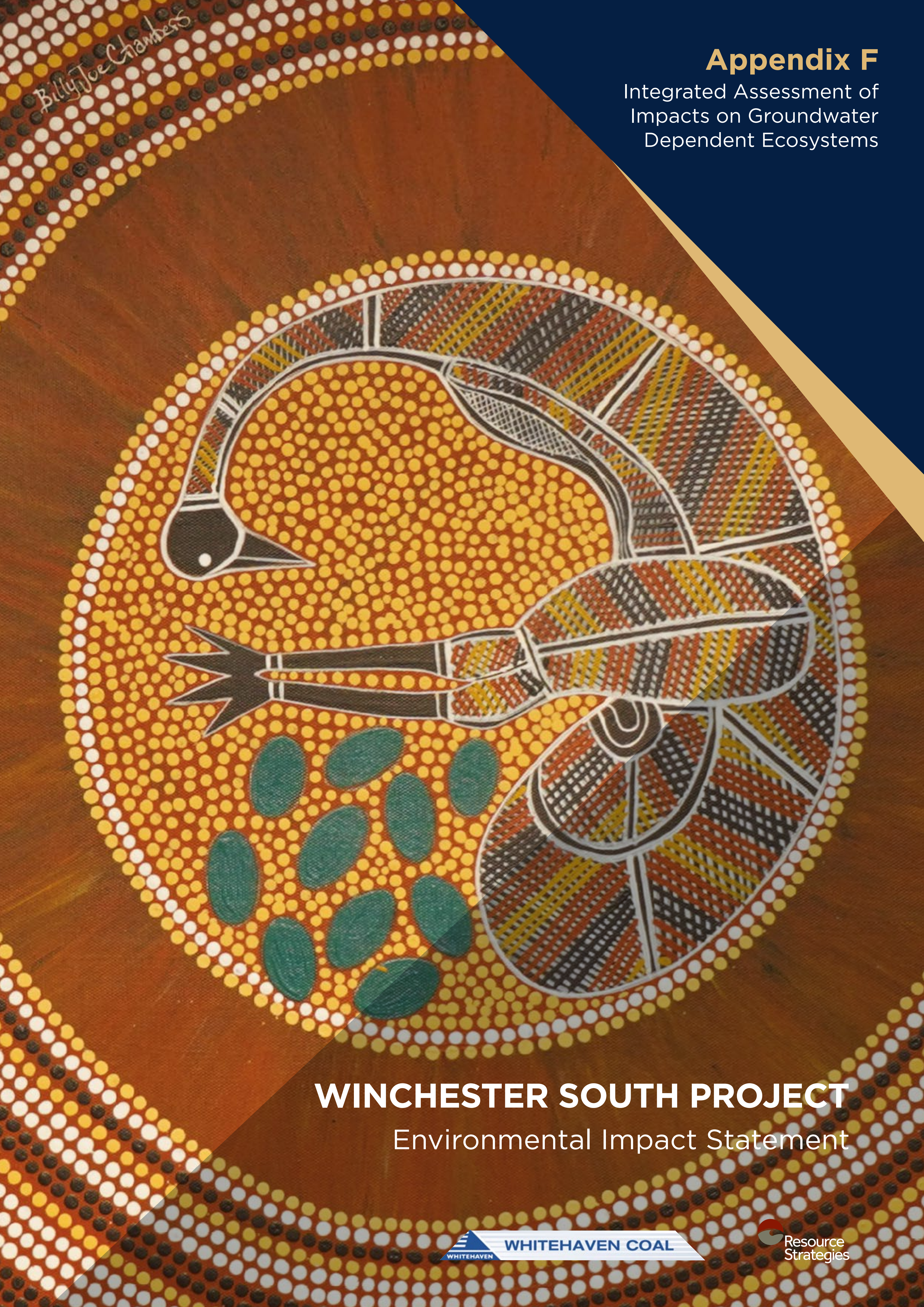

Appendix F

Integrated Assessment of Impacts on Groundwater Dependent Ecosystems

WINCHESTER SOUTH PROJECT

Environmental Impact Statement

WHITEHAVEN COAL

Resource Strategies

EXECUTIVE SUMMARY

This Integrated Assessment of Impacts on Groundwater Dependent Ecosystems (GDE Assessment) has been prepared to provide a comprehensive assessment of potential inputs of the Winchester South Project (the Project) on Groundwater Dependent Ecosystems (GDEs). The GDE Assessment has been prepared consistent with the requirements of the *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* (Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development, 2018) and *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody *et al*., 2019).

The aquatic in-stream ecosystems associated with the Isaac River and Cherwell Creek are largely not dependent on the surface-expression of groundwater. The wetlands and farm dams in the locality are not likely to be aquatic GDEs. Modelling has shown that the Project would result in negligible increased leakage from surface flows of the Isaac River to the underlying alluvium. Therefore, impacts to surface flows and subsequently aquatic ecosystems downstream of the Project area are not expected.

Any dependency on groundwater for riparian vegetation associated with the Isaac River and Cherwell Creek is likely to be facultative (i.e. intermittent) during dry times. However, there would be negligible drawdown in the alluvium along the Isaac River and Cherwell Creek as a result of the Project, as well as no impacts to groundwater quality. Therefore, there would be no adverse impacts to riparian vegetation associated with the Isaac River and Cherwell Creek as a result of the Project.

Any dependency on groundwater for riparian vegetation surrounding ephemeral wetlands is likely to be facultative. These ephemeral wetlands are not likely to be aquatic GDEs as these wetlands do not receive groundwater discharge, rather, the clay-rich substrates of these wetlands are likely to hold surface water run-off for extended periods. Further, as there would be no impacts on groundwater quality and resources, there would be no adverse impacts to riparian vegetation surrounding these ephemeral wetlands.

Any dependency on groundwater that the woodland dominated by Regional Ecosystem 11.3.2 on the floodplains on the Isaac River, Ripstone Creek and Cherwell Creek has is likely to be facultative. There would be no impacts to vegetation on the Isaac River, Ripstone Creek and Cherwell Creek floodplains (outside of wetlands) that may access water from the alluvium, as there would be negligible drawdown to the alluvium and no changes to groundwater quality within the alluvium.

The Project would result in a predicted drawdown of up to 5 metres (m) below the woodland mapped as a low potential terrestrial GDE to the north of Project. Outside the alluvium, it is unlikely that these woodland patches would be dependent on groundwater due to the poor quality (high salinity) of the groundwater source (i.e. associated with the regolith). Therefore, a predicted drawdown of up to 5 m below the woodland to the north of Project is unlikely to have any material impacts on this woodland.

In summary, the Project is not predicted to have any material impacts on potential or actual GDEs due to changes in groundwater quality or resources.

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1 INTRODUCTION

Whitehaven WS Pty Ltd (Whitehaven WS), a wholly owned subsidiary of Whitehaven Coal Limited (Whitehaven), proposes to develop the Winchester South Project (the Project), an open cut coal mine and associated infrastructure within the Bowen Basin, located approximately 30 kilometres (km) south-east of Moranbah, within the Isaac Regional Council Local Government Area (LGA) (Figure 1).

The Project involves the development of an open cut coal mine in an existing mining precinct for export of coal products. Products would include metallurgical coal for the steel industry and thermal coal for energy production. The Project would include construction and operation of a mine infrastructure area (MIA), including a Coal Handling and Preparation Plant (CHPP), train load-out facility and rail spur, which would be used for the handling, processing and transport of coal. An infrastructure corridor would also form part of the Project, including a raw water supply pipeline connecting to the Eungella pipeline network, an electricity transmission line (ETL) and a mine access road (Figure 2).

It is estimated the Project would extract 15 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal (and up to 17 Mtpa) for approximately 30 years. The coal resource would be mined by open cut mining methods, with product coal to be transported by rail to port for export.

This assessment forms part of an Environmental Impact Statement (EIS), which has been prepared in accordance with Part 4 of the *State Development and Public Works Organisation Act 1971* (SDPWO Act). This assessment has been prepared to satisfy the requirements of the *Terms of reference for an environmental impact statement – Winchester South Project* issued by the Office of the Coordinator-General on 4 September 2019.

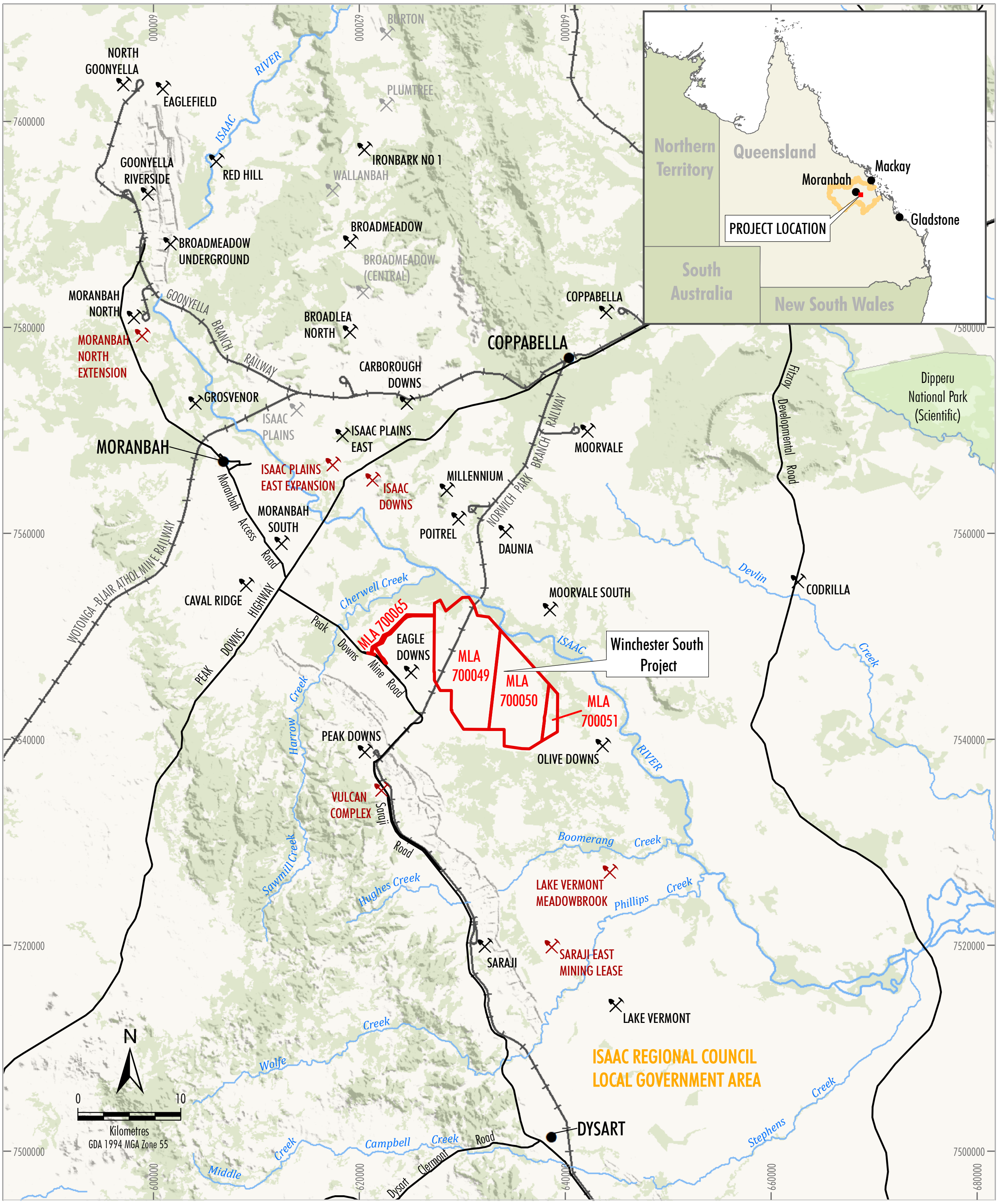
1.1 PURPOSE

This Integrated Assessment of Impacts on Groundwater Dependent Ecosystems (GDE Assessment) has been prepared to satisfy the assessment requirements pertaining to Groundwater Dependent Ecosystems (GDEs) in the Terms of Reference, regulatory input and relevant GDE guidelines.

