC Act and as Special Least Concern (migratory) under the NC Act have been recorded within subsidence footprint or surrounding Project area, including:

- the White-throated Needletail (also listed as Vulnerable); and
- the Crested Tern (*Thalasseus bergii*).

#### 2.6.2.5 Pest species

Nine introduced fauna species have been recorded within the study area through the detection of scats, tracks, traces, camera trap detection or direct observation. Six of the introduced fauna species are restricted matters under the Biosecurity Act.

Pest species known to occur in the subsidence footprint or surrounding Project area include the Cane Toad (*Rhinella marina*), European Cattle (*Bos taurus*), Wild Dog (*Canis familiaris*), European Red Fox (*Vulpes vulpes*), Red Deer (*Cervus elaphus*), Feral Cat (*Felis catus*), House Mouse (*Mus musculus*), Rabbit (*Oryctolagus cuniculus*), and Feral Pig (*Sus scrofa*).

### 2.6.3 Aquatic Ecology

#### 2.6.3.1 Aquatic habitat

Watercourses and wetlands within the Project study area (Figure 2.1) provide aquatic habitat values described as ranging from 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 livestock accessing the creeks, with runoff and the influence of edge effects from historic clearing also contributing to the degradation.

#### 2.6.3.2 Aquatic flora

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

#### 2.6.3.3 Aquatic fauna

Aquatic surveys across the Project study area identified nine fish species from five families and five crustacean species from four families. No listed Endangered, Vulnerable or Near-threatened (EVNT) aquatic species were noted at any of the survey sites during any of the aquatic 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 have been recorded within the Project study area.

No turtle species listed as either threatened under the EPBC Act or NC Act, or Least Concern under the NC Act have been encountered in the Project area. 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 availability of suitable habitat for turtle species listed under the EPBC Act or NC Act.

The Platypus (*Ornithorhynchus anatinus*) is listed as SLC under the NC Act and has been recorded from the Isaac River drainage sub-basin (DES 2021). However, the Platypus has not been recorded from the Project study area or within 50 km of the Project. Whilst there are Platypus records from the Connors River subcatchment, there are no records from the Isaac River Sub-catchment of the Fitzroy River Basin.

Preferred habitat for the species includes areas with clear, flowing water with coarse bed substrates (e.g. cobble and gravel), riffle zones and dense coverage of submerged aquatic vegetation. The ephemeral watercourses in the subsidence area and broader Project study area do not contain the specific habitat required by the species. For the short periods when the watercourses are in flow, the water is turbid and lacks the typical coarse bed substrates, riffle zones and submerged aquatic vegetation preferred by the species.

#### 2.6.3.4 Macroinvertebrates

The aquatic ecosystems surveyed were found to support a low to moderate diversity of macroinvertebrate taxa (between 10 and 17 taxa at each site) and a low diversity of sensitive macroinvertebrate taxa.

SIGNAL 2 scoring of macroinvertebrate communities across the study area indicates the habitat availability and environmental conditions are poor, which is generally consistent with ecosystems influenced by urban, industrial or agricultural pollution.

As indicated by the SIGNAL 2, sensitive and taxonomic richness scoring, macroinvertebrate assemblage across the study area is most likely influenced by habitat limitations and the ephemeral nature of local watercourses.

### 2.6.4 Wetlands

Several wetlands occurring within the Project site and surrounding lands are mapped under the VM Act as wetlands of General Ecological Significance (GES) or High Ecological Significance (HES). These wetlands are shown in Figure 2.8.

Several mapped GES wetlands occur within the northern portion of the subsidence impact area between One Mile Creek and Boomerang Creek. Other palustrine wetlands are mapped along the Isaac River, both upstream and downstream of the confluence of the Isaac River with Boomerang Creek.

Whilst ten HES wetlands have been identified within the vicinity of the Project, no HES wetlands occur within the subsidence impact area (Figure 2.9). All HES wetlands are assessed to be surface features with limited infiltration of surface water into underlying sediments and no inferred hydraulic linkage between surface waters and groundwater, with the exception of HES wetlands 8 and 10 (Figure 2.9). HES wetland 8 is identified as a type 2 GDE and HES wetland 10 is identified as a potential GDE, or surface feature, and is within the disturbance footprint of the approved Olive Downs project that will be removed by that project (DPM Envirosciences 2018).

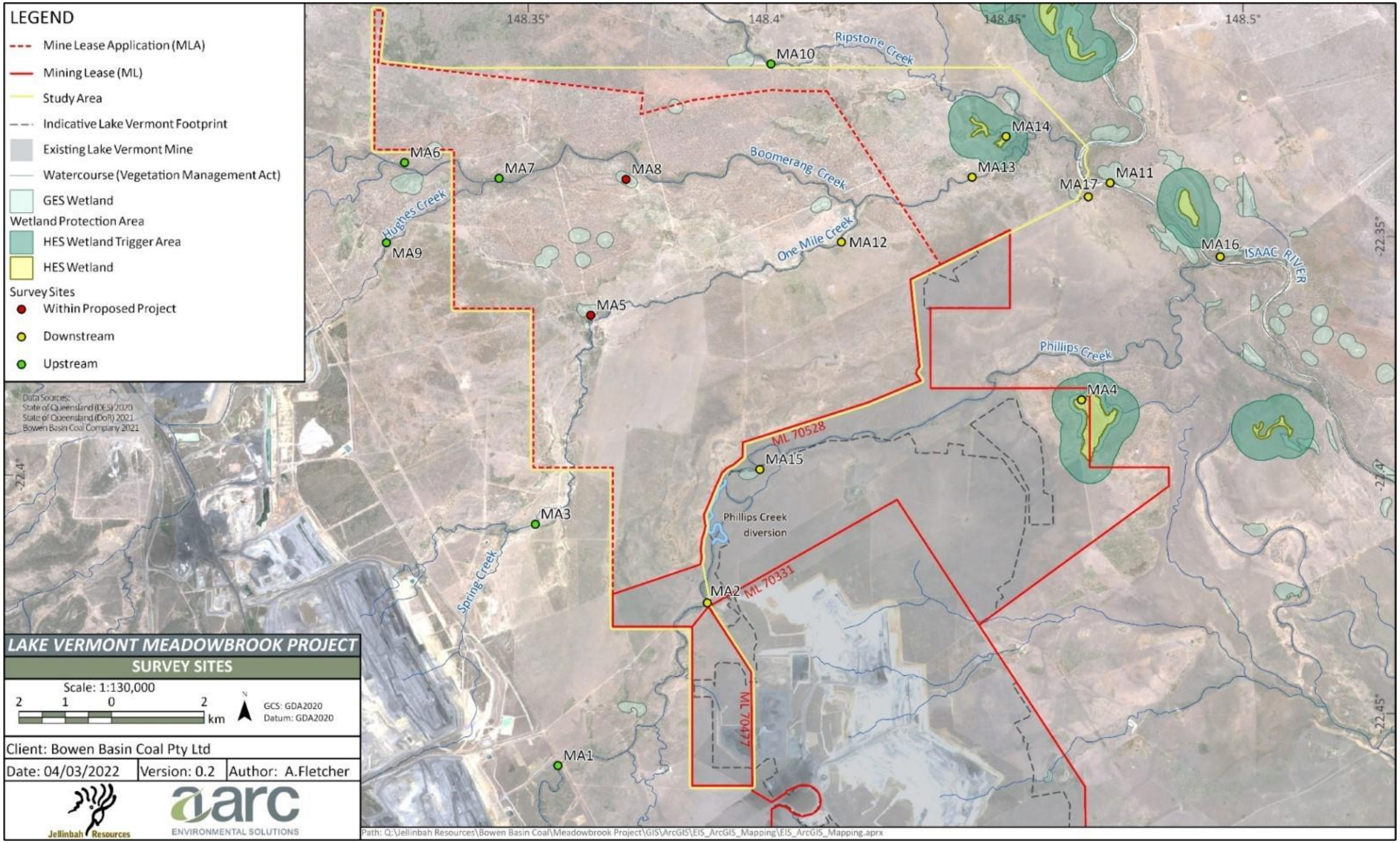


*Figure 2.8: Aquatic ecology study area, watercourses and wetlands*

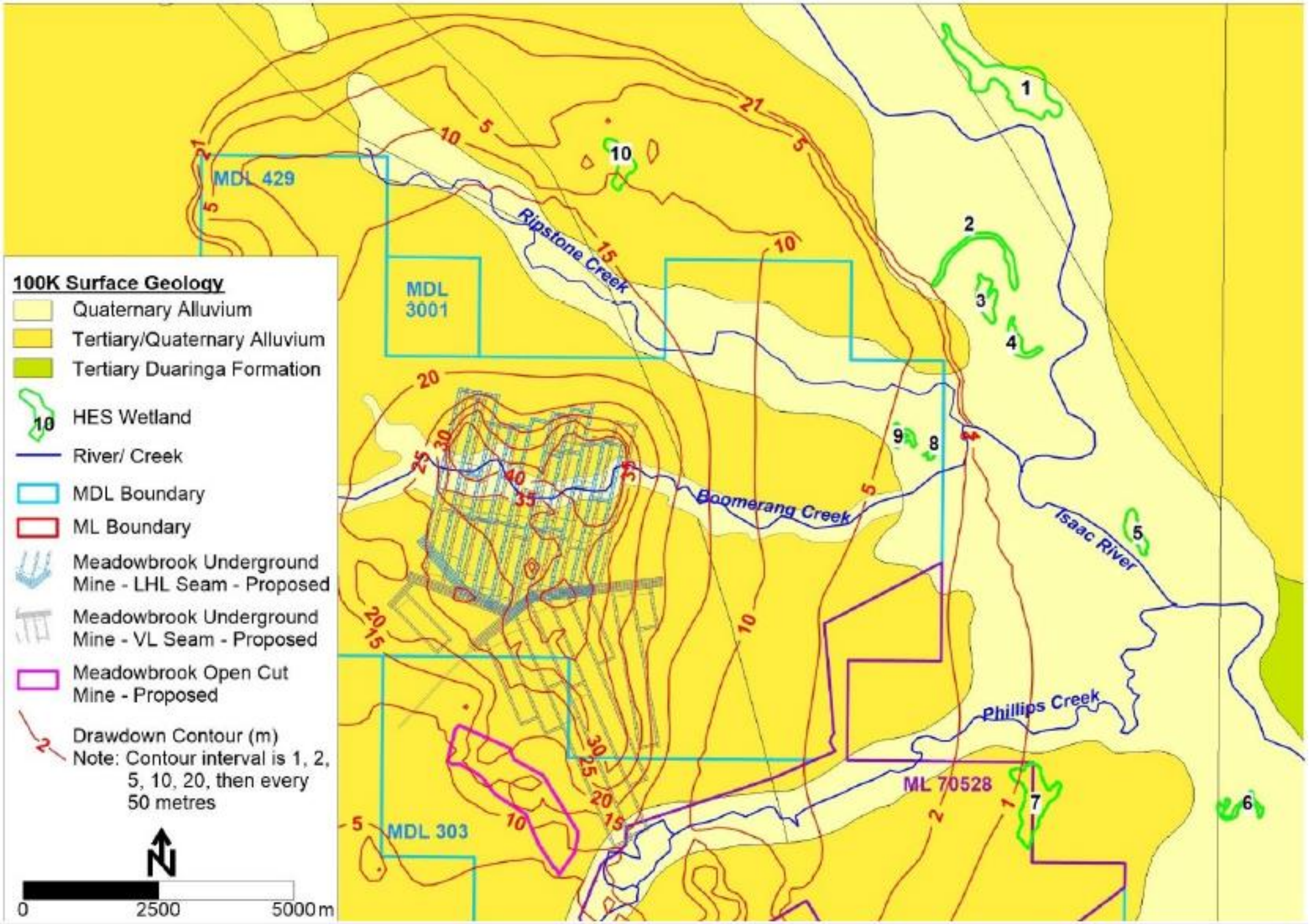


*Figure 2.9:* *HES wetlands occurring in the vicinity of the Project*

## 2.7 Cultural heritage

### 2.7.1 Indigenous cultural heritage values

The Project area is located within the Barada Barna People's Native Title application area, per determination reference (QCD2016/007), which was registered with the 'National Native Title Tribunal' on 31 August 2016. Native title has been extinguished over all land within the Project area and does not form part of the 'Barada Barna People's Native Title Determination Area'.

Bowen Basin Coal operates under a Cultural Heritage Management Plan (CHMP) which was established in March 2007. The CHMP was created for the "life of the Vermont Coal Project" and extends across all Bowen Basin Coal tenements relevant to the Lake Vermont Mine (inclusive of the Project site). The CHMP defines how land use activities will be managed by Bowen Basin Coal, to avoid or minimise harm to indigenous cultural heritage.

Consistent with the operations of the CHMP, Bowen Basin Coal has undertaken cultural heritage clearance surveys across the entirety of the Project area. As a result of completed survey works, cultural heritage clearance has been provided for the entirety of the Project site.

As part of Bowen Basin Coal obtaining Indigenous cultural heritage clearance, several scar trees were identified within the Project area (refer to Figure 2.10). Seven scar trees exist above or in close proximity to the proposed subsidence footprint. Ongoing discussions will occur with Barada Barna as the Project progresses, such as to facilitate opportunities to salvage any scar trees impacted by the Project.

### 2.7.2 Non-Indigenous cultural heritage values

Following European occupation, land use of the Project area was primarily focused on pastoral pursuits, an important historical theme in understanding heritage significance. The findings of the Cultural Heritage Assessment conducted by Converge Heritage + Community (2021) are summarised below.

- According to State and Commonwealth heritage registers no places of non-Indigenous cultural heritage are known to occur on the Project site.
- Eight sites/places of potential non-Indigenous cultural heritage significance have been identified in the Project area or immediate surrounds. Three of the potential non-Indigenous cultural heritage significance sites/places occur within the vicinity of the subsidence footprint, including the blaze tree, cattle yard and loading ramp and molasses lick. The locations of these places are shown in Figure 2.11.
- None of the eight potential non-Indigenous cultural heritage sites meet the threshold criteria for local heritage significance. All sites are considered common for this area and appear to have been constructed relatively recently.

