PEMBROKE

Olive Downs Coking Coal Project
Additional Information to the
Environmental Impact Statement

Appendix E

Assessment of Groundwater Dependant Ecosystems and Wetlands

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1 INTRODUCTION

Pembroke Olive Downs Pty Ltd (Pembroke) proposes to develop the Olive Downs Coking Coal Project (herein referred to as the Project), a metallurgical coal mine and associated infrastructure within the Bowen Basin, located approximately 40 kilometres (km) south-east of Moranbah, Queensland (Figure 1). The Project provides an opportunity to develop an open cut metallurgical coal resource within the Bowen Basin mining precinct that can deliver up to 20 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal.

The Project comprises the Olive Downs South and Willunga domains and associated linear infrastructure corridors, including a rail spur connecting to the Norwich Park Branch Railway, a water pipeline connecting to the Eungella pipeline network, an electricity transmission line (ETL) and access roads (Figure 2). The coal resource would be mined by conventional open cut mining methods, with product coal to be transported by rail to the Dalrymple Bay Coal Terminal. Up to 20 Mtpa of ROM coal would be extracted over the anticipated Project operational life of approximately 79 years.

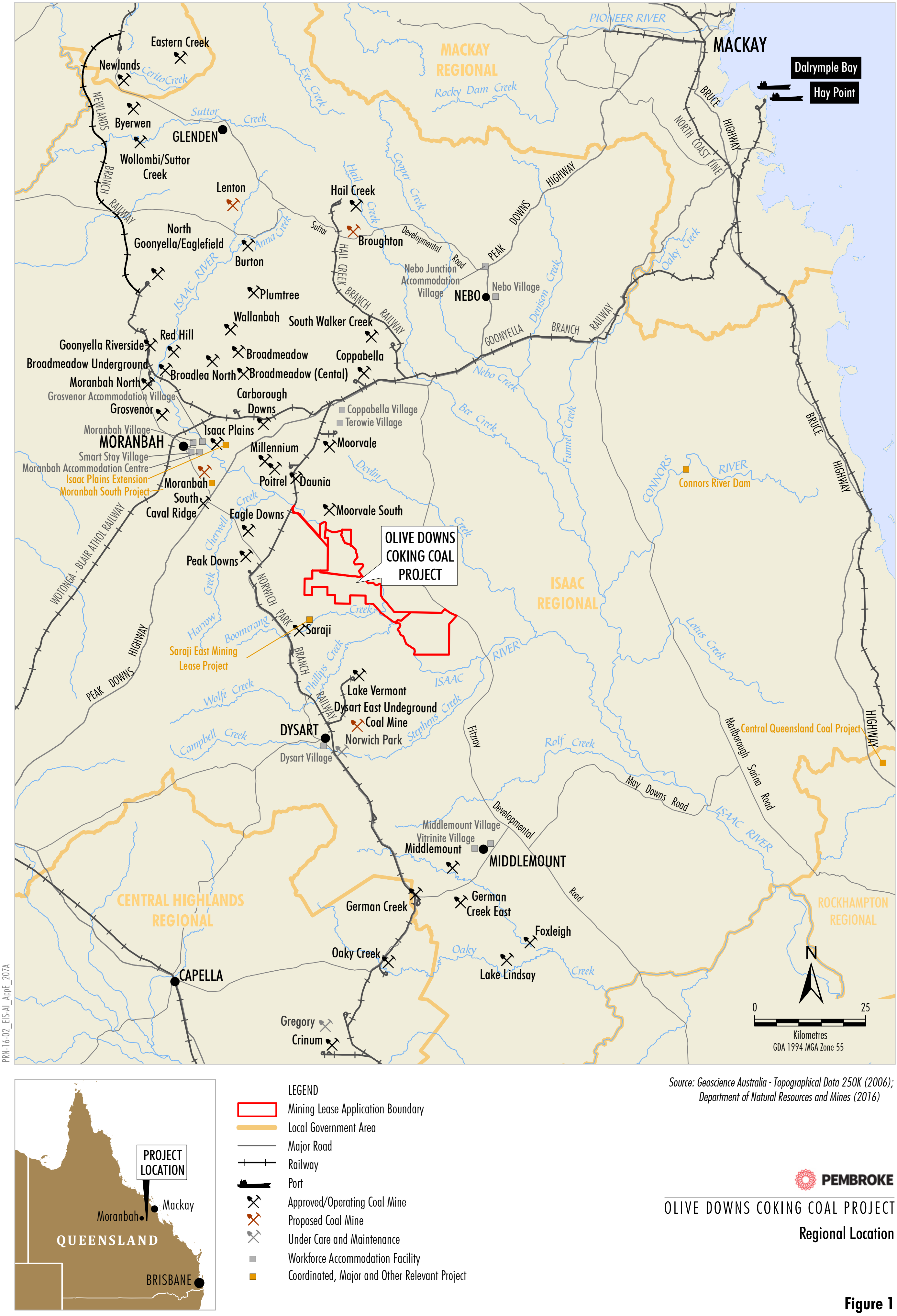
The four key Project components were referred to the Commonwealth Department of Environment and Energy (DEE) via separate referrals on 24 January 2017, namely:

- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867) (herein referred to as the Mine Site and Access Road);
- Olive Downs Project Water Pipeline (EPBC 2017/7868) (herein referred to as the Water Pipeline);
- Olive Downs Project Electricity Transmission Line (EPBC 2017/7869) (herein referred to as the Project ETL); and
- Olive Downs Project Rail Spur (EPBC 2017/7870) (herein referred to as the Rail Loop and Spur).

On 3 March 2017 the four key Project components were determined to be 'Controlled Actions' requiring assessment and approval under the EPBC Act. The following controlling provisions apply for each proposed action under the EPBC Act:

- Mine Site and Access Road;
  - listed threatened species and communities (sections 18 and 18A);
  - listed migratory species (sections 20 and 20A);
  - a water resource, in relation to coal seam gas development and large coal mining development (sections 24D and 24E).
- Water Pipeline;
  - listed threatened species and communities (sections 18 and 18A);
- Project ETL;
  - listed threatened species and communities (sections 18 and 18A); and
- Rail Spur and Loop;
  - listed threatened species and communities (sections 18 and 18A).

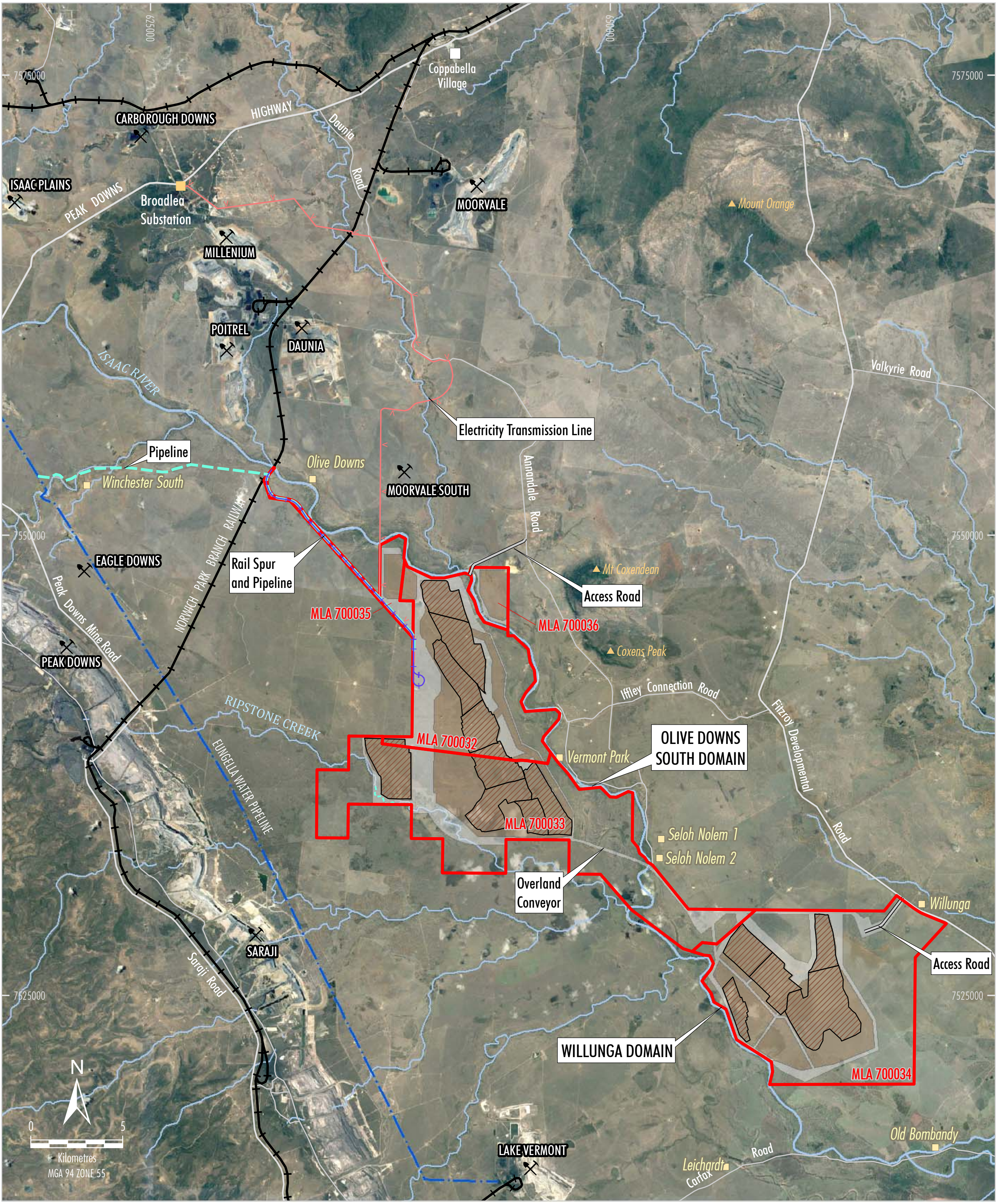
The *Environment Protection and Biodiversity Conservation Amendment Act 1999* provides that all water resources are a matter of national environmental significance (MNES) in relation to large coal mining development. Given this, and the listed controlling provision identified above, it should be noted that impacts to *a water resource, in relation to coal seam gas development and large coal mining development* (sections 24D and 24E) is considered to be relevant to all water sources (groundwater and surface water) in relation to the Mine Site and Access Road.



OLIVE DOWNS COKING COAL PROJECT

Regional Location

Figure 1



LEGEND

- Mining Lease Application Boundary
- Approved/Operating Coal Mine
- Dwelling
- Eungella Pipeline Network
- Railway
- Proposed Access Road
- Proposed Electricity Transmission Line
- Proposed Rail
- Proposed Water Pipeline
- Proposed Creek Diversion
- Open Cut Pit Extent
- Out-of-Pit and In-Pit Waste Rock Emplacement
- Infrastructure Area

Source: Geoscience Australia - Topographical Data 250K (2006)
Queensland Department of Natural Resources and Mines (2016)
Orthophotography: Google Image (2016)

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Project General Arrangement

Figure 2

On 27 July 2018, Pembroke lodged the draft Environmental Impact Statement (EIS) for the Project. The exhibition period for the draft EIS commenced on 12 September 2018 and concluded on 10 October 2018.

Following the public exhibition period, Pembroke received various comments from government agencies raising concern regarding the potential impacts of the Project on groundwater dependent ecosystems (GDEs) and wetlands.

Descriptions of the existing environment and potential impacts to water resources within the Project area and broader locality were presented in various sections throughout the draft EIS. Following the public exhibition of the draft EIS, Pembroke received various comments from government agencies raising concern regarding the potential impacts of the Project on GDEs and wetlands. Pembroke has prepared this stand-alone document to address these concerns, including through the provision of additional information, with particular reference to the following specialist reports, chapters and supporting reports/studies:

- *Olive Downs Coking Coal Project – Terrestrial Flora Assessment* (Appendix A of the draft EIS).
- *Olive Downs Coking Coal Project – Aquatic Ecology Assessment* (Appendix C of the draft EIS), including:
  - Chapter 6.5: Subterranean Fauna (Stygofauna); and
  - Chapter 6.6: Groundwater Dependent Ecosystems.
- *Olive Downs Coking Coal Project – Groundwater Assessment* (Appendix D of the draft EIS).
  - *AgTEM Groundwater Investigation for Olive Downs Coking Coal Project – July 2017* (Groundwater Imaging Pty Ltd, 2017).
- *Olive Downs Coking Coal Project – Surface Water Assessment* Appendix E of the draft EIS).
  - *Olive Downs Coking Coal Project – Technical Study Report Geomorphology*.
- *Olive Downs Coking Coal Project – Flooding Assessment* (Appendix F of the draft EIS).

