DOCUMENT NO	REVISION	DATE OF REVISION
P-WGP2-055	Rev 3	11/06/2024

Waitsia Gas Project Stage 2 – Water Management Plan

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RELATED DOCUMENTS

This document should be read in conjunction with following documents:

Document Number	Document Title
MS 1164	Ministerial Statement 1164: Waitsia Gas Project Stage 2

TERMS, ABBREVIATIONS AND DEFINITIONS

Term or Abbreviation	Definition
AHD	Australian Height Datum
ANZG	Australian and New Zealand Guidelines
ARI	Assessment on Referral Information
BTEXN	Benzene, toluene, ethylbenzene, xylene and naphthalene
CAR	Compliance Assessment Report
CO_2	Carbon Dioxide
DBNGP	Dampier to Bunbury Natural Gas Pipeline
Development Envelope	The authorised extent within which the Proposal comprises
DO	Dissolved Oxygen
DWER	Department of Water and Environmental Regulation
EIA	Environmental Impact Assessment
EP Act	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority
Flowline	Pipes that carry raw oil or gas products from the wells to a processing facility
GDE	Groundwater Dependent Ecosystem
GDV	Groundwater Dependent Vegetation
ha	Hectares
kL	Kilolitre
kL yr	Kilolitre per year
km	Kilometres
m	metres
MEPAU	Mitsui E&P Australia
MS 1164	Ministerial Statement 1164
OCPs	Organochlorine pesticides
PAHs	Polycyclic aromatic hydrocarbons
PJ	Petajoule
Pipeline	Pipes that carry processed oil or gas products from a processing facility to market.

Term or Abbreviation	Definition
RiWI Act	*Rights in Water and Irrigation Act 1914*
SWL	Standing Water Levels
TCV	Temporary Construction Village
TDS	Total Dissolved Solids
The Proposal	The Waitsia Gas Project Stage 2
TRH	Total Recoverable Hydrocarbons
WA	Western Australia
WGP	Waitsia Gas Plant
WGP2	Waitsia Gas Project Stage 2
Yaragadee	Yaragadee Aquifer

1.0 SUMMARY

A summary of this Water Management Plan is provided in Table 1-1.

Table 1-1 Summary of the Proposal

Proposal Title	Waitsia Gas Project Stage 2 (WGP2)
Proponent Name:	MEPAU Perth Basin Pty Ltd
Purpose of this Water Management Plan:	The purpose of this Water Management Plan is to identify the potential direct and indirect impacts on water systems and develop management and monitoring measures that protect existing systems as well as the groundwater-dependent ecosystems (GDE) adjacent to the Proposal project development envelope. This Water Management Plan has been written in accordance with the "Instructions on how to prepare *Environmental Protection Act* (EP Act) 1986 Part IV Environmental Management Plans" (EPA, 2024).
Ministerial Statement:	The Proposal has been assessed by the EPA (Assessment 2226) and on 1 February 2021, a Ministerial Approval was received via Ministerial Statement 1164 (MS 1164), with associated Proposal implementation conditions.
Condition Clauses:	Condition 7
Proposed Construction and Operation Dates:	Construction of the Proposal commenced in July 2021 and is anticipated to be finalised by mid-2026. The Waitsia Gas Plant (WGP) is expected to be operational for at least 20 years.
Plan Required Pre-Construction:	Yes.
Key Environmental Factor/s and Objective/s:	Key environmental factor: Inland Waters **EPA Objective:** *To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*
Key provision:	• Baseline ground and surface water monitoring; • Ongoing ground and surface water monitoring; • Trigger and threshold criteria and subsequent response actions; and • Annual reporting (including results of monitoring).

1.1 Ministerial Statement 1164 Conditions

Table 1-2 provides a summary of the conditions outlined in MS 1164 in relation to the Water Management Plan and the relevant sections of the Water Management Plan where these conditions have been addressed[1].

[1] MEPAU's Compliance Assessment Plan [WAT-HSE-PLN-00004] outlines MEPAU's approach to compliance with all conditions of MS 1164.

Table 1-2 Summary of MS 1164 Conditions Relating to the Water Management Plan

MS 1164 Condition No.	Description	Location in Document
7	**Water Management Plan**	-
7-2	To achieve the objectives of Condition 7-1, prior to groundwater abstraction within the development envelope delineated in Figure 2 of Schedule 1, unless otherwise agreed in writing by the CEO, the proponent shall implement the Waitsia Gas Project Stage 2: Water Management Plan [P-WGP2-055 Rev 1, May 2020]. This plan shall:	-
7-2 (1)	(1) when implemented, substantiate and ensure that condition 7-1 is being met;	-
7-2 (2)	(2) specify trigger criteria that will trigger the implementation of management and/or contingency actions to prevent further direct or indirect impacts to groundwater and/or Ejarno Spring;	Table 4-2
7-2 (3)	(3) specify threshold criteria to demonstrate compliance with condition 7-1;	Table 4-2
7-2 (4)	(4) specify monitoring methodology to determine if trigger criteria and threshold criteria have been met;	Table 4-5
7-2 (5)	(5) specify management and/or contingency actions to be implemented if the trigger criteria required by condition 7-2(2) and/or the threshold criteria required by condition 7-2(3) have not been met; and	Table 4-2
7-2 (6)	(6) provide a format and timing for the reporting of monitoring results against trigger criteria and threshold criteria to demonstrate that condition 7-1 has been met over the reporting period in the Compliance Assessment Report required by condition 4-6.	Table 4-2 & Section 4.3

2.0 INTRODUCTION

MEPAU Perth Basin Pty Ltd is a wholly-owned subsidiary of Mitsui E&P Australia Holdings Pty Ltd, which in turn is a wholly-owned subsidiary of Mitsui & Co., Ltd. The Mitsui E&P Australia Holdings Pty Ltd group of companies operates under the brand Mitsui E&P Australia (MEPAU).

3.0 CONTEXT, SCOPE AND RATIONALE

This Water Management Plan has been prepared to support the assessment, approval and implementation of the Proposal under Part IV of the *Environmental Protection Act* 1986 (EP Act).

The WGP2 was referred under the Act to the Environmental Protection Authority (EPA) on 23 August 2019 (EPA Assessment 2226). The EPA assessed the WGP2 as a significant proposal, through Assessment of Referral Information (ARI). The ARI included additional information requested under Section 40(2)(a) of the EP Act, including this Water Management Plan, which was subject to a two-week public review period. On 1 February 2021, Ministerial Approval was received for the Proposal via Ministerial Statement (MS) 1164.

Under s. 45C application of the EP Act, an application to amend the Development Envelope was submitted to the EPA due to further refine the well locations/reservoir targets and make associated minor changes to the flowline routes. MS 1164 was amended on 4 October 2021.

A s.45C application of the EP Act was submitted to the EPA on 12 June 2023 and amended on 27 November 2023 to amend the development envelope and footprint and increase the number of gas production wells to a maximum of nineteen (19) to allow further development of the Waitsia Gas Field and to enable the approved production rate to be achieved over the life of the project. MS 1164 was amended on 17 April 2024.

This Water Management Plan has been written in accordance with the “Instructions on how to prepare Environmental Protection Act 1986 Part IV Environmental Management Plans” (EPA, 2024).

3.1 Proposal

The Proposal (known as WGP2) is a conventional gas proposal located approximately 16km East-South-East of the Dongara-Port Denison town sites (Figure 3-1). It includes the construction and operation of the 91.25 Petajoule per annum WGP, related wells and gas gathering infrastructure.

Table 3-1 provides a summary of the WGP2.

Table 3-1 Proposal Overview

Proposal Title	Waitsia Gas Project Stage 2
Proponent Activities	Development of a conventional gas reservoir by designing and constructing wells, a gathering system, gas processing plant and export pipeline to the Dampier to Bunbury Natural Gas Pipeline (DBNGP).
Short Description	Waitsia Stage 2 includes the following components: • Construction and operation of the WGP with a maximum export capacity of 91.25 Petajoule (PJ) per annum; • Up to nineteen (19) gas production wells;

Proposal Title	Waitsia Gas Project Stage 2
	• Constructing of a (~1 km) pipeline (PL 128) to connect the WGP to the existing Waitsia Export Pipeline (PL 124); • Installation of a gas gathering system comprising flowlines and hubs to convey the extracted gas to the WGP and the gas distribution network; • Installation of a flowline from the WGP to up to three (3) water injection wells to inject produced water into a disused petroleum formation; • Clearing of no more than 16.5 ha of native vegetation within a 580.9 ha development envelope; • Disturbance footprint of up to 479.2 ha within the 580.9 ha development envelope; and • Scope 1 Emissions up to ~300,000 tCO_2-e per annum.