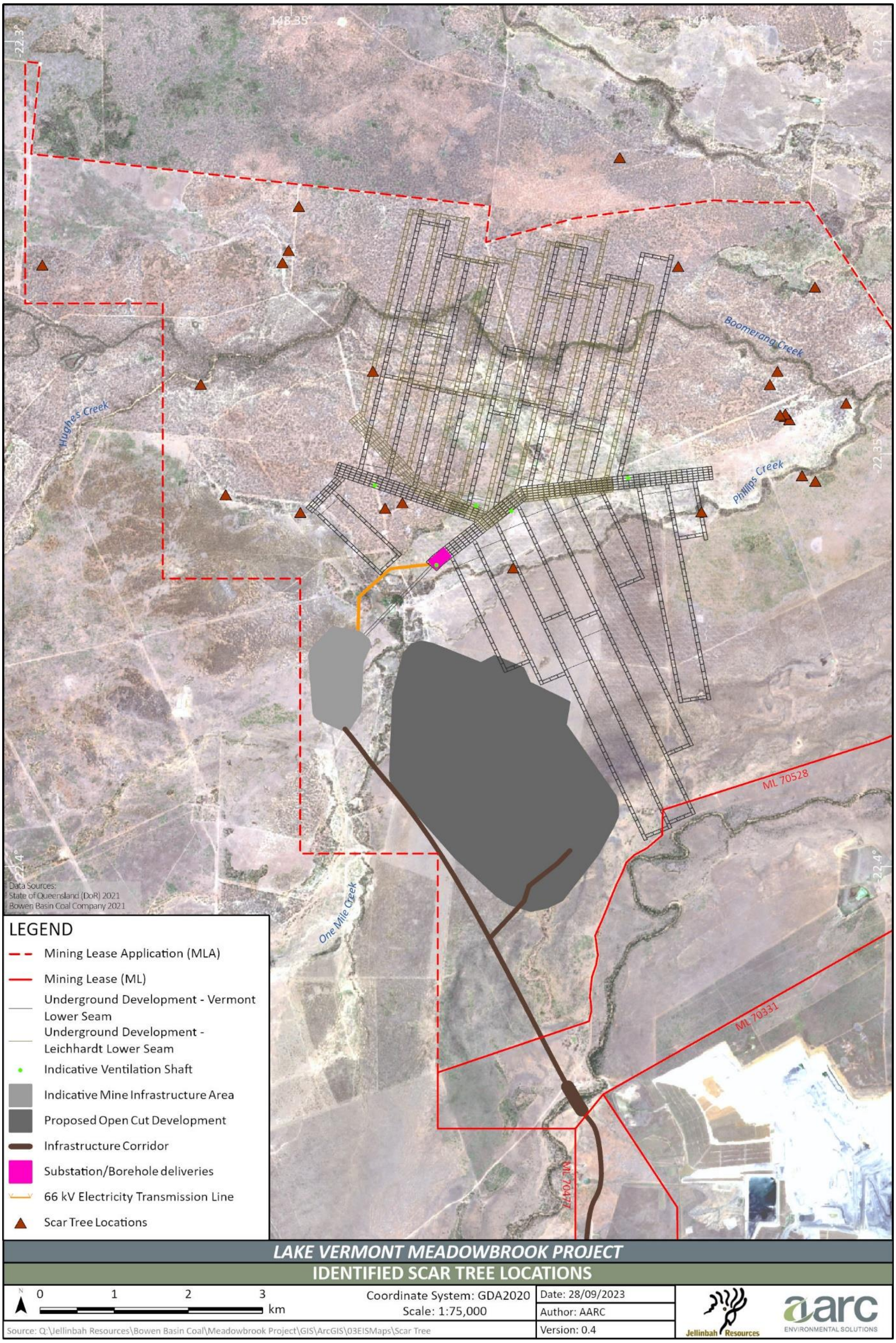


*Figure 2.10: Identified scar tree locations*

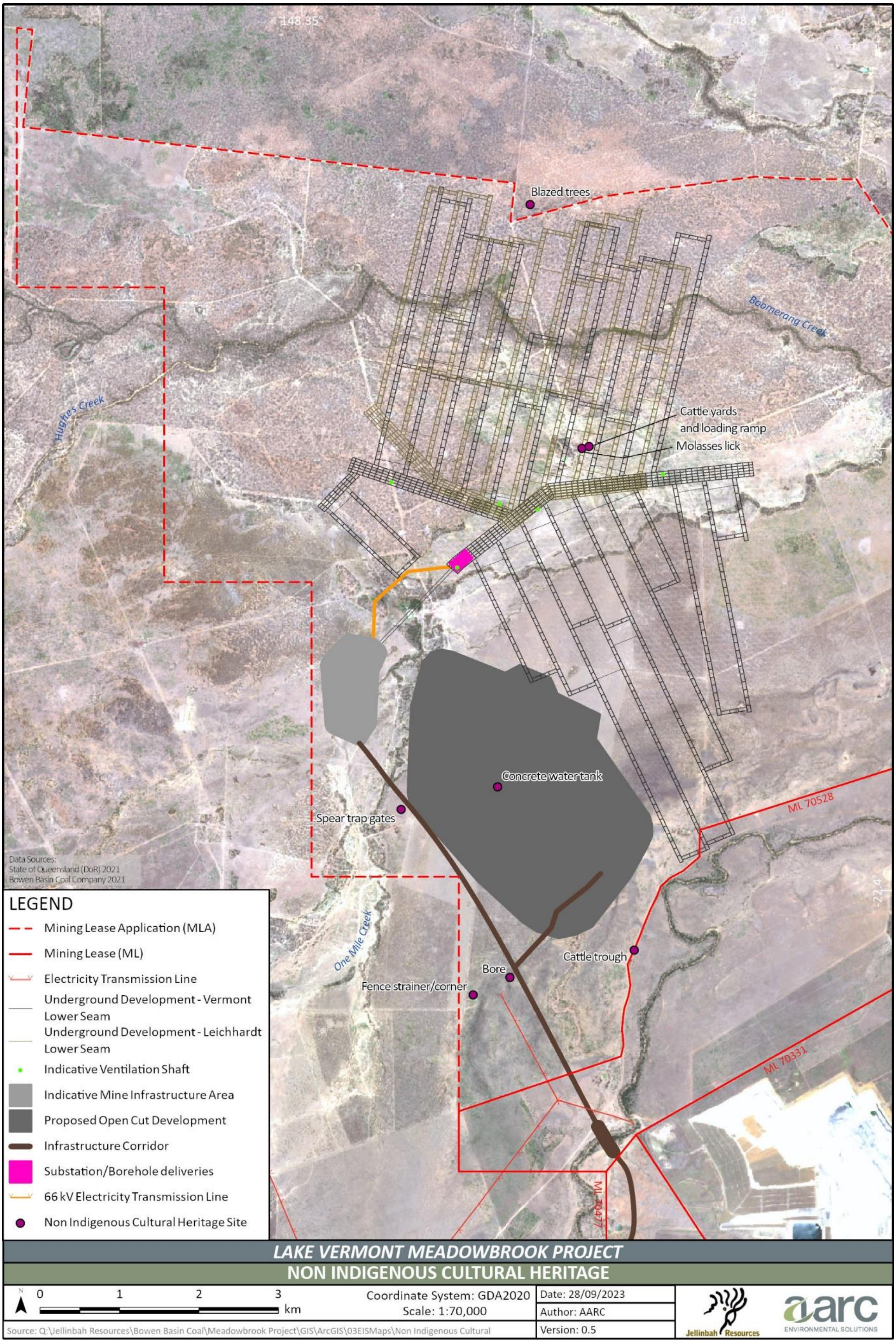


*Figure 2.11:* *Non-Indigenous cultural heritage sites*

# 3 Impact Assessment

## 3.1 Mine plan and subsidence predictions

The subsidence modelling has produced predictions about changes to landforms based on well-established methodologies that have been validated through application at numerous similar mining operations. The subsidence modelling predictions are made with conservative assumptions when uncertainty exists and are considered suitable for assessing the potential impacts of subsidence on the environment.

The subsidence modelling predicts subsidence, referred to as the vertical movement of a point at the surface. Subsidence vertical movement is predicted to occur over the underground mining areas to a maximum depth of 2.9 m for the southern mining area and a maximum depth of 5 m for the northern mining area. The modelled vertical subsidence after underground mining is presented in Figure 3.1. Longwall mining subsidence typically results in an altered topography above the underground mining footprint, with ridges above chain pillars and troughs over the goaf, or mined-out areas. Subsidence predictions also indicate the extent of vertical movement along the watercourses in the Project area. The maximum displacement in watercourse surface level modelled is approximately 4 m for Boomerang Creek and 2.5 m for One Mile Creek.

Subsidence can also result in horizontal ground movements at the surface, being the absolute horizontal movement at a point on the surface. The maximum horizontal ground movements are typically less than 1 m in the southern mining area and up to 1.6 m in the northern mining area.

Surface strain is the relative change in horizontal distance between two points at the surface caused by bending or stretching of the land surface. The maximum tensile strains resulting from subsidence are modelled at 24 mm/m. The maximum compressive strains modelled are 28 mm/m.

Tilt is the change in the slope of a subsided land surface as a result of differential subsidence. The maximum tilt modelled to develop over the underground mining area is 3.8%, or 38 mm/m.

The subsidence predictions are final values after longwall mining is completed. Based on subsidence modelling at other mines in the Bowen Basin, more than 97% of the maximum subsidence is predicted to occur within six weeks after single seam longwall mining is completed. For those areas where sequential dual seam mining occurs, subsidence will occur as two discrete events, with 97% of maximum subsidence estimated to occur within 6 weeks of completion of longwall mining in the Vermont Lower seam. Mining in the northern portion of the site will occur in two stages resulting in subsidence from the mining of the overlying Leichhardt Lower seam followed by further subsidence from the mining of the underlying Vermont Lower seam. Consequently, subsidence will not be considered as final until after the completion of mining of the Vermont Lower seam in the south and the north, respectively.

Subsidence is predicted to occur across approximately 2,168 ha of the Project area; the potential impacts of subsidence that may occur within this area are summarised in the following subsections.

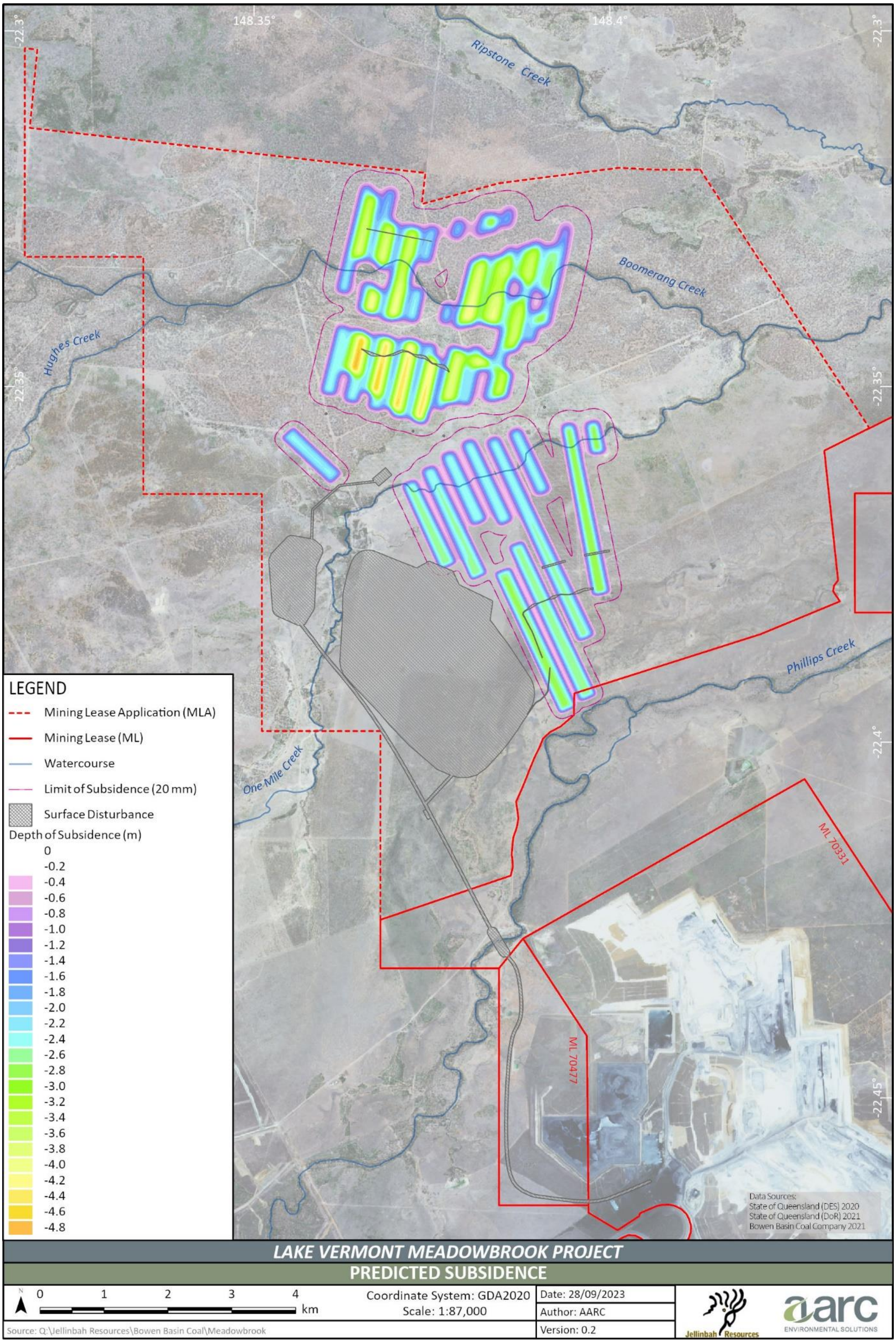


*Figure 3.1: Predicted subsidence after underground mining*

## 3.2 Geomorphic response

Land subsidence is expected to arise from the extraction of a coal seam and the consequent downward movement of the overlying strata and surface. Subsidence may result in sub-surface cracking, connective cracking to surface, surface cracking, buckling and heaving and surface drainage effects. The potential for each of these geomorphic responses to occur at the Project site is discussed in the subsections below.

### 3.2.1 Sub-Surface cracking

Discontinuous sub-surface cracking can cause changes to the existing hydrogeological regime. Cracks in the rock mass can change the permeability and water storage capacity of the strata overlying the mined areas.

The estimation of the extent and behaviour of subsurface subsidence cracking is a complex undertaking and requires information from multiple approaches and multiple lines of evidence. Estimation of the subsurface cracking resulting from underground mining in the Project area (Gordon Geotechniques 2022) is based on measured data, micro-seismic monitoring and empirical guidelines. The subsurface cracking predictions due to single seam longwall extraction can be summarised as:

- a zone of continuous cracking extending up to approximately 120 m above the extracted seam; and
- a zone of discontinuous cracking extending no higher than 180 m above the extracted seam.

