Central Queensland Coal Project

Appendix 10e – Groundwater Dependent Ecosystem Management and Monitoring Program

Central Queensland Coal

CQC SEIS, Version 3

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Groundwater Dependent Ecosystem Management and Monitoring Plan

Central Queensland Coal

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Abbreviations

Abbreviation	Description
CQC	Central Queensland Coal
DES	Department of Environment and Science
GDE	Groundwater Dependent Ecosystem
GDEMMP	Groundwater Dependent Ecosystem Management and Monitoring Plan
GMMP	Groundwater Management and Monitoring Plan
EIS	Environmental Impact Statement
ELA	Eco Logical Australia
EMP	Environmental Management Plan
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
MDL	Mineral Development Licence
ML	Mining Lease
MSES	Matters of State Environmental Significance
MNES	Matters of National Environmental Significance
REMP	Receiving Environment Monitoring Program
SEIS	Supplementary Environmental Impact Statement

1. Introduction

1.1 Background

Eco Logical Australia (ELA) has been engaged by Central Queensland Coal to develop a Draft Groundwater Dependent Ecosystem (GDE) Management and Monitoring Plan (GDEMMP) for the construction and operation of the Central Queensland Coal project (the Project) in the Styx Basin of central Queensland.

The Project is being assessed by the Queensland Department of Environment and Science (DES) through an Environmental Impact Statement (EIS) process under the *Environmental Protection Act 1994*. The Project is a controlled action under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), with assessment under the EPBC Act being facilitated by the bilateral agreement between the Commonwealth and Queensland governments.

An EIS and Supplementary EIS (SEIS v1) were prepared for the Project in November 2017 and May 2018 respectively, describing potential impacts of the Project on environmental values. Following review of SEIS v1 by DES and the Department of Agriculture, Water and the Environment (formally the Department of Environment and Energy), together with other key government stakeholders, further information was sought from Central Queensland Coal by the Departments. This information request was addressed in the December 2018 version of the SEIS (SEIS Version 2 or SEIS v2). A final information request from the Departments was submitted to Central Queensland Coal in June 2019. The issues and comments raised in the June 2019 information request are addressed in SEIS Version 3 or SEIS v3.

In response to the comments from regulatory agencies in June 2019, Central Queensland Coal undertook significant additional technical studies to support a revision of the SEIS material for SEIS v3. This included the completion of a new regional groundwater model (HydroAlgorithmics 2020), surface water modelling (WRM 2020), an assessment of groundwater and surface water interactions (ELA 2020a), GDE investigations (3D Environmental), transient electromagnetic (TEM) survey (Allen 2019), fluvial geomorphology study (Gippel 2020), analysis of surface water and groundwater data, including groundwater quality and water level data from several bores and stream flow data collected from gauges installed at Tooloombah and Deep Creek in 2019 (Orange Environmental 2020a, b), geological coring of the soil profile, observational pools surveys (Central Queensland Coal 2020a) and examination of aerial photography.

These additional studies have allowed for more detailed assessments to be made of potential Project impacts on groundwater and surface water resources. An assessment of impacts on groundwater dependent ecosystems (GDEs) has also been completed (ELA 2020b), based on results of the new technical studies.

The development of a draft GDEMMP addresses comments from regulatory agencies on SEIS v2 to provide further information on how impacts of the Project on GDEs will be avoided, minimised and managed by Central Queensland Coal. Accordingly, this draft GDEMMP has been prepared for submission to regulatory agencies for consideration as part of SEIS v3 (Central Queensland Coal 2020b).

It is anticipated that the draft GDEMMP will be further refined in consultation with regulatory agencies following completion of the EIS process, and in accordance with the conditions of an Environmental Authority (EA) issued by DES and an EPBC Act approval issued by the Commonwealth DAWE. The GDEMMP will also be subject to regular (annual) reviews and updates to incorporate the findings from ongoing implementation and associated monitoring.

1.2 Purpose

The purpose of this GDEMMP is to minimise and manage the environmental impacts of the Project on GDEs through the development of mitigation and monitoring measures for implementation prior to construction, during construction, during operations and post operations.

Objectives of the GDEMMP are as follows:

- Present the assessed impacts and threats to groundwater and ecological attributes for each of the GDEs.
- Detail the ecological and groundwater values that have been monitored during baseline phases of the Project.
- Identify management goals and triggers for each GDE, which will be refined over time as further information becomes available during the pre-impact and impact phases of the Project.
- Provide details of a monitoring program for both pre-impact and impact phases of the Project, including how this monitoring will build on existing baseline information, and inform the implementation of relevant mitigation, management and offset measures.
- Describe mitigation and management measures with specific criteria, timing, performance objectives, goals and corrective actions.
- Provide sufficient information on the intended management of GDEs to allow the Queensland and Commonwealth governments to make an assessment of the Project under relevant legislation.

1.3 Relationship with other plans

Central Queensland Coal has developed and will implement several other management plans to reduce the impacts of the Project on the environment. These include a Receiving Environment Monitoring Program (REMP; ELA 2020c), Offset Area Management Plan (C02 Australia 2020), Water Management Plan and Environmental Management Plan (EMP). This GDEMMP has a small number of specific management and monitoring measures related to GDEs, while also drawing upon several measures relevant to GDEs that are included in other management plans. There will be some interaction among the plans during all phases of the Project, with the results of monitoring informing the implementation of management actions.

The REMP has been developed to closely align with the GDEMMP and outlines how surface water monitoring will identify any Project-related impacts to environmental values of the receiving environment. Proposed controlled and uncontrolled releases will occur to the Styx River system and tributaries, which supports Subterranean, Aquatic and Terrestrial GDEs.

A separate Groundwater Management and Monitoring Plan (GMMP) has also been developed by Central Queensland Coal, and is included in the Project EMP. The GMMP describes the full range of groundwater monitoring that will be undertaken across the Project area to assist in managing impacts to groundwater values and validate the results of the regional groundwater model. Aspects of the GMMP that are relevant to GDEs have been summarised in this GDEMMP.

1.4 Structure of this management plan

This draft management plan has been developed to allow future amendments in consultation with regulatory agencies following completion of the EIS process. To facilitate practical implementation of management measures, this GDEMMP provides for the inclusion of ongoing review outcomes through an adaptive management framework.

A summary of key sections of the GDEMMP is provided below:

- A contextual description of the Project (**Section 2**).
- A description of the existing environmental and hydrogeological values within the Project area, including the supporting groundwater resources of GDEs (**Section 3**).
- The approach to the preparation of this GDEMMP (**Section 4**).
- A management plan for GDEs (**Sections 5)**.
- Arrangements for reporting and monitoring compliance with management plan actions (**Section 6**).

A single management plan is provided in **Section 5**, addressing each type of GDE, and is structured to provide the following information:

- Description of the ecological values of the GDEs.
- Distribution of the GDEs and relationship with the Project area and surrounding region.
- Relevant matters to be addressed under Commonwealth and Queensland legislation.
- Description of the baseline monitoring results and relevant studies.
- The assessed impacts of the Project on ecological and groundwater resources and associated threats to GDEs.
- The proposed monitoring program for the GDEs across the pre-impact and impact phases of the Project, to supplement baseline monitoring completed to date.
- Proposed triggers for groundwater and ecological values associated with each GDE.
- Details of mitigation and management measures to be implemented to avoid or reduce potential impacts on GDEs, including corrective actions.

This Draft GDEMMP has been prepared as part of the SEIS v3 documentation, and therefore has not been designed to address specific conditions of approval. However, the plan has been designed to be consistent with commonly applied approval conditions, and describes the relevant threats and potential impacts, management and mitigation measures, monitoring, ecological trigger levels and corrective actions. While this plan relates specifically to GDEs, the modes of impact considered within the plan cover all potential project-related activities, and are therefore not constrained to only those impacts related to groundwater interactions. In this context, a relatively broad consideration of the

GDE values has been applied, including for example, the potential for the GDE to provide habitat values for other significant ecological values (e.g. threatened fauna).

1.5 Definitions

The Study Area for the impact assessment and this associated management plan includes all areas that may be potentially impacted directly and indirectly by the Project, including adjacent terrestrial and aquatic lands and waters that may be affected by groundwater drawdown. The Study Area includes the mining tenures, adjacent watercourses, terrestrial areas containing aquatic habitats (e.g. wetlands), and estuarine and marine environments located downstream of the proposed mine, including the intertidal and subtidal areas of Broad Sound and the GBR.

The Disturbance Area is also referred to in this report, and includes the area that will be directly disturbed by construction and operation of the mine. The Disturbance Area includes all mine pits, roads, infrastructure, dams and associated constructed facilities. The Project Area generally refers to the mining leases (ML80187 and ML700022) and the surrounding local areas.

To assist with the conceptualisation of GDEs, the key terms shown in **Table 1-1** are defined and used in this management plan. The definitions are consistent with those provided in the IESC Guidelines (Doody et al. 2019), GDE Toolbox (Richardson et al. 2011), and as applied by the authors of various technical studies that supported the impact assessment (e.g. 3D Environmental 2020, HydroAlgorithmics 2020; WRM 2020; ELA 2020b). A conceptual representation of the definitions is provided in **Figure 1-1**.

Table 1-1: Key terms used in the discussion of GDEs

Term	Description
Alluvial corridor	A corridor comprising a creek or river, and the adjacent banks and associated riparian zone. Also referred to as the riparian corridor.
Aquifer	A geological formation or structure that stores water accessible by bores or springs. Aquifers typically supply economic volumes of groundwater.
Aquatic GDE	An ecosystem dependent on the surface expression of groundwater (e.g. river baseflow systems, springs)
Bank storage	Portion of the subsurface where water derived from infiltration associated with flooding is stored within the banks of creeks or rivers. During periods of high rainfall and associated creek flow, water levels in creeks rise, and surface water moves laterally into adjacent soils and alluvial sediments, infiltrating the stream bank (held in bank storage). There can be some uncertainty about when water held in bank storage meets the definition of groundwater, as it is applied to GDEs. Water held in bank storage may percolate downwards under gravity towards the aquifer underlying the riparian zone (if not connected to the regional water table aquifer),or be impeded by an impermeable layer of rock or clay. Once the water is captured through either of these mechanisms, the water meets the definition of groundwater as it relates to the assessment of GDEs. Water held in bank storage may be released to the adjacent creek or river over varying timescales following the recession of surface water levels. Water can also be stored in the bank for prolonged periods, where it may be accessed by Terrestrial GDEs.
Base flow	Streamflow derived from groundwater seepage into a stream.

Term	Description
Capillary fringe	The unsaturated zone above the water table containing water held by soil pores against gravity by capillary tension and in direct contact with the water table though at pressures that are less than atmospheric.
Groundwater	Those areas in the sub-surface where all soil or rock interstitial porosity is saturated with water. Includes the saturated zone and the capillary fringe. Includes water contained in perched aquifers in the unsaturated zone. Does not include soil moisture.
Groundwater dependent ecosystems (GDEs)	Ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis, to maintain their communities of plants and animals, ecosystem processes and ecosystem services
Infiltration	Passage of water into the soil by forces of gravity and capillarity, dependent on the properties of the soil and moisture content.
Percolation	The downward movement of water through the soil due to gravity and hydraulic forces.
Perched aquifer	An area in the regional unsaturated zone where the soil or rock may be locally saturated following rainfall events or the wet season because it overlies a low permeability unit.
Permeability	A material's ability to allow a substance to pass through it, such as the ability of soil or rocks to conduct water under the influence of gravity and hydraulic forces.
Saturated Zone	The area below the water table in which the pore spaces between grains of sediment or soil are completely full of water.
Subterranean GDE	Ecosystems associated with aquifers and caves (e.g. containing stygofauna)
Surface water	Movement of water at or above the ground surface as overland runoff or in streams, creeks or rivers
Terrestrial GDE	Ecosystems dependent on the subsurface presence of groundwater (e.g. some riparian vegetation)
Unsaturated Zone	The unsaturated zone is the portion of the subsurface above the groundwater table. Unlike the saturated zone, the pore spaces in the unsaturated zone are not completely full of water. Also known as the vadose zone.
Water table	The upper surface of the saturated zone in the ground, where all of the pore space is filled with water.
Water table aquifer	An aquifer associated with the water table. In most parts of the Project Area, this is the alluvial aquifer. However, in some locations, particularly at Tooloombah Creek, the creek channel intersects the deeper weathered Styx Coal Measures. The term 'water table aquifer' therefore refers to the aquifer associated with the water table, regardless of which geological layer the aquifer is located within.
Wetting front	The boundary of soil wet by water from rainfall, and dry soil, as the water moves downward in the unsaturated zone.

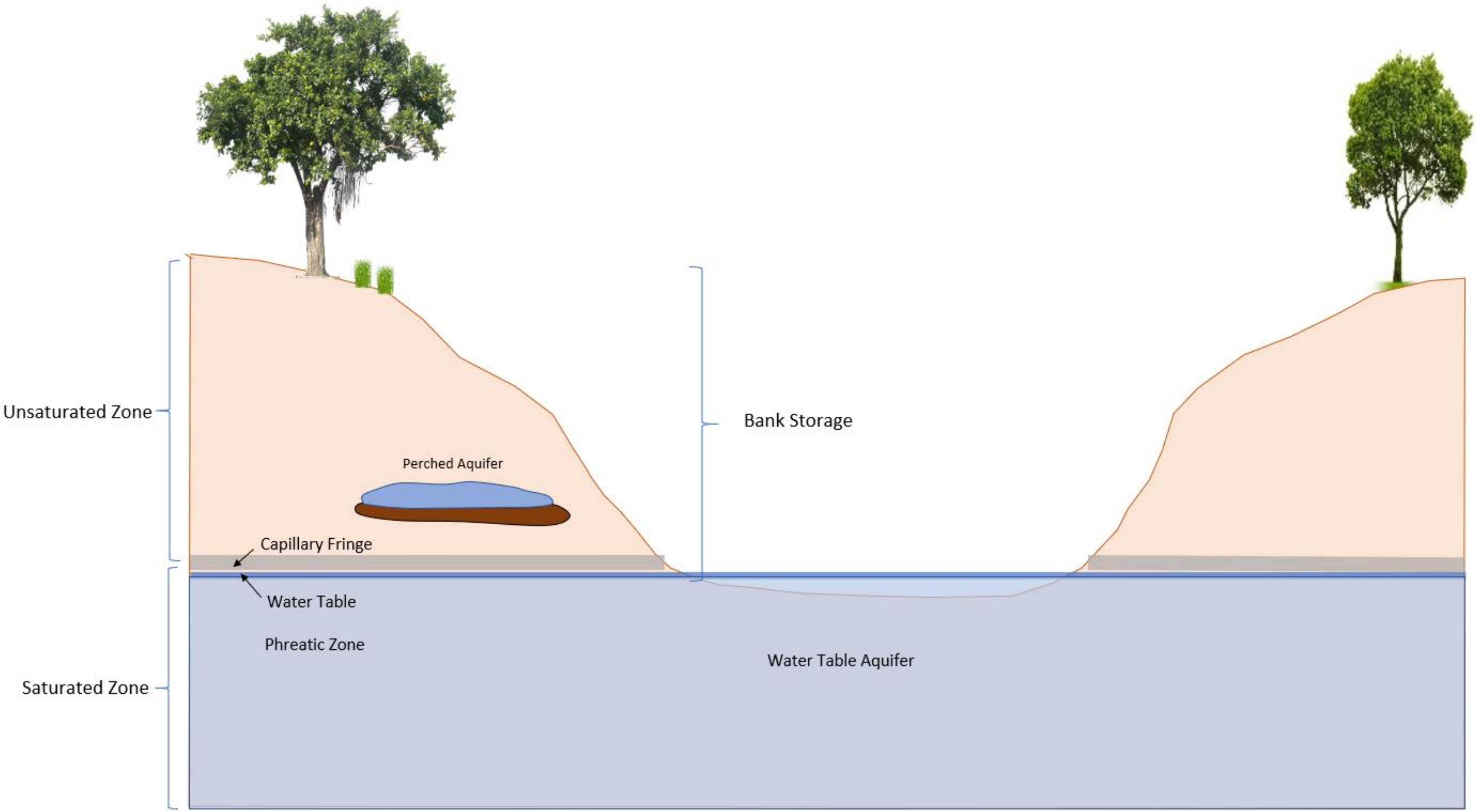


Figure 1-1: Conceptual diagram showing the location of key terms defined in relation to GDEs

2. Project Description

Central Queensland Coal proposes to develop a new open cut coal mine and associated infrastructure in the Styx Coal Basin, located approximately 130 km northwest of Rockhampton, Queensland (**Figure 2-1**). The Project is located on Mineral Development Licence (MDL) 324, and includes:

- Two open cut coal operations, associated mining activities and mining infrastructure (including waste rock stockpiles, water storage and environmental dams, mine industrial area, coal handling and preparation plants and conveyors).
- A train loadout facility to load coal onto trains and provide a new connection to the North Coast Rail Line, and
- A transport corridor to transport coal from the mine to the train load out facility.

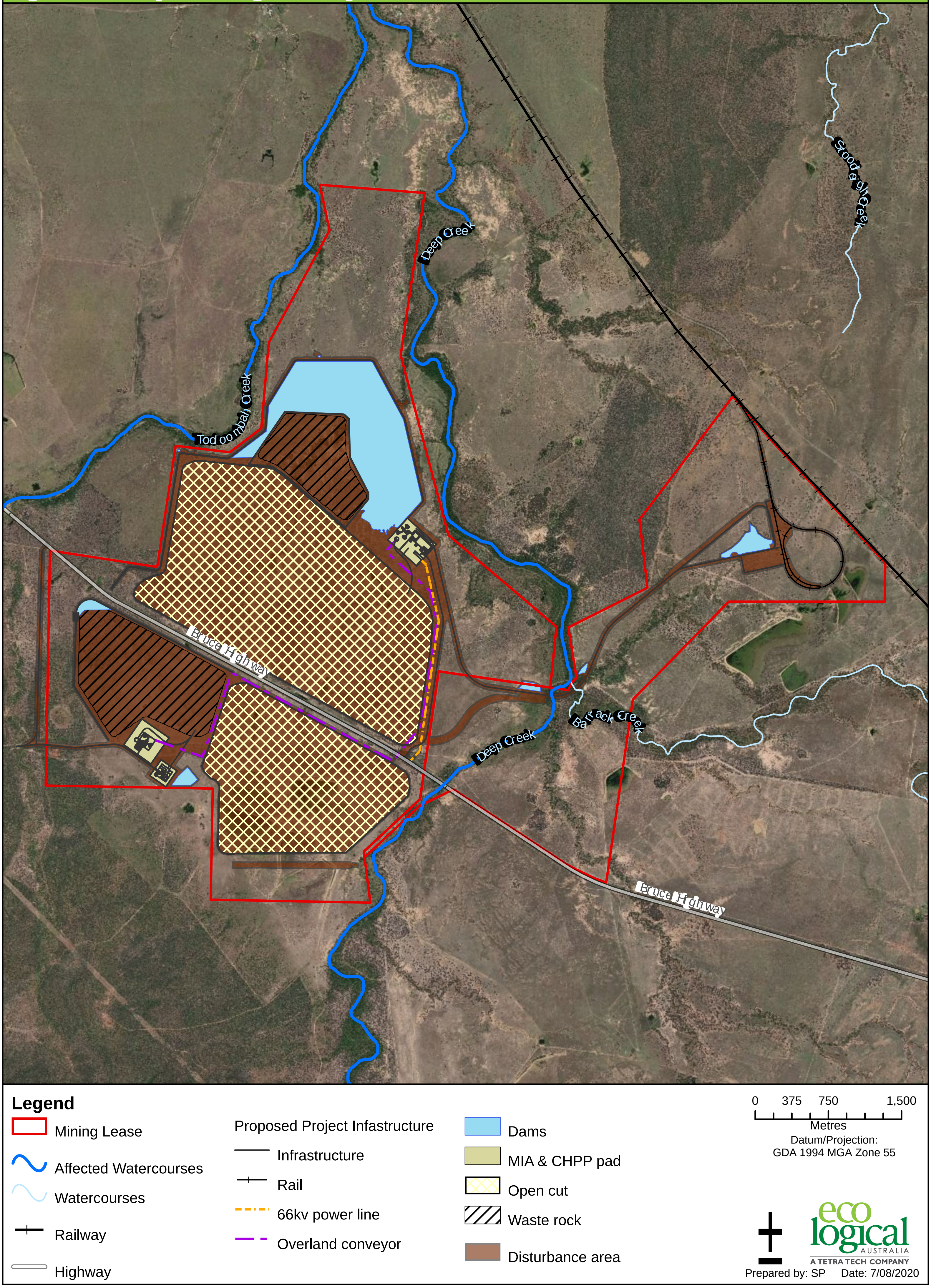
Two separate mining leases (ML) are proposed to cover the mining areas and train loadout facility. The disturbance area within the two MLs is 1,361 ha, with an additional 11.5 ha to be disturbed outside of the MLs to facilitate the Mt Bison western mine access roads. The two open cut mine operations will produce up to 10 million tonnes per annum of run-of-mine coal, comprising semi-soft coking coal and high-grade thermal coal.

Open Cut 2, located on the eastern side of the Bruce Highway, will be developed first, with Open Cut 1 to the west of the highway commencing operations approximately 9 years later. Production from the Project is expected to extend for a period of approximately 19 years, after which rehabilitation and mine closure activities will occur.

The layout of key Project infrastructure is presented in **Figure 2-2**. For a detailed description of the Project, reference should be made to Chapter 1 – Project Introduction and Description (SEIS v3; Central Queensland Coal 2020b).

Figure 2-1: Map showing location of the Project Area

Figure 2-2: Map showing mine layout



3. Existing Environment

3.1 Environmental setting

The Project Area is located within the Styx Basin and is bounded by Tooloombah Creek to the west and Deep Creek to the east. Within the Styx Basin, two small scale coal mines (the Ogmore and Bowman collieries) were in operation from 1919 to 1963. Lands within the Styx Basin are currently used predominantly for cattle grazing.

The Project area contains:

- Strategic Cropping Land (land likely to be highly suitable for cropping).
- Several wetlands of varying size including:
  - Artificial wetlands; and
  - Two wetlands mapped as Matters of State Environmental Significance (MSES).
- A section of haul road and the Bruce Highway which intersects the site.
- The lower catchment areas of Tooloombah Creek and Deep Creek (sub-catchments of the Styx River catchment).

The region experiences a tropical climate with a distinct wet season (December to March) and dry season (June to September). The average annual rainfall for the region is 759 mm (Strathmuir, BoM Station 033189), with February having the highest average rainfall (143 mm) and September the lowest (16 mm). Groundwater recharge and runoff potential is highest during the wet season, and significant weather events such as tropical cyclones or tropical lows can cause substantial increases in rainfall and surface water catchment flows.

The average annual evaporation is approximately 2,100 mm, averaging 240 mm for summer months and 105 mm for winter months (Rockhampton Aero, BoM Station 039083). Evaporation rates are therefore significantly higher than rainfall, with net evaporation occurring in every month of the year.

The Project is predominantly located within the Marlborough Plains subregion of the Brigalow Belt North bioregion. A small portion of the western ML and the Mount Bison Road realignment occurs in the adjacent Nebo-Connors Ranges subregion. The Marlborough Plains subregion is characterised by alluvial plains and colluvial slopes, with vegetation dominated by woodlands comprising Poplar Gum (*Eucalyptus platyphylla*), Ghost Gum (*Corymbia dallachiana*), Forest Red Gum (*Eucalyptus tereticornis*) and paperbarks (*Melaleuca spp.*).

The Brigalow Belt has been subject to significant clearing of remnant vegetation for grazing, agriculture and mining, resulting in a highly fragmented landscape. Most of the remaining vegetation occurs within the hills, rocky areas, roadside vegetation and riparian areas.

Widespread clearing of lands for cattle grazing within the Styx River Catchment has resulted in significant losses of native vegetation cover. However, the Project Area contains some state significant wetlands, as well as watercourses and ponds. The ephemeral Tooloombah Creek and Deep Creek border the

Project Area on the west and eastern side respectively, meeting at a confluence to the north, and forming the Styx River approximately 8 km downstream of the Project Area.

The Styx River catchment discharges directly into Broad Sound Wetland, which is listed in the Directory of Important Wetlands of Australia and contains Australia's largest Fish Habitat Area. This wetland forms part of the Great Barrier Reef Marine Park and World Heritage Area, and is adjacent to Shoalwater Bay. Shoalwater and Corio Bays are a listed as a Wetland of International Importance (RAMSAR Wetland) under the EPBC Act and contain extensive seagrass meadows, which provide significant habitat to species such as dugong and marine turtles. Broad Sound and Shoalwater Bay are also sites of international importance for migratory shorebirds.

A saline groundwater layer is generally present across the Project Area between 10 and 15 mbgl (HydroAlgorithmics 2020), and supplements drying pools of water within parts of Tooloombah Creek, and to a lesser extent, Deep Creek. Aquatic habitats are present for a range of freshwater fauna types, including stygofauna, macroinvertebrates, fish and freshwater turtles.

Riparian corridors are largely intact, and consist of a narrow band of vegetation dominated by Forest Red Gum (*Eucalyptus tereticornis*) and Melaleucas (*M. leucadendra* and *M. fluviatilis*; 3D Environmental 2020). However, riparian areas are also subject to significant levels of physical disturbance from cattle grazing, with extensive trampling of vegetation and stream banks occurring in some areas. There is also a high abundance of weeds (and some pests) along drainage lines, which reduces the quality of existing ecological values.

3.2 Types of GDEs in the Project Area

Through the EIS and SEIS assessments, the following GDEs have been identified within the Project Area (ELA 2020b):

- Subterranean GDEs comprising stygofauna within alluvial aquifers
- Aquatic GDEs of the Styx River and Tributaries, comprising groundwater fed waterways and pools and their associated ecological values
- Terrestrial GDEs comprising vegetation dependent on the sub-surface presence of groundwater in the riparian corridors of local waterways and at wetlands (specifically Wetland 1)

The impact assessment on GDEs concluded that there is likely to be impacts from Project-related groundwater drawdown on riparian vegetation located along sections of Deep Creek (Terrestrial GDEs). The potential impacts were conservatively predicted to involve up to 165 ha of riparian vegetation. Separate assessments were recommended to be undertaken to determine whether these potential impacts on vegetation are a significant residual impact, through consideration of relevant matters of national environmental significance (MNES) and matters of state environmental significance (MSES) significant impact criteria (e.g. for impacts on vegetation and threatened fauna habitat).

Effects of the Project on pools of Tooloombah Creek and Deep Creek, stygofauna and mapped wetlands were assessed to be relatively minor, and not a significant residual impact. However, these values have been included in the GDEMMP, to facilitate the implementation of mitigation measures to reduce impacts as far as practicable, and to allow for ongoing monitoring of values to confirm the accuracy of the impact assessment findings. An adaptive management approach to identifying impacts early and reassessing mitigation measures and corrective actions will be implemented for all GDEs, within and outside of predicted areas of impact.

3.3 Regional hydrogeology and relationship to GDEs

A schematic representation of the hydrogeological conceptual model for the Project is presented in **Figure 3-1**, and incorporates the following main hydrogeological units:

- Quaternary and Pleistocene Alluvium / Regolith: These units are considered unconfined aquifers. In terms of conceptualisation, a separation has been identified between the Quaternary (Holocene) Alluvium and the Quaternary Pleistocene Alluvium / Regolith on the basis of their hydraulic properties.
- Styx Coal Measures: The coal measures are generally considered as confined aquifers, with the expectation to be less confined where the coal measures sub-crop near the surface / regolith. In the shallower overburden, interburden and the seams itself, no clear discernible water level reductions or propagation can be observed.
- Permian Sequence (Back Creek Group, Boomer Formation and Carmila Beds): These units are generally considered to be confined aquifers. However, they are considered to be less confined, in areas where these units sub-crop near surface / regolith. For the purpose of the Project, the Back Creek Group has been separated as a discreet deep groundwater system for the purpose of separation of direct impacts on the overlying target coal seams. This deep system has been assigned a low sensitivity ranking based on the poor water quality, limited groundwater yields and limited potential for interaction with GDEs.

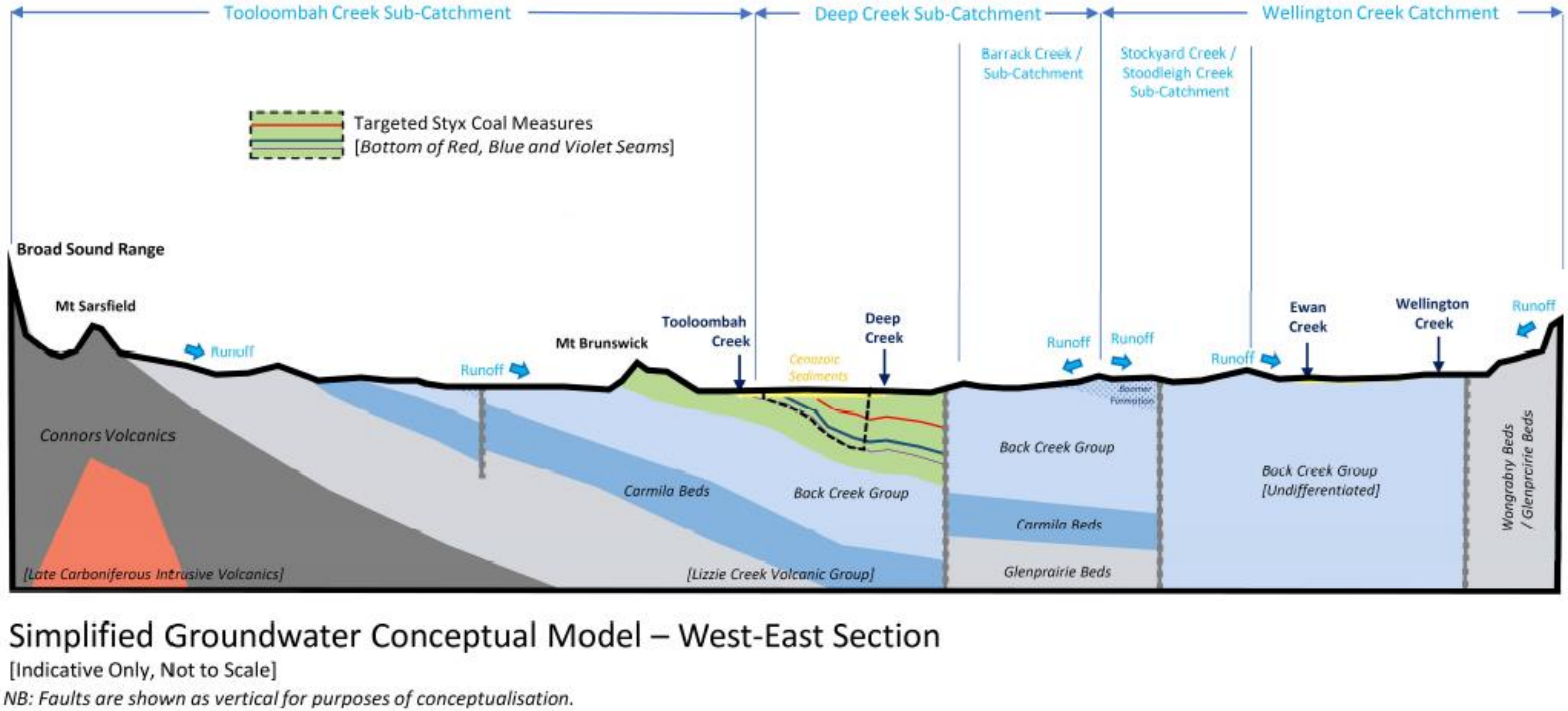


Figure 3-1: Simplified Conceptual Groundwater Model (HydroAlgorithmics 2020)

The depth to the water table across the Project Area and surrounding locations is typically in the range of 10 to 15 mbgl in floodplains. Water within the upper Quaternary Alluvium (Qa) is generally less saline than the underlying Quaternary Pleistocene Alluvium (QPa; HydroAlgorithmics 2020). Further from creeks, the depth to groundwater can be 15 metres or more.