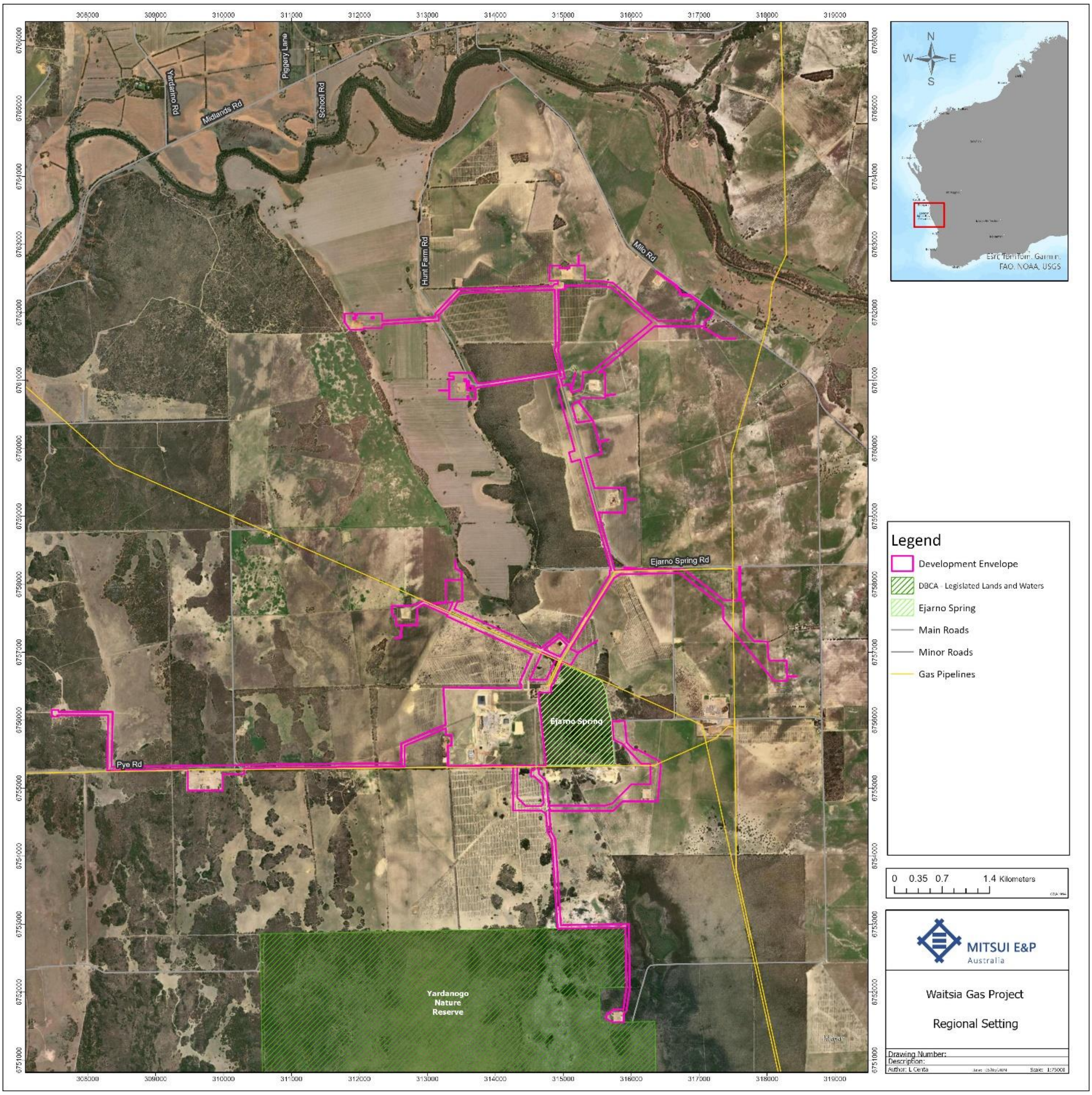

Figure 3-1 Regional Setting

3.1.1 Development Envelope

The total area of the development envelope for the WGP2 is 580.9 ha (Figure 3-2).

3.1.2 Water Abstraction

Groundwater is required to be abstracted to support the construction and operation of the WGP. A summary of the activities / systems that will require abstracted groundwater include:

- Construction;
- Dust suppression;
- Amine system (described below);
- Ablutions

- Lawn irrigation;
- Workover operations; and
- Fire water ring main.

The amine system is a gas sweetening system that is used to remove carbon dioxide (CO_2) from the reservoir gas to ensure it meets the specification required to be transported via the DBNGP. This is the key gas processing system where water is required to be used. The amine chemical is diluted with water, and this mixture (lean amine) then is bought in contact with the hydrocarbon gas and the CO_2 is stripped out of the gas. The amine-water-CO_2 mixture (rich amine) is then regenerated, and the CO_2 is driven off, resulting in the lean amine which in turn is recirculated back through the process. It is during the amine regeneration stage that water is lost from the system, and so make-up water is required. It is estimated that during peak production, the system may use up to 52 kL /day.

MEPAU estimates that water usage will be higher during the initial construction period, with volumes of groundwater required to support the WGP conservatively estimated to be in the order of 60,000 kL /annum for the life of the WGP2 (approximately 20 years). This includes water for all aspects of the WGP2 including gas sweetening, dust suppression, ablutions irrigation and other requirements.

3.1.3 Key Proposal Characteristics – Water Management

The Key Proposal characteristics specific to Water Management are summarised in Table 3-2.

Table 3-2 Key Proposal Characteristics - Water Management

Element	Characteristics
Water abstraction bore location	Abstraction bores located within the WGP area (Figure 3-4).
Number of abstraction bores	Up to four new abstraction bores are estimated to be required to support the WGP. Two bores have installed, one permanent bore for production operations and the second is for construction bore water supply.
Volume of water abstracted	The estimated volume required to be abstracted is conservatively estimated to be in the order of 60,000 kL /annum for the life of the WGP (approximately 20 years).

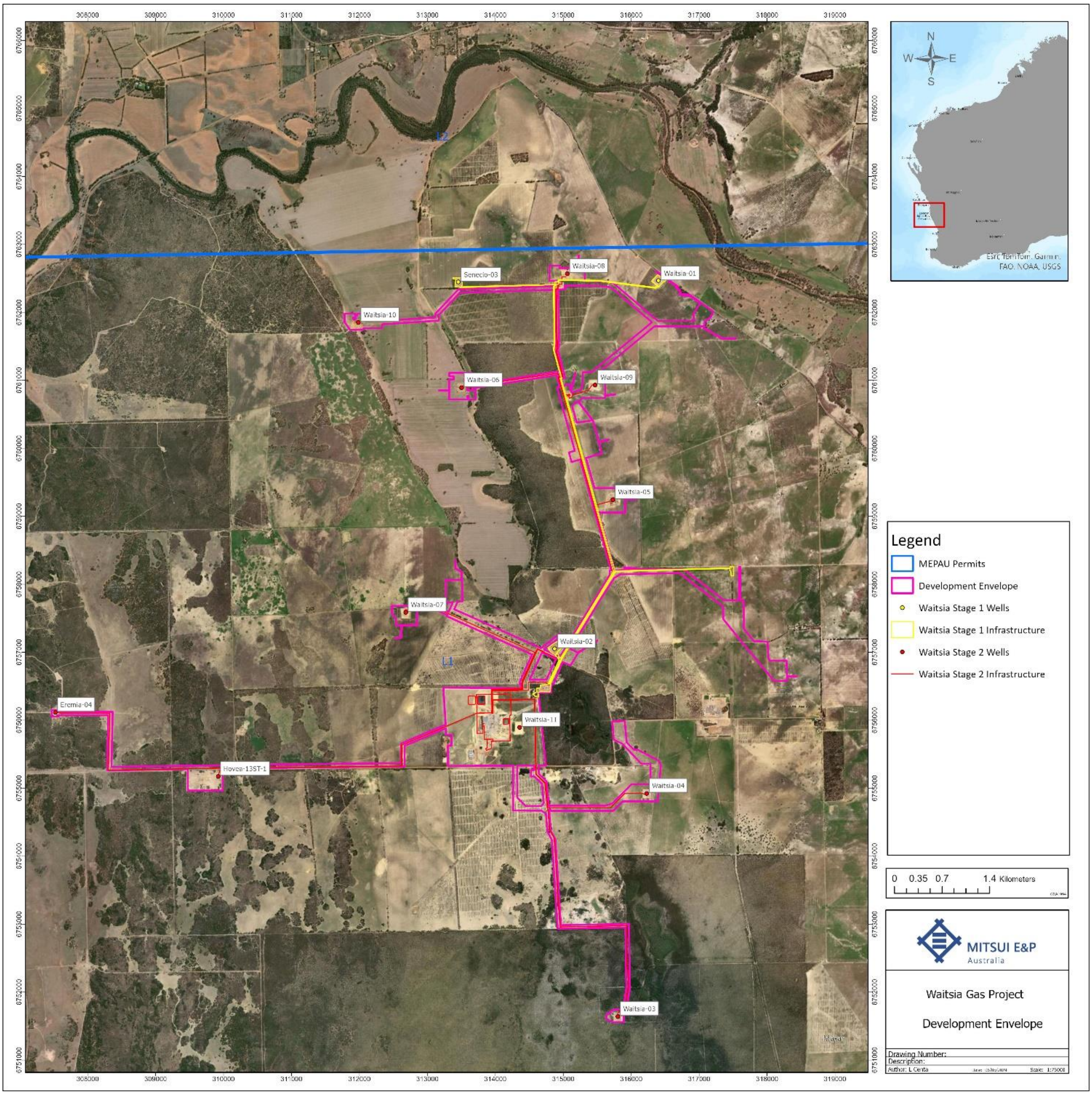

Figure 3-2 Waitsia Gas Project Stage 2 - Development Envelope

3.2 Key Environmental Factors

Water abstraction required for the Proposal (Section 3.1.23.1) has been identified as having the potential to affect the Key Environmental Factor – Inland Waters. A summary of the Inland Waters factor with a specific focus on the abstraction of groundwater and the impact relating to this activity is included below in Table 3-3.