The Groundwater Assessment and Surface Water Assessment were peer-reviewed by suitably qualified and experienced experts in their respective fields, including:

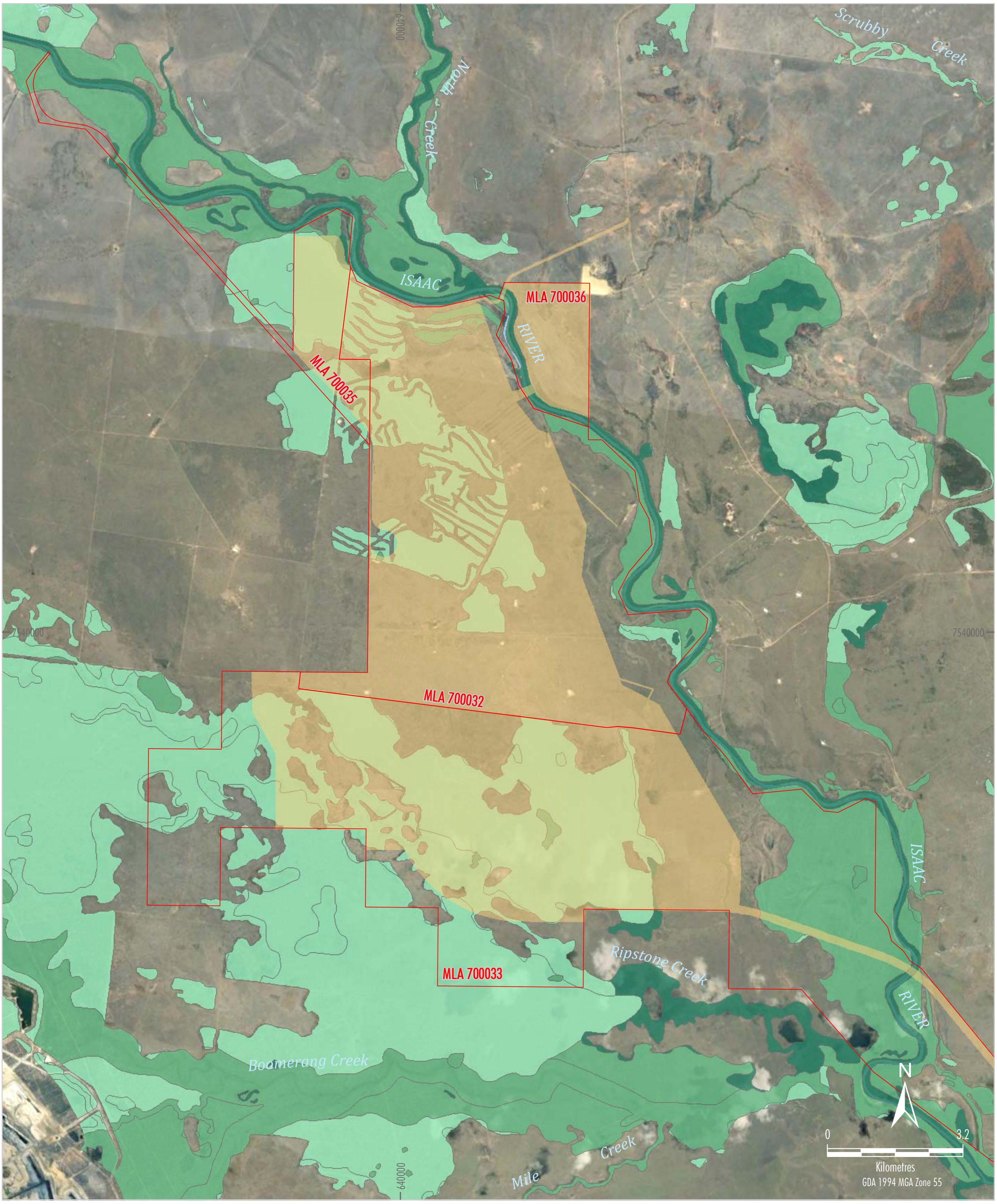
- Dr Frans Kalf (groundwater); and
- Mr Tony Marszalek (surface water).

2 DESKTOP ASSESSMENT OF GROUNDWATER DEPENDENT ECOSYSTEMS

GDEs are ecosystems that rely upon groundwater for their continued existence. GDEs may be completely dependent on groundwater, such as aquifer GDEs, or may access groundwater intermittently to supplement their water requirements, such as riparian tree species in arid and semi-arid areas (Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development [IESC], 2018).

Desktop mapping of potential GDEs throughout Queensland (Department of Science, Information Technology and Innovation [DSITI], 2017; Bureau of Meteorology [BOM], 2018) indicates terrestrial and aquatic ecosystems with possible high, moderate and low potential for groundwater interaction occur within the broader locality. As described in Appendix C of the draft EIS, the desktop GDE mapping (DSITI, 2017; BOM, 2018) shown on Figures 3 and 4, indicates:

- Terrestrial riparian vegetation associated with the Isaac River, North Creek, Cherwell Creek and Ripstone Creek is mapped as having a high potential to be dependent on subsurface expression of groundwater (Figures 3a and 3b).
- Aquatic habitat within the Isaac River, North Creek, Cherwell Creek and smaller associated tributaries are mapped as having a high potential to be dependent on the surface expression of groundwater (Figures 4a and 4b).
- Terrestrial vegetation and aquatic habitat associated with a number of palustrine wetlands surrounding the Olive Downs South and Willunga domains are mapped as having a moderate potential to be associated with the surface expression of groundwater (Figures 3a and 3b).
- Of the remaining terrestrial vegetation within the Project locality, the majority is shown as having a low to moderate potential to be dependent on subsurface expression of groundwater, with vegetation near creeks/drainage lines mapped as having moderate potential (Figures 3a and 3b).



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LEGEND
- Mining Lease Application Area
- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Potential Groundwater Dependent Ecosystems (BOM, 2018)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018)

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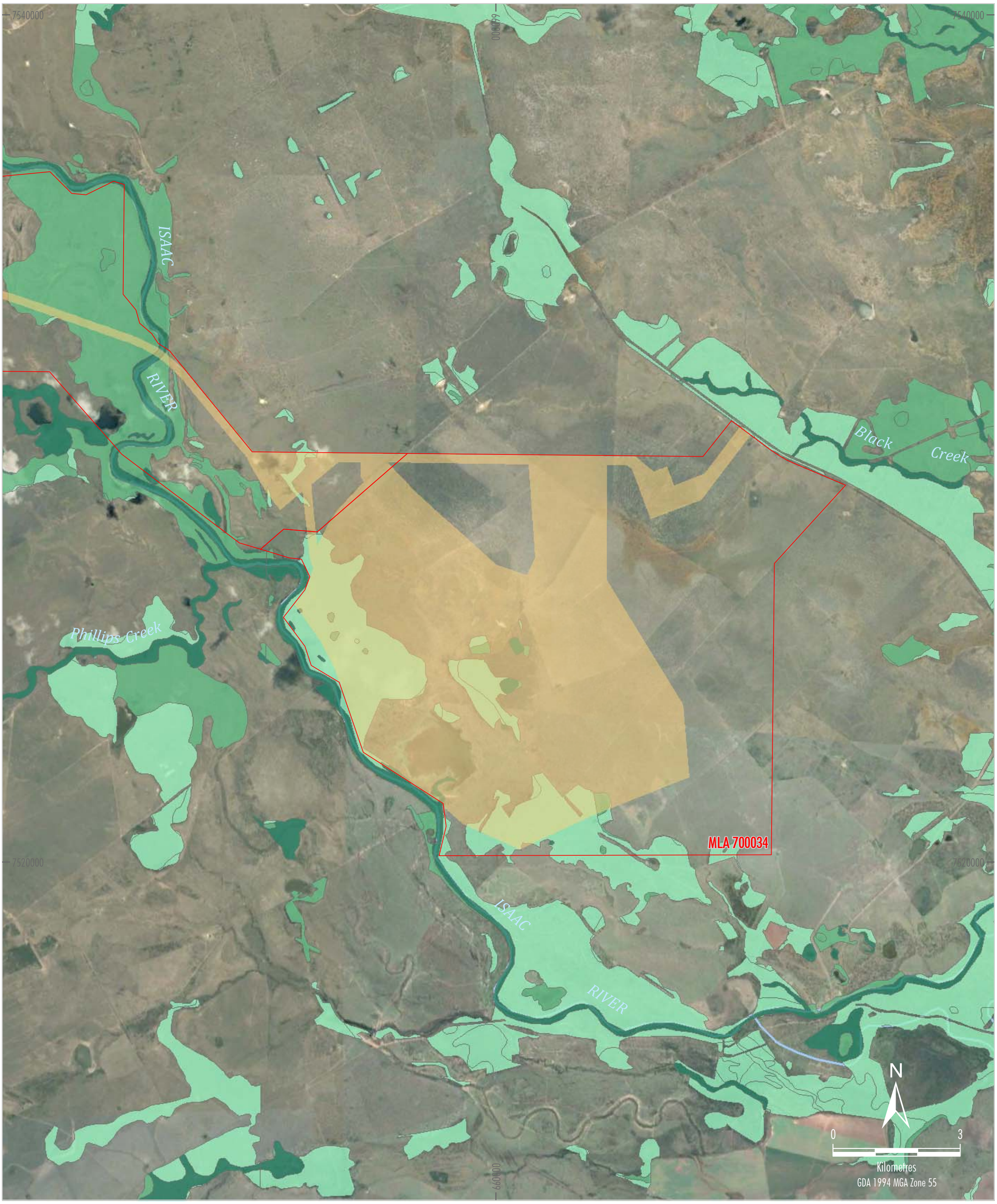
Potential Terrestrial Groundwater Dependent Ecosystems Olive Downs South Domain

Figure 3a



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LEGEND

- Mining Lease Application Area
- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Potential Groundwater Dependent Ecosystems (BOM, 2018)

- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018)

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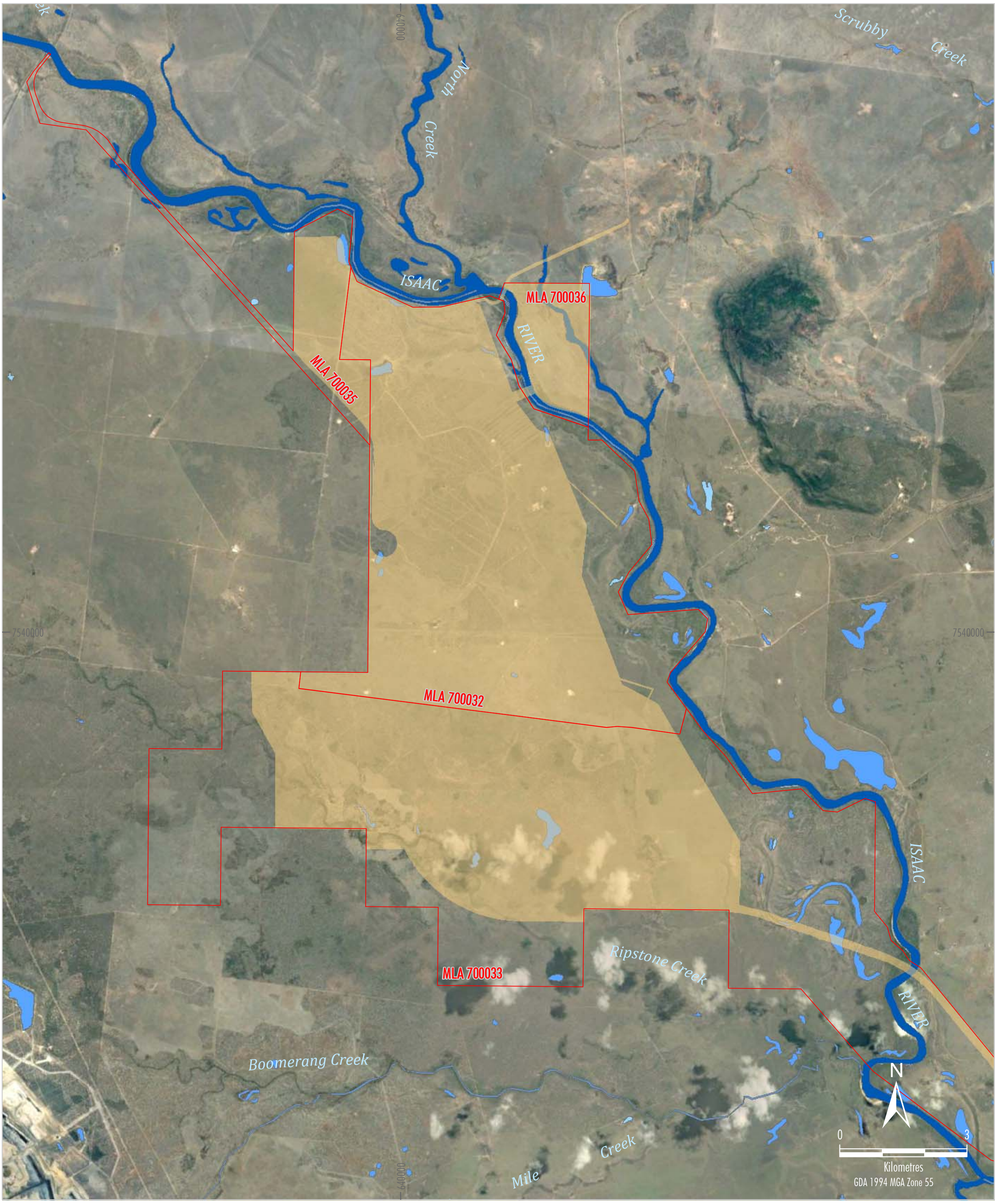
Potential Terrestrial Groundwater Dependent Ecosystems Willunga Domain

Figure 3b



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LEGEND

Mining Lease Application Boundary

Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Potential Groundwater Dependent Ecosystems (BOM, 2018)

High potential GDE (national assessment)

Moderate potential GDE (national assessment)

Low potential GDE (national assessment)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018)