The alluvial corridor and its associated GDEs experience a cyclic process of short-term flooding associated with high fresh surface water flows (during and immediately following significant rainfall events), followed by extended periods of little to no rainfall (WRM 2020). Variations in rainfall and associated surface water runoff drive the movement of water within creek systems, and regulate the expression of GDE values.

Groundwater sources supporting GDEs of the riparian corridors are derived from two primary sources:

- A brackish aquifer underlying the creek channel, which appears to supplement water levels in some of the pools within Tooloombah Creek that persist within the creek channel during dry periods.
- In dry periods, groundwater held in bank storage is returned to the creek, sustaining Aquatic GDEs, or is utilised by Terrestrial GDEs when their roots access the capillary fringe and associated saturated zone of the soil profile, or a perched aquifer in the unsaturated zone.

These two sources of groundwater are discussed separately in the following sections.

3.3.1 Saline groundwater inputs from the water table aquifer

Pools within Deep and Tooloombah Creek are primarily supported by bank storage return flow during the dry season, with this return flow the result of wet season recharge from wet season streamflow and seasonally elevated water tables (see **Section 3.3.2**). However, during the dry season, there are several pools within Tooloombah Creek that receive saline inflows, considered to be either from outcropping underlying saline aquifers into the stream beds (i.e. coal measures), or saline groundwater deposited into bank storage through seasonally elevated saline aquifers in the wet season. It is thought that the downstream reach of Deep Creek near to the confluence may also be subject to similar processes. However, only some locations will be dependent on this source of groundwater as:

- only some pools within Tooloombah Creek show evidence of saline inflows when others (located upstream and downstream of these locations) do not
- pools at Deep Creek are generally ephemeral
- pools generally increase is permanence downstream.

The inflow of saline groundwater from the aquifer is relatively small (when compared with surface water flows).

Evidence for groundwater inflow is provided by isotopic studies completed during the EIS baseline studies, as well as comparisons of the water levels and salinity within pools with what would be expected to be mainly a response to evaporation. For example, at the Tooloombah Creek gauging station pool (ToGS1), brackish to saline groundwater inflow of several thousand litres a day is required for the pool to maintain levels and reach the observed salinity of 9,000 µS/cm EC during a prolonged dry period (WRM 2020). A trend of increasing salinity within pools with increasing distance downstream is also evident in Tooloombah Creek, based on a review of surface water quality monitoring data (Central

Queensland Coal 2020b). These trends occur above the reach of tidal influences, and are thought to be explained by increasing quantities of saline groundwater inflows with distance downstream.

ELA (2020a) notes that water table level is generally below the creek bed across the Project Area, with intersections between the creek bed and groundwater level occurring in some locations on a seasonal basis. The regional groundwater model report (HydroAlgorithmics 2020) also notes that there is the potential for localised upward pressures from the aquifer units underlying Tooloombah Creek, and the stream gauge location is noted as containing outcropping coal measures within the creek bed.

Monitoring at Deep Creek suggests that this system receives far less saline groundwater inflow than Tooloombah Creek. Pools at Deep Creek are noted to be ephemeral and dry up faster during the dry season compared with Tooloombah Creek. Isotope sampling results from the EIS studies also indicated that there is less groundwater inflows to Deep Creek than to Tooloombah Creek.

Monitoring during the dry season demonstrates that pools at Deep Creek lose more water each day than pools in Tooloombah Creek (Amec 2019). Deep Creek pool levels and salinity concentrations can generally be explained by evaporation alone, rather than requiring the addition of saline groundwater. Whilst pools in the lower reaches of Deep Creek appear to be fed by groundwater at times, this does not occur to the same extent as in Tooloombah Creek (ELA 2020a).

Surveys of surface water levels in pools across both creek systems support these observations, and found only one pool in Deep Creek to be permeant or semi-permanent (in the lower reaches), while pools in Tooloombah Creek increase in permanence going downstream (ELA 2020b).

3.3.2 Baseflow and bank storage inputs of fresh water

During periods of high rainfall and associated creek flow, water levels in creeks rise, and surface water moves laterally into adjacent soils, infiltrating the stream bank. The degree to which stream banks absorb and store water is a function of their physical structure and soil properties. Water held in bank storage may percolate downwards under gravity towards the aquifer underlying the riparian zone (if not connected to the regional water table aquifer), or be impeded by an impermeable layer of rock or clay. Once the water is captured through either of these mechanisms, the water meets the definition of groundwater as it relates to the assessment of GDEs.

At times of river flooding, groundwater is of little relevance to GDEs. Aquatic GDEs have abundant surface water to meet their environmental water requirements. Soils utilised by vegetation are also moist as a result of rainfall infiltration and stream flooding, meaning there is unlikely to be any reliance on groundwater at this time. Trees can generally adapt their water harvesting approach to suit the water sources available within the reach of their root system.

As creek levels drop and soils in the unsaturated zone begin to dry out, the use of groundwater becomes more important for GDEs. Baseflow within creeks will be supported by water seeping out of bank storage, sustaining aquatic ecosystems and shallow-rooted riparian vegetation such as the Weeping Paperbark for an extended period of time. However, the capacity for bank storage to replenish water levels in the creek is not unlimited, and during dry periods, flow volumes and rates will reduce and cease over a duration of days, weeks or months, depending on the geological and hydraulic properties (e.g. particle size) of the stream bank sediments, which affect the volume of water that can be stored, and the rate at which this water is released to the waterway.

Transect drilling on site indicated that Tooloombah Creek has a high capacity for bank storage (ELA 2020a). The creek channel is supported by a large bank terrace in some locations, with a high clay content, particularly at the base of the alluvial sediments. This facilitates the capture and storage of flood water and the slow release of this water back to the creek during dry periods as surface water levels drop. In contrast, Deep Creek adjacent to the proposed mine follows the course of a fault, with the western bank having some clay content, as well as sand, while the eastern bank consists of coarse gravel layers with a high permeability (ELA 2020a). Bank storage is far less feasible at Deep Creek, with water likely to percolate through the coarser sediments and gravels to the east much faster than is the case at Tooloombah Creek. Such findings are consistent with the observations of pool persistence in both creeks, coupled with the above-mentioned cycle of drying.

For Terrestrial GDEs, prolonged dry periods are when access to groundwater is important. Water requirements of vegetation that cannot be met by rainfall and stream flooding during these periods will need to be met by groundwater, to avoid water stress. Forest Red Gums have a deep tap root, observed to extend to at least 9.5 m on site, which coincides with the approximate level of the creek base (3D Environmental 2020). Within this zone, fresh groundwater is present, stored after rainfall and river flooding and either captured as a perched aquifer above impermeable clay or rock layers in the bank, or connected to (sitting on top of) the alluvial aquifer in the Quaternary Alluvium layer (which is generally less saline than the underlying Quaternary Pleistocene Alluvium).

Evidence relating to the presence of this fresh source of groundwater is multi-faceted and includes:

- Transient Electromagnetic (TEM) studies of the Project Area (Allen 2019), which show that sediments within the riparian corridors surrounding the Project Area contain a layer of low conductivity signal, likely reflecting fresh water in the upper 10 m (held in bank storage). This is likely sourced directly from rainfall and high stream flow events, rather than from the underlying saline aquifers (upflow). At depths greater than 10 mbgl, the TEM conductivity increases, likely reflecting the existence of the permanent alluvial groundwater from the Quaternary Pleistocene Alluvium, which has been found to have salinities in the range 10,000 – 40,000 µS/cm EC (6,000 – 30,000 ppm).
- Field studies undertaken by 3D Environmental (2020) found that Forest Red Gums were utilising a deep and fresh water source at a time when shallow-rooted species, such as the Weeping Paperbark, were stressed from a lack of water. This fresh water source was found to be at a depth of approximately 9 mbgl.
- Salinity observations from drill holes associated with the alluvial transects show a transition in salinity from fresh to saline at approximately 10 mbgl (ELA 2020a; Central Queensland Coal 2020b).

GDEs of the riparian corridors of the Project Area are thus mainly supported by groundwater from two sources:

1. Saline groundwater inputs to the creek system from the underlying water table aquifer occur in Tooloombah Creek, and to a much lesser extent, in the lower reaches of Deep Creek. These inputs sustain pools of water during the dry season and extended periods of drought and result in some pools having high salinity. The creeks, pools and the flora and fauna that they support meet the definition of Aquatic GDEs. They include aquatic fauna such as macroinvertebrates, fish and

freshwater turtles, plus shallow rooted vegetation which utilises water derived from infiltrations into the stream bed and banks (e.g. Weeping Paperbark).

2. The other source of groundwater comprises a layer of fresh water located in the alluvial corridor in many locations, either as a perched aquifer in the unsaturated zone of the river bank, or immediately above or within the water table aquifer, most likely the Quaternary Alluvium layer (**Figure 3-2**). This groundwater held in bank storage is generally low in salinity (although may contain some dissolved salts) and provides a source of water for deep-rooted vegetation such as the Forest Red Gum at times when other water sources from rainfall and river flooding are not available.

Stygofauna are known to occur within alluvial aquifers of the Project Area and are likely to be supported to varying extents by both types of groundwater described above. Stygofauna have a preference for water of lower salinity and are likely to be present in highest abundances in areas where the salinity of the alluvial aquifer is low, or where water derived from river flooding reduces (as a result of mixing) the salinity of the underlying aquifer.

Of those sites studied in detail from the field studies completed by 3D Environmental (2020), Wetland 1 is the only mapped wetland to be confirmed as a GDE (Terrestrial), identifying that Melaleuca species are utilising water in the soil profile at a depth of approximately 8 mbgl. This water meets the definition of a perched aquifer, and lies approximately 4-5 m above the underlying water table. Wetland 1 is therefore classed as a Terrestrial GDE, given the structural importance of the Melaleuca trees to the wetland and its associated flora and fauna.

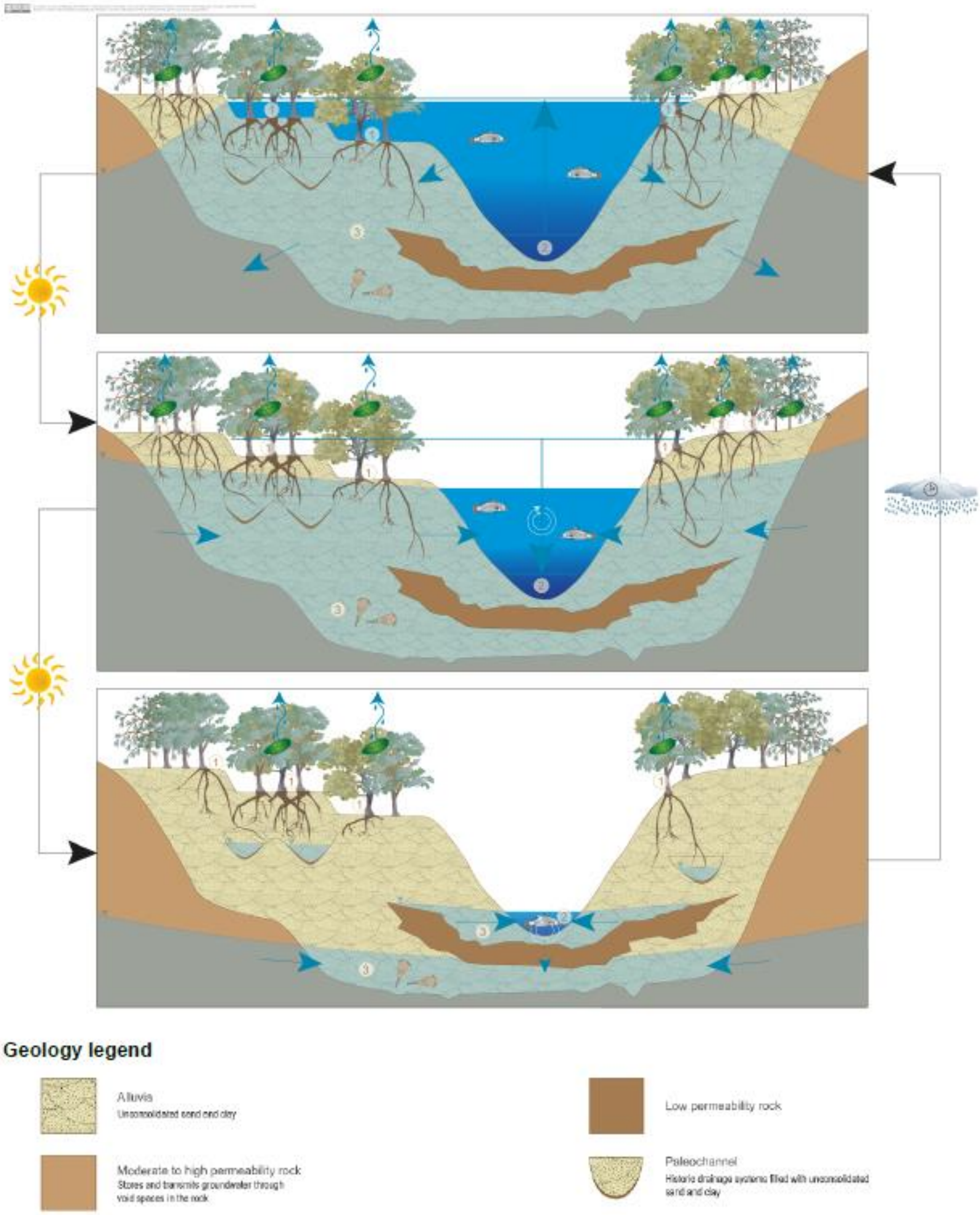


Figure 3-2: Conceptual diagram of recharge processes in the alluvial aquifer. 1 = Terrestrial GDE, 2 = Aquatic GDE and 3 = Subterranean GDE (WetlandInfo 2013).

3.4 Location of GDEs and conceptualisation of groundwater interactions

The location of GDEs in the Project Area is shown in **Figure 3-3**. The groundwater resources that support each type of GDE are discussed in the following sections alongside conceptual ecohydrological models.

3.4.1 Subterranean GDEs

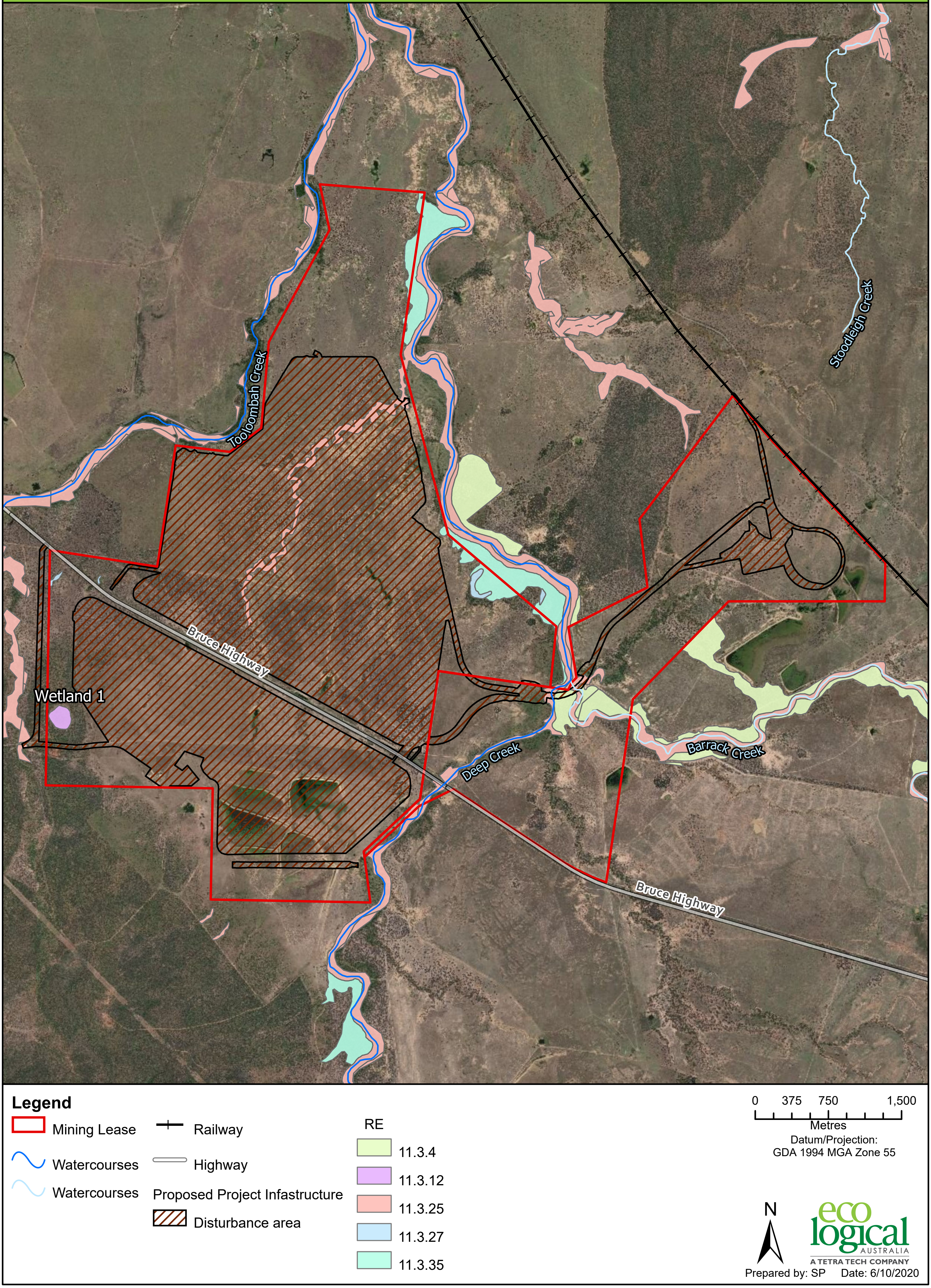
Subterranean GDEs (comprising stygofauna) that occur in the Project Area live within the fresh, shallow (<20 mbgl) groundwater of the alluvial aquifer; primarily within the alluvial sediments associated with surface drainage and fractured or weathered rock. This layer of freshwater likely overlays deeper saline water throughout much of the Styx River alluvium, as well as the alluvium of Tooloombah Creek and Deep Creek. The availability of supporting groundwater resources for subterranean GDEs is therefore dependent upon the specific hydrogeological conditions and depth of groundwater across the Project Area.

Subterranean GDEs are likely to be found most commonly in parts of the alluvial aquifer that have an EC less than 7,000 µS/cm. Based on the salinity data provided through monitoring of alluvial groundwater bores, there is spatial variability in the salinity of alluvial groundwater across the Project Area, creating a mosaic of suitable and unsuitable groundwater resources for stygofauna. Areas closest to waterways are more likely to provide supporting groundwater resources for stygofauna than are those in the central part of the aquifer where EC is higher and groundwater is deeper.

3.4.2 Aquatic GDEs and Terrestrial GDEs

The supporting ground water resources for riparian vegetation along both Tooloombah Creek and Deep Creek are similar. Red gum (*Eucalyptus tereticornis*; a Terrestrial GDE) that occur along the upper terraces of both creeks are likely to be sourcing groundwater held at or near the alluvial unconformity with the weathered Styx coal measures. Weeping paperbark (*Melaleuca leucadendra* and *Melaleuca fluviatilis*; an Aquatic GDE) also occur along these riparian zones but do not access the saturated zone. Instead they utilise surface water within the pools and fluvial sands. However some of the surface water within the creeks is sourced from groundwater, and therefore the weeping paperbark, along with the aquatic habitats of the creek, is also considered to be groundwater dependent (utilising the surface expression of groundwater; Aquatic GDE). Conceptualisation of the riparian vegetation and groundwater relationship during wet, dry and drought seasonal conditions is presented in **Figure 3-4**.

Figure 3-3: Map showing the location of GDEs across the Project Area and surrounding areas



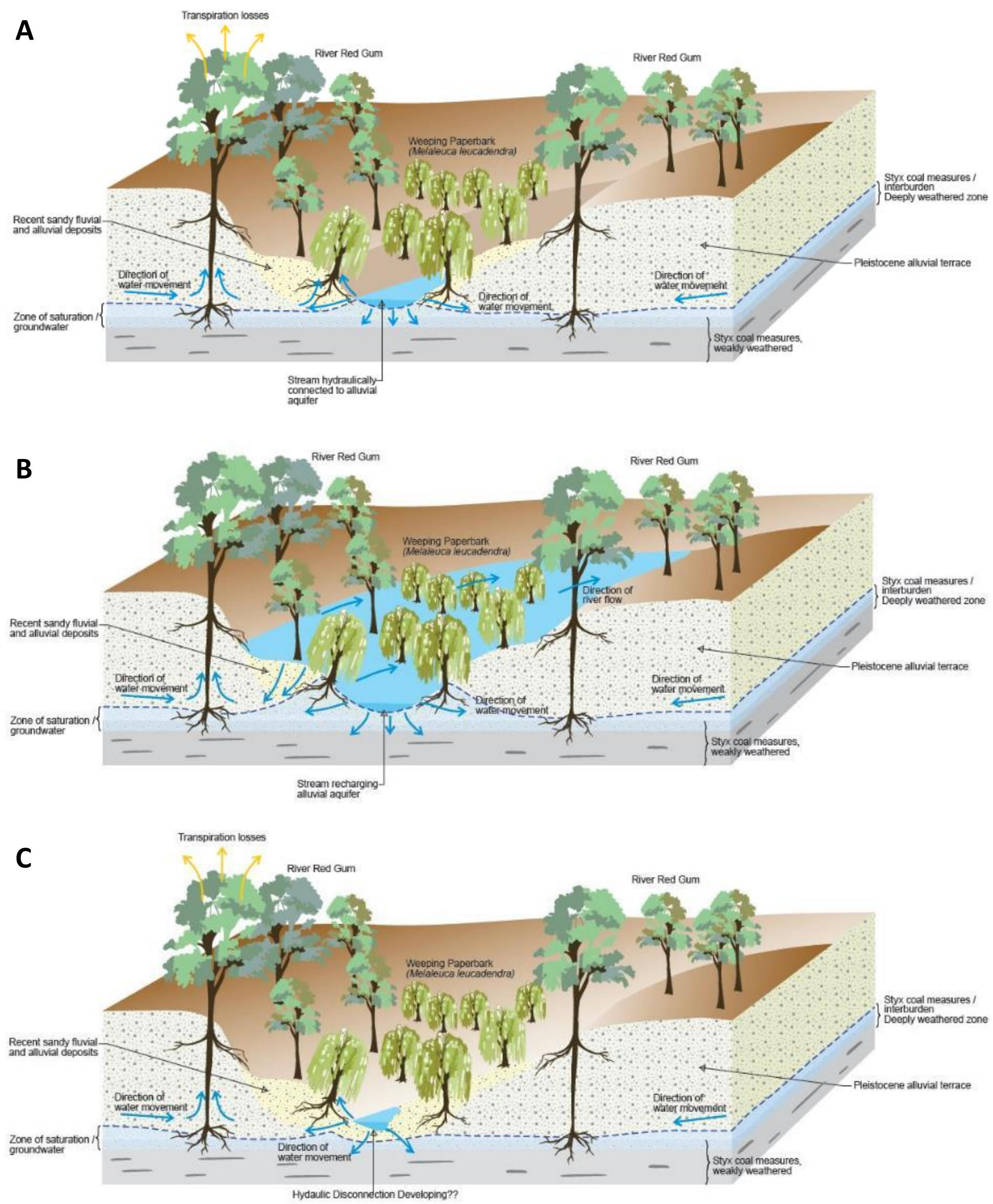


Figure 3-4: Conceptual ecohydrological model of the Tooloombah / Deep Creek vegetation and water relationship in dry season (A) wet season (B) and drought conditions (C), 3D Environmental (2020)

Additionally, a patch of Semi Evergreen Vine Thicket (SEVT; a Threatened Ecological Community) occurs adjacent to Tooloombah Creek, along an overflow channel. The Vine thicket is not considered to be accessing groundwater, instead accessing soil moisture in the unsaturated zone above the water table. However, the Forest Red Gums present on the fringe of this patch of vegetation are likely to be accessing fresh water within the shallow coal measures and associated alluvial unconformity (approximately 9 mbgl). This zone is recharged during high flow periods when there is lateral movement of water into bank storage, slowly returning to baseflow during dry periods. Therefore, the Forest Red Gum in this patch of vegetation is considered to be groundwater dependent (Terrestrial GDE), but not the vine thicket community. Conceptualisation of the vegetation and groundwater relationship during wet, dry and drought seasonal conditions at Tooloombah Creek, including the overflow channel, is presented in **Figure 3-5**.

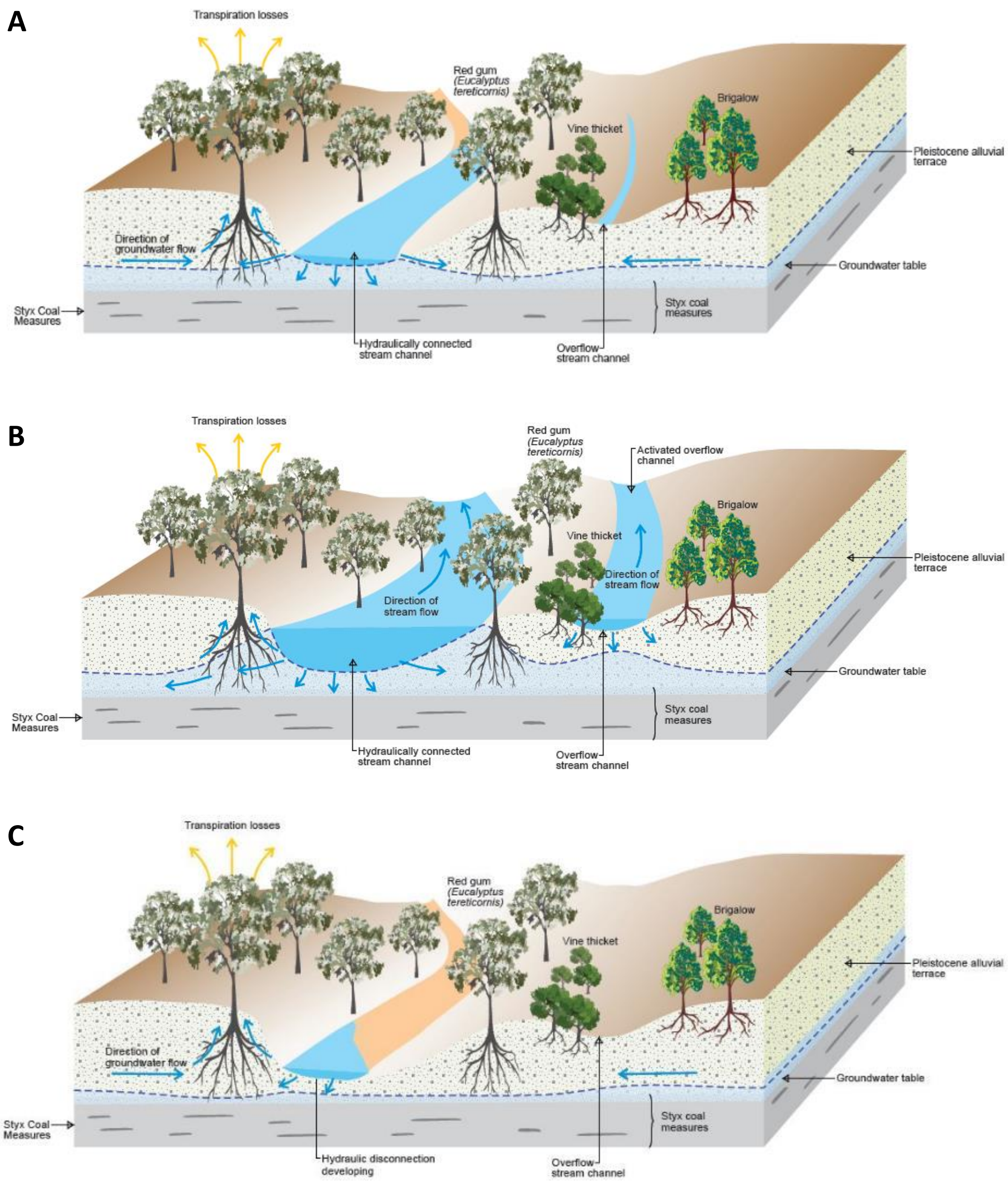


Figure 3-5: Conceptual ecohydrological model of the Tooloombah Creek (and channel) vegetation and water relationship in dry season (A) wet season (B) and drought conditions (C), 3D Environmental (2020)

Underlying Wetland 1 there is a narrow, perched aquifer approximately 8 mbgl. This saturated zone is likely to be supported by percolation of surface water through the overlying clay pan and rock. Based on the results of leaf water potential (LWP) and soil moisture potential (SMP), it is suggested that Broad-leaved paperbark (*Melaleuca viridiflora*) trees at Wetland 1 are accessing groundwater from the perched aquifer, predominantly during times of drought when the upper clay pan dries out (3D Environmental 2020). Wetland 1 therefore meets the definition of a Terrestrial GDE. Conceptualisation of the vegetation and groundwater relationship during wet and dry seasonal conditions are presented in **Figure 3-6**. A single Forest Red Gum is also present at this wetland. However, analysis of LWP and SWP indicates that this tree is only sourcing moisture from the upper clay pan and therefore relies upon recharge of the upper layer from surface water flows (3D Environmental 2020).