1.2 METHODOLOGY

This GDE Assessment draws on information and assessments in the following technical reports prepared for the Project:

- Terrestrial Ecology Assessment (E2M Pty Ltd [E2M], 2021);
- Groundwater Assessment (SLR Consulting, 2021);
- Surface Water and Flooding Assessment (WRM Water & Environment Pty Ltd [WRM], 2021);
- Aquatic Ecology and Stygofauna Assessment (Ecological Service Professionals Pty Ltd [ESP], 2021);
- Geochemistry Assessment (Terrenus Earth Sciences, 2020); and
- Geomorphology Assessment (Fluvial Systems Pty Ltd [Fluvial Systems], 2020).



LEGEND
Mining Lease Application Boundary
Approved/Operating
Proposed
Care and Maintenance
Local Government Area Boundary
Railway
Road

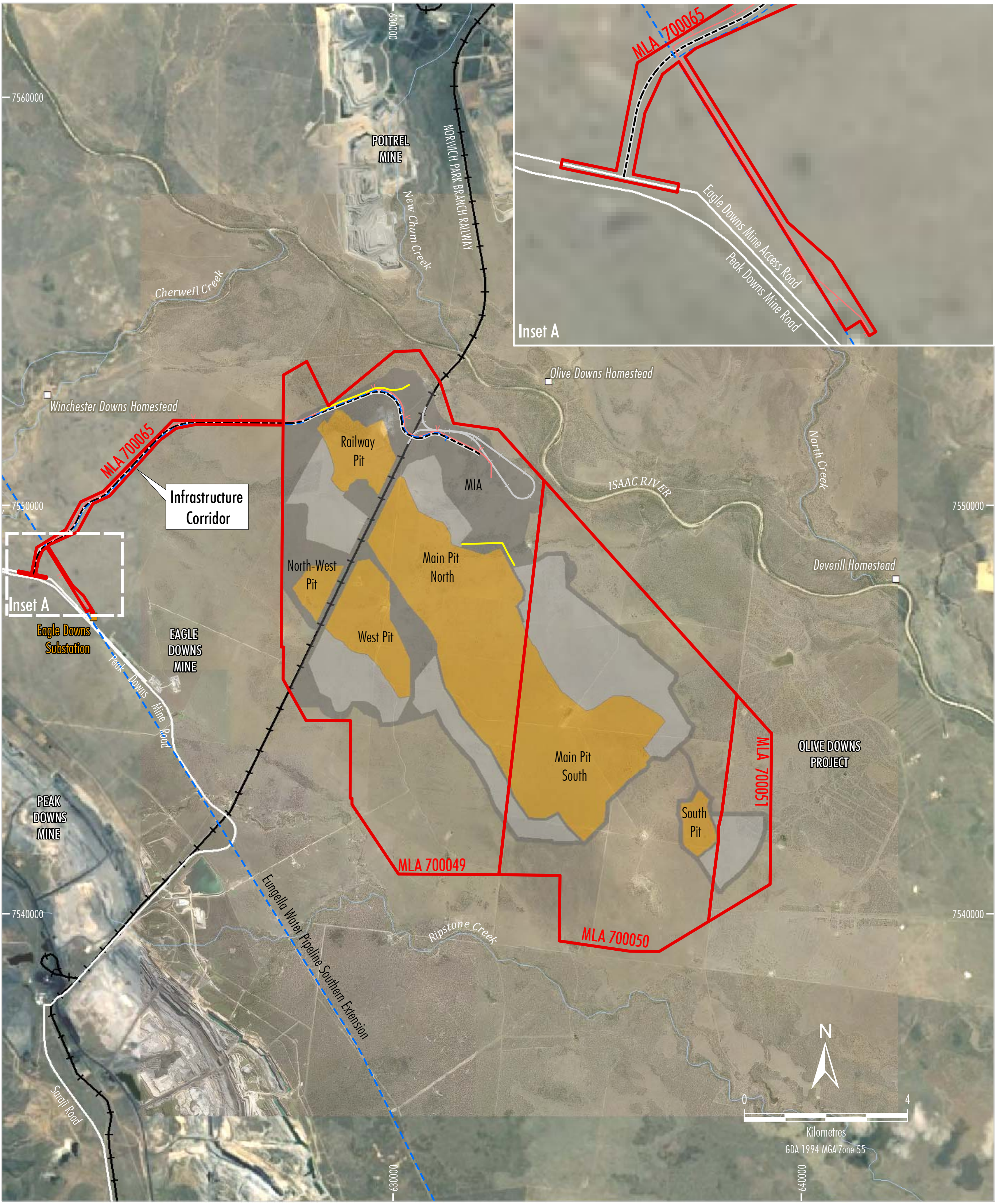
Source: The State of Queensland (2018 - 2020); Geoscience Australia (2018).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Regional Location

Figure 1



LEGEND

- Mining Lease Application Boundary
- Eungella Water Pipeline Southern Extension
- Railway
- Substation

Project Component*

- Indicative Infrastructure Area
- Indicative Out-of-pit Waste Rock Emplacement
- Indicative Open Cut Pit Including In-pit Waste Rock Emplacement
- Indicative Mine Access Road
- Indicative Rail Spur and Loop
- Indicative Electricity Transmission Line
- Indicative Raw Water Supply Pipeline
- Indicative Flood Levee

*Note: * Excludes some project components such as water management infrastructure, access tracks, topsoil stockpiles, explosives magazines, power reticulation, temporary offices, other ancillary works and construction disturbance.*

Source: The State of Queensland (2018 - 2020); Whitehaven (2020).
Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Project General Arrangement

Figure 2

The remainder of this GDE Assessment is structured as follows:

- Section 2 provides an overview of the Project.
- Section 3 outlines the regulatory requirements relevant to this GDE Assessment.
- Section 4 identifies potential GDEs, including their level of groundwater dependence and baseline condition.
- Section 5 assesses the likelihood, frequency and magnitude of potential impacts to each GDE.
- Section 6 outlines proposed measures to avoid or mitigate impacts to GDEs and establishes a monitoring program to assess the effectiveness of mitigation or identify unexpected impacts.
- Section 7 provides references of the documents used throughout this GDE Assessment.

2 PROJECT OVERVIEW

The Project provides an opportunity to develop an open cut coal mine and associated on-site and off-site infrastructure (e.g. ETL, water supply pipeline, mine access road) in an existing mining precinct. The open cut mine would produce a mix of products, including metallurgical coal for the steel industry and thermal coal for energy production.

The main activities associated with the development of the Project include:

- development and operation of an open cut coal mine within Mining Lease Application (MLA) 700049, MLA 700050 and MLA 700051 (Figure 2);
- development and operation of an infrastructure corridor within MLA 700065, located outside Mineral Development Licence 183;
- use of open cut mining equipment to extract ROM coal with a current forecast rate of approximately 15 Mtpa (and up to 17 Mtpa);
- a mine life of approximately 30 years;
- placement of waste rock (i.e. overburden and interburden) in out-of-pit waste rock emplacements and within the footprint of the open cut voids;
- construction and operation of the MIA, including a CHPP, ROM pads, workshops, offices, raw and product handling systems, coal processing plant and train load-out facility;
- construction and operation of a Project rail spur and loop to connect the Project to the Norwich Park Branch Railway, including product coal stockpiles for loading of product coal to trains for transport to ports;
- progressive rehabilitation of out-of-pit waste rock emplacement areas;
- progressive backfilling and rehabilitation of the mine voids with waste rock behind the advancing open cut mining operations (i.e. in-pit emplacements);
- installation of a raw water supply pipeline;
- construction of a 132 kilovolt (kV)/22 kV electricity switching/substation and 132 kV ETL to connect to the existing regional power network;
- on-site excavation, if suitable, and/or the use of the existing hard rock quarry for construction activities;
- drilling and blasting of competent overburden/waste rock material;
- construction of a mine access road (including associated railway crossing) from the Eagle Downs Mine Access Road, off Peak Downs Mine Road, to the MIA;
- construction and operation of ancillary infrastructure in support of mining, including electricity supply, consumable storage areas and explosives storage facilities;
- connection to the existing telecommunications network;
- co-disposal of coal rejects from the Project CHPP within the footprint of the open cut voids and/or out-of-pit emplacement areas;
- progressive development and augmentation of sediment dams and storage dams, pumps, pipelines and other water management equipment and structures (including up-catchment diversions, drainage channel realignments and levees);

- progressive construction and use of soil stockpile areas, laydown areas and gravel/borrow areas (e.g. for road base and ballast material);
- progressive development of haul roads, light vehicle roads and services;
- wastewater and sewage treatment by a sewage treatment plant;
- discharge of excess water off-site in accordance with relevant principles and conditions;
- an on-site landfill for the disposal of selected waste streams generated on-site;
- ongoing exploration activities; and
- other associated minor infrastructure, plant and activities.

3 REGULATORY REQUIREMENTS

3.1 TERMS OF REFERENCE

On 17 April 2019 the Office of the Coordinator-General declared the Project to be a 'coordinated project' for which an EIS is required. Draft Terms of Reference for an EIS for the Project were subsequently issued by the Office of the Coordinator-General on 24 June 2019 and were finalised on 4 September 2019. The Terms of Reference set out the matters to be addressed in the EIS for the Project.

The Terms of Reference state that the EIS must identify, describe and assess the natural environmental values of the terrestrial and aquatic ecology relevant to the Project, including Isaac River ecology, GDEs and high ecological significance wetlands.

Section 4 provides a description of the potential GDEs identified that are relevant to the Project and Section 5 provides an assessment of the impacts of the Project on these potential GDEs.

3.2 KEY GUIDELINES

The following guidelines have been considered in the preparation of this GDE Assessment:

- *Information Guidelines for the Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals* (Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development [IESC], 2018);
- *Information Guidelines Explanatory Note: Assessing Groundwater-dependent Ecosystems* (Doody *et al*., 2019);
- *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson *et al*., 2011);
- *Requirements for site-specific and amendment applications—underground water rights* (Department of Environment and Science [DES], 2016); and
- *Underground water impact reports and final reports* (DES, 2017).

4 IDENTIFICATION OF GROUNDWATER DEPENDENT ECOSYSTEMS

4.1 BACKGROUND

GDEs are ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis for maintenance of the ecosystem (Richardson *et al.,* 2011). GDEs are classified by Doody *et al.* (2019) into three broad types:

- aquifer and cave ecosystems (i.e. subterranean GDEs);
- ecosystems dependent on the sub-surface presence of groundwater (i.e. terrestrial GDEs, including some riparian vegetation communities); and
- ecosystems dependent on the surface-expression of groundwater (i.e. aquatic GDEs).

GDEs can require access to groundwater on a permanent (obligate) or intermittent (facultative) basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Doody *et al.*, 2019).

Obligate GDEs are made up of species that depend entirely on the groundwater (Doody *et al.*, 2019). Obligate GDEs tend to occupy areas of the landscape that optimise access to groundwater, such as on or below the lower banks of waterways. In the vicinity of the Project, obligate species (O'Grady *et al*., 2006; Roberts and Marston, 2000) may include (but not always) *Eucalyptus camaldulensis* (River Red Gum), *Melaleuca leucadendra* and *Melaleuca fluviatilis* (E2M, 2021). Species with an obligate dependence on groundwater may not require access to groundwater at all times; however, in order to survive long periods of drought access to groundwater is essential (E2M, 2021).

Facultative GDEs are those that use groundwater optionally or opportunistically rather than solely (Doody *et al.*, 2019). Facultative GDEs can utilise groundwater when it is available; however, will survive without it (Eamus *et al*., 2006). Facultative groundwater dependent species are usually located on the upper banks and floodplains of waterways, such as *Casuarina cunninghamiana* (River She-oak) and *Eucalyptus coolabah* (Coolibah) (Eamus *et al*., 2006; Roberts and Marston, 2000).

4.2 DESKTOP REVIEW OF GROUNDWATER DEPENDENT ECOSYSTEMS

The *Groundwater Dependent Ecosystem Atlas* (GDE Atlas) was developed by the Commonwealth Bureau of Meteorology (BoM) as a national dataset of Australian GDEs to inform groundwater planning and management (BoM, 2020). The GDE Atlas contains information about three types of ecosystems defined in the *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson *et al*., 2011).

GDEs derived in the GDE Atlas are mapped according to the following classifications:

- High potential for groundwater interaction.
- Moderate potential for groundwater interaction.
- Low potential for groundwater interaction.

