MALABAR COAL

MAXWELL PROJECT

APPENDIX V

Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems

MAXWELL PROJECT

INTEGRATED ASSESSMENT OF POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

JULY 2019
Project No. SHM-18-03
Document No. 00990868

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1 INTRODUCTION

Maxwell Ventures (Management) Pty Ltd, a wholly owned subsidiary of Malabar Coal Limited (Malabar), is seeking consent to develop an underground coal mining operation, referred to as the Maxwell Project (the Project).

The Project is in the Upper Hunter Valley of New South Wales (NSW), east-southeast of Denman and south-southwest of Muswellbrook (Figure 1).

Malabar owns and manages the existing infrastructure within Coal Lease (CL) 229, Mining Lease (ML) 1531 and CL 395 (known as the 'Maxwell Infrastructure') (Figure 2). The Maxwell Infrastructure includes an existing coal handling and preparation plant (CHPP), rail facilities and other infrastructure and services (including water management infrastructure, administration buildings, workshops and services). The Project would include the use of the substantial existing Maxwell Infrastructure, along with the development of some new infrastructure (Figure 2).

This Integrated Assessment of Potential Impacts on Groundwater Dependent Ecosystems (GDE Assessment) forms part of an Environmental Impact Statement (EIS), which has been prepared to accompany a Development Application for the Project in accordance with Part 4 of the NSW *Environmental Planning and Assessment Act, 1979*.

1.1 PURPOSE

This GDE Assessment has been prepared to satisfy the assessment requirements pertaining to Groundwater Dependent Ecosystems (GDEs) in the Secretary's Environmental Assessment Requirements (SEARs), regulatory input to the SEARs and relevant GDE guidelines.

1.2 METHODOLOGY

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

- Biodiversity Development Assessment Report (Hunter Eco, 2019);
- Groundwater Assessment (HydroSimulations, 2019);
- Surface Water Assessment (WRM Water & Environment Pty Ltd [WRM], 2019);
- Aquatic Ecology and Stygofauna Assessment (Eco Logical Australia [Eco Logical], 2019);
- Subsidence Assessment (Mine Subsidence Engineering Consultants Pty Ltd [MSEC], 2019); and
- Geomorphology Assessment (Fluvial Systems Pty Ltd [Fluvial Systems], 2019).

The remainder of this report 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.

LEGEND
- Mining Operation
- Proposed Mining Operation
- Railway
- Local Government Boundary
- State Forest
- National Parks and Wildlife Service Estate
- Maxwell Project Exploration Licence Boundary
- Maxwell Project Mining and Coal Lease Boundary
- Indicative Extent of Underground Development

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services and Innovation (2019); Office of Environment and Heritage NSW (2019)

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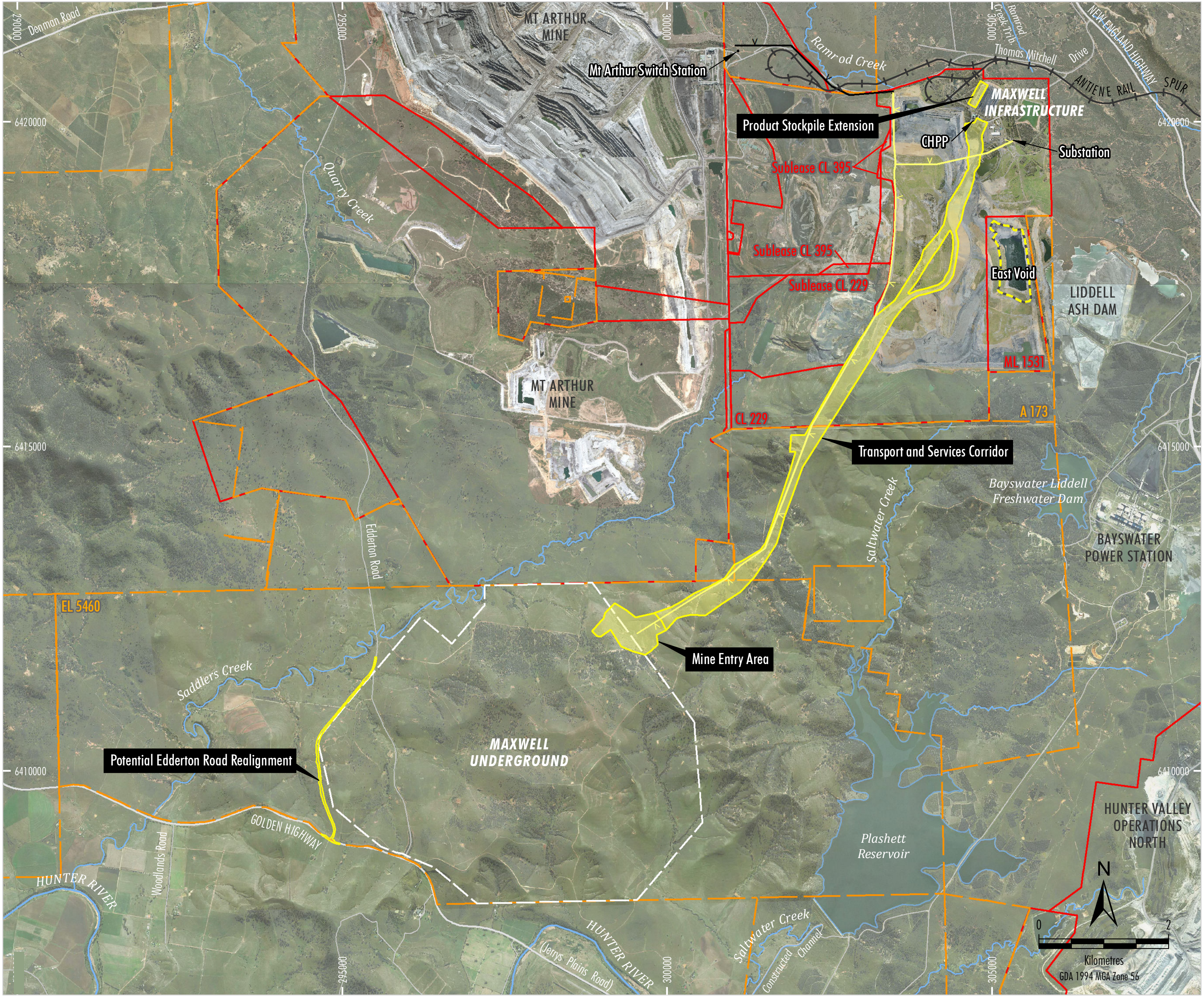
Regional Location

Figure 1



LEGEND
- Railway
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Extent of Underground Development
- Indicative Surface Development Area
- CHPP Reject Emplacement Area
- Proposed 66 kV Power Supply
- Proposed Ausgrid 66 kV Power Supply Extension #

Subject to separate assessment and approval.

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019) Orthophoto Mosaic: 2018, 2016, 2011

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Project General Arrangement

Figure 2

SHM-18-03 Maxwell_EIS_App GDE_202A

2 PROJECT OVERVIEW

The Project would involve an underground mining operation that would produce high quality coals over a period of approximately 26 years.

At least 75% of coal produced by the Project would be capable of being used in the making of steel (coking coals). The balance would comprise export thermal coals suitable for the new-generation High Efficiency, Low Emissions power generators.

The Project would involve extraction of run-of-mine (ROM) coal from four seams within the Wittingham Coal Measures using the following underground mining methods:

- underground bord and pillar mining with partial pillar extraction in the Whynot Seam; and
- underground longwall extraction in the Woodlands Hill Seam, Arrowfield Seam and Bowfield Seam.

The substantial existing Maxwell Infrastructure would be used for handling, processing and transportation of coal for the life of the Project. The Maxwell Infrastructure includes an existing CHPP, train load-out facilities, and other infrastructure and services (including water management infrastructure, administration buildings, workshops and services).

A mine entry area would be developed for the Project in a natural valley in the north of EL 5460 to support underground mining and coal handling activities and provide for personnel and materials access.

ROM coal brought to the surface at the mine entry area would be transported to the Maxwell Infrastructure area. Early ROM coal would be transported via internal roads during the construction and commissioning of an overland conveyor system. Subsequently, ROM coal would be transported to the Maxwell Infrastructure area via the overland conveyor system.

The Project would support continued rehabilitation of previously mined areas and overburden emplacements areas within CL 229, ML 1531 and CL 395. The volume of the East Void would be reduced through the emplacement of reject material generated by Project coal processing activities and would be capped and rehabilitated at the completion of mining.

An indicative Project general arrangement showing the underground mining area and key infrastructure is provided on Figure 2. A detailed description of the Project is provided in the main document of the EIS.

3 REGULATORY REQUIREMENTS

3.1 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The SEARs for the Project were issued by the NSW Department of Planning and Environment (DP&E) on 3 September 2018. Supplementary SEARs were issued on 20 November 2018 and revised SEARs were issued on 17 January 2019. Relevant government agencies provided input into the SEARs, including the Department of Industry – Water (DI – Water) and NSW Office of Environment and Heritage (OEH).

The SEARs state that the EIS must present an assessment of the likely impacts of the Project on GDEs. Relevant requirements from the DI – Water and OEH input to the SEARs include:

- A map showing the location of GDEs (Section 4).
- An assessment of potential impacts on GDEs (Section 5).

3.2 GATEWAY CERTIFICATE AND REPORT

Malabar lodged an application for a Gateway Certificate (Gateway Application) for the Project in August 2018.

A Conditional Gateway Certificate for the Maxwell Coal Project (Gateway Certificate) was issued by the NSW Mining and Petroleum Gateway Panel (Gateway Panel) on 20 December 2018. The Gateway Certificate recommended that Malabar complete studies on GDEs for the EIS.

The Gateway Certificate was accompanied by a report prepared by the Gateway Panel (Gateway Panel Report). The Gateway Panel Report was informed by advice provided by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (IESC) (IESC, 2018a). A summary of the IESC recommendations pertaining to GDEs is provided in Table 1.

3.3 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* (IESC, 2018b).
- *Assessing Groundwater Dependent Ecosystems: IESC Information Guidelines Explanatory Note [Consultation Draft]* (Doody, Hancock and Pritchard, 2018).
- *NSW State Groundwater Dependent Ecosystems Policy* (NSW Department of Land and Water Conservation, 2002).
- *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water, 2012).