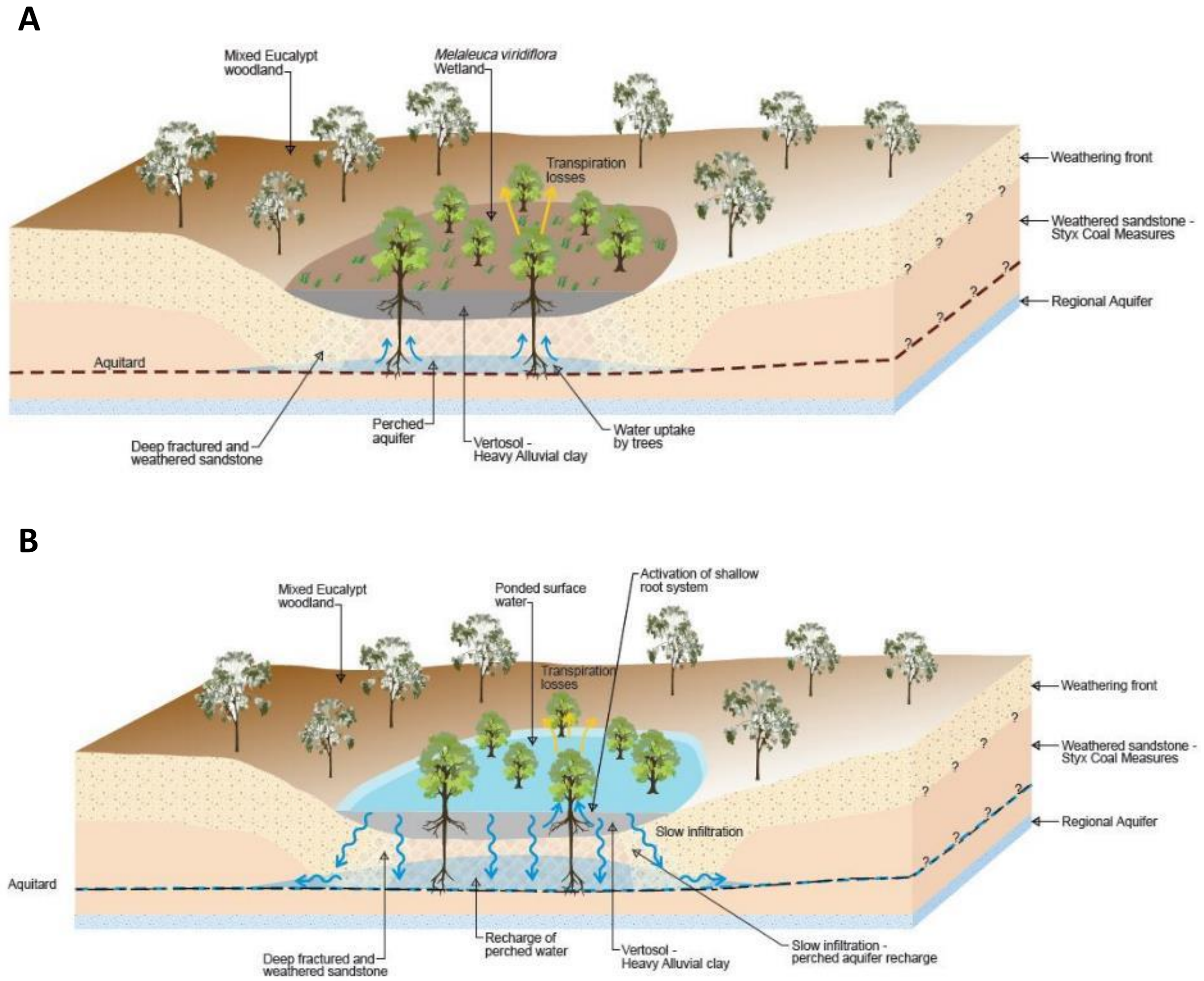


Figure 3-6: Conceptual ecohydrological model of the Wetland 1 GDE vegetation and water relationship in dry season (A) and wet season (B), 3D Environmental (2020)

4. General Approach

4.1 Overview

This GDEMMP provides an overarching framework for the management and monitoring of GDEs in the Project Area, and a management plan for each type of GDE.

The GDEMMP has been developed based on the following sequential approach that:

- Establishes an environmental baseline using data collected during the EIS and SEIS studies
- Analyses threats and potential impacts (direct and indirect) to each GDE
- Defines management objectives and performance criteria to limit and manage each of the potential impacts
- Provides a comprehensive suite of mitigation and management measures that specifically address the potential impacts to each GDE
- Develops pre-impact monitoring requirements to further develop the environmental baseline prior to the impacts of mining on GDEs
- Develops impact monitoring requirements, the results of which will be compared with trigger levels to determine whether investigations and corrective actions are required
- Provides an adaptive management framework including details of the investigative process and corrective actions that will be implemented.

The approach described above was informed by and is consistent with the GDE Toolbox, as described in detail in **Section 4.9**. Consideration has also been given to the more recent IESC Guidelines (Doody et al. 2019) in development of the GDEMMP.

4.2 Description of Project phases and implementation

This GDEMMP describes monitoring, mitigation and management actions for each of the GDEs across the Project phases outlined in **Table 4-1**. These include the baseline phase, encompassing all work that contributed to the Project EIS and SEIS. The pre-impact phase commences after the Project is approved and continues until mining related impacts on GDEs commence. The pre-impact phase allows the collection of an extended baseline for certain variables that will not be affected by mining until varying times into the future. The impact phase is the period after Project impacts commence.

Table 4-1: GDE Monitoring and implementation phases

Phase	Description	Purpose	Timing
Baseline	Beginning in 2010 and comprising all technical studies that contributed to the EIS and SEIS. Underpins the assessed impacts of the Project.	Describes the ecological values used for the impact assessment prior to the Project construction and the associated potential impacts (direct and indirect) commencing. Used to establish trigger levels.	Prior to October 2020

Phase	Description	Purpose	Timing
Pre-impact	Begins immediately following approval of the Project. Concludes at the time when mining-related activity and impacts will commence for each GDE. Relates to impacts to relevant source aquifers and/or ecological values.	Provides for the collection of pre-impact information to supplement baseline information. Used to inform future revision of triggers levels, based on extensive additional data collected during pre-impact monitoring and investigations. Allows consideration of groundwater and ecological changes that are not attributable to significant groundwater impacts arising from mining activities.	2021 to 2023
Impact	Begins when Project impacts on relevant GDEs first occur. Comprises information collected from the commencement of Project-related impacts to the relevant groundwater aquifers and/or ecological values.	Determines the extent of actual impacts on GDEs from the Project, providing the opportunity for comparison with those predicted in the EIS, and the implementation of corrective actions.	2024 onwards

Several hydrogeological and ecological studies have been undertaken as part of the Project's approval process (EIS and SEIS), which have provided Central Queensland Coal with an understanding of the presence, location, hydrogeological and ecological functions of GDEs within and proximal to the Project Area. These baseline studies are considered adequate and appropriate to meet the level of rigour required to obtain Project approvals under State and Commonwealth legislation.

This Draft GDEMMP details a summary of information derived from surveys that establish the baseline for each GDE. Baseline data will be complemented by future studies during the pre-impact phase before potential Project impacts commence. Results will be used to further refine and develop trigger values. These triggers will provide an early warning for potential impacts that will then warrant further investigation, monitoring and adaptive management measures.

4.3 Threats and potential impacts

Threats and potential impacts to each GDE were collated from relevant policy documents (e.g. Barnett et al. 2012; Doody et al. 2019; GDE Toolbox), the Project EIS and SEIS. For each threat and potential impact, an analysis was then undertaken to determine the extent to which each threat and potential impact is relevant to the GDE, including when in the life of the Project the threat and potential impact becomes relevant. This analysis forms the basis of the management objectives, performance criteria and the comprehensive suite of management and mitigation measures that will be implemented to limit and manage each of the threats and potential impacts.

4.4 Management and mitigation measures

A suite of mitigation and management measures that are relevant to GDEs have been developed throughout the Project EIS and SEIS and are presented in this GDEMMP. Some measures are specific to Subterranean, Aquatic or Terrestrial GDEs, while others are overarching measures that are relevant to a range of GDEs. One key measure is the overall design of the Project, which has been optimised to reduce the extent and magnitude of groundwater drawdown, thereby reducing potential impacts to the supporting groundwater resources of GDEs.

Although the key potential impacts to GDEs arise from groundwater drawdown, there are also a number of potential impacts to the ecological values of each GDE that are not directly related to groundwater. This GDEMMP provides a comprehensive suite of management and mitigation measures that will be implemented to address all relevant threats to GDEs throughout all stages of the life of the Project (pre-construction to rehabilitation). Management measures for groundwater issues that have no relationship with GDEs are not presented in this plan.

An adaptive management framework will be used to review and assess the effectiveness of management and mitigation measures at the completion of each assessment and monitoring stage. If monitoring identifies that management measures are ineffective, the GDEMMP will be updated with improved management measures. **Section 5.6** provides further details on the adaptive management approach.

The results of all mitigation actions will be recorded and reported as specified in any approval conditions from DAWE and DES. Further details of such reporting are provided in **Section 6**.

4.5 Monitoring approach

The monitoring program is required to have clear objectives and a rigorous statistical design to achieve the desired outcomes of characterising pre-impact conditions and measuring change in environmental variables. There is also a need for inherent flexibility in the design and application of the monitoring program, to achieve the application of an adaptive management approach.

There are a number of key criteria that must be addressed through the implementation of the monitoring program:

- Accommodate natural variation in environmental variables, including those influenced by wet and dry seasons
- Ensure that monitoring and investigation can distinguish between the influences / impacts of mining and non-mining activities through the various phases of the Project
- Ensure that data are collected over an appropriate time-scale that is relevant to the indicator being monitored
- Ensure that the magnitude of change relevant to a trigger is likely to be detectable.

The monitoring methodology described in the following sections, and in more detail in **Section 5.4**, is designed to enable the measurement and separation of mining and non-mining influences on the indicators across the three types of GDEs. This is achieved in part through the effective designation of control and impact monitoring sites.

This GDEMMP will be updated with revised triggers for monitoring indicators after a period of 12 months (from the date of approval). New triggers for monitoring indicators that do not yet have a specified trigger will be nominated at this time, and will be based on the findings of pre-impact field surveys and monitoring. Thereafter, triggers will be reviewed and refined on an annual basis, informed by the collection and analysis of additional information from ongoing field surveys and monitoring.

4.5.1 Monitoring design

TEAM SELECTION

Following approval of this GDEMMP, Central Queensland Coal will select a team of suitably qualified persons to implement the monitoring program. Details of the minimum qualifications and experience of the team are provided in **Section 6.5**. The team will comprise individuals with skills and experience in ecology, botany and GDEs (including hydrogeology). Selection and engagement of the team will be through Central Queensland Coals' internal procedures. Personnel within the Project team will be assigned to relevant aspects of the monitoring program aligned with their skills and experience.

DESKTOP REVIEW

The monitoring team will complete a desktop review of information available on the GDEs including information presented in this GDEMMP, and work completed by Central Queensland Coal during and following the completion of the EIS process (baseline data). Other scientific studies and experience related to the monitoring of GDEs will be considered, to assist in planning and implementation of field surveys.

FIELD SAMPLING PLAN

A field sampling plan will be developed for each GDE, which complies with the monitoring requirements specified in this GDEMMP. Data collection methods and equipment will be tailored to each environmental variable, and the approach to the selection of sampling sites will be documented. The selection of sampling sites for a long-term monitoring program is always best completed in consideration of issues 'on the ground'.

Key aspects of the sampling method are:

- Surveys will be undertaken bi-annually within the wet season and dry seasons, and more frequently for some key parameters (e.g. water quality).
- Survey sites are to be clearly marked (e.g. pegged) so that they can be monitored through time, and located near groundwater monitoring sites (e.g. bores) to allow interpretation and correlation of trends in data.
- Monitoring methods will be clear and repeatable.
- Data sheets will be developed to ensure consistent collection, storage and analysis of data.
- Survey activities must be safe to implement and avoid significant impacts on the environment as a result of conducting the monitoring (e.g. minimise trampling or collection of biological samples, where possible).

Meteorological data collected from nearby weather stations (e.g. St Lawrence, BoM Station 95369 and Rockhampton Aero, BoM Station 039083) will be used to assist in the interpretation of monitoring data related to water and ecological indicators.

4.5.2 Monitoring description and indicators

Consistent ecological monitoring descriptions and indicators have been developed in response to the established environmental baseline (**Section 5.4**). The monitoring of each indicator will allow for an assessment of the condition once impacts commence versus the baseline (which will be updated, based on pre-impact monitoring), to determine whether a trigger has been activated and a response is required.

4.5.3 Statistical analysis

There are two key statistical analytical considerations for a monitoring program which aims to detect change:

- Statistical power required to detect a change beyond natural variations
- Level of change that is considered to be significant.

Each of these variables influence the statistical merits of a monitoring program and the degree to which monitoring objectives will be achieved. It is generally accepted that statistical power should be 0.8 or greater, meaning that there is an 80% or greater chance of detecting a change of a given magnitude when one occurs.

The number and location of survey sites for various indicators has been nominated where possible, based on previous knowledge of the study site and indicator (baseline studies). A power analysis will be undertaken in the early stages of data collection during the pre-impact monitoring phase, to determine if the proposed number of sites is sufficient to obtain satisfactory statistical power. If, based on the magnitude and variability of the data, more sites are required to gain sufficient statistical power, then these will be included in the pre-impact monitoring program. The timeframe over which change can be detected must be early enough to identify and minimise any potential impacts.

It is important that the analysis of monitoring data is responsive so that changes, if detected, can be identified early and lead to further investigation of the potential causes, and implementation of additional mitigation measures if necessary, to avoid potential long term impacts occurring. High replication of data increases statistical power but may also take many years to establish. While an early warning mechanism for detected change is desirable, it is also important to minimise false triggers that indicate a change when one doesn’t really exist (Type I error).

In monitoring programs involving repeated measurement of environmental variables, determining the magnitude of change is also important. This GDEMMP adopts a threshold of any statistically significant change in baseline and pre-impact conditions for all GDEs. Multivariate ordination analysis will be used to assess change in biological communities, where multiple variables exist.

Control charts provide a robust approach to understanding trends in parameters over time by identifying deviations beyond those that would normally be expected. This is achieved by plotting a measure through time with reference to its expected value (Anderson and Thompson 2004). Control charts have been applied to environmental monitoring for many years and allow a responsive analysis of data with identification of deviations from what would normally be expected. This involves a comparison of environmental variables with their long-term baseline, with a deviation beyond control limits signifying the need for early investigation of the possible causes.

The Queensland Government has published a guideline which illustrates appropriate methods to identify suitable test criteria for control charting (DSITI 2017). While the guideline is based on groundwater quality, the approach is relevant to ecological triggers for GDEs. The guideline notes that a defining element of a control chart is the control limits that can be used to inform or trigger management actions. Control limits need to be appropriate to provide an early warning of change. Point data can be viewed and assessed graphically over time.

An example of the application of the control chart approach is provided in **Figure 4-1**, for illustration purposes only (based on imaginary data). The control chart illustrates the surface water level of a pool. Surface water depth in metres has been calculated through field measurements. There is some natural variation in the surface water level between the wet and dry seasons, and from year to year.

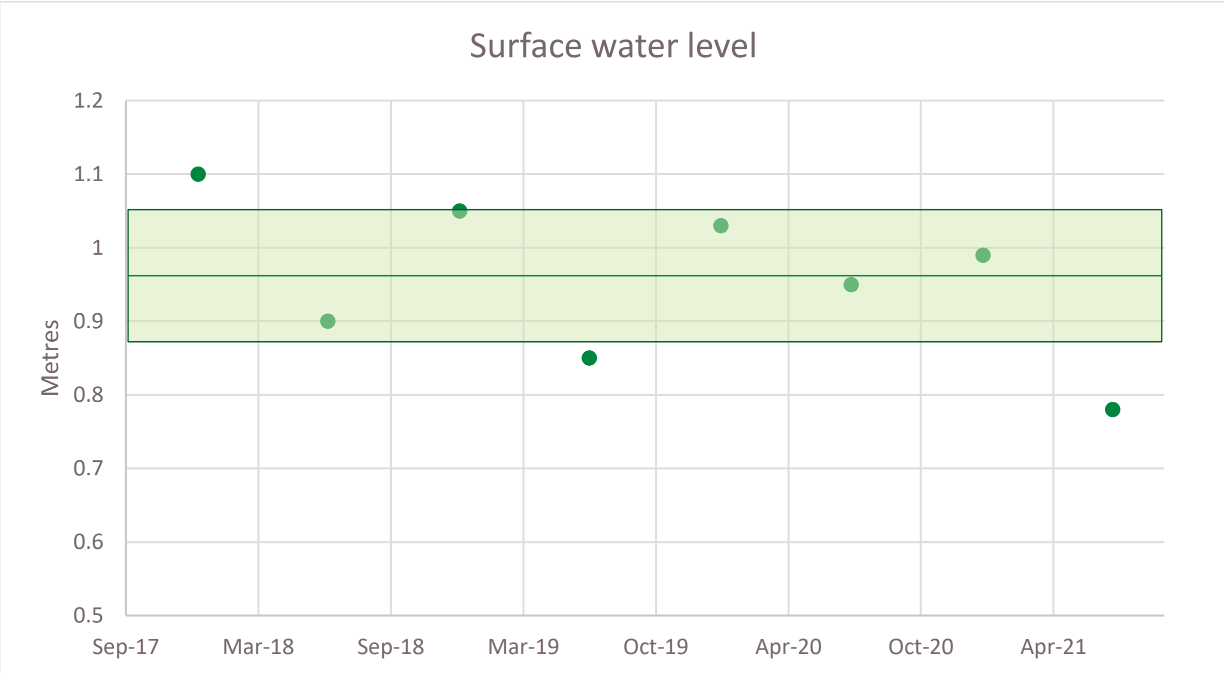


Figure 4-1: Example of application of a control chart to assess changes in ecological variables (mid-line indicates long term mean, with the limits of a statistically significant change shaded in green)

The approach taken to the establishment of control charts and identification of control limits needs to be tailored to each environmental variable. Many aspects of the data influence the approach that should be taken to analysis, such as whether data points are normally distributed, or if outliers are present. Given that the variability of measures among sites is not necessarily reflected in their mean alone, statistical significance between baseline/pre-impact and impact phases will also be assessed. For unique variables, differences will be tested using univariate f-tests to test for homogeneity of group variances, and then t-tests to test for differences in mean values.

For related variables such as water quality or vegetation condition, a multivariate approach will be taken. Multivariate statistical techniques allow for a robust assessment of the parameters that have the greatest influence on changes in data. They also allow for the combined effects of all variables to be considered. Multidimensional scaling (MDS) plots will be used to visually assess differences between impact and baseline data, with the significance of these differences tested using non-parametric multivariate analysis of variances (PERMANOVA). To understand which of the individual parameters are having the greatest influence on the groupings, Similarity Percentage (SIMPER) tests will be undertaken.

By combining the control charting approach with tests for statistical significance, changes to indicators over time will be effectively assessed in the context of the overall variation across the Study Area. If changes are noted outside the control limits (difference from baseline/pre-impact conditions) and these are statistically significant, then this is a trigger for further investigation, which would include (for example):

- Review of groundwater data from nearby bore locations, to determine whether the reduction in the water level of surface water pool is caused by groundwater drawdown
- Review of rainfall records to determine whether the reduction may be related to an unusually dry period (drought).

Details of the hypothesis being tested and statistical test for each monitoring parameter are provided for each GDE in **Section 5**.

4.5.4 Pre-impact monitoring

The first pre-impact monitoring survey will involve the field survey team collecting information on all variables listed in this GDEMMP. In the event that some variables are found to be inappropriate for ongoing application (e.g. not present or unable to be collected without impacting the environment), then alternative monitoring variables will be considered. Any proposed alternative monitoring arrangements will be developed in consultation with Commonwealth and State regulatory agencies, with the plan being subsequently updated.

Pre-impact monitoring, including any alternative approaches, will be undertaken prior to relevant Project impacts occurring. The pre-impact monitoring, combined with completed baseline monitoring, is considered to be adequate for compiling a substantial baseline/pre-impact dataset prior to the commencement of Project impacts.

Pre-impact studies will be undertaken for all three GDE types across the Styx River and tributaries (Deep Creek and Tooloombah Creek), riparian vegetation and Wetland 1 within the Project Area. These studies will build on existing information collected during the EIS and SEIS (baseline) phases and evaluate the pre-impact conditions, including seasonal variations and existing threats. This monitoring will continue in conjunction with the implementation of detailed studies to characterise the GDEs' reliance on groundwater and develop triggers that could indicate potential impacts.

Pre-impact monitoring will be carried out until the commencement of Project impacts for each GDE. These studies will be undertaken at various temporal scales, but generally on a seasonal basis (wet and dry season). The location of pre-impact monitoring sites is described in **Section 5.4** for each GDE, with maps provided. These locations will be updated in future revisions of the plan as pre-impact monitoring is completed.

Following the completion of pre-impact surveys, the frequency of monitoring will be reviewed, and the collection of ongoing monitoring data will contribute to the development of an extended baseline for each GDE to account for temporal variations in indicators occurring naturally. At the conclusion of the pre-impact monitoring for each individual GDE, triggers will be reviewed and updated for inclusion in a revised GDEMMP to be submitted to Commonwealth and State regulatory agencies. The conceptual model for each GDE will also be reviewed and updated at this time, to incorporate the most up to date information.

4.5.5 Impact monitoring

The monitoring programs outlined in **Section 5.4** will continue after activities that may impact GDEs commence. Results from this impact monitoring will be evaluated at the time of data collection to assess whether there has been any change from baseline conditions (i.e. if a trigger has been exceeded). This will typically be every three months for groundwater data and every six months for ecological data.

Investigations and corrective actions will be instigated promptly if a trigger is reached or exceeded. This approach will also assist in evaluating the effectiveness of mitigation measures and identify the condition of environmental values in relation to impact trigger levels. The purpose of this monitoring is to determine how closely actual impacts (if any) align with those predicted in the impact assessment, and to allow for the early identification of any deviations from approved or anticipated impacts. In particular, monitoring will aim to establish the Environmental Water Requirement and ecological response of each GDE to changes in groundwater (consistent with GDE Toolbox stage 3 – see **Section 4.9.3**).

4.6 Ecological trigger levels

In accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000, 2018), ecological indicator trigger levels have been determined for each GDE. These are based on statistical analysis of data collected during the baseline surveys and to be further monitored during the pre-impact period. Ecological and groundwater triggers aim to provide an early detection of potential impacts prior to ecological disturbance occurring and ensure appropriate management actions to minimise impacts.

Triggers have been adopted for each GDE, based on the results of baseline surveys and condition. These triggers follow the approach outlined in Section 3.2.4.2 of the ANZECC (2000) Guidelines, which seeks to identify a statistically significant deviation from baseline conditions. Triggers will be revised in the future with the approval of the administering authorities, using additional monitoring data collected during the pre-impact period for each GDE.

Groundwater quality triggers have been developed and included for each GDE in this plan (see **Appendix B**), and are based on the 20th or 80th percentile of baseline data (HydroAlgorithmics 2020). Groundwater level drawdown triggers have also been developed and are based 75% of the maximum groundwater drawdown predicted from a regional hydrogeological model at each monitoring bore (HydroAlgorithmics 2020; **Appendix A**).

Triggers will be updated, where appropriate, at the completion of pre-impact studies and monitoring, and where relevant updates are made to the GMMP. A revision of triggers will also occur when information from related management and monitoring plans becomes available (e.g. the REMP).

This GDEMMP will be updated on approval of the revised trigger levels, which will replace the previous triggers. Groundwater drawdown triggers will also provide an 'early warning' that changes in the groundwater environment may have occurred and that investigations into potential ecological responses must be undertaken. Surface water quality triggers have been derived for relevant Aquatic GDEs from the 80th percentile of surface water data, consistent with the ANZECC Guidelines (2000, 2018).

Areas of high conservation value have a lower level of acceptable change arising from Project related impacts, than areas of low conservation value. Whilst a number of the GDEs currently show evidence of disturbance from human activity such as grazing and from pests, the protection of listed species that depend on this environment (e.g. Koala and Greater Glider habitat) should be given a high priority. In this context, the level of acceptable change applied to GDEs in the Study Area is consistent with those applied to high environmental values systems (Condition 1 in ANZECC 2000 Guidelines).

Regardless of the ecosystem condition classification that may apply to the GDE, trigger levels for ecological parameters in this plan aim to detect statistically significant change ($p<0.05$) from baseline conditions at which point further investigations will be undertaken and/or corrective actions implemented. This approach recognises the ecological value of the ecosystems being monitored.

In the event that a groundwater quantity or quality trigger is met, then an investigation will be carried out to review the ecological condition of the associated GDEs. In the case that one or more ecological triggers are exceeded, then an investigation and corrective action process will be carried out. If required, concurrent investigation of groundwater triggers will also be undertaken. As environmental data are collected, control charts identifying the baseline mean and trigger thresholds will be developed and updated for each variable.

Ecological triggers will be reviewed and if required, updated following groundwater model review, when the conceptual understanding changes, pre-impact data are collected prior to the impact phase (for each relevant impact) and once Environmental Water Requirements of GDEs are known.

4.7 Investigations and corrective actions

In the event that an ecological trigger is reached or exceeded, an investigation into the potential cause will be initiated within 14 days of the detection. **Section 5** provides details of the investigation process that will be followed and what corrective actions will be taken, should it be found that mining activities have contributed to reaching or exceeding the trigger.

It should be noted that some impacts to GDEs are predicted as part of the impact assessment, and if approved by regulatory agencies, are an expected result of the Project. The GDEMMP aims to reduce the magnitude of approved impacts, and avoid any additional impacts that are beyond those predicted in the impact assessment and SEIS v3 (Central Queensland Coal 2020b).

As a guide, the following approach will generally be applied and tailored to the environmental variables of interest:

- Notification of DAWE and/or DES that an exceedance has occurred.
- Development of a decision tree model (before any investigation) for the possible effect of mining activities on the measured variable. This will involve developing a conceptual decision

tree using all of the information available at the time of the investigation, to identify the potential 'root cause/s' of the observed result.

- A detailed review of all existing data relevant to the environmental parameter will be completed, to quantify the nature, magnitude and reliability of the observed result.
- Site-specific investigations will be implemented involving the collection and interpretation of additional data.
- A review will be completed of relevant data related to potential non-mining causes of variability in environmental variables (e.g. climatic data). This will seek to either identify or rule out the contribution of non-mining activities to the identified trigger exceedance.
- A detailed model of relevant environmental variables will be developed
- Expert opinion on the potential for environmental harm will be sought.

Data that will be collected during an investigation, specific to each GDE, is provided in **Section 5.** The investigation process should not delay the implementation of corrective actions, once identified, and should be completed as soon as possible, within a maximum period of three months.

If the investigation determines that the exceedance is caused by mining activities, the administering authority will be notified within 28 days of the detection.

Corrective actions will be developed to reduce the effect of any mining related activity, based on the findings of the investigation. Corrective actions will be tailored to the particular environmental variables or trigger levels of relevance, and likely include:

- A review of mitigation measures and the implementation of additional or more effective controls.
- Implementation of additional monitoring to assess the effectiveness of mitigation measures and corrective actions.
- Actions that prevent the occurrence of impacts beyond those that are approved.
- Notification of relevant managing agencies and a revision to the Offset Management Plan (CO2 Australia 2020) will be proposed if an impact beyond that approved cannot be avoided.

4.8 Reporting

Reports will be provided regularly throughout the implementation of the GDEMMP and include:

- An annual report of the findings of this GDEMMP, including all monitoring results and interpretations (e.g. the results from the first year of pre-impact monitoring and proposed amendments to triggers).
- Any investigations and assessments into unexpected impacts, if authorised unavoidable impacts are exceeded or if trigger levels are exceeded as a result of mining activities.
- Notification to the Commonwealth and State governments within five business days of identifying any GDE not previously identified and reported in the Project area.

In the event that a new listed species or Threatened Ecological Community that is groundwater dependent is found, then DAWE and/or DES will be notified within five business days for further discussion on management approaches. These approaches may include updating the relevant management plan for re-assessment, based on the new information. Changes may also be required to the Project offsets strategy.

Further details on reporting are provided in **Section 6** and the GDE management plan (**Section 5**). All reports will be made available to the administering authority.

4.9 Consistency with GDE Toolbox

This management plan has been developed to be consistent with the approach detailed in the GDE Toolbox, and as described in the following sections.

4.9.1 GDE Toolbox Stage 1 – GDE location, classification and conceptualisation

GDE Toolbox Stage 1 assessments focus on developing a baseline understanding of where GDEs exist, classification of ecosystem type and conceptualisation of the ecohydrogeologic setting (Richardson et al. 2011a).

Classification and conceptualisation of GDEs associated with the Project area was completed as part of the EIS and SEIS process. This process will continue through the pre-impact stages of the Project and involves the refinement of the regional groundwater model and model of surface water and groundwater interactions. This work will build upon the studies and models completed during the EIS and SEIS, and include a gap analysis to identify additional survey requirements. These tasks are described in further detail within **Section 5**.

GDE Toolbox Stage 1 assessments aim to determine the reliance of groundwater for Aquatic GDEs by considering the following questions, many of which have been answered through technical studies associated with the SEIS:

- Does a stream / river continue to flow all year, or does a floodplain waterhole remain wet all year in dry periods?
- Does the volume of flow in a stream / river increase downstream in the absence of inflow from a tributary?
- Is the level of water in a wetland maintained during extended dry periods?
- Is groundwater discharged to the surface for significant periods of time each year at critical times during the lifetime of the dominant vegetation type?

For Terrestrial GDEs, the following questions are considered:

- Is groundwater of the capillary fringe above the water table present within the rooting depth of any vegetation?
- Does a proportion of the vegetation remain green and physiologically active (principally, transpiring and fixing carbon, although stem-diameter growth or leaf growth are also good indicators) during extended dry periods?
- Is the level of water in a wetland maintained during extended dry periods?

Some of this work has been completed during the extensive impact assessment studies conducted as part of the Project SEIS v3 (Central Queensland Coal 2020b).

4.9.2 GDE Toolbox Stage 2 – Characterisation of groundwater reliance

GDE Toolbox Stage 2 assessments seek to characterise potential reliance of identified GDEs on groundwater. Key questions that need to be considered at Stage 2 are:

- Is groundwater part of the ecosystem?
- How reliant is the system on groundwater?

To determine the groundwater interactions and dependency for each GDE, collection of time-series data is required to quantify the seasonal use of groundwater. The timing of groundwater use by each of the GDEs is a consideration in the development of ecological water requirements (EWRs; Richardson et al. 2011a).

There is no indication that vegetation at either of the two wetlands within the Project area is wholly reliant on groundwater. However, the trees at Wetland 1 access soil water during dry periods that is maintained by an impermeable layer above the underlying saturated zone (HydroAlgorithmics 2020; 3D Environmental 2020).

Surface pools and waterways associated with Tooloombah and Deep Creek have baseflow supported by groundwater, with aquatic plants and animals present in permanent and semi-permanent pools reliant on the surface expression of groundwater. Components of the riparian vegetation communities of Tooloombah Creek and Deep Creek (e.g. Forest Red Gum, Melaleucas) are likely to rely upon groundwater during dry periods only.

Water balance modelling can assist in determining whether groundwater is used by vegetation, by providing an understanding of the balance between rainfall, evapotranspiration (ET) and available soil moisture within the root zone. For instance this approach may be particularly beneficial for assessing groundwater dependency of riparian vegetation along Tooloombah Creek and Deep Creek through evidence such as pre-dawn leaf water potential measurements and use of stable isotopes of water analysis, to determine whether a groundwater 'signature' exists within the plant xylem (Richardson et al. 2011a). Such baseline studies were completed during the EIS stage of the Project (3D Environmental 2020) and will continue into the pre-impact and impact stages of the Project.