The GDE Atlas identifies the potential aquatic GDEs in the vicinity of the Project (Figure 3), including:

- the Isaac River and Cherwell Creek are mapped as having high potential for groundwater interaction;
- wetlands on the Isaac River floodplain or its tributaries are mapped as having high or moderate potential for groundwater interaction;
- wetlands to the east of the Project area are mapped as having moderate potential for groundwater interaction; and
- three farm dams within the Project area are mapped as having high or moderate potential for groundwater interaction.

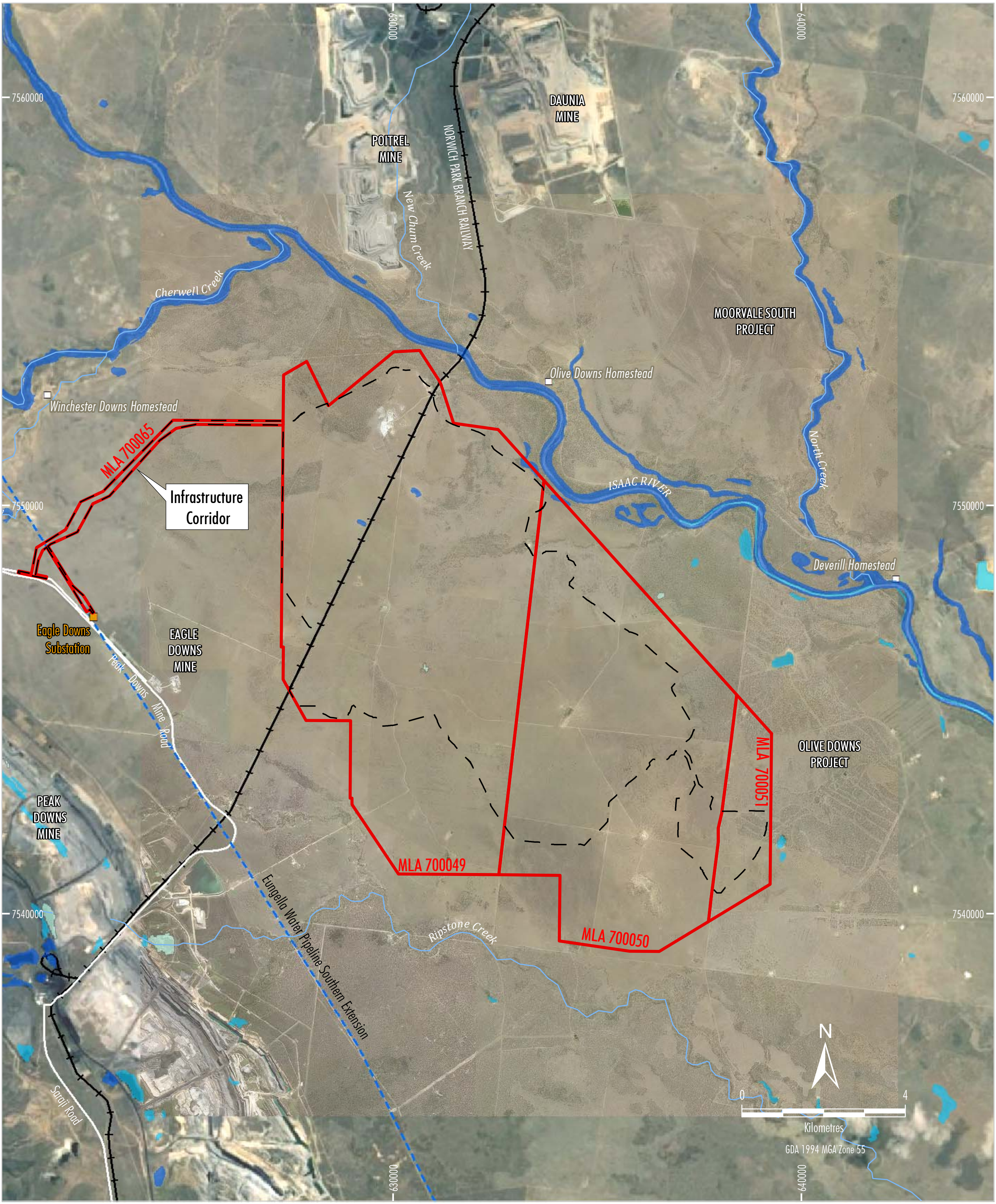
The GDE Atlas also identifies the potential terrestrial GDEs in the vicinity of the Project (Figure 4), including:

- the riparian vegetation along the Isaac River and Cherwell Creek is mapped as having high potential for groundwater interaction;
- the terrestrial vegetation associated with wetlands on the Isaac River floodplain and its tributaries is mapped as having high potential for groundwater interaction;
- terrestrial vegetation on the Isaac River and Ripstone Creek floodplains (outside of wetlands) mapped as having moderate potential for groundwater interaction; and
- some areas of terrestrial vegetation in the vicinity of the Project is mapped as having low potential for groundwater interaction, including areas in the north and south-west of the Project area.

4.3 GROUNDWATER SYSTEMS

The hydrogeological regime relevant to the Project comprises the following hydrogeological units (SLR Consulting, 2021):

- Cainozoic sediments:
  - Quaternary alluvium – unconfined aquifer (water-bearing strata of permeable rock, sand, or gravel) localised along Isaac River.
  - Quaternary to Tertiary colluvium and weathered units (regolith) – unconfined and largely unsaturated unit bordering alluvium.
- Triassic Rewan Group – aquitard overlying Permian coal measures across much of the Project area.
- Permian coal measures with:
  - Low permeability interburden units with aquitard properties.
  - Coal sequences that exhibit water-bearing properties associated with secondary porosity through cracks and fissures.



LEGEND

- Mining Lease Application Boundary
- Indicative Surface Disturbance Extent
- Eungella Water Pipeline Southern Extension
- Railway
- Substation

Potential Aquatic Groundwater Dependent Ecosystem (BoM, 2020)

- High potential GDE
- Moderate potential GDE
- Low potential GDE

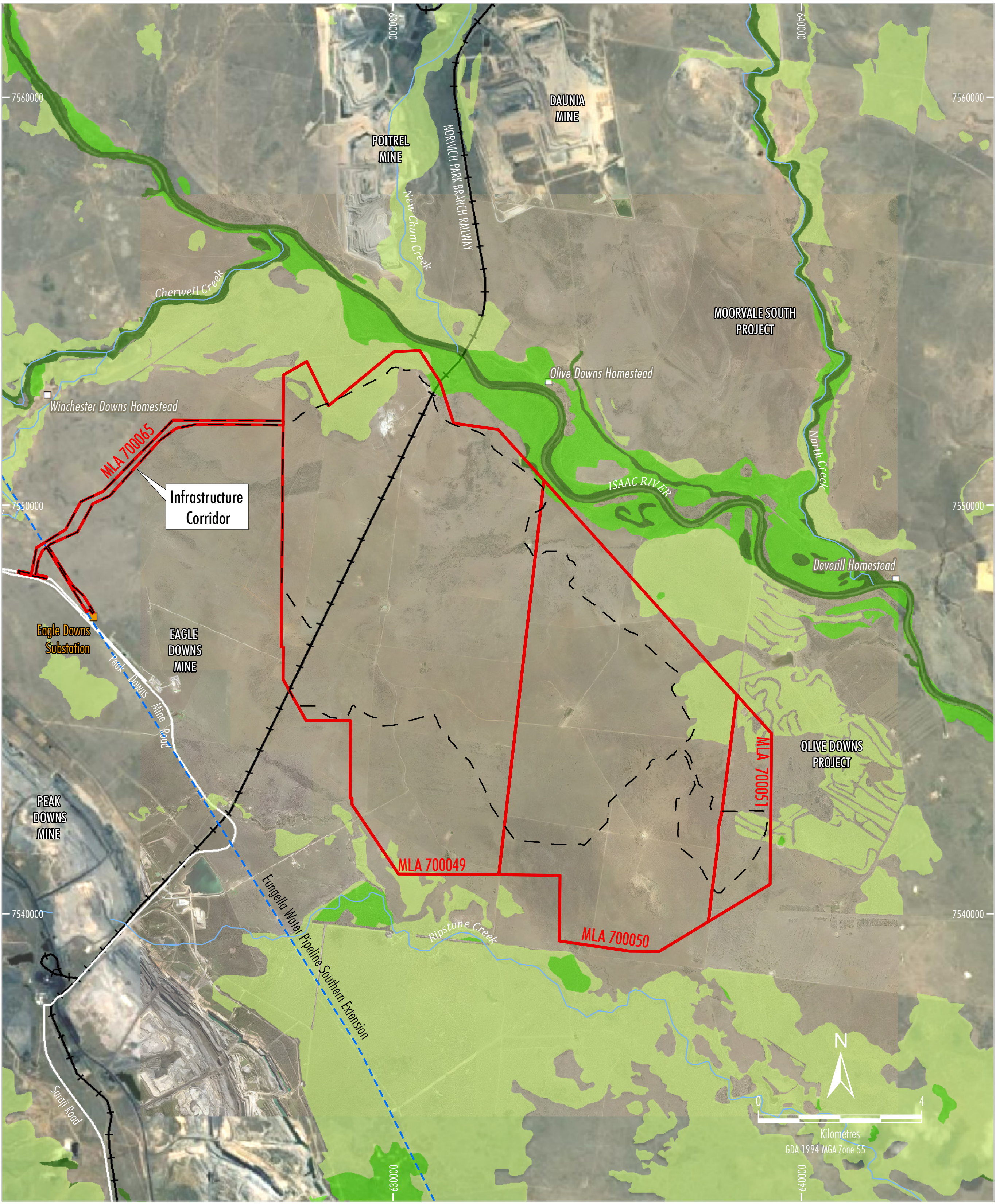
Source: The State of Queensland (2018 - 2020); Whitehaven (2020); BoM (2020).
Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Potential Aquatic Groundwater Dependent Ecosystems - BoM Atlas Mapping

Figure 3



LEGEND

- Mining Lease Application Boundary
- Indicative Surface Disturbance Extent
- Eungella Water Pipeline Southern Extension
- Railway
- Substation

Potential Terrestrial Groundwater Dependent Ecosystems (BoM, 2020)

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); BoM (2020).
Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Potential Terrestrial Groundwater Dependent Ecosystems - BoM Atlas Mapping

Figure 4

A Project-specific groundwater investigation program has been undertaken to ascertain the extent of the Isaac River alluvium in the vicinity of the Project, including:

- Groundwater Assessment (SLR Consulting, 2021);
- Geomorphology Assessment (Fluvial Systems, 2020); and
- *Winchester South Project AgTEM Survey for Groundwater Interference Investigation* (Groundwater Imaging, 2019).

Alluvial groundwater elevations range from around 179 metres Australian Height Datum (mAHD) at the northern end of the Project area, and between approximately 162 mAHD to 166 mAHD to the south-east, increasing with proximity to the Isaac River (i.e. losing stream conditions) (SLR Consulting, 2021).