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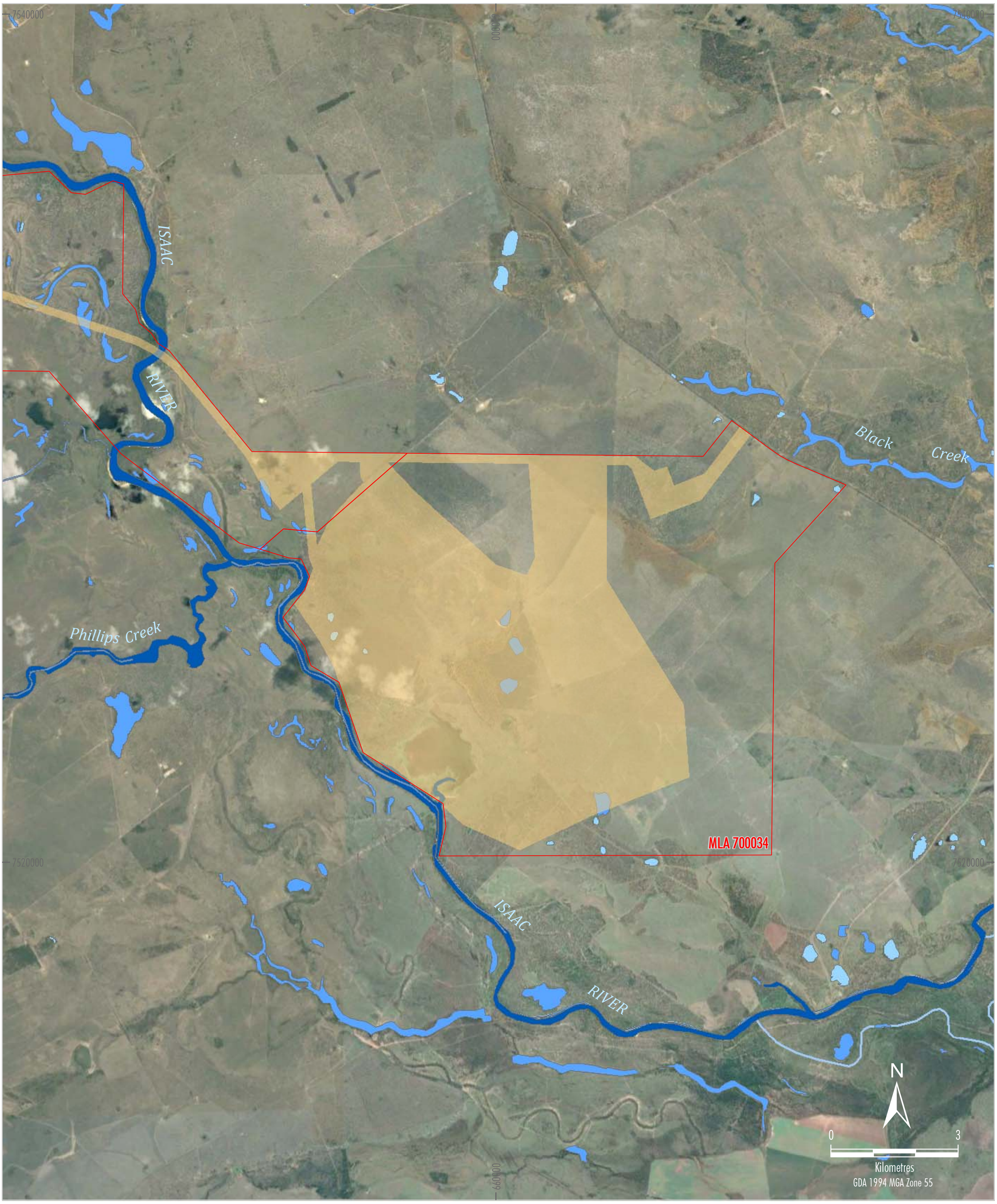
Potential Aquatic Groundwater Dependent Ecosystems Olive Downs South Domain

Figure 4a



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LEGEND
- Mining Lease Application Boundary
- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Potential Groundwater Dependent Ecosystems (BOM, 2018)
- High potential GDE (national assessment)
- Moderate potential GDE (national assessment)
- Low potential GDE (national assessment)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018)

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OLIVE DOWNS COKING COAL PROJECT
Potential Aquatic Groundwater Dependent Ecosystems Willunga Domain

Figure 4b

3 PRESENCE OF ALLUVIUM IN THE PROJECT AREA AND BROADER LOCALITY

3.1 REGIONAL GEOLOGY

The Project is located within the northern part of the Permo-Triassic Bowen Basin.

The Permian sediments occur at outcrop on the eastern and western edges of the basin and are unconformably overlain by the Triassic aged terrestrial sediments within the basin (Commonwealth Scientific and Industrial Research Organisation [CSIRO], 2015). The regional outcrop geology mapping shows the Permian Fair Hill Formation and Rangal Coal Measures (overlain by the Triassic Rewan Formation) across the Project area. Geological cross-sections are presented in the Groundwater Assessment (Appendix D of the draft EIS).

The Permian and Triassic sediments are covered by a thin veneer of unconsolidated to semi-consolidated Cainozoic sediments (Tertiary to Quaternary alluvium and colluvium). Broadscale geology testing, undertaken in 2011, by the Department of Environment and Resource Management (DERM), indicated the region is dominated by Tertiary sediments, with the Project area predominantly containing Cainozoic alluvium, as well as mixed Mesozoic sediments (Raymond and McNeil, 2011). The alluvial sediments are localised along rivers (i.e. Isaac River) and their tributaries.

The Australia 1:250,000 Geological Series depict surface geological units, which in the Project area comprised extensive undifferentiated sandy sediments and soils and Quaternary alluvium within river corridors. This suggests that sand bed rivers and streams would be naturally occurring in this region, and not necessarily the result of accelerated sediment delivery caused by land use change, although this process could have increased the rate of sand delivery to channels above background levels (Appendix E of the draft EIS).

3.2 TRANSIENT ELECTROMAGNETIC SURVEY

Alluvium is present in the Project area and broader locality on the northern and eastern edges of the Olive Downs South domain and on the western edge of the Willunga domain (Figure 5). The extent and thickness of the unconsolidated sediments were assessed using a transient electromagnetic (TEM) survey, verified with site geological logs, conducted by Groundwater Imaging Pty Ltd in July 2017 (Appendix D of the draft EIS).

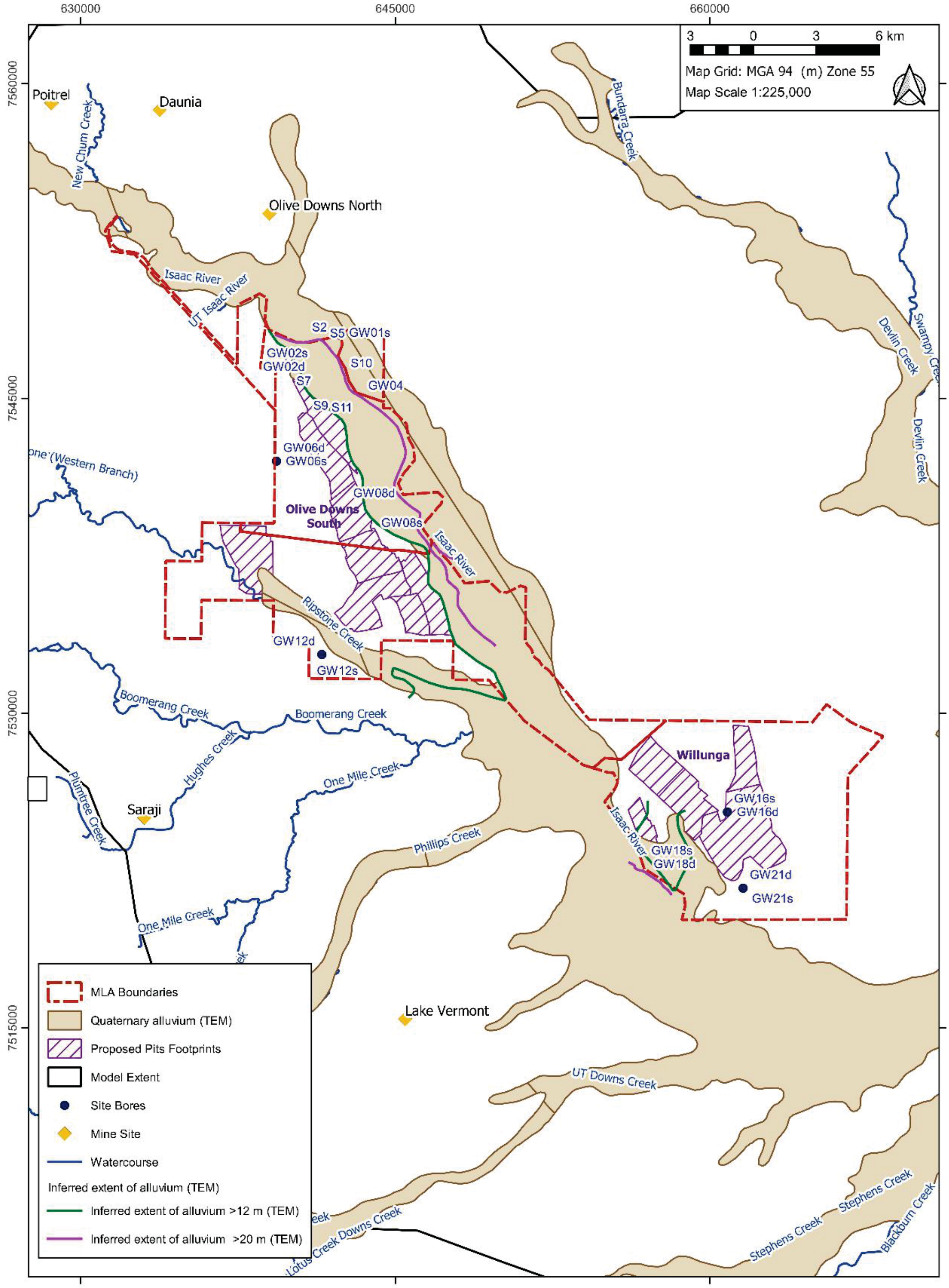
The TEM survey identified that alluvial sediments occur further west than are mapped by the Queensland Government at the Olive Downs South domain. These sediments are generally less than 12 metres (m) thick, but the alluvium can be up to 30 m thick within a narrow corridor along the Isaac River, thinning out with distance from the river (Figure 5) (Appendix D of the draft EIS).

The findings from the TEM survey, along with the CSIRO *Soil and Landscape Grid of Australia* (CSIRO, 2015) data and site geological logs have been used to refine the assessments of potential impacts to GDEs.

3.3 SATURATED THICKNESS IN ALLUVIUM

Of all the monitoring bores intersecting the tertiary/alluvium (18), four (GW04, GW08s, S2 and S11) have remained dry between June 2017 and February 2018. The remaining bores recorded a saturated thickness of between 2 to 12 m within the alluvium (Appendix D of the draft EIS).

The surficial alluvium along the upper reaches of tributaries to the Isaac River is largely dry, however, the alluvium of the Isaac River itself does appear saturated (Figure 6) (Appendix D of the draft EIS).



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Source Hydro Simulations (2018)

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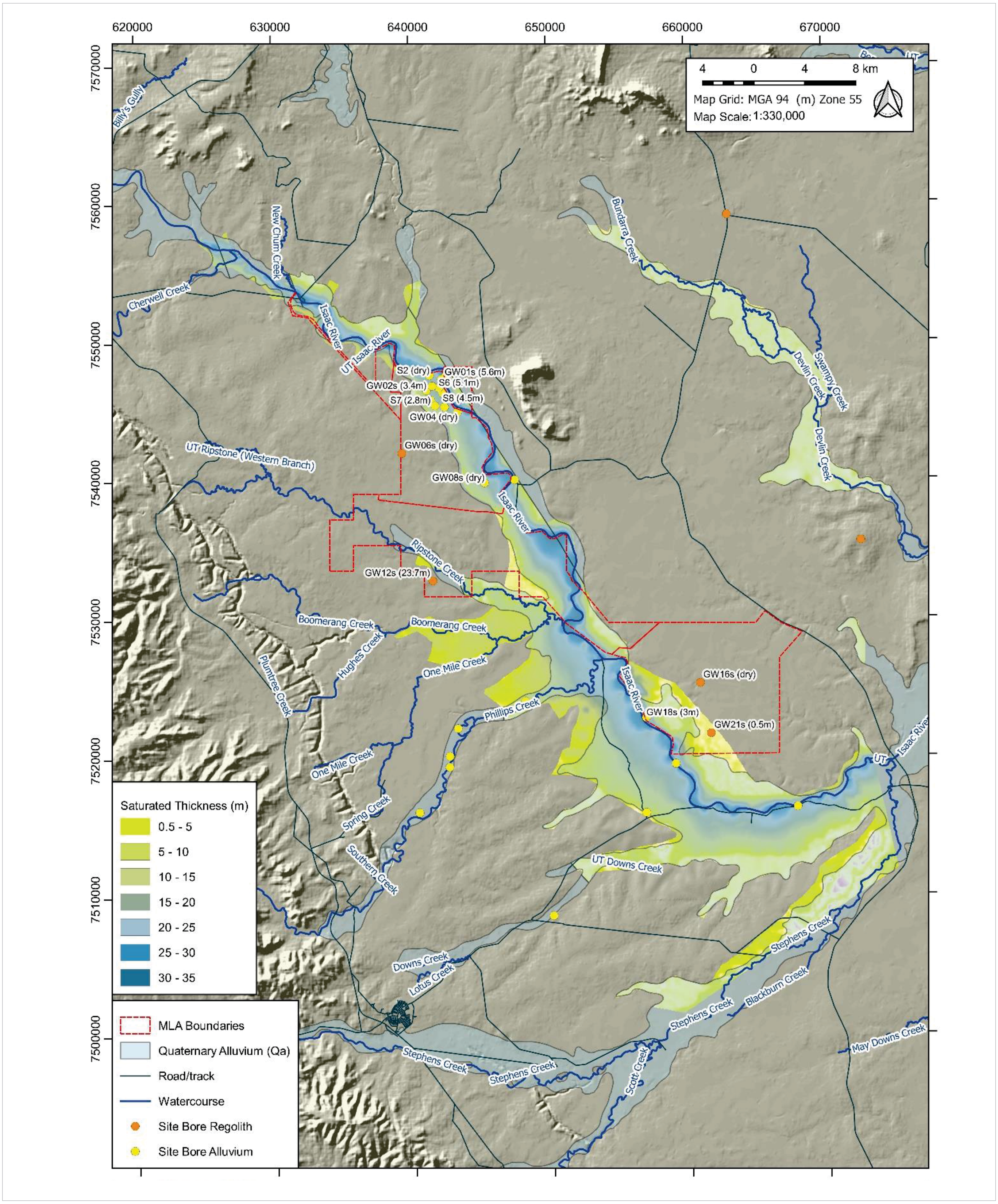
Site Alluvium

Figure 5



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Source Hydro Simulations (2018)

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Saturated Thickness in Alluvium

Figure 6

Alluvial groundwater levels at the Olive Downs South and Willunga domains are presented in the Groundwater Assessment (Appendix D of the draft EIS) including spatial contour distribution of the groundwater levels using a combination of water levels obtained in alluvial monitoring bores installed as part of the Project, and from water level observations collected during the landholder bore census survey. Groundwater within the alluvium is unconfined, with water levels generally between 10 to 20 metres below ground level (mbgl) (from the top of the unit) (Appendix D of the draft EIS).