Additional questions that are to be considered for Aquatic GDEs in Stage 2 assessments include:

- Is the vegetation associated with surface discharge of groundwater different (in terms of species composition, phenological pattern, leaf area index or vegetation structure) to vegetation nearby that is not thought to access groundwater?
- Is the annual rate of water use by the vegetation significantly larger than annual rainfall at the site and the site does not receive overland flow?
- Are plant water relations (especially pre-dawn and midday water potentials and transpiration rates) indicative of lower water stress (potentials close to zero, transpiration rate larger) than for vegetation nearby not accessing groundwater?
- Is occasional (or habitual) groundwater release at the surface associated with key developmental stages of vegetation (such as flowering, germination, seedling establishment)?

For Terrestrial GDEs the following questions are to be considered during Stage 2:

- Within a small region (and thus an area having the same rainfall and same temporal pattern of rainfall across its entirety), and in an area that does not receive overland flow and has no access to stream or river water, do some ecosystems show large seasonal changes in leaf area index while others do not?
- Is the vegetation associated with surface discharge of groundwater different (in terms of species composition, phenological pattern, leaf area index or vegetation structure) to vegetation nearby that is not thought to access groundwater?
- Are seasonal changes in groundwater depth larger than can be accounted for by the sum of lateral flows and percolation to depth (that is, is vegetation a significant discharge path for groundwater)?

GDE Toolbox Stage 2 assessments are analogous to the continued development of an extended set of pre-impact data for GDEs. The pre-impact monitoring will aim to quantify the EWRs for each GDE and will include a review of triggers based on more comprehensive data and knowledge of each of the GDEs.

Concurrent activities through the GMMP (documented in the Project EMP) will be undertaken to link changes in groundwater condition (e.g. drawdown of groundwater levels) with the driver of the threat (e.g. groundwater abstraction, drought, or land-use change). Modelling approaches should take into account potential interaction between surface water features and groundwater. It is critical that the scale of groundwater modelling is commensurate with the temporal and spatial scale of occurrence of the GDE, as often the ecohydrogeological analysis requires greater resolution than is available from many groundwater modelling approaches used to support regional management of groundwater systems. Multiple scales of models may be required to increase confidence (Richardson et al. 2011a).

Central Queensland Coal has undertaken modelling of groundwater, surface water and groundwater-surface water interactions as part of the SEIS v3 technical studies (Central Queensland Coal 2020b). The GDEMMP will assist in building on the knowledge developed from this work. These models will be further developed and validated over time, based on the results of the GMMP.

GDE Toolbox Stage 2 activities (i.e. pre-impact monitoring) will be undertaken from the approval of the GDEMMP until the commencement of groundwater drawdown impacts (the timing of which varies depending on each GDE and its location), but generally up to three years after the commencement of construction.

4.9.3 GDE Toolbox Stage 3 – Characterisation of ecological response to change

GDE Toolbox Stage 3 involves creating a detailed and quantified understanding of the ecological and biotic responses of GDEs to fluctuations and changes in groundwater. This will be achieved through analysis of monitoring data collected over the duration of this GDEMMP, including regular monitoring and research observations. This work will occur both during the pre-impact monitoring (i.e. response to natural variation in groundwater) and impact monitoring (i.e. response to mining-related impacts).

Key questions in Stage 3 are:

- What are the threats to the ecosystems and species presented by changes in groundwater?
- How might the ecosystems and species respond as a result of these groundwater changes?
- Is the actual impact as predicted by the groundwater model and impact assessment?

- What is the long-term ecosystem state due to the change (Richardson et al. 2011a)?

GDE Toolbox Stage 3 assessments will include the continued long-term monitoring of GDEs, and will include both the pre-impact monitoring and impact monitoring, which will commence at the anticipated initiation of groundwater drawdown impacts (approximately 3-5 years after Project commencement) and continue for the life of the Project. Monitoring will focus on the biotic responses of GDEs due to changes to groundwater conditions, and the effectiveness of management and mitigation measures (during impact monitoring stage).

5. Groundwater Dependent Ecosystem Management and Monitoring Plan

This section provides a management and monitoring plan for the Subterranean, Aquatic and Terrestrial GDEs of Project Area. Relevant GDEs as defined in **Section 3.2** are:

- Stygofauna living within the alluvial aquifers of creeks and rivers adjacent to the Project
- Aquatic plants and animals living within and adjacent to waterways supported by the surface expression of groundwater
- Vegetation dependent on the subsurface presence of groundwater (riparian vegetation and wetlands)

5.1 Summary of baseline monitoring results

5.1.1 Stygofauna

The groundwater invertebrate (stygofauna) community is generally dominated by small crustaceans, occurring in aquifers with sufficient pore space to complete their life cycle, and are most common in alluvial sediments, karstic aquifers, and fractured rock (Glanville et al. 2016). Stygofauna were collected from bores near the Styx River during baseline studies for the EIS, but are likely to occur more broadly than the points of collection (ALS 2010, GHD 2012). The Styx River alluvium extends south from the collection bores, through ML 80187, and further south for another 12 km. This makes it unlikely that the stygofauna taxa sampled as part of the Project investigations are short range endemics.

Six taxa were classified as stygofauna during baseline surveys as part of the EIS (GHD 2012):

- Bathynellacea (syncarid crustacean).
- Three Families of Oligochaeta (segmented worms).
- One species from the Subclass Copepoda.
- One species from the Subclass Acari.

Of these taxa, the oligochaetes and Acari are most likely to be members of the soil invertebrate community, rather than the stygofauna community (Halse and Pearson 2014). Copepoda could be stygofauna, as groundwater copepods are known in Queensland (NRM 2004). However, there is a possibility that these could also be of surface water origin and that eggs or adult specimens have entered an open bore cavity and persisted in the bore cavity. Bathynellacea is a group of crustaceans known only from aquifers, so this taxonomic group is definitely stygofauna. This order is amongst the most diverse and widespread group of stygofauna in Australia, with little information relating to this group known from Queensland (Little et al. 2016).

The stygofauna collected during baseline EIS surveys came from bores close to rivers and with water of relatively low EC. Stygofauna are most commonly found in groundwater with EC <5,000 µS/cm (Doody et al. 2019), although have been identified in aquifers exceeding 50,000 µS/cm on rare occasions (DES 2018). There is variability in the EC of the alluvial aquifers of Deep Creek, Tooloombah Creek and Styx River (HydroAlgorithmics 2020). Transient electromagnetic surveys indicate that soil moisture in upper layers to a depth of approximately 7 m is relatively fresh over most of the aquifers (EC < 4000 µS/cm), and saline below depths of approximately 12 m. EC in deeper parts of the aquifer is generally high, with alluvial bores screened between 12 and 18 m showing median ECs of 5,270 to 47,700 µS/cm.

The collated data suggest that there is a lens of fresh water either within or immediately above the water table aquifer overlying denser saline groundwater. If this is the case, then it is possible that the upper parts of the aquifer are a potentially suitable habitat for stygofauna. This is not always possible to determine from survey results, as most bores are screened below the fresh water layer. The Study Area is therefore likely to contain a mosaic of areas that are suitable and unsuitable for stygofauna, depending on local hydrogeological conditions and the depth of groundwater resources.

Most of the bores sampled for stygofauna in the modelled drawdown area (i.e. around the pit locations), extended to depths below the alluvium, where EC was low (GHD 2012). This suggests that the alluvial stygofauna community was sampled from only a few locations within the impact area. Nevertheless, stygofauna were collected from two locations, and the TEM surveys indicating a lens of fresh groundwater overlying saline aquifers, resulting in the possibility that stygofauna occur throughout much of the Styx River alluvium, from the proposed mine north to the coastal margins. Styx River alluvium may also be connected to the Herbert Creek alluvium, in which case the two systems are likely to share a similar stygofauna community.

There is a likelihood that stygofauna communities extend throughout the Styx River alluvium, as well as the alluvium of Tooloombah Creek and Deep Creek, but that their distribution is generally limited to parts of the aquifer where EC is less than 7,000 µS/cm. EC in the central part of the aquifer is higher (up to 37,400 mg/L) than in the coastal section near Broad Sound, or close to waterways (CDM Smith 2018-SEIS Chapter 10), and less suitable for stygofauna.

Likewise, there are areas suitable for stygofauna in the aquifer south of the mine, with BH29 having an EC <500 µS/cm (CDM Smith 2018- SEIS Appendix 5a). Although no stygofauna were collected from bores south of the mine, it is possible that stygofauna occur in this region. The taxa living in the southern section of aquifer is likely to be similar to those living in the northern section. However, numbers of stygofauna would probably be higher in the north, due to the more extensive distribution of suitable habitat in this area.

5.1.2 Surface water and groundwater resources supporting GDEs

The Styx River, Deep Creek and Tooloombah Creek are all designated stream order watercourses under the *Water Act 2000*. Some of these surface water resources are potentially affected by the Project (Tooloombah Creek and Deep Creek). Connections with groundwater are expressed during periods of low rainfall, as deep pools that provide habitat for aquatic plants and animals.

Analysis of shallow bore transects across the alluvial aquifers of Tooloombah Creek and Deep Creek indicate that aquifer materials exist in discontinuous pockets and generally presents with a poor hydraulic connection with the underlying Styx Coal Measures. The regional water table may rise to levels that coincide with the base of the alluvial sequence towards the end of the wet season and may provide limited baseflow for some reaches. Bank storage is a feasible recharge mechanism for both Tooloombah Creek and Deep Creek and is critical for Tooloombah Creek to sustain the soil moisture and GDEs in this region. Bank storage does not appear to be a critical process at Deep Creek, where the creek aligns with a north-south trending geological fault line present on the eastern side of the creek and Project area. In this area groundwater flow in bank storage is enhanced away from the creek towards the east (ELA 2020a).

The Styx River, Deep Creek and Tooloombah Creek are all considered to be slightly to moderately disturbed aquatic ecosystems under the ANZECC (2000, 2018) Guidelines. The Project Area is predominantly within an existing cattle grazing property, which includes a series of farm dams and surface contour bunds to capture and store runoff. Cattle grazing is also the dominant land use of the Styx River catchment.

Baseline surface water quality sampling was undertaken at several locations from 2011 to 2020, documented across the EIS and SEIS technical reports. Stream gauges were installed at Tooloombah Creek and Deep Creek in 2019 and have been recording flow continuously since this time. This information will assist in future interpretation of water quality results. Flows within the creek systems are highly variable, ranging from flood flow to dry. On average, creeks flow for approximately 24% of the time (WRM 2020).

Water quality objectives (WQO) under the EPP (water) have been established for a number of basins throughout Queensland, including the Styx Basin.

A summary of the results of baseline monitoring of surface water quality is as follows:

- Turbidity levels in Tooloombah Creek pools are lower than Deep Creek pools, likely due to a combination of catchment hydrology, local geology, reduced stock access at Tooloombah Creek, and increased residence time of pool water enabling sediments to settle.
- EC results are variable across the waterways with seasonal cycles (ranging from 125 µS/cm to more than 5,000 µS/cm EC). EC is generally low during flows, and high during the dry season, particularly in evaporating pools, and in pools with saline groundwater inputs (mostly located in Tooloombah Creek).
- The pH within the Styx River, Deep Creek and Tooloombah Creek has a broad range but generally sits between 7 and 8 (slightly alkaline). Elevated pH occurs in Tooloombah Creek during periods of low flow and is likely the result of groundwater inflow.
- Total nitrogen within Deep Creek, Tooloombah Creek and Styx River exceeds the WQOs often during the dry season. Deep Creek typically has the highest concentrations, which is likely influenced by increased stock access within the Project Area and upstream catchment. Deep Creek also often exceeds the WQO for phosphorus of 0.5 mg/L, as does the Styx River on some occasions.
- Concentrations of Ammonia within the waterways are often elevated above the WQOs and coincides with increased flows during the wet season.
- Concentrations of dissolved Aluminium, Copper and Zinc exceed their respective WQOs in all three waterways at various times.
- Elevated heavy metal concentrations typically occur following rainfall events, although Deep Creek also has high Copper concentrations during the dry season.

Alluvial groundwater quality is variable, with EC and Total Nitrogen sometimes exceeding QWQG aquatic ecosystem surface water quality guidelines. The pH of alluvial groundwater ranges from slightly acidic (6.5) to slightly alkaline (8.0), with the salinity generally ranging from 469 to 12,362 µS/cm, except for one bore (BH25) where the salinity ranges from 17,416 to 34,804 µS/cm (HydroAlgorithmics 2020). Water within the upper Quaternary Alluvium (Qa) is generally less saline than the underlying Quaternary Pleistocene Alluvium (QPa; HydroAlgorithmics 2020).

5.1.3 Aquatic habitats

The Styx River is tidally influenced, with the water surface level rising significantly on two occasions daily. The river generally supports a significant depth of water and well-established vegetation on the banks.

Deep Creek and Tooloombah Creek are ephemeral with incised channels and predominantly sand or rocky beds. Aquatic habitat is variable, with pools common but drying out or becoming isolated throughout periods of low rainfall. Other key habitat features present within the creeks are occasional riffles, large woody debris and undercut banks. During surveys undertaken for the SEIS, most sites along both creeks had multiple physical habitat features, indicating a robust environment for aquatic fauna and a healthy ecosystem. However, natural habitat values are degraded in some locations, due to access by cattle and the proliferation of weeds and pests.

The primary period of interest from the perspective of managing impacts of the Project on Aquatic GDEs is the dry season, when the aquatic ecology values of the creeks are essentially comprised of isolated pools. During the wet season, groundwater inputs have minimal influence on the amount of water in the system and the overall water chemistry. However, during the dry season, changes to the expression of groundwater to pools has the potential to result in a shorter duration of pool persistence through the dry season, as well as variation in water chemistry within pools.

Baseline studies have mapped the location of approximately 30 pools throughout Tooloombah Creek and Deep Creek (ELA 2020b). There have been a range of investigations of the number and distribution of pools that receive groundwater inputs during the dry season. Pool surveys have been undertaken at various periods during the EIS studies, with water quality sampling of the larger and more permanent pools undertaken on a regular (approximately monthly) basis over the period 2017 to present. This has resulted in over 40 inspections of a sub-set of the largest pools over a period of several years, with recordings made on whether the pool was flowing or dry. Each pool is likely to have a differing degree of groundwater input, which may be a permanent connection (groundwater inflow) or a temporary one through the wet season and parts of the dry season.

The majority of pools in Tooloombah Creek are permanent or semi-permanent. Most pools in Deep Creek are ephemeral, with only a few located in the lower reaches being semi-permanent, through a connection to groundwater (ELA 2020b). Overall, a reduction in groundwater inputs to pools affected by drawdown can be expected to result in pools drying up faster during the dry season than under baseline conditions, with a less saline water chemistry overall, as saline groundwater inputs are reduced. However, the magnitude of any impacts is dependent upon a number of factors, including the permeability of sediments in the alluvial corridor (ELA 2020a).

As there is spatial variability in the salinity of alluvial groundwater (as indicated through monitoring of alluvial groundwater bores), each pool is likely to have a unique pattern of water chemistry and persistence through the dry season. Pools provide habitat for a variety of aquatic fauna, including fish, invertebrates and freshwater turtles. Habitat values of pools and associated waterways are degraded in some locations due to direct access by cattle.

5.1.4 Aquatic Flora and fauna

Field surveys in 2011 collected 28 native fish species from the project area, including 12 that were not reported during the database search (CDM Smith 2018). The most abundant taxa in the fish community included Eastern Rainbowfish (*Melanotaenia splendida*), Empire Gudgeon (*Hypseleotris compressa*), Agassiz's Glassfish (*Ambassis agassizii*), Spangled Perch (*Leiopotherapon unicolour*), and Purple Spotted Gudgeon (*Mogurnda adspersa*). The commercially important species Barramundi (*Lates calcarifer*) was also common, though didn't occur at all sites, and Sea Mullet (*Mugil cephalus*) occurred at 2 sites. An unidentified eel was also collected, tentatively identified as the first record of swamp eels (*Ophisternon* sp.) in the Styx River catchment.

Three species of freshwater turtle were caught during the 2011 and 2017 surveys; Kreft's River Turtle (*Emydura macquarii krefftii*), Eastern Snake-necked Turtle (*Chelodina longicollis*), and Saw-shelled Turtle (*Wollumbinia latisternum*). As pools begin to dry out, turtles are able to move across land to find more permanent water. Pools with a saline groundwater inflow may not be suitable habitat for turtles during the extended dry season, due to their high salinities.

Four listed aquatic animal species have the potential to occur in waterways surrounding the Project Area. Evidence of Estuarine Crocodile (*Crocodylus porosus*) was found at two Styx River sites, and the species is likely to be present in Deep Creek, Granite Creek, and Tooloombah Creek. Neither the Fitzroy Turtle (*Rheodytes leukops*), nor the Southern Snapping Turtle (*Elseya albagula*) have been recorded in the Study Area, and they are considered unlikely to occur within the Project Area (CDM Smith 2018; Central Queensland Coal 2020b). The Platypus is listed as Special Least Concern under the *Nature Conservation Act 1992* (NC Act) and has potential to occur in waterways of the Project Area. The Platypus was not observed during baseline field surveys, but is known to be cryptic and may be difficult to detect.

Aquatic macroinvertebrate communities were sampled in June 2011 and February 2017 and were represented by 46 taxa (CDM Smith 2018). Fewer taxa were collected from the Styx River than from the creek sites sampled, possibly because invertebrates are more concentrated in the smaller water bodies, or that habitat diversity was higher in the creeks (CDM Smith 2018). The taxa collected are tolerant to poor water quality and periods of static or low flow. According to the AUSRIVAS Model for Central Queensland for riffle habitats, three sites had more taxa than reverence sites, two had similar numbers of taxa, and one had significantly fewer taxa and is 'significantly impaired'.

5.1.5 Vegetation dependent on groundwater

Five REs were determined by ELA (2020a) and 3D Environmental (2020) to comprise Terrestrial GDEs within the Project Area:

- 11.3.4 *Eucalyptus tereticornis* and/or *Eucalyptus spp.* woodland on alluvial plains
- 11.3.25 *Eucalyptus tereticornis* or *E. camaldulensis* woodland fringing drainage lines
- 11.3.12 *Melaleuca viridiflora*, *M. argentea* +/- *M. dealbata* woodland on alluvial plains
- 11.3.27 Freshwater wetlands
- 11.3.35 Eucalyptus platyphylla, *Corymbia clarksoniana* woodland on alluvial plains.

Field studies were completed in 2018 to examine the potential groundwater dependence of vegetation in a variety of locations across the Study area, including Wetlands 1 and 2, and the riparian corridors of Tooloombah Creek and Deep Creeks (3D Environmental 2020). A range of survey techniques were used to examine the potential for groundwater dependence of individual trees at these locations, including:

- Measurement of leaf water potential.
- Geological coring of the soil profile.
- Measurement of soil moisture potential.
- Stable isotope sampling and analysis.

Based on the results of these field studies, the main vegetation types with potential to be groundwater dependent are the riparian corridors along Deep Creek and Tooloombah Creek, which include Forest Redgum woodland, and Forest Red Gum Woodland on the alluvial plains. As noted above, Melaleucas at Wetland 1 are also consistent with the definition of a Terrestrial GDE, as they utilise a perched aquifer.

The results of drilling investigations (Central Queensland Coal 2020c) and analysis of associated data for a surface water – groundwater interactive model (ELA 2020a) indicate the following key characteristics of the alluvial corridors of Tooloombah Creek and Deep Creek which are likely to support Terrestrial GDEs:

- Soil salinity within the alluvium does not exceed 7,800 µS/cm at Tooloombah Creek and 3,060 µS/cm at Deep Creek. Therefore, moisture contained in the alluvium can be considered suitable for use by terrestrial vegetation.
- Tooloombah Creek has a higher potential for bank storage of water than does Deep Creek.
- Sediments of the Tooloombah Creek alluvial corridor have a very low permeability and a greater water holding capacity by virtue of their fine sediment grain size (clay).
- Groundwater level mostly remains below the base of the creek bed.

5.2 Threats and potential impacts

Threats and potential direct and indirect impacts associated with the Project as they apply to Subterranean, Aquatic and Terrestrial GDEs have been identified as part of the EIS and SEIS process. The potential impacts on GDEs due to the construction and operation of the Project are:

- Groundwater drawdown as a result of mine dewatering and depressurisation.
- Declines in groundwater quality.
- Minor changes in surface water runoff into the surrounding watercourses, due development of the mine and associated water storages in a small proportion of the catchment.
- Changes to surface water and groundwater flows into the watercourses associated with the Project Area.
- Degradation of surface water quality.
- Erosion of streambanks arising from construction activities and direct and indirect impacts to riparian vegetation.
- Altered stream morphology from scouring and deposition, leading to degradation of aquatic habitat quality.
- Clearance, degradation and fragmentation of aquatic and riparian habitats, including the obstruction and removal of fish passage due to waterway barrier works.
- Potential introduction and / or spread of weeds and pests.
- Changes to fire regimes, increasing the susceptibility of riparian vegetation to hot and destructive bush fires.

- Indirect impacts to the condition of ecological values from dust emissions, noise and vibration, and light spill.

Direct impacts are small in scale and are limited to minor changes in surface water hydrology (e.g. construction of diversion drains and channels) and disturbance or clearing associated with the construction of infrastructure across waterways. These include the mine haul road across Deep Creek and mine pits across several minor tributaries of Deep Creek. Other direct impacts to GDEs have been avoided through design of the Project to be located away from such areas. Indirect impacts include groundwater drawdown, and other indirect changes to aspects of the environment that may affect GDEs and their associated ecological values (e.g. increase in dust, pests and weeds and reductions in water quality).

The key threats and potential direct and indirect impacts on GDEs identified for the Project are detailed in **Table 5-1** and assessed in the following sections.

Table 5-1: Threats and potential direct / indirect project impacts on Subterranean, Aquatic and Terrestrial GDEs

#	Potential threat or impact	GDE Type relevant to threat or impact	Potential direct project impact identified in SEIS v3 (Central Queensland Coal 2020b)	Potential indirect threat or impact identified in SEIS v3 (Central Queensland Coal 2020b)	Project phase(s)	Earliest predicted potential impact	Impact addressed
1	Mine dewatering and depressurisation (groundwater drawdown)	Subterranean Aquatic Terrestrial	-	Yes	Operation Rehabilitation	Year 3	**Table 5-7** to **Table 5-9**
2	Ground water quality degradation	Subterranean Aquatic Terrestrial	-	Yes	Construction Operation Rehabilitation	Year 1	
3	Changes to surface water hydrology	Subterranean Aquatic Terrestrial	Yes	Yes	Construction Operation	Year 1	
4	Surface water quality degradation	Subterranean Aquatic Terrestrial	Yes	Yes	Construction Operation	Year 1	
5	Erosion of streambanks	Aquatic Terrestrial	Yes	Yes	Construction Operation	Year 1	
6	Direct disturbance of habitat	Aquatic Terrestrial	Yes	-	Construction	Year 1	
7	Introduction and spread of weeds and pests	Aquatic Terrestrial	-	Yes	Pre-construction Construction Operations Rehabilitation	Year 1	
8	Change in the fire regime	Aquatic	-	Yes	Pre-construction Construction	Year 1	

#	Potential threat or impact	GDE Type relevant to threat or impact	Potential direct project impact identified in SEIS v3 (Central Queensland Coal 2020b)	Potential indirect threat or impact identified in SEIS v3 (Central Queensland Coal 2020b)	Project phase(s)	Earliest predicted potential impact	Impact addressed
		Terrestrial			Operation Rehabilitation		
9	Increase in dust emissions	Aquatic Terrestrial	-	Yes	Construction Operation	Unlikely to impact, but may occur from Year 1	
10	Increase in noise and vibrations	Aquatic Terrestrial	-	Yes	Construction Operation	Unlikely to impact, but may occur from Year 1	
11	Increase in light spill and other visual impacts	Aquatic Terrestrial	-	Yes	Construction Operation	Unlikely to impact, but may occur from Year 1	

5.2.1 Mine dewatering and depressurisation (#1)

Mine dewatering and depressurisation will result in groundwater drawdown near the mine and extending below parts of Deep, Tooloombah, Barrack and Mamelon Creeks. This may impact on GDEs by isolating them either from aquifers permanently, or at critical life stages. Terrestrial vegetation that once utilised groundwater, can begin to show signs of stress if groundwater levels fall too low.

Large areas of dewatering have been modelled for the Project Area, with drawdown contours extending within the broader Study Area below Deep Creek, Tooloombah Creek, Barrack Creek and Mamelon Creek (HydroAlgorithmics 2020). Within the water table aquifer (model layer 2) the model predicts a maximum reduction in water levels of approximately 60 m beneath Deep Creek and 4.7 m below Tooloombah Creek (**Figure 5-1**; HydroAlgorithmics 2020).

Pit progression and associated drawdown will move in a south-easterly direction, and will affect Tooloombah Creek within the first three years of operation. Drawdown will not extend below Deep Creek until the period three to five years after Project commencement. At its maximum extent, a large part of the aquifer associated with the water table between Tooloombah Creek and Deep Creek will become dry. This will isolate much of the lower Styx alluvium from its upper reaches, potentially resulting in ecological impacts. Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow in downstream areas is not considered to be a potential impact of the Project.

Invertebrates that can confidently be classified as stygofauna were collected from two bores in the Styx River alluvium during baseline studies for the EIS. The bore containing four Parabathynellidae was located north of the Project lease, where the aquifer is broad (GHD 2012). An old windmill, just inside the western lease boundary, contained two Cyclopoida. It is likely that there are stygofauna in other sections of the Styx River alluvium where water has low EC and that dewatering of the aquifer as modelled, could isolate the extensive northern part of the aquifer from the more confined southern part This could result in a localised impact on the stygofauna community of the central Styx River alluvium and could also reduce diversity in the southern part of the aquifer over the life of the mine, since migration pathways may be severed. However, as mentioned above, the stygofauna taxa sampled as part of the Project investigations are unlikely to be short range endemics. Therefore, there are unlikely to be any species-specific impacts as a result of altered migration pathways.

The SEIS v3 found that impacts of groundwater drawdown on Aquatic GDEs is expected to be relatively minor because:

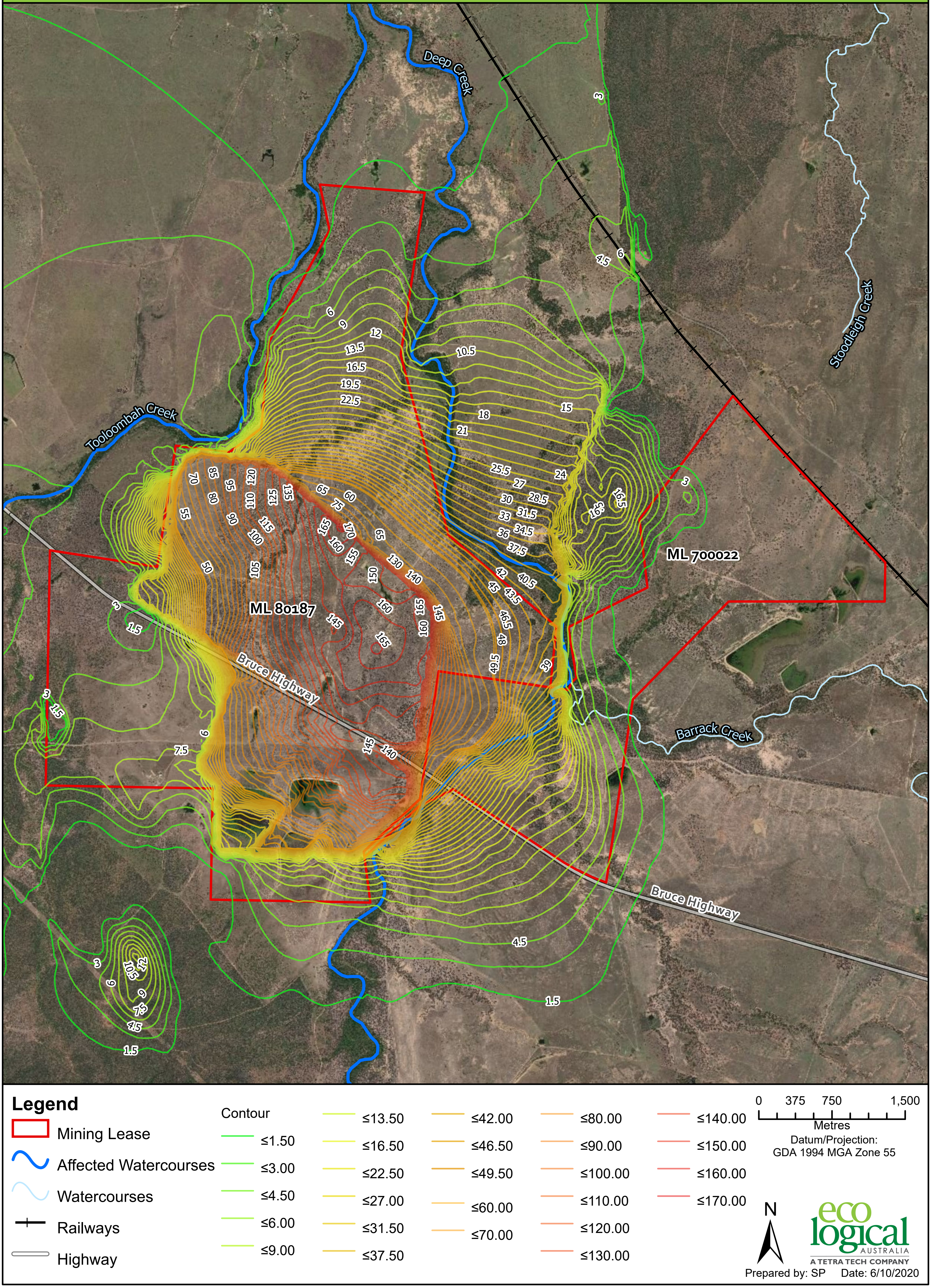
- Drawdown at Tooloombah Creek is relatively small (<4 m) and the sediments in these locations have a low permeability (reducing the potential for enhanced leakage).
- Bank storage at Tooloombah Creek is unlikely to be significantly affected by groundwater drawdown. This is because any downward movement of water held in bank storage is restricted, to some extent, by the impermeable layer of weathered clay underlying the alluvium of Tooloombah Creek. In addition, because drawdown of the water table aquifer at Tooloombah Creek is relatively small and sediments at these locations have a low permeability, the potential for enhanced leakage is reduced.
- The persistence of bank storage and associated return flows to Tooloombah Creek are likely to provide safeguards to mitigate impacts on pool persistence from drawdown of the water table

underneath the creek. Flows from bank storage were predicted to reach the creek for a period of approximately 150 days.

- Permanent pools are likely to still persist throughout most of the dry season, even under the worst-case scenario, with improvements in water quality (less variation in salinity).
- Most pools at Deep Creek are ephemeral. Whilst ephemeral pools are likely to dry up more quickly and for longer than under existing conditions, especially in the middle reaches of Deep Creek, these pools experience a natural cycle of drying under existing baseline conditions, and the aquatic ecosystem is adapted to these cycles.
- Recolonisation of pools will occur naturally as it currently does under existing conditions following rainfall, once the creeks begin flowing again. Flow currently occurs approximately 24% of the time and will not be affected by the Project. In addition, aquatic fauna recorded in pools during field surveys are all common species considered typical of a Central Queensland coast catchment.
- Groundwater drawdown is not predicted to occur beneath the Styx River and therefore loss of potential baseflow from Aquatic GDEs in downstream areas is not considered to be a potential impact of the Project.