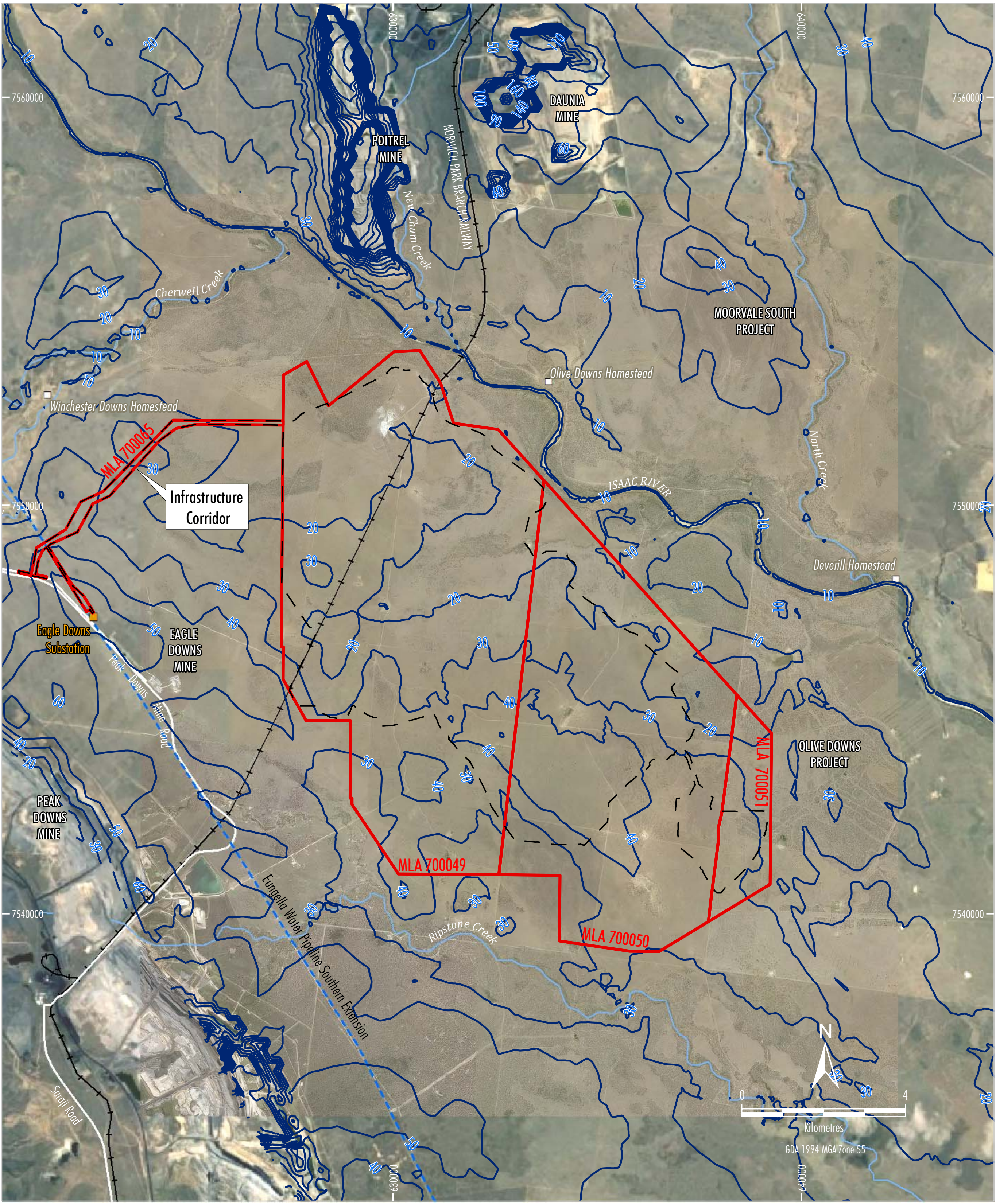
Overall, the regolith is considered to be largely unsaturated, with the presence of water restricted to lower elevation areas along the Isaac River and the lower reaches of its tributaries (i.e. Ripstone Creek). Flow within the regolith where it is saturated is a reflection of topography, flowing towards nearby drainage lines (SLR Consulting, 2021).

The water levels in the coal measures within the Project area generally follow the downstream flow gradient of the Isaac River, with south-easterly trending hydraulic gradients. Groundwater elevations range from around 188 mAHD in the north-west, down to 155 mAHD in the south-east (SLR Consulting, 2021).

The depth to the groundwater table in the vicinity of the Project is shown on Figure 5. The depth to groundwater within the Project area is typically greater than 30 to 40 metres (m), with isolated areas of shallower groundwater (10 to 20 m) associated with ephemeral tributaries of the Isaac River and a low-lying area to the north. It is expected that the deep aquifers associated with the Permian coal measures would be too deep for GDEs to access water, and therefore, only the alluvial and regolith aquifers have been considered as part of this GDE Assessment.

The Isaac River is largely a losing system with stream-stage above that of the local groundwater levels, resulting in the water draining through the alluvial sediments to the local groundwater system. Occasional periods of baseflow to the river from the underlying alluvium may occur after prolonged rainfall events or following flood events. Under these conditions, recharged alluvial sediments would drain to the Isaac River as the hydraulic gradient reverses and sustains stream-flow for a short period after the rainfall event (SLR Consulting, 2021).

Salinity is a key constraint to groundwater use in the region and can be described by total dissolved solids (TDS) concentrations. Baseline groundwater salinity for the Isaac River was analysed in the Groundwater Assessment (SLR Consulting, 2021). In summary, the surface water within the Isaac River is largely fresh, while water within the alluvium is fresh to saline with an average TDS of 863 milligrams per litre (mg/L) and ranging from 10 mg/L to 3,430 mg/L. Water within the regolith material is generally highly saline, but can be brackish to moderately saline with an average TDS of 10,510 mg/L and ranging from 1,460 mg/L and 18,600 mg/L (SLR Consulting, 2021).



LEGEND
Mining Lease Application Boundary
Indicative Surface Disturbance Extent
Depth to Water (metres below ground level)
Substation

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); BoM (2018).
Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Regional Water Table

Figure 5

4.4 SITE-SPECIFIC REVIEW OF GROUNDWATER DEPENDENT ECOSYSTEMS

4.4.1 Aquifer Ecosystems

An Aquatic Ecology and Stygofauna Assessment has been prepared for the Project by ESP (2021) and is presented in Appendix E of the EIS.

Stygofauna are subterranean aquatic fauna that live part of or all of their lives in groundwater systems (DES, 2018a). A desktop review and pilot survey for stygofauna in accordance with the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (Department of Science, Information Technology and Innovation, 2015) and the *Information Guidelines Explanatory Note: Assessing groundwater-dependent ecosystems* (Doody *et al.*, 2019), was conducted to:

- assess the suitability of local habitat for stygofauna based on the hydrogeology in the vicinity of the Project;
- assess the likely presence and composition of stygofauna in the vicinity of the Project; and
- assess the impact of the Project on subterranean aquatic fauna.

A comprehensive desktop review was completed to describe the relevant information available on stygofauna and the groundwater environment, including (ESP, 2021):

- the *Queensland Subterranean Aquatic Fauna Database* curated by the Queensland Herbarium (State of Queensland, 2020);
- bore records provided by Oasis Hydrology Pty Ltd (pers. comm., 2019);
- scientific publications regarding the habitat preferences and distribution of stygofauna, including the Commonwealth Scientific and Industrial Research Organisation (CSIRO) report to the Australian Coal Association Research Program on the extent of knowledge of stygofauna in Australian groundwater systems (Hose *et al.*, 2015);
- stygofauna studies previously completed in the vicinity of the Project, including baseline assessments for the adjacent Olive Downs Project EIS (DPM Envirosciences, 2018a); and
- geology mapping (URS, 2009).

Sampling for stygofauna was undertaken in May and October 2019, and January 2020 as per the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DES, 2019). Sampling was completed at eleven bores that target a range of strata (e.g. alluvium and Permian coal measures) distributed throughout the Project area and comparable nearby bores outside of the Project area. Each bore was established at least six months prior to stygofauna sampling and contained groundwater. *In situ* water quality measurements for electrical conductivity (EC) and pH were also taken at each bore, to aid in the interpretation of results.

No stygofauna specimens were recorded from bores sampled during the field survey (ESP, 2021).

Regolith is considered to be largely unsaturated throughout the region, with the presence of highly saline water occurring in the lower elevation areas along the Isaac River and the lower reaches of its tributaries. The high EC of the regolith throughout the broader region suggests that the groundwater environment is not ideal for stygofauna; however, stygofauna are more likely to occur in the alluvium associated with the Isaac River, due to the salinity (ESP, 2021).

Two bores in the Isaac River alluvium were sampled recently as part of a stygofauna pilot study completed for the Olive Downs Project EIS (DPM Envirosciences, 2018a). Although stygofauna were considered more likely to occur in these unconsolidated sediments, none were recorded during the study.

A recent stygofauna pilot study prepared for the Vulcan Complex Project (frc, 2020) in the Fitzroy Basin (located 10 km south-west of the Project) found one stygofauna taxon in two bores, namely a stygoxenic fauna of the Order Ostracoda. These stygofauna, however, are not obligate inhabitants of groundwater ecosystems and are unable to establish populations in such environments (frc, 2020).

4.4.2 Aquatic Ecosystems

Several riverine and wetland systems within the vicinity of the Project are mapped in the GDE Atlas (BoM, 2020) as low, moderate and high potential to be dependent on surface-expression of groundwater (Figure 3).

Potential aquatic GDEs were assessed in the Aquatic Ecology and Stygofauna Assessment (ESP, 2021) and the findings are summarised below. No listed threatened species or communities or their habitat were identified in the potential aquatic GDEs (ESP, 2021).

Isaac River and Cherwell Creek

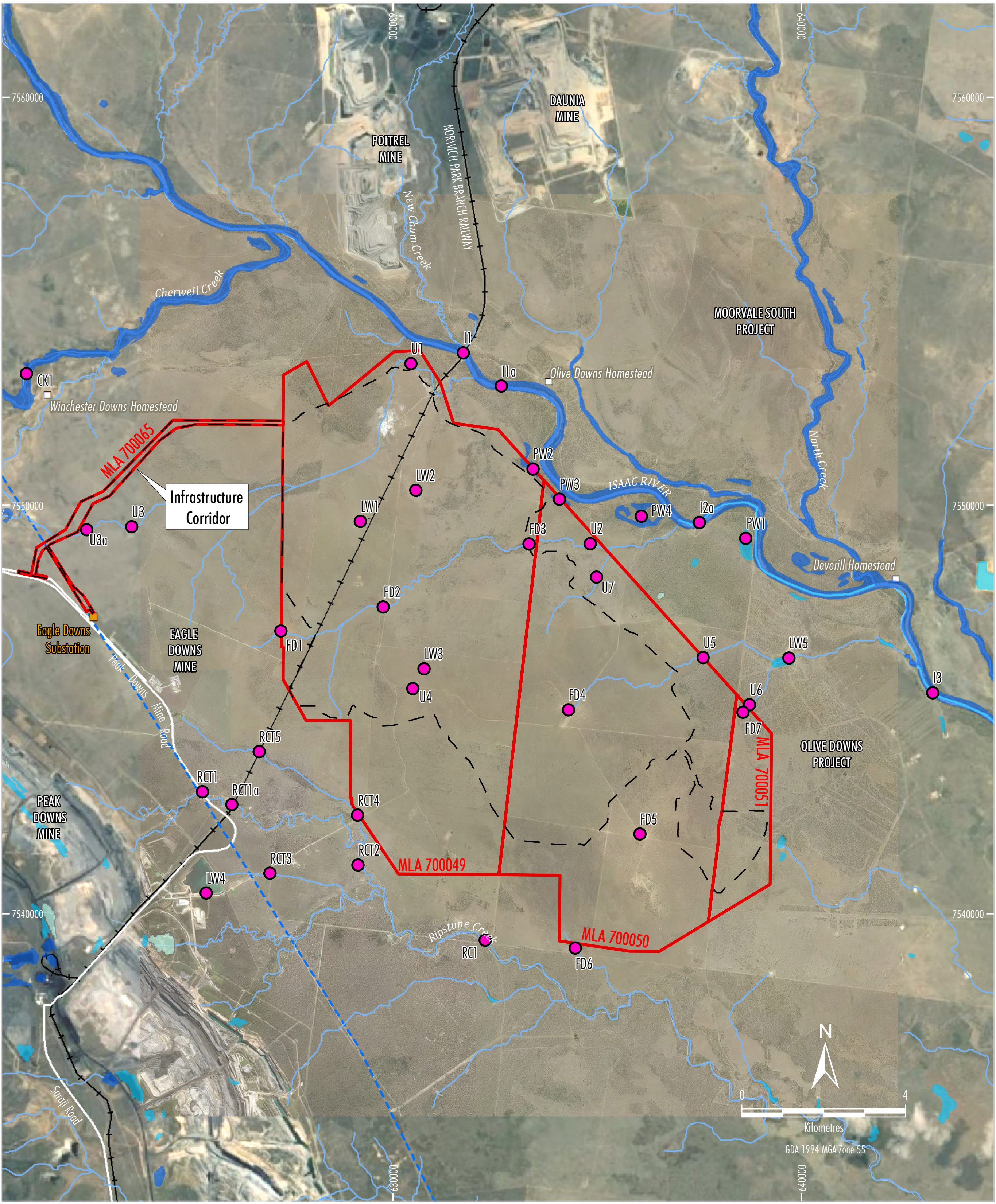
The Isaac River and Cherwell Creek are ephemeral, only flowing briefly after rainfall. As described above, aquatic and riparian ecosystems are classified as aquatic GDEs in or adjacent to streams which are fed by groundwater (Doody *et al.*, 2019).

Four sites (sites I1, I1a, I2a and I3) were surveyed on the Isaac River channel during the aquatic ecology field surveys, all of which were located within areas mapped as high potential aquatic GDEs (Figure 6).