Table 3-3 Summary of Key Environmental Factor – Inland Waters

Inland Waters	
EPA objective	*To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.*
Policy and guidance	• Environmental Key Factor Guideline – Inland Waters (EPA, 2018b) • Australian and New Zealand (ANZG) Guidelines for Fresh and Marine Water Quality (2018) • AS/NZS 5667.11:1998 Water Quality – Sampling - Guidance on Sampling of Groundwaters
WGP2 activities	• Water abstraction for the purpose of construction and operation of the Proposal.
Environmental Values	• Groundwater Dependent Ecosystems (GDE) – Ejarno Spring; • Other groundwater users.
Potential impacts – Direct impacts	• Reduction of SWL associated with the abstraction of groundwater volumes conservatively estimated to be in the order of 60,000 kL/annum for the life of the Proposal (approximately 20 years); • Changes to groundwater and surface water quality.
Potential impacts – Indirect impacts	• Reduction and/or changes in floristic diversity.

3.3 Condition Requirements

The WGP2 was assessed by the EPA (Assessment 2226) and on 1 February 2021, Ministerial Approval was received via MS 1164. Condition 7 outlines the objectives, requirements for implementation and reporting associated with this Water Management Plan.

3.4 Rationale and Approach

This section provides a concise description of the rationale and approach for this Water Management Plan. Specifically, the following sub-sections summarise:

- The site-specific environmental values, existing and/or potential uses, ecosystem health condition or sensitive component of the key environmental factor which will be affected (Section 3.4.1);
- Study findings (Section 3.4.2);
- Groundwater modelling overview and findings (Section 3.4.3);
- Key assumptions (Section 3.4.4);
- Management approach (Section 3.4.5); and
- Rational for choice of provisions (Section 3.4.6).

3.4.1 Receiving Environment

In the WGP2 Development Envelope, the groundwater system comprises predominantly unconfined Superficial formations overlying the Yarragadee Aquifer (Yarragadee). Superficial formations overlying the Yarragadee include alluvium, Tamala Limestone, Bassendean Sand and colluvium. These predominantly drain into the Yarragadee however some perched layers are known to exist in the area (DoW, 2017).

The WGP is located next to an alluvial depression (situated to the east of the site) which features surface expression of groundwater known as Ejarno Spring, a relic of palaeo-lake system, forming a permanently wetted depression of irregular morphology. Similar features also occur further away to the southeast of the WGP.

The main regional aquifer beneath the Waitsia Gas Field is the Yarragadee (the top, D unit), which has the following characteristics in the Waitsia Reservoir area:

- Composed of shale, siltstone and sandstone (Rockwater, 2015);
- Standing water levels (SWLs) vary from 75 m Australian height datum (m AHD) to 15 m AHD, corresponding to approximately 0 to 100 m below ground surface (m bgs);
- Hydraulic gradient is broadly west-southwest toward the Indian Ocean (DoW, 2017); and
- Salinity is typically fresh to marginal near the surface and increases to brackish with depth.

A review of groundwater levels in MEPAU monitoring bores screened in the Yarragadee around the WGP2 Development Envelope, suggests that the aquifer is likely to be confined or partially confined.

Groundwater recharge into the Yarragadee is by direct rainfall (in outcrops) as well as downward leakage from overlying aquifers i.e. the Superficial formations. In the area around the WGP2 site recharge is likely to be affected by:

- Concentrated surface water infiltration within the river valleys, for example, the Irwin River system to the north that receives runoff from its catchment;
- Restricted by clayey lithologies resulting in elevated groundwater salinity in the upper portion of the aquifer (Commander, 1981); and
- Alluvial depressions such as the one encountered to the east of the WGP site.

Localised siltstone and shale beds may support perched water table conditions in some areas. Low permeability lacustrine sediments may be present and result in the ponding of water in features such as the Ejarno Spring and the northern end of the Zeus Wetland, located more than 2 km south of the Ejarno Spring.

Groundwater discharges from the Yarragadee via upward groundwater flow into the Superficial aquifer and potentially express at the ground surface, as is possibly occurring in the Ejarno Spring area. Other discharge from the Yarragadee enters portions of the Irwin River and offshore into the Indian Ocean (DoW, 2017).

The Allanooka-Dongara Water Reserve is located about 12 km north of the WGP, on the northern side of the Irwin River and more than 3.5 km from the nearest WGP2 production well. The reserve is listed as Priority 1 Public Drinking Water Source protection area. The Allanooka-Dongara Water Reserve lies up-gradient of the WGP and there is little hydraulic connection between the Allanooka-Dongara Water Reserve and the WGP2.

The Irwin River is a significant hydrological feature located to the north of the WGP2 area that meanders towards the west and discharges into the Indian Ocean. The Indian Ocean is situated 16 km west from the Proposal area.

Figure 3-3 shows the approved development envelope in proximity to environmental sensitivities.

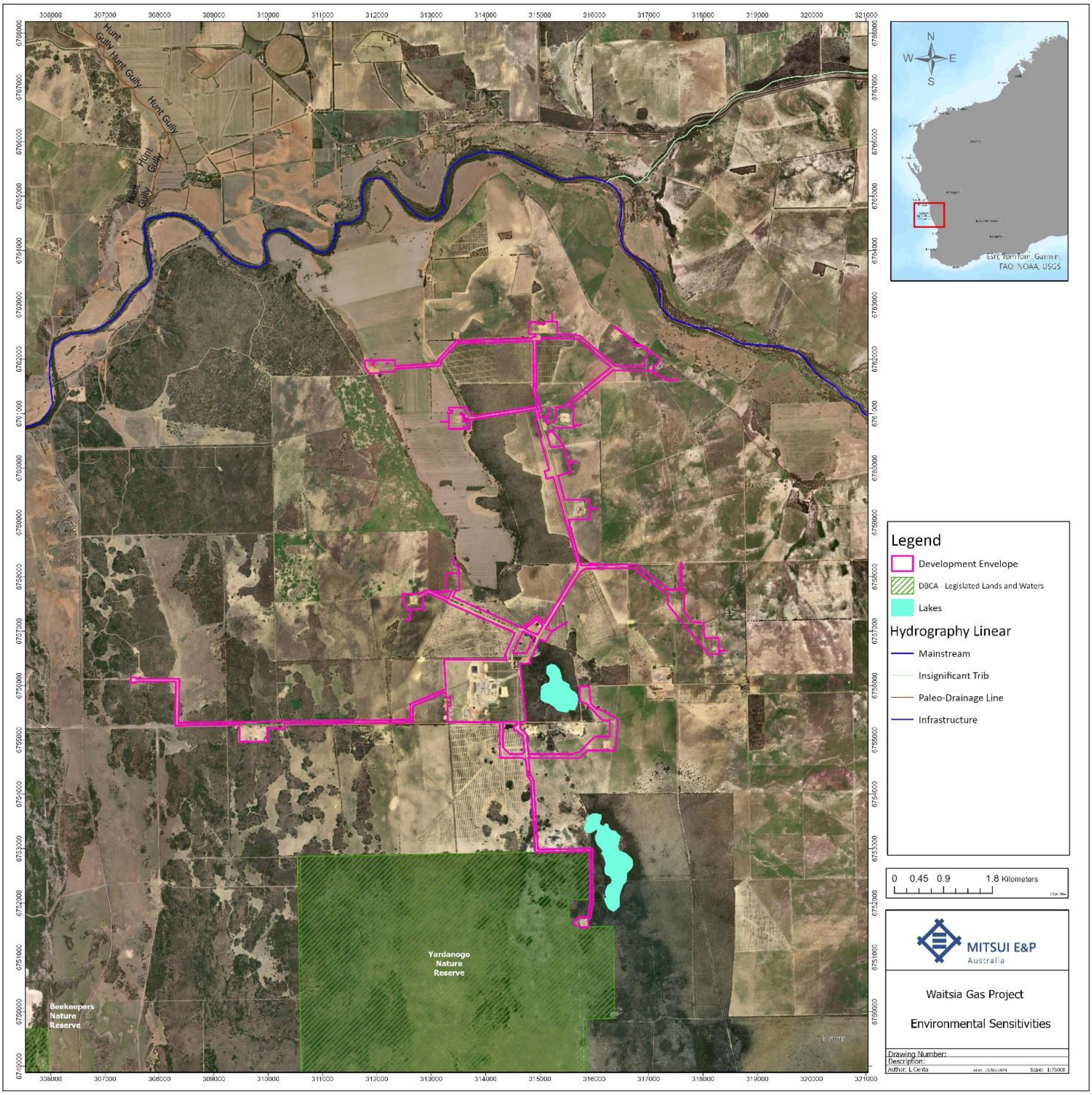

Figure 3-3 Proximity of the Development Envelope to Environmental Sensitivities

3.4.1.1 Ejarno Spring – GDE/GDV

A study of the northern Perth Basin was undertaken by Rutherford et al. (2005) to identify sites that are potentially reliant on groundwater – i.e. where depth to groundwater was less than 20 m. These sites were then classified as GDEs as any remnant vegetation in areas of shallow groundwater were considered to be potentially groundwater dependent.