Wetland 1, which is a Terrestrial GDE, is unlikely to be affected by groundwater drawdown, with significant physical separation between the perched aquifer and the water table. Drawdown at Wetland 1 is also predicted to be a maximum of 2.7 m, which is unlikely to influence the availability of water to Melaleucas mainly utilising the perched aquifer at this location (ELA 2020b).

Figure 5-1: Predicted maximum groundwater drawdown in the water table aquifer (all project stages)



The primary considerations for drawdown impacting Terrestrial GDEs is therefore the riparian zones of Tooloombah Creek and Deep Creek. The health of Forest Red Gum woodlands on alluvial plains and along drainage lines could be reduced in areas where groundwater drawdown occurs, as could the condition of the tree *Melaleuca viridiflora*. The extent to which such processes occur depends on a range of factors, including the extent of drawdown, local geology of alluvial sediments and their permeability to water movement.

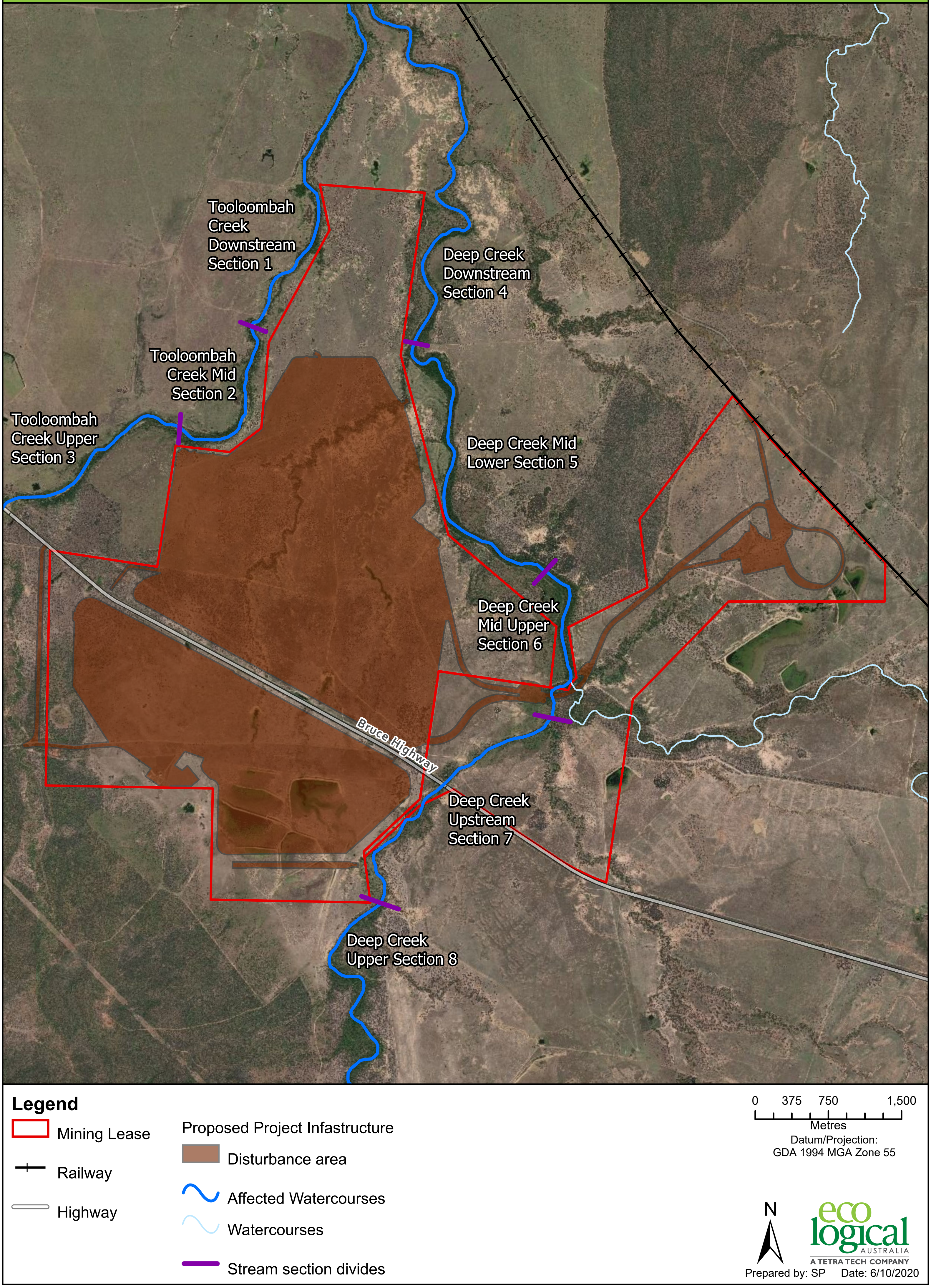
To facilitate the impact assessment of groundwater drawdown on Terrestrial GDEs along Deep Creek and Tooloombah Creek, the creeks were divided into several stream sections with similar environmental characteristics and predicted exposure to groundwater drawdown (**Figure 5-2**). A risk assessment was completed for each stream reach, taking into account all of the available information including the updated surface water and modelling. As the nature and magnitude of impacts to vegetation can vary significantly, a scaled system of potential impacts was developed and considered for each stream section, as summarised in **Table 5-2**.

Table 5-2: Impact description for five categories of impact on riparian vegetation, ranging from low to extreme

Impact Rating	Impact Description
Insignificant	10% decline in the BioCondition Scores against baseline or pre-impact scores. The regional ecosystem is retained as a functional ecosystem. There are reduced numbers of microhabitat features available for fauna.
Minor	50% decline in BioCondition Scores against baseline or pre-impact scores. Canopy cover < 50% of baseline or pre-impact condition, or canopy height <70% of baseline or pre-impact condition. Vegetation no longer meets the Regional Ecosystem description. Vegetation provides ecosystem services, including minimising erosion and some fauna habitat, but with elevated weed cover. There is limited microhabitat features for fauna, such as hollows.
Moderate	90% decline in the BioCondition Scores against baseline or pre-impact scores. Vegetation no longer meets the Regional Ecosystem description. Vegetation community still existing and provides some ecosystem services in limiting erosion, but significant change in structure and composition (increased weed cover) is evident, with reduced habitat values. Limited microhabitat features for fauna.
Major	Widespread vegetation loss. Vegetation no longer meets the Regional Ecosystem description. Regional Ecosystem only remains in patches, with grasses and shrubs elsewhere. There is a high abundance of weeds. Ecosystem services in limiting erosion are reduced by up to 50%, with some under cutting of banks resulting at times.
Extreme	Widespread vegetation loss. Vegetation no longer meets the Regional Ecosystem description. Grasses and shrubs dominate the riparian zone. Ecosystem services in limiting erosion are reduced by more than 50%, resulting in periodic bank collapse

The likelihood of each impact description (**Table 5-2**) occurring as a result of Project activities was assessed for each of the eight stream reaches identified as having similar environmental characteristics and exposures to Project impacts. If there was a Possible (or above) likelihood of there being a Minor impact on vegetation within the stream reach, then this was considered to be an impact for that stream reach.

Figure 5-2: The location of stream sections that were subject to impact assessment for Terrestrial GDEs



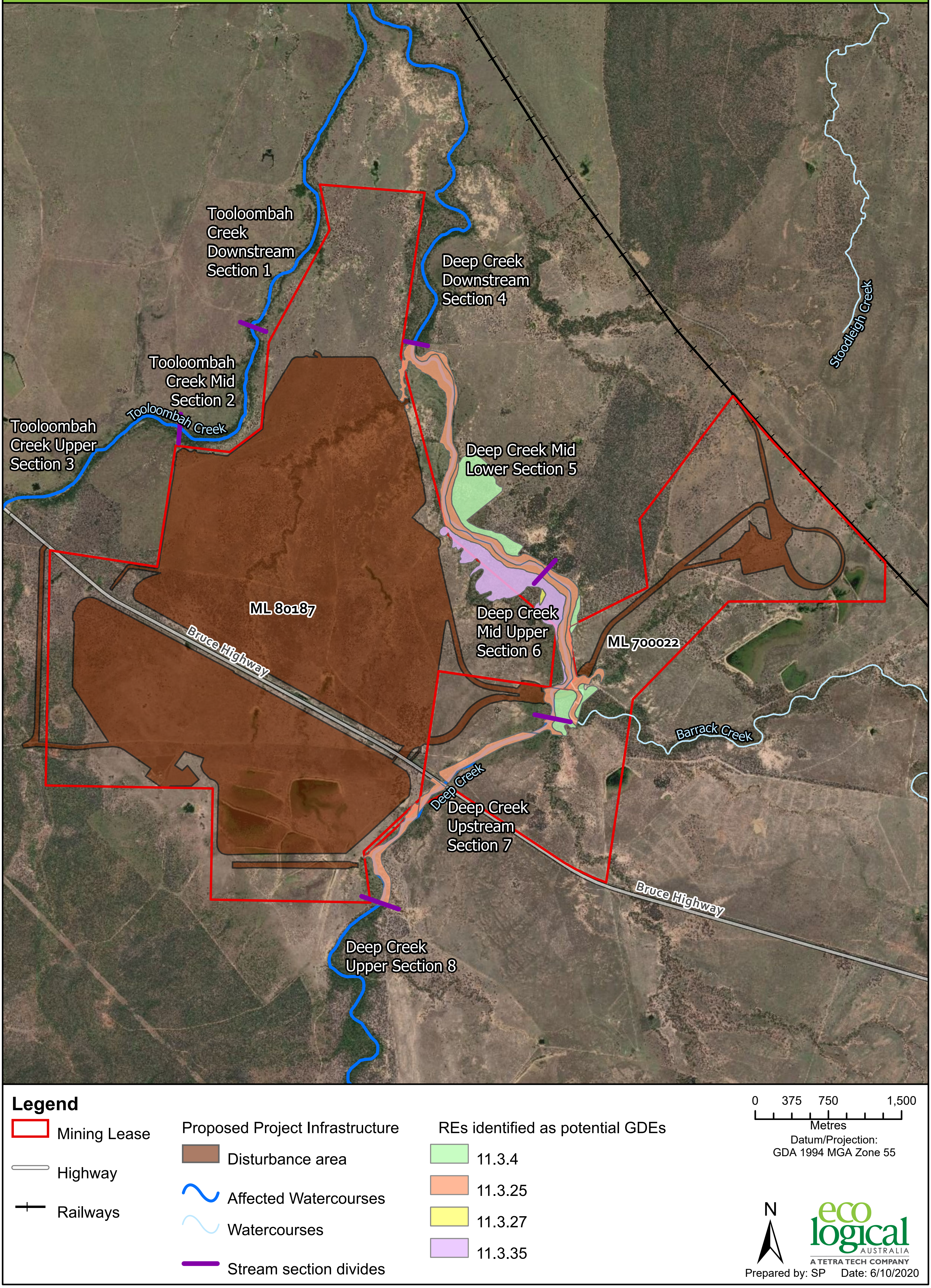
Detailed results of the impact assessment are provided in the Technical Report to the EIS (ELA 2020b) and Chapter 14 of the SEIS v3 – Terrestrial Ecology. An overview is presented in **Table 5-3**. An impact to riparian vegetation is expected as a result of groundwater drawdown for three stream reaches along Deep Creek (reaches 5, 6 and 7). These impacts can be expected to commence 10 to 20 years after commencement of the Project. A maximum area of impact is conservatively estimated at 165 ha as shown in **Figure 5-3.** A program of environmental offsets has been developed for areas and values subject to a significant residual impacts, as determined by the significant impact assessment for MNES and MSES. This is outlined in the Project Biodiversity Offset Strategy (C02 Australia 2020) and Chapter 14 of the SEIS v3 – Terrestrial Ecology.

Implementation of the GDEMMP will monitor actual vegetation impacts in comparison with those predicted (165 ha considered worst case) and also assess areas located on the fringe of the assessed impact area, and in areas not subject to groundwater drawdown.

Table 5-3: Summary of results of impact assessment for indirect impacts on Terrestrial GDEs along Tooloombah and Deep Creeks

	Scale of Impact					Approx. Max Drawdown (m)	Approx. Timing of Max Drawdown (years)	Impact Predicted?
Stream Section	Insignificant	Minor	Moderate	Major	Extreme			
Tooloombah Creek Downstream (1)	Unlikely	Rare	Rare	Rare	Rare	1.5	10	No
Tooloombah Creek Mid Section (2)	Possible	Rare	Rare	Rare	Rare	4.7	5	No
Tooloombah Creek Upstream (3)	Rare	Rare	Rare	Rare	Rare	3	5	No
Deep Creek Far Downstream (4)	Unlikely	Rare	Rare	Rare	Rare	6	10	No
Deep Creek Downstream Section (5)	Likely	Possible	Unlikely	Rare	Rare	40	15	Yes
Deep Creek Mid Section (6)	Likely	Possible	Unlikely	Rare	Rare	30	10	Yes
Deep Creek Upstream (7)	Almost Certain	Likely	Possible	Possible	Unlikely	60	15	Yes
Deep Creek Far Upper Section (8)	Unlikely	Rare	Rare	Rare	Rare	4.5	10	No

Figure 5-3: Map showing the location of vegetation that is expected to be subject to an impact



Management objectives under this plan aim to limit and manage the impact of hydrological changes to the GDEs as a result of mine dewatering and depressurisation. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.2 Ground water quality degradation (#2)

Reductions in groundwater quantity can have flow-on effects on groundwater quality. Changes in groundwater quality can occur in a number of ways including:

- Evaporative concentration of salts in temporarily open mine voids whilst they remain open (noting that all Project voids will be backfilled);
- Possible induced flow of groundwater of different quality towards depressurised parts of the groundwater system associated with dewatering / depressurisation;
- Infiltration of water from Waste Rock Stockpiles and mine water storages (Dams 1 to 4);
- Accidental release of chemicals (such as unintended fuel spill, leakage of sewage effluent, infiltration of stormwater from mine 'contact' areas); and
- Mobilisation of the freshwater – saltwater interface near the coast.

With the exception of a few shallow groundwater bores located immediately adjacent to watercourses, the groundwater quality within the Project Area is generally poor, and of limited human use, due to high salinity. Given the similarity of higher and variable salinity for the various source groundwaters, no appreciable change in groundwater salinity is expected as a consequence of mining. There is also limited potential for groundwater contamination to occur as a result of spills of hydrocarbons or other contaminants, due to the depth of groundwater typically being greater than 10 m below ground level.

Waste rock characterisation, detailed in Chapter 8 – Waste Rock and Rejects of SEIS v3, determined that the overwhelming majority of the waste rock and coal reject materials have a low reactive sulphur content, excess acid neutralising capacity, and are classified as non-acid forming. While a small fraction of the waste rock and coal reject materials may have some potential to generate acidity, the bulk materials will have excess acid neutralising capacity and will therefore generate alkaline surface runoff and seepage. Leachate testing also indicated a low salinity and typically low levels of trace metals/metalloids other than aluminium, arsenic and selenium which were elevated in some of the samples.

Groundwater quality within the alluvial aquifer (or underlying Styx Coal Measures) of the Project Area is highly variable and does not follow any consistent spatial or temporal pattern (HydroAlgorithmics 2020). Aquifers and other groundwater resources of the Project Area within 15 m of the surface commonly have high salinities (>10,000 µS/cm), which are beyond the tolerance of most terrestrial vegetation.

The upper soil salinity tolerance of key vegetation species present in the Study Area generally falls into the Moderately Saline category of DoA (2020), equivalent to an Electrical Conductivity of 4,000 to 8,000 µS/cm. This is consistent with published soil salinity tolerances that are available for vegetation species present in the Study Area (**Table 5-4**). Species in **Table 5-4** are those on site for which leaf water potential measurements were conducted (3D Environmental 2020), and represent typical species of the two major vegetation types present along Tooloombah and Deep Creeks (riparian vine thicket and tall open eucalypt woodland). Such information suggests that a conservative estimate for the maximum EC of groundwater that may sustain terrestrial vegetation at the site is 10,000 µS/cm. This is further supported by on site investigations by 3D Environmental (2020) which found that the Forest Red Gum (*Eucalyptus tereticornis*) was accessing a fresh water source (<5,000 µS/cm) during a prolonged dry period on the banks of Tooloombah Creek and Deep Creek.

Some caution should be used when interpreting soil salinity tolerances, especially in relation to potential deep (i.e. groundwater) sources of water that trees may use in times of surface water scarcity. Most estimates of salinity tolerance are based on surface (0-30 cm) soil salinity. For some eucalypts, 77-90% of roots are found in the top 50 cm of soil (Eamus et al. 2002; Laclau et al. 2013), although studies of rooting depth in natural ecosystems are lacking. In addition, the results of field-based soil salinity experiments are generally restricted to a very limited proportion of the potential genetic variation in tolerance present within a species, thereby rendering results relevant only to the provenance of seed used or location of the site.

Table 5-4: Published soil salinity tolerances for potential GDE vegetation species found within the Study Area

Species	Soil salinity tolerance (EC µS/cm)	Source	Notes
Acacia harpophylla	surface 400-1000 <1 m 1500-1700	Dalal et al. (2003)	Generally considered tolerant of moderate salinity
Brachychiton rupestris	unknown but probably low	-	Based on natural distribution and preferred soil types
Coatesia paniculata	unknown	-	Roots to 6.1 m (3D Environmental 2020)
Eucalyptus acmenoides	unknown but probably low	-	Based on natural distribution and preferred soil types
Eucalyptus coolabah	2,000-4,000 (surface) 27,000-36,000 (3-6 m depth)	DoA (2020) Costelloe (2016)	Opportunistic phreatophyte
Eucalyptus crebra	unknown but probably low	-	shallow rooted species
Eucalyptus tereticornis	4,000-8,000	DoA (2020), Dunn et al. (1994)	Survivorship high at moderate salinity: growth affected at low salinity (~1600 µS/cm). Opportunistic phreatophyte.
Flindersia australis	unknown but probably low		Based on natural distribution and preferred soil types
Melaleuca fluviatilis	unknown, possibly similar to *M. leucadendra*	-	-

Species	Soil salinity tolerance (EC µS/cm)	Source	Notes
Melaleuca leucadendra	2,000-8,000	Sun et al. (1995)	
Melaleuca viridiflora	unknown	Skull & Congdon (2008)	Adversely impacted by sea-water incursions in coastal areas
Siphonodon australis	unknown but probably low	-	Probably shallow-rooted.

Of the ten existing alluvial groundwater monitoring bores along the Styx River, Deep Creek and Tooloombah Creek, four have a salinity concentration (EC level) that is tolerable by terrestrial vegetation. The remaining six bores have a median EC above a conservative tolerance of 10,000 µS/cm, with minimal temporal variation in salinity. On the basis of these results, it can be concluded that the water table aquifer is unsuitable for utilisation by riparian vegetation in many locations along the riparian corridor adjacent to the Project Area, with groundwater of a quality suitable for use by vegetation occurring in some locations only. However, moisture held in bank storage above impermeable layers may still be utilised by riparian vegetation in these areas, meets the definition of groundwater, and may be influenced by groundwater drawdown.

Despite the salinity evident in some of the groundwater samples collected for the Project, it has been determined that the salinity in the groundwaters intersected by the Project is derived from regional geochemistry, and not an oceanic saltwater interface (the fresh-seawater interface). As described in detail in Chapter 10 – Groundwater of the SEIS v3, if any interface between oceanic saltwater and freshwater does exist within the groundwater in the vicinity of the Project, it will be hundreds of metres below sea level at the location of the pits, or beyond the extent of any drawdown influence from the Project, and would therefore not result in any movement of any interface between seawater and groundwater.

Management objectives under this plan aim to maintain groundwater quality. **Table 5-7 to Table 5-9** describes how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.3 Changes to surface water hydrology (#3)

Changes to surface water hydrology can potentially reduce or increase the geographic extent of local catchments, their run-off characteristics, the intensity of flood flows and overall stability of waterways and their structural elements such as stream banks. This has the potential to affect GDEs by changing the degree to which surface water contributes to their environmental water requirements. For example, reductions in hydrological flows may alter the characteristics of groundwater fed creeks, and the supply of water to Aquatic GDEs (which is usually a combination of surface and groundwater resources).

The key changes to surface water hydrology arising from the Project are minor, and relate to the installation of infrastructure, including:

- New dams to capture water runoff for use at the mine;

- Drains to divert surface water runoff around the mine site to waterways;
- Additional runoff as a result of the proposed mine hardstand areas; and
- Construction and use of mine discharge structures such as spillways and discharge drains.

The Project will have a small impact on existing surface water flows, as mine infrastructure will decrease the local catchment area, resulting in less rainfall runoff into creeks. Creek crossing structures may cause a localised increase in runoff velocity due to the construction of culverts and conveyance features that eliminate natural waterway features such as meanders, and increase slope and flow velocity. However, with appropriately designed stormwater and crossing structures, such processes are unlikely to cause more than localised and very minor changes to surface hydrology.

The two major mine pit components (Open Cut 1 and Open Cut 2) will require the installation of diversion structures, directing runoff to Deep Creek. Diversion structures will be constructed in a progressive manner as the pits expand. The haul road and other infrastructure will also cross Deep Creek and Barrack Creek, providing the potential for direct disturbance of the stream bed, and resulting in some alteration of hydraulic flows.

Access tracks and haul roads will affect natural contours of the landscape, and can act as either conduits for water, or barriers to flow. The potential impacts of these processes can be mitigated by constructing well designed roadside drainage channels. Spillways and discharge structures to facilitate the transfer of water from mine dams to the adjacent waterways also have the potential to change natural flow conditions. Such structures will generally only be utilised during periods of high flow, when large volumes of water are present within mine dams and the adjacent creek systems.

Ecological effects from changes to surface hydrology can manifest to two ways, both of which result in less water being available for vegetation and aquatic fauna. First, surface water flow rates and volumes may be altered due to mine infrastructure, which captures water that would otherwise have entered the natural system of waterways.

WRM (2020) conducted hydrological modelling of local waterways in response to the Project and found there will be negligible changes to the flow conditions of local waterways. Local creeks are ephemeral and flow approximately 24% of the time. As the Project is located in only a very small part of the catchment, there will be minimal changes to the existing baseline flow conditions.

Secondly, rainfall associated recharge and water storage within subsurface soils from rainfall infiltration may be reduced, either directly due to surface water diversion of runoff affecting infiltration and/or via groundwater drawdown increasing the rate and direction of water infiltration into underlying sediments; known as ‘enhanced leakage’. The magnitude of such changes are also expected to be minor (WRM 2020; HydroAlgorithmics 2020).

Riparian vegetation may utilise water derived from three sources: rainfall, stream flooding and groundwater. The nature and extent of soil moisture present in the riparian zone fluctuates according to changes in stream flows and stream level. During periods of high stream flow and/or high water level, soil moisture in the stream banks is largely driven by surface water seepage from the adjacent stream. As stream levels reduce through flows downstream, evaporation and evapotranspiration, upper levels of the stream bank dry out, and are subject to intermittent supplementation from rainfall.

Impermeable layers within the alluvial zone (if present) may retain moisture in patches, increasing the period over which soil moisture is available to vegetation. Shallow groundwater layers may be accessed by the deeper roots of vegetation and provide a temporary or permanent water source, particularly during dry periods when soil moisture levels in upper layers are low. Such shallow groundwater layers may be comprised of freshwater captured by an impermeable layer, which sits above the underlying and saline aquifer.

Vegetation, and in particular phreatophytes, has an ability to exploit various sources of soil moisture and change between these sources rapidly (within hours) using their extensive root systems. During dry periods, trees may use their deep roots to obtain moisture from aquifers or within deeper sedimentary layers that have retained moisture, provided that such water is of a suitable quality for use by plants (in particular, low in salinity).

Following a rainfall event, trees can switch their exploitation of water resources from deep to shallow root systems, taking advantage of increased soil moisture in upper layers, which is typically low in salinity and of a higher quality. These seasonal patterns of water use are thought to be implemented within riparian vegetation of the Study Area, which is subject to large fluctuations in annual rainfall and associated flow states within Tooloombah Creek and Deep Creek.

The degree to which enhanced leakage occurs is dependent on a range of factors, including the permeability of sediments and associated geological layers within the alluvium underlying streams. High permeabilities are consistent with increased enhanced leakage (and greater impacts on vegetation), while low permeabilities result in slower or minimal movement of water and support the retention of moisture levels in the alluvial soil profile (reducing impacts on vegetation).

Results of the drilling program undertaken by Central Queensland Coal show that there is sufficient clay present in the alluvium to suggest that the shallow (freshwater) groundwater sits above the deeper (generally saline) system, and there appears to be little connection between the alluvium and the Styx Coal Measures. Some transmissive units exist in some locations, comprised of sands and gravels. Banks storage of water is most extensive in Tooloombah Creek (ELA 2020a; Central Queensland Coal 2020b).

Management objectives under this plan aim to limit changes to surface water hydrology, which may reduce the contribution that surface waters make to meeting the environmental water requirements of GDEs. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.4 Surface water quality degradation (#4)

The Project has the potential to impact on surface water quality through an increase in sedimentation in waterways, accidental spills or leaks, or via the controlled release of water and associated parameters from the mine during periods of high rainfall. Changes in water quality may affect associated habitat values of groundwater fed creeks (Aquatic GDEs), or reduce the suitability of surface waters (and connected groundwaters) for utilisation by GDEs.

Baseline water quality monitoring undertaken as part of the EIS and SEIS studies indicated that existing waterways generally have low to moderate turbidity and suspended sediment loads during and following flow periods. During extended dry periods with no flow, when the waterways are reduced to isolated pools, high levels of turbidity and suspended sediment concentrations were recorded predominantly (but not solely) in Deep Creek sites. This is likely to be caused in part by access to waterways by cattle.

The potential impacts of erosion and sedimentation from surface runoff, if not adequately mitigated, could result in impacts on local water quality of the Styx River and tributaries. This may in turn affect aquatic ecosystem values of Aquatic GDEs, including those of downstream areas. Increased concentrations and loads of suspended sediments can reduce light penetration, decreasing the photosynthesis of aquatic flora and lowering dissolved oxygen concentrations, which are important for respiration processes of aquatic fauna.

Changes in land use at the Project site, from the current use of grazing to a mixture of mining and environmental offsets, is predicted to result in a reduction in sediment discharges and nutrients into waterways. A sediment budget for the Project site completed by Engeny (2020) identified that destocking will result in reduction in sediment runoff to the Styx River Basin of approximately 50%.

Groundwater drawdown has the potential to change the surface water quality of groundwater fed pools by reducing the volume and rate of saline groundwater inputs. In locations where this occurs (mostly Tooloombah Creek), the associated aquatic habitats are likely to become more suitable for freshwater plants and animals, and less dominated by macroinvertebrates that have a high degree of tolerance of varied water quality condition.

The release of pollutants such as metals and hydrocarbons to waterways can result in adverse impacts on flora and fauna. Such releases may occur accidentally as spills, or via controlled discharges during or immediately following intense rainfall events. The potential impacts of contaminant releases, if not adequately mitigated, may include a reduction in local and downstream water quality, affecting environmental values related to aquatic ecosystems, irrigation, farm supply, stock water and cultural / spiritual uses of the Styx River and tributaries.

High concentrations of metals may have toxic effects on aquatic flora and fauna (which are components of a GDE), reducing their overall abundance or resulting in chronic impacts such as reduced reproductive output. The ANZECC Guidelines (2000, 2018), local water quality guidelines and existing baseline data provide a useful reference to determine whether predicted changes to water quality are within acceptable limits.

The potential impact of controlled releases (and uncontrolled overflows) from the proposed water management system storages has been assessed for each of six modelled parameters, including EC, Arsenic, Molybdenum, Selenium, Vanadium and Sulphate. These parameters were chosen on the basis of geochemistry analyses for the site, which indicate that they are among the key parameters most likely to be present in high concentrations (RGS 2020; WRM 2020).

The results of the analysis demonstrate that the predicted concentrations of the six parameters at key points of Deep Creek, Tooloombah Creek and at the confluence of the two creeks are well within the range of historical receiving water concentrations for each element examined. Indeed, the highest predicted concentrations for all heavy metals examined are an order of magnitude lower than thresholds set out in model mining EA conditions for contaminant release (WRM 2020).

Across all water storages, the annual risk of overflows is considered to be low (between 1 – 10%) and would only occur under wet conditions. There are no predicted overflows from Dam 1 (the largest storage) during median and dry conditions. If uncontrolled discharges do occur, modelling predictions indicate that the concentrations of the modelled parameters at key points of Deep Creek, Tooloombah Creek and at the confluence of the two creeks will be well within the range of the typical historical receiving water concentrations for each element examined (WRM 2020).

Collectively, the information described indicates that discharges of water into the receiving environment pose a low risk to GDEs. The controlled release strategy will operate to minimise the risk of uncontrolled discharges. When water is released either during controlled releases or in the unlikely event of an uncontrolled spillway overflow, total water volumes in the receiving environment will be such that metals, Sulphate and Electrical Conductivity are diluted to concentrations below that of environmental concern.

Management objectives under this plan aim to maintain surface water quality, which often sustains GDEs in combination with groundwater, and reduce the risk of contamination from mine related activities. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.5 Erosion of streambanks (#5)

Erosion and the resulting sedimentation of waterways can occur when vegetation is cleared, and soil is exposed to overland flow. During construction and operation, sediment can be mobilised and transported by overland flow during rainfall events, ultimately discharging into watercourses within and surrounding the Project area. An increase in sedimentation can result in negative impacts on water quality and aquatic habitats of groundwater fed creeks (Aquatic GDEs). Erosion may also threaten the persistence of groundwater dependent vegetation (Aquatic and Terrestrial GDEs) occurring on creek banks.

Tooloombah Creek and Deep Creek are highly incised waterways that are likely to be partially reliant on the retention of riparian vegetation for streambank stability. The main channel of Deep Creek has steep slopes that are fully vegetated and with minimal erosion evident. The loss of riparian vegetation, either through direct clearing or indirect impacts associated with changes in hydrology, has the potential to compromise the stability of the banks. Mine water discharge also has the potential to cause local erosion of stream bed and banks, if not managed properly. Changes in land use at the Project site, from the current use of grazing to a mixture of mining and environmental offsets, may result in reduced streambank erosion through improved land management practices (destocking and vegetation regeneration).

A description of the geomorphological values of the Study area is provided by Gippel (2020). The geomorphology assessment concluded that while there could be isolated areas subject to somewhat higher risk of scour compared with baseline conditions, the overall risk of rapid and significant geomorphic change in Tooloombah Creek, Deep Creek and the Styx River is low. Impacts from the Project on hydraulic variables would be small enough that a rapid geomorphic response would not be expected. Rather, the channel will slowly adjust over the life of the mine to the altered hydraulic conditions through minor changes in bed and floodplain levels or channel widths (Gippel 2020).