All consisted of shallow, isolated pools during the May 2019 survey (excluding site I1a that was only surveyed in October 2019) (Figure 6). Sites I1, I2a and I3 were dry during the October 2019 survey, with only site I1a consisting of a shallow, isolated pool (Figures 7a to 7d) (ESP, 2021). The aquatic ecology site located on Cherwell Creek (i.e. site CK1) was dry during both surveys (Figure 8) (ESP, 2021). Previous surveys for the Olive Downs Project at aquatic ecology sites along Cherwell Creek were also dry (DPM Envirosciences, 2018a).

Data from the Deverill gauging station on the Isaac River indicates surface flow is likely to only occur in the wetter months from November to April, reducing to shallow sub-surface flows from May to October (WRM, 2021). At the Deverill gauging station, the Isaac River only flows on 27% of days in a year, with flows above 100 megalitres per day (ML/day) recorded for less than 12% of days of the year. A flow of 100 ML/day would not fully inundate the bed of the Isaac River at the Deverill gauging station (WRM, 2021).

WRM (2021) describes that the Isaac River stream flows are highly ephemeral with baseflows ceasing within a few days or weeks of a runoff event, or at least flowing below the top of the sandy bed.



WHC-18-62_EIS_AppF_215A

LEGEND

- Mining Lease Application Boundary
- Indicative Surface Disturbance Extent
- Watercourses and Drainage Features
- Substation
- Survey Sites (ESP, 2021)

Potential Aquatic Groundwater Dependent Ecosystem

- High potential GDE
- Moderate potential GDE
- Low potential GDE

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); BoM (2018); E2M (2021); ESP (2021). Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Location of Aquatic Ecology Survey Sites

Figure 6

Wet Season Survey

Plate 1: Upstream

Plate 3: Downstream

Dry Season Survey

Plate 2: Upstream

Plate 4: Downstream

WHC-18-62_AppF_103B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Isaac River - Site I1

Figure 7a
Plates 1-4

Wet Season Survey

Plate 5: Upstream

Plate 6: Left Bank

Plate 7: Downstream

Plate 8: Right Bank

WHC-18-62_AppF_106B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Isaac River - Site I1a

Figure 7b
Plates 5-8

Wet Season Survey

Plate 9: Upstream

Plate 11:Downstream

Dry Season Survey

Plate 10: Upstream

Plate 12: Downstream

WHC-18-62_AppF_104B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Isaac River - Site I2a

Figure 7c
Plates 9-12

Wet Season Survey

Plate 13: Upstream

Plate 15: Downstream

Dry Season Survey

Plate 14: Upstream

Plate 16: Downstream

WHC-18-62_AppF_105B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Isaac River - Site I3

Figure 7d
Plates 13-16

Wet Season Survey

Plate 1:Upstream

Plate 3: Downstream

Dry Season Survey

Plate 2: Upstream

Plate 4: Downstream

WHC-18-62_AppF_107B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Cherwell Creek - CK1

Figure 8
Plates 1-4

As described in Section 4.3, the Isaac River and Cherwell Creek are largely a losing system (i.e. not fed by groundwater) resulting in the water draining through the alluvial sediments to the underlying, local groundwater table (SLR Consulting, 2021). SLR Consulting (2021) described that occasional periods of baseflow to the Isaac River from the underlying alluvium may occur after prolonged rainfall events or following flood events. Under these conditions, recharged alluvial sediments would drain to the Isaac River as the hydraulic gradient reverses and sustains stream-flow for a short period after the rainfall event (SLR Consulting, 2021).

The surface water within the Isaac River is largely fresh, while water within the alluvium is fresh to saline with an average TDS of 863 mg/L and ranging between 10 mg/L to 3,430 mg/L (SLR Consulting, 2021).

Based on the above, the aquatic in-stream ecosystems associated with the Isaac River and Cherwell Creek are largely not dependent on the surface expression of groundwater, but would be for a short period after rainfall events. However, these waterways are ephemeral and inevitably dry out (ESP, 2021).

The surveys found that aquatic habitat condition at Isaac River and Cherwell Creek was representative of ephemeral waterway sites in the broader area (ESP, 2021). The field assessment concluded that the aquatic ecological value of these features was low to moderate.

No inconsistencies in aquatic ecological indicators were observed between waterways mapped by BoM (2020) as potential GDEs compared with those that are not mapped. However, the aquatic value of sample sites on the Isaac River and Cherwell Creek was higher than at other riverine sites, likely due to these waterways having a higher stream order (and therefore providing greater value in terms of fish passage, connectivity and aquatic habitat availability). No listed aquatic threatened species or communities or their habitat were identified within the Isaac River or Cherwell Creek (ESP, 2021).

Given the understanding of the groundwater regime described above, the riparian vegetation along the Isaac River and Cherwell Creek may access the surface-expression of groundwater for short periods of time after rainfall events; however, monitoring data within the Isaac River indicates that these events would occur infrequently (ESP, 2021).

Lacustrine Wetlands

There are several farm dams (i.e. 'lacustrine wetlands') that are mapped as having high or moderate potential for groundwater interaction due to surface-expression of groundwater (i.e. aquatic GDEs) in the GDE Atlas (BoM, 2020). Three of these sites are located within the Project area (i.e. LW1 to LW3), LW4 is located 8 km west of the Project and LW5 is located 2.5 km downstream of the Project (Figure 6).

All five sites coincide with areas mapped as having potential groundwater dependence (Figure 3):

- LW1, LW2 and LW4 are mapped as having high potential for groundwater interaction.
- LW5 is mapped as having moderate potential for groundwater interaction.
- LW3 is mapped as having low potential for groundwater interaction.

All of these lacustrine wetlands were identified as man-made dams, either for agriculture/stock watering (farm dams at sites LW1, LW2, LW3 and LW5) or mine water management (site LW4). Photographs are provided in Figures 9a to 9e for all five sites and were characterised as having poor in-stream and riparian condition with significant existing impacts, including:

- alteration of habitat to construct the dams;
- reduced riparian vegetation as a result of land clearing; and
- disturbance to bank stability and instream habitat from cattle access.

Of the three lacustrine wetlands that were mapped as having low and high potential for groundwater influence, two were dry in October 2019 (i.e. LW1 and LW2), and one consisted of a small shallow pool (i.e. LW3).

The depth to groundwater beneath the farm dams is typically 20 to 30 m (10 m in the vicinity of LW5 east of the Project) (Figure 5). Therefore, the waterbodies in these farm dams are not considered to be dependent on groundwater. Further, the farm dams within the Project area would be cleared for the Project so are not discussed further in the context of potential groundwater drawdown-related impacts to GDEs.

Palustrine Wetlands

There are several mapped palustrine wetlands (DES, 2020) in the vicinity of the Project, four of which were inspected during the aquatic field surveys and are considered representative (sites PW1 to PW4, refer Figures 6 and 10) (ESP, 2021). One of these wetlands (site PW1) is mapped as a 'high ecological significance' wetland (BoM, 2020).

The regionally mapped palustrine wetlands are also mapped as high or moderate potential aquatic GDEs (BoM, 2020) (Figure 3).

All mapped palustrine wetlands were dry during the aquatic field surveys in May and October 2019 (Figures 11a to 11d). The mapped palustrine wetlands were located adjacent to the Isaac River in the floodplain, and they would likely become inundated infrequently during periods of high rainfall and flooding (ESP, 2021).

Although the wetlands did not hold water in May 2019 (i.e. the late-wet season surveys), they contained emergent wetland indicator plant species and had features indicative of previously wet conditions (e.g. depressions indicating ponding, recently dried mud), showing that they contain water periodically (ESP, 2021).

The field assessment confirmed that the mapped palustrine wetlands meet the definition of a wetland under the *Queensland Wetland Definition and Delineation Guideline* (Department of Environment and Resource Management [DERM], 2011). The ground-truthed boundaries of the wetlands broadly aligned with the State mapping (Figure 10).

The dry beds contained several potential habitat features for aquatic fauna, including trailing and overhanging vegetation, a variety of woody debris and terrestrial detritus. The riparian zones were typically in good condition and consisted of semi-continuous bands of mature trees, shrubs and grasses, though vegetation clearing had occurred in the broader area for cattle grazing and access tracks (ESP, 2021).

Wet Season Survey


Plate 1: Upstream


Plate 2: Left Bank


Plate 3: Downstream


Plate 4: Right Bank

WHC-18-62_AppF_108B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Lacustrine Wetlands - LW1

Figure 9a
Plates 1-4

Wet Season Survey


Plate 5: Upstream


Plate 7: Downstream

Dry Season Survey


Plate 6: Upstream


Plate 8: Downstream

WHC-18-62_AppF_109B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Lacustrine Wetlands - LW2

Figure 9b
Plates 5-8

Wet Season Survey

Plate 9: Upstream

Plate 11: Downstream

Dry Season Survey

Plate 10: Upstream

Plate 12: Downstream

WHC-18-62_AppF_110B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Lacustrine Wetlands - LW3

Figure 9c
Plates 9-12

Wet Season Survey

Plate 13: Upstream

Plate 15: Downstream

Dry Season Survey

Plate 14: Upstream

Plate 16: Downstream

WHC-18-62_AppF_111B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites - Lacustrine Wetlands - LW4

Figure 9d
Plates 13-16

Dry Season Survey

Plate 17: Right Bank

Plate 18: Upstream

Plate 19: Left Bank

Plate 20: Downstream

WHC-18-62_AppF_112B

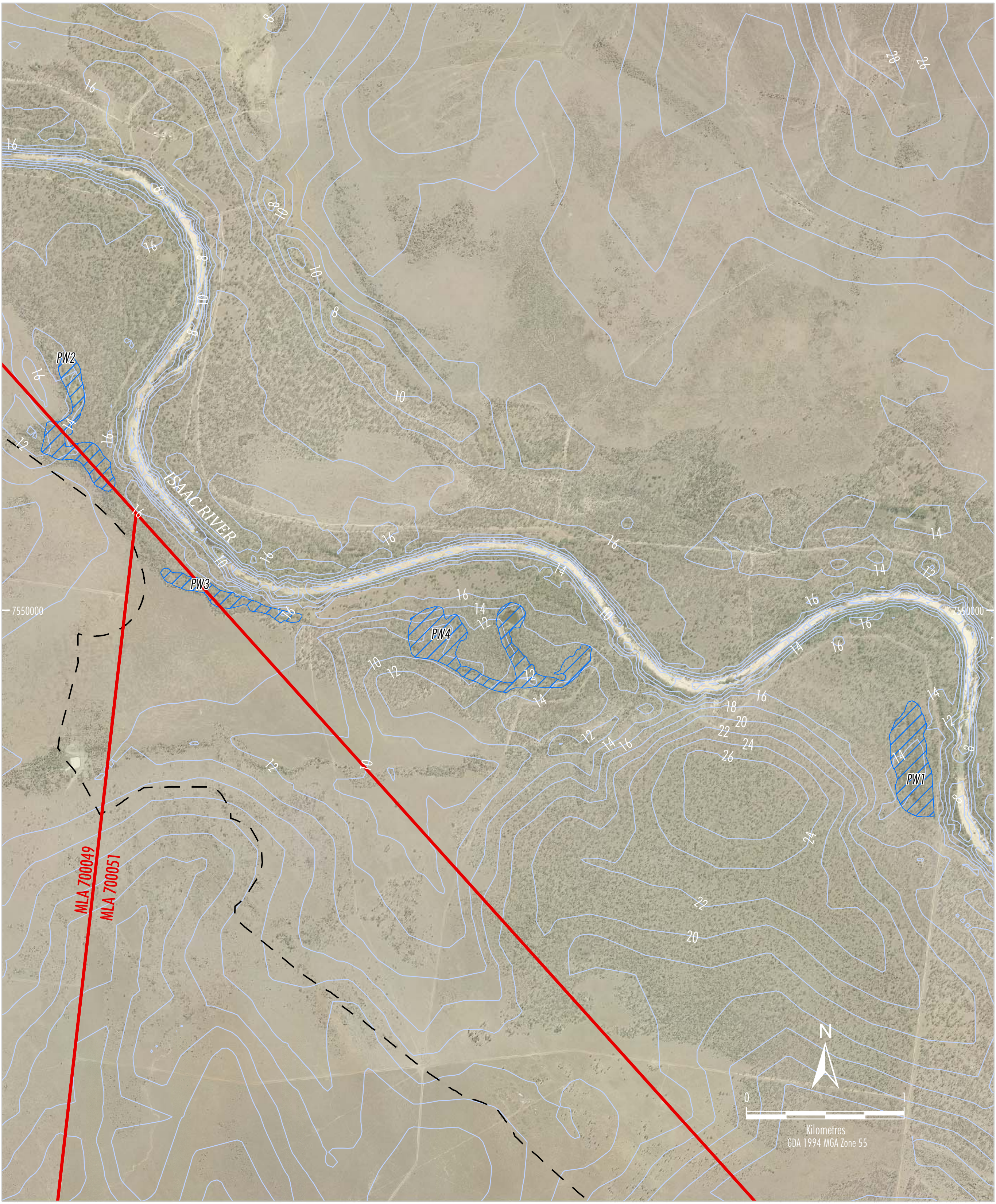
Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites - Lacustrine Wetlands - LW5