The nearest GDE, Ejarno Spring, is located approximately 500 m to the east of the WGP boundary. Ejarno Spring is associated with a topographic depression. The topographic depression suggests that the spring discharges into a system that may be perched, like those described west of Eneabba (Kern, 1997). Such a perched system would not be significantly impacted by small changes in groundwater levels in the Yarragadee.

In November 2020 a reconnaissance flora and vegetation survey, condition assessment and groundwater-dependent vegetation (GDV) assessment was undertaken at Ejarno Spring by Umwelt Environmental Consultants. Following the survey, the 'Ejarno Springs Study Area Reconnaissance Survey and GDV Assessment' Report was prepared in September 2021 (Umwelt 2021). The study did not note any significant vegetation communities within or in close proximity to Ejarno Spring. However, a total of five significant flora taxa were recorded by the survey, none of which were identified as threatened flora taxa.

With regards to GDV, the study concluded that 71% of the 'Study Area' is considered to represent potential GDV, i.e., where depth to groundwater is inferred to be within 10 m of the topographical surface. Potential GDV types and species identified by the study are:

- Tall open shrubland dominated by *Banksia attenuata*,
- Tall closed sedgeland dominated by *Baumea juncea* and *Typha domingensis;*
- Tall woodland of *Melaleuca rhaphiophylla*;
- Low open forest to woodland of predominately *Banksia prionotes*; and
- Mid open forest to woodland of *Eucalyptus camaldulensis*.

3.4.1.2 Ejarno Spring – Ground/Surface water Monitoring

As outlined further in Section 3.4.1.5, since Revision 1 of this Water Management Plan was approved, the Ejarno Spring Groundwater Monitoring Program has been expanded significantly to include a series of new Superficial, Yarragadee and perched aquifer monitoring bores installed between the WGP and Ejarno Spring.

Since their installation ongoing interpretation of the monitoring results from these bores has significantly increased MEPAU's understanding of the hydrogeological conditions that effect Ejarno Spring. Specifically, monitoring data indicates that changes in the Yarragadee aquifer, Ejarno Spring perched aquifer and Ejarno Spring surface water surface water levels appeared more aligned with one another than for the Superficial aquifer locations.

Additionally, monitoring data interpreted to date highlights very stable conditions with little seasonal variation in standing water levels at Ejarno Spring during the baseline monitoring period (July 2020 – June 2021). During the baseline period the standing water level fluctuated between a minimum of 31.17 m AHD recorded during both December 2020 and March 2021 monitoring events and 31.24 m AHD in July 2021. This represents a yearly seasonal fluctuation of just 0.07 m AHD, with stable standing water levels continuing to be recorded following the baseline period. Of particular note, surface water monitoring undertaken at Ejarno Spring during the commencement of construction demonstrates that standing water levels are unaffected by abstraction from both the Yarragadee and Superficial aquifers. Despite pump testing of production bores resulting in an observable drawdown at the monitoring bores corresponding with these aquifers (MB1-D and MB1-S2), such impacts were temporary, fully recoverable and did not result in any observed impact to standing water levels at Ejarno Spring or nearby perched aquifer standing water levels (GEMEC, 2022).

3.4.1.3 Groundwater Users

The WGP2 is located within the Eneabba Plains and Twin Hills sub-areas of the Arrowsmith groundwater area (DWER, 2021). Locations of active Department of Water and Environmental Regulation (DWER) *Rights in Water and Irrigation (RiWI) Act* 1914 groundwater licences to extract groundwater from the Yarragadee Aquifer within proximity of the WGP2 are provided in Figure 3-3. With the exception of the RiWI section 5C groundwater licence held by Tronox

Holdings PLC (3.5 M kL/yr) located about 5 km southeast of the Development Envelope, all other abstraction licences comprise lower volumes (~60 kL/yr) based upon the DWER databases. The available water in the Eneabba Plains sub-area was reaching the allocation limit for Licensing when considering the Yarragadee aquifer system in late 2021 (DWER, 2021) and was considered fully allocated in early 2022 (DWER, pers comm 2022).

MEPAU holds RiWI section 26D bore install and 5C water take licences across the Proposal area. At the WGP, this includes within the Superficial and Yarragadee aquifers, with details of the volumes and duration of licences denoted in Figure 3-4. The Superficial aquifer licence (GWL 206278(1)) became redundant once the Yarragadee aquifer licence came in to use.

3.4.1.4 Background Water Quality Overview

As part of its existing Perth Basin operations, MEPAU implements a comprehensive surveillance water quality monitoring program to ensure environmental management measures are effective. It also allows informed responses to regulatory requirements for water quality monitoring. The locations of the water quality sampling points are provided in Figure 3-4.

A summary of the ground and surface water quality studies over the recent years is included in Table 3-4.

Table 3-4 Recent Ground and Surface Water Studies

Document Title	Author and date
Hydrogeological Assessment of the Waitsia Reservoir Drilling Programme	Rockwater Hydrogeological & Environmental Consultants (2015)
Surface Water & Groundwater Monitoring Event Report - Waitsia 02 Location	GEMEC Environmental Consultants (2015)
Waitsia Gas Project Surveillance Monitoring Program - Senecio-03, Waitsia-01 & Waitsia-02 Well Sites	GEMEC Environmental Consultants (2016)
Surface Water & Groundwater Monitoring Event Report - Waitsia 02 Location & Ejarno Spring	GEMEC Environmental Consultants (2017)
Annual Water Monitoring Report July to June 2018	Mitsui E&P Australia Pty Ltd (2018)
Groundwater & Surface Water Monitoring Events - Waitsia Gas Project Stage 2 & Ejarno Spring (Quarterly reports from 2019 – 2023)	GEMEC Environmental Consultants (2019 - 2023)
Waitsia Gas Project Groundwater Assessment	GHD Pty Ltd (2020).
WGP2 Baseline Ground and Surface Water Monitoring Report (June 2020 – May 2021).	GEMEC Environmental Consultants (2021)
WGP2 Groundwater Salinity Modelling Report June 2021	GEMEC Environmental Consultants (2021)
Baseline Soil and Groundwater Investigation – Waitsia Gas Plant Development	Senversa Pty Ltd (2021-2022)
Baseline Soil, Groundwater & Vegetation Assessment – Waitsia Gas Project Stage 2, Wellsites & Flowlines	GEMEC Environmental Consultants (2021 - 2022)

Document Title	Author and date
Ejarno Spring Standing Water Level Trigger and Threshold Level Revision – February 2022	GEMEC Environmental Consultants (2022)