Management objectives under this plan aim to limit the erosion of streambanks (which are habitat for some GDEs) and associated sedimentation, which can degrade the water quality and habitat values of Aquatic GDEs. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.6 Direct disturbance of GDEs and their habitat (#6)

Direct disturbance of stygofauna habitat occurs following dewatering and depressurisation of the relevant aquifer and is therefore addressed in **Section 5.2.1**. For Aquatic and Terrestrial GDEs, the Project will require the clearing of some remnant vegetation during the construction phase. While the vast majority of riparian vegetation in the vicinity of the Project will not be cleared, there will be 12.36 ha of watercourse vegetation cleared to facilitate the construction of new Project infrastructure.

Apart from the haul road crossing over Deep Creek, clearing to facilitate the construction of Project infrastructure will not directly impact Tooloombah Creek or Deep Creek. Access tracks and other Project infrastructure may impact directly on aquatic habitats where infrastructure crosses or is located in close proximity to waterways.

Aquatic habitat connectivity within groundwater fed creeks may also be disturbed by the obstruction or movement of aquatic fauna across Deep Creek and Barrack Creek as a result of the haul road crossing. Where haul roads cross drainage gullies or Deep Creek, an appropriately sized culvert or bridge will be provided to allow for fish passage consistent with the accepted development requirements for operational work that is constructing or raising water barrier works, or State Development Assessment Provisions - State Code 18. Suitable waterway barrier designs will help to maintain habitat connectivity.

Remnant riparian vegetation to be cleared may comprise Aquatic GDEs (e.g. Melaleuca; 3D Environmental 2020), and may also provide aquatic fauna habitat. Additionally, ecosystem services provided by riparian vegetation may include the shading of waterways which regulates temperature and photosynthesis, the enhancement of bank stability from tree roots, and inputs of leaf litter, woody debris and fruits to instream waters, providing a source of food and shelter for aquatic organisms.

Management objectives aim to limit direct disturbance of GDEs and their habitat. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.7 Weeds and pests (#7)

The Project Area is highly modified (largely due to cattle grazing) and weeds are commonly observed within riparian corridors of Deep Creek and Tooloombah Creek. Common weed species include *Lantana camara* (Lantana), *Cryptostegia grandiflora* (Rubber Vine) and *Hymenachne amplexicaulis* (Olive hymenachne). These weed species are listed under Queensland's *Biosecurity Act 2014* and as Weeds of National Significance. Aquatic weed species can impact native aquatic ecosystems by shading out native plants, reducing the quality of habitat for aquatic fauna communities and degrading water quality. Terrestrial pest species present in the Project area include feral pigs (*Sus scrofa*), cane toads (*Rhinella marina*), rabbits (*Oryctolagus cuniculus*) and cats (*Felis catus*).

Terrestrial weed species may manifest in riparian areas when loss of open forest canopy will let in more light, favouring weeds and shrubs. If not controlled, Rubber Vine infestations may increase in height, area and density. Increased weed densities reduce species diversity and GDE complexity, reducing the ability of the watercourse to host a diverse range of species and life forms.

Fish surveys have indicated a relatively diverse range of native species and did not identify any introduced taxa such as Tilapia (*Oreochromis sp.*) and Mosquito fish (*Gambusia sp.*). Domestic cattle also extensively graze within the riparian corridor, causing disturbance to ecological values through the foraging of natural vegetation, trampling of stream banks and defecation. Any unmitigated introductions of weeds and pests have the potential to impact the productive capacity of the Styx River and tributaries, resulting in impacts to the local fish community and other aquatic species.

Weeds can be introduced through the movement and operation of construction vehicles and personnel. Pests can also be attracted to the Project area by the presence of artificial food sources including waste. A weed and pest management plan will be developed and implemented for the Project as part of the EMP, and strict hygiene measures will be utilised during Project construction activities. A key management measure will also be the removal of cattle from the Project Area and at offsets sites to improve riparian condition and reduce nutrient loads.

Management objectives under this plan aim to maintain and improve the ecological condition of GDEs through reduced weed incursion and habitat degradation from pest species. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.8 Fire (#8)

The threat of fire for the Styx River and tributaries exists during the pre-construction (baseline and pre-impact), construction, operational and rehabilitation phases. The Project is located within a mosaic of cleared grasslands and remnant woodlands. Fire is a natural component of these areas in Central Queensland, with historical ignition sources including lightning-strike and low intensity wet season fires.

Inappropriate fire regimes lead to intense bushfires that can result in death of vegetation (Terrestrial and/or Aquatic GDEs), reduced recruitment from damaged trees and burning of seeds. Bare ground is susceptible to erosion and degradation from cattle, further impacting the banks of the Styx River and associated tributaries.

Fire intensity will be greater with high fuel biomass, continuity of the fuel layer, a high degree of curing (drying) of the grassy fuel, combined with ambient conditions of high temperatures, low humidity and high wind speeds. Lower intensity fires will occur when fuel biomass is low and / or discontinuous, fuel moisture levels are high, ambient temperatures and wind speeds are low and atmospheric humidity is high.

Due to the combustibility of coal, mining operations are also potentially subject to fire which can spread to surrounding vegetation. The open and grazed nature of much of the surrounding habitat is considered likely to reduce the potential for catastrophic fires which can result in large scale tree mortality. However, there are still large areas of continual vegetation, particularly to the west of the Project Area including the Tooloombah Creek Conservation Park. The removal of stock from extensive areas may increase the need for additional management practices to reduce fuel loads.

Management objectives under this plan are to maintain and improve the ecological condition of GDEs by reducing the risk of bushfire ignition, maintaining a mosaic of fire history and reducing the risk of bushfire spread. **Table 5-7 to Table 5-9** describe how the management objectives will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.9 Dust emissions (#9)

Earthworks, vehicle movements and coal transport during the construction and operational phases of the Project will likely result in dust emissions. Excessive dust settling on vegetation (Aquatic and/or Terrestrial GDEs) could suppress vegetation growth by limiting the photosynthesis of plants in close proximity to construction zones. Dust can also influence soil properties within these habitats, potentially impacting water quality and the health of Aquatic GDEs following runoff into local waterways.

Dust deposition associated with earthworks activities will generally occur relatively close to areas of disturbance and hence, plants within 50 m to 100 m of construction activities may be affected by dust. Earthworks within this distance to GDEs will generally be limited to construction of the proposed haul road crossings and other minor activities. Therefore, emissions of dust from construction activities in these areas will be short-lived.

Dust impacts as a result of the Project are likely to be minimal compared with background atmospheric dust and no significant impact on groundwater dependent species is predicted.

A management objective under this plan is to minimise dust emissions which may reduce the ecological condition of GDEs. **Table 5-7 to Table 5-9** describe how the management objective will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.10 Noise and vibration (#10)

During the construction phase, standard construction equipment, general trade equipment and specialised equipment will be used as required. Noise and vibration from construction activities (particularly the construction of the haul road crossings) and operations, may temporally reduce the quality of habitat for aquatic and riparian fauna, such as Koalas and Greater Glider. However, it is not anticipated that noise and vibration will significantly impact the GDEs of the Project Area.

Whilst there are unlikely to be impacts to GDEs associated with noise and vibration, a management objective under this plan is to minimise habitat disturbance as a result of noise and vibration. **Table 5-7 to Table 5-9** describe how the management objective will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.2.11 Light spill and other visual impacts (#11)

During the construction phase, lighting for safety and security of operations will be installed as the mine will operate 24 hours per day. Impacts from lighting will involve static floodlights associated with mine operations, lighting around the mine infrastructure area, workshops and ancillary buildings and vehicle lights moving around the site. Artificial night lighting levels within the Project Area are expected to be very low, and impacts on GDEs are therefore considered unlikely.

Whilst there are unlikely to be impacts to the Project Area associated with light spill and visual impacts, a management objective under this plan is to minimise light spill and other visual impacts. **Table 5-7 to Table 5-9** describe how the management objective will be met for each GDE, including performance criteria, management actions, monitoring, triggers for adaptive management and corrective actions.

5.3 Mitigation and management measures

5.3.1 Overview

In relation to minimising the impacts of groundwater drawdown on GDEs, the primary mitigation measure has been implemented in design, to avoid where possible the direct disturbance of GDEs, and to reduce the extent of overlap of groundwater drawdown contours and GDEs. This approach has led to the avoidance of direct disturbance at Wetland 1 and most riparian corridors, and keeping drawdown to a minimum, particularly at Wetland 1 and Tooloombah Creek.

A range of actions will also be implemented to improve the resilience of Aquatic and Terrestrial GDEs and thereby reduce the potential impacts of Project-related groundwater drawdown. Such actions include the removal of cattle grazing from the riparian corridor where trampling and impacts on water quality currently occur, the implementation of weed and pest control measures to reduce existing infestations of introduced species, and the rehabilitation and widening of riparian vegetation corridors through revegetation activities. An adaptive management approach will be applied, where the ongoing results of monitoring will be used to assess the effectiveness of mitigation measures, and further refine environmental management activities.

A revegetation program will be developed and implemented in areas within the riparian corridor expected to be affected by groundwater drawdown with the aim of building ecological resilience. Revegetation will include expansion of the existing riparian corridor by a width of 10 m. A revegetation program will be designed to ensure the planting of drought tolerant, and non-groundwater dependent, species of similar ecological function as those with the potential to be impacted. This will ensure that existing habitat for terrestrial species is maintained, as well as reducing the potential for consequential impacts such as erosion and sedimentation which may be associated with vegetation loss. The revegetation program will be implemented from Project commencement ensuring sufficient timeframes for establishment of vegetation, given potential impacts as a result of changes to groundwater are not expected to commence until at least 10 years after Project commencement.

A number of documents have or will be developed for the Project which contain mitigation and management measures addressing a range of impacts on GDEs. An overarching Environmental Management Plan (EMP) has been developed to provide measures to avoid and reduce impacts to key environmental values. Additional specific plans will be developed, or form part of the EMP, including:

- Erosion and Sediment Control Plan
- Receiving Environment Monitoring Program (REMP)
- Water Management Plan (WMP), incorporating a Controlled Release Strategy (CRS)
- Weed and Pest Management Plan
- Fire Management Plan
- A rehabilitation framework
- Groundwater Management and Monitoring Plan

- Significant Species Management Plan
- Offset Area Management Plan for Mamelon

Key plans of relevance to the GDEMMP are summarised in the following sections. Further details of management measures are provided in **Section 5.7**.

5.3.2 Erosion and Sediment Control Plan

Vegetation clearing, topsoil stripping, earthworks and stockpiling will result in the disturbance and exposure of soils to erosive forces from either overland flows of water or wind action. Soil loss reduces soil productivity and removes nutrients and organic matter. Sediment mobilised by overland flow can affect waterways through increased turbidity, deposition of sediment on aquatic ecosystems, geomorphological changes and reduced water quality for other water users.

Management of erosion and sedimentation will be undertaken in accordance with the Erosion and Sediment Control Plan. This plan identifies all practices to be implemented prior to, during, and post-construction to minimise the potential for erosion to occur, including (but not limited to) timing of clearing activities, sediment and erosion control measures to be implemented, performance criteria and corrective actions. Monitoring and reporting protocols are detailed within this plan, and responsible parties for implementing the plan’s actions identified.

Controls include the following activities:

- Design stormwater systems to include sediment retention basins.
- Locate infrastructure away from drainage lines and steep slopes, wherever practicable.
- Where practical, schedule works to avoid wet conditions, or if in streams, outside times of flow.
- Minimise the areas to be disturbed.
- All disturbed areas to be revegetated or protected from erosion using suitable control measures.

Monitoring activities will include the inspection of sediment control devices and stormwater systems, including diversion drains and outlets.

5.3.3 Receiving Environment Monitoring Plan

A Receiving Environment Monitoring Program (REMP) has been developed for the Project and will be implemented by a suitably qualified person to monitor, identify and describe any adverse impacts to surface water quality from mining activities. The program includes:

- Monitoring water quality, sediment quality and biological indicators at locations both upstream and downstream from the Project (reference and impact monitoring locations), and in adjacent catchments.
- Daily monitoring during release events.
- Processes to assess the results of monitoring to determine if local, state and national water quality guidelines have been met, for fresh, estuarine and marine waters.
- Identification of sensitive receiving waters or environmental values downstream of the mining activity that will potentially be directly affected by a release of mine affected water.

- Monitoring frequency and timeframes (including scientific rationale).
- Data analysis and reporting requirements.

5.3.4 Water Site Water Management Plan

The WMP describes the procedures that will be implemented to manage water within the Project Area, to provide sufficient water for construction and operation of the mine, while also outlining how excess water will be managed, sourced from rainfall or from groundwater seepage into the mine pits.

The controlled release strategy (which forms part of the WMP) will operate to minimise the risk of uncontrolled releases from the mine. Controlled releases will also be regulated by the Mine EA. Across all storages the annual risk of overflows is considered to be low (between 1 – 10%) and would only occur under wet conditions. There are no predicted overflows from Dam 1 (the largest storage) during median and dry conditions. If uncontrolled discharges do occur, modelling predictions also indicate that the concentrations of the modelled parameters at key points of Deep Creek, Tooloombah Creek and at the confluence of the two creeks will be well within the range of the typical historical receiving water concentrations for each element examined (WRM 2020).

5.3.5 Groundwater Management and Monitoring Plan (GMMP)

A GMMP has been developed as part of the Project EMP and will be implemented across the Project Area. The plan is based on the recommendations arising from the regional groundwater model (HydroAlgorithmics 2020) and will involve regular monitoring of bores within the various groundwater layers. A subset of bores that will be monitored as part of the EMP are of particular interest to GDEs, comprising those that are located within the water table aquifer and in close proximity to GDEs. The monitoring results from these bores will be utilised in the implementation and refinement of the GDEMMP. The GMMP will also collect data to facilitate future validation of the model and any exchange of water between groundwater layers. The numerical groundwater model will be reviewed prior to mining commencing on-site and every three years from commencement of mining. Additional data collected will be utilised to validate the model and any required revisions or updates will be made accordingly.

5.4 Monitoring

A monitoring program has been developed for GDEs identified in the Project Area, to determine whether mitigation and management measures are adequate and successfully implemented. This work will build upon the baseline studies completed during the EIS and SEIS.

This section summarises the Subterranean, Aquatic and Terrestrial GDE monitoring program, which will be implemented following approval of this GDEMMP. **Table 5-5** summarises the monitoring frequency, duration, type and indicators for each type of GDE. Indicative monitoring locations are shown in **Figure 5-4**, and will be confirmed by scientists completing pre-impact monitoring, based on the suitability of sites with respect to the presence of relevant ecological values. As outlined in **Section 4.5.1** a field sampling plan will be developed prior to the commencement of pre-impact monitoring to further describe the monitoring methods to be implemented. This approach recognises the importance of scientists who implement the plan having a role in determining the final methodology and approach.

An overview of the approach to monitoring is provided in the following sections for each GDE. Groundwater level and quality, and surface water flow and quality will be monitored in accordance with the REMP and GMMP. The results of these monitoring tasks are relevant to each type of GDE, with groundwater level at nearby bores providing an early indication of draw down potentially affecting the adjacent ecological values.

5.4.1 Stygofauna

The network of alluvial bores that is in place across the Project Area will be sampled for stygofauna in accordance with the Guideline for the Environmental Assessment of Subterranean Aquatic Fauna (DSITI 2015). Bores will be samples twice in the first year (at the end of the wet season and the end of the dry season), with monitoring locations and frequency then adapted, depending on the results. Bores sampled as part of baseline studies in 2011 and 2012 (GHD 2012) will also be prioritised for sampling if available, with a focus on those bores where stygofauna were confirmed to be present. Groundwater quality will be determined at the same time as sampling. Bores sampled will include a representation of bores located within, outside and on the fringe of areas where groundwater drawdown is predicted.

Objectives of the stygofauna monitoring will be to:

- Describe the distribution and nature of existing stygofauna assemblages on site, building on existing baseline data collected during the EIS.
- Determine the similarity and potential connectedness of stygofauna assemblages across the Project Area and surrounding region.
- Identify the range of groundwater quality conditions that support stygofauna assemblages.

5.4.2 Groundwater fed creeks

The ecological values of the groundwater fed creeks will be determined through the implementation of a comprehensive monitoring program, involving the following variables:

- Water quality at all sites (monthly).
- Sediment quality at all sites (six monthly).
- Aquatic ecology habitat assessments at DE1, TO4, Mo1, Gr1, TO1, TO2, TO3, De2, De3, De4, De5, St1 (six monthly).
- Macroinvertebrate abundance and composition at DE1, TO4, Mo1, Gr1, TO1, TO2, TO3, De2, De3, De4, De5, St1 (six monthly).
- Fish surveys at De1, TO4, Mo1, Gr1, TO1, TO2, TO3, De2, De3, De4, De5, St1, St2 (six monthly).
- Surveys of the physical characteristics of pools at the end of the dry season (pool size, water depth, fish assemblages; annually).

All monitoring tasks will be completed as part of the REMP, with the exception of the survey of pool characteristics at the end of the dry season, which is a task specific to the GDEMMP. This task will allow the ongoing monitoring of the presence and persistence of pools during the dry season under baseline, pre-impact and impact phases of the Project. This will allow the effects of groundwater drawdown to be monitored in the receiving environment, to determine to degree to which pools are affected (drying up faster), the locations that are affected, and the potential ecological consequences of these changes.

The comprehensive monitoring program of the receiving environment outlined in the REMP will facilitate an assessment of the ecological condition of the habitats of Aquatic GDEs and the flora and fauna that they support. Interpretation of the results will be undertaken in consideration of the activities being undertaken at the mine (e.g. controlled releases to the receiving environment) and the results of groundwater monitoring data from nearby bores.

Objectives of the monitoring of groundwater fed creeks will be to:

- Describe the distribution and nature of existing aquatic ecology values on site, building on existing baseline data collected during the EIS.
- Assess the effects of groundwater drawdown on the persistence of pools within waterways during the dry season, and resultant effects on aquatic ecology values.
- Determine the extent to which local aquatic ecology values change over the annual wet season and dry season cycle, and the influence, if any, of mining-related impacts on these patterns.

5.4.3 Groundwater dependent vegetation

Vegetation dependent on the presence of groundwater (either subsurface or surface) will be monitored extensively, to determine the effects of groundwater drawdown and other mining-related impacts on GDEs. Monitoring sites will be established at the same locations as those monitored during baseline studies, with additional sites provided within, on the fringe of and outside of areas predicted to be affected by groundwater drawdown. Initially, the focus will be to collect extensive data during the pre-impact phase of the Project, to supplement existing baseline data. This will provide an environmental baseline from the period before groundwater drawdown commences, from which the assessment of impacts from the Project can be based.

Monitoring variables will include the following:

- Leaf water potential and isotope studies to determine the source of water utilised by vegetation.
- Foliage cover measurements using digital cameras from a set position and height.
- Normalised Difference Vegetation Index (NDVI), to identify areas where vegetation and/or foliage dieback is occurring.
- BioCondition and CORVEG assessments of vegetation community condition and health.
- Weed and pest surveys of the riparian zone and Wetland 1

Objectives of the monitoring of groundwater dependent vegetation will be to:

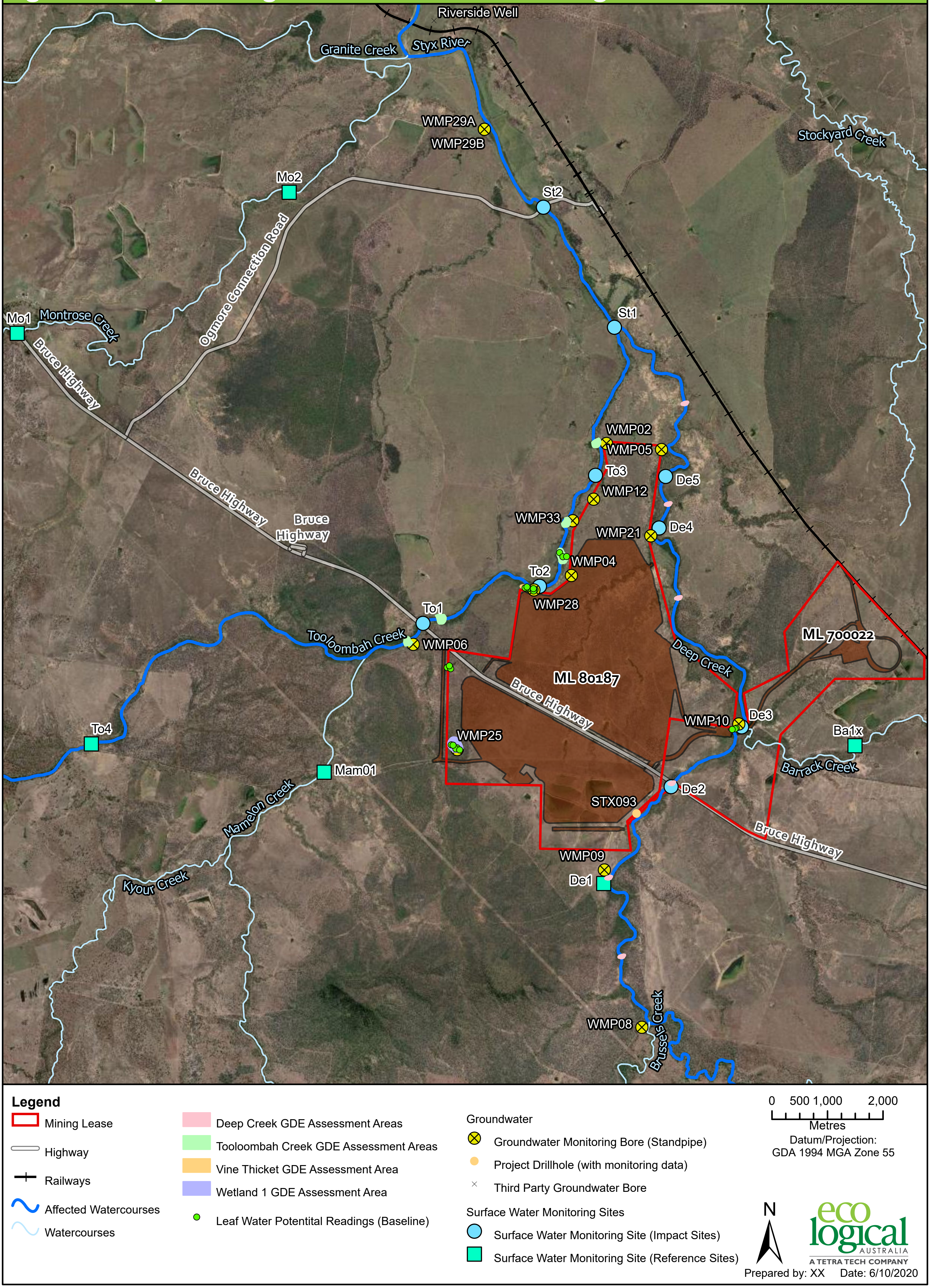
- Collect further data on the degree to which vegetation within the riparian corridor and Wetland 1 utilises groundwater, and the seasonal nature of these characteristics.
- Assess the effects of groundwater drawdown on the availability of water to vegetation, with a focus on key species of Forest Red Gum and Melaleuca.
- Determine the extent to which reduced groundwater availability to groundwater dependent vegetation impacts on the ecological condition of individual trees and the vegetation communities within which they occur.
- Assess the effectiveness of weed and pest management activities at increasing the resilience of the riparian vegetation communities and Wetland 1 to the effects of groundwater drawdown.

Table 5-5: Monitoring frequency, duration, type and indicators for Subterranean, Aquatic and Terrestrial GDEs of the Styx River and Tributaries

Monitoring description	Frequency and duration	Monitoring type	Indicators	Plan for implementation
Subterranean GDE monitoring				
Stygofauna monitoring surveys	Every six months	Pre-impact Impact	Stygofauna presence, taxonomic composition, diversity and abundance at alluvial aquifer bores	GDEMMP
Aquatic GDE monitoring				
Pre-clearance surveys	Prior to clearing	Pre-impact	Riparian vegetation which may comprise Aquatic GDEs (e.g. Melaleucas)	EMP
Riparian condition surveys	Twice per year (wet and dry season) until drawdown commences and quarterly thereafter	Pre-impact Impact	Vegetation condition, vegetation health, foliage cover, vegetation health indices, leaf water potential, soil water potential, stable isotope analysis (relevant to vegetation that is an Aquatic GDE; Melaleuca). Normalised Difference Vegetation Index (NDVI) remote sensing.	GDEMMP
Pool location and condition survey	Once per year at the end of the dry season (October)	Pre-impact Impact	Pool location, Pool size and depth	GDEMMP
Aquatic ecology surveys (as per REMP)	Twice per year (macroinvertebrate survey and habitat assessment) Twice per year (fish)	Pre-impact Impact	Macroinvertebrate abundance and composition Aquatic habitat condition Fish abundance and composition	REMP
Terrestrial GDEs				
Riparian and wetland condition surveys	Twice per year (wet and dry season) until drawdown commences and quarterly thereafter	Pre-impact Impact	Vegetation condition, vegetation health, foliage cover, vegetation health indices, leaf water potential, soil water potential, stable isotope analysis (relevant to vegetation that is a Terrestrial GDE; Forest Red Gum, Melaleuca at Wetland 1). Normalised Difference Vegetation Index (NDVI) remote sensing.	GDEMMP
Weeds and pest surveys (as per EMP)	Twice per year (wet season and dry season), for a period of two years and then annually	Pre-impact Impact	Presence of weed species, extent of weed coverage, presence of feral animals, extent of feral animal disturbance.	EMP

Monitoring description	Frequency and duration	Monitoring type	Indicators	Plan for implementation
Monitoring relevant to all GDE types				
Groundwater levels (as per GMMP)	Quarterly	Pre-impact Impact	Groundwater level	GMMP
Surface water flow (as per REMP)	Continuously (daily)	Pre-impact Impact	Surface water level, surface water flow	REMP
Groundwater quality (as per GMMP)	Quarterly	Pre-impact Impact	Groundwater quality	GMMP
Surface water quality (as per REMP)	Monthly (water) Twice per year (sediment)	Pre-impact Impact	Surface water quality Sediment quality	REMP

Figure 5-4: Maps showing the location of GDE monitoring sites



5.5 Triggers for adaptive management and corrective actions

The regional groundwater model (HydroAlgorithmics 2020) identifies groundwater drawdown level triggers that have been included in **Appendix A**. These are relevant for all GDE types along the riparian corridors and Wetland 1. The triggers relate to alluvial groundwater bores, which are located in close proximity to GDEs and provide insight into how the groundwater resources of GDEs may be affected by the Project.

Ecological triggers have been established and will be reviewed following the completion of the pre-impact surveys. Triggers are based on a statistically significant deviation in baseline and pre-impact conditions (as relevant). Water quality triggers will be set as the 80th percentile of baseline concentrations in accordance with the GMMP (**Appendix B**).

Triggers for the following characteristics of GDEs are specified in **Table 5-6** and include:

- Changes in groundwater level.
- Statistically significant reduction in riparian community health indicators (CORVEG and BioCondition data; foliage cover) from baseline conditions.
- Statistically significant reduction in aquatic ecology indicators from baseline conditions.
- Statistically significant reduction in stygofauna indicators from baseline conditions.
- Significant increase in weed cover, pests or pest activity above baseline levels.
- Identification of new weeds or feral animals within GDEs.
- Water quality guidelines for groundwater and surface water.
- Changes in surface water flows.
- Reduction in the number and extent of surface water pools at the end of the dry season.

If a trigger is exceeded, an investigation will be conducted to determine whether the detected result is a direct result of mining activities, and consistent with what has been approved, as outlined in SEIS v3 (Central Queensland Coal) and relevant approval conditions. The investigation will follow the broad approach outlined in Section 3.3 of the ANZECC (2000) Guidelines, and will involve:

- Development of a decision tree model for the possible effect of mining activities on the measured variable.
- Site-specific investigations involving the collection and interpretation of additional data.
- A review of relevant data related to potential non-mining causes of variability in environmental variables (e.g. climatic data).
- Development of a detailed model of relevant environmental variables.
- Expert opinion on the potential for environmental harm.

Table 5-6: Summary of GDE triggers and statistical analysis approaches

Indicator	Relevant triggers	Design*	Parameters	Statistical analysis
Groundwater level	Trigger levels as outlined in the GMMP (Appendix A) are exceeded. (Triggers are based on 75% of the maximum predicted groundwater drawdown.)	Monitoring at the bores listed in Appendix A.	Groundwater level (Mbgl)	Univariate comparison between groundwater level at time of sampling and groundwater level threshold.
Groundwater Quality	Trigger levels as outlined in the GMMP (Appendix B) are exceeded. (Triggers are the 20th or 80th percentile of baseline values.)	Monitoring at the alluvial aquifer bores listed in HydroAlgorithmics (2020)	Water quality parameters as outlined in Appendix B	Descriptive comparison with defined groundwater quality trigger levels.
Surface Water Flow (periods of flow) Surface Water Level and extent (periods of no flow)	Significant deviations from the baseline conditions, which are predicted to remain unchanged in response to the Project.	Monitor flow (continously) at stream flow stations in the watercourse Monitor surface water level, and extent at monitoring locations throughout Styx River and tributaries (AMEC and DES manual methods)	Surface water flow Surface Water Level Pool location, size and depth	Descriptive comparison of daily flow with the 20th percentile of baseline flow. Descriptive comparison of water level, pool size and pool depth at time of sampling to baseline conditions.
Surface water quality Sediment quality	Surface water quality trigger levels as outlined in the REMP are exceeded. (Triggers are the 20th or 80th percentile of baseline values.)	Monitor in accordance with the REMP at designated monitoirng locations. *In situ* and sample collection of laboratory analysis as per DES Manual for water quality Composite samples from pool areas for sediment quality	Water quality parameters as outlined in REMP (including Dissolved and Total metals, TSS, Turbidity, EC, pH, DO, Temperature) Sediment quality parameters as outlined in REMP (Particle Size Distribution, Metals (< 2mm fraction), Total Organic Carbon)	Descriptive comparison with defined surface water quality and sediment quality trigger levels.