Figure 9e
Plates 17-20



LEGEND

- Mining Lease Application Boundary
- Indicative Surface Disturbance Extent
- Potential Ground-truthed Aquatic GDE (ESP, 2021)
- Depth to Water (metres below ground level)

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); ESP (2021); SLR (2021). Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Palustrine Wetlands

Figure 10

Wet Season Survey

Plate 1: Upstream

Plate 3: Downstream

Dry Season Survey

Plate 2: Upstream

Plate 4: Downstream

WHC-18-62_AppF_113B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites - Palustrine Wetlands - PW1

Figure 11a
Plates 1-4

Wet Season Survey

Plate 5: Upstream

Plate 7: Downstream

Dry Season Survey

Plate 6: Upstream

Plate 8: Downstream

WHC-18-62_AppF_114B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Palustrine Wetlands - PW2

Figure 11b
Plates 5-8

Wet Season Survey


Plate 9: Upstream


Plate 11: Downstream

Dry Season Survey


Plate 10: Upstream


Plate 12: Downstream

WHC-18-62_AppF_115B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Palustrine Wetlands - PW3

Figure 11c
Plates 9-12

Wet Season Survey


Plate 13: Upstream


Plate 15: Downstream

Dry Season Survey


Plate 14: Upstream


Plate 16: Downstream

WHC-18-62_AppF_116B

Source: ESP (2021).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Aquatic Ecology Survey Sites
- Palustrine Wetlands - PW4

Figure 11d
Plates 13-16

In May 2019, the dry beds were filled with an abundance of emergent aquatic plants (Figure 11a to 11d). However, most of these aquatic plants were not present in the October 2019 survey due to the dry conditions (Figure 11a to 11d). All of the palustrine wetlands were slightly to moderately disturbed by cattle access and trampling, and some contained a low abundance of terrestrial weed species (ESP, 2021).

All four palustrine wetlands surveyed (PW1 to PW4) have limited connectivity to the Isaac River are ephemeral, only holding water during periods of high rainfall. All four wetlands were dry during May and October 2019 surveys, indicating that these, and other similar wetlands rely on rainfall, rather than the surface-expression of groundwater (ESP, 2021).

The depth to groundwater beneath the palustrine wetlands ranges from 10 m to 20 m (Figure 10) (SLR Consulting, 2021), meaning that the aquatic ecosystem associated with the wetlands do not receive groundwater discharge, and therefore are not aquatic GDEs. Rather, the clay-rich substrates of these wetlands are likely to hold surface water run-off for extended periods creating the above-ground conditions for the aquatic ecosystem. This conclusion is supported by alluvial drillholes and logs and the transient electromagnetic (TEM) survey undertaken in the vicinity of PW2 (the most proximal Palustrine Wetland to the Project), which confirm the presence of clay-rich sediments near the surface (Figure 12) (SLR Consulting, 2021).

In the context of GDEs, the term 'groundwater' includes water occurring naturally below ground level (e.g. in an aquifer), and includes water in the soil capillary zone (capillary fringe above a saturated groundwater zone), but not the water held in the soil above this zone in the unsaturated or vadose zone (Doody *et al.*, 2019). Therefore, these wetlands do not fit the definition of an aquatic GDE.

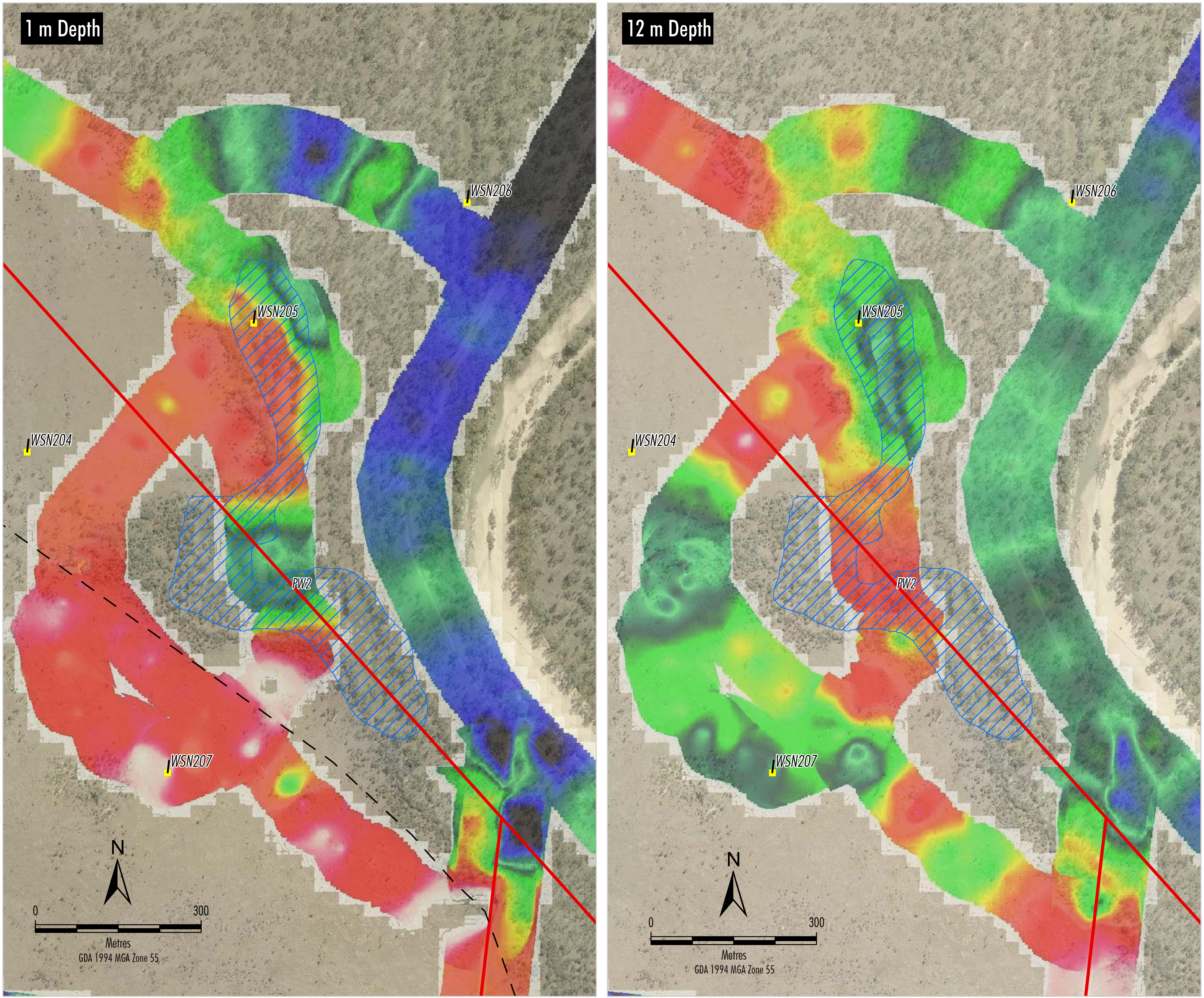
Summary

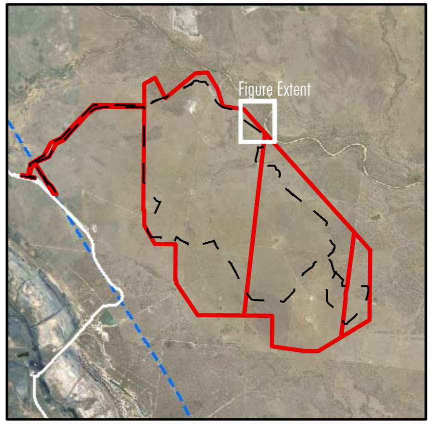
The aquatic in-stream ecosystems associated with the Isaac River and Cherwell Creek are largely not dependent on the surface-expression of groundwater, but would access groundwater for a short period after rainfall events. The wetlands and farm dams in the locality are not likely to be aquatic GDEs.

4.4.3 Terrestrial Ecosystems Dependent on Sub-surface Presence of Groundwater

Riparian Vegetation Along Isaac River and Cherwell Creek

The riparian vegetation associated with the Isaac River and Cherwell Creek is recognised as Regional Ecosystem (RE) 11.3.25 and comprises predominantly overstorey species of *Eucalyptus tereticornis* (Forest Red Gum), *Eucalyptus camaldulensis* (River Red Gum), *Eucalyptus coolabah* (Coolibah), *Eucalyptus populnea* (Poplar Box), *Casuarina cunninghamiana* (River Oak) and *Melaleuca fluviatilis* (DPM Envirosciences, 2018b; DES, 2018b). Trees along the Isaac River grow from fringes of the stream bed up to the high bank (recorded up to 8 m higher than the stream bed [ESP, 2021]). Cherwell Creek is less incised, with the high bank recorded 3-6 m higher than the stream bed (ESP, 2021).





Source: The State of Queensland (2018 - 2020); Whitehaven (2020); Groundwater Imaging (2019); ESP (2021). Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Transient Electromagnetic Surveys at Palustrine Wetland PW2

Figure 12

WHC-18-62_EIS_AppF_216B

The Isaac River and Cherwell Creek are ephemeral, only flowing briefly after rainfall. Data from the Deverill gauging station on the Isaac River indicate surface flow is likely to only occur in the wetter months from November to April, reducing to shallow subsurface flows from May to October (WRM, 2021). The Isaac River and Cherwell Creek are largely a losing system (i.e. not fed by groundwater but instead recharges groundwater) resulting in the water draining through the alluvial sediments to the underlying, local groundwater table (SLR Consulting, 2021). SLR Consulting (2021) described that occasional periods of baseflow to the Isaac River from the underlying alluvium may occur after prolonged rainfall events or following flood events. Under these conditions, recharged alluvial sediments would drain to the Isaac River as the hydraulic gradient reverses and sustains stream-flow for a short period after the rainfall event as water levels in the waterway fall (SLR Consulting, 2021).

The depth to groundwater in the Quaternary alluvium beneath the riparian vegetation along the Isaac River ranges from 6 m to 12 m and along the Isaac River ranges from 3 m to 12 m (SLR Consulting, 2021). During and following wet seasons, the groundwater levels are likely to be higher, and more accessible by the riparian vegetation; however, at these times water is also available in the soil profile from rainfall (surface water) infiltration. During and following flooding events, the riparian vegetation is unlikely to be dependent on sub-surface presence of groundwater (E2M, 2021).

During dry seasons, the depth to groundwater would increase and may either become a more important source of water for the trees or become too deep for trees to access. It is possible that the sub-surface presence of groundwater is used by larger trees during these times, as some of these species have been reported to use groundwater when the depth is within this range (Orellana *et al.*, 2012; Kath *et al.,* 2014). If the trees use the sub-surface presence of groundwater, the dependency is likely to be facultative, given that the water available in the soil profile and from rainfall would be used during the wet season. Facultative GDEs can require groundwater in some locations but not in others, particularly where an alternative source of water can be accessed to maintain ecological function. These trees can use groundwater when it is available; however, they will survive without it (Eamus *et al.*, 2006).

It is concluded that the riparian vegetation associated with the Isaac River and Cherwell Creek (RE 11.3.25) has a moderate to high potential to meet the definition of a terrestrial GDE, and any dependency on groundwater in the Quaternary alluvium is likely to be facultative, during dry times.