Table 1
IESC Recommendations to Gateway Panel

Recommendation	Report Section
30. *A detailed, independent and peer reviewed assessment of the potential surface to seam fracturing with an integrated hazard map (c.f. Herron et. al. 2018) overlaying the GDEs, BSAL areas, geological structures and drainage lines close to the Hunter River alluvium is needed.*	Sections 4 and 5
39. *An assessment of the extent and condition of GDEs and water-dependent flora and fauna is needed, followed by an appropriate risk assessment (e.g. Serov et al. 2012). These studies should consider the ecological water requirements for any water-dependent species and their habitat. The locations of any shallow groundwater discharge points and other GDEs should be included, especially in areas where drawdown is predicted. A systematic approach to the assessment of GDEs is recommended in which:*	Section 4.3.2
a. *the methods from, for example, the Australian GDE Toolbox (Richardson et al. 2011) and Eamus et al. (2015) are used to assess groundwater use by vegetation (especially during dry periods).*	Section 4.3.2
b. *the hydrogeological conceptualisation is used to identify areas of shallow groundwater (less than 20 m below ground level) and potential areas of groundwater discharge.*	Section 4.2
c. *vegetation, seasonal depths to groundwater and shallow groundwater drawdown maps are overlaid to identify areas of potential GDEs. These maps should be supported by monitoring data gathered near the regions occupied by potential GDEs, with the shallow groundwater monitoring locations also plotted on the maps.*	Sections 4.2 and 5; Figures 3, 4, 5 and 7
d. *ecohydrological conceptualisations are used that integrate results from hydrogeological, hydrological, geomorphological and ecological investigations at a spatial and temporal scale that is suitable for predicting potential impacts to GDEs and pathways of likely effects of the proposed development. The identified potential impact pathways should then be used to develop proposed mitigation strategies and to monitoring of these strategies' effectiveness.*	Sections 5 and 6

4 IDENTIFICATION 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 (IESC, 2018a).

There are two main types of GDEs (Hunter Eco, 2019):

- ecosystems that are dependent in whole or in part on water reserves held in the ground; and
- ecosystems that are dependent on the surface expression of groundwater.

Water reserves held in the ground form the saturated part of the aquifer soil matrix that sits below the 'water table' or 'phreatic surface', and are differentiated from water bound in the soil matrix in the unsaturated zone above the water table (Hunter Eco, 2019). Water in the soil aquifers originates from all or any of (Hunter Eco, 2019):

- rainfall directly on the aquifer surface;
- runoff from areas immediately adjacent to the aquifer; or
- sub-surface inflow.

The structure of these water reserves or aquifers is significant for plant use of the available water. For root access to water, the aquifer needs to be unconstrained by any impenetrable rock layers. Unconstrained aquifers consist of a lower saturated zone above which lies an unsaturated zone, referred to as the capillary fringe or vadose zone. The surface of the saturated zone where water pressure equals atmospheric pressure is the phreatic zone (Hunter Eco, 2019).

Vegetation making up a GDE, termed 'phreatophytic' and consisting of 'phreatophytes', can have varying degrees of dependency on the groundwater. Obligate GDEs are made up of species that depend entirely on the groundwater and are capable of living with their roots continually wet, or at least for seasonal periods of inundation. Facultative GDEs contain species that access the groundwater via the capillary fringe and also take up water from within the soil matrix above this area (Hatton and Evans, 1998). These plants cannot cope with having their roots inundated with water (Hunter Eco, 2019).

Depth to water is an important consideration for identifying potential GDE and in this context plant rooting depth is relevant. While some plants are capable of sending roots tens of metres into the soil, generally the plants in dry sclerophyll woodland, including trees, would have maximum root depth of approximately 5 metres (m) (Canadell *et al.*, 1996).

The time scale of availability of water to GDEs also needs to be considered and this has been shown to vary from annual seasonal to as infrequently as 6 months in 10 – 20 years (Eamus *et al.*, 2006).

A GDE can also be in a perched system where the soil matrix holds water and prevents this water from penetrating the deeper soil layers. In these perched systems, the vegetation will consist of species that are dependent on a generally permanently wet environment. There can be a link between perched GDEs and an underlying aquifer where the replenishing of the water in the perched system occurs when, as a result of sufficient rainfall, the groundwater overflows into the perched system (Hunter Eco, 2019).

4.1 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, 2018). The Atlas contains information about three types of ecosystems:

- Aquatic ecosystems that rely on the surface expression of groundwater, including surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs.
- Terrestrial ecosystems that rely on the subsurface presence of groundwater.
- Subterranean ecosystems, including cave and aquifer ecosystems.

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 following potential aquatic and terrestrial[1] GDEs in the vicinity of the Project (Figure 3):

- Aquatic habitat within the Hunter River is mapped as having high potential for groundwater interaction.
- Aquatic habitat within Saddlers Creek is mapped as having moderate to high potential for groundwater interaction.
- Terrestrial vegetation along the Hunter River and Saddlers Creek is mapped as having low potential for groundwater interaction.
- The majority of the remaining terrestrial vegetation in the vicinity of the Project is mapped as having low potential for groundwater interaction.

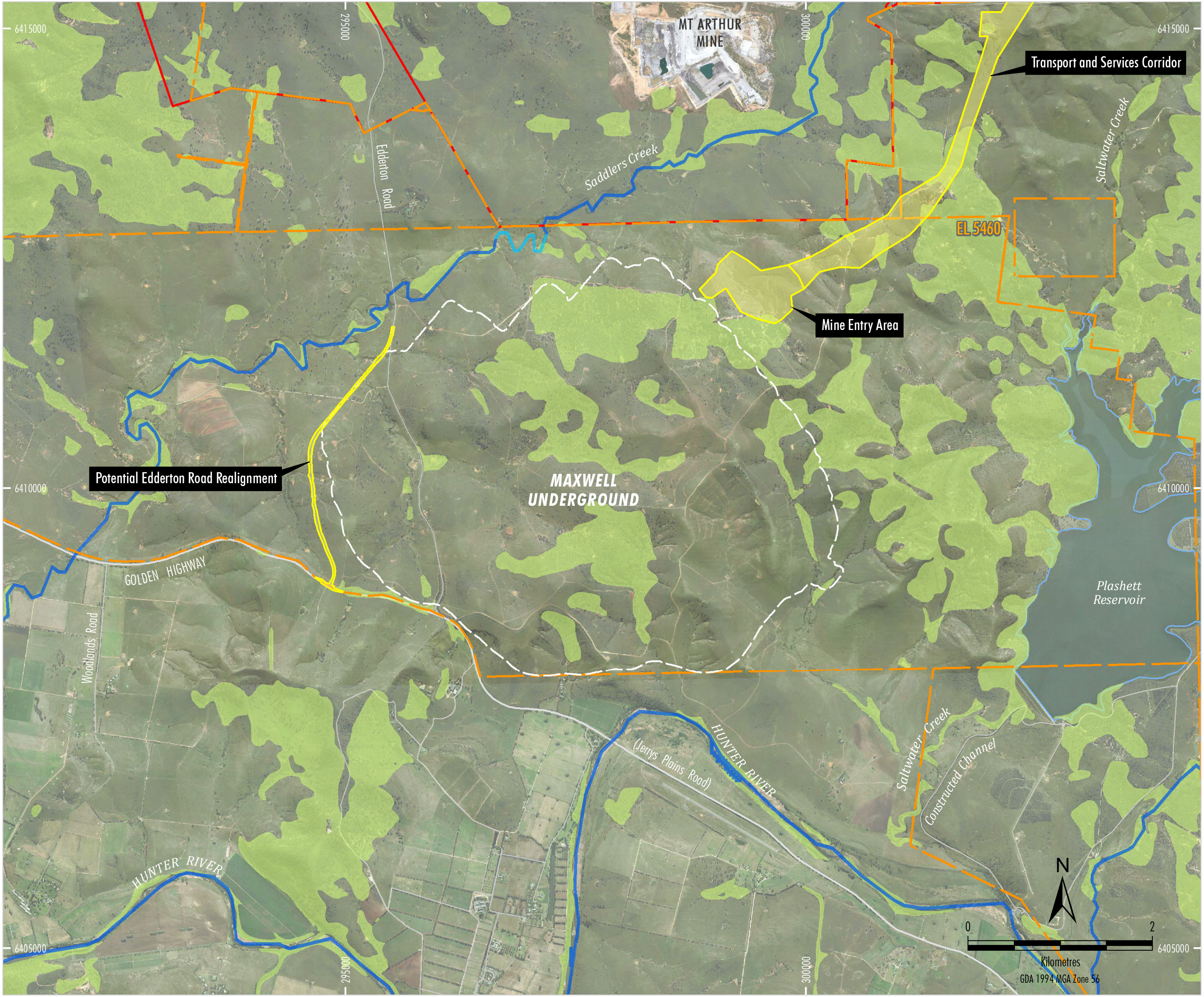
4.2 GROUNDWATER SYSTEMS

A conceptual hydrogeological model of the existing groundwater regime was developed by HydroSimulations (2019), based on the review of the available baseline groundwater data and relevant water sharing plans (Appendix B). The three main groundwater systems identified by HydroSimulations (2019) are:

- alluvium associated with the Hunter River;
- alluvium associated with Saddlers Creek; and
- Permian strata that host the coal measures.

The Project coal resource is located within the Jerrys Plains Subgroup, forming part of the upper and middle units of the Wittingham Coal Measures. The Jerrys Plains Subgroup is within the porous rock (i.e. sedimentary rock) groundwater systems of the Sydney Basin and lies within the boundary defined in the *Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources 2016.*

[1] The GDE Atlas has not analysed the presence of subterranean ecosystems in NSW.



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)

Potential Terrestrial Groundwater Dependent Ecosystems

- Low Potential GDE

Potential Aquatic Groundwater Dependent Ecosystems

- High Potential GDE
- Moderate Potential GDE

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); BOM Atlas (2019) Orthophoto Mosaic: 2018, 2016, 2011

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Groundwater Dependent Ecosystems - Atlas Mapping

Figure 3

SHM-18-03 Maxwell_EIS_App GDE_203B

Alluvial sediments associated with Saddlers Creek, the Hunter River and Saltwater Creek exist to the north-west, south and east of the proposed Maxwell Underground.

The Hunter River alluvium is the most productive aquifer in the region and comprises surficial silts and clays overlying basal sands and gravels up to 20 m depth. The basal sands and gravels are thickest along the alignment of the Hunter River, thinning out toward the edges of the extent of mapped alluvium (HydroSimulations, 2019).

The thick sequences of permeable sands and gravels in the Hunter River alluvium are considered ‘highly productive’ in accordance with the Aquifer Interference Policy (AIP) (NSW Government, 2012). The edge of the Hunter River alluvium primarily consists of silts and clays that are largely unsaturated and considered ‘less productive’ (HydroSimulations, 2019).

The stratigraphy of the alluvium along Saddlers Creek varies along the reach due to changes in the depositional environment. HydroSimulations (2019) summarises the stratigraphy of the Saddlers Creek alluvium as follows:

- Basal sands and gravels associated with a higher energy fluvial system occur at the lower reaches of the creek, at the confluence with the Hunter River.
- Further upslope, away from the Hunter River, the stratigraphy comprises surficial clays/silt overlying a heterogeneous distribution of sands and gravels.
- Within the upper reaches of the creek, the stratigraphy largely comprises clays and sandy clays.