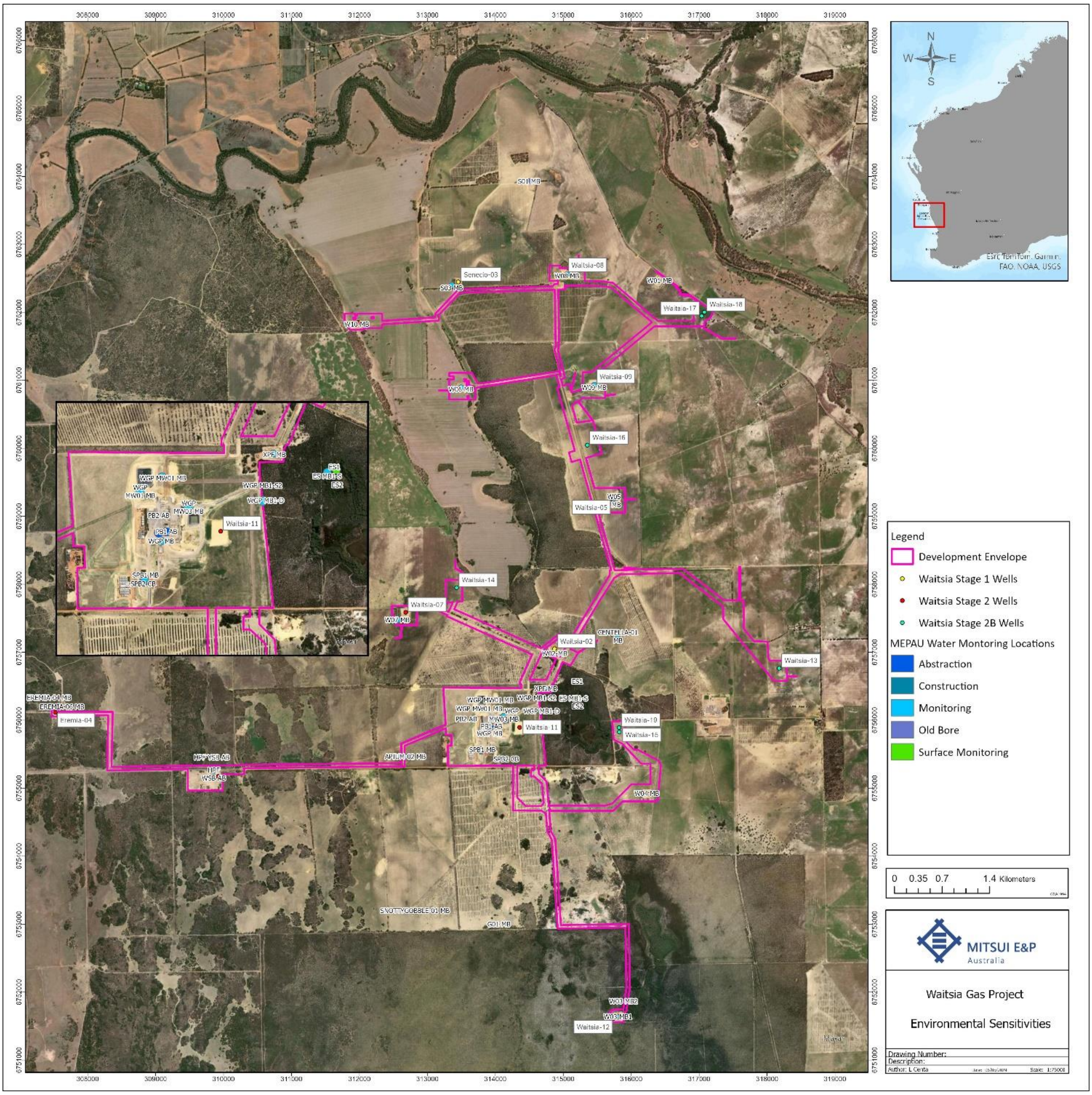

Figure 3-4 Water Monitoring Locations

3.4.1.5 Water Quality Monitoring Program

Since Revision 1 of this Water Management Plan was approved, the groundwater monitoring program has been expanded significantly to include a new Superficial aquifer monitoring bore (WGP MB1-S2) and Yarragadee aquifer monitoring bore (WGP MB1-D) monitoring bore that have been installed between the WGP and Ejarno Spring. Both of these monitoring bores have been fitted with a logger to provide a continuous understanding of groundwater level for the duration of baseline monitoring. A shallow (perched aquifer) monitoring bore has also been established at Ejarno Spring (ES MB1-S).

As per the Monitoring Schedule of the RiWI section 5C licence at the WGP (GWL 206523), a redundant Superficial aquifer production bore used for early construction works at WGP (SPB) has been converted into a groundwater monitoring bore, and the Superficial aquifer monitoring bore (MB) is now utilised to monitor potential impacts from the more recently installed Yarragadee aquifer production bore at the WGP. All ground and surface water monitoring locations are depicted in Figure 3-4.

For the purposes of this Water Management Plan, the baseline monitoring period is considered to be July 2020 to June 2021. This period represents the timeframe between the establishment of the aforementioned additional groundwater monitoring bores between Ejarno Spring and WGP and the commencement of site construction activities and associated groundwater abstraction. Quarterly monitoring of groundwater bores during construction shall occur in accordance with the monitoring program outlined in Table 4-5.

Given the installation of additional ground and surface water monitoring points depicted in , quarterly monitoring from the Waitsia-02 bore is now considered superfluous to the purpose of this Water Management Plan, as the additional sampling locations are better positioned to monitor potential impacts to Ejarno Spring.

3.4.1.6 Baseline Water Quality (Pre-Construction)

Monitoring of the Waitsia-02 groundwater monitoring bore continues on an annual basis, however, is outside the requirements of this Water Management Plan. Prior to the installation of the Superficial (WGP MB1-S2) and Yarragadee (WGP MB1-D) monitoring bores, the Waitsia-02 MB was the closest bore to the WGP and provided a suitable groundwater quality baseline reference. Groundwater and surface water monitoring have been conducted at, and near, the Waitsia-02 site since June 2015 by an experienced third-party subject matter expert (GEMEC, 2018). Monitoring initially consisted of a baseline phase, prior to drilling the Waitsia-02 Well, and until January 2017 samples were collected six-monthly and tested for a comprehensive analytical suite. Ongoing surveillance monitoring has been conducted on samples collected annually and tested for petroleum hydrocarbons and hydrogeochemical indicators.

In addition to the groundwater samples collected from Waitsia-02 AB, surface water samples have been collected from two locations within the nearby Ejarno Spring (ES1 and ES2). Dissolved sodium and chloride were dominant within both groundwater and surface water, with total dissolved solids ranging from marginal to brackish. Groundwater was of neutral pH and moderate hardness, with surface water very slightly alkaline and hard to very hard. Concentrations of dissolved metals and metalloids were generally consistent between groundwater and surface water samples, with dissolved barium, boron, iron and lithium detected during each event.

Minor concentrations of methane have been detected in surface water samples collected from Ejarno Spring, a result of the decomposition of organic material – a common wetland process. The conclusion of the wetland source of methanogenesis was supported by the absence of formation supplied ethane in the surface water samples. Petroleum hydrocarbons including Total Recoverable Hydrocarbons (TRH), Light fraction organic compounds (e.g. BTEXN compounds), Polyaromatic hydrocarbons (PAH’s) nor organochlorine pesticides (OCP’s) or phenols have not been detected in any groundwater or surface water samples collected to date.

MEPAU also conducts a broader operational surveillance groundwater monitoring program for its activities throughout the Perth Basin, with the results of Waitsia-02 AB indicating water quality is generally consistent throughout the region.

A summary of the most recent ground and surface water quality studies over the past seven years are summarised in Table 3-4.

3.4.2 Study Findings (Pre-Construction)

A number of studies were undertaken or reviewed to assess the feasibility and practicability of various design components and aspects of the WGP2. Specifically, the amine system, currently selected to support the removal of acid gas requires significant water use (per Section 3.1).

A technical scoping study was conducted to consider various acid gas removal solutions. On the balance of all variables including capital and operational expenditures, flexibility, reliability, efficiency, water use and historic technology use, MEPAU has selected the amine system as the preferred technology of choice for removal of acid gases. Table 3-5 provides a summary of this study.

Table 3-5 Recent Study Findings

Study	Description of Findings
A Comparison of Physical Solvents for Acid Gas Removal (Burr and Lyddon, 2008)	This study describes the options for acid gas removal, and also compares the ability of four physical solvents to remove acid gas (such as hydrogen sulphide or CO_2), from product gas streams. More commonly used methods are chemical solvents, physical solvents, membranes, and cryogenic fractionation, summarised as follows: • Chemical solvent processes which rely on chemical reactions to remove acid gas constituents from sour gas streams and include compounds such as ethanolamines (often abbreviated to “amines”) and hot potassium carbonate. Heat is required to regenerate chemical solvents. • Physical solvents rely on the physical interaction between CO_2 and other acid gases. Physical solvents can often be stripped of impurities they remove by reducing the pressure without the application of heat. • The membrane process is applicable for high pressure gas containing high acid gas concentrations. Waste streams often require significant recompression and secondary treatment to reduce overall hydrocarbon losses. • Cryogenic fractionation has the advantage that the CO_2 can be obtained at relatively high pressure as opposed to the other methods of recovering CO_2. However, this advantage is offset by significant refrigeration requirements. In addition, special materials are also required for this method. Physical solvents are typically preferred over chemical solvents when the gas is at a high pressure or when the concentration of acid gases or other impurities is very high, because the solvents are non-corrosive and thus only require carbon steel constructions. However, physical solvents are impractical for gases at low partial pressures because the compression of the gas for absorption is expensive. A physical solvent may also not be the best option in scenarios where the concentration of heavy hydrocarbons in the feed gas is high, due to higher co-absorption of hydrocarbons (Burr and Lyddon, 2008). This study indicates that for the adopted design measures, the amine system is most appropriate as it is capable of managing the concentration of heavy hydrocarbons present within the natural gas.

3.4.3 Groundwater Modelling Overview and Findings (Pre-Proposal)

MEPAU engaged a specialist consultant to undertake numerical modelling to determine the likely drawdown of the proposed abstraction on groundwater levels in order to assess the potential effect on:

- Ejarno Spring; and
- Existing groundwater users.

The groundwater modelling study involved a desktop review of key information and available reports to develop an understanding of the hydrogeology and establish the hydrogeological conceptualisation of the site (Attachment 1). A numerical model was then developed to simulate groundwater flow at a regional scale, based on the hydrogeological conceptualisation.

Simulations of pumping from a theoretical production bore set in the top section of Yarragadee and located at the eastern boundary of the WGP processing area (approximately 500 m west of the Ejarno Spring) was undertaken to evaluate the potential water level change at Ejarno Spring and the nearby licensed groundwater users (see Figure 3-4).

