Central Eyre Iron Project
Environmental Impact Statement

APPENDIX U

INFRASTRUCTURE GROUNDWATER IMPACT ASSESSMENT

JACOBS

REPORT

Central Eyre Iron Project: Infrastructure Groundwater Impact Assessment

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Glossary

Aquifer	A formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield economical quantities of water to wells and springs
Aquitard	A saturated but poorly permeable bed, formation, or group of formations that can store water but only yields it slowly to a well or a spring, it may transmit appreciable water to or from adjacent aquifers
Cone of depression	A depression in the groundwater table or potentiometric surface that has the shape of an inverted cone, and develops around a well or mine pit from which water is being withdrawn, either by pumping or evaporation
Confined aquifer	An aquifer that lies below low permeability material and where the piezometric surface lies above the base of the confining material, eg. artesian and sub-artesian aquifers
Drawdown	The distance between the static water level and the surface of the cone of depression at any one location
Groundwater	The water contained in interconnected pores, gaps or fractures located below the water table
Hydraulic conductivity	A coefficient of proportionality describing the rate at which water can move through a permeable medium
Hydraulic gradient	The change in total head per unit distance in a given direction
Potentiometric surface	The level to which water will rise in wells screening a discrete aquifer, the water table represents the potentiometric surface for an unconfined aquifer
Total dissolved solids	The total amount of dissolved solid matter found in a sample of water
Transmissivity	The rate at which water moves through a unit width of aquifer or aquitard under a unit hydraulic gradient, it is calculated as the product of aquifer thickness and hydraulic conductivity
Unconfined aquifer	A water table aquifer
Water table	The surface between the unsaturated and saturated zones of the subsurface at which the hydrostatic pressure is equal to that of the atmosphere
Well	A borehole that has been cased with pipe, usually steel or PVC plastic, in order to keep the borehole open in unconsolidated sediments or unstable rock, often used interchangeably with the term bore

1 Introduction

1.1 Overview

Iron Road Limited (Iron Road) is proposing to develop an iron ore mining and minerals processing operation referred to as the Central Eyre Iron Project (CEIP) at Warramboo, approximately 28 km south-east of Wudinna on the Eyre Peninsula, South Australia. Significant ancillary infrastructure is required to support the mine and to provide the logistics chain to enable export of the iron ore concentrate. The required ancillary infrastructure includes a deep water port on the east coast of the Eyre Peninsula, a standard gauge rail line, a water supply borefield and associated pipeline for process water, a 275 kV transmission line and an operations village to provide long term accommodation for the mine site workforce.

This report presents an assessment of potential impacts to existing groundwater users arising from Water Affecting Activities (WAA) associated with the CEIP Infrastructure. This assessment forms part of the larger Environmental Impact Assessment (EIS) for the CEIP Infrastructure. A study area has been defined to encompass an area where effects arising from WAA are predicted to be contained within (Figure 1). The area encompasses a 20 km buffer zone either side of the proposed railway and an area surrounding the proposed borefield which is located near the township of Kielpa.

This Groundwater Impact Assessment (GIA) draws on other technical investigations which should be read in conjunction with this report:

- Kielpa Groundwater Supply Study (GWS, 2014a)
- Central Eyre Iron Project Utilities Corridor Construction Water Supply Groundwater Investigation (GWS, 2014b)
- Central Eyre Iron Project Construction Water Supply Study (GWS, 2013)

Groundwater impacts associated with the mine site are assessed and reported in the CEIP Mine Site GIA (Jacobs, 2014).

1.2 Approach to assessing potential groundwater effects

To understand the potential effects posed to groundwater systems and sensitive receptors as a result of project WAA it is necessary to consider how operations such as groundwater pumping and infrastructure development might change the pre-development groundwater regime.

Direct potential groundwater impacts relate to the physical influence of WAA associated with project activities and supporting infrastructure on groundwater and connected systems. Four categories of direct potential impacts have been identified by Brereton and Moran (2008):

- *Groundwater quantity*;
  Includes consideration of changes to groundwater levels / pressures and flux.
- *Groundwater quality*;
  Includes consideration of salinity and concentrations of other important water quality constituents.
- *Groundwater – surface water interaction*;
  Includes consideration of changes to the level of interaction between groundwater and surface water systems.
- *Physical disruption of aquifers*;
  Includes consideration of whether or not there will be permanent disruption of a groundwater system from the proposed activities, and to what extent.

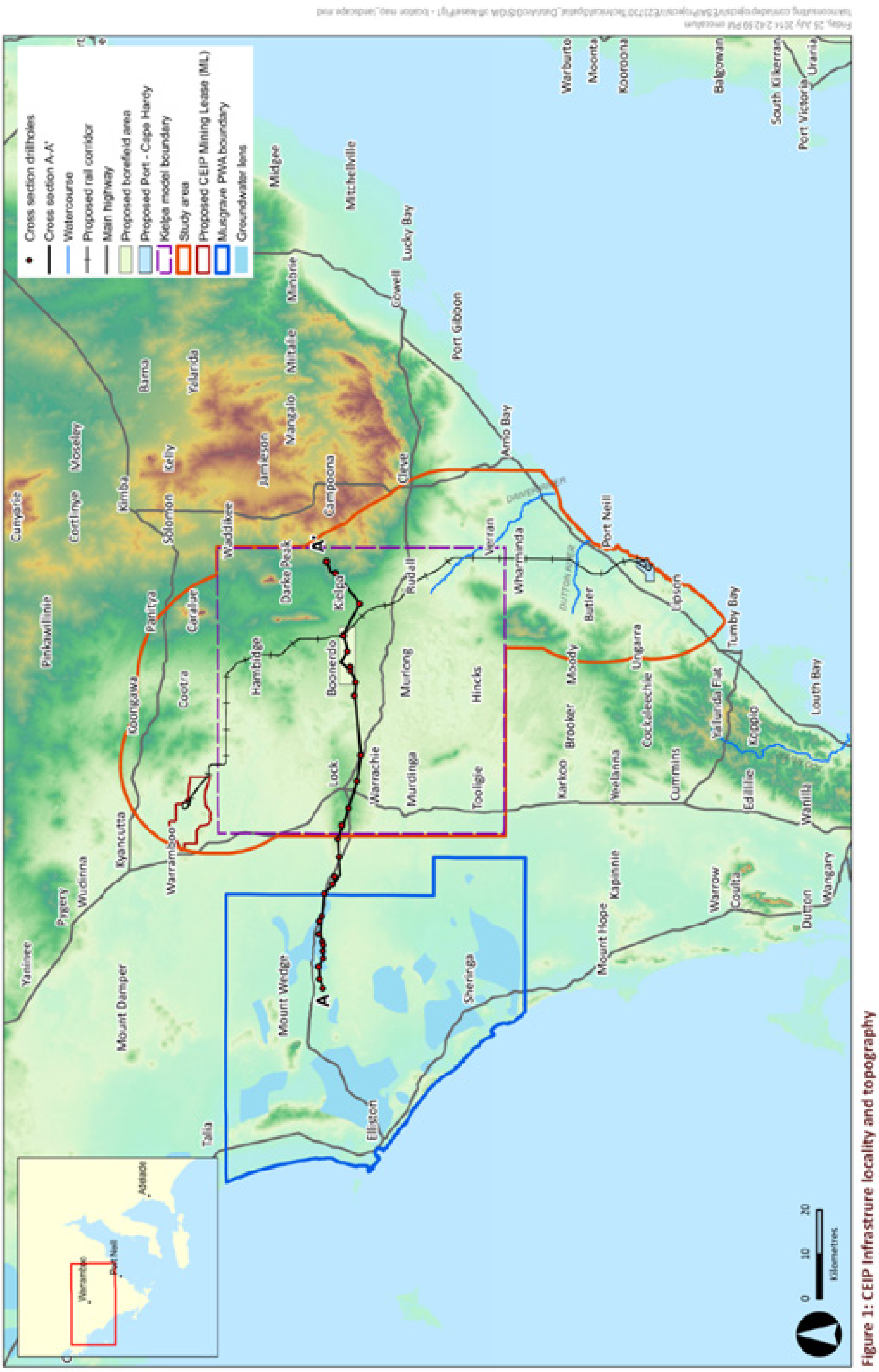

Figure 1: CEIP Infrastructure locality and topography

Direct potential groundwater impacts have the potential to affect 'receptors' within the predicted zone of influence. The term 'receptor' is used here to include environmental, social (and cultural) and economic users of groundwater resources.

1.3 Assessment framework

The National Water Commission (NWC, 2010) developed an assessment framework which provides a risk-based approach to managing local and cumulative effects of mining and associated infrastructure on groundwater and connected systems. This approach is similar to the traditional 'source, pathway, receptor' model, whereby the assessment of risk posed to a potential receptor is determined by the level of receptor exposure to a threatening process and adverse effect arising from that exposure. Figure 2 presents the assessment framework developed by the NWC (2010) which has been used as a framework for this GIA. For a threat to emerge there needs to be an exposure pathway linking direct groundwater impacts with receptors.

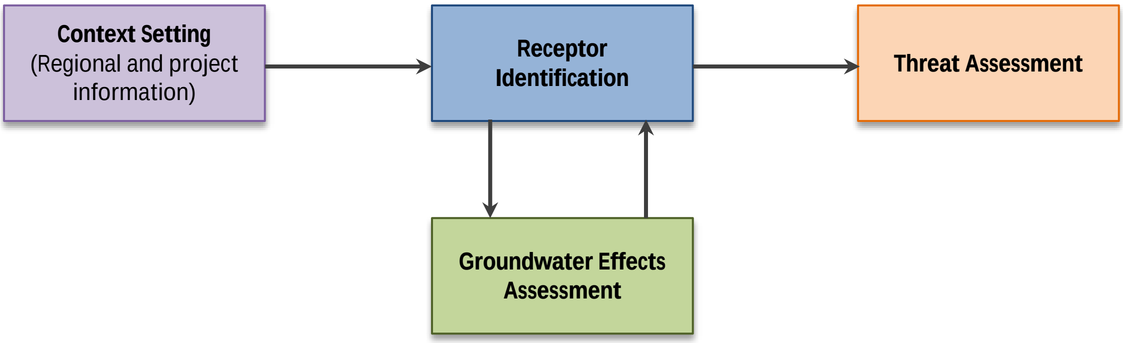

Figure 2: Framework for assessing local and cumulative effects of mining on groundwater systems (adapted from NWC, 2010)

Table 1 presents a summary of the framework stages as presented in this report.

Table 1: Summary of the groundwater impact assessment framework

Chapter	Framework Stage	Comments
2	Context setting	Involves placing the activity of concern into context, e.g. interactions between groundwater flow systems
3	Receptor Identification	Involves developing an understanding of the receiving environment that will potentially be altered by potential direct effects and clearly identifying those receptors that may be at risk
4	Groundwater Effects Assessment	Comprises identification of direct potential impacts to the groundwater system arising from project activities
5	Threat Assessment	Involves an assessment of the degree to which direct potential impacts will impact on receptors that have been identified as having a linkage to direct impacts, both spatially and temporally

1.4 Legislative requirements

In South Australia, WAA are administered under Section 127 of the *Natural Resources Management Act 2004* (NRM Act). To undertake most types of WAA, a permit is required from the relevant authority, which in most cases is the Minister for Sustainability, Environment and Conservation through the South Australian Government Department of Environment, Water and Natural Resources (DEWNR) or the relevant Regional Natural Resources Management Board (NRM Board). The proposed CEIP Infrastructure is located within the Eyre Peninsula (EP) NRM Board region.