The yield of the Saddlers Creek alluvium near the confluence with the Hunter River is expected to be similar to that of the Hunter River alluvium, while the yield further upslope is expected to be lower due to the dominant silts and clays.

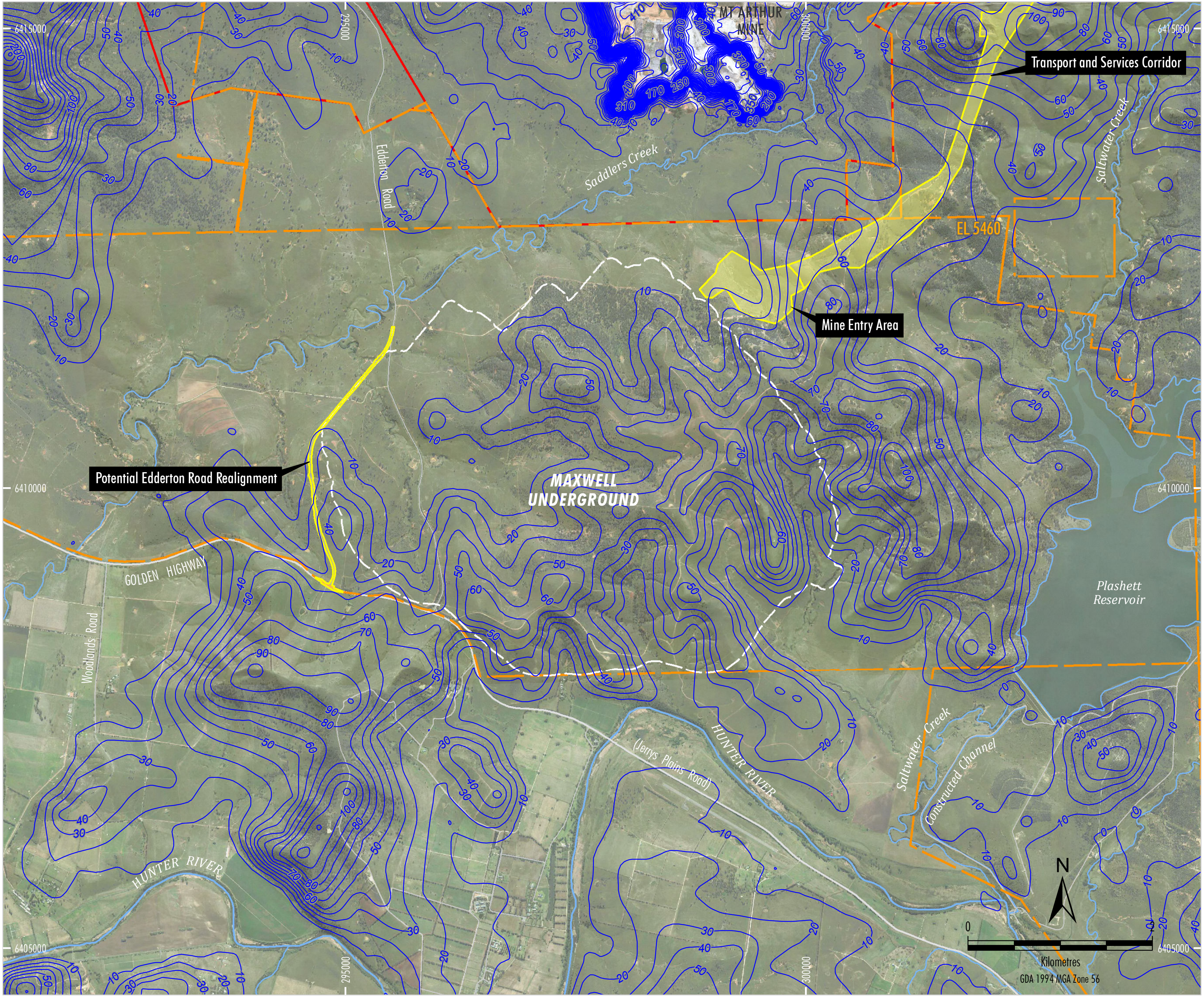
A Project-specific groundwater investigation program has been undertaken to ascertain the extent of the Saddlers Creek alluvium and Hunter River alluvium in the vicinity of the Project, including:

- *Maxwell Project Geomorphology Assessment* (Fluvial Systems, 2019);
- *Alluvial Drilling Report – Maxwell Project* (ENRS, 2018); and
- *AgTEM Survey Investigating Groundwater on Maxwell Underground Coal Mine prospect* (Groundwater Imaging, 2018).

The depth to the groundwater table in the vicinity of the Project is shown on Figure 4. The depth to groundwater within the Maxwell Underground area is typically greater than 20 m.

Shallower groundwater (less than 20 m below the surface of the ground) is present within the alluvium adjacent to the Maxwell Underground area. The interpreted extent of the alluvium in the vicinity of the Project is shown on Figures 5a to 5c.

The tributaries of Saddlers and Saltwater Creek within the Maxwell Underground area comprise narrow and shallow clayey units and were dry at the time of the geomorphology field survey. The tributaries are likely to intermittently store water only during, and for a limited period after, significant rainfall events. Thus, they are unlikely to contain a significant exploitable groundwater resource (Fluvial Systems, 2019).



LEGEND
- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Depth to Water (m)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); MSEC (2019); HydroSimulations (2019) Orthophoto Mosaic: 2018, 2016, 2011

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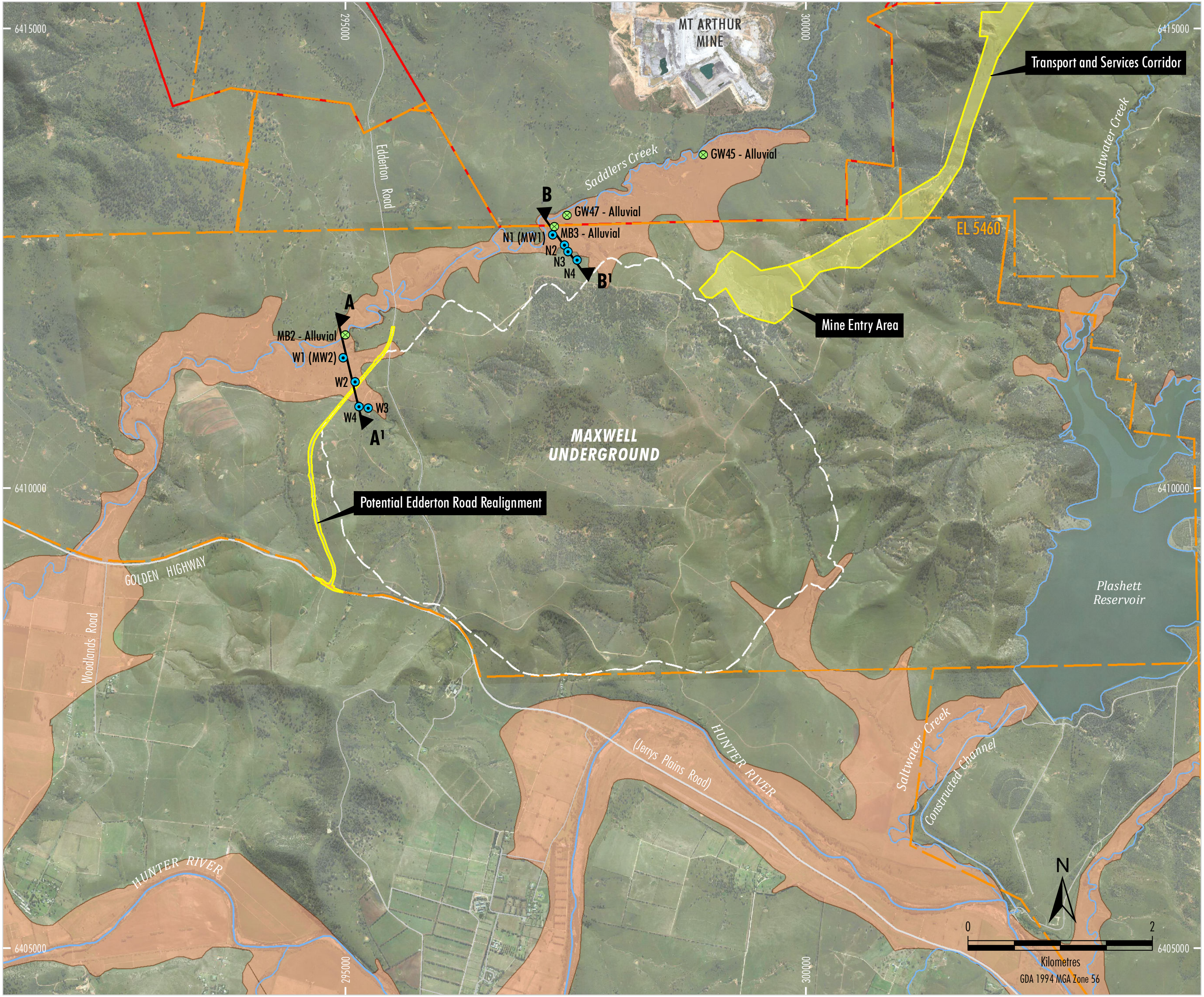
Regional Water Table

Figure 4

SHM-18-03 Maxwell_EIS_App GDE_204A



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Interpreted Alluvial Boundary
- Alluvial Investigation Drillhole
- Existing Alluvial Monitoring Bore

Refer Figures 5b and 5c for cross-sections.