For areas planned to undergo dual seam extraction, subsurface cracking is predicted as a zone of continuous cracking extending up to 180 m above the lower extracted seam (Vermont Lower Seam).

Based on a review of available information from underground mining operations in the Bowen Basin, the subsidence assessment (Gordon Geotechniques 2022) has also identified that surface water inflows to mining areas have not occurred where depth of cover exceeds 120 m and that groundwater inflows have not occurred where distance to the aquifers exceeds 90 m. The potential impacts of subsurface cracking on groundwater values were assessed as part of the Groundwater Impact Assessment (JBT Consulting 2023) and are described in section 3.5 of this plan.

### 3.2.2 Connective cracking to surface

Connective cracking is not anticipated to occur, as the depth of cover is greater than the expected height of subsurface cracking for all underground mining areas. Despite this, the possibility of a low conductivity fracture connection to the surface has been considered in the groundwater model for the Project underground area as discussed in Section 3.5 of this plan.

### 3.2.3 Surface cracking

Cracking can occur at the ground surface where differential lowering of the ground surface results in areas of residual tensile strain, which are most likely to occur at the perimeter of subsidence troughs. While depth of cover, panel and pillar width and geology are factors, subsidence troughs typically align with the longwall panel layout. Surface cracks typically occur in areas under tensile strain, but they can also occur in areas under compressive strain.

While surface cracking is anticipated to occur, the visible extent of cracking is dependent on the soils overlying the underground mining area and the interaction between cracks, soil and water. Heavy cracking clay soils such as Knockane and Norwich overlie much of the underground mining footprint (Figure 2.3). In Queensland conditions, heavy cracking clay soils are capable of self-mulching over developing subsidence caused surface cracks within three wetting and drying cycles (Lechner et al. 2016). Knockane and Norwich are strongly cracking soils with self-mulching properties. It is anticipated that subsidence cracks will therefore reduce or diminish over time as a result of the self-mulching properties of these soils. Soils with weaker structures, such as Mayfair sodic variant, Moreton and Parrot, will retain surface cracks longer than heavy clay soils (Lechner et al. 2016).

Based on experience at a number of operating Bowen Basin longwall mines, maximum crack widths up to 200 mm could be expected above the shallower longwall panels, decreasing to less than 50 mm in the deeper parts of the Project longwall mining area, during single seam extraction. Some reworking and widening of existing cracks is anticipated above dual seam mining areas. The maximum predicted depth of cracking above the longwall panels in the Meadowbrook longwall mining area is 10–15 m, with the majority of cracks predicted to be less than 1 m deep.

Cracks of the expected width and depth are amenable to small scale rehabilitation works. This typically involves stripping of the topsoil, excavating and backfilling the cracks, followed by the replacement of topsoil and revegetation.

### 3.2.4 Buckling and heaving

Buckling or heaving may result where near-surface strata breaks occur, and the resulting blocks of rock interact to produce localised movement. This process may be exhibited above central areas of longwall panels but is less likely to occur than tension cracking.

### 3.2.5 Surface drainage effects

Localised depressions in the surface topography resulting from underground mining subsidence can result in areas of ponding depending on the local topography. It has been estimated that prior to mitigation efforts, up to 370 ha of land within the subsidence area may be subject to intermittent ponding. The drainage works are expected to reduce the area subject to intermittent ponding to 213 ha. Some areas of intermittent ponding will occur on sodic soils, which have a higher risk of erosion due to the dispersive qualities of the soil. Although the ponded areas are expected to be depositional zones, there is a risk of tunnel and gully erosion occurring on slopes.

Underground mining operations are proposed beneath Boomerang and One Mile Creeks, and within 50 m of Phillips Creek. Subsidence predictions indicate that the underground mining will likely result in alterations to the bed levels of Boomerang Creek and One Mile Creek, where these creeks traverse the northern longwall panels. Boomerang Creek is predicted to experience a maximum subsidence extent of 4.0 m, while One Mile Creek is predicted to experience subsidence up to 3 m.

The channel of Phillips Creek is located outside the subsidence footprint and will not be directly impacted by subsidence. The potential impacts of subsidence on the surface water features of the Project area are discussed further in Section 3.3.

## 3.3 Watercourses

Surface water values within the Project area predicted to be affected by subsidence include:

- Boomerang Creek and its floodplain;
- One Mile Creek and its floodplain; and
- part of the Phillips Creek floodplain.

Boomerang Creek and One Mile Creek have been defined as watercourses under the *Water Act 2000*. The impacts of subsidence on watercourses are summarised in this section.

Gordon Geotechinques (2022) predicted that no loss of surface water is expected as a result of subsidence-induced surface and subsurface cracking, but loss of water to the broader catchment may occur due to the residual post-subsidence depression in the floodplain between Boomerang and One Mile Creeks.

Hydraulic models (detailed in WRM 2023a) indicate due to the increase in floodplain water storage caused by subsidence:

- localised flood levels would be reduced, but the depth and extent of localised flooding would be increased; and
- downstream flood flows, levels and extents would be reduced.

The impacts on each watercourse are described in further detail in the following subsections.

### 3.3.1 Boomerang Creek

The channel and floodplain of Boomerang Creek are expected to experience maximum subsidence depths of up to 4 m. The subsided areas would partially fill with local rainfall and runoff at which point surface water will evaporate or seep into the local soils. The water balance modelling indicates subsided areas would be unlikely to fill completely and would store more than 1 m of water less than 10% of the time. However, during the 50% AEP flood, the subsided areas would be expected to fill with Boomerang Creek floodwater at least every few years. The ponded water would then persist up to several months post filling depending on the rates of evaporation or seepage into the underlying soil.

Due to the additional water storage in the subsided areas, flood levels would be locally reduced by up to approximately 3.5 m and 3.0 m in the 50% AEP and 2% AEP floods respectively, while the extent of inundation would increase slightly. The water storage would significantly reduce the peak flow rate and peak flood levels in the downstream reaches during small flood events. In floods larger than 2% AEP event, the impact of subsidence on downstream flows would be minimal.

Alterations to the flow velocities and sediment transport capacity would vary across the subsidence areas in Boomerang Creek and its floodplain:

- Flow velocity would be significantly reduced across much of the floodplain, which would promote sediment deposition and gradual accretion in the subsided areas. In small floods, floodwater stored in the subsided areas in Boomerang Creek would increase the amount of floodwater flowing into One Mile Creek. The velocity is expected to slightly increase (0.25 m/s to 0.5 m/s) over the broad area where the floodwater flows into One Mile Creek, but the increase would be insufficient to erode the floodplain except in the localised areas as it drains into subsidence troughs.
- Flow velocity would decrease in the areas of subsidence in the channel bed, which promotes aggradation of the bed in these areas. These troughs are expected to rapidly aggrade sediment during flow events from the abundant sediment present within the catchment.
- Where water drains into the subsided area at Ch 9,250 (WRM 2023b), flow velocity would increase, which increases the sediment transport capacity and the deep bed sediment is expected to erode quickly into the subsided areas. This may lead to marginal increases in bank erosion as the channel capacity increases.
- Where water drains into the second and forth subsidence troughs, flow velocity would increase and the bed sediments on the downstream side of these elevated sections of stream bed are expected to be eroded down to the upstream and downstream bed levels. This aggradation could accelerate the formation of a new Boomerang Creek, which could form even in the absence of the subsidence.

### 3.3.2 One Mile Creek

Subsidence predictions indicate that the One Mile Creek channel and southern floodplain may experience maximum subsidence depths of up to 3.0 m (within the channel). Maximum subsidence depths in the floodplain between One Mile Creek and Boomerang Creek would be over 4.5 m in localised areas. All subsidence troughs associated with the One Mile Creek floodplain would be directly connected to the main channel, and during flood flows, water would flow laterally into the subsidence areas.

Underground mine subsidence would reduce peak flood levels by up to 1.3 m and 1.5 m in the 50% AEP and 2% AEP flood events respectively. In floods larger than 2% AEP event, the impact of subsidence on downstream flows would be minimal.

The changes to flow velocities and sediment transport capacity in One Mile Creek and its floodplain are:

- Parts of the channel within subsidence troughs would experience decreases in flow velocity, reduction in sediment transport capacity, and further aggradation of the channel bed in these areas.
- Where water flows into the subsided areas, flow velocity would increase but would remain low. However, due to the relatively fine sediments in the creek and limitation in sediment supply, increases in bank erosion would be expected as the channel capacity increases.
- Where water flows into the second to fifth subsidence troughs, flow velocity would increase and the bed sediments on the downstream side of the elevated sections of stream bed will be eroded.

Local catchment draining to One Mile Creek is expected to be reduced by approximately 9 $km^2$ (6.9%), as a result of some unmitigated ponding capturing runoff in the floodplain between Boomerang Creek and One Mile Creek. This potential catchment loss would impact the downstream 4 km reach of One Mile Creek in minor runoff events, but would not significantly alter the flow regime. The impacts of the catchment loss would be minimal downstream of the confluence, where it would make up 1.8% of the 48,900 ha total catchment.

### 3.3.3 Phillips Creek

The channel of Phillips Creek is not expected to be impacted by subsidence. Subsidence would impact flooding and drainage across the northern Phillips Creek floodplain, where the maximum subsidence depths would be up to 3.0 m.

### 3.3.4 Floodplains

Floodplains of Boomerang Creek, One Mile Creek and Phillips Creek will be impacted by the development of subsidence induced ponding. These ponds have the potential to capture overland flow, reducing the volume of water available to the downstream receiving environment.

The frequency and volume of water being held within floodplain ponds is highly variable, subject to seasonal rainfall. It is therefore difficult to accurately quantify the expected frequency and volume of water that will be captured within ponds, in any given period. Notwithstanding this, the Project EIS sought to quantify this impact by providing that "the duration of ponding in these depressions would depend on the depth and duration of rainfall, but based on water balance modelling, they would be unlikely to fill completely, and would be expected to store more than 1 m of water less than 10% of the time. However, based on modelling of the 50% AEP flood, the depressions would be expected to fill with Boomerang Creek floodwater at least every few years. The ponded water would then persist until it evaporated or seeped into the underlying soil. In the absence of seepage, depending on their depth, the ponds could then be expected to persist for several months post filling." (WRM 2023b).

It is noted that no use/take of water from within these ponds proposed to occur. To reduce the total volume of overland flow captured, the proponent proposes to pump ponded water from the ponds into the downstream flow paths when accumulated volumes become significant. Pumps would be located at the deepest sections of each subsidence depression and deliver water to the pre-mining overland flow path. Pumping would occur when the ponded water depth exceeds 0.5 m above the lowest point of a depression (WRM 2023b). Indeed, water retained in subsided areas will remain available to the environment, supporting habitat values and replenishing localised alluvium.

Mitigation works have also been proposed to further minimise the extent of water captured within floodplain depressions (resultant of subsidence). This includes a series of mitigation drains (to drain water caught within ponds - back to natural drainage lines); as well as the proposed construction of mitigation bunds (to prevent overland flow from accessing subsided areas).

Ponding of runoff captured within the floodplain between Boomerang and One Mile Creeks would effectively reduce the local catchment draining to One Mile Creek by approximately 900 ha (6.9%). During open-cut operations, water which would normally flow to One Mile Creek would be intercepted by the proposed mine water management system within the levees protecting the mine pit and sediment dams. During the period of peak open-cut mining disturbance, the temporary maximum additional reduction in catchment area to One Mile Creek would be approximately 300 ha (i.e. a total of 1,200 ha in catchment reduction).

At the completion of mining and rehabilitation of the final landform, this would reduce by approximately 150 ha (i.e. a total catchment loss of 1,050 ha - 8%). This catchment loss would impact the downstream 4 km to 6 km reach of One Mile Creek in minor runoff events, (which has been impacted by historical mining activities in the upper catchment) but would not significantly alter the flow regime. The impacts of the catchment loss would be minimal downstream of the confluence (of Boomerang and One Mile Creeks) where it would make up 1.8% of the 48,900 ha total catchment. As such, water losses to the receiving environment are minor.

Impacts to ecological values as a result of hydrological and geomorphological changes have also been considered, with offsets arising where significant impacts have been considered likely. While offsets have been adopted, it is noted that the offset areas (ponds) will retain ecological function (distinct from offsets arising from direct clearing).

Further, it is noted that repairs to subsided areas within floodplains (such as backfilling of depressions) has been assessed as being impracticable (due to the volume of material that would be required); whilst also noting that such an approach would also present a more significant impact to environmental values than the subsidence impacts themselves (e.g. creation of significant direct disturbance to place fill, importation of significant potential sediment/fill, loss of vegetation cover in reshaping landforms etc.). In contrast, managing the subsided landform to minimise water capture, will maintain ecosystem function, while also providing habitat value for conservation significant species.

As such, the monitoring of floodplain depressions (ponds) will focus on supporting the management of impacts such as erosion, water quality and ecological condition.

## 3.4 Ecology

Subsidence may impact ecological values by directly disturbing habitat, or indirectly by changing natural conditions such as stream morphology, surface and groundwater hydrology. Potential subsidence-induced impacts to ecological values of the Project area are discussed below.

### 3.4.1 Subsidence and residual ponding impacts

As discussed in Section 3.3.4, subsidence induced changes to stream morphology and hydrological regimes are expected to result in areas of residual ponding. Residual ponding is anticipated to remain for a maximum period of several months in every few years and is predicted to affect approximately 96.9 ha of remnant vegetation. Areas subject to predicted residual ponding that cannot be mitigated are considered to pose potentially deleterious impacts to vegetation (with these impacts having been offset). Any unmitigated areas of periodic inundation and ponding are expected to cause changes to vegetation structure and composition.

The relatively small (and temporary) areas of disturbance associated with residual ponding in the northern portion of the study area are unlikely to limit opportunities for faunal dispersal through the woodland habitats, but residual ponding on One Mile Creek may impact on a species ability to disperse through the ponding areas.

Outside of predicted ponding areas, the broader subsidence footprint is expected to demonstrate no material changes to the surface landform, with impacts to have a short duration (i.e. land movement once the panel is mined). Subsidence-induced changes to the surface landform are not expected to impact ecological values, outside of areas where residual ponding is resultant or disturbance for mitigation works is proposed. Non-ponding subsidence areas are expected to retain viability and provision of habitat values, and therefore, are not considered to be subject to any substantial impacts on flora or fauna species.