Vegetation Associated with Wetlands on the Isaac River Floodplain and Tributaries

There are various patches of woodland associated with ephemeral wetlands on the Isaac River floodplain and its tributaries that are mapped as having high or moderate potential for groundwater interaction due to sub-surface presence of groundwater (i.e. terrestrial GDEs) in the GDE Atlas (BoM, 2020).

The woodland surrounds the wetland basin. The Aquatic Ecology and Stygofauna Assessment (ESP, 2021) describes how these ephemeral wetlands are not likely to be aquatic GDEs as these wetlands do not receive groundwater discharge, rather, the clay-rich substrates of these wetlands are likely to hold surface water run-off for extended periods, thereby creating the temporary aquatic habitat.

The riparian vegetation surrounding these ephemeral wetlands comprises woodlands dominated by *Eucalyptus coolabah*, with *Eucalyptus populnea* (within RE 11.3.3c or RE 11.3.27) (Figure 13). Both of these eucalypt species are known to be facultative users of groundwater in some locations (Doody *et al.,* 2019; Kath *et al.,* 2014; Orellana, 2012). These species were observed in a number of locations within the study area for the Terrestrial Ecology Assessment (E2M, 2021) where the depth to groundwater is in excess of 40 m (SLR Consulting, 2021) and therefore, would be too deep for the trees to access (e.g. RE 11.4.9).

Depth to groundwater in the Quaternary alluvium beneath the wetlands ranges from 12 m to 15 m (SLR Consulting, 2021). At this depth, it is possible that these trees could potentially access groundwater; however, due to their location on the banks of the wetland, these trees would experience periodic inundation and the primary water source would be from rainfall (surface water) infiltration, with the clay-rich substrates of these wetlands likely to hold surface water run-off for extended periods.

It is concluded that the riparian vegetation surrounding these ephemeral wetlands has a moderate potential to meet the definition of a terrestrial GDE, and any dependency on groundwater is likely to be facultative, during dry times (E2M, 2021).

Vegetation on the Isaac River Floodplains and Tributaries (Outside of Wetlands)

There are various patches of woodland dominated by RE 11.3.2 (*Eucalyptus populnea*) on the floodplains of the Isaac River, Ripstone Creek and Cherwell Creek (outside of wetlands – discussed above) that are mapped as having moderate potential for groundwater interaction due to sub-surface presence of groundwater (i.e. terrestrial GDEs) in the GDE Atlas (BoM, 2020).

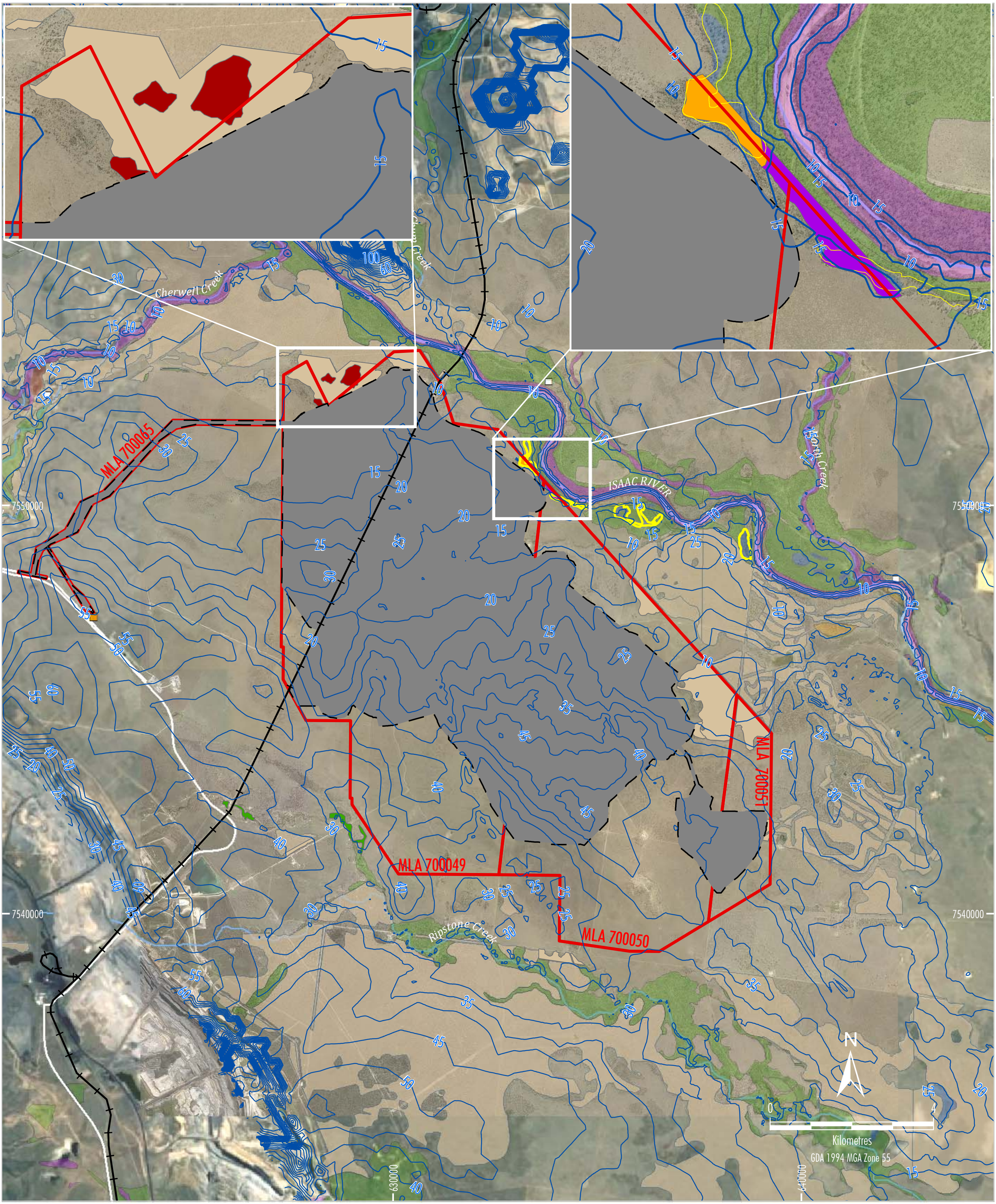
As discussed above, *Eucalyptus populnea* is known to be a facultative user of groundwater in some locations (Kath *et al.,* 2014). In the floodplain locations, *Eucalyptus populnea* is most likely to access groundwater following floods when groundwater levels rise. Depth to groundwater in these floodplain locations ranges from 9 m to 16 m in the Quaternary alluvium (SLR Consulting, 2021).

It is concluded that the woodland dominated by RE 11.3.2 has a moderate potential to meet the definition of a terrestrial GDE, and any dependency on groundwater is likely to be facultative, during dry times (E2M, 2021).

Vegetation in the Vicinity of the Project Mapped as Having Low Potential for Groundwater Interaction

There are various patches of woodland in the vicinity of the Project that are mapped as having low potential for groundwater interaction due to sub-surface presence of groundwater (i.e. terrestrial GDEs) in the GDE Atlas (BoM, 2020).

One of these patches of woodland is within the northern portion of the Project and consists of mostly RE 11.5.3, but also with RE 11.3.2 and RE 11.3.4. Other patches of woodland mapped as having low potential for groundwater interaction (BoM, 2020) occur to the east of the Project (also RE 11.5.3). These REs comprise of mainly *Eucalyptus populnea* (which is discussed above as a facultative user of groundwater in some locations). The depth to groundwater beneath these patches ranges from 12 m to 23 m as the shallowest aquifer is associated with the regolith (SLR Consulting, 2021). Water within the regolith material is generally highly saline, but can be brackish to moderately saline with an average TDS of 10,510 mg/L, ranging between 1,460 mg/L and 18,600 mg/L (SLR Consulting, 2021). As shown on Figure 13, RE 11.5.3 occurs elsewhere where the depth to groundwater is in excess of 40 m (SLR Consulting [2021]) and too deep for the trees to access.



LEGEND

Mining Lease Application Boundary
Indicative Surface Disturbance Extent
Depth to Water (5 m Contour)
Substation

Vegetation Communities with Potential for Groundwater Dependence

Ground-truthed (E2M, 2021)

- RE 11.3.2
- RE 11.3.25
- RE 11.3.3c
- RE 11.3.4
- RE 11.5.3

State Mapped (Dominant) (DNRME, 2020)

- RE 11.3.25
- RE 11.3.2
- RE 11.3.3
- RE 11.3.4
- RE 11.3.27b
- RE 11.5.3
- Palustrine Wetland (ESP, 2021)

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); E2M (2021); ESP (2021). Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Terrestrial Vegetation and Groundwater Depth

Figure 13

WHC-18-62_EIS_AppF_219B

It is concluded that these woodland patches have a low potential to meet the definition of a terrestrial GDE, and any dependency on groundwater in the regolith is likely to be facultative, during dry times (if at all). It is unlikely that these REs would be dependent on the groundwater due to the poor quality (high salinity) of the groundwater source (E2M, 2021).

Conclusion

The Terrestrial Ecology Assessment (E2M, 2021) concluded that there is a moderate to high potential that the riparian vegetation associated with the Isaac River and Cherwell Creek (RE 11.3.25) is a facultative terrestrial GDE. There is a low to moderate potential that the areas of RE 11.3.2, 11.3.3c, 11.3.4 and 11.5.3 comprising woodlands dominated by *Eucalyptus coolabah* and *Eucalyptus populnea* are facultative terrestrial GDEs in some locations. In locations where these REs are able to use groundwater as part of the plants' water use, they do not necessarily rely on groundwater for continued survival. Table 1 provides a summary of the REs and the potential for groundwater dependence.

Table 1
Vegetation Communities in the Vicinity of the Project and Potential for Groundwater Dependence

Regional Ecosystem Number	Vegetation Community Description	Potential for Groundwater Dependence
11.3.1	*Acacia harpophylla and/or Casuarina cristata open forest on alluvial plains*	Nil
11.3.2	*Eucalyptus populnea woodland on alluvial plains*	Low to moderate potential facultative GDE
11.3.3c	*Eucalyptus coolabah woodland to open woodland (to scattered trees) with a sedge or grass understorey in back swamps and old channels*	Moderate potential facultative GDE
11.3.4	*Eucalyptus tereticornis and/or Eucalyptus spp. woodland on alluvial plains*	Low potential facultative GDE
11.3.25	*Eucalyptus tereticornis or Eucalyptus camaldulensis woodland fringing drainage lines*	Moderate to high potential facultative GDE
11.3.27	*Freshwater wetlands with fringing eucalypt woodlands*	Moderate potential facultative GDE
11.4.4	*Dichanthium spp., Astrebla spp. grassland on Cainozoic clay plains*	Nil
11.4.8	*Eucalyptus cambageana woodland to open forest with Acacia harpophylla or A. argyrodendron on Cainozoic clay plains*	Nil
11.4.9	*Acacia harpophylla shrubby woodland with Terminalia oblongata on Cainozoic clay plains*	Nil
11.5.3	*Eucalyptus populnea +/- Eucalyptus melanophloia +/- Corymbia clarksoniana woodland on Cainozoic sand plains and/or remnant surfaces*	Low potential facultative GDE
11.5.9	*Eucalyptus crebra and other Eucalyptus spp. and Corymbia spp. woodland on Cainozoic sand plains and/or remnant surfaces*	Nil
11.9.2	*Eucalyptus melanophloia +/- Eucalyptus orgadophila woodland on fine-grained sedimentary rocks*	Nil
11.9.3	*Dichanthium spp., Astrebla spp. grassland on fine-grained sedimentary rocks*	Nil
11.9.5	*Acacia harpophylla and/or Casuarina cristata open forest on fine-grained sedimentary rocks*	Nil

Obligate GDE - permanent dependence on groundwater.
Facultative GDE - intermittent dependence on groundwater.

5 POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

Pathways of potential Project impacts on GDEs have been identified by E2M (2021), ESP (2021) and SLR Consulting (2021) as follows:

- A reduction in the availability of groundwater.
- Adverse changes to groundwater quality.

Changes to groundwater quality and quantity can have an indirect impact on ecosystems surrounding a development site and particularly ecosystems that are dependent or partially dependent on groundwater. The process of mining reduces water levels in the surrounding groundwater units. The extent of the zone affected is dependent on the properties of the aquifers/aquitards and is referred to as the zone of drawdown. Aquifer drawdown is greatest at the working coal-face and, generally, gradually decreases with distance from the mining operations (SLR Consulting, 2021).