The higher groundwater elevations (167 metres Australian Height Datum [m AHD]) were recorded for bores positioned closest to the Isaac River in the north-west (S8 and GW01s). Lower groundwater elevations (140 m AHD) at the Willunga domain in the south-east are approximately 13 mbgl (Appendix D of the draft EIS).

The water levels in the alluvium clearly follow the downstream flow gradient of the Isaac River, with south-easterly flow gradients (Appendix D of the draft EIS).

3.4 RECHARGE TO THE ALLUVIUM

Recharge to the alluvium is considered to be mostly from stream flow or flooding, with direct infiltration of rainfall also occurring where there are no substantial clay barriers in the shallow sub-surface. Groundwater within the alluvium is likely discharged as evapotranspiration from riparian vegetation growing along the Isaac River, as well as potential baseflow contributions after significant rainfall and flood events (Appendix D of the draft EIS).

The groundwater hydrographs presented in HydroSimulations (Appendix D of the draft EIS) demonstrate that the elevation of water (ponded or flowing) between June 2017 and February 2018 at the Deverill stream gauge (located approximately 200 m from bore GW01s that recorded levels more than 3 m below the river elevation) indicate losing conditions, that is no contribution to the baseflow component in the Isaac River at the Olive Downs South domain (Appendix D of the draft EIS).

Notwithstanding, occasional periods of contribution to baseflow in the Isaac River from the adjacent/underlying alluvium may occur after prolonged rainfall events or following flood events. Under these conditions, recharged alluvial sediments would drain to the river as the hydraulic gradient reverses and sustains stream-flow for a short period after the rainfall event (Appendix D of the draft EIS).

Geological logs indicate that the alluvium is underlain by low permeability stratigraphy (i.e. claystone, siltstone and sandstone) at the site, which likely restricts the rate of downward leakage to underlying formations.

Localised perched water tables within the alluvium are evident where waterbodies continue to hold water throughout the dry period (e.g. pools in the Isaac River and floodplain wetlands), occurring where clay layers slow the percolation of surface water (Appendix D of the draft EIS).

4 IDENTIFICATION OF POTENTIAL GROUNDWATER DEPENDENT ECOSYSTEMS USING SITE-SPECIFIC DATA

The accuracy of the desktop GDE mapping (DSITI, 2017; BOM, 2018) proximal to the Project was reviewed by HydroSimulations (Appendix D of the draft EIS) and DPM Envirosciences (Appendices A and B of the draft EIS). Identification of potential GDEs was undertaken based on site specific observations (e.g. identification of potentially groundwater dependent flora species and communities during the ecology surveys) and data collected during the preparation of the specialist studies identified in Section 1 (e.g. identification of depth to groundwater, extent of saturated alluvium).

4.1 TERRESTRIAL RIPARIAN VEGETATION

The terrestrial riparian vegetation associated with the Isaac River, North Creek, Cherwell Creek and the downstream reaches of Ripstone Creek may well have a high potential to be intermittently dependent on subsurface expression of groundwater (i.e. facultative GDEs) (Figure 7). This is because the vegetation (Regional Ecosystem [RE] 11.3.4, RE 11.3.25 and RE 11.3.27) comprises predominantly forest red gum (*Eucalyptus tereticornis*) and river oak (*Casuarina cunninghamiana*), both species which have been shown to access groundwater in other locations (IESC, 2018) and the alluvium appears to be saturated along the Isaac River and lower reaches of the creeks at the confluence with the Isaac River (HydroSimulations, pers. comm.).

An indicative cross-section of the riparian vegetation associated with the Isaac River demonstrating the occurrence of groundwater within the alluvium during and after significant rainfall events is shown on Figure 8.

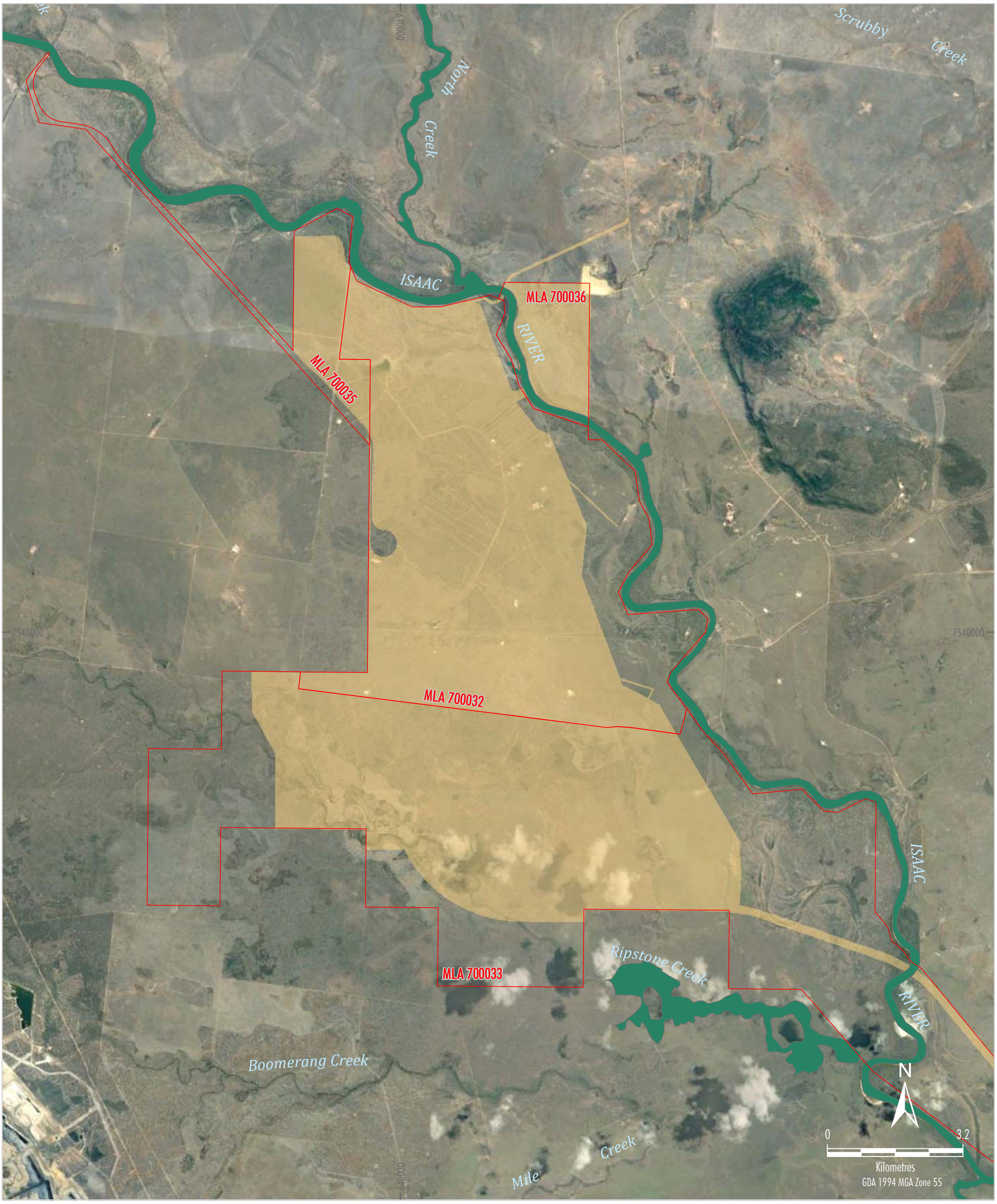
4.2 AQUATIC HABITATS

Aquatic habitat within Isaac River, North Creek, Cherwell Creek and smaller associated tributaries may also have a high potential to intermittently use the surface expression of groundwater during occasional periods of baseflow from the adjacent/underlying alluvium after prolonged rainfall events or following flood events (i.e. facultative GDEs) (Appendix D of the draft EIS) (Figure 9). Under these conditions, recharged alluvial sediments may drain to the watercourses as the hydraulic gradient reverses, the result of which may sustain stream-flow for short periods (in the order of days to possibly weeks in the lower reaches) depending on the sequence of rainfall events (Appendix D of the draft EIS).

An indicative cross-section of the aquatic habitats associated with the Isaac River demonstrating the occurrence of groundwater within the alluvium during and after significant rainfall events is shown on Figure 8.

4.3 TERRESTRIAL VEGETATION ASSOCIATED WITH WETLANDS

Terrestrial vegetation and aquatic habitat associated with the palustrine wetlands surrounding the Olive Downs South and Willunga domains are unlikely to constitute a GDE, given that groundwater levels in these areas have been identified as being in excess of 10 mbgl (Appendix D of the draft EIS). These wetlands are represented by RE 11.3.27 and RE 11.5.17 (Appendix A of the draft EIS), which contain predominantly river red gum (*Eucalyptus camaldulensis*), and coolabah (*Eucalyptus coolabah*) (DPM Envirosciences, pers. comm.).



LEGEND

Mining Lease Application Area

Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Terrestrial Riparian Vegetation Likely to be Groundwater Dependent Ecosystems Based on Field Surveys

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018), DPM Envirosciénce (2018)

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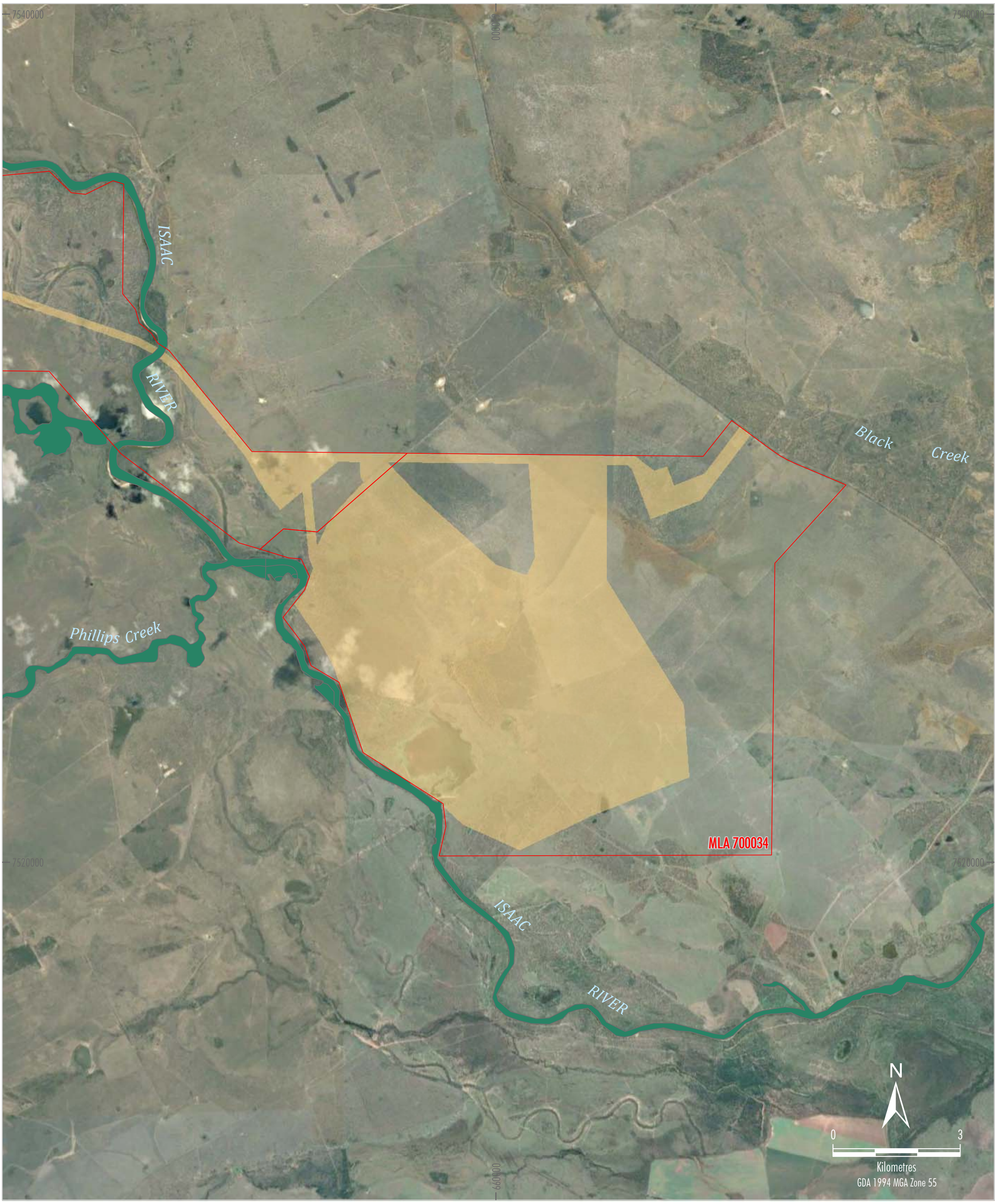
Likely Terrestrial Groundwater Dependent Ecosystems Olive Downs South Domain

Figure 7a



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LEGEND

Mining Lease Application Area

Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Terrestrial Riparian Vegetation Likely to be Groundwater Dependent Ecosystems Based on Field Surveys

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018), DPM Envirosciencе (2018)