The potential subsidence-induced impacts to riparian communities overlying the subsidence footprint are summarised as follows:

- The channel of Boomerang Creek is an unvegetated sandy stream substrate that does not contain any conservation significant vegetation or fauna habitat value. The predicted subsidence troughs are not expected to impact any terrestrial ecological values. The marginal risk of increased bank erosion where the creek enters the first subsidence trough is not expected to result in an impact to the vegetation adjoining the creek.

- With respect to One Mile Creek, the predicted subsidence troughs within the channel and associated lateral areas connected to the channel ponds are considered to represent areas of direct impact to the existing vegetation. Subsidence-induced erosion where the creek enters the subsidence trough is predicted to be minor and will be subject to monitoring. The troughs are predicted to extend into areas of riparian vegetation including Brigalow TEC vegetation and impacts to this vegetation are discussed in Section 3.4.3.3.
- Subsidence is not expected to have any substantial impact on the catchment or stream channel of Phillips Creek. No terrestrial ecology values are expected to be impacted by hydrological changes in this stream.

There is no predicted impact on terrestrial ecology values due to changes to surface water flows (duration or velocity) from the Project. The predicted changes to flood hydrology are not predicted to result in any significant impacts on terrestrial ecology values. The functions of flood regimes are expected to be retained for vegetation and habitat features, including areas of gilgai habitat that undergo inundation in periodic flood conditions.

Subsidence-induced changes to stream morphology and hydrological regimes are discussed in Section 3.3 of this plan.

### 3.4.2 Surface cracking impacts

Where surface cracks are temporary and self-ameliorating, they are not expected to cause any significant impacts to vegetation or fauna habitat quality. Where necessary, the remediation of soil cracks is expected to adequately rehabilitate persistent cracking and the rehabilitation works are not expected to result in significant impact to terrestrial ecology values. However, if surface cracking creates conditions which allow soil erosion to develop, vegetation could be impacted as a result of erosion. Given the proposed monitoring and management measures for erosion, no substantial erosion is expected to occur, and it is considered unlikely that erosion will impact vegetation.

The proposed monitoring and management measures are considered effective to maintain the quality, viability, and availability of fauna habitat, including that of threatened species such as the Ornamental Snake and Squatter Pigeon. Therefore, subsidence-induced cracking is not expected to pose a significant impact to fauna.

### 3.4.3 Flora

#### 3.4.3.1 Vegetation Communities

As discussed in section 3.4.1, areas of residual ponding are considered to have potentially detrimental impacts to vegetation, and communities within such areas are considered to be impacted. Consequently, residual ponding is predicted to impact on eight vegetation communities.

Areas of vegetation within the subsidence footprint, but outside of predicted residual ponding areas are not expected to be deleteriously impacted. Given the proposed monitoring and management measures for erosion, no substantial erosion is expected to occur and it is considered unlikely that erosion will impact vegetation communities.

Table 3.1 details the extent of each vegetation community occurring within the subsidence footprint as well as the predicted extent of subsidence-induced (ponding) impacts to each community.

*Table 3.1: Predicted subsidence-induced impacts to vegetation communities*

| Map unit | Vegetation community | Associated RE | Extent within subsidence footprint (ha) | Extent within unponded subsidence footprint (ha) | Extent of residual ponding impact (ha) |
|---|---|---|---|---|---|
| **1: Brigalow Woodlands** | | | | | |
| VC 1a | Remnant Brigalow woodland on alluvial plains | 11.3.1 | 33.2 | 25.0 | 8.2 |
| VC 1b | Remnant Dawson Gum woodland with Brigalow on undulating Cainozoic clay plains | 11.4.8 | 7.2 | 7.1 | 0.1 |
| VC 1d | High value regrowth Brigalow | — | 6.7 | 1.6 | 5.1 |
| **2: Eucalypt Woodlands** | | | | | |
| VC 2a | Remnant Poplar Box woodland on alluvial plains | 11.3.2 | 371.5 | 313.2 | 58.3 |
| VC 2c | Remnant Eucalypt and Bloodwood spp. Woodland on alluvial plains | 11.3.4 | 65.9 | 61.0 | 4.9 |
| VC 2d | Remnant Poplar Gum and Clarkson's Bloodwood woodland on floodplains | 11.3.9 | 10.2 | 10.2 | 0.0 |
| VC 2e | Remnant Poplar Box with occasional Clarkson's Bloodwood and Silver-leaved Ironbark woodland on sand plains | 11.5.3 | 514.4 | 496.7 | 17.7 |
| VC 2f | Remnant Poplar Gum woodland on Cainozoic sand plains | 11.5.8c | 32.2 | 32.2 | 0.0 |
| **3: Riparian Woodlands** | | | | | |
| VC 3a | Remnant River Red Gum or Blue Gum woodland fringing drainage lines | 11.3.25 | 40.2 | 35.0 | 5.2 |
| **4: Vegetation Associated with Wetlands** | | | | | |
| VC 4a | Remnant River Red Gum, Poplar Gum and/or Blue Gum fringing lacustrine wetlands | 11.3.27b | <2.5 | <0.1 | 2.4 |
| VC 4c | Palustrine swamp with fringing Blue Gum woodland in depressions on Cainozoic sand plains and remnant surfaces | 11.5.17 | 4.5 | 4.5 | 0.0 |

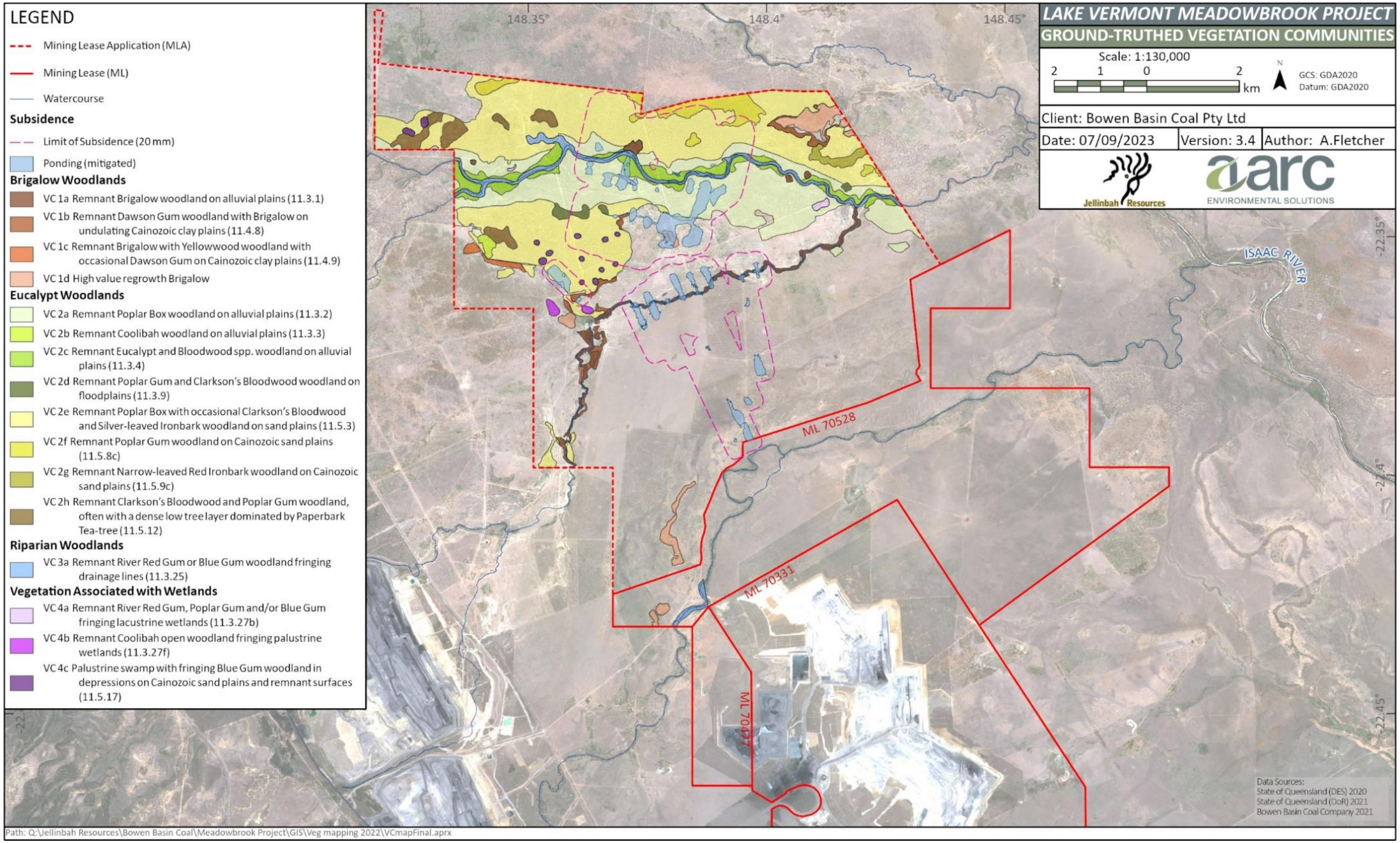


*Figure 3.2: Impacts of residual ponding to vegetation communities*

#### 3.4.3.2 Matters of State Environmental Significance (MSES)

The potential for subsidence to impact Matters of State Environmental Significance (MSES) has been considered and potential impacts to MSES values have been assessed under the 'Queensland Environmental Offsets Policy Significant Residual Impact Guideline' (DEHP 2014). The impact assessments consider the potential impacts of the Project and the proposed avoidance, mitigation and management measures. The predicted subsidence-induced impacts have been identified as having significant residual impacts on MSES including regulated vegetation and wetlands and watercourses.

***Regulated vegetation***

Those areas of residual periodic ponding are considered to undergo impacts equivalent to the loss of existing vegetation. A total of 96.9 ha of remnant vegetation is predicted to be substantially impacted by residual ponding, including two 'Endangered' REs (RE 11.3.1 and RE 11.4.8) and two 'Of Concern' REs (RE 11.3.2 and RE 11.3.4) as defined under the VM Act.

Residual ponding is also expected to impact on remnant vegetation belonging to RE 11.3.1 and RE 11.3.25 within the defined distance of a VM Act watercourse in the subsidence management area.

The extents of predicted residual ponding impacts to regulated vegetation are shown Figure 3.2.

***Wetlands and watercourses***

The proposed subsidence area also contains three VM Act wetlands. Hydraulic modelling indicates that these wetlands will experience changes in hydraulic conditions post subsidence:

- One VM Act wetland of 1.8 ha located 400 m to the south of Boomerang Creek is within the underground mining predicted periodic ponding footprint. The predicted increase in ponding represents a change in habitat that may increase the frequency and duration of ponding in the wetland and is expected to result in a change detrimental to the vegetation fringing the current extent of the wetland. This change is considered to be a significant impact and will be mitigated through environmental offsets.
- One VM Act wetland of 3.5 ha located between Boomerang Creek and One Mile Creek will be partially impacted by subsidence. The area of the wetland that will receive periodic inundation is predicted to be reduced as a result of the predicted surface subsidence. The lack of periodic inundation is expected to be detrimental to the vegetation of the wetland, and it is considered that the portion of the wetland that will receive reduced inundation (0.8 ha) will be significantly impacted. This impact will be mitigated through environmental offsets.
- One VM Act wetland of 2.1 ha located between Boomerang Creek and One Mile Creek will be entirely impacted by subsidence. A longwall pillar will be located under the wetland, and the wetland is predicted to not receive periodic inundation as a result of the predicted surface subsidence. This change is considered to be a significant impact and will be offset.

A total of 4.7 ha of VM Act wetlands of RE 11.5.17 are predicted to be impacted by the Project. This impact exceeds the thresholds relevant to the vegetation structure categories and will be offset.

#### 3.4.3.3 Matters of National Environmental Significance (MNES)

Assessments have been conducted in accordance with the Commonwealth 'Significant Impact Guidelines 1.1: Matters of National Environmental Significance' (DoE 2013a) to assess the potential subsidence impacts on Matters of National Environmental Significance (MNES). Residual ponding is expected to impact on two TEC MNES, being the Brigalow TEC and Poplar Box TEC, as discussed below and shown in Figure 2.7.

*Brigalow TEC*

Subsidence drainage works (mitigation channels and mitigation bunds) will be implemented in the northern portion of the subsidence footprint to reduce ponding impacts to the Brigalow TEC; however, some ponding is unable to be effectively mitigated (due to surrounding topography). The change in stream morphology due to residual ponding is expected to impact riparian vegetation adjacent to One Mile Creek, which includes Brigalow TEC vegetation. A total of 7.0 ha of the Brigalow TEC occurring across three patches (B2, B15, and B17) will be impacted. An area of 6.9 ha in patch B2 will experience changes to stream morphology, while patch B15 will undergo a 0.1 ha reduction in patch size. The construction of the northern mitigation channel will impact 0.3 ha of Brigalow patch B17. A very small area of Patch B17 (<0.01 ha) will also be impacted by predicted subsidence related ponding.

In each case, the patches (B2, B15, and B17) that are expected to remain post-subsidence will meet the minimum TEC patch size criteria and are expected to remain viable. Given the proposed monitoring and management measures for erosion, it is considered unlikely that subsidence-induced cracking and erosion will impact Brigalow TEC vegetation. Impacts to Brigalow TEC will be mitigated through the establishment of Brigalow TEC offsets, a commitment of the Lake Vermont Meadowbrook Offset Management Plan.

*Poplar Box TEC*

Areas of potential ponding are expected to occur adjacent to Boomerang Creek, and are considered likely to impact Poplar Box TEC patches in this area. The predicted residual ponding will impact 44.4 ha of Poplar Box TEC occurring across three patches (P3, P4 and P5). Residual ponding is predicted to impact 1.6 ha of the 18.6 ha patch P3, 42 ha of the 395 ha patch P4, and 0.8 ha of the 67.7 ha patch P5. With respect to patch P3 and P5, the residual ponding is not expected to fragment the Poplar Box TEC, and all remaining sections of each patch are expected to retain existing connectivity and viability. However, the potential ponding is predicted to fragment the patch P4 into three patches of 14.3 ha and 17.3 ha and 196.13 ha. Despite this, each patch of Poplar Box TEC (P3, P4, and P5) expected to remain post-subsidence will meet the minimum TEC patch size criteria and is expected to remain viable.

The increased patch edges around the ponded areas may increase the edge effects on affected Poplar Box patches. The predicted ponding areas are expected to undergo changes to suitability of plant species, but since no active soil disturbance or movement will be undertaken within the residual ponding areas, the ponding is not expected to generate conditions likely to cause weed incursion in the Poplar Box patches.