Source: © NSW Department of Planning and Environment (2018); NSW Department of Finance, Services & Innovation (2018); HydroSimulations (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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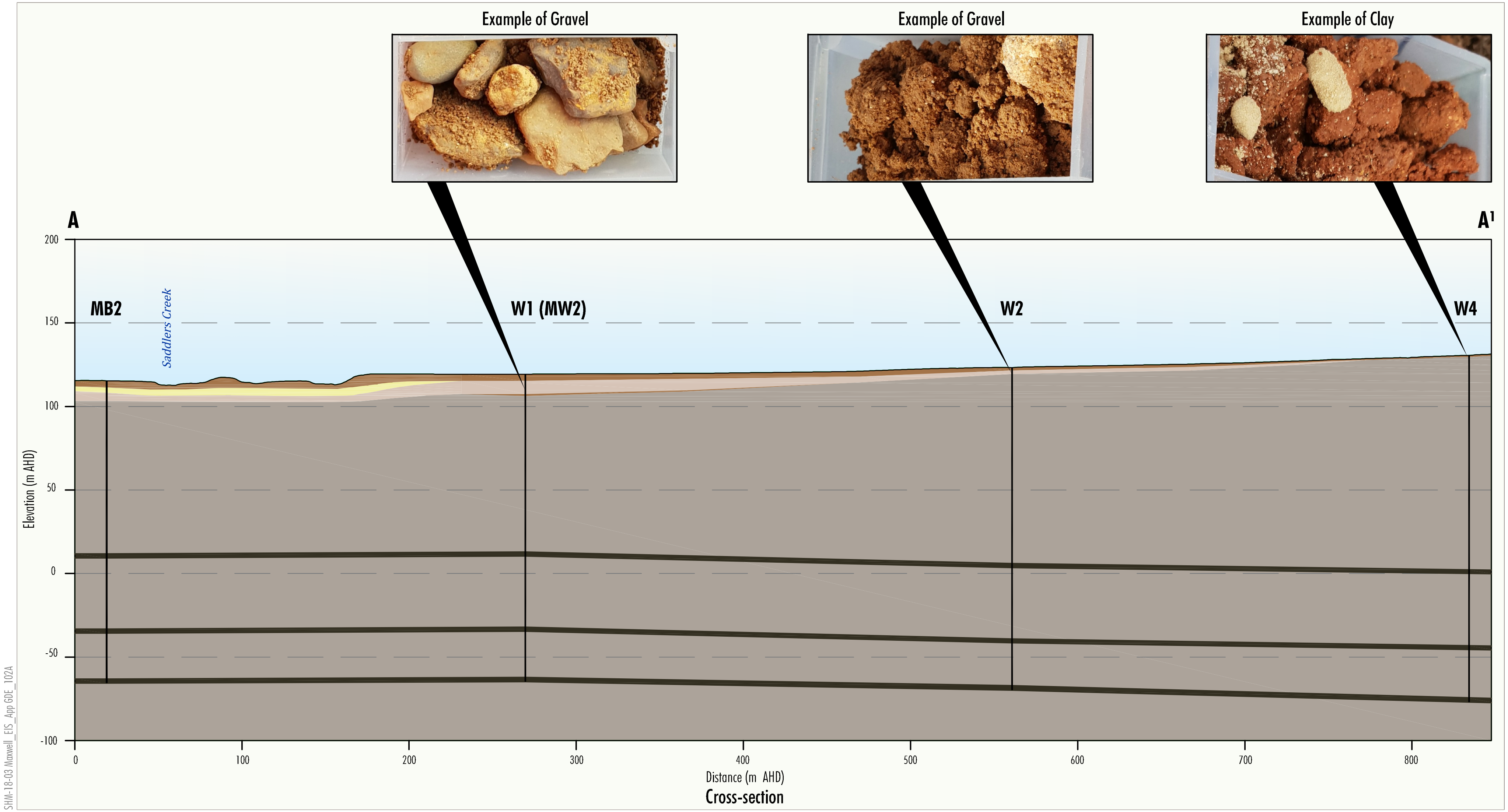
M A X W E L L   P R O J E C T

Interpreted Extent of Alluvium

Figure 5a

SHM-18-03 Maxwell_EIS_App GDE_211A



LEGEND

- Clay
- Sand
- Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100
Metres
Scale 1 Horizontal :1 Vertical

Source: After Hydrosimulations (2019) and ENRS (2019)

Refer Figure 5a for cross-section location.

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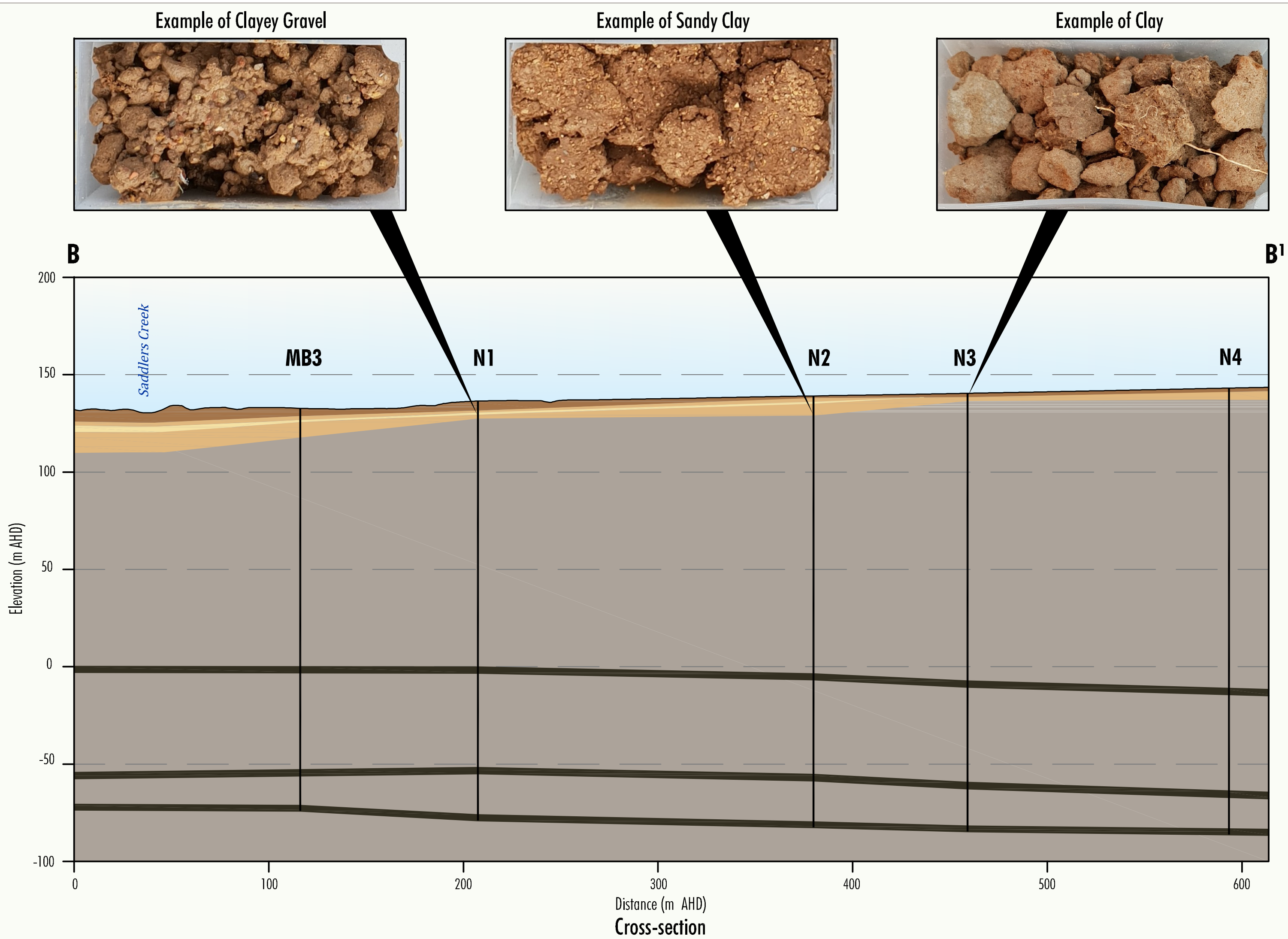
M A X W E L L P R O J E C T

Saddlers Creek Alluvium
Cross-section A - A[1]

Figure 5b



LEGEND
- Clay
- Sandy Clay
- Clayey Gravel
- Denman Formation/Jerrys Plains Subgroup
- Target Coal Seam

0 100
Metres
Scale 1 Horizontal :1 Vertical

Source: After Hydrosimulations (2019) and ENRS (2019)

Refer Figure 5a for cross-section location.

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Saddlers Creek Alluvium
Cross-section B - B1

Figure 5c

Groundwater levels in the Hunter River alluvium range between 6.6 m and 12.0 m below surface, and have remained relatively stable over time, despite periods of below average rainfall (HydroSimulations, 2019).

The depth to groundwater within the upper reaches of Saddlers Creek ranges between 3.7 m and 10.9 m below surface. The depth to groundwater within the lower reaches ranges between and 3.3 m and 6.4 m below surface (HydroSimulations, 2019).

Salinity is a key constraint to groundwater use and can be described by total dissolved solids (TDS) concentrations. Baseline groundwater salinity is analysed in the Groundwater Assessment (HydroSimulations, 2019). In summary:

- The Hunter River alluvium is generally fresh but can range between fresh to moderately saline. Measured TDS averages 791 milligrams per litre (mg/L) and ranges between 354 mg/L and 5,070 mg/L.
- Alluvium within the upper reaches of Saddlers Creek is generally moderately saline, with an average TDS of approximately 3,400 mg/L.
- Where water is present within the regolith material, it is generally moderately saline with an average TDS of approximately 5,400 mg/L.

4.3 SITE-SPECIFIC REVIEW OF GROUNDWATER DEPENDENT ECOSYSTEMS

The IESC stated the following regarding types of GDEs potentially impacted by the Project (IESC, 2018a):

> *At least two types of GDEs are potentially impacted:*
>
> *a. Type 1 – Aquifer and cave ecosystems. Stygofauna are known from the alluvial aquifers and hyporheic zones of the Hunter River and its tributaries (Hancock 2006; Hancock and Boulton 2009) and may be affected by altered groundwater regimes. Surveys (Eco Logical 2015 and 2018 cited in Attachment C, pp. 32 – 33) for stygofauna in the Hunter River alluvium and Saddlers Creek alluvium near the proposed project found one known stygofaunal taxon (Syncarida, Notobathynella sp.) from the Hunter River alluvium and two likely stygofaunal taxa (Cyclopoida and Ostracoda) in the Hunter River and Saddlers Creek alluvium.*
>
> *b. Type 3 – Ecosystems dependent on subsurface presence of groundwater. Groundwater-dependent vegetation is likely to occur, especially along riparian zones and on floodplains of Saddlers Creek, Saltwater Creek, the Hunter River and other relevant tributaries in the predicted areas of groundwater drawdown. Further assessment is needed to determine which vegetation in these areas is dependent on groundwater (see response to Question 4, paragraph 39), and how it may be affected by the proposed mining and associated drawdown. In particular, assessments are needed on the possible impacts to EPBC Act listed critically endangered ecological communities (e.g. White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland, Central Hunter Valley eucalypt forest and woodland) which may contain species that are opportunistically dependent on groundwater.*

Further information regarding the presence of these GDEs in the vicinity of the Project is provided in the following sub-sections.

4.3.1 Aquifer Ecosystems

Stygofauna are animals that occur in subsurface waters (NSW Department of Primary Industries, 2012).

An Aquatic Ecology and Stygofauna Assessment has been prepared for the Project by Eco Logical (2019) and is presented in Appendix F of the EIS.

Invertebrates were collected from six of the 13 bores sampled. During the surveys one known and two likely stygofauna taxa were collected from the Hunter River alluvium (Syncaarida: *Notobathynella* sp., Cyclopoida: *Diacyclops* sp. and Ostracoda crustacean). One likely stygofauna taxon (*Diacyclops* sp.) was collected from the Saddlers Creek alluvium (Eco Logical, 2019).