2 Context setting

2.1 Location and project description

The CEIP is located on the Eyre Peninsula, South Australia and comprises a mine site, infrastructure corridor, port facility and employee village. The infrastructure corridor which connects the mine site with the port facility extends approximately 145 km.

A summary of the infrastructure required to support the CEIP is provided in Table 2 along with an assessment of the potential for groundwater interaction. The infrastructure elements thought to interact with groundwater have been further assessed in this GIA.

Table 2: Summary of infrastructure elements

Infrastructure element	Groundwater interaction
Infrastructure corridor production wells	Yes
Kielpa Borefield	Yes
Port facility (train unloader excavation)	Yes
Railway line	No
Employee village	No

The major WAA required to support the CEIP infrastructure include:

- Abstraction from groundwater wells located along the infrastructure corridor required to supply groundwater through the construction period (2 years);
- A saline groundwater borefield located approximately 60 km south-east of the proposed mine site. The borefield will incorporate approximately 10 bores and will have the capacity to deliver 15 GL/yr for the life of mine which is scheduled to operate for 25 years; and
- Excavation below the groundwater table at the port site to accommodate the train unloading facility.

A study area has been defined which encompasses an area where effects arising from WAA are predicted to be contained within (Figure 3). The study area includes the boundary of the numerical groundwater flow model which has been developed to assess the viability and impacts of the proposed Kielpa Borefield and a 20 km buffer zone either side of the proposed railway line.

Within the study area, a large proportion of land has been cleared for agricultural purposes, including broad acre cropping and grazing. Significant areas of native vegetation remain intact, although these areas are largely restricted to conservation reserves such as Hambidge Wilderness Protection Area (Figure 3).

2.2 Climate

The study area is located within an arid to temperate climate zone that experiences hot summers and cool winters. Mean annual rainfall on the Eyre Peninsula ranges from 263 mm at inland areas such as Wudinna, to 381 mm at coastal locations such as Port Lincoln. Mean annual maximum and minimum temperatures at Wudinna and Kimba range from 25.1°C to 10.2°C and 23.5°C to 10.3°C respectively.

2.3 Topography

The central Eyre Peninsula is dominated by sand dune covered plains, with several hilly areas and granite plains. Within the study area, the topography ranges from approximately 5 m AHD at the coast to approximately 175 m AHD in the area surrounding Darke Peak (Figure 1).

2.4 Hydrology

Surface water on the Eyre Peninsula is sparse, with the occurrence of creeks and rivers limited by the topography and low rainfall. There are no prescribed surface water areas on the Eyre Peninsula. The Tod River, which is located approximately 50 km south-west of the port site flows south from Yallunda Flat to its mouth near Port Lincoln. The Tod River is the only permanent stream on the Eyre Peninsula. Other stream systems are ephemeral or seasonal with limited connection to the ocean.

Two ephemeral creek lines are present in the southern region of the study area that flow toward the Spencer Gulf. These are the Dutton River and Driver River. Inland, along the central and northern regions of the study area, there are no significant ephemeral creek lines present. This is likely due to the relatively flat topography in these areas.

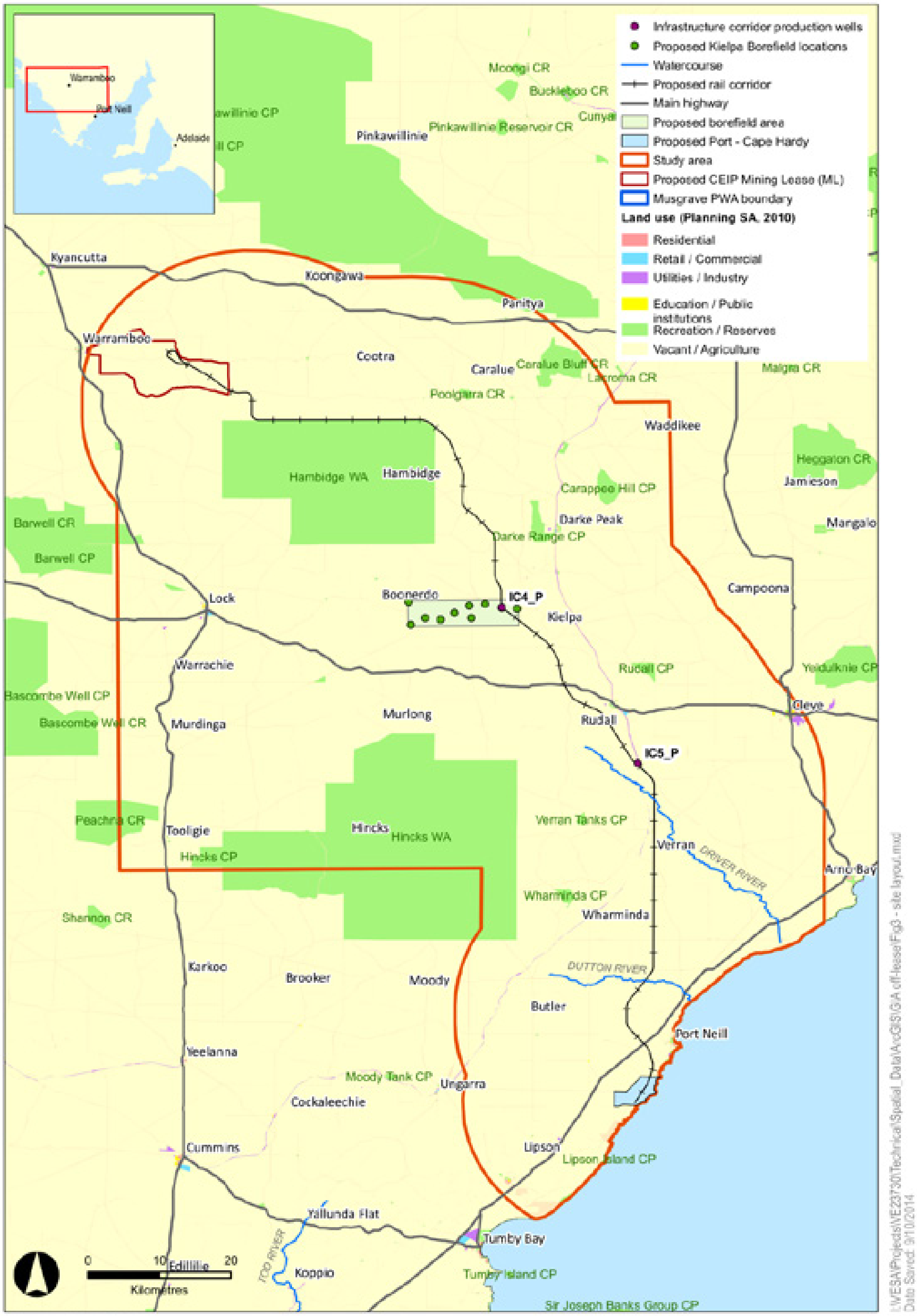

Figure 3: CEIP Infrastructure study area and land use

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2.5 Geological setting

The infrastructure corridor traverses four geological domains which have been defined for the purposes of this study as the Northern Domain, Kielpa Domain, Verran Domain and Dutton River Domain (GWS, 2014b). The locations of these geological domains are illustrated in Figure 4 and are summarised in Table 3.

Table 3: CEIP geological domains (GWS, 2014b)

Domain	Description
Northern Domain	This area hosts granite and gneiss of the Sleaford Complex which is overlain by Tertiary and Quaternary Sediments
Kielpa Domain	This area hosts the Polda Trough, a Permian aged structural depression infilled with up to 400 m of Permian, Jurassic, Tertiary and Quaternary Sediments
Verran Domain	This area hosts the Blue Range Beds characterised by fluvial, massive to cross-bedded sandstone
Dutton River Domain	This area hosts the Lincoln Complex granites overlain by a thin veneer of Quaternary cover

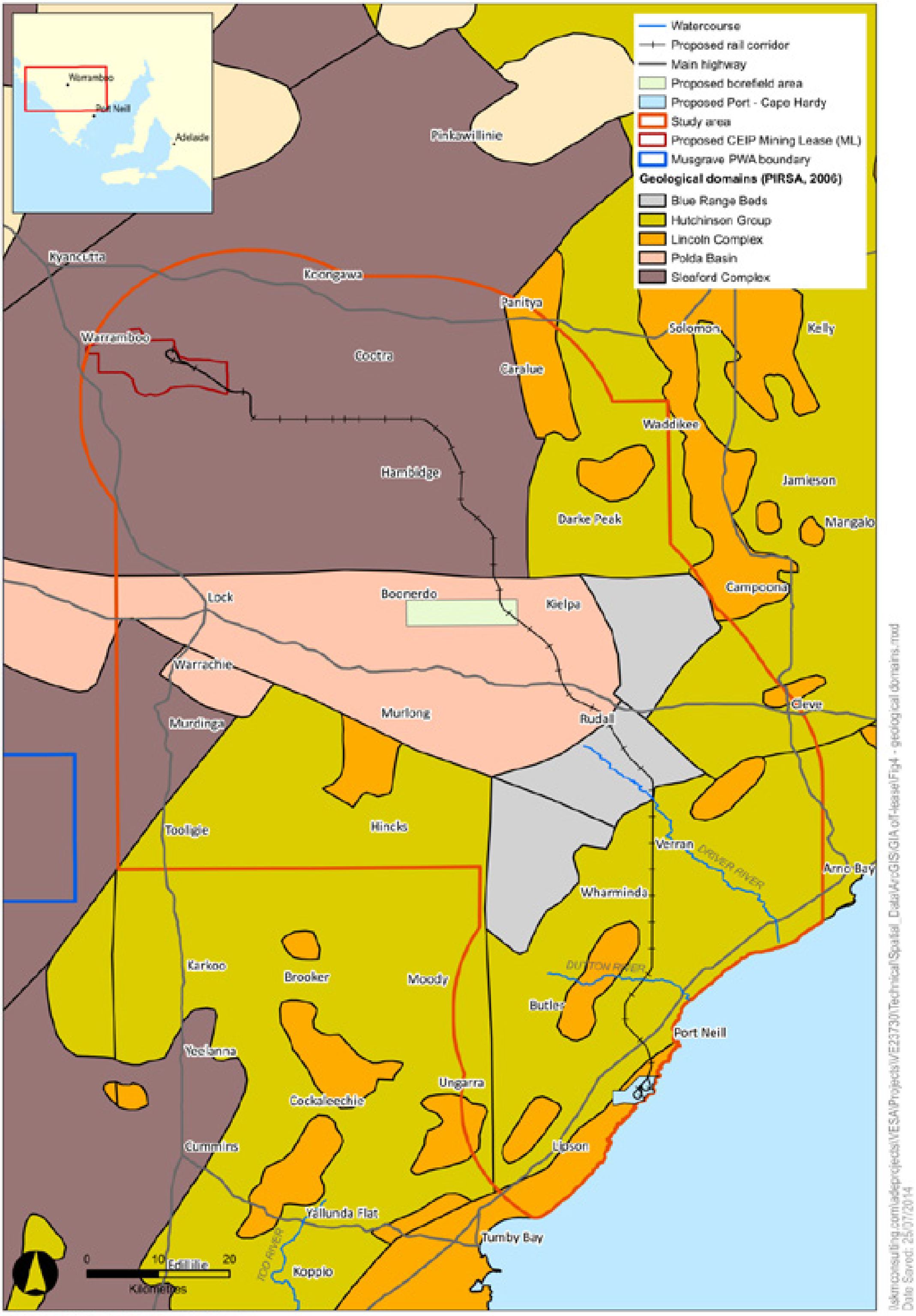

Figure 4: Geological domains

Figure 4: Geological domains

2.6 Regional hydrogeology

2.6.1 Overview

Groundwater resources over much of the Eyre Peninsula are of variable quality and quantity, and most groundwater occurs in saline or brackish aquifers with generally low yields (Berens *et al*, 2011). The infrastructure corridor crosses the east-west trending Polda Basin approximately midway between the proposed port site and the mine. The basin is in-filled with Permian, Jurassic and a thickened sequence of Tertiary Sediments. The Tertiary Sediments have been identified as having the potential to yield a significant saline groundwater resource (GWS, 2014a). Further south along the infrastructure corridor, the sedimentary cover is thin, and the only significant aquifers are hosted in fractured rock settings (GWS, 2014b). The following sections provide a summary of the key hydrogeological formations relevant to this assessment.