Due to some uncertainties around the conceptual hydrogeological model, three scenarios were evaluated:

1. 'Base case' – the model with locally calibrated parameters;
2. 'GARAMS parameterisation case' – as above but with hydraulic parameters taken from the GARAMS model; and
3. 'Lacustrine low K case" – as (1) with a low hydraulic conductivity unit beneath the Ejarno Spring.

The impact of the abstraction on water levels is evaluated as change in groundwater level and delineation of drawdown for both the Yarragadee and Superficial aquifer units. Drawdown contours (reduction in water level) suggest that water level changes attributable to pumping from a theoretical bore at the WGP processing area are minor to negligible (Attachment 1; Figure 10 – Figure 15).

The modelled changes in Superficial aquifer at the western edge of the lake at Ejarno Spring show a minimum of no change to a maximum reduction in water levels of 0.06 m after five years of pumping (Table 3-6). The modelled changes in Yarragadee water levels show a decrease of between 0.13 to 0.19 m. The anticipated impact on water levels for neighbouring licensed abstractions is predicted to be negligible or very minor due to the distance from the WGP2 site.

Table 3-6 Predicted Drawdown in Water Levels at western side of Ejarno Spring after 5 Years

Scenario	Superficial Drawdown (m)	Yarragadee Drawdown (m)
Base Case	0.06	0.15
GARAMS parameterisation case	0.00	0.19
Lacustrine low K case	0.05	0.13

3.4.4 Key Assumptions

In accordance with EPA (2018a), key assumptions or parameters, that are used to support any numerical modelling are to be described in the Water Management Plan. Specifically, key assumptions and uncertainties used in numerical groundwater modelling to understand the potential for water level drawdown associated with the Proposal are detailed in Table 3-7.

Table 3-7 Key Assumptions and Uncertainties

Number	Assumptions and Uncertainties	Comment
1	Number and location of abstraction bores	Up to four new abstraction bores[2] are estimated to be required to support the WGP2, to be located within the WGP Proposed Area (Figure 3-2).
2	Volume of water required to be abstracted for the WGP2	The volume of water required to be abstracted is conservatively estimated to be in the order of 60,000 kL/annum. This volume has been used throughout this Plan to enable a worst-case conservative impact assessment to be undertaken.
3	Various Model Assumptions	There are areas where the model calibration was impacted by lack of data and/or gaps in the hydrogeological understanding, specifically in the Ejarno Spring area. There is limited data available on the base elevation of the Superficial aquifer and its connectivity with the Yarragadee in the Ejarno Spring area. To address this data gap conservative assumptions were made by discounting the potential presence of perched groundwater or the presence of lower permeability layers preventing the upward flow of groundwater from the Yarragadee into the Superficial layers. In the current numerical model, each hydrogeological unit was assigned a uniform hydraulic conductivity. However, the hydraulic conductivity can vary significantly across individual hydrogeological units. At the local scale the match between observed and simulated water levels in available monitoring bores suggests that the model is sufficiently representative of local conditions.
3a	Model domain set-up	The numerical model domain is based on the two major aquifers and extends to the Irwin River in the north and northeast, follows the surface catchment divide in the east and Indian Ocean coast in the west (Attachment 1; Figure 1, with details in Figure 2 and 3). The southern boundary of the model is arbitrary in absence of any hydrologically relevant features. The model was vertically split into four layers, with two base layers representing the Yarragadee overlain by a thin clay-rich layer observed at the base of the Superficial formation and the overlying Superficial formation. Layer 1 (top layer) is divided into 'alluvial' unit that also includes the Ejarno Spring and Tamala Limestone of the Superficial Formations. The Yarragadee is assumed to subcrop to the east of the WGP2 area (Attachment 1; Figure 5). The base of layer 1 was derived from previous studies (Attachment 1; Figure 6). The bases of layers 2 to 4 were derived by applying uniform thicknesses of 2 m, 50 m and 100 m, respectively. The model does not represent the full thickness of

[2] Since the previous revision of this Water Management Plan four abstraction bores, including two temporary construction bores and two permanent abstraction bores, were commissioned, as planned.

Number	Assumptions and Uncertainties	Comment
		Yarragadee since only the top part of the aquifer is relevant for this assessment.
3b	Boundary conditions	The model domain is bounded in the north and northeast by RIV boundary, representing the Irwin River in the top model layer. The eastern boundary in layers representing the Yarragadee are CHD (fixed head or water level) simulating regional groundwater throughflow. Head information taken from GARAMS and Rockwater (2015). The southern boundary is considered 'no flow' as it is aligned in the generally east to west direction of groundwater flow with no additional inputs expected along this boundary. The western boundary is a general head boundary (GHB) with set level of 0.3 m AHD representing the ocean. The locations of the boundary conditions are presented in Attachment 1; Figure 7.
3c	Aquifer parameters	The initial aquifer parameters assigned to the model hydrogeological zones were sourced from GARAMS (2011) and DoW (2017). Some modifications to these parameters were made during the steady state and transient calibration to achieve a good fit between the observed and simulated groundwater levels.
3d	Recharge rates / volumes	The initial aquifer parameters assigned to the model hydrogeological zones were sourced from GARAMS (2011) and DoW (2017). Some modifications to these parameters were made during the steady state and transient calibration to achieve a good fit between the observed and simulated groundwater levels. The recharge estimate was obtained from regional studies and set at 55 mm/year. This was uniformly applied across the model domain.
3e	Abstraction volumes from other groundwater users	Groundwater abstractions within the model domain (more than 60 kL/yr) were assigned to the current licenced groundwater allocation rate collected from DWER databases, with one exception, the 3.5M kL/yr for Tronox Management Pty Ltd, about 5 km southeast of the Development Envelope, which would have caused drawdown that has not being observed in the nearby monitoring bores.

3.4.5 Management Approach

MEPAU plans to implement outcome-based provisions under this Water Management Plan. The reason for this approach is that the outcome can be readily measured with clear thresholds set to enable a level of protection to be achieved.

3.4.6 Rationale for Choice of Provisions

The provisions proposed are based on the following rationale:

- Groundwater modelling indicates that a drawdown of groundwater is not expected to result in a significant impact to sensitive receptors within proximity of the WGP2 (i.e. a drawdown of 0.06 m in the Superficial aquifer at the western side of Ejarno Spring over five years);

- Establishment of an outcome-based provision is achievable, and monitoring of groundwater parameters provide a direct insight into any potential environmental impact arising from the WGP2;
- Expected changes in rainfall and recharge were accounted for in the model and conservatively set for 55 mm/year which would be expected to fluctuate from year to year; and
- The adaptive management framework enables for clear decisions regarding water abstraction to be made where any impacts may be observed. Where additional mitigation is implemented, the timeframe for mitigation to take effect is expected to be relatively short given the dynamic nature and throughflow of groundwater in the region.

4.0 WATER MANAGEMENT PLAN

An environmental objective has been developed to mitigate environmental impacts on water associated with the implementation of the WGP2. It identifies the environmental criteria that will be used to measure performance and the monitoring that will be undertaken in relation to these environmental criteria. Finally, it defines the response actions (trigger level and contingency actions) that will be undertaken if the environmental criteria are exceeded.

Table 4-1 details the environmental objective for this Water Management Plan.

It identifies the environmental criteria that will be used to measure performance and the monitoring that will be undertaken in relation to these environmental criteria. Finally, it defines the response actions (trigger level and contingency actions) that will be undertaken if the environmental criteria are exceeded.

Table 4-1 Environmental Objective

Potential Impact	Environmental Objective
Impact to Ejarno Springs from groundwater abstraction and groundwater quality from the WGP2.	Minimise and manage impacts from groundwater quality and groundwater level management on the major environmental values adjacent to the WGP, which includes other groundwater users and Ejarno Spring. Protection of these environmental sensitivities requires the depth to groundwater to be maintained so as to not significantly impact the hydrological regime and alter the ecosystem from groundwater abstraction activities.

Table 4-2 details the provisions of this Water Management Plan.

4.1 Water Management Plan Provisions

Table 4-2 identifies the legal provisions and outcome based provisions that MEPAU will implement to ensure that the environment outcomes are met during the implementation of the WGP2.