All of the above taxa have been previously collected from the Hunter River alluvium from Singleton upstream to Aberdeen (Hancock and Boulton, 2008, 2009; Eco Logical, 2015). None of the stygofauna taxa collected in 2018 are endemic to the Project area and surrounds, as all are widespread along aquifers of the Hunter River and associated tributaries (Eco Logical, 2019).

4.3.2 Ecosystems Dependent on Presence of Groundwater

Vegetation mapping was conducted for the Project by Hunter Eco (2019) (Figures 6a to 6d).

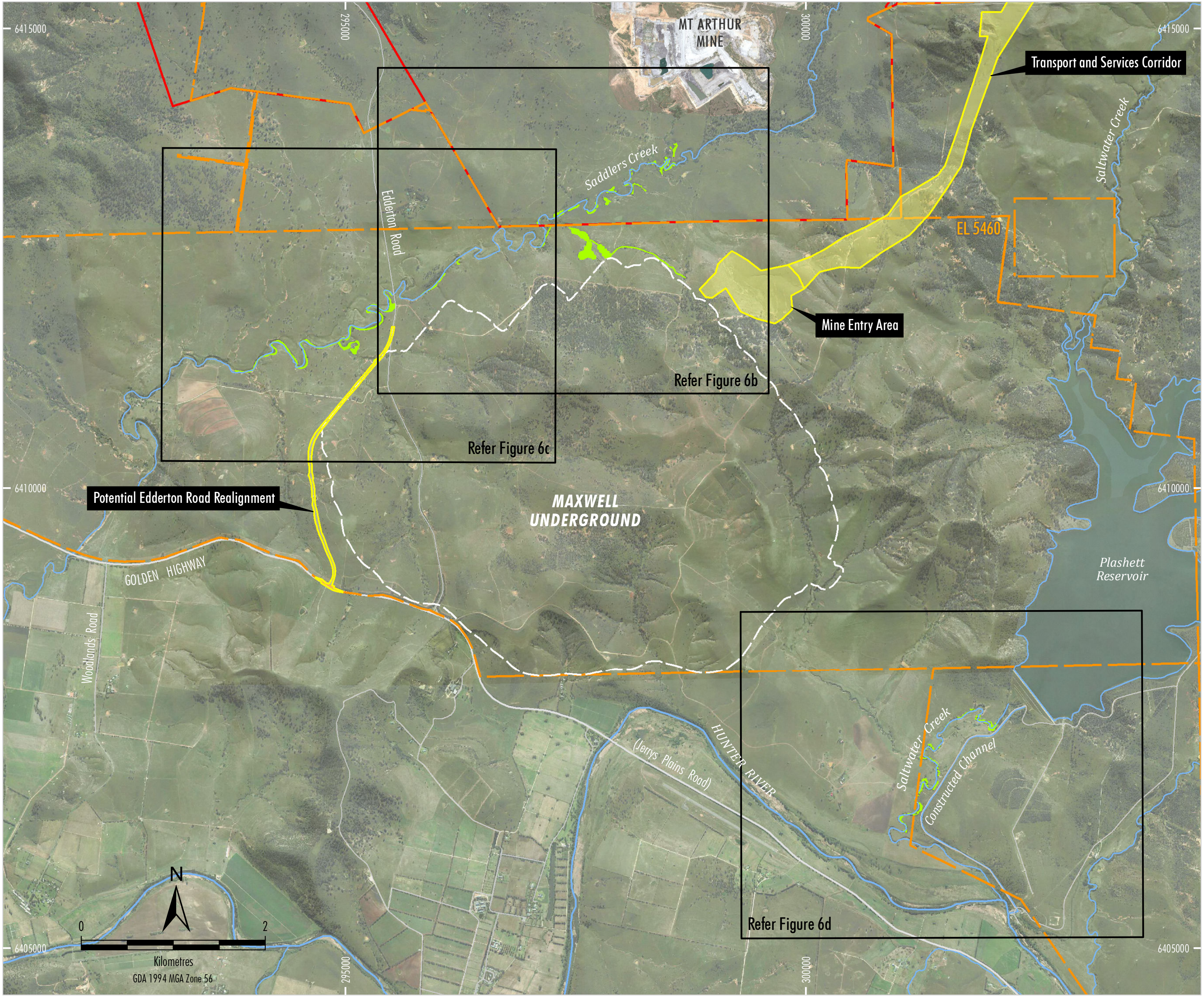
The mapping showed the majority of the Maxwell Underground area was covered with native perennial grassland due to historical land clearing. Remnant and regrowth forest and woodland occur in isolated areas, generally localised along riparian corridors (Hunter Eco, 2019).

Across the rest of the Maxwell Underground area, the identified vegetation was dry sclerophyll woodland/forest, which is not groundwater dependent. This is consistent with the conceptual hydrogeology of the area, which indicates the depth to groundwater within the Maxwell Underground area is typically greater than 20 m (Figure 4).

Hunter Eco (2019) found that the riparian vegetation associated with Saddlers and Saltwater Creeks consists of Swamp Oak (*Casuarina glauca*) that is restricted to the stream edge and immediate high bank to a width of between 10 m and 30 m. Swamp Oak is a clonal suckering species and forms dense thickets that expand at the edges with suckering new growth. Plant height varies from less than a metre to approximately 10 m to 15 m tall (Hunter Eco, 2019).

BioNet Atlas (OEH, 2019) showed a single River Red Gum (*Eucalyptus camaldulensis*) paddock tree on the Saddlers Creek floodplain west of the Study Area. This tree was inspected by Hunter Eco (2019) on 3 July 2019 and found to be a Yellow Box, positively identified by the colour of the foliage, and the shape of buds and fruit. In particular the fruit was of a Box type (cup-shaped with recessed disc and enclosed valves) rather than Red Gum type (globose/ovoid with disc raised and exserted valves). There were no River Red Gum in the vicinity of Saddlers Creek or Saltwater Creek.

Swamp Oak essentially forms a monoculture along Saddlers Creek which is likely a result of the very high recorded salinity values (Section 4.2) that Swamp Oak can tolerate (Cramer *et al.*, 1999), but Eucalypts cannot (Hunter Eco, 2019).



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); MSEC (2019)
Orthophoto Mosaic: 2018, 2016, 2011

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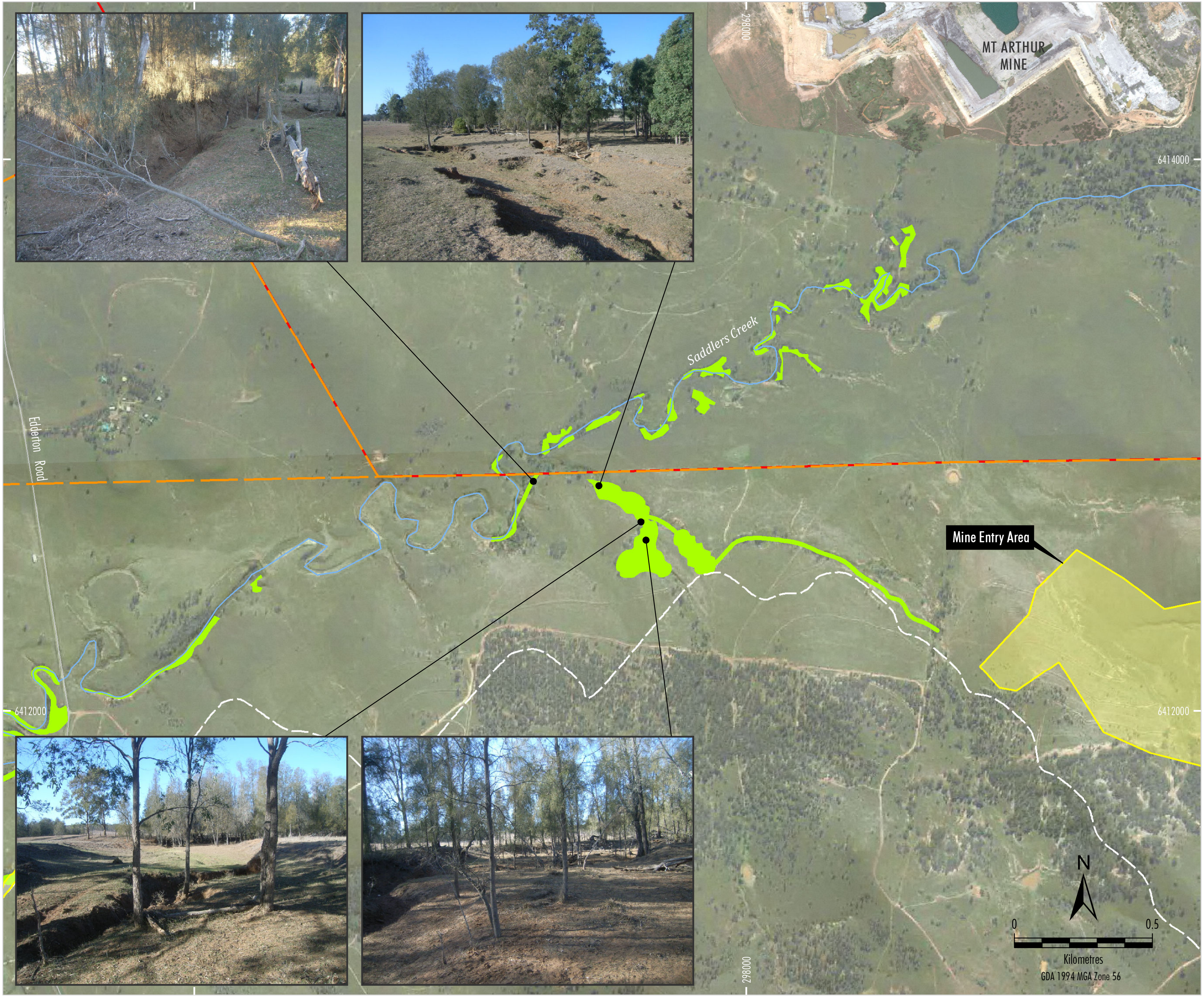
Swamp Oak Forest Identified in the Vicinity of the Project