With respect to potential subsidence-induced surface disturbance, the application of management and monitoring measures shall prevent erosion within the Poplar Box TEC habitat. Given these controls, the Project is not predicted to cause erosion-related impacts that will modify or destroy factors necessary for the survival of the Poplar Box TEC.

Given the lack of direct disturbance to patches of the Poplar Box TEC and the fact that the patches affected by residual ponding will not be fragmented by the intermittent ponding, all patches of Poplar Box TEC are expected to remain viable following surface subsidence. Subsidence is considered unlikely to represent a significant impact to the Poplar Box TEC. Notwithstanding this, impacts to Poplar Box TEC will be mitigated through the establishment of Poplar Box TEC offsets, a commitment of the Lake Vermont Meadowbrook Offset Management Plan.

### 3.4.4 Fauna

*Fauna habitat*

The Project terrestrial ecology assessment has been completed based on the assumption that the impact to vegetation from residual ponding will be equivalent to the clearance of vegetation. The fauna habitat values provided by cleared agricultural areas are considered to be retained, despite residual ponding development because the pre-mining conditions of these areas involve intermittent ponding of gilgai depressions which will continue post-subsidence.

The areas of ponding impact to each major habitat type are presented in Table 3.2. The portions of the subsidence footprint not predicted to undergo ponding are expected to retain viability and provision of habitat values and are, therefore, considered not to be subject to any substantial impacts resulting from subsidence.

*Table 3.2: Proposed disturbance of major habitat types within the study area*

| Major habitat type | Extent within study area (ha) | Area of residual ponding disturbance (ha) |
|---|---|---|
| Brigalow woodlands | 287.3 | 13.4 |
| Eucalypt dry woodlands | 2,825.7 | 76.0 |
| Eucalypt open forest to woodlands on floodplains | 326.0 | 10.2 |
| Freshwater wetlands | 43.0 | 2.4 |
| Cleared agricultural areas | 5,446.7 | 111.7 |

#### 3.4.4.1 Matters of State Environmental Significance (MSES)

Subsidence-induced impacts have the potential to impact on the following fauna species listed as Endangered or Vulnerable under the NC Act:

1) Ornamental Snake
2) Squatter Pigeon (Southern)
3) White-throated Needletail
4) Koala; and
5) Greater Glider.

These species are also listed under the EPBC Act as MNES and potential impacts to each species are summarised in Section 3.4.4.2.

The Short-beaked Echidna has also been identified within the subsidence area and is listed as Special Least Concern under the NC Act. The subsidence footprint is thereby considered to provide protected wildlife habitat for this species. Areas of indirect disturbance, such as predicted ponding and predicted subsidence, are not expected to constitute a disturbance with magnitude or intensity sufficient to impact the habitat utility for the Short-beaked Echidna. Subsidence areas, including the areas which may undergo intermittent ponding, are expected to retain vegetation sufficient to provide echidna habitat. Subsidence is therefore unlikely to result in a significant impact to the Short-beaked Echidna.

#### 3.4.4.2 Matters of National Environmental Significance (MNES)

Some impacts on the ecological values relating to fauna are expected as a result of subsidence-induced changes, but the impacts are not considered to be significant. Notwithstanding this, the Lake Vermont Meadowbrook Offset Management Plan provides commitments to offset Project impacts to Brigalow TEC, Poplar Box TEC, and habitat for the Ornamental Snake, Greater Glider, and Koala.

For Ornamental Snake and Squatter Pigeon, subsidence does not represent a removal of habitat, therefore, no direct impact to these fauna species is expected. Subsidence will cause several changes however, such as changes to geomorphology, stream morphology, and flood regimes. These changes are not expected to significantly impact terrestrial or riparian vegetation, or habitat features (e.g. gilgai and soil cracks). Subsidence-induced temporary and permanent ponds will provide suitable habitat for both species by:

a) providing foraging and breeding habitat for frogs, a key source of prey for the Ornamental Snake; and

b) creating an expansion of the potential climatic-dependent breeding habitat for the Squatter Pigeon into areas of foraging habitat that do not support breeding habitat because of their distance to water.

Given that the predicted subsidence ponding areas are considered to support foraging and/or breeding habitat for these species, it is expected that the habitat and its viability for these species will be retained, and no deleterious impact is expected. Notwithstanding this, impacts to Ornamental Snake habitat will be mitigated through the establishment of suitable offsets as detailed in the Lake Vermont Meadowbrook Offset Management Plan.

For Koala, the residual ponding is expected to negatively impact staple forage tree species and is therefore considered a direct removal of 96.9 ha habitat. Koala habitat occurs within riparian vegetation adjacent to Boomerang Creek and One Mile Creek, including in reaches that will be subject to stream morphology changes from subsidence. All potential or likely GDEs were considered unlikely to be significantly impacted by the Project and groundwater impacts are thereby considered unlikely to impact Koala habitat. Impacts to Koala habitat will be mitigated through the establishment of suitable Koala habitat offsets.

For Greater Glider, the residual ponding is expected to negatively impact the staple forage tree species, therefore, considered a removal of 88.7 ha habitat. The reduction in a small area of habitat may result in fragmentation of the low and moderate amenity habitat for Greater Glider. But the disturbances are not expected to substantially impact the species considering the remaining area of habitat. Impacts to Greater Glider habitat will be mitigated through the establishment of suitable Greater Glider habitat offsets.

As for White-throated Needletail, potential habitat modification through occasional residual ponding of up to 96.9 ha of remnant vegetation is unlikely to decrease the size of the population given the extent of habitat available to this species across eastern and south-eastern Australia.

The areas of residual ponding occur over a 29.5 ha portion of the identified Australian Painted Snipe habitat and are expected to represent a change to the habitat. Residual ponding is likely to provide an increase of habitat suitability and potentially extend the habitat area for the Australian Painted Snipe.

Residual ponding will impact 29.5 ha of habitat for migratory species, which represents a change in this habitat rather than a removal of this habitat. A total of 213.9 ha is modelled to undergo increased ponding as a result of changed hydrology due to surface subsidence (WRM 2022). There would be no negative impacts of subsidence on migratory birds as the subsidence will increase ponding and provide more habitat for migratory species that use wetland habitats.

The impacts of changes to flood regimes are not expected to be significant in the MNES fauna species habitat, therefore, the associated impacts are not expected to be significant. Given the proposed monitoring and management measures for erosion, no substantial erosion is expected to occur and it is considered unlikely that erosion will impact the habitat of MNES fauna species.

### 3.4.5 Aquatic ecosystems

Aquatic ecosystems may be directly impacted by subsidence due to the lowering of the stream bed level. Subsidence may also impact indirectly on aquatic ecosystems through changes in hydrological conditions (i.e. affecting cues for movement, migration and breeding), diversity and structure of in-stream aquatic habitat, water quality due to erosion, and connectivity between aquatic habitats.

As assessed in Section 3.3, residual ponding reduces the downstream flood peak in the channels, and increases flow velocity and erosion at the elevated sections (i.e., the point where the stream flows from the longwall panel into the troughs). These changes may cause localised loss of catchment area and loss of in-stream habitat, and therefore, resulting in reduced habitat availability for macroinvertebrate species and aquatic flora at a local scale. Ponding is unlikely to impact habitat availability for other aquatic species such as fish and turtles, given that currently there is limited in-stream habitat for these species.

The current turbidity of water in Boomerang Creek and One Mile Creek typically exceeds the water quality guidelines values. The increased sediment load associated with the subsidence-induced localised erosion and change in sediment transport is not expected to impact water quality to the extent that aquatic ecology values will be negatively impacted.

Given the existing ephemeral streamflow conditions, expected in-filling of subsidence troughs, use of bank protection measures (if required) and the predicted minor changes to flows, subsidence-induced changes to stream bed morphology are considered unlikely to negatively impact habitat connectivity or 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.

During flood events, the subsidence-induced changes in flood regimes are not expected to significantly impact aquatic ecological values, given the adaptation of the aquatic flora and fauna to the existing relatively harsh environmental conditions.

No aquatic flora or fauna are recorded as MNES within, or considered likely to occur within, the study area. However, the potential impacts on the Fitzroy River Turtle and the Southern Snapping Turtle, were assessed in accordance with the MNES impact assessment hierarchy. As the subsidence area does not extend to their preferential habitat (e.g., Issac River), it is unlikely the two MNES species will be impacted by subsidence.

### 3.4.6 Wetlands

Hydraulic modelling has determined that subsidence will likely cause alteration to the hydrology of three VM Act wetlands and may impact vegetation within the mapped wetlands. The three VM Act wetlands are located within the stage three subsidence area and are expected to be significantly impacted as described below:

- the 1.8 ha wetland located 400 m to the south of Boomerang Creek will experience an increase in the frequency and duration of ponding, which is expected to be detrimental to fringing vegetation;
- 0.8 ha of the 3.5 ha wetland located between Boomerang Creek and One Mile Creek will receive reduced periodic inundation, which is expected to be detrimental to the vegetation of the wetland; and
- the 2.1 ha wetland located between Boomerang Creek and One Mile Creek will not receive periodic inundation as a result of a longwall pillar being located under the wetland.

The total area of wetlands of RE being impacted exceeds the thresholds relevant to the vegetation structure categories. Therefore, a significant residual impact is expected to occur to 4.7 ha and offsets will be established.

The subsidence may cause a reduction in the extent of inundation at VM Act wetlands, and therefore, negatively impact the aquatic flora and fauna species composition. This is likely to impact only on some common species within the local area but is unlikely to significantly impact on any threatened species. During flood events, the wetland areas within the study area are all expected to receive water, despite the change in the flood regimes.

There are no HES wetlands within the Project area, therefore, no direct impact on HES wetland will occur. However, there are 10 HES wetlands in the vicinity of the Project, both to the north and east, which may be indirectly impacted through changes to hydrogeological or hydrological flows. All HES wetlands are assessed to be surface features with limited infiltration of surface water into underlying sediments and no inferred hydraulic linkage between surface waters and groundwater, except for HES wetland 8 and HES wetland 10 (Figure 2.9). HES wetland 8 is identified as a type 2 GDE formed through the presence of a perched lens of fresh groundwater lying at depth below the wetland pan. HES wetland 10 is also identified as a potential GDE but will be removed by the approved Olive Downs Coking Coal Project (DPM Envirosciences 2018) and therefore, will not be subject to impacts resultant of the Project.

Given the hydrogeological nature of the HES wetlands and the measures proposed for the management of impacts to Groundwater-Dependent Ecosystems, it is considered unlikely that the Project will impact any HES wetlands resultant of groundwater drawdown.

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.

Gilgai wetland systems have also been identified, but since these features are not groundwater features and therefore there is no predicted groundwater related impacts to gilgai wetlands.

## 3.5 Groundwater

The impacts of subsidence on groundwater, GDEs, and stygofauna are discussed in this section.

As subsurface cracking may provide new flow paths for groundwater and alter the permeability of the strata overlying longwall mining areas, groundwater level drawdown is predicted by groundwater modelling. The base-case scenario assumed a zone of continuous fracturing extending to approximately 120 m above the extracted seam for a single-seam mining scenario and zone of continuous fracturing extending to approximately 180 m above the extracted seam for a dual-seam mining scenario. A worst-case scenario, which assumes the continuous fracturing to surface, has also been assessed. The results show that the extent of groundwater level drawdown for the two scenarios are similar and the majority of additional drawdown for the fracture-to-surface scenario is observed in the area above the mining panels. It is also predicted that the maximum extent of groundwater level drawdown will occur at the end of mining but will recover and post-mining groundwater levels may be above pre-mining level in some areas.

A post-mining conceptual groundwater model shows the main groundwater level impacts that relate to deformation of the strata are restricted to the zone within the angle of draw, i.e. the angle between the end of the underground workings and the point on the ground surface to which subsidence may extend.

There may be an increase in permeability but this is not likely to result in significant inflows to the underground mine workings. The rate of groundwater inflow to the underground workings for the base-case model was compared to the modelled potential increase in vertical hydraulic conductivity (limited to 2-orders of magnitude above the unfractured hydraulic conductivity) due to fracturing. Under the fracturing scenario, the total volume of groundwater that is predicted to be taken over the life of the Meadowbrook underground mine is 5,110 ML, at an average of approximately 204 ML/year.

Impacts to groundwater resources are regulated/managed through Schedule D of the proposed EA.

### 3.5.1 Groundwater dependent assets

The risk of impact on the GDEs within the Project impact area is identified as 'low to insignificant' due to the following:

- The recharge of sandy lenses is controlled by surface flows and surface water infiltration into the soil profile. As such, there will be no significant impact on surface flows or flood regimes that will act to recharge the groundwater source that supports GDEs.
- The groundwater perched in the alluvial systems is subject to natural fluctuations in volume in response to changing seasonal conditions and may dry for significant periods.
- Tree species that characterise the riparian GDE areas are resilient and have the capacity to adapt to possible minor reductions in soil moisture that may propagate in areas of predicted drawdown.

The assessment has determined that there is no significant residual risk to the GDEs in the vicinity of the Project; however, ongoing monitoring is proposed.

The stygofauna identified in the Project area are of low ecological value, and potential Project impacts on groundwater present a low risk to stygofauna.

## 3.6 Cultural Heritage

### 3.6.1 Indigenous cultural heritage

Project activities involving surface disturbance may present a risk of harm to Indigenous cultural heritage items, including potential residual items not identified by completed survey works. Potential impacts of the Project on residual Indigenous cultural heritage will be managed during the construction and operational phases of the Project, pursuant to the existing CHMP and Bowen Basin Coal's statutory duty of care.

Subsidence resulting from underground longwall mining has the potential to impact on identified Indigenous cultural heritage items (e.g. scar trees). Indigenous cultural heritage survey work has identified that seven scar trees exist above or in close proximity to the proposed underground mine workings. The locations of these scar trees are shown in Figure 2.10. While subsidence impacts are not anticipated to damage or destroy mature trees, consistent with the obligations of the existing CHMP, Bowen Basin Coal has engaged with the Barada Barna People in respect of the potential impacts to scar trees resultant of the Project. Should it be considered appropriate, salvage of scar trees would occur in conjunction with the processes established within the CHMP.

### 3.6.2 Non-Indigenous cultural heritage

Whilst eight places of potential non-Indigenous cultural heritage significance have been identified in the vicinity of the Project site, only the blaze tree, cattle yard and loading ramp and molasses lick are located within the vicinity of the underground mining footprint (Figure 2.11). These features are considered unlikely to be impacted by subsidence.