Indicator	Relevant triggers	Design*	Parameters	Statistical analysis
Stygofauna	Statistically significant change in stygofauna metrics compared with baseline/pre-impact conditions or approved impacts.	Monitoring at the alluvial aquifer bores listed in HydroAlgorithmics 2020.	Stygofauna presence, taxonomic composition, diversity and abundance	Descriptive comparison of stygofauna presence, taxonomic composition, diversity and abundance at time of sampling to baseline conditions. MDS graphs to show relative spread of stygofauna composition, diversity and abundance. Follow up SIMPER tests to detect the main indicators driving the patterns in the data.
Riparian and wetland vegetation condition and community health	Statistically significant reduction in vegetation health and condition indices	COREVEG / BioCondition survey (plots) Transects within riparian zones and wetlands Foliage cover measured using either hemispherical cameras or wide angel digital cameras from set positions at each monitoring site. Normalised Difference Vegetation Index (NDVI) remote sensing	COVEG and BioCondition data Foliage cover Vegetation health (NDVI) Spatial extent of terrestrial GDEs Condition of vegetation (evidence of poor health including evidence of fire damage, erosion or drought stress). Habitat condition (presence and abundance of weeds and evidence of pests). Environmental water requirement measures: • Leaf water potential • Soil water potential Stable isotope analysis to determine depth of soil water absorbed by Terrestrial GDEs and to determine whether a	Descriptive comparison of mean health indicators across plots between the current sampling time and baseline. MDS graphs to show relative spread of plots based on community health indicators. Multivariate PERMANOVA test on health indicators to detect significant differences in the community health of the riparian zones sampling time and baseline. Follow up SIMPER tests to detect the main indicators driving the patterns in the data. Determine environmental water requirements

Indicator	Relevant triggers	Design*	Parameters	Statistical analysis
			groundwater ‘signature’ exists within the plant xylem	
Aquatic ecology condition	Macroinvertebrate parameters fall below baseline values. Changes to taxonomic composition and abundance of the fish population from baseline levels	Macroinvertebrate sampling using AusRivAS methods (Dip netting of edge and bed habitats as per Queensland AusRivAS manual) Electrofishing, fyke netting and seine netting.	Macroinvertebrate abundance and taxonomic diversity via PET taxa, Signal2 scores and OE50 (biological diversity). Fish abundance and taxonomic composition.	Descriptive comparison of mcroinvertebrate and fish parameters at time of sampling to baseline conditions. MDS graphs to show relative spread of macroinvertebrate and fish composition and abundance. Follow up SIMPER tests to detect the main indicators driving the patterns in the data.
Presence of weed species Extent of weed coverage Presence of feral animals Extent of feral animal disturbance	A significant increase in the abundance of weeds, or identification of new species or infestations. Significant increase in the population of any invasive species from baseline and pre-impact scores.	Weed and pest surveys undertaken at COREVEG / BioCondition plots	Inventory of all weed and feral animals present. Identify spatial extent of weeds within the Project Area Identify areas of Riparian habitat subject to pig damage and cattle damage.	Descriptive comparison of weed cover, pest abundance, and area of pest damage at time of sampling to baseline conditions. Log the occurrence of new weed or feral animal compared to baseline.

5.5.1 Groundwater Level

Thresholds have been developed for drawdown of the alluvial groundwater table as summarised in **Appendix A** (HydroAlgorithmics 2020). The triggers are based on 75% of the maximum predicted groundwater drawdown. When trigger levels are exceeded, an investigation and review of groundwater modelling will be instigated within 14 days of detection. Trigger (threshold) levels will be reviewed by a suitably qualified person every five years after the issue of the EA. A groundwater model validation will be undertaken after three years, based on the results of monitoring data collected at this point in time.

5.5.2 Riparian and Wetland Vegetation Health

Triggers for riparian vegetation health are based on CORVEG / BioCondition indicators and scores, as well as signs of dieback in trees. Foliage cover will be a key indicator of vegetation health, as measured using either hemispherical cameras or wide angel digital cameras from set positions at each monitoring site. This information be interpreted using leaf water potential, isotope and soil moisture potential data, to determine whether changes in the water stress of vegetation has occurred over time as a result of the Project.

Vegetation health will also be assessed using the remote sensing technique of Normalised Difference Vegetation Index (NDVI). This is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum and assists in assessing whether the target contains live green vegetation or not. The method is useful for identifying areas where vegetation and/or foliage dieback is occurring, with triggers associated with a statistically significant change from baseline and pre-impact values.

5.5.3 Aquatic ecology

Triggers for macroinvertebrates and fish include statistically significant changes in taxonomic composition and abundance. For macroinvertebrates, the AusRivAS variables PET taxa, Signal2 scores and OE50 (biological diversity) will be the primary indicators utilised.

5.5.4 Surface Water Flows

Triggers for surface water flow are associated with significant deviations from the baseline flow conditions, which were predicted to remain unchanged in response to the Project.

5.5.5 Ground and Surface Water Quality

Ground and surface water quality triggers will be the 20^{th} or 80^{th} percentile of baseline values. Trigger levels for receiving waters will be in accordance with the approved EA and local water quality guidelines as outlined in the REMP and GMMP.

5.6 Adaptive management

An adaptive management framework will be employed to mitigate impacts from the Project and will include a review of trigger levels during the course of the Project, particularly in response to long term monitoring and studies undertaken during each assessment and monitoring stage.

The effectiveness of management and mitigation measures will be reviewed and assessed at the completion of each assessment and monitoring stage. If monitoring identifies that management measures are ineffective, the GDEMMP will be updated with improved management measures.

In general, the approach to adaptive management will involve:

- An investigation within 14 days of detection to determine whether the fluctuations are the result of mining activities, pumping from licensed bores, seasonal variation or neighbouring land use.
- If the investigation determines that the exceedance is caused by mining activities, the following tasks will be undertaken:
  - Determine whether impacts to GDEs have occurred or are likely to occur.
  - Identify long term mitigation and management measures to address the impact.
  - Identify corrective actions.
  - Notify the administering authority within 28 days of the detection, if the impact is beyond what has been approved.
- Undertake an assessment of the associated impacts to GDEs.
- Update the GDEMMP if required.

When adaptive management and corrective actions are triggered, the first step is to investigate the cause of the trigger. Such investigations will involve a review of available data (including groundwater levels), consideration of the potential influence of mining and non-mining activities, natural fluctuations that may have contributed to the result, and the input of specialist advice. The specific details of the investigation will be tailored to identify the root cause or best available solution to the identified issue.

If a trigger is exceeded, an investigation will be conducted to determine whether the detected result has been caused by mining activities. The investigation will include consideration of groundwater monitoring data, surface water flow and quality data and ecological data collected on the GDE of interest. The investigation will focus on determining whether an observed decline in an environmental variable is caused by the Project, and will involve:

- A review of groundwater monitoring data to determine the potential for drawdown to be impacting the relevant GDEs.
- Site-specific investigations involving the collection and interpretation of additional ecological data.
- A review of relevant data related to potential non-mining causes of variability in environmental variables (e.g. climatic data).
- Developing a detailed model of relevant environmental variables.
- Expert opinion on the potential for environmental harm.

5.7 Management objectives, performance criteria, adaptive management triggers and corrective actions

The threats to GDEs and actions to minimise impacts are summarised in **Table 5-7** for Subterranean GDEs, **Table 5-8** for Aquatic GDEs and **Table 5-9** for Terrestrial GDEs. The tables address the following for each GDE:

- Management objectives
- Performance criteria
- Management actions
- Monitoring
- Triggers for adaptive management and corrective actions

- Specific, measurable and time-bound corrective actions.

The relevant statistical analyses outlined in **Section 4.5.3** support the performance criteria for the Subterranean, Aquatic and Terrestrial GDEs of the Project Area. **Table 5-7 to Table 5-9** and **Table 5-6** (statistical approach for GDE triggers and monitoring) will be used to guide the assessment of the success of management measures against goals, triggers, with the implementation of corrective actions if the criteria are not met within specified timeframes.

At the conclusion of pre-impact monitoring, the performance criteria, monitoring and triggers will be reviewed, and updated as required, via the review and the adaptive management process detailed in **Sections 6.2 to 6.4**. The objectives are applicable for the life of the approvals, and the life of this plan, subject to updates arising from reviews.

Table 5-7: Management objectives, performance criteria, adaptive management triggers and corrective actions for Subterranean GDEs (stygofauna)

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
1	Mine dewatering and depressurisation	Minimise changes to groundwater / surface water flow interactions.	No impact greater than predicted in the SEIS v3 to Subterranean GDEs from mine dewatering.	Implement groundwater monitoring and management program as per the EMP.	**Pre-impact monitoring:** GMMP REMP Stygofauna monitoring **Impact monitoring:** EMP REMP Stygofauna monitoring	Groundwater level Groundwater quality Surface water flow and level Surface water quality Stygofauna presence, abundance and diversity	Groundwater level drawdown thresholds as outlined in the GMMP (**Appendix A**) are exceeded. Groundwater quality trigger levels as outlined in the GMMP (**Appendix B**) are exceeded. Changes to groundwater modelling outcomes and predicted drawdown results. Surface water quality trigger levels as outlined in the REMP are exceeded. Statistically significant change in stygofauna metrics compared with baseline/pre-impact conditions or approved impacts.	The appropriate corrective actions will be implemented and will include: • Immediately limiting mining activities to current activities, until monitoring indicates the trigger level(s) are no longer being exceeded, or at further risk of being exceeded. • If the investigation indicates that there is a risk of impacts to the Subterranean GDEs of the Styx River and tributaries beyond that approved, monitoring will be reviewed and a report prepared within 3 months to identify the actual impact from the mining activities.
		Minimise the impacts of groundwater water drawdown on GDEs.	Project impacts are less than or equal to predicted impacts at the equivalent stage of the mine life.					
2	Ground water quality degradation	Maintain ground water quality in accordance with the WMP. Protection of environmental values within the Styx River and tributaries.	Groundwater quality is not impacted from mining operations and associated activities other than predicted from mine dewatering and depressurisation.					
3	Changes to surface water hydrology	Minimise changes to surface flows and flooding. Reduce the impact of drainage line diversions on GDEs. Minimise the loss of catchment area.	No hydrological changes to the Styx River and tributaries greater than those predicted as a result of catchment loss and stream diversions.	No water for the Project will be sourced directly from the Styx River or tributaries within the reach of ML area. Implement the Project CRS.	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP	Surface water flow Surface water level (periods of no flow)	Flooding / inundation is greater than predicted in the EIS flood modelling Decreases in water flows within the Styx River and tributaries due to loss of catchment area exceed those predicted from hydrological modelling in the EIS. Water is sourced from the Styx River or tributaries	The appropriate corrective actions will be implemented and may include: • If water is sourced from the river, immediately ceasing the activity • Inform the administering authority within 30 days of incident. An investigation into potential impacts within 14 days of detection. • If it is determined that impacts to the Styx River and tributaries have resulted, the administering authority will be notified within 28 days and mitigation measures implemented. • Supplementing water flow with additional water from the mine site, via the approved discharge locations • Rehabilitation activities to be undertaken in areas of temporary disturbance.
		No greater impact than approved in the EIS from the quality or quantity of water released from the Project area.	Water from the Project area released into the Styx River and tributaries meets the quantity conditions outlined in the CRS.	Monitoring of released water quantity must be undertaken by an appropriately qualified person in accordance with specified frequencies and trigger investigation levels. Stream flow gauging stations installed, operated and maintained to determine and record stream flows at locations and flow recording	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP which includes monitoring requirements before, during and after a discharge event.	Surface water flow Surface water level (periods of no flow) Surface water quality	The flow conditions for release of Mine affected water outlined in the CRS are not complied with.	The appropriate corrective actions will be implemented and will include: • Notify the administering authority of discharges occurring outside of approved flow conditions • Investigate reasons for not complying with flow conditions for release, and review the CRS on the basis of updated hydrological information

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				frequency specified in the REMP and CRS. Release of water to the receiving environment in accordance with the CRS in relation to the maximum release rate for combined release point flows for each receiving water flow criterion specified in the CRS.				
4	Surface water quality degradation	Maintain surface water quality of the receiving environment. Protection of environmental values within waterways of the receiving environment.	Water quality is not impacted from mining operations and associated activities, other than predicted short-term and localised changes as a result of discharge under the CRS.	Water release points will be optimally located within local creeks to ensure sufficient dilution of flows to control water quality.	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP that includes monitoring requirements before, during and after a discharge event.	Surface water quality Sediment quality	Surface water quality trigger levels in the REMP are exceeded.	The appropriate corrective actions will be implemented and may include: • During a release event, comparing the downstream results to the upstream results in the receiving waters will be undertaken and: ○ if the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action will be taken; or ○ if the downstream results exceed the upstream results, complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining the details of the investigations carried out; and actions taken to prevent environmental harm • If there is potential for environmental harm identified, implementing management actions targeted at correcting the water quality parameter for which an exceedance occurred (e.g. implement changes to the discharge of mine affected water to achieve compliance).
		Reduce and minimise the risk of contamination of the Styx River and tributaries from mine affected water or from chemicals, fuel, heavy metals etc.	Water from the project area released into the Styx River/tributaries meets quantity and quality conditions provided in the CRS and Project Environmental Authority.	Any sites used for chemical and fuel storage will be located a safe distance away from the Styx River and tributaries, with bunding or other raised barrier, resistant to normal flood events, between chemicals and habitat. All vehicles and machinery will be cleaned and maintained to minimise the introduction of contaminants such as oil and fuel. Compliance with management actions included in the CRS.	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP	Surface water quality Sediment quality	Surface water quality trigger levels as outlined in the REMP are exceeded. Pollution of the Styx River and/or tributaries by contaminants due to spills.	The appropriate corrective actions will be implemented and will include: • Minimising immediate impacts and rectifying through clean-up actions • Reporting to DES as per statutory and project requirements where incidents trigger reporting thresholds.
5	Erosion of streambanks	Not relevant to stygofauna						

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
6	Direct disturbance of habitat	Not relevant to stygofauna – occurs following dewatering						
7	Weeds and pests	Not relevant to stygofauna						
8	Fire	Not relevant to stygofauna						
9	Dust emissions	Not relevant to stygofauna						
10	Noise and vibration	Not relevant to stygofauna						
11	Light spill and other visual impacts	Not relevant to stygofauna						

Table 5-8: Management objectives, performance criteria, adaptive management triggers and corrective actions for Aquatic GDEs (groundwater fed waterways)

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
1	Mine dewatering and depressurisation	Prevent any changes to groundwater / surface water flow interactions. Minimise the impacts of groundwater water drawdown on GDEs.	No impact greater than predicted in the SEIS v3 to Aquatic GDEs of the Styx River and tributaries from mine dewatering. Project impacts are less than or equal to predicted impacts at the equivalent stage of the mine life.	Implement groundwater monitoring and management program as per the EMP.	**Pre-impact monitoring:** GMMP REMP **Impact monitoring:** GMMP REMP	Groundwater level Groundwater quality Surface water flow and level Surface water quality Vegetation health and condition	Groundwater level drawdown thresholds as outlined in the GMMP (**Appendix A**) are exceeded. Groundwater quality trigger levels as outlined in the GMMP are exceeded (**Appendix B**). Changes to groundwater modelling outcomes and predicted drawdown results. Surface water quality trigger levels as outlined in the REMP are exceeded. Statistically significant change in aquatic ecological condition metrics compared with baseline/pre-impact conditions. Statistically significant reduction in vegetation health and condition indices compared with baseline/pre-impact conditions.	The appropriate corrective actions will be implemented and will include: • Immediately limiting mining activities to current activities, until monitoring indicates the trigger level(s) are no longer being exceeded, or at further risk of being exceeded. • If the investigation indicates that there is a risk of impacts to the Aquatic GDEs of the Styx River and tributaries beyond that approved, monitoring will be reviewed and a report prepared within 3 months to identify the actual impact from the mining activities. • If the investigation finds that the actual areas of impact differ from the area of impact as detailed in the Offset Management Plan (if relevant to Aquatic GDEs), the Offset Management Plan will be amended within 30 days and the amended offset delivered within 12 months.
2	Ground water quality degradation	Maintain ground water quality in accordance with the WMP. Protection of environmental values within the Styx River and tributaries.	Groundwater quality is not impacted from mining operations and associated activities other than predicted from mine dewatering and depressurisation.					
3	Changes to surface water hydrology	Minimise changes to surface flows and flooding. Reduce the impact of drainage line diversions on GDEs. Minimise the loss of catchment area.	No hydrological changes to the Styx River and tributaries greater than those predicted as a result of catchment loss and stream diversions.	No water for the Project will be sourced directly from the Styx River or tributaries within the reach of ML area. Implement the Project WMP and Erosion and Sediment Control Plan.	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP	Surface water flow Surface water level (periods of no flow)	Flooding / inundation is greater than predicted in the EIS flood modelling Decreases in water flows within the Styx River and tributaries due to loss of catchment area exceed those predicted from hydrological modelling in the EIS. Water is sourced from the Styx River or tributaries	The appropriate corrective actions will be implemented and may include: • If water is sourced from the river, immediately ceasing the activity • Informing the administering authority within 30 days of incident. An investigation into potential impacts within 14 days of detection. • If it is determined that impacts to the Styx River and tributaries have resulted, the administering authority will be notified within 28 days and mitigation measures implemented. • Supplementing water flow with additional water from the mine site, via the approved discharge locations • Re-run of the hydrological model, using most recent stream flow data for calibration • Rehabilitation activities to be undertaken in areas of temporary disturbance.
		No greater impact than approved in the EIS from the quality or quantity of water released from the Project area.	Water from the Project area released into the Styx River and tributaries meets the quantity conditions outlined in the CRS.	Monitoring of released water quantity must be undertaken by an appropriately qualified person in accordance with specified frequencies and trigger investigation levels. Stream flow gauging stations installed, operated and maintained to	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP which includes monitoring requirements before, during and after a discharge event.	Surface water flow Surface water level (periods of no flow)	The flow conditions for release of Mine affected water outlined in the CRS are not complied with.	The appropriate corrective actions will be implemented and will include: • Notify the administering authority of discharges occurring outside of approved flow conditions • Investigate reasons for not complying with flow conditions for release, and review the CRS on the basis of updated hydrological information

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				determine and record stream flows at locations and flow recording frequency specified in the REMP and CRS. Release of water to the receiving environment in accordance with the CRS in relation to the maximum release rate for combined release point flows for each receiving water flow criterion specified in the CRS.				
4	Surface water quality degradation	Maintain surface water quality of the receiving environment. Protection of environmental values within waterways of the receiving environment.	Water quality is not impacted from mining operations and associated activities, other than predicted short-term and localised changes as a result of discharge under the CRS.	Vegetation clearing near, or within ephemeral waterways will be avoided when rain is falling, or imminent. Management of erosion and sedimentation will be undertaken in accordance with the Erosion and Sediment Control Plan.. Remove cattle grazing from large parts of the Mamelon property (over 2,000 ha) including waterways (reducing sediment and nutrient inputs), and establish environmental offsets in accordance with the Offset Management Plan. Water release points will be optimally located within Deep Creek to ensure sufficient dilution of flows to control water quality.	**Pre-impact monitoring:** REMP **Impact monitoring:** REMP that includes monitoring requirements before, during and after a discharge event.	Surface water quality Macroinvertebrate abundance and taxonomic diversity. Fish abundance and taxonomic diversity. Aquatic ecology habitat condition	Surface water quality trigger levels in the REMP are exceeded. Macroinvertebrate and/or fish diversity, abundance and/or aquatic ecosystem condition deviates by more than statistically significant change from baseline conditions.	The appropriate corrective actions will be implemented and may include: • During a release event, comparing the downstream results to the upstream results in the receiving waters will be undertaken and: ○ if the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action will be taken; or ○ if the downstream results exceed the upstream results complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining the details of the investigations carried out; and actions taken to prevent environmental harm • If there is potential for environmental harm identified, implementing management actions targeted at correcting the water quality parameter for which an exceedance occurred (e.g. implement changes to the discharge of mine affected water to achieve compliance).

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
		Reduce and minimise the risk of contamination of the Styx River and tributaries from mine affected water or from chemicals, fuel, heavy metals.	Water from the project area released into the Styx River/tributaries meets quantity and quality conditions provided in the CRS and Project Environmental Authority.	Any sites used for chemical and fuel storage will be located a safe distance away from the Styx River and tributaries, with bunding or other raised barrier, resistant to normal flood events, between chemicals and habitat. All vehicles and machinery will be cleaned and maintained to minimise the introduction of contaminants such as oil and fuel. Compliance with management actions included in the CRS.	**Impact monitoring:** REMP	Surface water quality Sediment quality	Surface water quality trigger levels as outlined in the REMP are exceeded. Pollution of the Styx River and/or tributaries by contaminants due to spills.	The appropriate corrective actions will be implemented and will include: • Minimising immediate impacts and rectifying through clean-up actions • Reporting to DES as per statutory and project requirements where incidents trigger reporting thresholds.
5	Erosion of streambanks	Minimise impacts to the geomorphology of Styx River and tributaries Reduce and minimise the risk of sedimentation of the Styx River and tributaries from erosion of streambanks	Prevent impacts to the Styx River and tributaries from erosion and sediment inputs. Water release flow rates into the Styx River meet quantity and quality conditions outlined in the CRS to prevent geomorphology impacts such as erosion. Water quality is not impacted from sedimentation associated with erosion of streambanks.	An Erosion and Sediment Management Plan will be implemented for the water discharge locations and for construction activities within riparian/aquatic zones (e.g. haul road crossings). Compliance with management actions included in the CRS. The water release channel will be designed such that released water does not result in localised or downstream scour or erosion. Removal of cattle from over 2,000 ha to reduce erosion of streambanks from cattle accessing the waterways. Regeneration of vegetation and restoration of habitat	**Pre-impact monitoring:** REMP Riparian condition survey **Impact monitoring:** REMP Riparian condition survey	Surface water quality Riparian condition Aquatic habitat condition	Evidence of erosion and / or sedimentation within the vicinity and immediately downstream of discharge locations and / or construction activities	The appropriate corrective actions will be implemented and may include • Reviewing erosion and / or sedimentation controls • Stabilising riverbank / bed • Implementation of revised controls prior to earthworks re-commencing • Undertaking targeted weekly inspections of erosion and sediment controls for the following month to review effectiveness

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				on the property to create vegetation buffers, increase bank stability and reduce sedimentation.				

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions

6	Direct disturbance of aquatic ecology habitats associated with the Styx River and tributaries	Minimise riparian vegetation loss and aquatic habitat disturbance in the Styx River and tributaries.	No unapproved clearing or disturbance to vegetation beyond what was approved in the Project EIS.	Prior to the commencement of site works, the limits of clearing and exclusion areas will be clearly marked.
				The construction footprint for the haul road crossings (Deep Creek and drainage gullies) will avoid any permanent pools, where possible.
				The design of the haul road crossings will maintain aquatic habitat connectivity and fish passage.
				Construction activities within/near riparian and aquatic habitats will occur during the dry season where possible to eliminate the need to divert water around the construction area and to minimise risks to instream environmental values.
				Existing access tracks will be used within aquatic/riparian habitats to reduce the amount of additional clearing required.
				Prior to the commencement of site works, any conditions listed in the Permit to Disturb must be implemented (e.g. clearing extents clearly marked, trees/areas requiring protection clearly marked).
					Pre-impact monitoring:
					Riparian condition survey
					REMP
					
					Impact monitoring:
					Pre-clearance surveys
					REMP
					Close out report for the Permit to Disturb process includes check for compliance with:
					• clearing only in the approved footprint
					• no clearing in the no-go zone/s.
					Regular site inspections in accordance with the EMP.
						Areas of aquatic and riparian habitat cleared or directly disturbed.
						Aquatic habitat condition.
							Disturbance or clearing in the Styx River and/or tributaries:
							• Outside approved clearing footprint
							• In no-go zone/s
							• without a Permit to Disturb issued
								The appropriate corrective actions will be implemented and will include:
								• When clearing outside approved clearing footprint, no go zones or without a "Permit to Disturb Permit" issued:
								  ○ Environment Manager ensure that all clearing activities cease immediately
								  ○ Area assessed by a suitably qualified ecologist/person within 15 business days of investigation
								  ○ additional barricading to be installed
								  ○ Reviewing and modifying Permit to Disturb process and no-go zone identification and communication protocols
								  ○ Implement remediation measures within 1 month to promote revegetation
								• The provision of offsets, as an overarching corrective action to achieve the objective of minimising habitat loss.

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
		Minimise habitat fragmentation	Manage offset areas to maintain and improve the condition of the Styx River and tributaries.	Management and monitoring of the offset areas to occur in accordance with the Offset Area Management Plan (OAMP).				
		Rehabilitation of temporarily disturbed habitat	Rehabilitation of temporary disturbance areas to pre-existing vegetation and habitat condition	Rehabilitation of the disturbed habitat will be undertaken at the completion of the construction and once temporary construction areas are no longer required. Rehabilitation will focus on the reinstatement of ground cover to reduce erosion, run-off and to stabilise the creek banks.	**Pre-impact monitoring:** Riparian condition survey REMP **Impact monitoring:** REMP Erosion and Sediment Control Plan	Rehabilitation success criteria for parameters such as vegetation cover, evidence of erosion Surface water quality Aquatic habitat condition	Rehabilitation not meeting success criteria for parameters such as vegetation cover, evidence of erosion. Surface water quality trigger levels as outlined in the REMP are exceeded. Long-term deterioration in aquatic habitat condition	The appropriate corrective actions will be implemented and will include: • Installing additional erosion and / or sedimentation in accordance with Erosion and Sediment Control Plan. • Stabilising the river bank / bed in accordance with Erosion and Sediment Control Plan • Reviewing the process for temporary disturbance and monitoring to improve response time
7	Weeds and pests	Minimise weed incursion	No introduction of weeds within the Styx River and tributaries. Prevent the spread of weeds across the Project Area and into / from adjacent habitat.	Weed control, as part of the Weed and Pest Management Plan, will focus on managing declared pest plants and invasive species during construction and operations. Weed hygiene controls, including the use of weed wash down stations, will be implemented in accordance with the Weed and Pest Management Plan to prevent the introduction and spread of declared pest plants and other invasive weeds. Weed free areas within in the Styx River and tributaries will be identified and mapped with strict weed control requirements for entering weed free areas.	**Pre-impact monitoring:** Riparian condition survey REMP Weed and pest survey **Impact monitoring:** Riparian condition survey REMP Weed and pest survey	Presence of weed species Extent of weed coverage	Introduction or establishment of declared pest plants, and invasive species into previously unaffected areas. Results of weed monitoring indicate a degradation of the Styx River and/or tributaries, due to a proliferation of weeds. A significant increase in the abundance of weeds, or identification of new infestations. Weed species recorded at pool and riparian monitoring sites on the Styx River and/or tributaries that did not have that weed species recorded during baseline and pre-impact ecology surveys.	The appropriate corrective actions will be implemented and will include: • Eliminating potential sources or reasons that may have attributed to an increase in species richness and/or relative abundance of weeds • Amending weed hygiene restrictions within 1 week of concluding the investigation • Providing additional educational awareness training for all staff and contractors to ensure weed hygiene restrictions are adhered to • Revising weed control methods in accordance with the *Biosecurity Act 2014* • Increasing the frequency and intensity of weed controls for the following 12 months • Updating weed control methods in targeted weed control programs and plans.

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
		Reduce habitat degradation by introduced herbivores Minimise predation risk from invasive mammals	No measured increase in feral animal numbers in the Project Area.	Adaptive management of pest controls to minimise threats to the Styx River and tributaries. A project Weed and Pest Management Plan will be implemented prior to construction and operations, including measures for controlling cane toads, pigs, rabbits, wild dogs and cats. The plan will be implemented in conjunction with neighbouring landowners, and will focus on tracks, waterways and habitat edges. Destocking of large parts of the property will occur and domestic animals will not be permitted into the Project Area.	**Pre-impact monitoring:** Riparian condition survey REMP Weed and pest survey **Impact monitoring:** Riparian condition survey REMP Weed and pest survey	Presence of feral animals Extent of damage from feral animals	Significant increase in the population of any invasive species from baseline and pre-impact scores. Observed bed and bank degradation of the Styx River and/or tributaries attributed to feral animals. Cattle / domestic animals not permitted are observed in the Project Area.	The appropriate corrective actions will be implemented and may include: • Increasing the frequency and intensity of feral animal control. • Revising methods of pest animal control in accordance with Queensland Department of Agriculture and Fisheries (DAF) guidelines, and coordinate with neighbouring landowners to ensure a consistent approach • Reviewing actions and methods included in the project pest management plan • Updating feral animal control methods in targeted pest animal control programs • Increasing feral herbivore management efforts, in conjunction with neighbouring landowners • Communication with personnel involved and across all site team members (for example, via toolbox meetings).
8	Fire	Maintain a mosaic of fire history in the Project Area. Reduce the risk of bushfire spread	No uncontrolled fires (bushfires) in the Project Area. Fire management is conducted in accordance with a plan.	Fire will be managed to develop a patchwork of areas of different fire frequencies and times but biased toward low intensity fires. This regime will also help to reduce the risk of widespread hot fires by reducing fuel loading at the landscape scale. The existing network of roads and tracks will be used to manage fire, rather than establishing additional firebreaks. This will help reduce the risk of weed incursion through movement of traffic.	**Pre-impact monitoring:** Riparian condition survey REMP **Impact monitoring:** Fire Management Plan (EMP) Riparian condition survey REMP Regular site inspections in accordance with the EMP	Riparian vegetation condition Riparian community health Fuel load levels as described in the EMP	Dense shrub layers forming due to fire promoted germination. Incidence of uncontrolled bushfire.	The appropriate corrective actions will be implemented and will include: • Review fire regime based on monitoring results and aim to achieve appropriate balance of groundcover/shrub layer management • Review effectiveness of firebreaks, and establishment of additional fire breaks • Modify the timing and/or intensity of controlled burns.

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
		Reduce the risk of bushfire ignition	No bushfires sparked by Project activities.	Prior to site entry, all relevant site personnel, including contractors, will be made aware of fire safety and risks, including compliance with the Fire Management Plan (EMP). Bushfire mitigation measures will be outlined in the Fire Management Plan (EMP) and will include, but not be limited to: • Monitoring of weather conditions to identify high fire risk days, with controls to be upgraded on these days • Restrictions on vehicles being left idling with the exhaust in contact with dry grass • Designation of smoking areas • Development of bushfire fuel management practices in the Project Area • Implement actions to prevent and suppress the spread of fire, should bushfire be ignited.	**Pre-impact monitoring:** Riparian condition survey **Impact monitoring:** Fire Management Plan (EMP) Riparian condition survey Regular site inspections in accordance with the EMP	Riparian vegetation condition Riparian community health Fuel load levels as described in the EMP	Bushfire sparked by Project activities.	The appropriate corrective actions will be implemented and will include: • Mitigating the established source, arising from the investigation, as to why and how the bushfire was sparked by project activities • Reviewing the existing Fire Management Plan (EMP), ensuring consideration of ecological values and Rural Fire Service recommendations • Increasing monitoring of adherence to fire management measures • Modifying timing and/or intensity of controlled burns • Re-training of site team members
9	Dust emissions	Minimise dust emissions	Prevent disturbance from dust emissions on photosynthetic species within the Styx River and tributaries. Prevent habitat degradation from contaminated dust	Regular watering of Project areas in accordance with procedures under the EMP. Disturbance areas on either side of the haul road crossings kept	**Pre-impact monitoring:** Riparian condition survey REMP **Impact monitoring:**	Event monitoring for total suspended particulate matter Surface water quality Riparian vegetation condition Riparian community health	Statistically significant change in indicators compared with baseline / pre-impact conditions. Growth of vegetation known in, and adjacent to, the Styx River and/or tributaries are inhibited due to dust emissions. Water quality within the Styx River and/or tributaries decreases due to dust emissions.	The appropriate corrective actions will be implemented and will include: • Where monitoring shows a reduction in habitat condition due to dust, mitigate source of dust • Reviewing and re-designing to avoid reoccurrence and reduce dust emission impacts on habitat. • Communicating with personnel involved and across all site team members (for example, via toolbox meetings).