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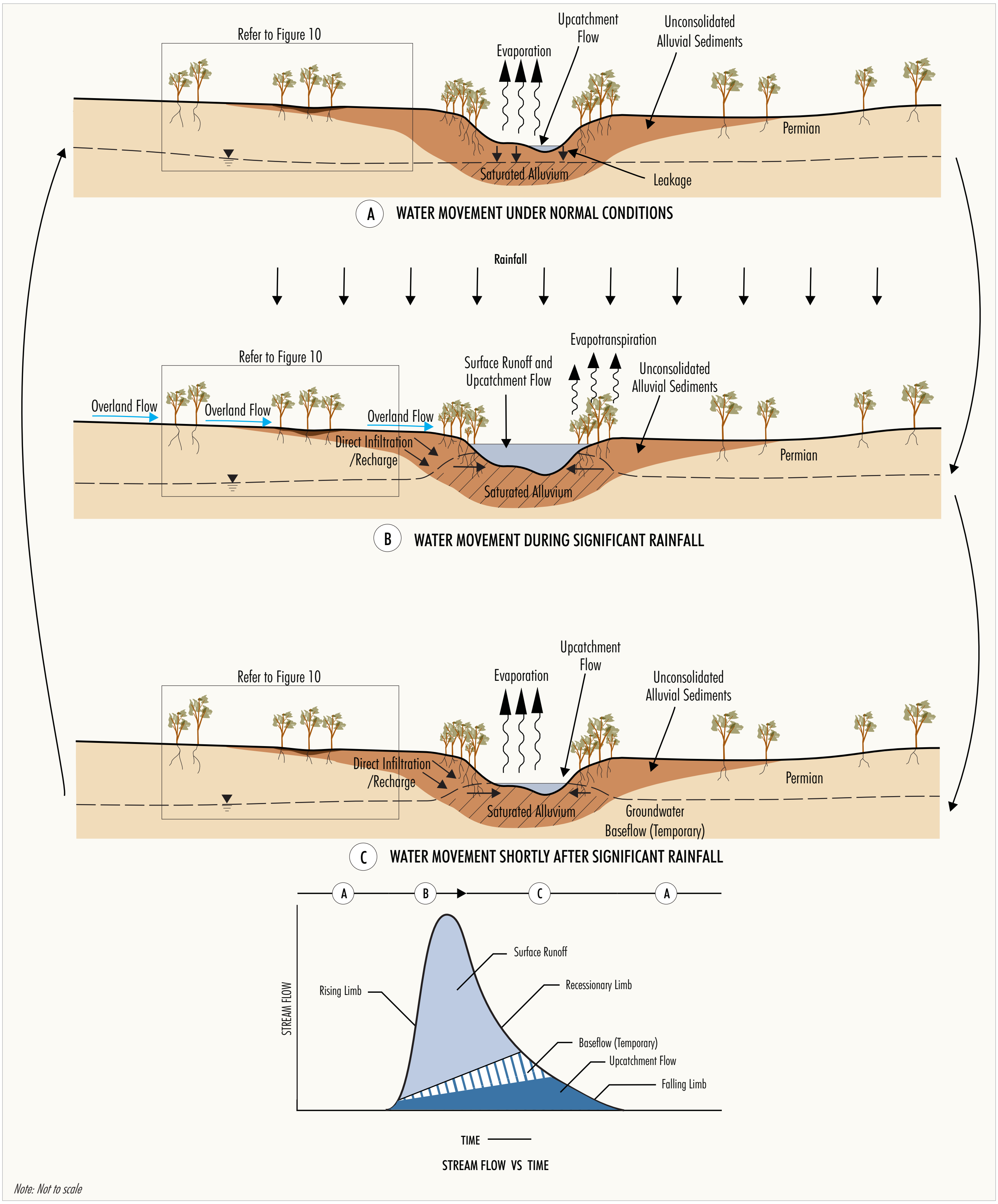
Likely Terrestrial Groundwater Dependent Ecosystems Willunga Domain

Figure 7b



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Note: Not to scale

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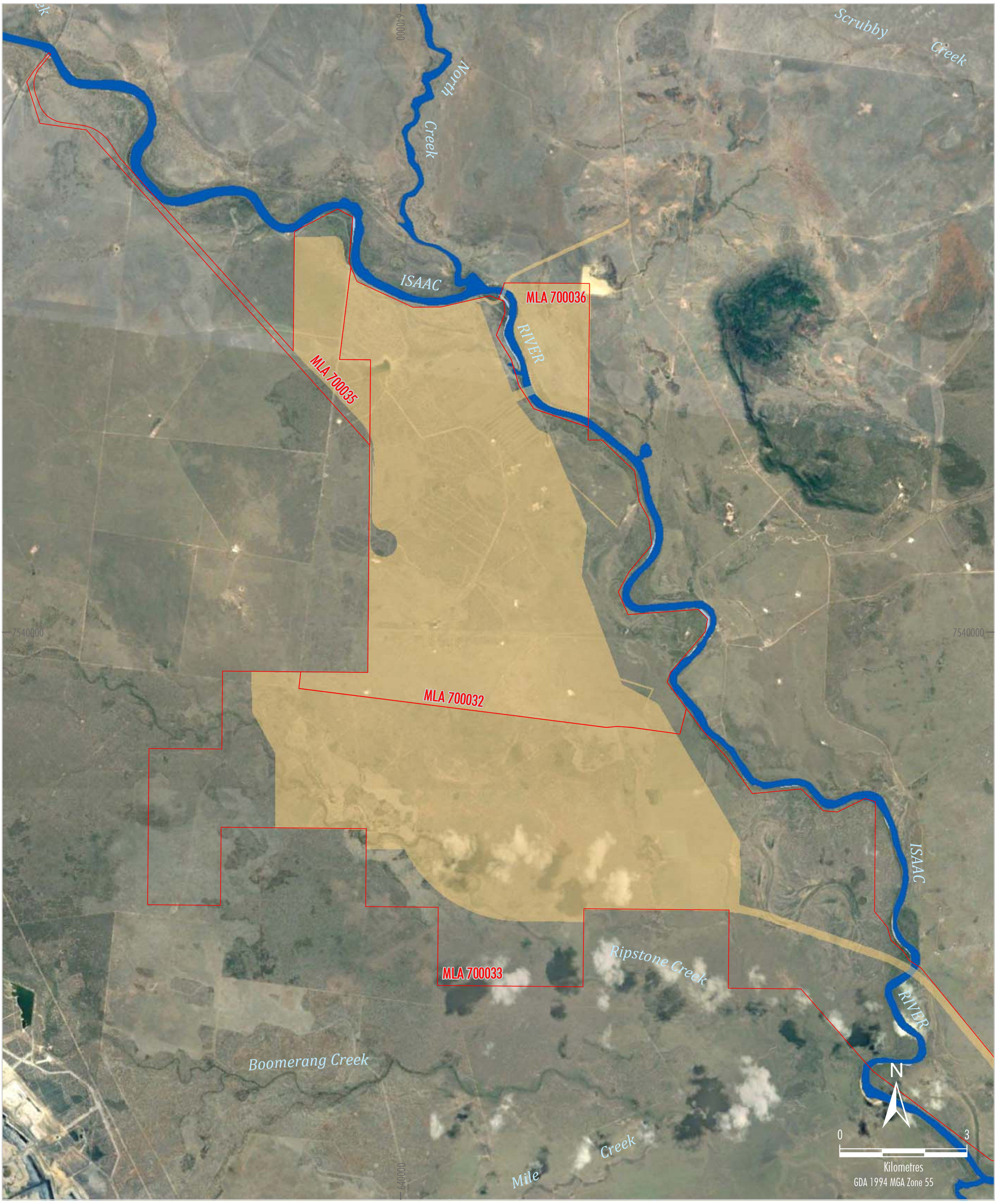
Waterflow Processes Schematic
Riparian Vegetation and Aquatic Habitat
Isaac River

Figure 8



LEGEND

Mining Lease Application Boundary

Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)

Aquatic Habitat Likely to be Groundwater Dependent Ecosystems Based on Field Surveys

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018), DPM Envirosciences (2018)
Orthophoto: Google Image (2015)

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Likely Aquatic Groundwater Dependent Ecosystems
Olive Downs South Domain

Figure 9a

PRN-16-02_EIS-AI_AppE_205B

LEGEND

- Mining Lease Application Boundary
- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)
- Aquatic Habitat Likely to be Groundwater Dependent Ecosystems Based on Field Surveys

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Bureau of Meteorology (2018), Pembroke (2018), DPM Envirosciences (2018)
Orthophoto: Google Image (2015)

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Likely Aquatic Groundwater Dependent Ecosystems
Willunga Domain

Figure 9b

The watertable depth where these species use groundwater is generally less than 6 mbgl (IESC, 2018), although the species root depths may be deeper (e.g. Colloff [2014] describes that roots of mature river red gums extend to depths of at least 9 to 10 mbgl, noting some recorded roots to a depth of 30 mbgl).

Despite this potential root depth, localised perched water tables within the alluvium are evident where waterbodies, such as these palustrine wetlands, continue to hold water throughout the dry period, occurring where clay layers slow the percolation of surface water (Appendix D of the draft EIS). It is likely that these wetlands rely on the slow percolation of surface water after rainfall events to sustain their health rather than on direct access to the groundwater system. An indicative cross-section of the wetland habitats demonstrating the occurrence of localised perched water tables is shown on Figure 10.

Given the above, the Project would not result in an adverse impact to these communities through any potential impacts to the groundwater system. Potential impacts to these wetlands are assessed in Section 6.

4.4 OTHER TERRESTRIAL VEGETATION

All other terrestrial vegetation (i.e. the remaining REs) within the Project locality, have a low likelihood of being dependent on the presence of groundwater as the vegetation comprises eucalypt dry woodlands dominated by Poplar Box (*Eucalyptus populnea*) and the groundwater table is at least 10 mbgl (Appendix D of the draft EIS), which would be too deep for these vegetation communities to rely upon. It is noted that Poplar Box is not listed by IESC (2018) as a species likely to be a GDE.

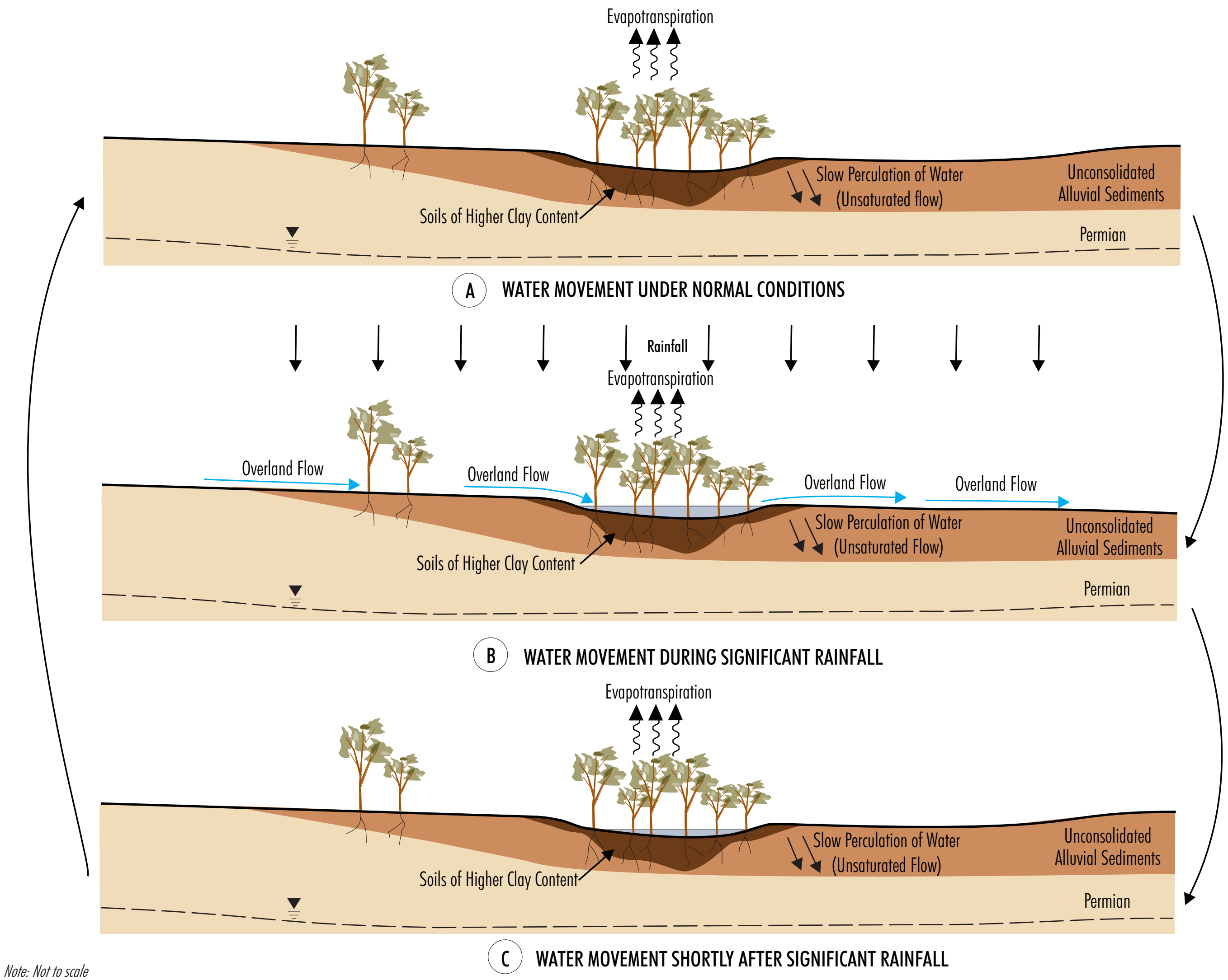
Although *E. populnea* are able to access groundwater below 10 m in some situations (such as those described by Kath *et al.* 2014), it is unlikely that these species would be dependent on the deeper groundwater in the locality of the Project due to the poor quality (high salinity) of the groundwater source (Appendix D of the draft EIS). It is more likely that these tree species rely intermittently on deep soil moisture infiltrating after rainfall above the more saline groundwater source.

4.5 STYGOFAUNA

The stygofauna assessment provided in Appendix C of the draft EIS comprised a desktop review of potential habitat and sampling (conducted in accordance with the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITIA, 2014).

A pilot survey was carried out to sample the local presence of subterranean aquatic fauna in consideration of the *Guideline for the Environmental Assessment of Subterranean Aquatic Fauna* (DSITIA 2015). HydroSimulations (Appendix D of the draft EIS) installed 17 groundwater monitoring bores in nine locations across the broader locality from November 2016 to March 2017, comprising eight paired bores (one shallow and one deep) and a single shallow bore.