Figure 6a

SHM-18-03 Maxwell_EIS_App GDE_206A



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

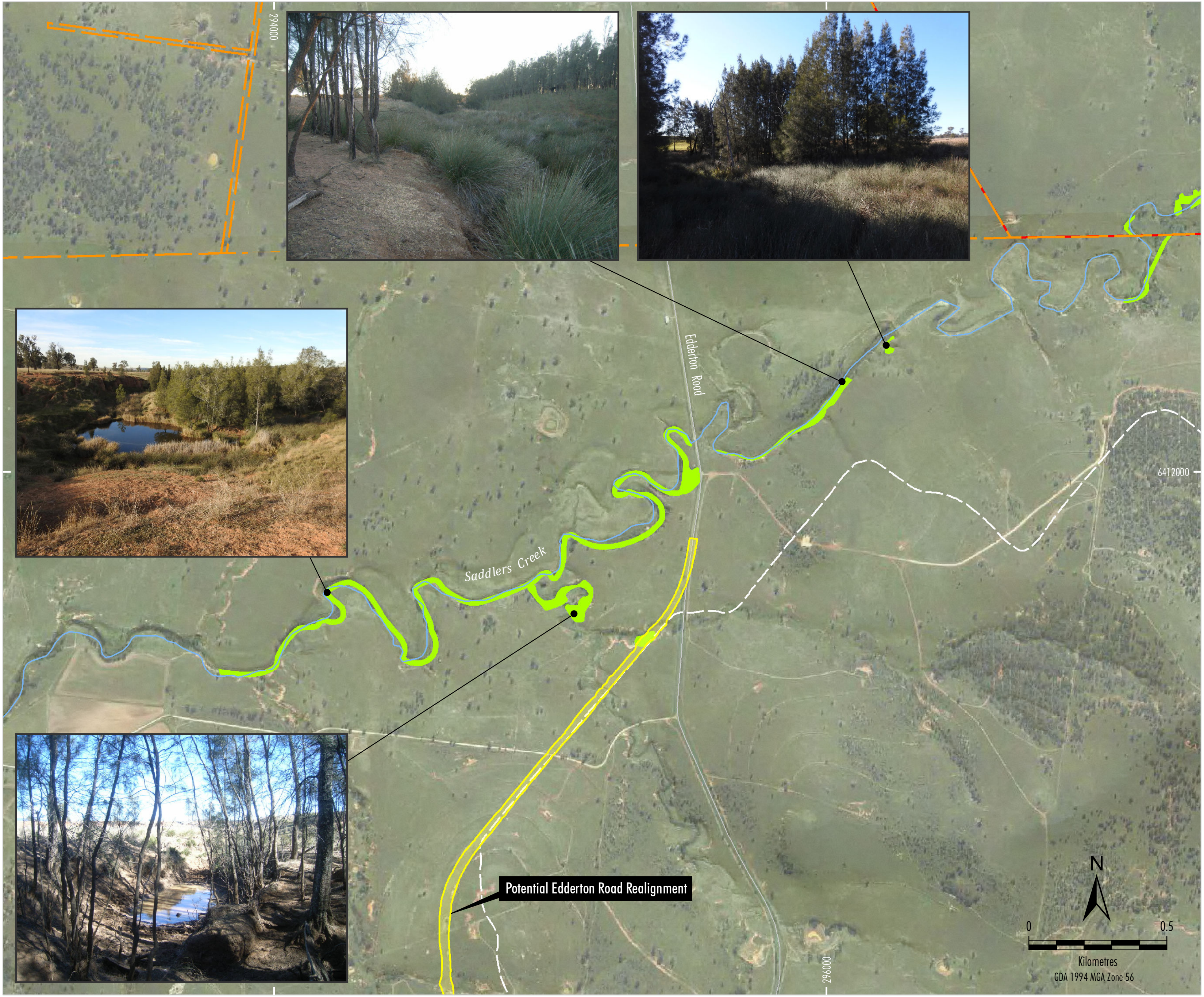
MALABAR COAL

M A X W E L L   P R O J E C T

Swamp Oak Forest - Saddlers Creek (North)

Figure 6b

SHM-18-03 Maxwell_EIS_App GDE_207A



LEGEND

- Exploration Licence Boundary
- Mining and Coal Lease Boundary
- Indicative Surface Development Area
- Extent of Conventional Subsidence (20 mm subsidence contour)
- Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

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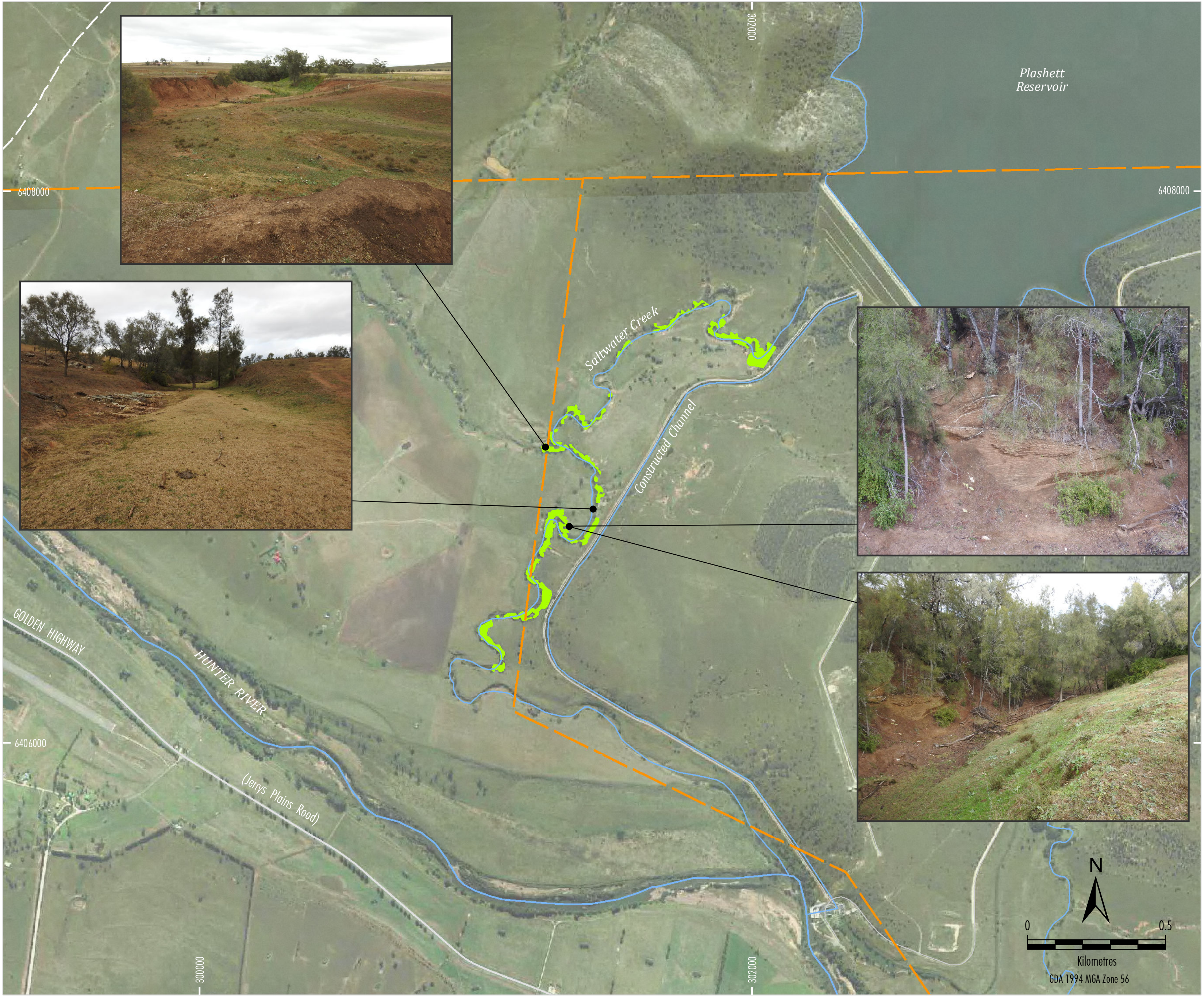
M A X W E L L   P R O J E C T

Swamp Oak Forest - Saddlers Creek (South)

Figure 6c



LEGEND

Exploration Licence Boundary

Extent of Conventional Subsidence (20 mm subsidence contour)

Swamp Oak Forest (PCT 1731)

Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); Hunter Eco (2019); Fluvial Systems (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

N

0 0.5

Kilometres

GDA 1994 MGA Zone 56

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M A X W E L L   P R O J E C T

Swamp Oak Forest - Saltwater Creek

Figure 6d

SHM-18-03 Maxwell_EIS_App GDE_209A

While there are no data on the root depth of Swamp Oak there are root depth data for some of its congeners. Canadell *et al.* (1996) report maximum root depths for *Casuarina pusilla* (2.4 m) and *Casuarina muelleriana* (2.0 m). Stone and Kalisz (1991) report depths for *Casuarina cristata* (>2.5 m) and *Casuarina equisetifolia* (4.0 m). Both *Casuarina equisetifolia* and *Casuarina cristata* are trees of approximately the same maximum size of Swamp Oak. It is therefore reasonable to assume for this assessment that the maximum root depth for Swamp Oak could be up to 4.5 m. Cramer et al (1999) reported Swamp Oak in a different environment (in Queensland) accessing groundwater at depths of 1.6 m and 3.0 m at the two sites studied (Hunter Eco, 2019).

Along the length of both Saddlers and Saltwater Creeks the creek bed is often deeply incised to over 3 m below the high bank. Swamp Oak grows from the stream bed level up to the high bank (a height at which trees are not likely to be able to access the groundwater table) indicating that the Swamp Oak along Saddlers and Saltwater Creeks are primarily accessing the stream baseflow and seepage in the soil profile rather than the deeper groundwater. This assessment is further confirmed by the restriction of the Swamp Oak to the immediate streamline; were they to be dependent on the deeper water table, they would be more widely dispersed (Hunter Eco, 2019).

Accordingly, the Swamp Oak are considered to be a Type 2 GDE (ecosystems dependent on the surface expression of groundwater) as defined in the *Australian Groundwater-Dependent Ecosystems Toolbox* (Richardson *et al.*, 2011).

No groundwater dependent, listed threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation Act, 1999* or NSW *Biodiversity Conservation Act, 2016* were identified in the vicinity of the Project (Hunter Eco, 2019).

There are no 'high priority GDEs' (as defined in the relevant water sharing plans) in the vicinity of the Project.

Vegetation mapping was not undertaken for the Hunter River for this Project. Notwithstanding, given the Hunter River is mapped as having high potential for groundwater interaction (Section 4.1 and Figure 3), potential impacts on any GDEs along the Hunter River have been considered in Section 5.

5 POTENTIAL IMPACTS ON GROUNDWATER DEPENDENT ECOSYSTEMS

GDEs in the vicinity of the Project are constrained to the shallow groundwater available in the alluvium associated with Saddlers Creek, Saltwater Creek and the lower sections of their tributaries. Potential impacts on any GDEs that may be present along the Hunter River have also been considered.

Pathways of potential Project impacts on GDEs have been identified by Hunter Eco (2019) and HydroSimulations (2019) as follows:

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

5.1 GROUNDWATER AVAILABILITY

The Groundwater Assessment prepared by HydroSimulations (2019) has evaluated the potential impacts of the Project on groundwater resources using a numerical regional groundwater model. Groundwater modelling included predictive modelling over the life of the Project as well as recovery modelling for a 1,000-year period post-mining.