2.6.2 Quaternary aquifers

Within the study area, Quaternary sediments are dominated by quartz sand and clayey sand overlain by white to pale grey aeolian sand dunes. Calcrete horizons are found to varying degrees over the Eyre Peninsula. Quaternary Sediments are generally unsaturated within the study area and therefore contain no significant groundwater resources.

West of the study area, along the coastal margin of the Eyre Peninsula, the Quaternary limestone sediments of the Bridgewater Formation act as isolated aquifers or disconnected lenses. These aquifers have formed as a result of slightly elevated rainfall (local to the western margins of the Eyre Peninsula) and the surface exposure of suitable host rock (Quaternary Limestone) to receive and store recharge (Department for Water Resources, 2001). They are located within the Musgrave Prescribed Wells Area (PWA) which is the administrative boundary that surrounds the groundwater lenses (Figure 1).

The major groundwater lenses within the Musgrave PWA generally have high yields (from 5 to 50 L/s) and low salinity (less than 1000 mg/L) (Department for Water Resources, 2001). Groundwater levels within the Bridgewater Formation are generally higher than those in underlying aquifers, and as such a downward gradient is generally observed (Department for Water Resources, 2001). The closest groundwater lens to the proposed Kielpa Borefield is the Polda Lens, located approximately 45 km west of the proposed borefield (Figure 1). Although the Musgrave PWA is located outside of the defined study area, it is acknowledged in this assessment due to its importance in supplying potable groundwater to the Eyre Peninsula.

2.6.3 Tertiary aquifers

Tertiary sediments are distributed throughout the majority of the study area, except where the basement outcrops at topographic highs. The lower part of the Tertiary sequence, the Poelpena Formation is typically sandy and is characterised by fine to medium grained fluvial and marine sandy facies (Hou *et al*, 2003).

Within the Polda Trough structural depression (Kielpa Domain), a thickened sequence of Tertiary Sediments has been deposited. Recent investigation drilling and aquifer testing at three sites to depths ranging from 234 to 302 m provided estimates of transmissivity of 120 to 2,700 m^2/d. Groundwater salinity was reported to be in the range of 25,000 to 40,000 mg/L (GWS, 2014a).

Further north towards the mine site the Tertiary sequence thins and aquifer transmissivity is in the order of 4 to 37 m^2/d with groundwater salinity in excess of 35,000 mg/L (SKM, 2014a).

To the south of the Polda Trough, Tertiary sediments are thin to absent based on the mapped extent of Tertiary sediments (Hou *et al*, 2012) and recent drilling investigations (GWS, 2014b).

2.6.4 Polda Trough

The Polda Trough is an east-west trending geological feature ranging between 10 and 40 km in width, and extending more than 350 km from near Cleve in the east, beyond Elliston to the continental margin in the Great Australian Bight. The Polda Trough is encompassed by basement rocks of the Gawler Craton and is the area of interest for the proposed Kielpa Borefield.

The Neoproterzoic Kilroo Formation forms the basal unit of the trough and consists of siltstone and mudstone with interbedded volcanics (primarily basalt). The Permo-Carboniferous Coolardie Formation unconformably overlies the Kilroo Formation in the eastern region of the trough. The formation consists of between 40 and 90 m of diamictite with thin inter beds of siltstone, claystone and conglomerate (GWS, 2014a).

The Late Jurassic Polda Formation has in-filled topographic lows of the Coolardie Formation, and is therefore variable in thickness across the Polda Trough (between 11 to 282 m). The formation can be divided into two intervals. The lower zone is sand-prone with regular interbeds of coal and siltstone, while the upper zone is dominated by claystone, siltstone and sandstone (GWS, 2014a).

2.6.5 Fractured rock aquifers

Basement lithology in the study area includes gneisses, volcanics and granites of the Gawler Craton. In the Northern Domain basement comprises gneiss and granite of the Sleaford complex. Aquifer testing of this formation by Iron Road in support of mine dewatering studies indicates a regional transmissivity in the range of 2 to 4 m^2/day with salinity in excess of 100,000 mg/L (SKM, 2014a).

Within the Verran Domain, basement comprises the Blue Ranges Beds which is characterised by consolidated sandstone and gritty conglomeritic sandstone. A single aquifer test in this unit yielded a transmissivity estimate of 16 m^2/day with a groundwater salinity of 63,500 mg/L (GWS, 2014b).

Further south within the Dutton River Domain, basement consists of schist and gneiss of the Hutchinson group. Recent investigation drilling revealed little potential for groundwater supply within this area (GWS, 2014b). The Hutchinson Group is also interpreted as being present beneath the Polda Trough, however due to the depth of the basement little information exists regarding groundwater yield and salinity.

Groundwater recharge to fractured rock aquifers is considered to be localised and irregular with the volume of recharge governed by the fracture permeability of the rock. Recharge to fractured rock systems on the Eyre Peninsula is not well understood, but recharge may occur where basement material outcrops and sub-crops, as well as via vertical and lateral leakage from adjacent aquifers.

2.6.6 Water quality and beneficial use

The beneficial use of an aquifer can be assessed through the comparison of native groundwater quality with guidelines for specific types of water use. Beneficial use categories commonly used are potable (i.e. drinking water), agriculture and stock watering, and industrial. Measured groundwater quality in the study area (SKM 2014a) has been compared with the State Environment Protection Policy (Groundwaters of Victoria) 1997). The groundwater beneficial use assessment found the water quality within Tertiary, Polda Trough and Fractured Rock aquifers has no beneficial use other than some types of industry (such as mining) without treatment. The groundwater in the Shallow Quaternary Polda Lens aquifer is considered of beneficial use for stock, irrigation and potable use, however as mentioned, this formation is situated 45 km from the proposed borefield and not considered significant in terms of the CEIP Infrastructure GIA. Table 4presents a summary of the groundwater quality in relation to possible beneficial use.

Table 4 Groundwater quality - comparison of water standards (without treatment)

Aquifer	Aquifer Salinity (mg/L)[1]	Potable Beneficial use <1000 mg/L[2]	Agriculture Beneficial use <3,500 mg/L[2]	Stock water Beneficial use <13,000 mg/L[2]	Industrial/Maintenance of Ecosystems >13,000 mg/L[2]
Quaternary (Polda Lens)	<1000	ü	ü	ü	ü
Tertiary	>35,000	û	û	û	ü
Polda Trough	25,000-40,000	û	û	û	ü
Fractured Rock	>100,000	û	û	û	ü

Notes:1) Water quality values are for tested areas (SKM 2014a) and may not be representative of entire study area; 2) State Environment Protection Policy (Goundwaters of Victoria 1997

2.6.7 Summary

Figure 5 provides a schematic representation of the hydrogeological units within and adjacent to the Kielpa Domain. The hydrogeological cross sections also show known groundwater levels and salinities from wells located along the section line. The location of the hydrogeological cross section runs from the proposed Kielpa Borefield west to the Musgrave PWA (refer to Figure 1 for cross section location).

Key features of the hydrogeological cross section are:

- At the location of the proposed borefield, Quaternary Sediments are characterised by sand, silt and clay, however the sediments are unsaturated and the water table sits within the underlying Tertiary Sediments.
- West of the proposed Kielpa Borefield the Quaternary Sediments are characterised by aeolian calcarenite of the Bridgewater Formation. The Bridgewater Formation contains fresh groundwater recharged via direct infiltration of rainfall within the Musgrave PWA (Department for Water Resources, 2001). The aquifers associated with the Bridgewater Formation are not connected to the Quaternary Sediments found in the vicinity of the proposed Kielpa Borefield. The lack of demonstrated connectivity and physical distance between the Polda Lens and the Tertairy Sediments within the Polda Trough demonstrates that the proposed Kielpa Borefield will not impact adversely on the Musgrave PWA.
- Thickened Tertiary Sediments within the Polda Trough are the target aquifer for the proposed Kielpa Borefield. Groundwater salinity within this aquifer is in the range of 25,000 mg/L to 40,000 mg/L.
- Groundwater flows in an east to west direction, however the presence of a groundwater divide between the township of Lock and the Polda Lens (Eberhard and Waterhouse, 1979) suggests that flow is not continuous across the entire Peninsula.
- All aquifers excluding the Quaternary aquifers have salinities considered too high for any beneficial use except some industrial.