5.1 AQUATIC ECOSYSTEMS

The aquatic in-stream ecosystems associated with the Isaac River and Cherwell Creek are largely not dependent on the surface-expression of groundwater, but would be for a short period after rainfall events. The wetlands and farm dams in the locality are not likely to be aquatic GDEs.

Modelling has shown that the Project would result in negligible increased leakage from surface flows of the Isaac River to the underlying alluvium. The change in flows as a result of the increased hydraulic gradient between the alluvium and the Isaac River expected to be an average of approximately 4 megalitres per year (ML/year) (0.01 ML/day) compared to a baseline average flow of 161,863 ML/year (443 ML/day) when the Isaac River flows (SLR Consulting, 2021). This is a negligible reduction in average flow when the Isaac River flows; therefore, impacts to surface flows and subsequently aquatic ecosystems downstream of the Project area are not expected.

The Project is likely to result in fewer impacts (proportionally) on baseflow contributions to New Chum Creek, North Creek or Cherwell Creek given the distance of these waterways from the Project (SLR Consulting, 2021).

5.2 TERRESTRIAL ECOSYSTEMS DEPENDENT ON SUB-SURFACE PRESENCE OF GROUNDWATER

5.2.1 Riparian Vegetation Along Isaac River and Cherwell Creek

As described in Section 4.4, the riparian vegetation associated with the Isaac River and Cherwell Creek (RE 11.3.25) has a moderate to high potential to meet the definition of a terrestrial GDE, with any dependency on groundwater likely to be facultative, during dry times.

In regard to changes to groundwater quality and quantity, the Groundwater Assessment (SLR Consulting, 2021) concludes that there would be negligible drawdown in the Quaternary alluvium along the Isaac River and Cherwell Creek as a result of the Project with no adverse changes to groundwater quality. The Project would not directly intercept groundwater from the Quaternary alluvium (SLR Consulting, 2021). Interference of the alluvial groundwater would be largely due to increased leakage to the underlying Permian coal measures that would be depressurised as a result of the Project. The numerical groundwater modelling predicted that the increase in seepage from the Quaternary alluvium to the underlying Permian coal measures would be negligible (SLR Consulting, 2021).

As no measurable impacts to groundwater quality and quantity are likely to occur from the Project, no adverse impacts are likely to occur on the riparian vegetation associated with the Isaac River and Cherwell Creek.

5.2.2 Vegetation Associated with Wetlands on the Isaac River Floodplain and Tributaries

As described in Section 4.4, the riparian vegetation surrounding these ephemeral wetlands has a moderate potential to meet the definition of a terrestrial GDE, and any dependency on groundwater is likely to be facultative, during dry times. The Aquatic Ecology and Stygofauna Assessment (ESP, 2021) describes how these ephemeral wetlands are not likely to be aquatic GDEs as these wetlands do not receive groundwater discharge. Rather, the clay-rich substrates of these wetlands are likely to hold surface water run-off for extended periods, thereby creating the temporary aquatic habitat.

The Groundwater Assessment (SLR Consulting, 2021) concludes that there would be negligible drawdown in the Quaternary alluvium beneath these wetlands as a result of the Project with no adverse changes to groundwater quality. As no measurable impacts to groundwater quality and quantity are likely to occur from the Project, no adverse impacts are likely to occur on the riparian vegetation surrounding these ephemeral wetlands.

5.2.3 Vegetation on the Isaac River Floodplain and Tributaries (Outside of Wetlands)

As described in Section 4.4, the woodland dominated by RE 11.3.2 on the floodplains on the Isaac River, Ripstone Creek and Cherwell Creek has a moderate potential to meet the definition of a terrestrial GDE, and any dependency on groundwater is likely to be facultative, during dry times.

There would be no impacts to vegetation on the Isaac River, Ripstone Creek and Cherwell Creek floodplains (outside of wetlands) that may access water from the Quaternary alluvium, as there would be negligible drawdown to the Quaternary alluvium (SLR Consulting, 2021). Where the vegetation on the Isaac River, Ripstone Creek and Cherwell Creek floodplains (outside of wetlands) occurs outside of the mapped extent of the Quaternary alluvium, negligible drawdown to the underlying water table is predicted.

Further, there would be no impacts on the vegetation on the Isaac River and Ripstone Creek floodplains (outside of wetlands), as the Project would not result in adverse changes to groundwater quality, including the Quaternary alluvium (SLR Consulting, 2021).

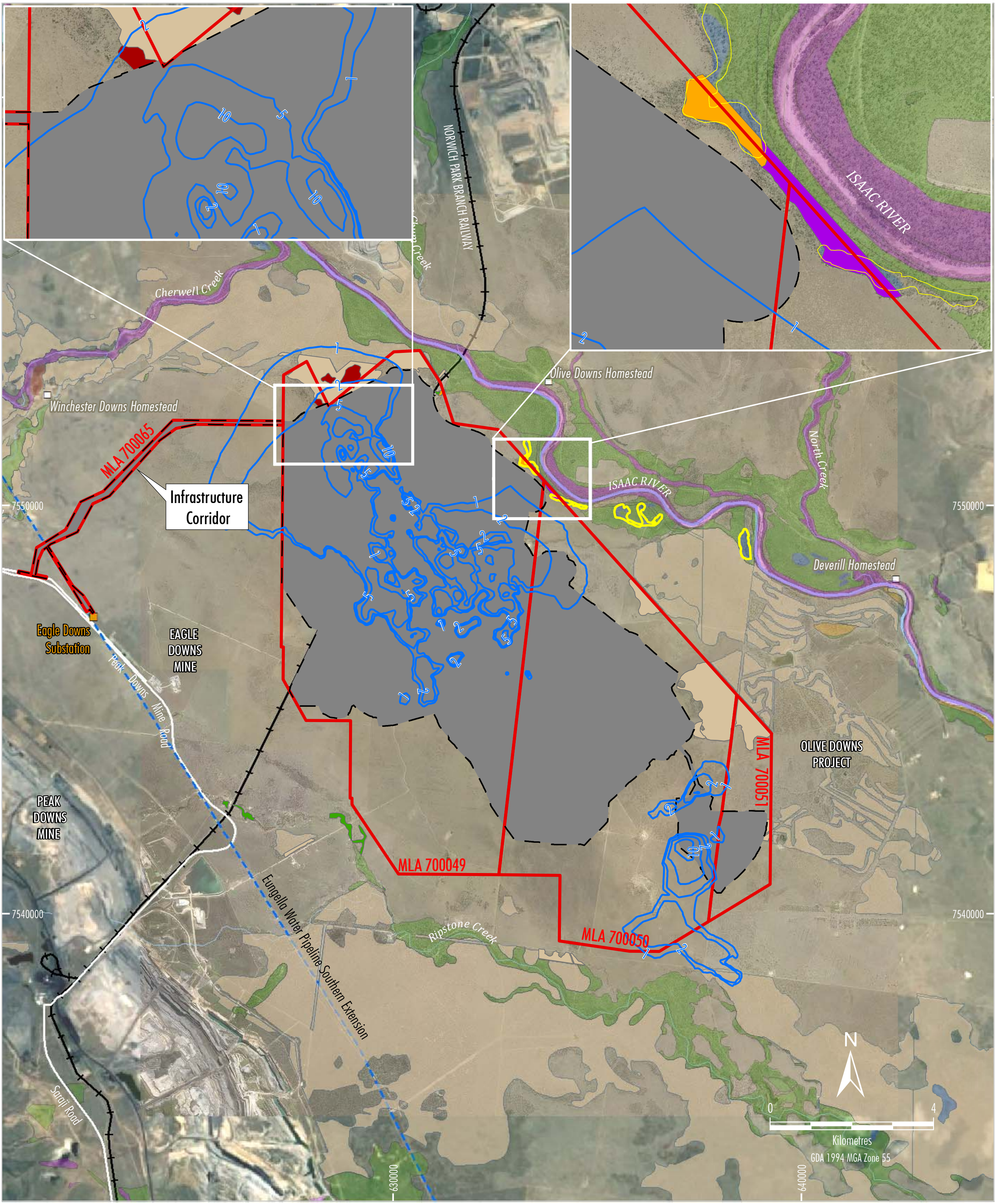
5.2.4 Vegetation in the Vicinity of the Project Mapped as Having Low Potential for Groundwater Interaction

As described in Section 4.4, there are various patches of woodland to the north and east of the Project that are mapped as having low potential for groundwater interaction due to sub-surface presence of groundwater (i.e. terrestrial GDEs) in the GDE Atlas (BoM, 2020).

The numerical groundwater modelling predicted areas of drawdown in the regolith, largely constrained to the Project area, and only extending up to approximately 1.7 km to the north-west and 1.5 km to the south-east of the Project (Figure 14) (SLR Consulting, 2021). The Project would result in a predicted drawdown of up to 5 m below the woodland to the north of Project (Figure 14).

It is concluded that these woodland patches have a low potential to meet the definition of a terrestrial GDE, and any dependency on groundwater in the regolith is likely to be facultative, during dry times, if at all. It is unlikely that these REs would be dependent on the groundwater due to the poor quality (high salinity) of the groundwater source. Therefore, a predicted drawdown of up to 5 m below the woodland to the north of Project is unlikely to have any material impacts on this woodland (E2M, 2021).

Further, there would be no impacts on the vegetation in the vicinity of the Project mapped as having low potential for groundwater interaction, as the Project would not result in adverse changes to groundwater quality, including the regolith (SLR Consulting, 2021).



LEGEND

- Mining Lease Application Boundary
- Indicative Surface Disturbance Extent
- Project Drawdown (Regolith)
- Substation

Vegetation Communities with Potential for Groundwater Dependence

Ground-truthed (E2M, 2021)

- RE 11.3.2
- RE 11.3.25
- RE 11.3.3c
- RE 11.3.4
- RE 11.5.3

State Mapped (Dominant) (DNRME, 2020)

- RE 11.3.25
- RE 11.3.2
- RE 11.3.3
- RE 11.3.4
- RE 11.3.27b
- RE 11.5.3
- Palustrine Wetland (ESP, 2021)

Source: The State of Queensland (2018 - 2020); Whitehaven (2020); E2M (2021); ESP (2021). Orthophoto: Google Image (2019); Whitehaven (2017).

WHITEHAVEN COAL

WINCHESTER SOUTH PROJECT

Terrestrial Vegetation and Predicted Drawdown in Regolith (Layer 2)

Figure 14

6 MITIGATION MEASURES AND MONITORING

6.1 WATER MANAGEMENT PLAN

A Water Management Plan (including a Groundwater Management Plan) would be prepared for the Project in consideration of the DES guideline for the *Preparation of water management plans for mining activities* (DERM, 2010) and would include:

- details of the potential sources of contaminants that could impact on water quality;
- a description of the water management system for the Project;
- measures to manage and prevent saline drainage and sodicity;
- measures to manage and prevent acid rock drainage;
- corrective actions and contingency procedures for emergencies; and
- a program for monitoring and review of the effectiveness of the Water Management Plan.

Every five years, the validity of the groundwater model predictions would be assessed and, if the data indicates significant divergence from the model predictions, the groundwater model would be updated.

Based on the detailed assessment undertaken as part of this GDE Assessment, monitoring of potential or actual GDEs is neither warranted nor necessary.

6.2 GROUNDWATER LEVEL MONITORING

A groundwater monitoring program would be established and would continue throughout the life of the Project. Recording of groundwater levels from existing monitoring bores vibrating wire piezometers (VWPs) would continue to enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts of the Project.

Each year, an annual review of groundwater level trends would be conducted by a suitably qualified person. The review would assess the change in groundwater level over the year, compared to historical trends and impact assessment predictions. The annual review would discuss any groundwater trigger exceedances or where data trends show potential for environmental harm.

6.3 GROUNDWATER QUALITY

Groundwater quality sampling would be conducted to monitor groundwater quality during the Project.

Groundwater quality monitoring would be undertaken on a quarterly basis. In addition to recording field parameters (EC and pH) quarterly, annual water sampling would be submitted to a National Association of Testing Authorities accredited laboratory for analysis of:

- physio-chemical indicators (TDS and total suspended solids [TSS]);
- major ions, hardness and ionic balance;
- total alkalinity as calcium carbonate ($CaCO_3$), bicarbonate (HCO_3), carbonate (CO_3);
- total and dissolved metals;
- nutrients; and
- organics.

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