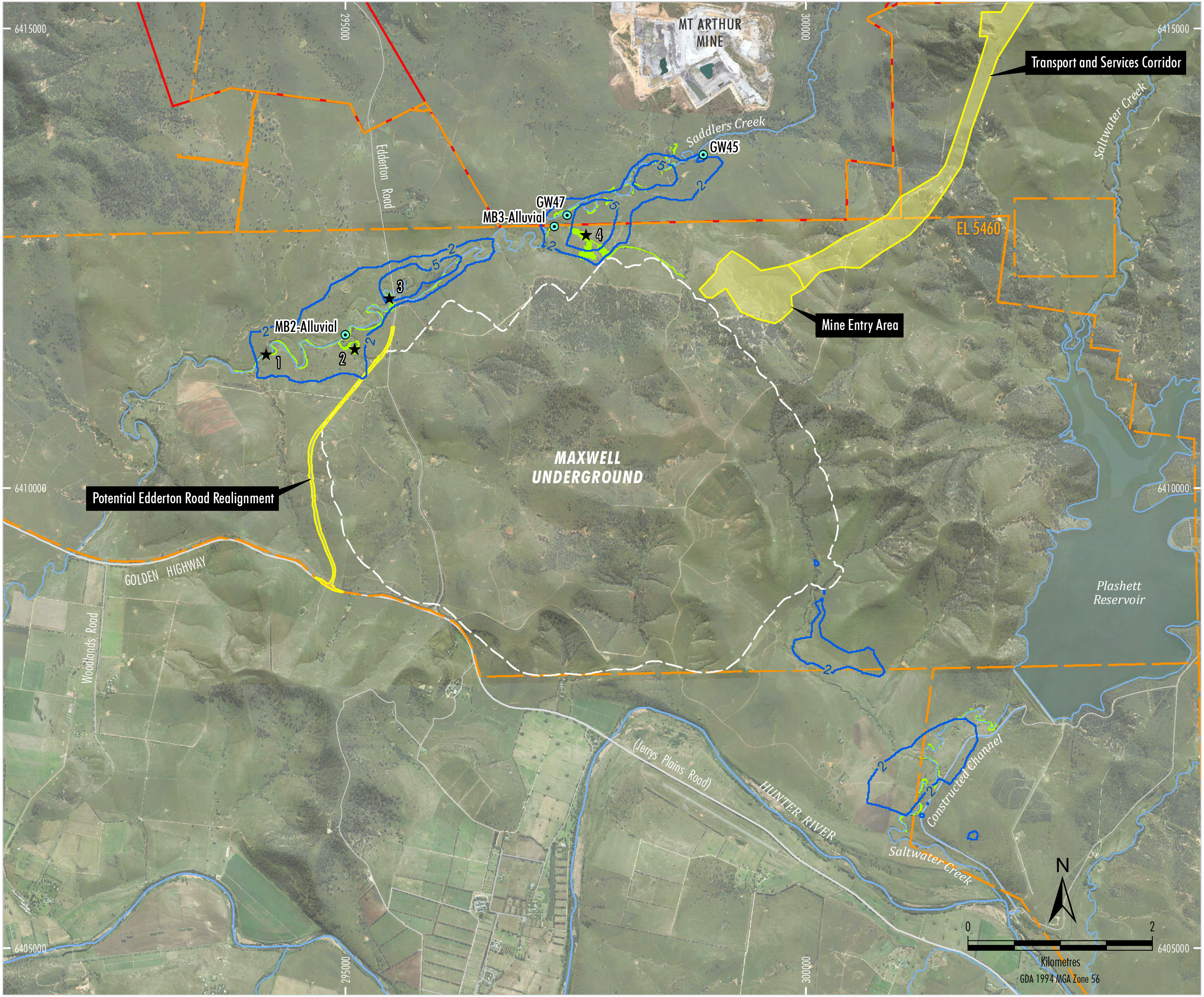
The extent of drawdown predicted in the alluvium as a result of the Project (including the Saddlers Creek alluvium, Saltwater Creek alluvium and Hunter River) is shown on Figure 7. Figure 7 shows:

- No drawdown greater than 2 m was predicted within the Hunter River alluvium.
- Drawdown exceeding greater than 2 m was predicted within the Saddlers Creek alluvium.
- Drawdown exceeding greater than 2 m was predicted within the Saltwater Creek alluvium.
- Drawdown exceeding greater than 2 m was predicted within the alluvium along a tributary of Saltwater Creek.

Hydrographs from the predictive and recovery groundwater modelling have been developed for four areas where Swamp Oak has been mapped along Saddlers Creek. The locations of the representative points are shown on Figure 7. The hydrographs are presented on Figures 8a and 8b and show the timing associated with groundwater level change due to the Project.

Groundwater drawdown in the alluvium would develop slowly over time, reaching a maximum hundreds of years post-mining. The maximum predicted drawdown in the Saddlers Creek alluvium would occur at a rate of approximately 1 m every 50 years (Figures 8a and 8b).

The drawdown in the alluvium remains sustained over time due to the assumptions in the recovery model with constant averaged rainfall and Saddlers Creek modelled as dry. This results in reduced potential recharge to the alluvium compared to conditions that have been observed along Saddlers Creek, providing a conservative estimate of impacts (HydroSimulations, 2019).



Source: © NSW Department of Planning and Environment (2019); NSW Department of Finance, Services & Innovation (2019); HydroSimulations (2019); Hunter Eco (2019); MSEC (2019) Orthophoto Mosaic: 2018, 2016, 2011

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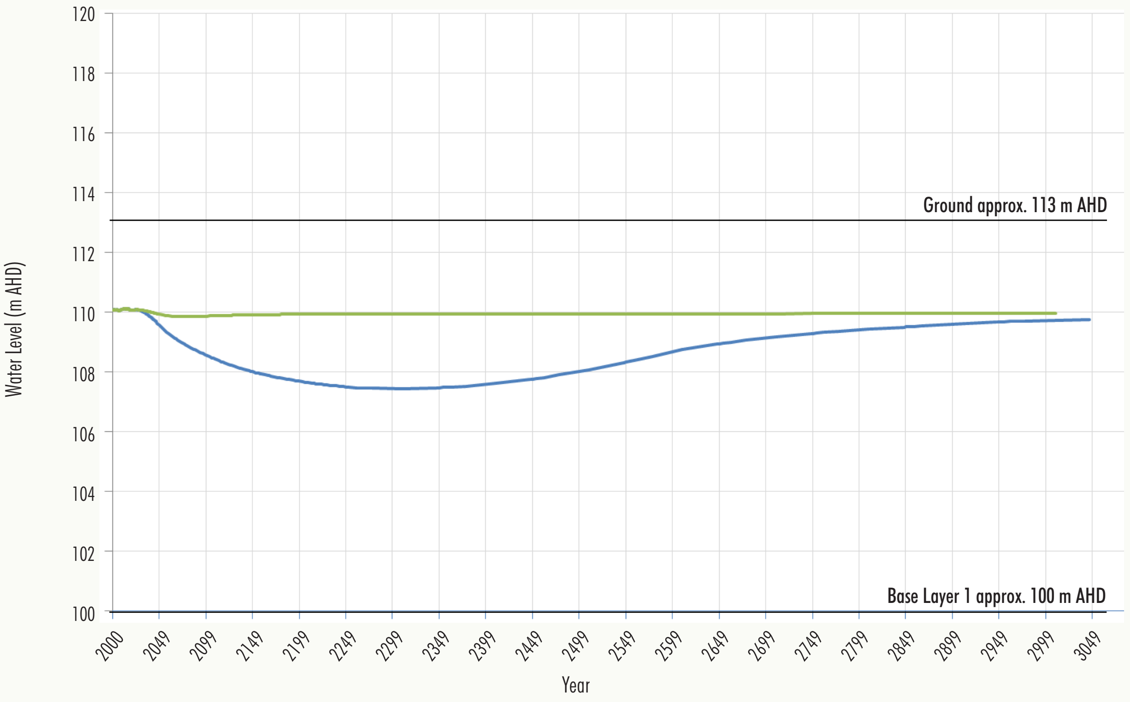
MAXWELL PROJECT

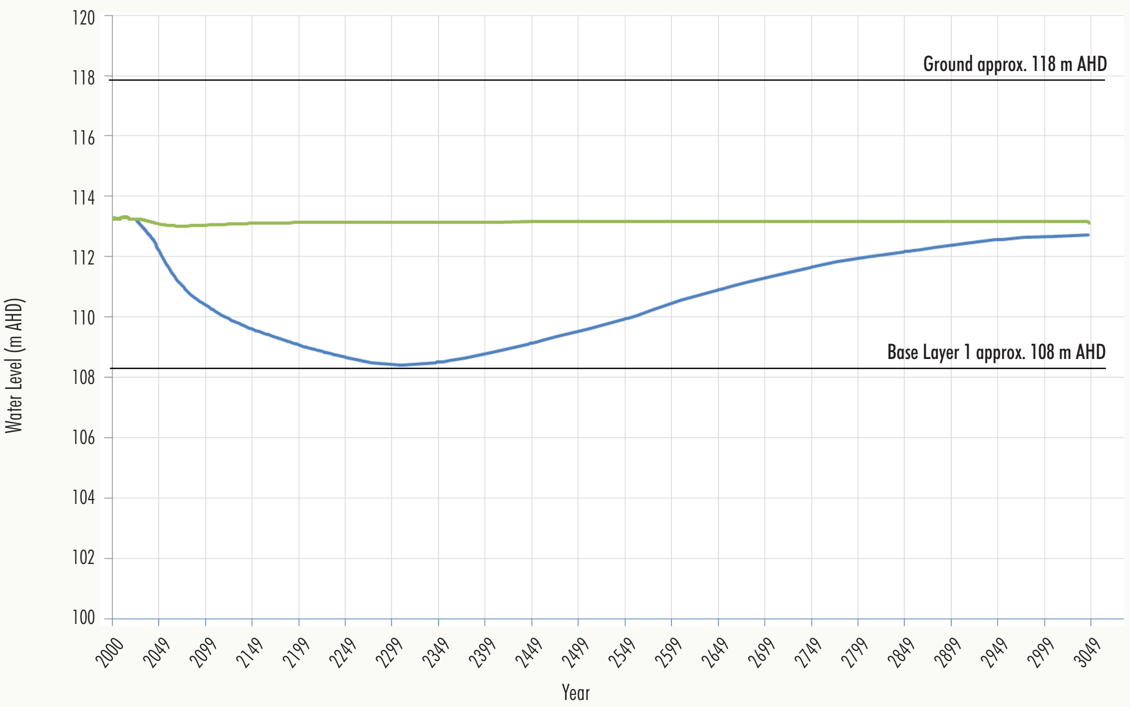
Extent of Predicted Alluvial Drawdown

Figure 7

SHM-18-03 Maxwell_EIS_App GDE_210C



Representative Swamp Oak Location 1



Representative Swamp Oak Location 2

SHM-18-03 Maxwell_EIS_App GDE_001A

LEGEND

Predicted Water Level (with Project)

Predicted Water Level (without Project)

Refer Figure 7 for Representatvie Swamp Oak Locations.