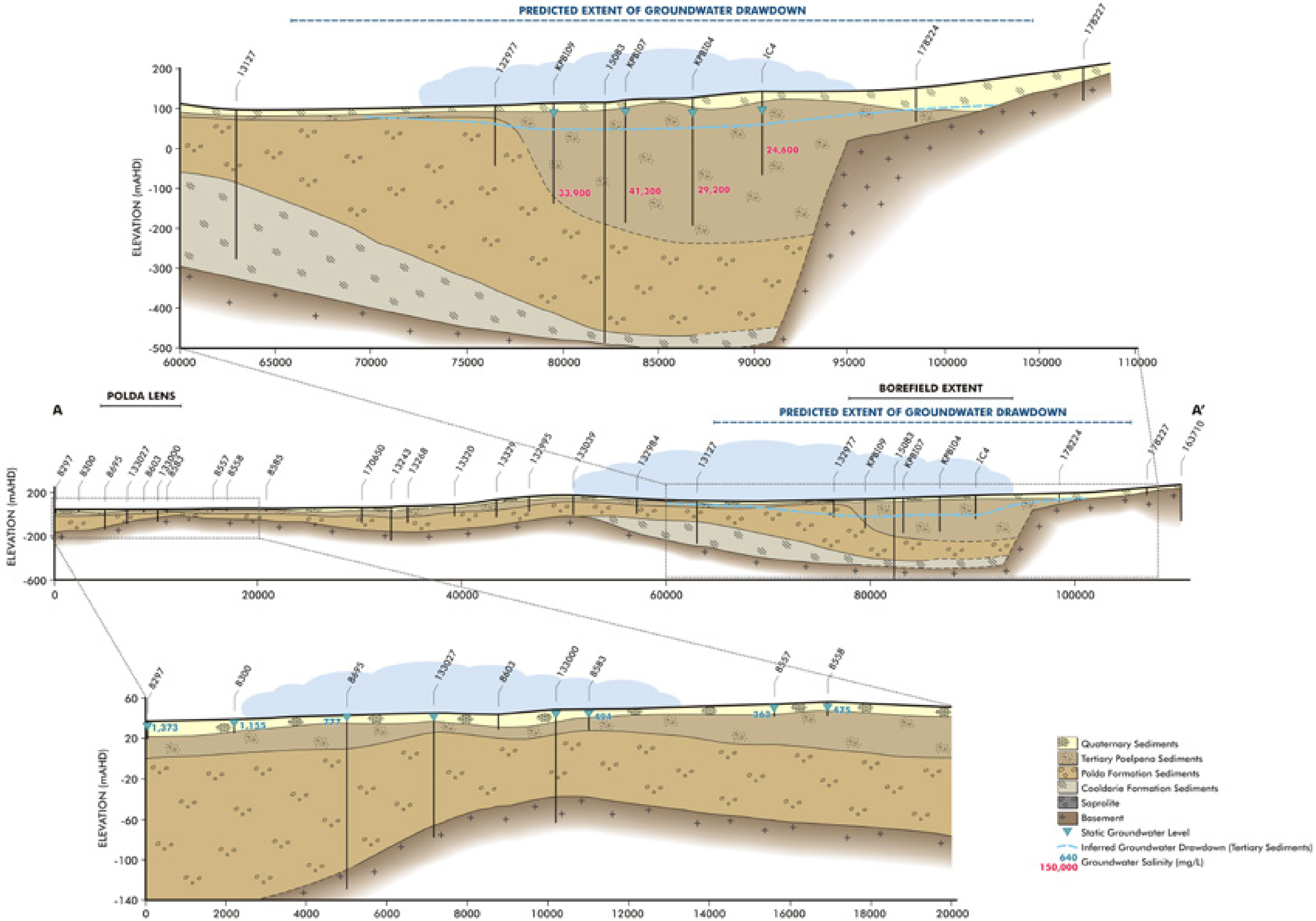

Figure 5: Hydrogeological cross section Kielpa Borefield to Musgrave PWA

3 Groundwater receptor identification

3.1 Introduction

Groundwater forms an important water supply for many regions in South Australia. It is a source for domestic and stock water supplies in many areas, and sustains a diverse range of ecosystems across the state. To meet growing community and regulatory expectations with regard to sustainable use of natural resources, there is a need to balance the water requirements of the pastoral, mining and energy industries with cultural and social values, as well as environmental water requirements.

The following sections outline the environmental, social/cultural and economic receptors within the study area based on available data from public records and studies conducted by Iron Road.

3.2 Environmental

3.2.1 Overview

Some ecosystems rely on groundwater to meet ecological water requirements, and as a result may be sensitive to changes in the natural groundwater regime. Such ecosystems are described as Groundwater Dependent Ecosystems (GDEs). The Australian GDE Atlas (published by the National Water Commission) provides a starting point to assist with the identification of GDEs and the management of their water requirements (SKM, 2011). GDEs, as defined by the Australian GDE Atlas are broadly classified as follows (SKM, 2011):

- Ecosystems dependent on the surface expression of groundwater (e.g. wetlands, lakes, seeps, springs, and river baseflow systems); and
- Ecosystems dependent on the subsurface presence of groundwater (e.g. terrestrial vegetation which depends on groundwater on a seasonal, episodic or permanent basis).

3.2.2 GDEs reliant on sub-surface presence of groundwater

The majority of natural vegetation within the study area has been cleared for agricultural purposes. Other than dedicated conservation parks such as Hambidge, the vegetation that remains is restricted to scattered and isolated scrub blocks of varying size on farmland and as roadside vegetation. Many of these stands of remnant vegetation are identified by the GDE Atlas as potential GDEs. The vegetation within these areas broadly comprises of Mallee associations that include mixed or *Melaleuca* dominated shrubland with an understorey of *Triodia* (Spinifex), native grasses or Chenopod species.

Although these areas have been identified in the GDE Atlas as potential GDEs, assessment of the site conditions in the vicinity of the proposed borefield reveals that groundwater salinity in the water table aquifer is in the range of 25,000 to 40,000 mg/L and groundwater levels are in excess of 20 m below ground level (GWS, 2014a). Therefore, vegetation within the study area and in particular within the vicinity of the proposed borefield is unlikely to be reliant on groundwater given these conditions.

3.2.3 GDEs reliant on surface expression of groundwater

There are no permanent watercourses or surface water bodies within the study area. Two ephemeral creek lines are present in the southern region of the study area that flow toward the Spencer Gulf. These are the Dutton River and Driver River (Figure 6). A number of other small creek lines are identified which flow from the ranges south of Darke Peak (Gum Creek, Sheoak Creek, Yadnarie Creek and Mangalo Creek). These creek lines have been identified as having a low to moderate potential for supporting GDEs.

A small number of salt lakes are also present in the study area in which surface water pools following large rainfall events. These areas may provide, at best, a temporary refuge for migratory birds when flooded. The salt lakes identified in the study area include White Lagoon and Red Lagoon located approximately 10 km north of

Darke Peak and Lake Warramboo located approximately 1.5 km north of the proposed mine lease boundary (Figure 6).

At these locations, groundwater is shallow, however it is not known to discharge to the surface and provide a permanent water source (i.e. evaporation exceeds groundwater discharge for the majority of the season). Groundwater may influence, to a certain extent, the length of time in which water pools, but this is primarily controlled by the magnitude of rainfall and evaporation during pooling periods. Potential impacts to Lake Warramboo from activities occurring on the proposed mine lease are addressed in the mine site GIA (Jacobs, 2014)

The location of potential GDEs reliant on the surface expression of groundwater within the study area are illustrated in Figure 6.

3.3 Social and cultural

3.3.1 Existing users

Iron Road undertook a bore audit to identify any groundwater users whom may be affected by CEIP impacts on groundwater. The bores were selected by a groundwater impacts investigation undertaken by Jacobs based on the bore being located within a 10km of the modelled radius of influence for the borefield and mine pit dewatering operations. The impacts investigation identified 10 bores suiting the criteria from data obtained from the South Australian State Government online Water Connect database (https://www.waterconnect.sa.gov.au). Bore records from the Water Connect database are shown in Figure 7.

The landowners of the bores were contacted and it was found out of the ten bores identified nine no longer exist. The remaining bore (6030-803) was reported by the land owner to be too saline and was never used for stock watering. This bore was used for a short period in 2013 by Centrex Mining for mining exploration but is currently not in use. All land owners interviewed advised that no groundwater was used for stock in the area. Table 5 presents the 10 bores identified and their current status. Details of each of the wells identified within the study area are provided in Appendix A.

Table 5 Water bore status

Well ID	Easting	Northing	Date Drilled	Current Status
6030-1	592485	6288970	5/12/1969	Non existent
6030-13	579814	6266713	2/12/1958	Non existent
6030-803	581138	6269009	9/05/1966	Not used[1]
6031-23	569843	6310604	4/12/1975	Non existent
6031-24	567714	6311332	4/12/1975	Non existent
6031-129	558913	6326555	29/08/1961	Non existent
6031-130	562803	6324579	1/09/1961	Non existent
6031-160	579181	6320935	20/03/1986	Non existent
6031-161	579565	6321269	16/02/1987	Non existent
6130-115	615621	6286113	4/12/1969	Non existent

Note: 1. No future use intended by landholder due to high salinity

3.3.2 Indigenous heritage

Indigenous heritage is being assessed as a part of the broader impact assessment for Iron Road.

3.4 Economic

3.4.1 Agriculture

The dominant land use in the study area is dryland agriculture, including mixed cereal crops and grazing (Figure 3). Project WAA in support of the CEIP Infrastructure have the potential to lower groundwater levels as a result of groundwater abstraction. Lowering of the groundwater table is not likely to generate any issues for crop production as crops are reliant on seasonal rainfall stored in the unsaturated zone rather than being reliant on groundwater. This is especially true for the CEIP study area where groundwater salinity in the water table aquifer is generally saline exceeding 25,000 mg/L (SKM 2014a; GWS 2014a and GWS 2014b).

There are no WAAs associated with the CEIP Infrastructure that have been identified as having the potential to increase groundwater levels.

3.4.2 Mineral and energy industry

There are 73 mineral deposits recorded within the study area, two of which are currently recorded as active mines (Figure 8). To the west of the Kielpa Borefield there is a gypsum mine (Bayley Plain) which commenced operation in 2008. In the south of the study area there is an active mine targeting a sand commodity (Port Neil Sand located approximately 10 km north of the port facility) which commenced operation in 2011.

3.5 Summary

Table 6 presents a summary of the identified groundwater receptors within the study area that may be impacted by WAA occurring in support of the CEIP Infrastructure. As identified in Table 6 there are a number of receptors that have been identified as being unlikely to be impacted by WAA and these are therefore not discussed further in this report. These include GDEs reliant on the sub-surface presence of groundwater existing groundwater users and the agricultural industry. Receptors that will be reviewed as a part of the threat assessment include GDEs reliant on the surface expression of groundwater, existing groundwater users (wells) and the mining and energy industry.

Table 6: Receptor identification summary

Receptor group	Receptor	Potential for impact	Comment
Environment	GDEs reliant on sub-surface presence of groundwater	No	Mallee vegetation not considered to be reliant on groundwater due to salinity
	GDEs reliant on surface expression of groundwater	Possible	Playa lakes and ephemeral creek lines
Social and cultural	Existing groundwater users	No	Stock wells
	Indigenous communities	N/A	N/A
Economic	Agriculture	No	Groundwater does not support agriculture productivity due to salinity
	Mining and energy industry	Possible	Bayley Plain and Port Neil Sand