There is low potential for additional historic places/items to exist within the subsidence area. Any unidentified sites would likely consist of sites relating to pastoral activities, dams, historic survey trees and remnant boundary fence lines.

## 3.7 Cumulative

### 3.7.1 Surface water

Cumulative impact assessment for surface water has been conducted using hydrological and hydrogeological modelling, which included all current and known future coal mining operations. Cumulative impacts on flooding have been assessed using a TUFLOW model. The potential cumulative impacts are described in the Surface Water Impact Assessment (WRM 2023c) and Flood Modelling Assessment (WRM 2023a) and are summarised below.

The cumulative impacts on loss of catchment and associated reduction in stream flows in the Issac River catchment are relatively small, as the Project only accounts for less than 0.26% of the total area of Issac River catchment and the combined area of the existing projects are less than 10%. The loss of catchment impacts will also be mitigated through the proposed pumping regime to be implemented during significant ponding conditions (refer Section 3.3.4).

Regional flood modelling has determined that cumulative flooding impacts of the Project and the approved Olive Downs project will extend onto the Isaac River floodplain downstream of the Project. However, the flooding impacts of the Project will be minor, and the cumulative impact of the Project and the Olive Downs project will also be minimal.

### 3.7.2 Groundwater

Cumulative impact assessment has been conducted using groundwater modelling, which included all current and known future coal mining operations. These cumulative impacts have been described in the Groundwater Impact Assessment (JBT Consulting 2023) and are summarised below.

Cumulative drawdown was not assessed for the Quaternary alluvium as the unit is generally dry in the Meadowbrook project area and the modelling report (SLR 2022) predicts little to no drawdown to alluvial groundwater units in the area, including no impacts from the Meadowbrook Project to the Isaac River alluvium. Therefore, the units discussed in this section include the Tertiary sediments (Layer 2), the Rewan Group (Layer 3), the Leichhardt Coal Seam (Layer 5) and the Vermont Coal Seam (Layer 7).

In Tertiary sediments, drawdown from the Meadowbrook operation, is predicted to result in an additional 2 to 10 m of drawdown beneath Boomerang Creek and an additional 2 to 15 m of drawdown beneath Ripstone Creek. None of the drawdown beneath the Isaac River is attributable to the Meadowbrook Project.

In the Rewan Group, the Project will increase drawdown by 5 to 50 metres to the north of the Meadowbrook underground mining area. Drawdown at the south of Boomerang Creek will not be cumulatively impacted by other projects, and Meadowbrook will not contribute to drawdown at the eastern block of the Rewan Formation.

In the Leichhardt Seam, drawdown to the north of the Meadowbrook underground mining area increases by 10 to 50 m, with this drawdown attributable to mining at Eagle Downs and Olive Downs South. Meadowbrook will not contribute to drawdown at the eastern block of Permian Coal Measures.

In the Vermont Seam, drawdown to the north of the Meadowbrook underground mining area increases by 10 to 50 m, with this drawdown attributable to mining at Eagle Downs and Olive Downs South. Meadowbrook will not contribute to drawdown at the eastern block of Permian Coal Measures.

It was assessed that there would be limited risk to GDEs as the HES wetlands in the Project area are not groundwater dependent.

### 3.7.3 Ecology

Findings of the Meadowbrook cumulative impact assessment indicate that the Project is unlikely to contribute to cumulative impacts on the following terrestrial and aquatic MNES at the subregional scale:

- the Brigalow TEC;
- the Poplar Box TEC;
- Ornamental Snake habitat;
- Squatter Pigeon habitat;
- Koala habitat;
- Greater Glider habitat;
- Fitzroy River turtle; or
- Southern Snapping Turtle.

# 4 Monitoring and reporting program

## 4.1 Background

Monitoring will be undertaken pre- and post-subsidence to assess and validate subsidence predictions against the actual subsidence impacts. The full impact of subsidence is not likely to be evident until mining of each section of panels in the Vermont Lower seam in the south and the north of the underground footprint is complete. Land subject to subsidence will be observed for an additional three wet seasons to allow time for surface cracking to naturally rehabilitate, at which time the land will be considered available for rehabilitation, and the rehabilitation sequence will commence.

Monitoring will determine if any areas of subsidence require mitigation activities prior to the commencement of the rehabilitation sequence proper, to prevent environmental harm.

## 4.2 Monitoring program elements

This section provides an overview of the monitoring requirements pre and post subsidence to ensure relevant data is captured with respect to monitoring impacts to landform, surface water and ecology.

### 4.2.1 Landform

A ‘Baseline Lidar Survey’ will be undertaken (prior to underground longwall mining commencement) to determine pre-subsidence topographic conditions of the future subsided area.

An 'Initial Assessment Report’ will also be prepared (prior to underground longwall mining commencement) to provide a summary of pre-mining landform conditions. Subsided longwall panels will then be inspected annually by a suitably qualified and experienced person, to assess topographical changes occurring due to subsidence. ‘Annual Monitoring Inspections’ will utilise ground survey methodologies and reference available Lidar information. Lidar survey is proposed to be flown at maximum 2 year intervals. It is noted that Lidar provides high accuracy topographic survey information that enables landform changes to be tracked over time.

Results and analysis of data collected through ‘Annual Monitoring Inspections’ will be presented through an ‘Annual Subsidence Monitoring Report’. This report will be provided to the administering authority on request.

### 4.2.2 Surface cracking, soil erosion and ponding

A ‘Baseline Lidar survey’ will be undertaken to determine pre-subsidence topographic conditions.

An 'Initial Assessment Report’ will also be prepared (prior to underground longwall mining commencement) to provide a summary of pre-mining landform conditions. ‘Annual Monitoring Inspections’ will then be undertaken across subsided areas, including for a period of at least three wet seasons following completion of each longwall panel, to ensure identification of surface cracking, soil erosion and/or instances of ponding.

#### 4.2.2.1 Surface cracking

Subsidence areas containing self-mulching soils, such as the cracking clays that occur over much of the southern portion of the Project site, are not expected to require remediation of minor cracks. These will resolve through geomorphological processes over time.

Areas of surface cracking will be monitored over a period of three wet seasons to determine if mitigation measures are required. After this period, areas containing unhealed surface cracks will be scarified or ripped to fill minor cracks, control erosion and assist revegetation. Larger or persistent cracks that are identified as requiring remediation will be rehabilitated through removal of topsoil, backfilling, re-spreading of topsoil, and natural regeneration and recruitment.

The locations of conservation significant species and ecosystems will be carefully considered during the planning and completion of remediation with the use of machinery limited to that suitable for such sensitive areas. The SMP will integrate an adaptive management approach such that when unpredicted subsidence impacts and environmental consequences occur, previously approved processes will be considered to prevent their re-occurrence. Livestock should be excluded from potential subsidence areas prior to the commencement of mining in that area. Livestock may be allowed to access subsided areas once subsidence is no longer actively occurring, and the area has been deemed stable in accordance with the relevant rehabilitation milestone criteria.

#### 4.2.2.2 Soil erosion

Changes in hydrological regimes may cause erosion. To secure stream banks and prevent streambank erosion, temporary or permanent bank protection measures will be applied as needed, which may include:

- revegetation of stream banks;
- exclusion of stock from stream bed and banks;
- placement of soft material along the stream banks; and
- construction of rock armouring.

Natural mitigation and rehabilitation measures, such as revegetation and fencing to exclude stock along the stream banks, will be preferred over artificial structures to stabilise banks, prevent erosion and maintain streamflow. Where artificial structures are required, soft material, such as woody debris, jute matting, and coir logs, will be placed to further assist in erosion management and rehabilitation. Rock armouring will be used if other bank protection measures are not effective.

To promote the movement of water and sediment, therefore, to promote the recovery of One Mile Creek from bed erosion, the existing upstream farm dam on One Mile Creek may be decommissioned prior to the commencement of mining.

Where subsidence-induced erosion is observed to have arisen, and is assessed as being unlikely to self-remediate, repairs (rehabilitation works) will be recommended to be undertaken as soon as practicable. Erosion repairs will be managed through the operation of this Subsidence Management Plan.

#### 4.2.2.3 Ponding

Instances of ponding will be monitored as part of ‘Annual Monitoring Inspections’, including collection of data on depth and extent of ponding. Existing site rainfall records will be referenced to assist annual analysis of ponding information. Opportunistic inspections of ponded areas (such as following rainfall events and/or during REMP sampling) should also be adopted to support ongoing data availability on ponds. Permanent depth markers (staff gauges) will be established at key pond monitoring sites, with photographic monitoring points also to be established. Suitable locations for photographic monitoring points and the installation of staff gauges will be identified in the ‘Initial Assessment Report’.

Results and analysis of data collected through ‘Annual Monitoring Inspections’ will be presented through an ‘Annual Subsidence Monitoring Report’. This report will be provided to the administering authority on request.

Drainage works will be implemented to mitigate changes in surface water flow and the pooling of water in subsided areas and are ultimately expected to reduce the extent and duration of ponding (Figure 4.1).

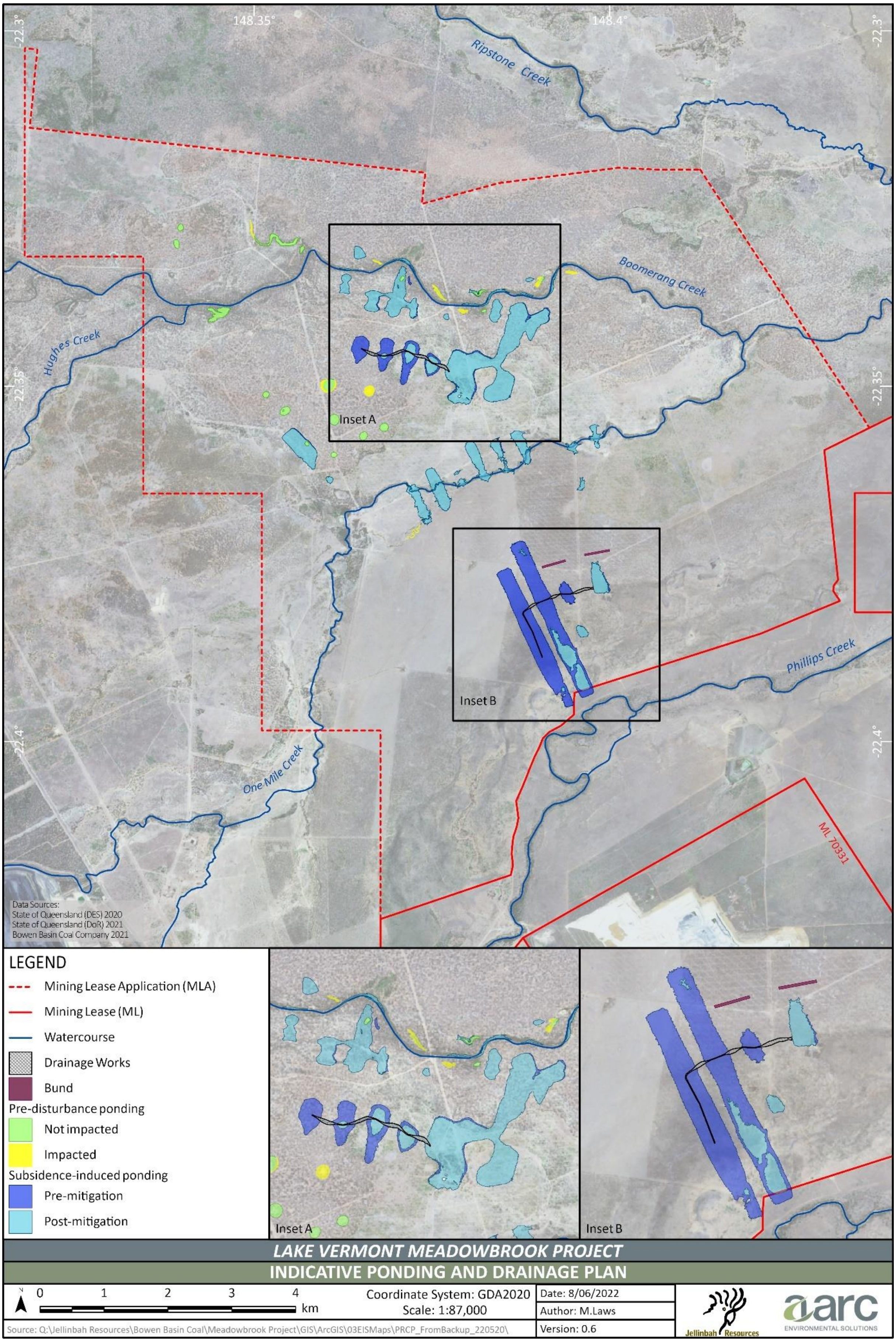


*Figure 4.1: Indicative mitigation drainage channels and mitigation bunds*

Drainage mitigation works (per Figure 4.1) include:

- A drainage channel (mitigation drain) to alleviate the extent of downstream ponding within the subsidence panels immediately to the north of Phillips Creek that will divert flows downstream to a tributary of Phillips Creek. This channel is proposed to drain the four subsided panels downstream, to the existing minor drainage path. The proposed earthworks would extend for approximately 2.5 km from the deepest point of the westernmost panel. The channel would be up to 2.8 m deep at the peak of each pillar and would have a base with of approximately 5 m – consistent with the existing floodplain channel in the area. In later stages of design, alternative alignments of the downstream reaches would be considered with a view to minimising the grade along the proposed flow path.
- the strategic placement of two small bunds (each approximately 1 ha) across subsidence panels to prevent floodwaters flowing north and into One Mile Creek.
- A drainage channel to alleviate the extent of ponding in the subsidence panels to the south of Boomerang Creek. This drainage channel is proposed to drain four subsided panels. The proposed earthworks would extend for approximately 1.4 km from the deepest point of the westernmost panel. The channel would be up to 3 m deep at the peak of each pillar, and would have a base with of approximately 5 m.

Where vegetation impacts occur due to ponding, grazing native vegetation areas will be revegetated with suitable native species adapted to the changed conditions to maintain ecosystem structure and function as far as practicable. A revegetation species list has been developed for subsidence areas subject to intermittent ponding where monitoring identifies a need for revegetation in grazing native vegetation areas. This list is based on the native vegetation communities already present at the Project site, with the selected species tolerant of any potential ephemeral ponding conditions (Table 4.1).