Table 4-2 Key Performance Environmental Criteria (Outcome Based)

<table>
<tr><th colspan="2">EPA Objective</th><th colspan="3">To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected</th></tr>
<tr><th>Phase</th><th>Environmental Criteria</th><th>Response Actions</th><th>Monitoring</th><th>Reporting</th></tr>
<tr><td rowspan="2">Construction and Operation</td><td>Trigger Criteria
Groundwater levels measured at monitoring locations in Table 4-5 exceed the following year-on-year variation values for any particular quarterly monitoring event[3]
• WGP MB1-D: 0.18m
• WGP MB1-S2: 0.17m
• ES MB1-S: 0.11m
Surface water levels measured at ES 1 exceed a year-on-year variation value of 0.15m, as applied to the established baseline range, for any particular quarterly monitoring event.
Threshold Criteria
Groundwater levels measured at monitoring locations in Table 4-5 exceed the following year-on-year variation values, as applied to the established baseline range, for two consecutive quarterly monitoring events and is likely to be project attributable:
• WGP MB1-D: 0.18m
• WGP MB1-S2: 0.17m
• ES MB1-S: 0.11m
Surface water levels at ES 1 exceed a year-on-year[5] variation value of 0.15m, as applied to the established baseline range, for two consecutive quarterly monitoring events and is likely to be project attributable.</td><td rowspan="2">Trigger Contingency Actions
• Undertake a thorough investigation to determine whether the changes observed are project attributable. Assessment to include comparison to data from the baseline period and other relevant sites, investigation of other non-WGP2 groundwater abstraction in the area, as well as regional groundwater patterns, both year-on-year and long-term;
• Re-examine monitoring results (QA/QC) to validate data. Re-monitor or undertake additional monitoring if required to determine likely causes of exceedances;
• Following investigation, document the most probable cause(s) for the observed exceedance;
• If the exceedance is likely to be project attributable, implement additional adaptive management response measures, as deemed appropriate, including additional monitoring. Re-assess monitoring results at next quarterly monitoring event to determine whether the threshold criteria may have been met;
• If the exceedance is unlikely to be project attributable, document justification and continue normal monitoring frequency to assess for any potential future exceedances.
Threshold Contingency Actions
Initiate implementation of contingency measures including:
• Re-examine monitoring results (QA/QC) to validate data. Re-monitor if required';
• Ground truth the monitoring results to validate findings of the assessment and identify any further causes of the exceedance. Where cause is identified during ground truthing and can be rectified, undertake action immediately. For actions which require alternate resources, schedule works to be undertaken as soon as possible;
• Cross reference groundwater monitoring results with most recent vegetation/surface water surveys to determine whether an impact can be identified;
• Where the threshold exceedance was not caused by construction or operation, resume standard monitoring frequency;
• Where the threshold exceedance can be attributed to the Proposal activities:
  ○ Implement adaptive management response (modified abstraction) management guidance within Section 5.0. This may include a reduction in abstraction volumes or sourcing water from other sources.
  ○ Once management actions have been completed, extend the monitoring program to include an additional recharge event to determine if groundwater quality and level values recover.
  ○ Continue to implement actions to remediate the exceedance until approval to cease has been given by the relevant regulator.</td><td rowspan="2">Refer to Table 4-5</td><td rowspan="2">Ministerial Conditions Annual Compliance Assessment Report (CAR)Reporting any exceedance of threshold criteria and contingency actions that have been implemented due to the exceedance of threshold criteria within 48 hours.</td></tr>
<tr><td>Trigger Criteria
Changes to groundwater and surface water quality at defined monitoring locations (Table 4-5) attributable to the Proposal exceed historical averages.
Threshold Criteria
Changes to groundwater and surface water quality at defined monitoring locations (Table 4-5) attributable to the Proposal exceed historical averages over two consecutive monitoring events</td></tr>
</table>

[3] Year-on-year variations refer to a comparison of the same quarter over two consecutive years. Variation values presented are based on systematic analysis of data from the monitoring of Ejarno Spring groundwater bores by an experienced, subject matter expert, including comparison with other Perth Basin reference sites and baseline data. Revised trigger levels are based on recommendations made by GEMEC Environmental Consultants per 'Report on Standing Water Level Trigger and Threshold Level Revision – Ejarno Spring, (GEMEC, 2022)'.

4.2 Monitoring

To clearly understand if the environmental criteria have been met or exceeded, MEPAU has (and will continue) to monitor ground and surface waters adjacent to the WGP. Specifically, the monitoring program will be used to:

- Establish historic groundwater levels and groundwater quality within proximity of Ejarno Spring (a GDE);
- Establish historic surface water quality within Ejarno Spring;
- Establish the floristic diversity and vegetation quality of Ejarno Spring; and
- Verify groundwater level and water quality trends during construction and operations do not significantly affect baseline levels.

4.2.1 Establish Historic Groundwater Level and Groundwater Quality

MEPAU maintains a Perth Basin Surveillance Sampling Program [PB-HSE-PRO-119], developed based on historical gas field results and legislative sampling requirements. Groundwater sampling is conducted in accordance with the requirements of AS/NZS 5667.11:1998 Water Quality – Sampling - Guidance on Sampling of Groundwaters. Specifically, the Perth Basin Surveillance Sampling Program includes the:

- Location of groundwater sampling bores; and
- Frequency and monitoring parameters at these locations.

Since the previous revision of this Water Management Plan, the groundwater monitoring program has been expanded to include a number of Superficial and Yarragadee aquifer monitoring bores located within the WGP, and between the WGP and Ejarno Spring. Although the Waitsia-02 AB shall no longer be actively used for monitoring potential impacts to Ejarno Spring (Section 3.4.1.5), this bore location has provided a suitable historic reference point to support the establishment of groundwater level and quality baseline data and shall continue to be monitored per the Perth Basin Surveillance Sampling Program (but not under this Water Management Plan).

Table 4-3 summarises the monitoring parameters for sites that have been used to inform baseline levels.

Table 4-3 Baseline Groundwater Monitoring

Infrastructure	Frequency	Number of Years	Monitoring Parameters
Waitsia-02 AB	Biannually	• 2015 • 2016	• TRH • BTEXN compounds • pH • Standing water level (SWL) • Electrical conductivity • Total Dissolved Solids (TDS) • Dissolved Metals • Cations • Anions • Alkalinity

Infrastructure	Frequency	Number of Years	Monitoring Parameters
			• Nutrients
	Annually	• 2017 • 2018 • 2019 • 2020 • 2021 • 2022	• TRH • BTEXN compounds • pH • SWL • Electrical conductivity • TDS • Dissolved Oxygen

4.2.2 Establish Historic Surface Water Quality Within Ejarno Spring

Surface water monitoring is conducted in accordance with the Perth Basin Surveillance Sampling Program [PB-HSE-PRO-119]. The surface water quality of Ejarno Spring is currently being monitored quarterly. Table 4-4 summarises the monitoring parameters for surface water at Ejarno Spring that have been used to inform baseline levels.

Table 4-4 Baseline Surface Water Monitoring (Ejarno Spring)

Infrastructure	Frequency	Number of Years	Monitoring Parameters
ES1 & ES2	Biannually	2015 2016	• TRH • BTEXN compounds • pH • Standing water level (SWL) • Electrical conductivity • TDS • Dissolved Metals • Cations • Anions • Alkalinity • Nutrients
	Annually	2017 2018 2019	• TRH • BTEXN compounds • pH • SWL • Electrical conductivity • TDS • Dissolved Oxygen
	Quarterly	2020 (From June) 2021 2022	• TRH • BTEXN compounds • pH • SWL • Electrical conductivity

Infrastructure	Frequency	Number of Years	Monitoring Parameters
			• TDS • Dissolved Oxygen

4.2.3 Establish the Floristic Diversity and Vegetation Quality of Ejarno Spring

In November 2020, and prior to the commencement of construction, MEPAU completed a detailed flora and vegetation survey of Ejarno Spring with the purpose of establishing the floristic diversity and quality of vegetation associated with the GDE. Following the survey, the 'Ejarno Springs Study Area Reconnaissance Survey and GDV Assessment' Report (Umwelt 2021) was produced that provides a baseline level to which future studies, potentially triggered by exceeding threshold criteria, can be compared and analysed. The purpose of this analysis is to establish if changes in water level or quality, attributable to the Proposal, have impacted on the diversity and quality of Ejarno Spring.

4.2.4 Understand Groundwater Level and Water Quality Trends During Construction and Operations

Since the latest revision to this Water Management Plan a series of Superficial and Yarragadee aquifer monitoring bores have been installed between the WGP and Ejarno Spring and at the WGP. In addition, a surface water sampling location has been established at Ejarno Spring The monitoring bores between Ejarno Spring and the WGP have been fitted with data loggers to provide a continuous understanding of groundwater level for the duration of baseline monitoring. Two Superficial aquifer monitoring bores have also been installed at the WGP.

Water samples will be collected quarterly to further inform baseline water quality for the WGP2. Groundwater levels and water quality results from pre-construction samples will be averaged and the trigger and threshold criteria in this Water Management Plan updated accordingly.

Further to this, monitoring during the construction phase of the WGP2, will continue to be utilised to understand trends and inform more frequent review of trigger and threshold criteria. It is expected that following the completion of construction, the volume of water abstracted will reduce, thus MEPAU plans to reduce the frequency of monitoring events if no significant changes to baseline levels are identified during construction.

The proposed monitoring program during construction and operations is presented in Table 4-5.