HydroSimulations (Appendix D of the draft EIS) recorded the characteristics of the groundwater (standing water level [SWL], pH and electrical conductivity [EC]) for each of the bores installed. Of the nine shallow bores, only two were suitable for stygofauna sampling (GW01-S and GW18-S) (Appendix C of the draft EIS), as four bores were dry and two were hypersaline (>20,000 µS/cm) and were therefore considered unlikely to be suitable for stygofauna. Although a literature review conducted by Glanville et al. (2016) indicates that a stygofauna has been recorded in hypersaline, these environments typically provide limited habitat for stygofauna, as demonstrated by the general negative trend between stygofauna richness and EC identified in Glanville et al. (2016). This is further supported by the fact that the average and median EC values which stygofauna were identified in Glanville et al. (2016) was less than 4,000 µS/cm.



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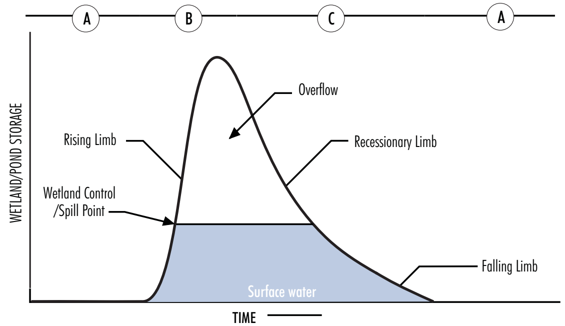
Note: Not to scale

Source: Hatch (2018)



WETLAND/POND STORAGE VS TIME

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Waterflow Processes Schematic
Wetlands

Figure 10

All suitable bores (two) were sampled. HydroSimulations (Appendix D of the draft EIS) incorporated slot widths of 1.5 mm into the screened interval of these bores so that they are also suitable for stygofauna sampling (Appendix C of the draft EIS). Although the number of bores dipped (two) was lower than the preferred number described in the guidelines (10), this limitation is acknowledged in the recently released IESC *Information Guidelines Explanatory Note: Assessing Groundwater-Dependent Ecosystems* (IESC, 2019):

> *… stygofauna surveys usually rely on access to an already existing bore network, which limits where samples can be collected and the number of suitable bores available for each aquifer type.*

4.6 SUMMARY

In summary, the terrestrial riparian vegetation (RE 11.3.4 and RE 11.3.25) and aquatic habitats associated with the Isaac River are likely to be facultative GDEs (Figures 7, 8 and 9). The terrestrial riparian vegetation (RE 11.3.25) associated with the North Creek, Cherwell Creek and the downstream reaches of Ripstone Creek may also be facultative GDEs. The terrestrial vegetation (RE 11.3.27 and RE 11.5.17) and aquatic habitat associated with the palustrine wetlands are unlikely to be GDE (Figure 10).

5 POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

5.1 CLEARANCE OF GROUNDWATER DEPENDENT ECOSYSTEMS

5.1.1 Terrestrial Riparian Vegetation

Small area of terrestrial vegetation associated with the Isaac River, and likely to be facultative GDEs, would be removed by the Project through direct clearance. The clearance is associated with mine site access road, haul road to the eastern emplacement and the overland conveyor (Figure 7). A total of approximately 6 ha of terrestrial vegetation likely to be a GDE would be cleared.

5.1.2 Aquatic Habitats

Although the Project would require crossing of the Isaac River, and associated aquatic habitat (Figure 9), all watercourse crossings would be constructed with consideration to the relevant waterway zoning maps. This would allow Pembroke to apply the appropriate management measures in accordance with the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF, 2017b) (i.e. using box culverts to permit crossing during low flow events, enabling flow through the watercourses to be maintained within the Project area). As a result, the Project would not result in the direct removal of any aquatic habitat likely to be a GDE.

5.2 POTENTIAL GROUNDWATER DRAWDOWN

5.2.1 Terrestrial Riparian Vegetation

The areas of terrestrial riparian vegetation (RE 11.3.25 and RE 11.3.4) associated with the Isaac River are likely to be facultative GDEs, following period of heavy rainfall, when the thickness of saturate alluvium increases to the extent that these communities may be able to access it (Figures 7 and 8). In addition, the areas of terrestrial riparian vegetation along the downstream reaches of Ripstone Creek may also be facultative GDEs. These communities are unlikely to constantly rely on access to the groundwater under normal conditions for their survival (Figure 8).

Groundwater drawdown predictions were modelled by HydroSimulations (Appendix D of the draft EIS), indicating that drawdown in the alluvium is only predicted to reach/extend past the Isaac River in a 4 km stretch of the Isaac River at the very northern extent of the Project area and a 2.5 km stretch of the Isaac River adjacent to the Willunga domain. The drawdown in these areas is not expected to exceed 2 m, while the potential drawdown at the downstream reaches of Ripstone Creek may reach up to 5 m (Appendix D of the draft EIS).

Although the potential drawdown of approximately 2 to 5 m is predicted to occur in areas where vegetation may be intermittently dependent on subsurface expression of groundwater, it is unlikely that this potential impact would result in a significant impact to terrestrial riparian vegetation. This is due to the fact that this vegetation is subject to continuous (natural) wetting and drying cycles and these communities are most likely facultative GDEs which rely more heavily on the replenishment of moisture in the soil following rainfall rather than access to the groundwater system (as shown on Figure 8). The Project would not result in a drawdown in the alluvial aquifers that would dewater the aquifer to the extent that it would not recover following rainfall (HydroSimulations, pers comm.).

As described in Section 4.1, the terrestrial riparian vegetation associated with North Creek and Cherwell Creek may also be a GDE. The terrestrial riparian vegetation and aquatic habitats along North Creek and Cherwell Creek are unlikely to be impacted by the Project as they are located outside the extent of the potential drawdown shown in Appendix D of the draft EIS (HydroSimulations, pers comm.).

5.2.2 Aquatic Habitats

The aquatic habitat associated with the Isaac River, North Creek, Cherwell Creek and downstream reaches of Ripstone Creek may be a facultative GDE at times for a short period after significant rainfall events (Section 4.2) (Figure 9). However, the watercourses are ephemeral and the aquatic species that occur within these habitats are adapted to wetting and drying cycles as shown on Figure 8.

The Project is unlikely to result in any noticeable impacts to baseflow contributions (as detailed in Section 3.4) to North Creek or Cherwell Creek, given that these creeks are outside the potential zone of influences of the Project (HydroSimulations, pers comm.).

Appendix D of the draft EIS predicts that the Project would result in a potential 0.5% reduction in flow within the Isaac River during mining operations. It should be noted that this potential reduction only applies to the reach of the Isaac River adjacent to the Project area. Given the ephemeral nature of the Isaac River and the small local contribution of baseflow, which only occurs after periods of prolonged rainfall, this predicted reduction in baseflow is expected to have only a minimal impact on aquatic habitat within the Isaac River and associated tributaries.

The aquatic species that inhabit these waterways have adapted to wetting and drying cycles and are expected to persist in the environment despite the potential reduction in baseflow. Hydrosimulations (Appendix D of the draft EIS) also considered potential baseflow impacts to Ripstone Creek and concluded that there would be no discernible change in baseflow contributions.

5.2.3 Final Voids

The Groundwater Assessment prepared by HydroSimulations (Appendix D of the draft EIS) describes that interference of the alluvial groundwater associated with the final voids largely relates to increased leakage to the underlying Permian coal measures that are depressurised as a result of the Project.

The modelling results show that the recovered heads in the backfilled waste rock at the Olive Downs South and Willunga domains are very similar to and/or below the adjacent alluvium (HydroSimulations, pers comm.).

Although the final voids would result in continual take of groundwater from the adjacent alluvium, it is unlikely that this potential impact would result in a significant impact to any GDEs surrounding the Project. This is due to the fact that the vegetation in these locations is subject to continuous (natural) wetting and drying cycles and any potential GDEs are most likely facultative GDEs that rely more heavily on the replenishment of moisture in the soil following rainfall rather than access to the groundwater system (Appendix A of the draft EIS). As stated in Section 5.2.1, the Project would not result in a drawdown in the alluvial aquifers that would dewater the aquifer to the extent that it would not recover following rainfall, as demonstrated in Figure 8 (Appendix D of the draft EIS).

5.3 POTENTIAL IMPACTS TO GROUNDWATER QUALITY

5.3.1 Waste Rock Emplacement Areas

As the mine progresses, waste rock material would be placed in out-of-pit and in-pit emplacement areas. Seepage may occur from the base of the waste rock emplacement areas as a result of rainfall inundation.

Leachate analysis of the waste rock material, conducted as part of the draft EIS, found that waste rock material was non-acid forming, fresh (electrical conductivity of 158 µS/cm to 1,050µS/cm) and low in sulphur content (4 mg/L to 92 mg/L) (Appendix D of the draft EIS). The waste rock material exhibits similar water quality compared to water within regolith material (the surficial material that covering much of the Project site), however, it is of generally poorer quality compared to the alluvium (Appendix D of the draft EIS).

Where the low permeability surficial clays are present, potential seepage from the waste rock emplacement to the underlying regolith and alluvium would be inhibited which reduces the potential for impacts on groundwater quality. Clay layers are interspersed as lenses throughout the regolith and alluvium. Monitoring of groundwater levels within the alluvium in the Olive Downs South and Willunga domains indicates a lack of response to rainfall trends which indicates the presence of surficial clays restricting groundwater recharge (Appendix D of the draft EIS).

Seepage from in-pit emplacements is not expected to migrate to the surrounding alluvium, as the groundwater level that would ultimately equilibrate within the waste rock would be below the base of the alluvium (Appendix D of the draft EIS). Groundwater levels within the in-pit emplacements are predicted to recover to approximately 140 mAHD to 161 mAHD in the north of the Olive Downs South domain, and approximately 25 mAHD to 100 mAHD in the south of the Olive Downs South domain. Groundwater levels within the Willunga domain backfilled open cuts would recover to approximately 143 mAHD (Appendix D of the draft EIS).

In cases where the groundwater level within the in-pit waste rock emplacement could occur above the base of the alluvium (in the fully backfilled Pit ODS1 at the northern end of the Olive Downs South domain and Pit WIL1 in the Willunga domain), examination of paired simulated hydrographs in the waste rock and in the adjacent alluvium shows that there would be no hydraulic gradient from the waste to the alluvium (i.e. groundwater levels in the waste rock would be lower than groundwater levels in the adjacent alluvium) (Appendix D of the draft EIS). Given this, the Project is not expected to have a significant impact on groundwater quality that would lead to any adverse impact on potential GDEs.

5.3.2 Final Voids

Water within final voids would evaporate from the lake surface and draw in groundwater from the surrounding geological units. Evaporation from the lake surface would concentrate salts in the lake slowly over time (Appendix D of the draft EIS). This gradually increasing salinity is not expected to pose a risk to the surrounding groundwater regime as the final voids are predicted to remain permanent sinks (i.e. no hydraulic gradient driving water from the final void pit lakes to groundwater sources) (Appendix D of the draft EIS). Given that the final voids would be sinks, the final voids are not expected to result in any adverse groundwater quality related impacts on GDEs.

5.4 FLOODING

The Flood Assessment prepared by Hatch (Appendix F of the draft EIS) for the Project determined that areas that are 'wet now dry' are those behind the temporary levees, permanent highwall emplacements and waste rock emplacements within the disturbance footprint of the Project. That is, the ecological values of these areas have already been considered and offset (where appropriate) during the assessment of impacts of the mining/development activities in Appendices A and B of the draft EIS.

Hatch (Appendix F of the draft EIS) concludes that the Project is not considered to result in any significant change to the existing flood risk for surrounding privately-owned properties or infrastructure. Cumulative impacts on flooding are not expected to lead to any significant adverse impacts on human populations, property or other environmental or social values.

Updated flood modelling to reflect the final (detailed) design of the temporary levees and waste rock emplacements would be undertaken prior to construction as part of the detailed design and at regular stages during the life of the Project, as described in the Water Management Plan.

5.5 STYGOFAUNA

As indicated in Section 4.5, all available groundwater bores within the predicted groundwater drawdown extent were sampled to detect the presence of stygofauna, yet no stygofauna were recorded (Appendix C of the draft EIS). Despite this, an assessment of potential impacts to stygofauna was conducted by DPM Envirosciences (Appendix C of the draft EIS) assuming that stygofauna are present within the alluvium.

The stygofauna desktop review and water quality analysis indicate that stygofauna could potentially occur in the alluvium associated with the Isaac River. The alluvium along the upper reaches of tributaries to the Isaac River is typically dry, however, the alluvium of the Isaac River itself is saturated (Figure 6). As shown on Figure 6, the saturated thickness of the alluvium along the Isaac River is up to 35 m (Appendix D of the draft EIS). Recharge to the alluvium is intermittent, and mostly as a result of stream flow or flooding following rainfall (Appendix D of the draft EIS).

The alluvium is not limited to the Project area and appears to be saturated along the Isaac River and lower reaches of the creeks at the confluence with the Isaac River (Appendix D of the draft EIS).

The Project would result in a drawdown in the Isaac River alluvium of 5 m, predominantly adjacent to the Olive Downs South Domain (Appendix D of the draft EIS). As the saturated thickness of the alluvium along the Isaac River is up to 35 m, the maximum predicted drawdown within the Isaac River alluvium (5 m) is not expected to dewater the alluvial aquifer.

Given the above, if stygofauna were present within the alluvium the potential drawdown associated with the Project would not limit their ability to disperse throughout the wider extent of the alluvium along the Isaac River and associated tributaries. As such, the potential drawdown associated with the Project is not expected to result in an impact to the stygofauna community (if they were to occur) as stygofauna would continue to persist in the alluvial aquifer.

6 POTENTIAL IMPACTS ON SURFACE WATER FEATURES

There are no wetlands of National or International Importance identified within the Project area and broader locality (Appendix C of the draft EIS).

DES (2018) regional mapping indicates that 10 wetlands of high ecological significance (HES) occur in the Project area and broader locality and flora surveys confirmed these wetlands are present (Figure 11) (Appendix A of the draft EIS).