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
			within the Styx River and tributaries.	minimal and stabilised as soon as possible. Laydown, storage areas and parking outside of the Styx River and tributaries area. Coal dust to be managed in accordance with the EMP.	Regular site inspections in accordance with the Project EMP. Riparian condition survey REMP			
10	Noise and vibration	Minimise impacts to the Styx River and tributaries as a result of noise and vibration	No disturbance to fauna species within in the Styx River and tributaries due to noise or vibration disturbance	Disturbance areas on either side of the haul road crossings kept minimal and stabilised as soon as possible. Laydown, storage areas and parking outside of the Styx River and tributaries. Plant and equipment are serviced and maintained to minimise machinery noise and vibration. Impacts from noise and vibration minimised by the implementation of the EMP.	**Impact monitoring:** Regular site inspections in accordance with the Project EMP.	Event monitoring for: • dB(A) • peak particle velocity (PPV)	Disturbance of fauna within Aquatic GDEs of the Styx River and tributaries, due to high levels of noise and vibration.	The appropriate corrective actions will be implemented and may include: • Determining the root and contributing causes as being likely caused by noise or vibration • Reviewing and re-designing to avoid reoccurrence and address actual cause • Communicating with personnel involved where appropriate and across all site team members (for example, via toolbox meetings).
11	Light spill and other visual impacts	Minimise light spill	Prevent light disturbance to species within the Styx River and tributaries, adjacent to works.	Install light controlling devices to deflect lighting away from adjacent habitats. Avoid using unnecessary lighting. Impacts from lighting will be minimised by the implementation of the EMP	**Impact monitoring:** Regular site inspections in accordance with the Project EMP	Observations of amount of light falling on the Styx River and tributaries	Direct light spill >100 m into the Styx River or tributaries.	The appropriate corrective actions will be implemented and may include: • Reviewing and re-designing light controlling devices, or adjusting the location of light, to reduce light spill and lighting levels • Communicating with personnel involved and across all site team members (for example, via toolbox meetings).

Table 5-9: Management objectives, performance criteria, adaptive management triggers and corrective actions for Terrestrial GDEs

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
1	Mine dewatering and depressurisation	Prevent any changes to groundwater / surface water flow interactions. Minimise the impacts of groundwater water drawdown.	No impact to Terrestrial GDEs from mine dewatering greater than predicted in the EIS Project impacts are less than or equal to predicted impacts at the equivalent stage of the mine life.	Implement groundwater monitoring and management program as per the EMP.	**Pre-impact monitoring:** GMMP REMP Terrestrial GDE condition surveys **Impact monitoring:** GMMP REMP Terrestrial GDE condition survey	Groundwater level Groundwater quality Vegetation condition	Groundwater level drawdown thresholds as outlined in the GMMP (**Appendix A**) are exceeded. Groundwater quality trigger levels as outlined in the GMMP are exceeded (**Appendix B**). Changes to groundwater modelling outcomes and predicted drawdown results. Statistically significant reduction in vegetation health and condition indices	The appropriate corrective actions will be implemented and will include: • Immediately limiting mining activities to current activities, until monitoring indicates the trigger level(s) are no longer being exceeded, or at further risk of being exceeded. • If the investigation indicates that there is a risk of impacts to Terrestrial GDEs beyond that approved, monitoring will be reviewed and a report prepared within 3 months to identify the actual impact from the mining activities. • If the investigation finds that the actual areas of impact to Terrestrial GDEs differ from the area of impact as detailed in the Offset Management Plan, the Offset Management Plan will be amended within 30 days and the amended offset delivered within 12 months.
2	Ground water quality degradation	Maintain ground water quality in accordance with the WMP. Minimise impacts to Terrestrial GDE condition and population structure.	Ground water quality is not impacted from mining operations and associated activities other than predicted from mine dewatering and depressurisation.					
3	Changes to surface water hydrology	Minimise impacts to surface water levels or flow. Reduce the impact of drainage line diversions and loss of catchment area.	No impact, greater than that predicted in the EIS, to Terrestrial GDEs from changes to water levels or flow.	Implement the Project WMP and EMP	**Pre-impact monitoring:** REMP Terrestrial GDE condition survey **Impact monitoring:** REMP Terrestrial GDE condition survey	Surface water flow Surface water level (periods of no flow) Terrestrial GDE condition	Decreases in water level or flows exceed those predicted from hydrological modelling in the EIS. Statistically significant change in condition metrics compared with baseline/pre-impact conditions.	The appropriate corrective actions will be implemented and may include: • Re-run of the hydrological model, using most recent stream flow data for calibration • GDE monitoring be reviewed, and a report prepared within 3 months to determine the impact to Terrestrial GDEs • If the investigation finds that the actual areas of impact to Terrestrial GDEs differ from the area of impact as detailed in the Offset Management Plan, the Offset Management Plan will be amended within 30 days and the amended offset delivered within 12 months.
4	Surface water quality degradation	Maintain surface water quality of the receiving environment in accordance with the REMP. Protection of Terrestrial GDEs within waterways of the receiving environment.	Water quality is not impacted from mining operations and associated activities, other than predicted short-term and localised changes as a result of discharge under the CRS.	Vegetation clearing near, or within ephemeral waterways will be avoided when rain is falling, or imminent. Management of erosion and sedimentation will be undertaken in accordance with the Erosion and Sediment Management Plan. Remove cattle grazing from over 2,000 ha of the Mamelon property including waterways	**Pre-impact monitoring:** REMP Terrestrial GDE condition survey **Impact monitoring:** REMP that includes monitoring requirements before, during and after a discharge event.	Surface water quality Terrestrial GDE condition	Surface water quality trigger levels in the REMP are exceeded. Statistically significant change in ecological condition metrics compared with baseline/pre-impact conditions.	The appropriate corrective actions will be implemented and may include: • During a release event, comparing the downstream results to the upstream results in the receiving waters will be undertaken and: ○ if the downstream result is the same or a lower value than the upstream value for the quality characteristic then no action will be taken; or ○ if the downstream results exceed the upstream results complete an investigation into the potential for environmental harm and provide a written report to the administering authority in the next annual return, outlining the details of the investigations carried out; and actions taken to prevent environmental harm If there is potential for environmental harm identified, implementing management actions targeted at correcting the water quality parameter

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				(reducing sediment and nutrient inputs) and establish environmental offsets in accordance with the Offset Management Plan. Water release points will be optimally located within Deep Creek to ensure sufficient dilution of flows to control water quality. Regeneration of vegetation and restoration of habitat on the property to create vegetation buffers to reduce sediment and nutrient run-off.	Terrestrial GDE condition survey Erosion and Sediment Control Plan			for which an exceedance occurred (e.g. implement changes to the discharge of mine affected water to achieve compliance).
		Reduce and minimise the risk of contamination of Terrestrial GDEs from mine affected water or from chemicals, fuel, heavy metals etc.	No pollution of Terrestrial GDEs by contaminants (e.g. chemicals, fuel etc.)	Any sites used for chemical and fuel storage will be located a safe distance away from Terrestrial GDEs, with bunding or other raised barrier, resistant to normal flood events, between chemicals and habitat. All vehicles and machinery will be cleaned and maintained to minimise the introduction of contaminants such as oil and fuel. Compliance with management actions included in the CRS.	**Impact monitoring:** GMMP REMP	Surface water quality Sediment quality Groundwater quality	Surface water quality trigger levels as outlined in the REMP are exceeded. Groundwater quality trigger levels as outlined in the GMMP (part of the EMP) are exceeded.	The appropriate corrective actions will be implemented and will include: • Minimising immediate impacts and rectifying through clean-up actions • Reporting to DES as per statutory and project requirements where incidents trigger reporting thresholds.
5	Erosion of streambanks	Minimise impacts to the geomorphology of Styx River and tributaries to prevent degradation and	Prevent impacts to the Styx River and tributaries from erosion. Water release flow rates into the Styx River meet quantity and quality conditions	An Erosion and Sediment Management Plan will be implemented for the water discharge locations and for construction activities within riparian/aquatic	**Pre-impact monitoring:** Riparian condition survey **Impact monitoring:** REMP	Surface water quality Riparian condition	Evidence of erosion and / or sedimentation within the vicinity and immediately downstream of discharge locations and / or construction activities. Loss of Terrestrial GDEs as a result of erosion of streambanks.	The appropriate corrective actions will be implemented and may include • Reviewing erosion and / or sedimentation controls • Stabilisation and or rehabilitation of riverbank / bed • Implementation of revised controls prior to earthworks re-commencing

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
		loss of Terrestrial GDEs.	outlined in the CRS to prevent geomorphology impacts such as erosion. No loss of riparian terrestrial GDEs as a result of erosion of streambanks.	zones (e.g. haul road crossings). Compliance with management actions included in the CRS. Where the water release channel meets Deep Creek, it will be designed such that released water does not result in localised or downstream scour or erosion. Removal of cattle from over 2,000 ha of the property to reduce erosion of streambanks from cattle accessing the waterways. Regeneration of vegetation and restoration of habitat on the property to create vegetation buffers and increase bank stability.	Riparian condition survey			Undertaking targeted weekly inspections of erosion and sediment controls for the following month to review effectiveness.

6	Direct disturbance of vegetation	Minimise loss of Terrestrial GDEs.	No unapproved clearing or disturbance to vegetation beyond what was approved in the Project EIS.	Prior to the commencement of site works, any conditions listed in the Permit to Disturb must be implemented (e.g. the limits of clearing and exclusion areas will be clearly marked).
				Prior to site entry and during pre-start meetings, all relevant site personnel including contractors shall be appropriately trained in the identification of terrestrial GDE species at all life stages and made aware of the sensitive environments (i.e. riverine areas) in which they will be working, including the extent of works and the
					Pre-impact monitoring:
					Terrestrial GDE condition survey
					Impact monitoring:
					Pre-clearance surveys
					Terrestrial GDE condition survey
					Close out report for the Permit to Disturb process includes check for compliance with:
					• clearing only in the approved footprint
						Terrestrial GDE condition	Visual evidence of unapproved disturbance or clearing.
							Trampling or clearing of Terrestrial GDEs:
							• Outside approved clearing footprint
							• In no-go zone/s
							• Without a Permit to Disturb issued
								The appropriate corrective actions will be implemented and will include:
								• When clearing outside approved clearing footprint, no go zones or without a "Permit to Disturb Permit" issued,
								  ○ Environment Manager ensure that all clearing activities cease immediately
								  ○ Area assessed by a suitably qualified ecologist/person within 15 business days of investigation
								  ○ Additional barricading to be installed
								  ○ Reviewing and modifying Permit to Disturb process and no-go zone identification and communication protocols
								  ○ Implement remediation measures within 1 month to promote revegetation
								  ○ Communication with personnel involved and across all site team members (for example, via toolbox meetings).
								If mitigation is unsuccessful, the provision of offsets, as an overarching corrective action to achieve the objective of minimising habitat loss.

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				extent of terrestrial GDEs. No-go zones for vegetation clearance and machinery to be developed for Terrestrial GDEs outside of the clearing footprint, and to be depicted on site plans and maps to restrict access and prevent unapproved clearing Existing access tracks will be used within riparian habitats to reduce the amount of additional clearing required. Vehicles and machinery only drive on pre-determined roads only, and adhere to all speed limits, which will be clearly communicated.	• no clearing in the no-go zone/s. Regular site inspections in accordance with the EMP.			
		Minimise habitat fragmentation	Manage offset areas to maintain and improve the condition of Terrestrial GDEs	Management and monitoring of the offset areas to occur in accordance with the Offset Area Management Plan (OAMP).				
		Rehabilitation of temporarily disturbed vegetation/ habitat	Rehabilitation of temporary disturbance areas to pre-existing vegetation and habitat condition	Rehabilitation of the disturbed areas will be undertaken at the completion of the construction and once temporary construction areas are no longer required. Rehabilitation will focus on the reinstatement of ground cover to reduce erosion and stabilise the creek banks.	**Pre-impact monitoring:** Terrestrial GDE condition survey REMP **Impact monitoring:** Terrestrial GDE condition survey REMP	Rehabilitation success criteria for parameters such as vegetation cover, weed abundance and evidence of erosion. Surface water quality	Rehabilitation not meeting success criteria for parameters such as vegetation cover, weed abundance, and evidence of erosion. Surface water quality trigger levels as outlined in the REMP are exceeded.	The appropriate corrective actions will be implemented and will include: • Installing additional erosion and / or sedimentation in accordance with Erosion and Sediment Management Plan. • Reviewing the process for temporary disturbance and monitoring to improve response time
7	Weeds and pests	Minimise weed incursion	No introduction of weeds within terrestrial GDE habitat.	Weed control, as part of the Weed and Pest Management Plan, will focus on managing declared pest plants and invasive species	**Pre-impact monitoring:** Terrestrial GDE condition survey	Presence of weed species Extent of weed coverage	Introduction or establishment of declared pest plants, and invasive species into previously unaffected areas.	The appropriate corrective actions will be implemented and will include: • Eliminating potential sources or reasons that may have attributed to an increase in species richness and/or relative abundance of weeds • Amending weed hygiene restrictions within 1 week of concluding the investigation

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
			Prevent the spread of weeds across the Project Area and into / from adjacent habitat.	during construction and operations. Weed hygiene controls, including the use of weed wash down stations, will be implemented in accordance with the Weed and Pest Management Plan to prevent the introduction and spread of declared pest plants and other invasive weeds. Weed free areas around Terrestrial GDEs will be identified and mapped with strict weed control requirements for entering weed free areas.	Weed and pest survey **Impact monitoring:** Terrestrial GDE condition survey Weed and pest survey		Results of weed monitoring indicate a degradation of terrestrial GDEs or their habitat, due to a proliferation of weeds. A significant increase in the abundance of weeds, or pests or identification of new infestations. Infestation of new weed species.	• Providing additional educational awareness training for all staff and contractors to ensure weed hygiene restrictions are adhered to • Revising weed control methods in accordance with the *Biosecurity Act 2014* • Increasing the frequency and intensity of weed controls for the following 12 months • Updating weed control methods in targeted weed control programs and plans.
		Reduce degradation to terrestrial GDEs or their habitat by introduced fauna	No measured increase in feral animal numbers in the Project Area.	Adaptive management of pest controls to minimise threats to Terrestrial GDEs. A project Weed and Pest Management Plan will be developed and implemented prior to construction and operations, including measures for controlling cane toads, pigs, rabbits, wild dogs and cats. The project pest management plan will be developed in conjunction with neighbouring landowners, and will focus on tracks, waterways and habitat edges. Destocking of over 2,000 ha will occur and domestic animals will not be permitted into the Project Area.	**Pre-impact monitoring:** Terrestrial GDE condition survey Weed and pest survey **Impact monitoring:** Terrestrial GDE condition survey Weed and pest survey	Presence of feral animals Extent of damage from feral animals	Significant increase in the population of any invasive predator species from baseline and pre-impact scores. Observed degradation of terrestrial GDEs or their habitat attributed to feral animals. Cattle / domestic animals not permitted are observed in the Project Area.	The appropriate corrective actions will be implemented and may include: • Increasing the frequency and intensity of feral animal control. • Revising methods of pest animal control in accordance with Queensland Department of Agriculture and Fisheries (DAF) guidelines, and coordinate with neighbouring landowners to ensure a consistent approach • Reviewing actions and methods included in the project pest management plan • Updating feral animal control methods in targeted pest animal control programs • Increasing feral herbivore management efforts, in conjunction with neighbouring landowners • Communication with personnel involved and across all site team members (for example, via toolbox meetings).

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
8	Fire	Maintain a mosaic of fire history in the Project Area. Reduce the risk of bushfire spread	No uncontrolled fires (bushfires) in the Project Area. Fire management is conducted in accordance with the EMP.	The fire regime will be managed to utilise a patchwork of areas of different fire frequencies and times but biased toward low intensity fires. This regime will also help to reduce the risk of widespread hot fires by reducing fuel loading at the landscape scale. The existing network of roads and tracks will be used to manage fire, rather than establishing additional firebreaks. This will help reduce the risk of weed incursion through movement of traffic.	**Pre-impact monitoring:** Terrestrial GDE condition survey **Impact monitoring:** Fire Management Plan. Terrestrial GDE condition survey Regular site inspections in accordance with the EMP	Terrestrial GDE condition Fuel load levels as described in the Fire Management Plan	Dense shrub layers forming due to fire promoted germination. Incidence of uncontrolled bushfire.	The appropriate corrective actions will be implemented and will include: • Reviewing fire regime of EMP based on monitoring results and aim to achieve appropriate balance of groundcover/shrub layer management • Reviewing effectiveness of firebreaks, and establishment of additional fire breaks • Modifying the timing and/or intensity of controlled burns.
		Reduce the risk of bushfire ignition	No bushfires sparked by Project activities.	Prior to site entry, all relevant site personnel, including contractors, will be made aware of fire safety and risks, including compliance with the Fire Management Plan. Bushfire mitigation measures will be outlined in the Fire Management Plan and will include, but not limited to: • Monitoring of weather conditions to identify high fire risk days, with controls to be upgraded on these days • Restrictions on vehicles being left idling with the exhaust in contact with dry grass • Designation of smoking areas	**Pre-impact monitoring:** Terrestrial GDE condition survey **Impact monitoring:** Fire Management Plan Terrestrial GDE condition survey Regular site inspections in accordance with the EMP	Terrestrial GDE condition Threatened and endemic flora populations Fuel load levels as described in the Fire Management Plan	Bushfire sparked by Project activities.	The appropriate corrective actions will be implemented and will include: • Mitigating the established source, arising from the investigation, as to why and how the bushfire was sparked by project activities • Reviewing the existing Fire Management Plan, ensuring consideration of ecological values and Rural Fire Service recommendations • Increasing monitoring of adherence to fire management measures • Modifying timing and/or intensity of controlled burns • Re-training of site team members Assessing the benefits of strategic burning prior to the storm season to address pasture biomass

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				• Development of bushfire fuel management practices in the Project Area • Minimise the residency time of accumulated coal around coal handling facilities to reduce the risk of spontaneous combustion • Ensure all crews are equipped to deal with fires. This includes both fire-fighting equipment and training • Monitor pasture biomass at the beginning of the wet season • Work sites will be provided with adequate fire-fighting equipment (water cart) and training Implement actions to prevent and suppress the spread of fire, should bushfire be ignited.				
9	Dust emissions	Minimise dust emissions	Prevent disturbance from dust emissions on photosynthetic ability of terrestrial GDE species within the Project Area	Regular watering of Project areas in accordance with procedures under the EMP. Vehicles are to be cleaned regularly and are not to be overloaded. Disturbance areas on either side of the haul road crossings kept minimal and stabilised as soon as possible.	**Pre-impact monitoring:** Terrestrial GDE condition survey **Impact monitoring:** Terrestrial GDE condition survey Regular site inspections in accordance with the Project EMP.	Event monitoring for total suspended particulate matter	Statistically significant change in ecological indicators compared with baseline / pre-impact conditions Growth of Terrestrial GDEs within, and adjacent to, the Project Area are inhibited due to dust emissions.	The appropriate corrective actions will be implemented and will include: • Where monitoring shows a reduction in habitat condition due to dust, mitigate source of dust • Reviewing and re-designing to avoid reoccurrence and reduce dust emission impacts • Communicating with personnel involved and across all site team members (for example, via toolbox meetings).

#	Potential project impacts	Management objective	Performance Criteria	Management Actions	Monitoring	Monitoring Indicators	Trigger for adaptive management and corrective actions	Corrective actions
				Laydown, storage areas and parking outside of terrestrial GDE habitat. Coal dust to be managed in accordance with the EMP.				
10	Noise and vibration	Minimise impacts to the Styx River and tributaries as a result of noise and vibration	No disturbance to fauna species within in the Styx River and tributaries due to noise or vibration disturbance	Disturbance areas on either side of the haul road crossings kept minimal and stabilised as soon as possible. Laydown, storage areas and parking outside of the Styx River and tributaries. Plant and equipment are serviced and maintained to minimise machinery noise and vibration. Impacts from noise and vibration minimised by the implementation of the EMP.	**Impact monitoring:** Regular site inspections in accordance with the Project EMP.	Event monitoring for: • dB(A) • peak particle velocity (PPV)	Disturbance of fauna within Terrestrial GDEs of the Styx River and tributaries, due to high levels of noise and vibration.	The appropriate corrective actions will be implemented and may include: • Determining the root and contributing causes as being likely caused by noise or vibration • Reviewing and re-designing to avoid reoccurrence and address actual cause Communicating with personnel involved where appropriate and across all site team members (for example, via toolbox meetings).
11	Light spill and other visual impacts	Minimise light spill	Prevent light disturbance to species within the Styx River and tributaries, adjacent to works.	Install light controlling devices to deflect lighting away from adjacent habitats. Avoid using unnecessary lighting. Impacts from lighting will be minimised by the implementation of the EMP	**Impact monitoring:** Regular site inspections in accordance with the Project EMP	Observations of amount of light falling on the Styx River and tributaries	Direct light spill >100 m into the Styx River or tributaries.	The appropriate corrective actions will be implemented and may include: • Reviewing and re-designing light controlling devices, or adjusting the location of light, to reduce light spill and lighting levels Communicating with personnel involved and across all site team members (for example, via toolbox meetings).

6. Plan updates, reporting and compliance

6.1 Plan updates

The GDEMMP will be reviewed within two years of commencement of mining and then every five years. The plan will be amended as required, and in response to new information. This may include updates to the conceptual models of GDEs and trigger levels, changes in the status of listed species or the identification of listed species in the Project Area that had not been previously recorded. The groundwater model will be reviewed and validated after three years, with the GDEMMP updated accordingly.

If impact monitoring identifies an exceedance of trigger levels (approaching or beyond what has been approved), Central Queensland Coal will notify the relevant Department/s in writing within five business days of any exceedance noted. Within 28 business days, Central Queensland Coal will submit a report detailing the findings of investigations including the known or likely cause and potential magnitude of impacts, corrective actions, recommended mitigation and management measures. An updated GDEMMP will then be prepared and submitted to DAWE and DES for approval.

In all other circumstances, Central Queensland Coal will revise the management plan following the completion of pre-impact monitoring and resubmit it to DAWE and DES for approval within 3 months of completion. Once approved, the revised management plan will be implemented.

6.2 Pre-impact studies, reporting and updates

Pre-impact studies will be undertaken for the Subterranean, Aquatic and Terrestrial GDEs (**Section 4.5.4**). These studies will build on existing baseline information collected during and post the EIS and evaluate the pre-impact conditions including seasonal variations and existing threats.

Following the completion of these pre-impact surveys, the frequency of monitoring will be reviewed, and ongoing monitoring data will contribute towards the development of an extended baseline for each GDE to account for temporal variations. Trigger levels for potential impacts (discussed in **Section 5.5**) will be reviewed, and if appropriate, refined. Central Queensland Coal will verify that pre-impact data are not influenced by mining activities. A pre-impact report containing proposed new recommended trigger levels (to be applied to the operational monitoring of each GDE) will be compiled and submitted for DAWE and DES approval prior to implementation.

This GDEMMP will be updated upon approval of the revised trigger levels, which will replace the existing triggers (where appropriate). Groundwater drawdown triggers will also provide an ‘early warning’ that changes in the groundwater environment may have occurred and that investigations into potential ecological responses must be undertaken.

6.3 Annual and compliance reporting

Initially, an annual report on the findings of pre-impact monitoring will be prepared. This will include establishing a database for existing baseline and new pre-impact data. The report will identify any constraints for ongoing monitoring, and identify any changes required to the field sampling plan (on the basis of results from the first year of monitoring). Any changes to the monitoring program will be submitted to DAWE and DES for approval.

Annual reporting requirements in line with both the EPBC Act and EA approval conditions will be met. These requirements are expected to include annual reports to both DAWE and DES addressing compliance with each of the conditions of approval, including implementation of management plans (including this GDEMMP).

The following provides an overview of items included in the annual reports:

- An assessment of baseline groundwater levels.
- The condition of each GDE compared with previous monitoring results.
- An assessment of long-term trends in the results.
- Information on whether any triggers have been exceeded.
- The suitability of current groundwater trigger thresholds.
- Details of the effectiveness of avoidance, mitigation and management actions in curtailing adverse impacts on GDEs.
- A description of any adaptive management initiatives implemented.
- Details of monitoring undertaken and proposed revisions to existing triggers.
- Any offsets required for significant residual impacts.

The condition assessment of each GDE will include a statistical comparison with baseline conditions to ensure seasonal variations are accounted for and identify any change from the baseline, and any planned actions.

Central Queensland Coal will conduct periodic audits to monitor compliance with management plan commitments, in accordance with the company's quality system. Non-compliances with the plan will be reported to the relevant Department (DAWE and DES) within five business days. Central Queensland Coal will integrate the management plan commitments with other aspects of the Project construction and operations, to avoid actions being overlooked.

This GDEMMP will be available to all employees, contractors and subcontractors and will be published on Central Queensland Coal's website. The GDEMMP will be amended in response to regular reviews, monitoring results and changes in legislation, in consultation with regulatory authorities. Amendments to the GDEMMP will be updated on Central Queensland Coal's website within 30 business days.

6.4 Reporting and monitoring of related management plans and programs

Central Queensland Coal has developed a number of associated management plans and programs as part of the EIS process. Any additional management plans or programs required to meet approval conditions under both Commonwealth and Queensland legislation will be prepared post-approval.

Linkages between this GDEMMP and the associated management plans and programs are summarised in **Section 1.3**. These plans and programs will be subject to ongoing monitoring, review, update and approval (as required).

6.5 Qualifications

Persons implementing key tasks described in this GDEMMP will have appropriate skills and qualifications. For GDE pre-impact surveys and monitoring, the lead ecologist will have >5 years of experience undertaking assessments of GDEs. Qualifications and experience requirements are summarised in **Table 6-1**. Field surveys will be led by ecologists or botanists with at least 5 years of experience on the Brigalow Belt Bioregion. A hydrogeologist with at least 5 years of experience will be involved in the analysis of data and reporting, to assist in the interpretation of ecological and hydrological data.

If the identification of a suspected threatened flora species or previously unrecorded species is not certain, a specimen will be collected and submitted to the Queensland Herbarium for confirmation of identification. If previously unrecorded species or suspected threatened fauna species are observed or collected, the Queensland Museum will be the first contact for identification confirmation (via photographs and / or specimens), followed by persons with demonstrable identifications skills for the suspected threatened species, as outlined in **Table 6-1**.

Persons undertaking ground and surface water monitoring will be trained or be able to demonstrate practical experience in the completion of water monitoring in accordance with relevant sampling manuals or standards.

Table 6-1: Qualification requirements for GDE monitoring and reporting

Component	Qualifications required	Experience required	Demonstrable specialist skills required
Ecological survey of: • Subterranean GDEs • Aquatic GDEs • Terrestrial GDEs • Weeds and pests	Ecologist / Botanist with tertiary degree in relevant field	Ecologist / Botanist with degree and >5 years' of experience in the Brigalow Belt Bioregion (or with aquatic fauna surveys for Aquatic and Subterranean GDEs)	Experience in the identification of: • Subterranean, Aquatic and Terrestrial GDEs • Threatened flora and fauna species associated with aquatic / terrestrial GDEs • Weeds and pests • Other relevant threatened flora or fauna species
Data analysis and reporting	Ecologist / Botanist with tertiary degree in relevant field Hydrogeologist with tertiary degree in relevant field	Ecologist / Botanist with degree and >5 years of experience in the Brigalow Belt Bioregion Hydrogeologist with >5 years of experience	Interpretation and analysis of complex ecological data Interpretation of groundwater monitoring results in an ecological context

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Appendix A Groundwater drawdown triggers

The following groundwater drawdown triggers are from the SEIS v3 (Central Queensland Coal 2020b), based on HydroAlgorithmics (2020)

Monitoring Points	Preliminary Groundwater Level (Change, m) Investigation Trigger Threshold		
WMP05, WMP08, WMP08D, WMP11, WMP11D, WMP13, WMP16, WMP16D, WMP17D, WMP19, WMP19D, WMP20D, WMP29A, WMP29B, WMP33	2.0	2.0	2.0
WMP06D, WMP29C, WMP29D, WMP29E, WMP31	5.0	5.0	5.0
WMP02, WMP06, WMP07, WMP10, WMP12, WMP14, WMP17, WMP18, WMP18D, WMP20, WMP21, WMP27, WMP28	2.0	Dry	-
WMP04, WMP22A, WMP22B, WMP30A, WMP30B	Dry	Dry	-
WMP21D	2.1	Dry	-
WMP26	5.3	Dry	-
WMP25	2.0	2.0	2.7
WMP09	2.0	2.9	3.8
WMP15	2.0	5.3	7.1
WMP23A	2.0	12.0	16.0
WMP23B	5.0	20.3	27.1
WMP24	4.5	4.5	5.3
WMP04D	13.4	16.2	21.6
WMP22C	12.4	27.6	36.7
WMP30C	12.6	27.9	37.1
WMP21B	5.0	11.0	14.6
WMP33B	5.0	5.5	7.3
WMP28B	3.3	3.2	4.2

Appendix B Groundwater quality triggers

The following groundwater quality triggers are sourced from Groundwater Management and Monitoring Plan and are based on 80th percentiles, or 20th to 80th percentiles for pH.

	Sites	pH	Alk	EC	TDS	Al	As	Fe	Mn	Mo	Se	V	Zn
Quaternary Alluvium	WMP05	7.1 - 7.5	662	2890	1770	0.22	0.0048	0.25	0.323	0.003	<0.01	0.02	0.0232
	WMP21	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID	ID
	WMP29A	7.0 - 7.2	446	8720	5610	ID	0.0056	ID	ID	ID	ID	ID	0.0252
Quaternary Pleistocene Alluvium	WMP02	6.5 – 7.0	446	17400	12400	0.01	0.002	<0.05	0.381	0.002	<0.01	<0.01	<0.005
	WMP04	7.4 - 8.1	539	21900	14500	0.02	0.004	<0.05	0.0648	0.033	<0.01	<0.01	<0.005
	WMP08	6.7 – 7.0	722	27800	19800	<0.042	0.003	0.056	1.3	0.00297	<0.042	<0.042	0.0234
	WMP09	6.6 - 6.9	800	22200	15300	<0.01	0.002	<0.05	0.595	0.001	<0.01	<0.01	0.0314
	WMP12	6.9 - 7.3	391	8710	5740	0.064	0.0042	0.058	0.378	0.0056	<0.01	0.01	0.002 - 0.006
	WMP25	6.1 - 6.7	45.8	801	612	ID	0.002	ID	ID	ID	ID	ID	0.029
	WMP29B	6.5 - 6.9	421	22500	15800	ID	0.029	ID	ID	ID	ID	ID	0.0586

Table notes:

* Bore investigations need to be conducted to determine the source of the identified high pH

Alk = total alkalinity; EC = electrical conductivity; TDS = total dissolved solids; Al = dissolved aluminium; As = dissolved arsenic; Fe = dissolved iron; Mn = dissolved manganese; Mo = dissolved molybdenum; Se = dissolved selenium; V = dissolved vanadium; Zn = dissolved zinc

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