Some areas expected to be subject to intermittent ponding occur on sodic soils, which have a higher risk of erosion due to the dispersive qualities of the soil. These areas are predominantly on land to be rehabilitated to pasture. The ponded areas are expected to be deposition zones, however there is a risk of tunnel and gully erosion occurring on slopes. This risk will be minimised by instigating erosion control measures as soon as any areas of high erosion potential are identified and revegetating with appropriate pasture species to achieve sufficient groundcover to stabilise soils. Suitable pasture species are identified in Table 4.2.

*Table 4.1: Revegetation species list for subsidence areas subject to intermittent ponding*

| **Scientific name** | **Common name** | **Native Wetland indicator species** |
|---|---|---|
| Grasses and forbs | | |
| *Cyperus difformis* | Dirty Dora | Y |
| *Cyperus exaltatus* | Tall Flatsedge | Y |
| *Cyperus gracilis* | Slender Sedge | Y |
| *Echinochloa turneriana* | Channel Millet | Y |
| *Juncus aridicola* | Tussock Rush | Y |
| *Juncus usitatus* | Rush | Y |
| *Lomandra longifolia* | Longleaf Matrush | Y |
| Shrubs | | |
| *Sida rohlenae* | Shrub Sida | Y |
| *Acacia salicina* | Sally Wattle | Y |
| *Melaleuca nervosa* | Paperbark Tea-tree | Y |

| Scientific name | Common name | Native Wetland indicator species |
|---|---|---|
| Trees | | |
| *Melaleuca leucadendra* | Broad-leaved Tea-tree | Y |
| *Acacia harpophylla* | Brigalow | Y |
| *Eucalyptus platyphylla* | Poplar Gum | Y |
| *Lophostemon suaveolens* | Swamp Box | Y |
| *Corymbia clarksoniana* | Clarksons Bloodwood | Y |
| *Corymbia tessellaris* | Moreton Bay Ash | Y |

*Table 4.2: Grazing PMLU seed mix for subsidence areas subject to intermittent ponding*

| Scientific name | Common name |
|---|---|
| *Dicanthium aristatum* | Bluegrass |
| *Echinochloa frumentacea* | Japanese Millet |
| *Echinochloa turneriana* | Channel Millet |
| *Enteropogon ramosus* | Curly Windmill Grass |
| *Panicum coloratum* var. *makarikariense* | Bambatsi |
| *Panicum decompositum* | Native millet |

### 4.2.3 Creek channels

Mitigation and maintenance measures are expected to be required in some areas for several years following longwall retreat, with continued monitoring to assess the trajectory towards a stable condition.

Baseline Lidar survey' will be undertaken to determine pre-subsidence topographic conditions (including capture of channel geometry conditions for the affected sections of Boomerang Creek and One Mile Creek). Ongoing Lidar surveys (to be flown at maximum 2 year intervals) will then facilitate ongoing monitoring of Boomerang Creek and One Mile Creek channels, to detect potential subsidence induced changes to stream geometry.

An 'Initial Assessment Report' will also be prepared (prior to underground longwall mining commencement) to provide a summary of pre-mining stream conditions.

'Annual Monitoring Inspections' will then be undertaken along impacted sections of both Boomerang Creek and One Mile Creek (post-subsidence) to identify any impacts arising from subsidence. The physical form of the stream and geomorphological processes that shape the stream will be monitored at a range of sites along Boomerang Creek and One Mile Creek within the area of predicted subsidence, as well as sites outside the area of impact, which will function as control or reference sites. Subsidence monitoring transects shall be established in high risk areas within the upper, middle and lower sections of the impacted area along each creek, whilst control or reference transects should be established up to 1km upstream and downstream of the impact area.

Baseline and ongoing monitoring will involve visual observations and detailed photographic monitoring at the set monitoring locations. To detect subsidence-induced changes on watercourses, the pre- and post-mining monitoring program will monitor the following parameters:

- Geomorphic condition monitoring, involving visual observations and photographic monitoring of:
  - Pool/riffle/run sequences;
  - bank erosion;
  - sediment transport and channel alteration (sediment deposition, bar formation, scouring);
  - in-stream ponding;
  - tension cracking;
  - bank stability; and
  - channel profile and dimensions, channel slope, bank height
- water quality and biological variables in surface waters;
- riparian vegetation health (foliar discoloration, dieback, uprooting and tree mortality);
- flow conditions; and
- wetland conditions and hydrology.

Monitoring will also be undertaken within One Mile Creek and Boomerang Creek in accordance with the Receiving Environment Monitoring Program (REMP) for the Project. The REMP will be designed to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows resultant of the Project's activities. Available REMP reports will also be considered as part of the annual subsidence monitoring and reporting process.

Results and analysis of data collected through 'Annual Monitoring Inspections' will be presented through an 'Annual Subsidence Monitoring Report'. This report will be provided to the administering authority on request.

### 4.2.4 Ecology

An 'Initial Assessment Report' will be prepared (prior to underground longwall mining commencement) to provide a summary of pre-mining ecology conditions.

'Annual Monitoring Inspections' will include a vegetation monitoring program for the collection of ongoing data to assist with the management of associated risks to flora and fauna values, validate subsidence predictions and analyse the relationship between subsidence effects and impacts on the surrounding habitat values.

Vegetation monitoring will occur along the set landform monitoring transects following the completion of longwall mining within each relevant subsidence area. Baseline vegetation composition and habitat data has been collected for the footprint of the subsidence area and has informed the development of revegetation species lists.

'Annual Monitoring Inspections' will assess vegetation health as an indicator of subsidence-induced vegetation impacts. Indicators of declining vegetation health may include foliar discolouration, defoliation, signs of pathogenic attack and death.

Vegetation monitoring transects will be established in subsidence areas in accordance with the monitoring assessment methods defined in Section 4.3.1.3. 'Annual Monitoring Inspections' for subsidence-induced impacts to vegetation communities will include the following parameters:

- for each strata (emergent, canopy, sub-canopy and understory) the dominant species, their height class and lifeform will be identified;
- foliage projective cover for each strata;
- cover of coarse woody debris;

- groundcover composition;
- vegetation health; and
- fauna utilisation, whereby species may be detected through:
    - bird survey;
    - active searching (for frogs and reptiles); and
    - passive observation of fauna and indicators of their presence (e.g. scats, scratch marks, tracks).

Results and analysis of data collected through 'Annual Monitoring Inspections' will be presented through an 'Annual Subsidence Monitoring Report'. This report will be provided to the administering authority on request.

Areas of residual ponding will also be monitored to assess habitat suitability for the Ornamental Snake (and their prey species) by monitoring ponding depth and duration, presence of aquatic vegetation and the availability of surface soil cracks in the vicinity of ponded areas. Depending on the abundance of soil cracks, these may be measured along the transect or in 1m quadrants to provide a relative abundance.

## 4.3 Monitoring program sequence

The main elements and sequence of this subsidence monitoring program are outlined below:

- A 'Baseline Lidar survey' will be undertaken to determine pre-subsidence topographic conditions (**prior to underground longwall mining commencement**). The content and function of the 'Baseline Lidar Survey' is detailed through Section 4.3.1.1 of this plan.
- An 'Initial Assessment Report' will be prepared (**prior to commencement of underground longwall mining operations**) to provide a summary of pre-mining conditions. The content and function of the 'Initial Assessment Report' is detailed through Section 4.3.1.2 of this plan.
- 'Annual Monitoring Inspections' will be undertaken (**each calendar year**) to identify any areas of observable or measurable impact that might be associated with subsidence or associated surface disturbance. Monitoring will be accomplished by observations along set transects and any identified zones more at risk to subsidence impacts. Monitoring will also include establishment of depth gauges to measure pond water depth, as well as establishment of photographic monitoring points. 'Annual Monitoring Inspections' will continue until subsidence movement in the northern subsidence area is considered to have finalised.
- An 'Annual Subsidence Monitoring Report' will be prepared (**annually, within 3 months of the completion of each Annual Monitoring Inspection**) to provide the results and analysis from the monitoring event(s), as well as detail any required repair/rehabilitation activities.
- Periodic review of the operation of the Subsidence Management Plan, through preparation of a 'Subsidence Management Plan Review Report' (**every 4 years, following the commencement of underground longwall mining**).

### 4.3.1 Monitoring program deliverables

#### 4.3.1.1 Baseline Lidar Survey

The 'Baseline Lidar Survey' will be undertaken prior to commencement of underground longwall mining operations, across the predicted subsidence area.

Airborne laser scanning (ALS) is to be undertaken at the following times:

- prior to commencement of longwall panel operations within the southern and northern underground mining areas;
- prior to commencement of longwall panel operations within the underlying Vermont Lower seams; and
- at intervals not exceeding 2 years.

Slope changes and areas of surface soil loss or gain by can be determined by DEM of Difference analysis from this ALS data in comparison with that of the pre-mining condition ALS survey.

#### 4.3.1.2 Initial Assessment Report

Preparation of the 'Initial Assessment Report' will present the Baseline Lidar survey results, while also presenting the information collected from the pre-mining surveys, prior to subsidence impacts occurring.

The 'Initial Assessment Report' will establish the monitoring transects for ongoing impact observations, and identify suitable locations for photographic monitoring and the installation permanent depth markers (staff gauges). The 'Initial Assessment Report' will also establish monitoring locations in consideration of Project risk zones (as detailed below).

As part of the initial assessment, pre-impact consideration will be provided to existing landform conditions, existing erosion, existing channel conditions (watercourses and drainage lines), as well as existing ecological conditions. This report will therefore provide an important record of baseline environmental conditions prior to subsidence impacts occurring.

***Longwall transects***

Ground survey transects will be established both parallel to the progressing longwall panel on either side of the panel, and perpendicular to the progressing panel. Each transect will consist of eight (8) observation sites.

Each monitoring event will include:

- Observations along specific transects, using a specific check-sheet, to identify:
  - instances of erosion, cracking, ponding or drainage impediment;
  - instances of vegetation change or other impacts including a description and photographic record.
- Ground survey along transects to identify/ confirm:
  - elevation and slope changes;
  - location of any surface cracking or other impacts.
- A photographic record to be made at each observation site i) along the line of transect, ii) perpendicular to line of transect, iii) land surface condition, cracking, at all four cardinal points.

*Risk zones*

Risk zones will be identified within the subsidence area based on areas expected to have a greater risk of impact from subsidence or surface disturbance. These zones will include areas where slope changes are predicted to be greatest or where existing surface conditions (slope, drainage) or ecosystems may be more susceptible to impacts. Any areas where specific mitigation or restoration works are deemed to be required (and undertaken) will be included as a risk zone and mapped accordingly.

Risk zones will be subject to random meander surveys and observations with each monitoring event comprising:

- Observations made during random meander surveys to identify:
  - instances of erosion, including a description and photographic record;
  - instances of vegetation change or other impacts including a description and photographic record;
  - instances of surface cracking, including survey of initial large cracks observed, and photographic record; and
  - surface ponding, prolonged wetness or drainage impediment, including marking of the occurrence and estimation of areal extent, and photographic record.
- A photographic record to be made where any instances of potential impact are identified.
- Any changes effected by ongoing restoration activities.

Results and outcomes from this sequence of monitoring events and any resulting restoration activities will be collated and reported following completion of longwall mining activities in the area.

#### 4.3.1.3 Annual Monitoring Inspections

'Annual Monitoring Inspections' will be undertaken annually from the commencement of longwall mining activities. 'Annual Monitoring Inspections' will replicate the survey methodology adopted within the 'Initial Assessment Report'. The purpose of annual monitoring is to identify any areas of impact associated with subsidence, or associated surface disturbance.

Monitoring efforts will focus on risk zones identified within the subsidence area, including areas of predicted maximum slope, any existing drainage lines, and areas of surface disturbance. Within the risk zones, random transects or meandering survey will be established where appropriate.

Monitoring will be accomplished by observations along set transects and any identified zones more at risk to subsidence impacts. Monitoring events will continue until material subsidence is considered to have finalised (expected to be three wet season cycles following completion of longwall mining activities). Monitoring transects and high-risk zones are required to be established/ identified within ponded areas, areas of ecological significance, and waterways within subsidence impact areas.

Impact monitoring will also identify areas requiring any repairs or rehabilitation works.

#### 4.3.1.4 Annual Monitoring Assessment Reports

Preparation of the 'Annual Subsidence Monitoring Report' will be undertaken annually from the commencement of longwall mining activities. The 'Annual Subsidence Monitoring Report' will identify any impacts associated with subsidence, or associated surface disturbance.

The 'Annual Subsidence Monitoring Report' will report on the annual monitoring inspections. Each subsided longwall panel is to be inspected annually by a suitably qualified and experienced person in accordance with conditions G22 to G24 of the EA. The 'Annual Monitoring Assessment Report' must be prepared each calendar year, within 3 months of completing the annual monitoring inspections. The 'Annual Monitoring Assessment Report' must be made available to the administering authority, on request.

Any monitored areas identified to require repair or restoration activities will be identified through the 'Annual Monitoring Assessment Report'. Repair works will be presented as required actions. Subsequent 'Annual Monitoring Assessment Reports' will then assess the effectiveness of the completed restoration activities.

In the event that major repair or restoration work requirements arise, these works should be captured within the Progressive Rehabilitation and Closure Plan (PRCP) and scheduled accordingly. It will be important therefore, that future PRCP developments consider the information becoming available through the operation of this Subsidence Management Plan.

Subsidence Monitoring data will be compiled and managed in a Project monitoring database to support internal and external reporting purposes. Monitoring and internal reporting will be completed in stages according to the sequence of underground mine development.

In accordance with condition G24 of the EA, annual reports are to be certified by a suitably qualified and experienced person and provided to the administering authority upon request.

The scope of the 'Annual Monitoring Assessment Report' should include:

- an assessment of landform conditions (consistent with Section 4.2.1 of this plan);
- an analysis of surface cracking (consistent with Section 4.2.2.1 of this plan);
- an analysis of any erosion arising (consistent with Section 4.2.2.2 of this plan);
- an analysis of ponding impacts (consistent with Section 4.2.2.3 of this plan);
- an analysis of creek channel/geomorphic conditions (consistent with Section 4.2.3 of this plan);
- collection and analysis of ecological data (consistent with Section 4.2.4 of this plan);
- development of recommendation actions (including required repairs or rehabilitation works); and
- an assessment of the adequacy of any completed repair works or recommended actions from the previous monitoring period.

## 4.4 Review of this Subsidence Management Plan

This Subsidence Management Plan should be reviewed every four years, through the preparation of a 'Subsidence Management Plan Review Report'. This report will be made available upon request of the administering authority, in accordance with EA condition G20.