Source: HydroSimulations (2019)

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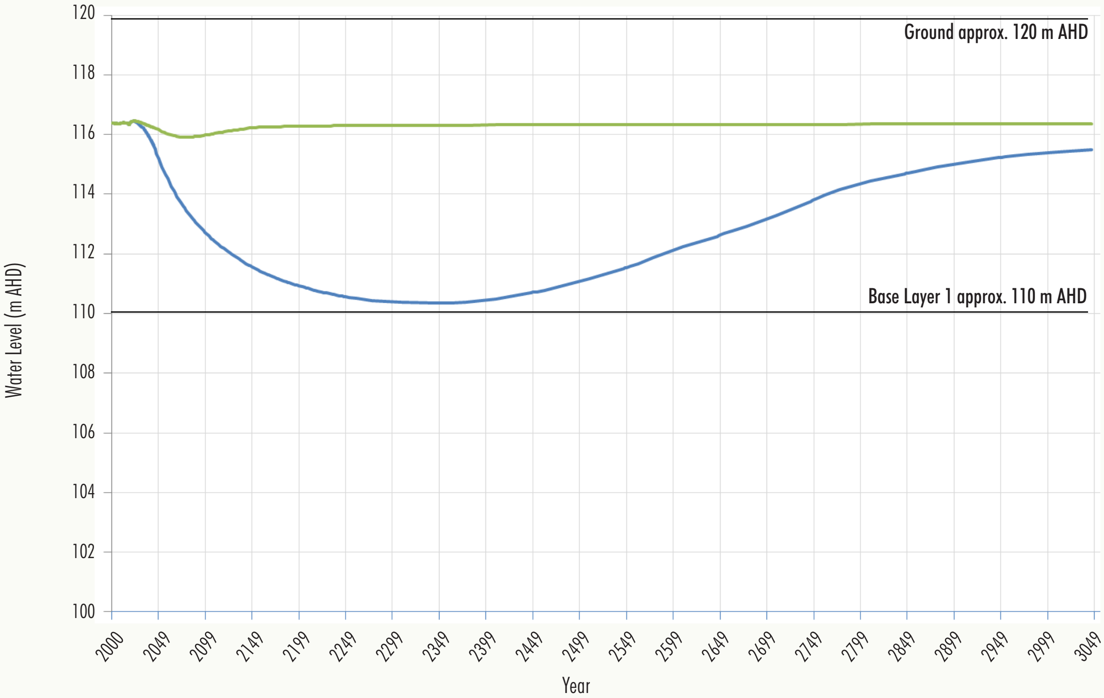
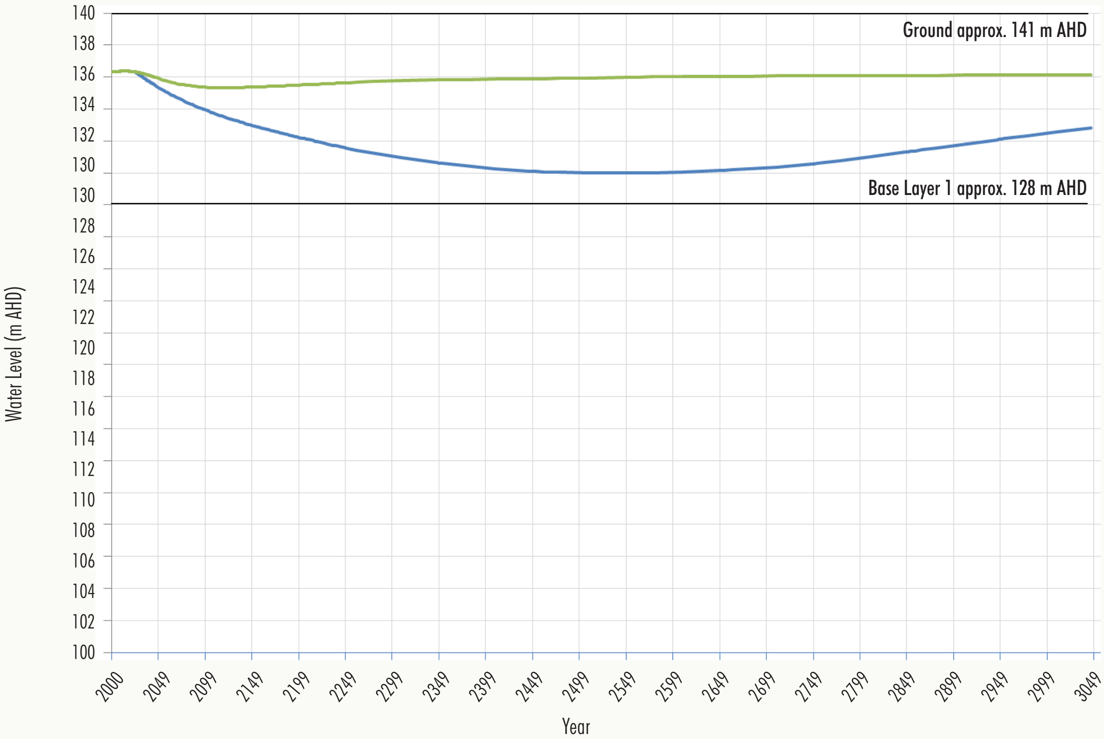
Predicted Hydrographs at Representative Swamp Oak Locations

Figure 8a



Representative Swamp Oak Location 3



Representative Swamp Oak Location 4

SHM-18-03 Maxwell_EIS_App GDE_002A

LEGEND
Predicted Water Level (with Project)
Predicted Water Level (without Project)

Refer Figure 7 for Representatvie Swamp Oak Locations.

Source: HydroSimulations (2019)

MALABAR COAL

M A X W E L L   P R O J E C T

Predicted Hydrographs
at Representative Swamp Oak Locations

Figure 8b

The potential impact of the Project on baseflow in Saddlers Creek, Saltwater Creek and the Hunter River has been determined by HydroSimulations (2019). The assessment concluded the following:

- no impact on baseflow in Saddlers Creek or Saltwater Creek; and
- a maximum baseflow reduction of 0.55 megalitres per year (ML/year) in the Hunter River.

In the context of the Hunter River regulated system, a baseflow loss of 0.55 ML/year is negligible. Hence, the Project would not measurably affect baseflow in the downstream waterways (WRM, 2019).

The Swamp Oak along Saddlers Creek and Saltwater Creek are Type 2 GDEs that are dependent on the surface expression of groundwater (i.e. baseflow) (Section 4.3.2). Consequently, it is unlikely that the predicted Project groundwater drawdown would adversely impact the Swamp Oak along either Saddlers or Saltwater Creeks (Hunter Eco, 2019).

Stygofauna were recorded in the Hunter River and Saddlers Creek alluvial aquifer, although none of the taxa collected are endemic to the Project area and surrounds. Negligible drawdown has been predicted for the Hunter River alluvium as a result of the Project. Some drawdown of alluvial groundwater along Saddlers Creek is expected, although habitat connectivity between the downstream reaches of Saddlers Creek and the Hunter River alluvial aquifers would be maintained. In consideration of the above, Eco Logical (2019) concluded the Project is not likely to have a significant impact on stygofauna.

5.2 GROUNDWATER QUALITY

The Project is predicted to reduce upward leakage from the Permian coal measures to the overlying alluvium in localised areas along Saddlers Creek, Saltwater Creek and the Hunter River. These results demonstrate that as the Permian coal measures become depressurised, flow from the Permian to the alluvium reduces (HydroSimulations, 2019).

This can be considered beneficial as it reduces the inflow rate of higher salinity groundwater from the Permian to the overlying alluvium. Accordingly, the Project is considered to have negligible adverse impacts on groundwater quality in the alluvium (HydroSimulations, 2019).

In consideration of the above, Hunter Eco (2019) and Eco Logical (2019) determined that the Project would not have an impact on GDEs due to adverse changes to groundwater quality.

6 MITIGATION MEASURES AND MONITORING

Water Management Plans (including a Groundwater Management Plan) would be prepared for the Project as part of the Extraction Plan process (i.e. Extraction Plans would be prepared progressively over the life of the Project).

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

6.1 GROUNDWATER LEVEL MONITORING

Groundwater monitoring would be undertaken in accordance with the Groundwater Management Plan (as part of the Water Management Plan). Manual groundwater level monitoring would be conducted for all monitoring bores, with dataloggers installed within selected bores to gather temporal variations in water levels. Data would also be downloaded from the existing Vibrating Wire Piezometers, pressure readings recorded and converted to groundwater elevations within a central database.

Ongoing monitoring would enable natural groundwater level fluctuations (such as responses to rainfall) to be distinguished from potential groundwater level impacts due to depressurisation resulting from Project. Ongoing monitoring of groundwater levels would also be used to assess the extent and rate of depressurisation against model predictions.

Yearly reporting of the water level results from the monitoring network would be included in the Annual Review. The reporting would include a comparison to climate trends and surface water monitoring results to identify changes in the surface water and groundwater interactions. The Annual Review would also identify if any additional monitoring sites are required, or if optimisation of the existing monitoring sites should be undertaken.

6.2 GROUNDWATER QUALITY

Groundwater quality sampling would be conducted to monitor groundwater quality during and post-mining. Additional data would be collected prior to commencement of mining, particularly for bores recently installed as part of the Project.

Sampling would include the collection of field analytes of pH and electrical conductivity (EC) on a quarterly basis, as well as annual sampling for laboratory analysis of a full suite of analytes to determine any changes in beneficial groundwater, including:

- physio-chemical indicators – pH, EC, TDS;
- major ions – calcium, fluoride, magnesium, potassium, sodium, chloride, sulphate;
- total alkalinity as calcium carbonate ($CaCO_3$), bicarbonate (HCO_3), carbonate (CO_3); and
- dissolved and total metals – aluminium, arsenic, barium, boron, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, strontium, silver, vanadium and zinc.

Similar to the water level monitoring, yearly reporting of the water quality results from the monitoring network would be included in the Annual Review. The Annual Review would consider if any additional monitoring sites are required, or if optimisation of the existing monitoring sites, frequency of sampling and analytical suite should be undertaken.

6.3 STREAM HEALTH MONITORING

The extent of riparian vegetation and extent of erosion and sedimentation deposits would be used as an indicator of stream health.

Monitoring would be undertaken quarterly by taking photographs at each of the Saddlers Creek surface water monitoring sites. The photographs would be taken at the same location (identified by GPS or permanent photographic ID post) and taken of the relevant bed and bank features looking upstream and downstream.

These photographs would be documented with the location, direction and date as well as a log of erosional and depositional features at each location.

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