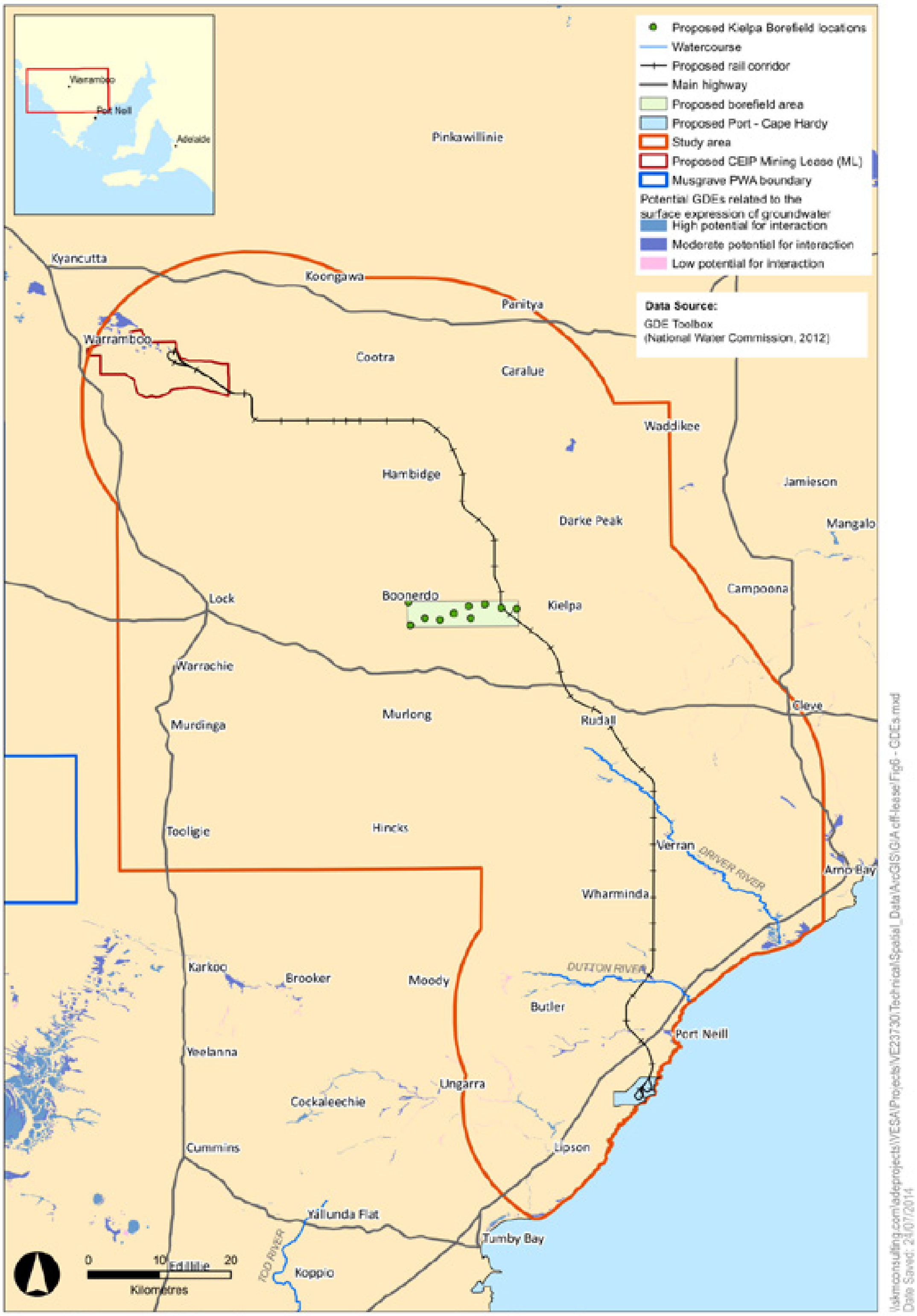

Figure 6: Potential GDEs reliant on the surface expression of groundwater

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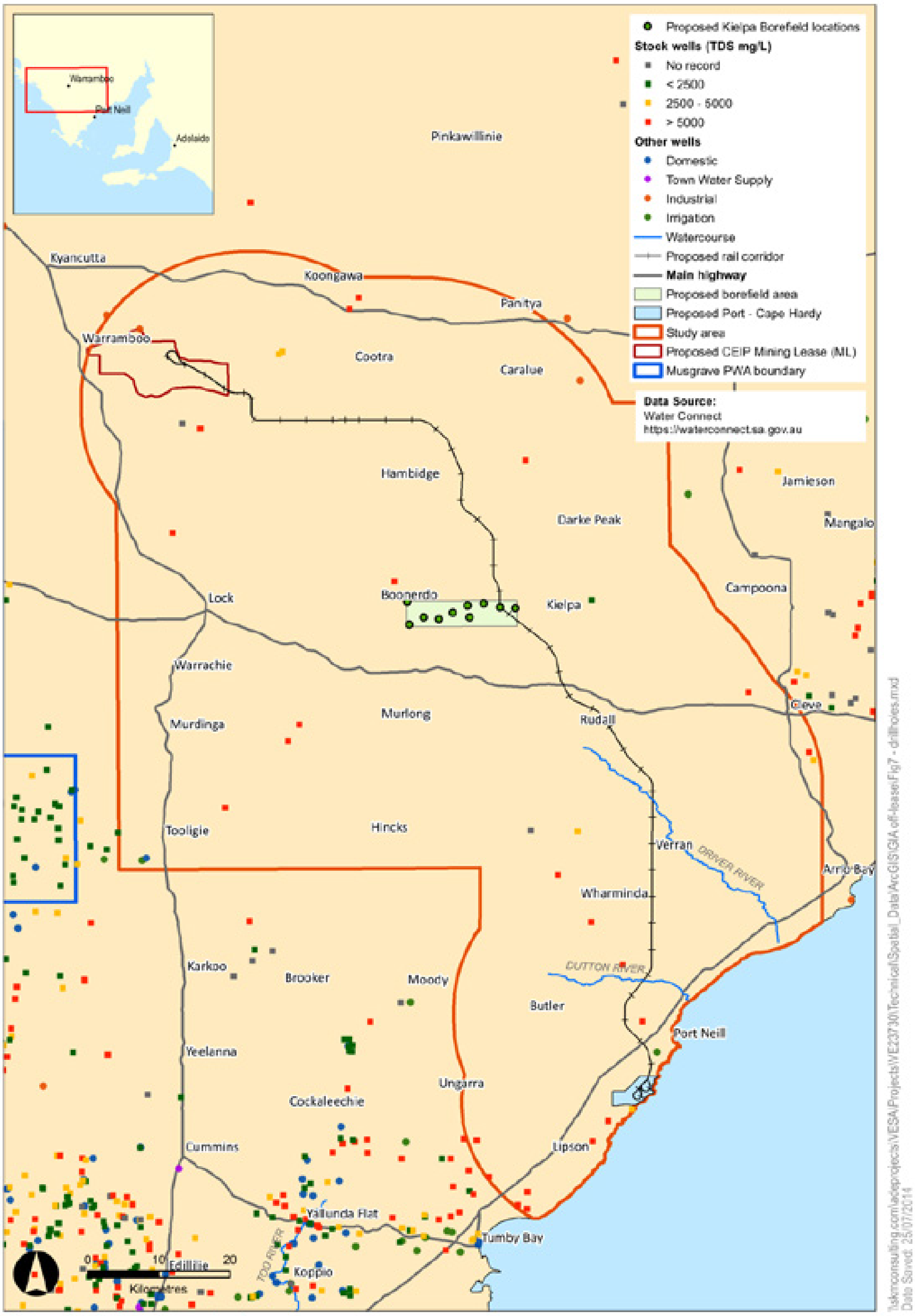

Figure 7: Existing groundwater users

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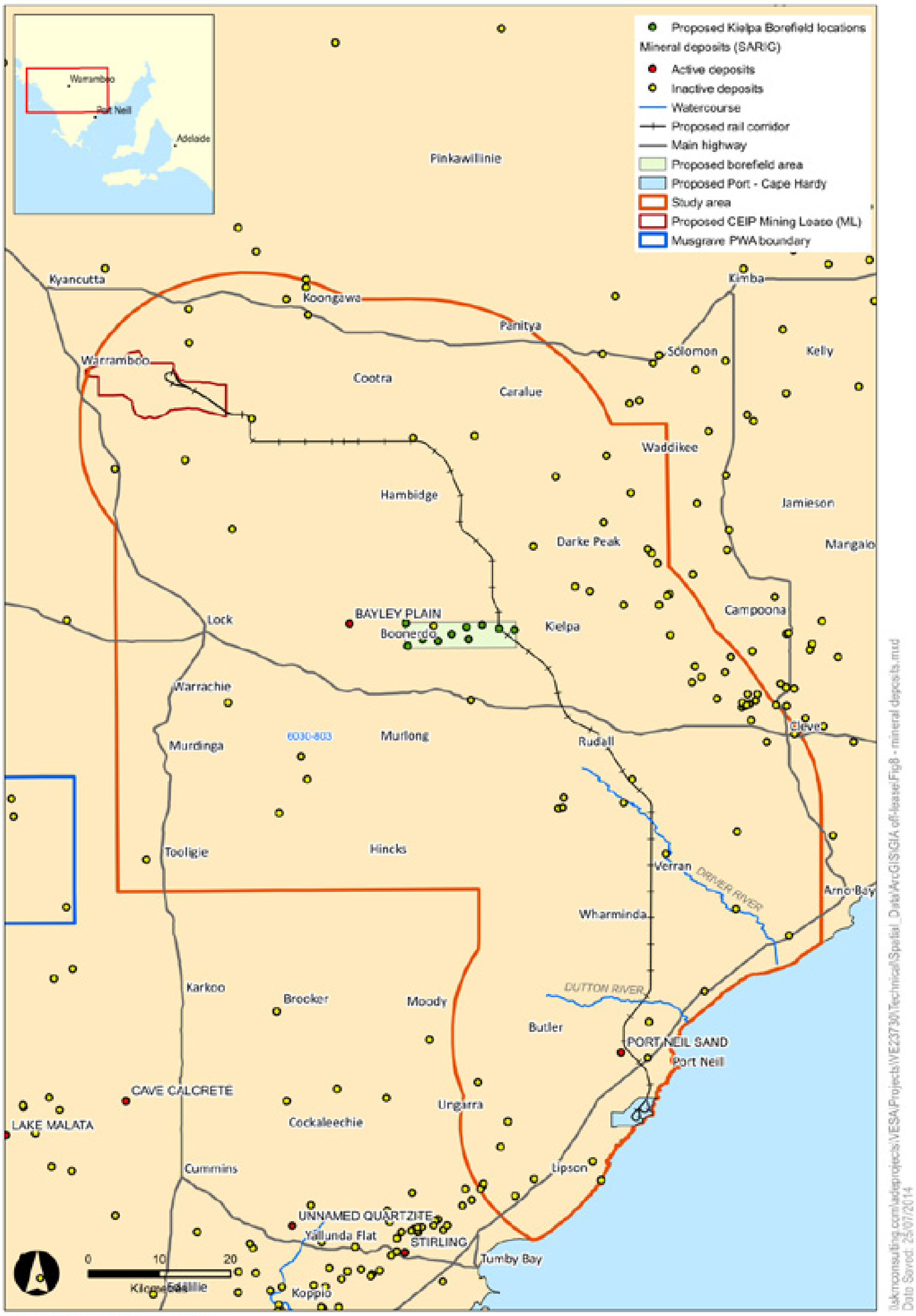

Figure 8: Mineral deposits

Figure 8: Mineral deposits

4 Groundwater effects assessment

4.1 Overview

WAA are activities that can affect the existing water regime, which may in turn cause adverse impacts to receptors which are reliant on groundwater. The following sections present a description of the WAA occurring in support of the CEIP Infrastructure that have the potential to alter groundwater conditions within the study area. The assessment of affects relies on predictions made by the numerical groundwater flow model developed for the Kielpa Borefield (GWS, 2014a) and by analytical modelling to assess the impacts associated with the infrastructure corridor production wells and the excavation required to accommodate the train unloading facility.

4.2 Kielpa Borefield

4.2.1 Overview

The proposed Kielpa Borefield has been designed to supply 15 GL per year of saline groundwater from the borefield to the mine site for the life of mine (25 years). The proposed borefield is located approximately 60 km south-east of the mine site, 7.5 km west of Kielpa and will incorporate ten bores, nine of which will be located west of the infrastructure corridor, with one located east of the corridor adjacent to Kilroo-Kiepla Road.