The review of the Subsidence Management Plan will assess the operation of the plan against EA condition G19, including recommended actions and identification of any amendments required to the Subsidence Management Plan.

# 5 Residual Risk Assessment

A residual risk assessment was developed to inform the SMP and should be reviewed on an annual basis as part of the SMP review process. The residual risk assessment provides a summary of the potential risk scenarios, causes, impacts and controls as described through this SMP. The assessment methodology and outcomes are detailed in Appendix A.

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# Appendix A. Residual Risk Assessment

## A1.1 Risk assessment requirements

A risk assessment has been carried out in accordance with the following standards:

- AS/NZS ISO 31000:2018 Risk management - Guidelines; and
- HB203:2012 Managing environment-related risk.

## A1.2 Risk assessment process

For this risk assessment, risk scenarios (or 'threats') were identified and considered for both riparian and terrestrial areas associated with subsidence. The causes attributable to each risk scenario were documented as well as the potential impacts. Existing controls were noted, defined as those reasonably expected to be in place for a Project of this nature and having appropriate and contemporary management systems. Each risk scenario was then assessed with respect to health, safety, the environment and compliance against the risk assessment schema outlined in Section A1.3.

## A1.3 Risk assessment schema

Risks specific to subsidence were classified using the risk classification schema described below. The risk assessment schema used is comparable to those used widely within the mining industry and comprises the following components:

- a control effectiveness ranking (Table A) used for assessing the operational controls expected to be in place for a project of this type;
- a likelihood classification descriptors table (Table A); and
- a consequence classification descriptors table (Table A) intended to guide a consistent assessment of consequence.

Following a consensus determination of likelihood and consequence, the risk level was determined using the matrix shown in Table A. For any risks classified as 'significant' or above, additional mitigation and management measures were identified and documented. Mitigation and management measures were also documented for some lower-level risks, where these were considered to be feasible if required.

*Table A.6.1: Control effectiveness ranking*

| Control Rank | Description | Guidance |
|---|---|---|
| C1 | Substantially effective/adequate design | Controls considered adequate and operating effectively on almost all occasions |
| C2 | Mostly effective/adequate design | Controls considered adequate and operating effectively on most occasions |
| C3 | Inadequate design/partially effective | Controls considered inadequate or only operating to partial effectiveness on most occasions |
| C4 | No controls/ineffective | There are no controls, or the existing controls are operating ineffectively on all occasions |

*Table A.6.2: Likelihood of exposure to the hazard*

| Level of Risk Probability | Descriptive Guidance | Probability | Frequency |
|---|---|---|---|
| Highly Likely | The event is expected to occur in most circumstances | >25% | The event and consequence is expected to occur at least twice per year |
| Likely | The event will probably occur in most circumstances | 10% - 25% | The event and consequence is expected to occur once to twice per year |
| Possible | The event could occur at some time | 1% - 10% | The event and consequence is expected to occur at least once in 1 to 10 years |
| Unlikely | Not expected but the event may occur at some time in the future | 0.1% - 1% | The event and consequence is expected to occur at least once in 10 to 100 years |
| Rare | The event may occur only in exceptional circumstances | <0.1% | The event and consequence is expected to occur less than once in every 100 years |

## A1.4 Risk assessment outcomes and management

In total, 17 subsidence-related risk scenarios or hazards were identified and assessed. All the risks are Class I or Class II. No risk has been identified as Class III or Class IV. The final outcomes of the risk assessment are detailed in Table A which provides a summary of the risk classifications for riparian and terrestrial subsidence areas. The detailed risk assessment outcomes are included below in Table A.

*Table A.6.3: Consequence classification descriptors*

| **Category** | **Consequence Scale** | | | | |
|---|---|---|---|---|---|
| | **1. Very Low** | **2. Low** | **3. Moderate** | **4. High** | **5. Very High** |
| **Safety & Health** | • Reversible health effects of little concern<br>• Low-level, short-term subjective symptoms<br>• First aid treatment | • Reversible health effects of concern<br>• Medical treatment<br>• Reversible injuries requiring treatment, but not leading to restricted duties | • Severe reversible health effects of concern<br>• Lost time illness/injury<br>• Reversible injury or moderate irreversible damage to one or more persons | • Single fatality or irreversible health effects or disabling illness or severe impairment to one or more persons | • Multiple fatalities or serious disabling illness to multiple people |
| **Environmental** | • Near-source confined and promptly reversible impact (a shift) | • Near-source confined and short-term, promptly reversible impact (a week) | • Near-source confined and medium-term recovery impact (on-site a month, off-site a week) | • On-site impact that is unconfined and requiring long-term recovery or residual impact<br>• off-site impact that is near-source confined<br>• recovery on-site = years, off-site a month | • Impact that is widespread unconfined and requiring long-term recovery, leaving major residual damage |
| **Legal/ Compliance/ Regulatory** | • Non-conformance with internal requirement with very low potential for impact<br>• Non-compliance with community commitment goes unnoticed by external parties, minimal effort to correct | • Non-compliance with external or internal requirement with low potential for impact<br>• Formal censure<br>• Non-compliance with community commitment, requiring limited effort to correct | • Non-compliance with internal/external requirement with moderate impact<br>• Moderate penalties for breach of permit<br>• Non-compliance with community commitment reported formally | • Breach of licence(s), regulation with high potential for prosecution<br>• Systemic internal standards breach-high impact<br>• Community commitment breach | • Suspended or severely reduced operations imposed by regulators<br>• Breach of community commitment results in direct loss of established consents |

*Table A.6.4: Risk level classification matrix*

| Likelihood | Consequence | | | | |
|---|---|---|---|---|---|
| | **Very Low** | **Low** | **Moderate** | **High** | **Very High** |
| **Highly Likely** | Class II | Class III | Class IV | Class IV | Class IV |
| **Likely** | Class II | Class III | Class III | Class IV | Class IV |
| **Possible** | Class I | Class II | Class III | Class IV | Class IV |
| **Unlikely** | Class I | Class I | Class II | Class III | Class IV |
| **Rare** | Class I | Class I | Class II | Class III | Class III |

*Table A.6.5: Risk assessment outcomes by subsidence area*

| Subsidence area | Risk level | | | | |
|---|---|---|---|---|---|
| | **Class I** | **Class II** | **Class III** | **Class IV** | **Total** |
| Riparian areas | 1 | 5 | 0 | 0 | **6** |
| Terrestrial areas | 4 | 7 | 0 | 0 | **11** |
| **Total** | **5** | **12** | **0** | **0** | **17** |

*Table A.6.6: Risk assessment*

| Ref. | | | | Risk Description | | | | | Risk Evaluation | | | | | | Risk Rating | | | | Count | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Risk Type (T=Threat) | Category | Subcategory | Item | Risk Scenario/Threat Title | Causes (Triggers / Indicators) | Impacts (Consequences) | Controls | Control Effectiveness | Likelihood - Frequency | Likelihood - Probability | Health | Safety | Environment | Compliance | Health | Safety | Environment | Compliance | IV | III | II | I | Final Risk Rating |
| **T** | **B** | | | **Subsidence areas (riparian)** | | | | | | | | | | | | | | | | | | | |
| **T** | **B** | **01** | | **Safe** | | | | | | | | | | | | | | | | | | | |
| T | B | 01 | 01 | Surface roughness (rockiness, depressions) in excess of that expected for the PMLU | Erosion gullies etc due to some dispersive subsoils/ topsoils, inadequate surface preparation, localised settlement | Safety hazard for personnel, stock and wildlife | Surface preparation measures (initial), maintenance controls (pre-closure), rehabilitation monitoring and assessment, undertake repairs and maintenance as required. | **C2** | | U | | L | | | | I | | | 0 | 0 | 0 | 1 | I |
| **T** | **B** | **03** | | **Stable - erosional risk** | | | | | | | | | | | | | | | | | | | |
| T | B | 03 | 01 | Creek does not achieve geomorphic stability within scheduled timeframe | Erodible topsoils and subsoils, Adverse climatic events and/or climatic sequences beyond modelled capacity, rehabilitation failure/ vegetation disease/loss | Ongoing watercourse erosion, water quality impacts, bank stability impacts | Geomorphic monitoring program pre- and post-subsidence, adequate/effective subsoil and topsoil amelioration, prompt revegetation establishment, revegetation monitoring, revegetation maintenance and repairs as required, sediment controls as required, bank stabilisation / engineering controls if required. | **C2** | U | | | | M | M | | | II | II | 0 | 0 | 2 | 0 | II |
| **T** | **B** | **05** | | **Non-polluting - other environmental harm** | | | | | | | | | | | | | | | | | | | |
| T | B | 05 | 01 | Downstream water quality impacts and sedimentation | Erodible topsoils and subsoils, Adverse climatic events and/or climatic sequences beyond modelled capacity, Rehabilitation failure/ vegetation disease/loss | Water quality impacts, bank stability impacts | Geomorphic monitoring program pre- and post-subsidence, adequate/effective subsoil and topsoil amelioration, prompt revegetation establishment, revegetation monitoring, revegetation maintenance and repairs as required, sediment controls as required, bank stabilisation / engineering controls if required. | **C2** | U | | | | M | | | | II | | 0 | 0 | 1 | 0 | II |
| **T** | **B** | **06** | | **Sustainable - PMLU** | | | | | | | | | | | | | | | | | | | |
| T | B | 06 | 01 | Pests and weeds | Poor local, regional or site property management practices. | Increased risk of not achieving designated PMLU | Pest and weed management practices, monitoring programs to allow early detection and management. | **C2** | | U | | | M | | | | II | | 0 | 0 | 1 | 0 | II |
| T | B | 06 | 02 | Insufficient riparian habitat (native vegetation) density/diversity and recruitment | Weather, poor soil characteristics, poor management practices impacting germination, vegetation establishment and PMLU density/diversity metrics | Insufficient vegetation productivity | Adaptive rehabilitation methodologies, management and maintenance activities, rehabilitation performance monitoring and assessment, undertake revegetation improvement works as required. | **C2** | | U | | | M | | | | II | | 0 | 0 | 1 | 0 | II |
| **T** | **F** | | | **Subsidence areas (terrestrial)** | | | | | | | | | | | | | | | | | | | |
| **T** | **F** | **01** | | **Safe** | | | | | | | | | | | | | | | | | | | |
| T | F | 01 | 01 | Initial/ongoing surface cracking | Tensile strain around perimeter of subsidence troughs | Trip hazard for personnel, stock and wildlife | Monitoring and maintenance (pre- and post-mining), rehabilitation activities (infilling, regrading, revegetation etc) commencing after 3 wet seasons if required, rehabilitation area monitoring and assessment, undertake repairs and improvement works as required | **C2** | | P | | L | | | | II | | | 0 | 0 | 1 | 0 | II |
| T | F | 01 | 02 | Localised increases in slope | Subsidence | Trip hazard for personnel, stock and wildlife | Monitoring and maintenance (pre- and post-mining), rehabilitation activities (infilling, regrading, revegetation etc) commencing after 3 wet seasons if required, early assessment and localised remediation of assessed hazards | **C2** | | P | | L | | | | II | | | 0 | 0 | 1 | 0 | II |
| **T** | **F** | **02** | | **Stable - geotechnical risk** | | | | | | | | | | | | | | | | | | | |

| Ref. | | | | Risk Description | | | | | Risk Evaluation | | | | | | Risk Rating | | | | Count | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Risk Type (T=Threat) | Category | Subcategory | Item | Risk Scenario/Threat Title | Causes (Triggers / Indicators) | Impacts (Consequences) | Controls | Control Effectiveness | Likelihood - Frequency | Likelihood - Probability | Health | Safety | Environment | Compliance | Health | Safety | Environment | Compliance | IV | III | II | I | Final Risk Rating |
| T | F | 02 | 01 | Surface land disturbance beyond predicted subsidence | Unknown geological anomalies | Unpredicted surface disturbance, trip hazard for personnel, stock and wildlife | Surface monitoring to validate expected subsidence | C1 | | R | | L | | | | I | | | 0 | 0 | 0 | 1 | I |
| T | F | 02 | 02 | Post-closure residual subsidence | Potential long-term settlement | Unpredicted surface disturbance, trip hazard for personnel, stock and wildlife | Medium term monitoring surveys of additional subsidence | C1 | | R | | L | | | | I | | | 0 | 0 | 0 | 1 | I |
| **T** | **F** | **03** | | **Stable - erosional risk** | | | | | | | | | | | | | | | | | | | |
| T | F | 03 | 01 | Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas | Surface cracking exposing dispersive subsoils | Localised land impacts and downstream water quality impacts | Landform reshaping to moderate slope, infilling or regrading to stabilise cracks, prompt revegetation establishment, revegetation monitoring and management as required, sediment controls during establishment | C2 | | U | | | L | | | | I | | 0 | 0 | 0 | 1 | I |
| T | F | 03 | 02 | Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas | Inadequate rehabilitation drainage capacity and/or design | Localised land impacts and downstream water quality impacts | Drainage network design with acceptable design standards for drainage structures, avoidance of flow concentration, sub-catchment delineation, sufficient water storage structures, engineered flow channels, effective revegetation techniques, rehabilitation monitoring and management as required, regular (typically annual) review of water management design parameters, monitoring of drainage network performance, prompt remediation and causal feedback loop to water management system review | C2 | | U | | | M | | | | II | | 0 | 0 | 1 | 0 | II |
| T | F | 03 | 03 | Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas | Adverse climatic events and/or climatic sequences beyond design capacity | Localised land impacts and downstream water quality impacts | Landform design moderating slope, adequate/effective subsoil and topsoil amelioration, prompt revegetation establishment, revegetation monitoring and management as required, regular (typically annual) review of water management design parameters, monitoring of drainage network performance, prompt remediation and causal feedback loop to water management system review | C2 | | U | | | M | | | | II | | 0 | 0 | 1 | 0 | II |
| T | F | 03 | 04 | Initial/ongoing gully, pipe and/or sheet erosion of rehabilitated areas (medium-long term risk) | Rehabilitation failure/ vegetation disease/loss, climatic events (drought), other | Localised land impacts and downstream water quality impacts | Landform design moderating slope, adequate/effective subsoil and topsoil amelioration, prompt revegetation establishment, revegetation monitoring and management as required, modify revegetation methods and techniques and other contributing factors to improve the likelihood of revegetation success on rehabilitation slopes, rehabilitation area monitoring and assessment, undertake repairs and maintenance as required | C2 | | U | | | L | | | | I | | 0 | 0 | 0 | 1 | I |
| | | | | **End of record** | | | | | | | | | | | | | | | | | | | |