The following sections provide an assessment of the potential impacts from the Project on these wetlands associated with direct removal, reduction in surface water quality, and catchment excision.

6.1 REMOVAL OF WETLANDS

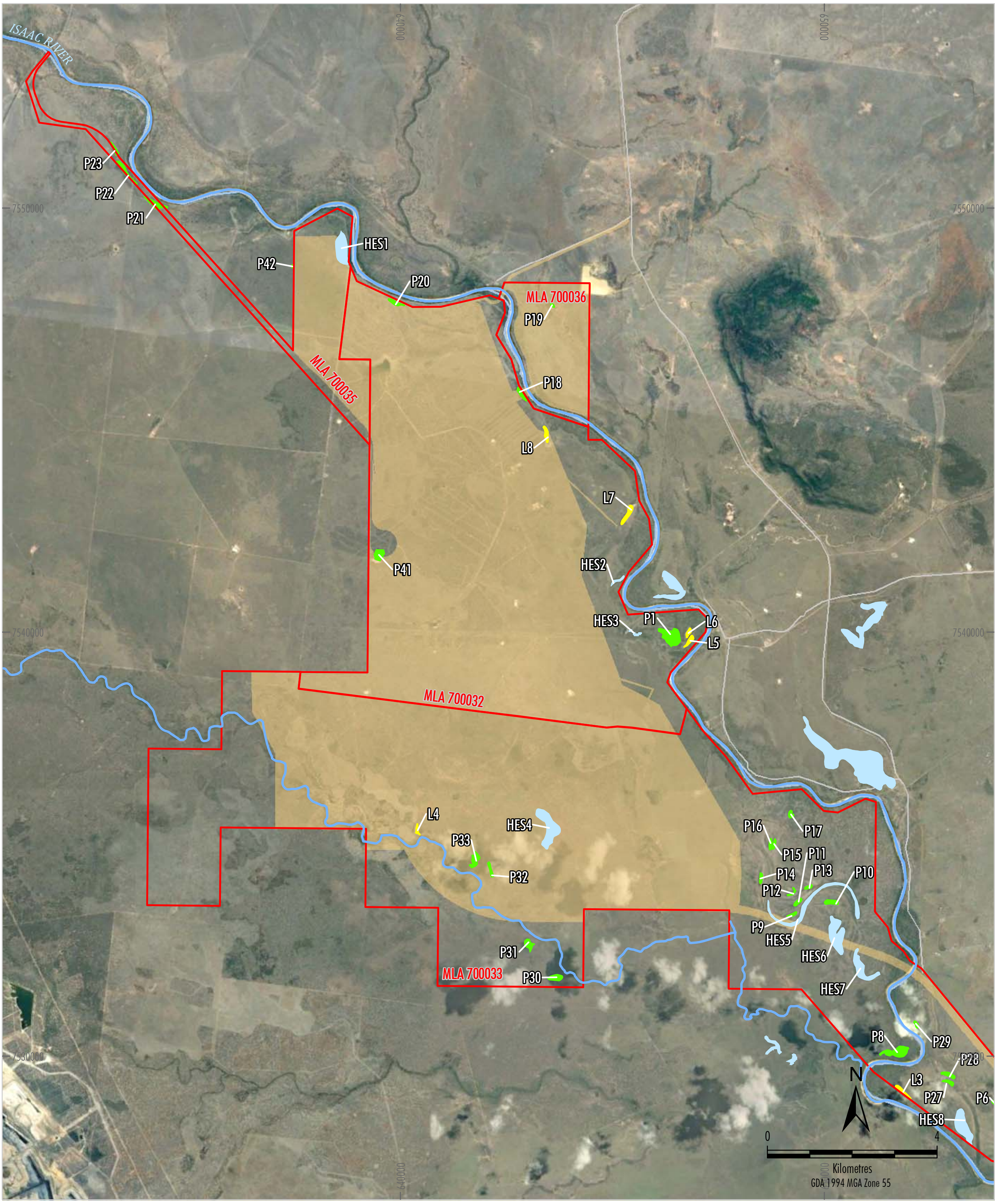
The Project would not remove any wetlands of National or International Importance.

The Project would result in the loss of 120 ha of palustrine and lacustrine wetlands. This includes 61 ha of HES wetlands and a further 59 ha of general ecological significance wetlands (e.g. pools of standing water within the Isaac River and associated tributaries) and lacustrine wetlands (i.e. man-made dams), (Appendix C of the draft EIS).

The general ecological significance wetlands have been impacted by stock, which use the systems for water and camps, and only fill during floods and retain water for relatively short periods (Appendix B of the draft EIS). These habitats are not expected to support aquatic species of conservation significance listed under the *Nature Conservation Act, 1994* or EPBC Act, given the lack of suitable habitat features (Appendix C of the draft EIS). Notwithstanding, these general ecological significance wetlands provide a water source for an array of aquatic and terrestrial fauna, as well as foraging and breeding habitat for waterbirds (in particular the Australian Painted Snipe), frogs, reptiles, water rats and other mammals.

The following is a list of direct impacts to wetlands related to each of the activities within the Project area (Appendix C of the draft EIS):

- Mining area – the mining activities will result in the removal of wetlands located within the Project area. This would include removal of riverine, palustrine and lacustrine wetlands (including modification and/or removal of seven HES wetlands). The mining area would also involve the construction of an overland conveyor and access road between the Olive Downs South and Willunga Domains which traverses wetland habitat (Figure 11). Pembroke has also provided further justification for the alignment of the overland conveyor and access road within Section 8 of the Additional Information to the EIS document main text.
- Haul road – the Olive Downs South Domain haul road (to the eastern waste emplacement) would require one crossing of the Isaac River and associated instream wetlands, limited to a 60 m wide disturbance corridor. Construction of the haul road would result in the removal of temporary aquatic habitat from within the watercourse and include low flow culverts to minimise potential impacts on fish passage.
- Project rail spur and loop – the Project rail spur and loop would require two crossings of palustrine wetlands associated with the Isaac River. Disturbance associated with the Project rail spur and loop would be limited to a 70 m wide corridor which would be co-located with the proposed water pipeline. New culvert crossings would be installed along the rail spur, with the final locations to be determined during the detailed design. The water pipeline would result in the removal of approximately 6 ha of wetlands.



LEGEND

- Mining Lease Application Boundary
- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)
- Lacustrine wetlands
- Palustrine wetlands
- High Ecological Significance Wetland
- Determined Watercourse (as determined by DNRME)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Pembroke (2018), DPM Envirosciences (2018)

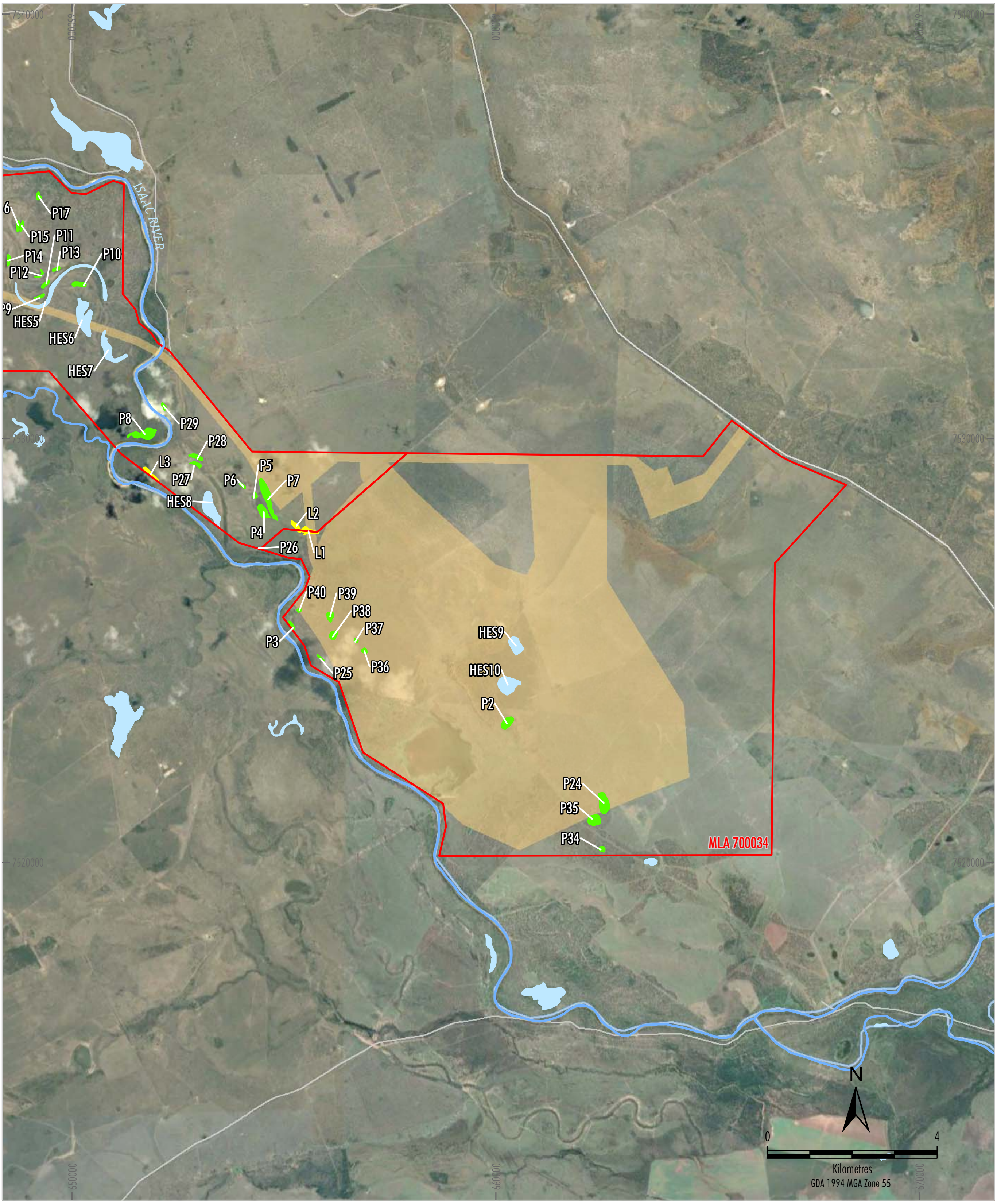
PEMBROKE

OLIVE DOWNS COKING COAL PROJECT

Surface Water Resources

Olive Downs South Domain

Figure 11a



LEGEND

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- Olive Downs Project Mine Site and Access Road (EPBC 2017/7867)
- Lacustrine wetlands
- Palustrine wetlands
- High Ecological Significance Wetland
- Determined Watercourse (as determined by DNRME)

Source: Queensland Department of Natural Resources, Mines and Energy (2018), Pembroke (2018), DPM Envirosciences (2018)

PEMBROKE

OLIVE DOWNS COKING COAL PROJECT

Surface Water Resources
Willunga Domain

Figure 11b

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- Water pipeline – the water pipeline would require two crossings of palustrine wetlands associated with the Isaac River. Disturbance associated with the water pipeline would be limited to a 20 m wide corridor. The water pipeline would result in the removal of approximately 1 ha of wetlands.
- ETL – the detailed design of the ETL would implement aerial crossings over waterways (including the Isaac River) and thereby avoid clearing of instream wetlands. The ETL would not result in the removal of any wetlands.

Of the 120 ha proposed to be removed by the Project, 113 ha would be associated with the Mine Site and Access Road, as outlined in Table 1 and shown on Figure 11. Given the Mine Site and Access Road was determined to be a controlled action in relation to a *water resource, in relation to coal seam gas development and large coal mining development*, these wetlands are considered to be MNES.

Table 1
Wetlands proposed to be Removed by the Mine Site and Access Road

Wetland ID	Wetland Type	Size of Wetland (ha)	Area to be Removed (ha)
HES1	High Ecological Significance Wetland	17.00	9.5
HES10	High Ecological Significance Wetland	15.50	15.5
HES4	High Ecological Significance Wetland	23.50	23
HES5	High Ecological Significance Wetland	22.00	4
HES6	High Ecological Significance Wetland	22.00	5
HES7	High Ecological Significance Wetland	13.50	0.5
HES9	High Ecological Significance Wetland	10.00	9.5
L1	Lacustrine Wetland	4.50	2
L4	Lacustrine Wetland	1.50	1.5
L8	Lacustrine Wetland	3.00	2
P2	Palustrine Wetland	6.00	6
P7	Palustrine Wetland	13.00	3.5
P18	Palustrine Wetland	3.00	2
P19	Palustrine Wetland	1.00	1
P20	Palustrine Wetland	3.00	2.5
P24	Palustrine Wetland	9.50	8
P32	Palustrine Wetland	2.00	2
P33	Palustrine Wetland	5.00	5
P36	Palustrine Wetland	1.50	1.5
P37	Palustrine Wetland	1.00	1
P38	Palustrine Wetland	3.50	3
P39	Palustrine Wetland	3.00	2.5
P40	Palustrine Wetland	1.00	0.5
P41	Palustrine Wetland	5.00	2
		Total	**113 ha**

6.2 REMOVAL OF WATERCOURSES

The ‘watercourses’ (as defined by the *Water Act 2000*) that would be directly impacted by the Project are (Figure 11):

- the Isaac River due to road crossings and conveyor crossings;
- Ripstone Creek due to the permanent watercourse diversion; and

- Cherwell Creek due to crossings associated with the proposed water pipeline.

The other drainage features within the Project area were determined by DNRM to not meet the criteria to be mapped as a 'watercourse' as per the definition in the *Water Act, 2000*.

All watercourse crossings would be constructed with consideration to the relevant waterway zoning maps. This would allow Pembroke to apply the appropriate management measures in accordance with the *Accepted Development Requirements for Operational Work that is Constructing or Raising Waterway Barrier Works* (DAF, 2017b) (i.e. using box culverts to permit crossing during low flow events, enabling flow through the watercourses to be maintained within the Project area).