The target aquifer for groundwater abstraction is approximately 150 to 300 metres below ground level. It is proposed that each bore will be drilled to approximately 300 m depth and cased with 300 mm DN Class 12 PVC casing to 150 m, the underlying aquifer from 150 m to 300 m will be screened with 200 mm DN 316 grade stainless steel wire wound screens. Bores will be equipped with electric submersible pumps with the capacity to deliver approximately 4000 m^3/day. The locations of the proposed bores are illustrated in Figure 3.

Saline groundwater from the borefield will be transferred to the mine site via a nominal 750 mm diameter carbon steel pipeline. The pipeline will be constructed above ground and the route follows the railway line within the infrastructure corridor between the borefield and the mine site.

4.2.2 Assessment of affects

The operation of the Kielpa Borefield has been assessed using the Kielpa Borefield groundwater numerical flow model which was constructed to assess the viability of the borefield and to assess the impacts of its operation (GWS, 2014a). The model was constructed using data from field investigations and other available hydrogeological data (GWS, 2014a). The model is classified as a Class 1 confidence level model as defined by the Australian Groundwater Modelling Guidelines (Barnett *et al*, 2012). This level is defined as being suitable for predicting long-term impacts of proposed developments in low value aquifers.

The assessment assumes 10 groundwater wells operating at 4000 m^3/d for the life of mine (25 years) as summarised in Table 7. The estimated drawdown in individual production wells ranges from 70 to 115 m (GWS, 2014a).

Table 7: Estimated Kielpa Borefield drawdowns (GWS, 2014a)

Well ID	SWL (m)	Pump depth (m)	Flow rate (m^3/day)	Available drawdown (m)	Total drawdown (m)[1]
KPB01	50	140	4000	90	70
KPB02	50	140	4000	90	82
KPB03	39.8	140	4000	100	83
KPB04	39.8	140	4000	100	87
KPB05	39.8	140	4000	100	88
KPB06	34.4	160	4000	125	115
KPB07	34.4	160	4000	125	113
KPB08	34.4	160	4000	125	112
KPB09	26.8	160	4000	123	110
KPB10	26.8	160	4000	123	107

Notes: [1] Total drawdown is the sum of aquifer drawdown, near-well drawdown and well losses

A sensitivity analysis was conducted to simulate and present the possible ranges of drawdown that could be expected in response to operation of the Kielpa Borefield for a duration of 25 years. The sensitivity analysis was conducted by varying aquifer transmissivity and storage parameters. For a given pumping duration, the radius of the cone of drawdown is a function of the square root of transmissivity divided by the storage coefficient, a term called aquifer diffusivity. A high aquifer diffusivity (high transmissivity and low storage) will produce an extensive relatively flat cone of drawdown while a low aquifer diffusivity (low transmissivity and high storage) will produce a less extensive relatively steep cone of drawdown. The sensitivity analysis considered credible ranges of aquifer diffusivity to simulate both of these scenarios.

The results of the numerical modelling are presented in Figure 9. The base case model predicts a drawdown cone (as defined by the position of the 1 m predicted drawdown contour) extending approximately 12 km from the borefield (Figure 9). The high diffusivity model predicts an increased drawdown extending approximately 20 km from the borefield while the low diffusivity model predicts a constrained drawdown extending approximately 7 km from the borefield. The base case model simulates transmissivity and storage parameters which are most reflective of the values derived from field testing and these results have therefore been used as a basis for the threat assessment.

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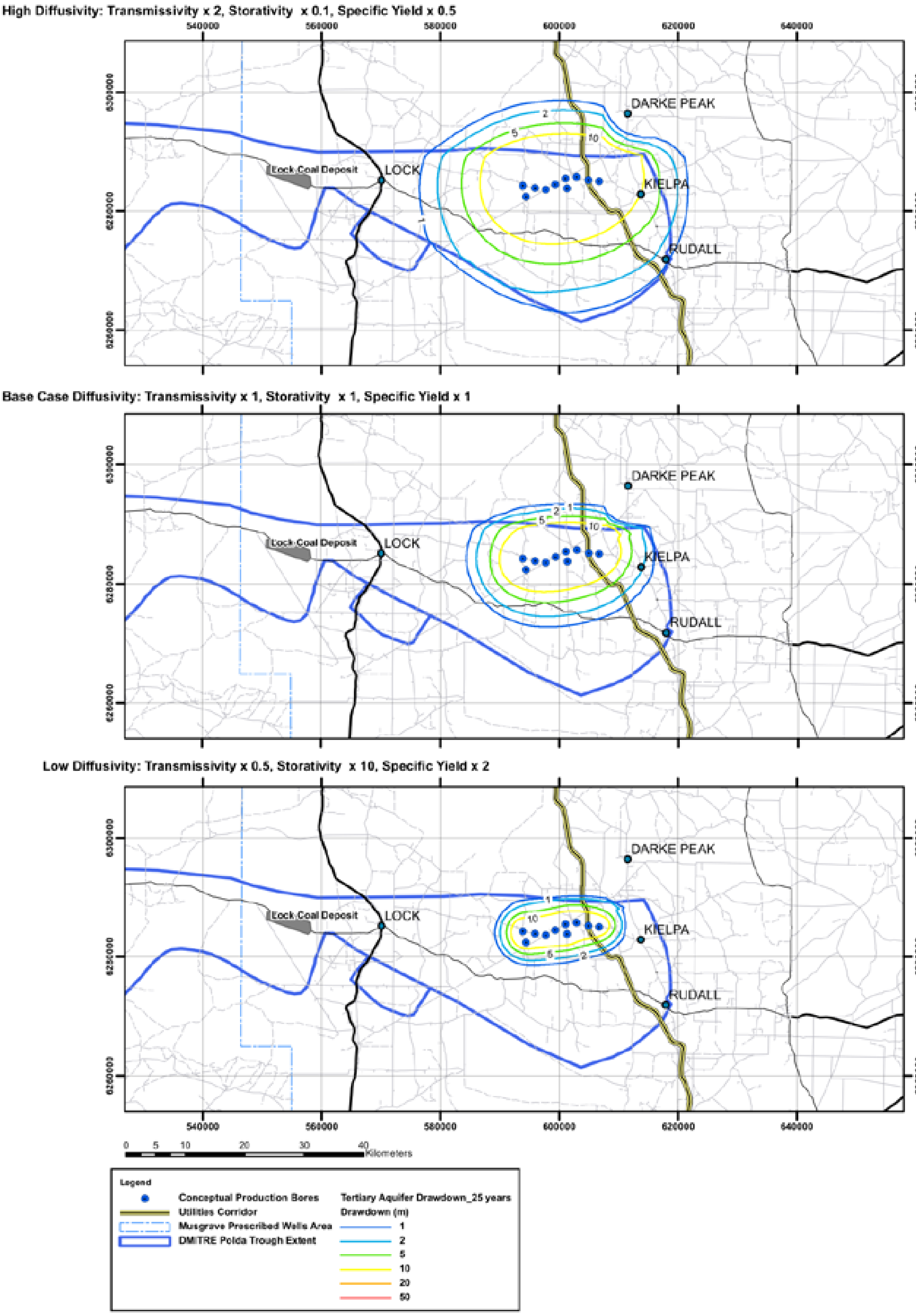

Figure 9: Predicted drawdown following 25 years of Kielpa Borefield pumping (GWS, 2014a)

Analysis was undertaken to simulate and present the possible timing of groundwater level recovery following borefield decommissioning for a range of possible aquifer recharge rates. A literature review of recharge rates in the study area conducted by GWS (2014a) presents recharge rates of between 1 and 30 mm per year. Recharge was simulated in the numerical groundwater flow model at 1, 7 and 15 mm per year. The time required for complete recovery of groundwater levels ranged from approximately 350 years for the 1 mm recharge scenario (conservative) to approximately 75 years for the 15 mm recharge scenario (GWS, 2014a).

4.3 Infrastructure corridor production wells

4.3.1 Overview

Saline groundwater is required along the infrastructure corridor to support construction activities including earthworks, dust suppression and material placement. Water points for construction supply will be ideally distributed every 20 km along the infrastructure corridor. The saline water demand at each water point is approximately 430 m^3/day (GWS, 2013). Drilling and aquifer testing conducted in support of the infrastructure corridor groundwater supply is reported in the CEIP Infrastructure Corridor Construction Water Supply Investigation (GWS, 2014b). Table 8 presents a summary of the proposed groundwater supply strategy required to meet the demand while Figure 3 presents the tested production well locations. The water supply strategy consists of a combination of groundwater wells and temporary water storages.

Table 8: Construction water supply details for each geological domain

Domain[1]	No. wells	Yield (m^3/day)[2]	Location
Northern	N/A	N/A	Water demand to be met by water piped from the Borefield (Kielpa Domain)
Kiepla	1	430	IC4_P
Verran	1	430	IC5_P
Dutton River	N/A	N/A	Unsuitable for water supply development, water to be piped south from Verran Domain

Notes: 1. Refer to Figure 4 for locations of geological domains
2. Recommended abstraction rate at each production well (GWS, 2014b)

4.3.2 Assessment of affects

The operation of production wells along the infrastructure corridor will result in a radius of influence that will reduce the current groundwater level. Analytical modelling (Theis, 1935) has been used to predict the distance that the radius of influence may extend during production well operation. Input data used in the drawdown calculations (including recommended bore yields, aquifer transmissivity and storativity) have been sourced from the Utilities Corridor Construction Water Supply Investigation (GWS, 2014b). Table 9 presents the predicted radius of influence (as defined by the 1 m drawdown contour) for the production wells at the end of two years of continuous operation. The radius of influence for the higher transmissivity well in the Kielpa Domain produces a relatively flat cone of depression which extends further than that of the well in the Verran Domain when looking at the 0.1 drawdown contour. Calculation sheets for the proposed production wells are provided in Appendix B.

Table 9: Predicted infrastructure corridor production well drawdown

Domain	Yield (m^3/day)[1]	Transmissivity (m^2/day)[2]	Near well drawdown (m)[3]	Extent of 1 m drawdown contour (m)
Kiepla	430	450	1.9	40
Verran	430	18	41.5	5,300

Notes: 1. Recommended abstraction rate at each production well (GWS, 2014b)
2. Average transmissivity calculated from constant rate testing (GWS, 2014b)
3. Near well drawdown calculated at 0.1 m from pumping well

4.4 Groundwater management at the port site to accommodate the train unloading facility

4.4.1 Overview

Drainage is required at the port facility at the base and perimeter of the excavation required to accommodate the train unloading facility. Groundwater is to be collected in trench drains positioned around the perimeter of the excavation and collected in sumps for disposal to the transfer pump station header tank. A groundwater inflow rate of up to 3.5 m^3/d has been estimated using Darcy's law (SKM, 2014b). The perimeter of the drain is estimated to be 100 m while the depth of the excavation is estimated to be 24 meters below ground level.

Groundwater at the port site in the vicinity of the proposed excavation is approximately 8 m below ground level based on levels gauged within wells installed as a part of the Port Site Infrastructure Investigation. Estimates of hydraulic conductivity based on empirical correlation of rock joint frequency and fracture width from boreholes in the location of the car dumper are in the order of 10^{-8} m/s to 10^{-10} m/s (SKM, 2014b).