Further to this, the diversion of Ripstone Creek would be designed to replicate natural features and provide similar conditions to the original waterway, including stream hydraulics, geomorphology, instream habitat, bank profiles and bank vegetation, which, consequently, will provide habitat and refuge for fish inhabiting or passing through the diversion of Ripstone Creek

To avoid direct impacts to Cherwell Creek, the pipeline crossing would be constructed using horizontal directional drilling, rather than excavating a trench and laying the pipeline through the watercourse itself. A drill rig would be used to drill a hole beneath the watercourse and the pipeline would be fed through the hole.

As a result, no watercourses would be removed by the Project.

6.3 REDUCTION IN SURFACE WATER QUALITY

Erosion and Sedimentation

An Erosion and Sediment Control Plan would be developed and implemented throughout construction and operations. A 'best practice' approach would be adopted that is consistent with the International Erosion Control Association (IECA) recommendations. The following broad principles would apply:

- minimise the area of disturbance;
- where possible, apply local temporary erosion control measures;
- intercept runoff from undisturbed areas and divert around disturbed areas; and
- where temporary measures are likely to be ineffective, divert runoff from disturbed areas to sedimentation basins prior to release from the site.

If implemented effectively, environmental risks to water quality from disturbed area runoff are expected to be low (Appendix C of the draft EIS).

Waste rock emplacements would be progressively rehabilitated, which would minimise potential for sediment transport downstream of the Project towards wetlands. This would involve construction of graded banks, rock-lined waterways, and/or diversion banks, and establishment of an initial protective vegetation cover crop followed by establishment of perennial species.

Surface runoff from the waste rock emplacements would be directed to dedicated sediment dams. Sediment dams would be retained until the revegetated surface of the waste rock emplacements are stable and runoff water quality reflects runoff water quality from similar un-mined areas, at which time these controls would be removed and the areas would be free-draining.

Given the above, the final landform is unlikely to lead to an increase in sediment transport downstream of the Project that would result in adverse impacts on watercourses and/or wetlands.

Mine Water Discharge

The Surface Water Assessment (supported by site water balance modelling) prepared by Hatch (Appendix C of the draft EIS) concludes that:

- No uncontrolled spills of mine-affected water from the worked water dams are predicted under normal operating conditions.
- Some overflow of water from sediment dams (designed in accordance with the Best Practice Erosion and Sediment Control guideline [IECA, 2008]) may occur during wet periods; however, it is unlikely that this would have a measurable impact on receiving water quality.
- There is a predicted negligible impact on the downstream water quality through releases from the Project.

Based on the implementation of management strategies (e.g. Erosion and Sediment Control Plan), the risks of elevated dissolved solids and other contaminants impacting downstream wetlands is considered to be low (Appendix C of the draft EIS).

Based on the analysis undertaken by Hatch (Appendix C of the draft EIS), no measurable impacts on surface water quality are likely to occur from discharge of mine-affected waters. If no measurable impacts on surface water quality are likely to occur then it follows that no adverse impacts are likely to occur on surrounding watercourses and/or wetlands.

Leaks and Spills

Leaks or spills of hydrocarbon-based fluids from construction equipment and spread of coal dust represents a potential risk to wetlands downstream of the Project.

The Preliminary Risk Assessment conducted by Operational Risk Mentoring (Appendix O of the draft EIS) concluded that there is a ‘Low’ risk of this event (or one similar) occurring given the implementation of suitable management measures, including implementation of a spill response and appropriate water management system.

As such, the Project is unlikely to result in leaks/spills that would eventuate in serious environmental harm to watercourses and/or wetlands surrounding the Project area.

6.4 CATCHMENT EXCISION OF REMAINING WETLANDS

This section provides a detailed assessment of the potential impacts of catchment excision on the wetlands identified in the Project area and broader locality. No assessment of the potential loss of catchment of the wetlands that would be removed by the Project was undertaken.

WRM Water and Environment conducted an assessment of the potential reduction in existing catchment to each of these wetlands (Table 2). As demonstrated in Table 2, there would be a temporary reduction in catchment to each of these wetlands, however, once the rehabilitated landform is established, the majority of these catchments would be reinstated. This includes the entire catchment for HES1, HES5, HES6, HES7 and HES8 (Table 2). It should be noted that although not listed in Table 2, the remaining palustrine and lacustrine wetlands not proposed to be disturbed by the Project all lie within a small portion of the catchments for the remaining seven HES wetlands (i.e. HES1 to HES3 and HES5 to HES8) (as shown on Figure 11). For example, wetlands P9 to P16 all fall within the catchment for HES5. As such, the assessment has focused on the catchments for these HES wetlands as they represent the largest wetland within each catchment, and therefore would be subject to the largest potential impact should be catchment be reduced.

Table 2
Area of Existing Catchment of Wetlands being Excised by the Project

Wetland*	Size of HES Wetland (ha)	Size of Existing Catchment (ha)	Temporary Reduction in Catchment During Operations (ha)	Size of Catchment During Operations (ha)	Size of Catchment in the Final Landform (ha)
HES1	17	169	102	67	169
HES2	2.5	1,820	1,418	402	1,096
HES3	2	2,600	2,182	418	2,193
HES5	24	1,056	30	1,026	1,056
HES6[#]	16	350	24	326	350
HES7	14	261	67	194	261
HES8	18	603	114	489	603

* Refer to Figure 11.

[#] HES6 would be traversed by the overland conveyor and access road, resulting in the removal of approximately 5.5 ha of this wetland. As such, the wetland would be reduced to 16 ha once the conveyor and access road have been constructed.

All wetlands shown on Figure 11 act as ‘flow-through’ systems. That is, once the wetland has reached its maximum storage capacity, any additional input (either from rainfall or overland flow) would cause the wetland to spill, and runoff would continue towards the Isaac River. As the wetlands are very small relative to the size of their existing catchments, it is expected that they would only hold a very small portion of the water captured within these catchments, and the vast majority of water would continue to flow through the wetland. The flow-through system is presented graphically on Figure 10.

In addition to the water captured by their catchments, these wetlands would intermittently receive input from the Isaac River floodwaters during flood events.

As demonstrated by Table 2, the Project would result in the temporary removal of a portion of the catchments of each of the remaining wetlands. Despite this, the size of the remaining catchments relative to the size of the wetlands is still very large (i.e. the remaining catchment is greater than approximately 4 times the size of the wetland in all cases) and the majority of the catchments for these wetlands would be re-instated once rehabilitation is complete (Table 2).

Further to this, as stated in Section 4.3, the wetland substrate and associated clay layers slow the percolation of surface water (Appendix D of the draft EIS) that allows these wetlands to continue to hold water for extended periods. An indicative cross-section of these wetlands across a wetting and drying cycle is shown on Figure 10.

Given the above, it is expected that potential hydrological changes to these wetlands would be minimal, as the wetlands would continue to be inundated during and following rainfall/flood events. In addition, these wetlands are ephemeral in nature and the flora and fauna species associated with them have developed a tolerance to continual wetting and drying cycles (Plates 1 and 2) such that they are expected to persist in the environment.

In order to confirm that this reduction in catchment does not result in an adverse impact to the ecological values of the wetlands, Pembroke would undertake further investigation and monitoring through the installation of shallow piezometers within these wetlands and the development and implementation of a GDE and Wetland Monitoring Program (Section 8.3).

Plates 1 and 2: High Ecological Significance Wetland 5 (HES5) during a dry period (October 2017)

7 SIGNIFICANT RESIDUAL IMPACTS AND OFFSET REQUIREMENTS FOR WATER RESOURCES

As described in Section 1, impacts to *a water resource, in relation to coal seam gas development and large coal mining development* (sections 24D and 24E) is considered to be relevant to all water sources (groundwater and surface water) in relation to the Mine Site and Access Road. The other components of the Project (i.e. the rail spur, water pipeline and ETL) were not determined to be a Controlled Action with respect to a water resource, and as such, it is concluded that the impacts to watercourses and wetlands associated with these components of the Project would not result in a significant impact to any water resources (including wetlands).

The Project would result in the removal of 120 ha of ephemeral palustrine and lacustrine wetlands, all of which could provide potential habitat for the Australian Painted Snipe. As such, Pembroke proposes to offset the removal of these wetlands through the implementation of an offset for the Australian Painted Snipe in accordance with the *EPBC Act Environmental Offsets Policy* (DSEWPC, 2012a) and *EPBC Act Offsets Assessment Guide* (DSEWPC, 2012b). The Australian Painted Snipe potential habitat is conservatively considered to include all wetlands in the Project area.

The Stage 1 Impact Area would result in the clearance of approximately 21 ha of ephemeral wetlands which could provide potential habitat for the Australian Painted Snipe, comprising lacustrine and palustrine wetlands. The Stage 1 Offset Area provides for the conservation and enhancement of approximately 86 ha of wetland habitat for the Australian Painted Snipe, four times the area of wetlands to be removed.

Further to the above, the Mine Site and Access Road is not expected to result in a significant impact to any water resources downstream of the Project area given:

- no watercourses are proposed to be removed by the Project (Section 6.2);
- no significant impacts to potential GDEs are predicted as a result on groundwater drawdown or contamination (Section 5);
- the final landform is unlikely to lead to an increase in sediment transport downstream of the Project that would result in adverse impacts on water resources (Section 6.3);
- no measurable impacts on water resources are likely to occur from discharge of mine-affected waters (Section 6.3);
- the Project is unlikely to result in leaks/spills that would eventuate in serious environmental harm to water resources (Section 6.3); and
- the Project would not result in a significant reduction in the catchments for the water resources downstream (Section 6.4).

8 MITIGATION MEASURES, MANAGEMENT AND MONITORING

8.1 WATER MANAGEMENT PLAN

A Water Management Plan would be prepared cognisant of the DES (formerly known as the DERM) 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.

8.2 RECEIVING ENVIRONMENT MONITORING PROGRAM

Pembroke would prepare a Receiving Environment Monitoring Program (REMP) for the Project in accordance with the *Receiving Environment Monitoring Program Guideline* (DEHP, 2014b). The REMP would identify:

- the Environmental Values (EVs) that need to be enhanced or protected for receiving waters potentially affected by a release;
- measurable indicators associated with these EVs (physical, chemical or biological);
- Water Quality Objectives (WQOs) for these indicators;
- suitable test sites within the receiving waters that are potentially impacted by the release;
- suitable control sites where a background or reference condition can be established;
- methodologies for assessing the condition of, and impacts to, EVs at test sites using both WQOs and control site data based on appropriate and valid assessment protocols from relevant guideline documents; and
- quality control and assurance procedures adopted to produce monitoring results that are reliable and useful.

The REMP would be prepared prior to construction.

8.2.1 Groundwater Monitoring

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 levels over the year, compared to historical trends and impact assessment predictions.

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 for simulation of mining.

The groundwater monitoring program established during the preparation of the groundwater assessment for the EIS would continue throughout the life of the Project, with modification and addition of monitoring sites, parameters and frequency as required.

Recording of groundwater levels from existing monitoring bores and vibrating wire piezometers (VWPs) would continue and would enable natural groundwater level fluctuations (e.g. response to rainfall) to be distinguished from potential groundwater level impacts due to the proposed mining activities.

Groundwater quality sampling would continue in order to provide longer-term baseline groundwater quality around the Project site, and to detect any changes in groundwater quality during and post-mining.

Groundwater monitoring criteria would be established to monitor predicted impacts on both EVs and predicted changes in groundwater quality. Impact assessment criteria for the site would be documented within an Underground Water Impact Report for the Project, prior to the commencement of mining activities.

8.2.2 Surface Water Monitoring

Monitoring of surface water quality both within and external to the mine site would form a key component of the surface water management system. Monitoring of upstream, onsite and downstream water quality would assist in demonstrating that the site water management system is effective in meeting its objective to protect the integrity of local and regional water resources, and would also allow for early detection of any impacts and appropriate corrective action.

The surface water monitoring protocols would:

- be implemented to comply with the Project Environmental Authority;
- provide valuable information on the performance of the water management system; and
- facilitate adaptive management of water resources on the site.

Surface runoff and seepage from ROM and product coal stockpiles would be monitored for ‘standard’ water quality parameters including, but not limited to, pH, Electrical Conductivity (EC), major anions (sulphate, chloride and alkalinity), major cations (sodium, calcium, magnesium and potassium), total dissolved solids (TDS), total suspended solids (TSS), turbidity and a broad suite of soluble metals/metalloids.

Monitoring of upstream, on-site and downstream water flows (and storage levels and controlled release volumes) would assist in demonstrating that the site water management system is effective in meeting its objective to protect the integrity of local and regional water resources and allow for early detection of any impacts and appropriate corrective action.

Monitoring of surface water levels and flows would continue to be undertaken based on data from Department of Natural Resources, Mines and Energy streamflow gauges in the Isaac River catchment as well as data from the ISDS monitoring station installed by Pembroke on the Isaac River, downstream of the Project.

8.3 GROUNDWATER DEPENDENT ECOSYSTEM AND WETLAND MONITORING PROGRAM

Pembroke will prepare and implement a GDE and Wetland Monitoring Program to detect potential impacts on GDEs and wetlands associated with the Project.

The GDE and Wetland Monitoring Program to be implemented by Pembroke within/adjacent riparian vegetation and HES wetlands not proposed to be cleared by the Project (e.g. HES2, HES3, HES5, HES7 and HES8 [Figure 11]). This will include monitoring of:

- groundwater depth and quality;
- health of the terrestrial vegetation; and
- surface water quantity and quality.

Selection of GDE monitoring sites will be undertaken in consideration of the GDE mapping tools recommended in Richardson *et al.* (2011) and Emelyanova *et al.* (2017).

The GDE and Wetland Monitoring Program to be developed and implemented by Pembroke will include details of:

- the nature and ecological values of each GDE and wetland being monitored;
- a field validation survey and baseline description of the current condition of the GDE and wetlands;
- a map and coordinates of the location of the GDEs and wetlands subject to the monitoring program, including justification for the selected locations;
- sampling and analysis methodologies for detecting impacts associated with the Project;
- environmental quality indicators, impact thresholds and triggers;
- corrective actions and timing to address impacts associated with the Project, should they be detected; and
- sampling and analysis reporting.

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