4.4.2 Assessment of affects

Groundwater inflow will be managed by drains located around the perimeter of the excavation. To estimate the extent of the radius of influence resulting from abstraction of the collected groundwater the following equation has been used;

$$R_0 = \sqrt{\frac{2.25Tt}{S}}$$

Cooper and Jacob (1946) [Eq.1]

Where: T = Transmissivity (m^2/d)

t = time since the start of dewatering (days)

S = Storativity (dimensionless)

Table 10 provides the input data used to calculate the potential radius of influence associated with drainage into the perimeter drains surrounding the train unloading facility. The estimated zone of influence is approximately 500 m, however this estimate is conservative in that it assumes no recharge to the groundwater system. The lateral continuity of fracturing in the basement over this distance may also limit the actual extent of influence. The zone of influence is within the proposed port facility footprint and does not interact with any of the identified receptors identified in Section 3.

Table 10: Calculation of radius of influence from train unloading facility excavation

Parameter	T[1]	t[2]	S[3]	R_0
Unit	**m^2/d**	**days**	**unit less**	**m**
Value	0.014	9125	0.001	532

Notes: 1. Dewatering of pit to 24 metres below ground level, 16 m below the water table with hydraulic conductivity of 0.00086 m/d
2. A period of dewatering of 25 years has been assumed
3. Storage coefficient of the aquifer is 0.001 typical for a confined aquifer (Fetter, 1994)

5 Groundwater threat assessment

5.1 Overview

The threat assessment follows the NWC (2010) framework in terms of direct effects relating to groundwater quantity, groundwater quality, surface water – groundwater interaction and aquifer disruption. The following sections present an assessment of the degree to which WAA will impact on the identified receptors within the study area.

5.2 Groundwater quantity

The extent of the impact resulting from groundwater abstraction from the proposed Kielpa Borefield is presented in Figure 10 along with the receptors identified in Section 3. The predicted zones of influence associated with operation of the infrastructure corridor production wells are also presented in Figure 10.

Bayley Plain is an active mineral deposit located approximately 20 km west of Kielpa within the predicted zone of influence of the Kielpa Borefield. The groundwater users search has not identified any groundwater abstraction wells associated with this deposit.

The predicted extent of influence from operation of the proposed Kielpa Borefield has been superimposed on the Kielpa Borefield to Musgrave PWA hydrogeological cross section (Figure 5). The figure shows that the distance between the predicted drawdown impacts and the Musgrave PWA is greater than 40 km.

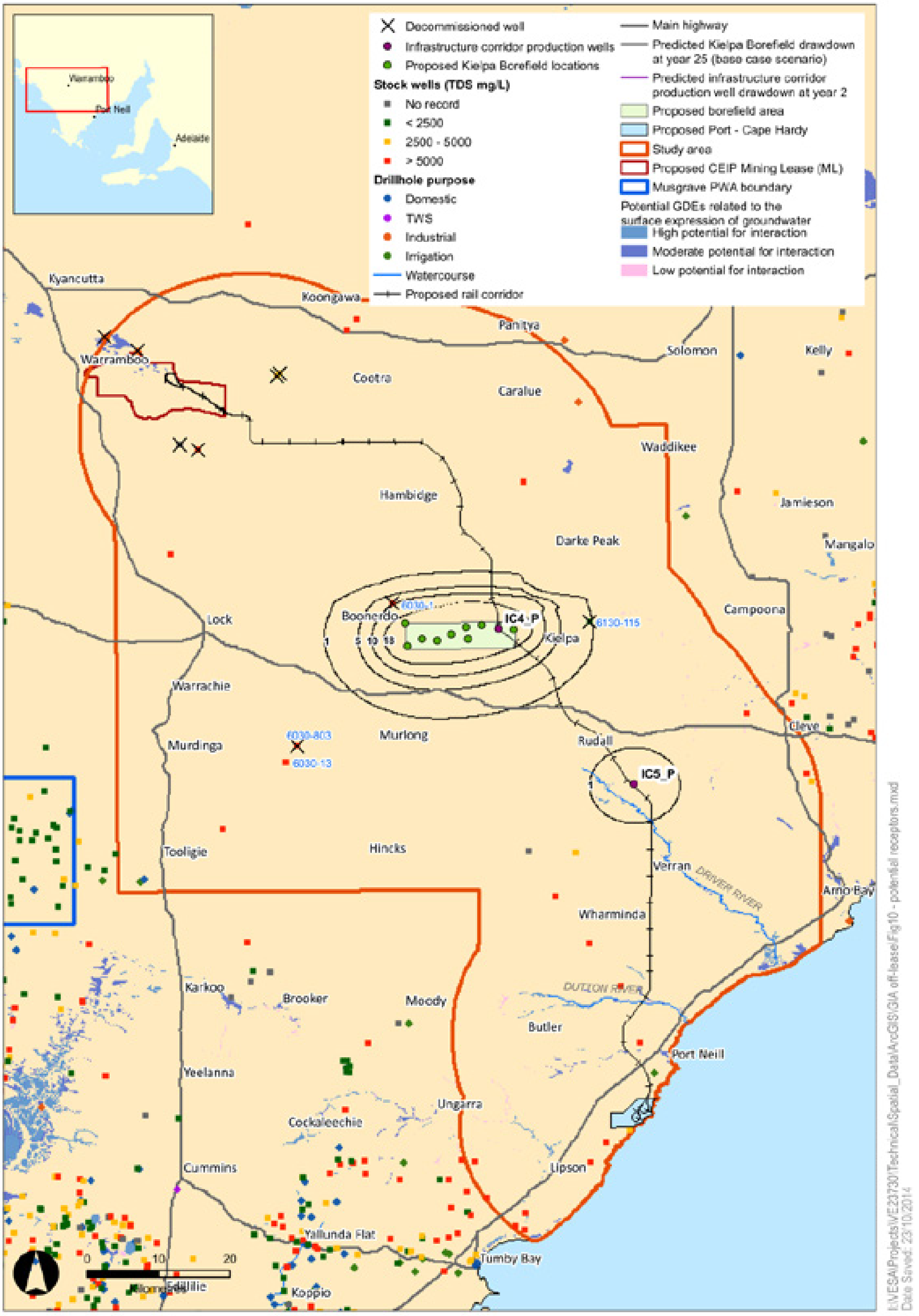

Figure 10: Predicted zone of pumping influence and receptor identification

Figure 10: Predicted zone of pumping influence and receptor identification

5.3 Groundwater quality

Groundwater salinity data from recent drilling investigations targeting the Tertiary sediment aquifer indicate that salinity ranges from 35,000 to 40,000 mg/L in the vicinity of the Kielpa Borefield (GWS, 2014a) and from 35,000 to 53,600 mg/L within the vicinity of the mine site (SKM, 2014a). Fractured rock groundwater salinity from recent drilling investigations is variable, ranging from 63,500 mg/L in the Verran Domain (GWS, 2014a) to greater than 100,000 mg/L at the mine site (SKM, 2014a). Based on the available groundwater salinity data, the beneficial use category in the vicinity of the proposed borefield and infrastructure corridor production wells is considered suitable for limited industrial purpose only.

Some wells within the broader study area have lower recorded groundwater salinities (refer to Figure 10), however none of these exist within the predicted zones of influence.

There are a number of activities that are required to support the proposed project which may have the potential to impact on groundwater quality through the release of potential contaminants into the environment, e.g. hydrocarbons, solvents and nutrients. These activities include, but are not limited to, camp operations, waste water treatment facilities, and fuel storages. These facilities will be engineered and constructed according to appropriate industry guidelines to reduce the likelihood of uncontrolled releases. In the case of hazardous goods and fuel storages, secondary containment to capture uncontrolled releases will be included to further reduce the potential for contaminants entering the environment.

5.4 Groundwater – surface water interaction

Infrastructure corridor production well IC5_P is located approximately 2.5 km from the Driver River and operation of the well during the construction period (2 years) has the potential to lower the groundwater level in the fractured rock aquifer in the vicinity of the river. The predicted zone of influence in relation to the Driver River is illustrated in Figure 10.

Based on the analytical modelling results discussed in Section 4.3.2 and presented in Appendix B, groundwater levels are predicted to decrease by approximately 3 m in the vicinity of the Driver River after two years of continuous operation. Based on this it is possible that some level of effect, depending on the degree of interaction this system has with groundwater, may be expected. Impacts will be controlled by the connection between the aquifer and the river.

The Driver River typically flows from autumn to spring, is slow moving, and saline. The EPA has reported salinity measurements in the Driver River of 16,800 mg/L in autumn 2010, and 47,224 mg/L in spring 2010 at a location approximately four kilometres north of Verran (EPA, 2010). Overall, no special environmental features have been identified in the Driver River (EPA, 2010). Livestock have direct access to the river, causing erosion, and there is limited natural riparian vegetation. These factors have led the EPA to assign the river a condition overview score of "Poor" (EPA, 2010).

The EPA has also identified saline groundwater inflow as a threat to the Driver River which has the potential to reduce the ecological integrity of the system (EPA, 2010). As such, any drawdown of groundwater level beneath the Driver River is unlikely to adversely impact ecosystems supported by the Driver River. The river flows intermittently, and groundwater extraction may reduce flow during these times, however groundwater quality may improve as a result of the reduced saline groundwater inflow.

5.5 Aquifer disruption

Aquifer disruption relates to the physical disturbance of an aquifer by directly mining through the aquifer or by causing compaction of the aquifer matrix. There are not predicted to be any WAA associated with the CEIP Infrastructure which have the potential to cause aquifer disruption.

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6 Summary

Table 11 presents a summary of the receptors that have the potential to be affected by WAA associated with the CEIP Infrastructure. Although existing groundwater users and the mining and energy industry have been identified as potential groundwater receptors, the threat assessment indicates that there will be no predicted impacts to these receptors.

The potentially sensitive receptor that may be impacted by CEIP Infrastructure WAA is the Driver River.

The results of the threat assessment indicate that:

- Groundwater levels within the vicinity of the Driver River at infrastructure corridor production well IC5_P are predicted to reduce by up to 3 m during the construction period which is scheduled to last for two years. Although a change in groundwater – surface water interaction may occur, the threat is considered negligible as saline groundwater inflow to the Driver River is reported to be detrimental to the ecosystems it supports.

Table 11: Summary of potential effects to groundwater receptors

Receptor	Groundwater quantity	Groundwater quality	Groundwater – surface water interactions	Aquifer disruption
Driver River	ü (small reduction in level, negligible impact)	û	ü (reduction of detrimental outflow)	û
Existing groundwater users	û	û	û	û
Mining and energy industry	û	û	û	û

7 References

Barnett *et al*, (2012). Australian groundwater modelling guidelines, Waterlines report, prepared for National Water Commission, Canberra.

Berens, V. Alcoe, D, and Watt, E. (2011). Non-prescribed Groundwater Resources Assessment — Eyre Peninsula Natural Resources Management Region, Phase 1 – Literature and Data Review

Brereton D. and C. Moran. (2008). Cumulative effects: What are they and how can they be better understood and managed? In: Sustainable Development Conference Workbook, Darwin 2008.

Department for Water Resources (2001). Understanding the Musgrave Prescribed Wells Area http://www.epnrm.sa.gov.au/Portals/4/Water/Understanding_Musgrave.pdf

Eberhard, B. A. and Waterhouse, J. D., October (1979). Lock Coal Field Hydrogeological Study, Study by the SA Department of Mines and Energy

EPA (2010) (http://www.epa.sa.gov.au/reports_water/c0204-ecosystem-2010)

Fetter, C. (1994). Applied Hydrogeology.- Prentice Hall, New Jersey

Groundwater Science (2014a). Kielpa Groundwater Supply Study, prepared for Iron Road Limited (E-F-66-RPT-2001)

Groundwater Science (2014b). Central Eyre Iron Project Utilities Corridor Construction Water Supply Groundwater Investigation, prepared for Iron Road Limited (E-F-66-RPT-0039)

Groundwater Science (2013). Central Eyre Iron Project Construction Water Supply Study, prepared for Iron Road Limited (E-F-66-RPT-0047)

Hou et al (2012). Palaeodrainage and Cenozoic Coastal Barriers of South Australia. DMITRE August 2012.

Hou, B., Frakes, L.A. & Alley, N.F. (2003). Palaeochannel evolution, northwestern Gawler Craton, South Australia. CRC LEME Volume, Perth

Jacobs (2014). CEIP Mine Site Groundwater Impact Assessment, prepared for Iron Road

NWC (2010). Framework for assessing cumulative potential impacts of mining operations on groundwater systems. Report 3. National Water Commission.

SKM (2014a). CEIP Mine Site Hydrogeological Studies, prepared for Iron Road Limited (report reference no. E-F-16-RPT-0015)

SKM (2014b). CEIP Definitive Feasibility Assessment – Port Site Infrastructure, prepared for Iron Road Limited (report reference E-F-82-RPT-0019).

SKM (2013). CEIP hydrogeological data and information review, prepared for Iron Road Limited (report reference no. E-F-16-RPT-0006-B)

SKM (2011). Australian Groundwater Dependent Ecosystems Toolbox - Part One: Assessment Framework. Waterlines reports No 69 and No 70 - December 2011, National Water Commission. http://www.nwc.gov.au/publications/waterlines/australian-groundwater-dependent-ecosystems-toolbox/

Appendix A Recorded groundwater wells located within the study area

Well ID	Easting	Northing	Bore Depth (m)	Purpose	EC	EC Date	DTW	DTW Date
6030-1	592484.9	6288970	45.72	STK	28452	5/12/1969	-	-
6030-13	579813.7	6266713	0	STK	30263	2/12/1958	1.52	2/12/1958
6030-30	572373.9	6257434	54.86	STK	11470	1/01/1967	-	-
6030-610	562602.1	6250192	21	IRR	-	-	-	-
6030-629	563113.2	6250447	18	DOM	1219	14/02/2007	11.5	15/02/2007
6030-803	581138	6269009	18.29	STK	23721	9/05/1966	-	-
6031-5	588664.8	6328764	0	STK	18565	25/09/1961	20.42	25/09/1961
6031-17	566507.8	6295975	36.88	STK	20877	15/09/1972	-	-
6031-23	569842.6	6310604	39	STK	47500	21/01/1976	-	-
6031-24	567713.7	6311332	42	STK	-	-	29	10/12/1975
6031-130	562802.7	6324579	11.28	IND	29569	31/08/1961	-	-
6031-160	579180.7	6320935	15.85	STK	5330	14/03/1987	13.89	30/03/1987
6031-161	579564.8	6321269	15.24	STK	5192	14/02/1987	13.4	16/02/1987
6031-219	587528.7	6327221	84	STK	9130	26/03/1992	-	-
6129-11	620783.8	6226969	29.26	STK	57484	14/02/1939	-	-
6129-15	616650.8	6213068	0	STK	16659	13/06/1948	-	-
6129-28	601313.9	6210528	0	STK	17337	10/06/1948	-	-
6129-30	614809	6210268	3.05	STK	30764	12/06/1948	2.74	12/06/1948
6129-106	607154	6203278	0.61	STK	24267	11/06/1948	-	-
6129-129	602708.8	6205418	0	STK	10631	10/06/1948	-	-
6129-256	605973.9	6201451	4.57	STK	13259	11/06/1948	3.66	11/06/1948
6129-298	607049.9	6200905	1.83	STK	14025	11/06/1948	1.52	11/06/1948
6129-537	618628.9	6234951	102	STK	42200	26/07/1997	32	26/07/1997
6129-538	622454	6222719	96	IRR	36400	30/05/1997	36	30/05/1997
6129-547	619450.3	6214720	12	STK	7410	21/06/2002	8.5	21/06/2002
6130-100	613582.9	6253705	91.44	STK	7651	15/10/1962	-	-
6130-102	608124	6253928	24.38	STK	-	-	23.47	Unknown
6130-106	611173.7	6247654	36.58	STK	13621	1/02/1939	18.29	6/05/1949
6130-115	615620.7	6286113	79.25	STK	2209	4/12/1969	-	-

Well ID	Easting	Northing	Bore Depth (m)	Purpose	EC	EC Date	DTW	DTW Date
6130-131	633878.8	6272971	0	STK	10500	15/12/1994	-	-
6130-1022	615008.8	6240971	97	STK	42300	6/07/1997	-	-
6131-87	614626.9	6316922	49.99	IND	29569	16/05/1961	15.85	17/05/1961
6131-92	608055.8	6305811	73.15	STK	28452	25/08/1967	42.67	25/08/1967
6230-185	640789.9	6264490	14.35	STK	9014	4/04/1979	9.9	4/04/1979
6230-187	641360	6263356	19.4	STK	6713	3/04/1979	12.9	3/04/1979

Appendix B Infrastructure corridor production well calculation sheets

Kielpa Domain

Project: **IRD Kielpa Domain**

Calculate Drawdown (s) for known Discharge (Q) — THEIS Analytical Solution (Theis, 1935)

	INPUTS
Pumping rate of well (m3/day):	430
Storage coefficient (s) of aquifer:	1.00E-03
Transmissivity (m2/day):	450
Time since pumping started (days):	730
Saturated thickness (m):	
Hydraulic conductivity (m/d):	

NOTE 1: Estimating 'T' from specific capacity data use:
[log t = -2.31 +0.81 log (spec cap)]

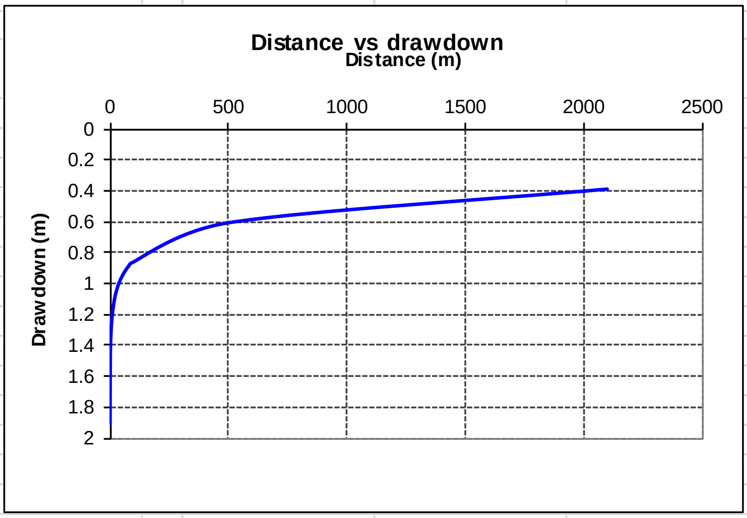
NOTE 2: If using 'T', divide by saturated thickness to give hydraulic conductivity (T=kB)

NOTE 3: Estimates of s (conservative): Unconfined=0.05, Semi=0.005, Confined=0.00005

NOTE 4: To convert Gallons/minute to litres/sec, divide by 13.2

NOTE 5: To convert litres/sec to cubic metres/day, multiply by 86.4

Distance (m)	u	W(u)	Drawdown (m)
0.1	7.61E-12	2.50E+01	1.9
2	3.04E-09	1.90E+01	1.4
5	1.90E-08	1.72E+01	1.3
10	7.61E-08	1.58E+01	1.2
20	3.04E-07	1.44E+01	1.1
30	6.85E-07	1.36E+01	1.0
40	1.22E-06	1.30E+01	1.0
50	1.90E-06	1.26E+01	1.0
60	2.74E-06	1.22E+01	0.9
70	3.73E-06	1.19E+01	0.9
80	4.87E-06	1.17E+01	0.9
90	6.16E-06	1.14E+01	0.9
500	1.90E-04	7.99E+00	0.6
2100	3.36E-03	5.12E+00	0.4



Verran Domain

Project: **IRD Verran Domain**

Calculate Drawdown (s) for known Discharge (Q) — THEIS Analytical Solution (Theis, 1935)

	INPUTS
Pumping rate of well (m3/day):	430
Storage coefficient (s) of aquifer:	1.00E-03
Transmissivity (m2/day):	18
Time since pumping started (days):	730
Saturated thickness (m):	
Hydraulic conductivity (m/d):	

NOTE 1: Estimating 'T' from specific capacity data use:

[log t = -2.31 +0.81 log (spec cap)]

NOTE 2: If using 'T', divide by saturated thickness to give

hydraulic conductivity (T=kB)

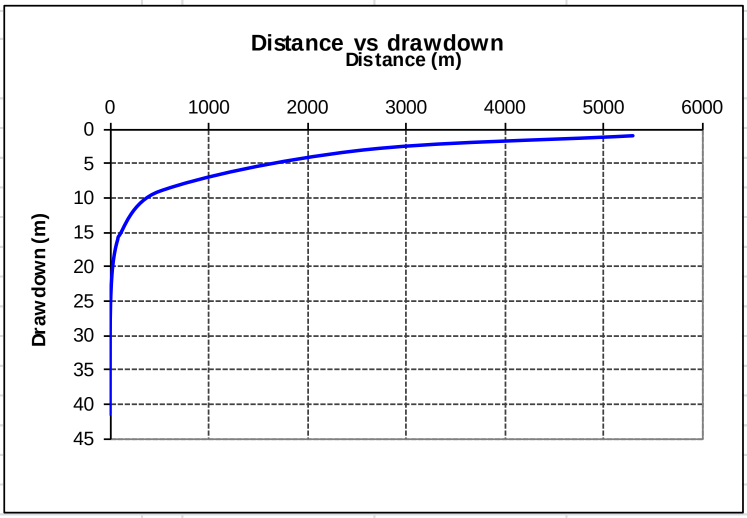
NOTE 3: Estimates of s (conservative): Unconfined=0.05,

Semi=0.005, Confined=0.00005

NOTE 4: To convert Gallons/minute to litres/sec, divide by 13.2

NOTE 5: To convert litres/sec to cubic metres/day, multiply by 86.4

Distance (m)	u	W(u)	Drawdown (m)
0.1	1.90E-10	2.18E+01	41.5
2	7.61E-08	1.58E+01	30.1
5	4.76E-07	1.40E+01	26.6
10	1.90E-06	1.26E+01	23.9
20	7.61E-06	1.12E+01	21.3
30	1.71E-05	1.04E+01	19.8
40	3.04E-05	9.82E+00	18.7
50	4.76E-05	9.38E+00	17.8
60	6.85E-05	9.01E+00	17.1
70	9.32E-05	8.70E+00	16.5
80	1.22E-04	8.44E+00	16.0
90	1.54E-04	8.20E+00	15.6
500	4.76E-03	4.78E+00	9.1
2500	1.19E-01	1.67E+00	3.2
5300	5.34E-01	5.20E-01	1.0



Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to carry out the groundwater impact assessment for the proposed CEIP infrastructure project in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

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