Table 4-5 Monitoring Program

Type	Sampling location	Phase	Frequency	Monitoring Parameters
Groundwater	• Waitsia-02 AB (baseline only) • Ejarno Spring (ES MB1-S) • Between the WGP and Ejarno Spring (WGP MB1-S2 and WGP MB1-D)	All Phases	Quarterly	• Water Level
		Baseline	Quarterly	• TRH • BTEXN compounds • pH • Electrical conductivity • TDS • Dissolved Oxygen

Type	Sampling location	Phase	Frequency	Monitoring Parameters
		Construction	Quarterly	• TRH • BTEXN compounds • pH • Electrical conductivity • TDS • Dissolved Oxygen • Water Level
		Operations / Ongoing	Annually[4]	
Surface Water	• Ejarno Spring (ES1 and ES2)	Construction	Quarterly	• TRH • BTEX compounds; • pH • SWL; • Electrical conductivity; • TDS • Dissolved Oxygen .
		Operations	Annually[3]	
Ejarno Spring floristic diversity and vegetation condition	• Ejarno Spring	Construction	One-off	• Baseline vegetation condition report that details vegetation quality and diversity prior to the Proposal commencing
			Ad-hoc	• As triggered by exceedance of threshold criteria
		Operations	Ad-hoc	• As triggered by exceedance of threshold criteria

4.3 Reporting

The environmental outcome will be reported against Trigger and Threshold criteria (Table 4-2) for each calendar year in the Annual CAR for the Proposal.

The CAR will also include a summary of analysis of monitoring data to facilitate adaptive management.

In the event that trigger and threshold criteria are exceeded during the reporting period, the annual report will include a description of the effectiveness of any management contingency actions that have been implemented to manage the impact.

[4] Following the completion of construction activities and submission of reports to DWER, MEPAU plan to reduce the frequency of the monitoring program to be commensurate with the level of impact and risk and be undertaken annually.

5.0 ADAPTIVE MANAGEMENT AND REVIEW OF THIS PLAN

5.1 Monitoring and Adaptive Management

A monitoring program is required to measure the effectiveness of the management actions as defined in this Water Management Plan. The outcomes of the monitoring program will contribute to ongoing improvements in management actions to ensure an adaptive management approach is adopted.

MEPAU will implement adaptive management to learn from the implementation of mitigation measures, monitoring and evaluation against trigger and threshold criteria, to more effectively meet the conditioned environmental outcome.

The following approaches will apply:

- Monitoring data will be systematically evaluated and compared to baseline;
- The effectiveness and relevance of trigger level and threshold contingency actions will be evaluated on an annual basis to determine if any changes to management actions are required; and
- Increased understanding of the hydrogeological regimes based on additional internal and external studies will be incorporated into the monitoring and management approach when newer relevant information becomes available where applicable.

Adaptive management practices that will be assessed as part of this approach may include:

- Evaluation of the monitoring program, data and comparison to baseline data and reference sites on an annual basis to verify whether responses to project activities are the same or similar to predictions;
- Evaluation of assumptions and uncertainties of the management and monitoring program;
- Re-evaluation of the risk assessment and revision of risk-based priorities as a result of monitoring outcomes;
- Review of data and information gathered over the review period that has increased understanding of site environment in the context of the regional ecosystem; and
- Assessment of changes which are outside the control of the project and the management measures identified (i.e. a new project within the area or region; regional change affecting management).

5.2 Management Plan Review

This Water Management Plan is intended to be dynamic and may be updated to reflect changes in management practices and the natural environment over time. This approach will allow flexibility to adopt new approaches/management measures. The effectiveness and relevance of trigger level and threshold contingency actions will be evaluated on an as needs basis, and any amendments to management actions will be made accordingly. This will include:

- Amendment of management actions that are not achieving the desired outcomes;
- Monitoring that identifies additional impacts requiring additional management actions or changes to existing management actions;

- Changes to relevant legislation that may affect the implementation of management actions;
- Improvements to management practices to achieve a greater environmental outcome; and
- Updates to trigger and threshold criteria following the completion of baseline sample collection prior to commencing any groundwater abstraction.

6.0 STAKEHOLDER ENGAGEMENT

Consistent with the EPA's expectations for this Water Management Plan to align with the principles of EIA, MEPAU consulted with stakeholders, including but not limited to DWER during the development of the EPA referral. For a full summary of stakeholder engagement records refer to MEPAU, 2019.

Any additional consultation regarding this Water Management Plan will be captured in subsequent revisions.

7.0 PUBLIC AVAILABILITY

A copy of this Water Management Plan is available on the MEPAU website. As per MEPAU's Compliance Assessment Plan [WAT-HSE-PLN-00004], this Water Management Plan and any associated validated environmental data shall be made available to members of the public within 7 days of MEPAU receiving such a request.

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ATTACHMENTS

ATTACHMENT 1

WAITSIA GAS PROJECT GROUNDWATER ASSESSMENT (2020)

Mitsui E&P Australia Pty Ltd

Waitsia Gas Project Groundwater Assessment

February 2020

Executive summary

GHD Pty Ltd (GHD) was commissioned by Mitsui E&P Australia Pty Ltd (Mitsui) to undertake a groundwater impact assessment of the proposed groundwater abstraction for Stage 2 of the Waitsia Gas Project.

The proposed project comprises a conventional gas plant located approximately 16 km east-south-east of Dongara in Western Australia and proposes abstraction of groundwater for use during the construction and operational phases. The water demand for the Project has been estimated by Mitsui to be 60,000 cubic meters (m^3) per annum (1.9 litres/second) which is to be sourced from the underlying Yarragadee aquifer, through installation of up to four new abstraction bores within the proposed area of the Waitsia Gas Plant.

The Mitsui submission included a water management plan (WMP) which aimed to identify the potential impacts on water systems and develop management and monitoring measures that protect the existing systems. The WMP identified that key environmental values were the neighbouring groundwater dependent ecosystem (GDE), referred to as Ejarno Spring, and other licensed groundwater users.

To assess the potential impact of the proposed Waitsia Gas Plant abstraction on the GDE and licensed groundwater users, GHD developed a groundwater model to assess the reduction in groundwater levels (drawdown). To achieve this the following steps were undertaken: hydrogeological conceptualisation, model construction, calibration and running predictive scenarios, with basic uncertainty analysis.

The model used for this assessment was constructed in MODFLOW-USG software and built on learnings from previous hydrogeological assessments and investigations including the development of the regional groundwater model (GARAMS). The two-aquifer model (Superficial and Yarragadee aquifers) covers an area of 460 km^2 surrounding the proposed Gas Plant area. Due to the hydrogeological data available, a level of conservatism was applied when constructing the model. The model was calibrated to local groundwater level records over a 10 year period (2011 to 2019) and calibration results suggest that the model adequately represents the local hydrogeological conditions and is considered appropriate for the purpose of the impact assessment.

Groundwater abstraction from the Yarragadee aquifer in the gas plant area was modelled at a rate of 2 L/s for the period of five years. The model results indicate a very minor reduction in groundwater levels which would represent up to 6 cm drawdown in the Ejarno Spring area (GDE) in the Superficial aquifer and 15 cm in the confined Yarragadee aquifer. Third party groundwater users are not considered to be affected by the proposed abstraction at the Waitsia gas plant.

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1. Introduction

1.1 Background

GHD Pty Ltd (GHD) was commissioned by Mitsui E&P Australia Pty Ltd (Mitsui) to undertake a groundwater impact assessment of the proposed groundwater abstraction for Stage 2 of the Waitsia Gas Project (referred to as the Project).

The proposed Project comprises a conventional gas plant located approximately 16 km east-south-east of Dongara in Western Australia (Figure 1). The Project proposes abstraction of groundwater for use during the construction and operational phases. The water demand for the Project has been estimated by Mitsui to be 60,000 cubic meters (m^3) per annum (1.9 litres/second) which is proposed to be sourced from the underlying Yarragadee aquifer. The Project proposes the installation of up to four new abstraction bores within the proposed area of the Waitsia Gas Plant.

Mitsui referred the Project to the Environmental Protection Authority (EPA) under Part IV of the Environmental Protection Act 1986 in August 2019. The EPA decided to assess the Project as a significant proposal, through Assessment of Referral Information.

The Mitsui submission included a water management plan (WMP) which aimed to identify the potential impacts on water systems and develop management and monitoring measures that protect the existing systems. The WMP identified that key environmental values were the neighbouring groundwater dependent ecosystem (GDE), referred to as Ejarno Spring, and other licensed groundwater users. The WMP included a conservative assessment of potential drawdown in groundwater levels using the Theis-equation, which is an analytical solution for calculation of well drawdown for a confined aquifer. The assessment suggested a water level drawdown was estimated in the order of 0.22 m at approximately 500 m from the extraction point following 5 years of abstraction.

GHD understands that following a review of the WMP submitted in December 2019, the EPA requested additional information including undertaking modelling of the impact of groundwater abstraction.

In fulfilment of the project scope GHD developed a simple but robust groundwater model for drawdown estimation purposes including the following steps: hydrogeological conceptualisation, model construction, calibration and running predictive scenarios, with uncertainty analysis.

1.2 Objectives

The objective of this scope of work is to carry out numerical groundwater modelling to estimate the likely drawdown of the proposed abstraction on groundwater levels, in order to assess the potential impact of proposed abstraction on:

1. Ejarno Spring
2. Existing groundwater users

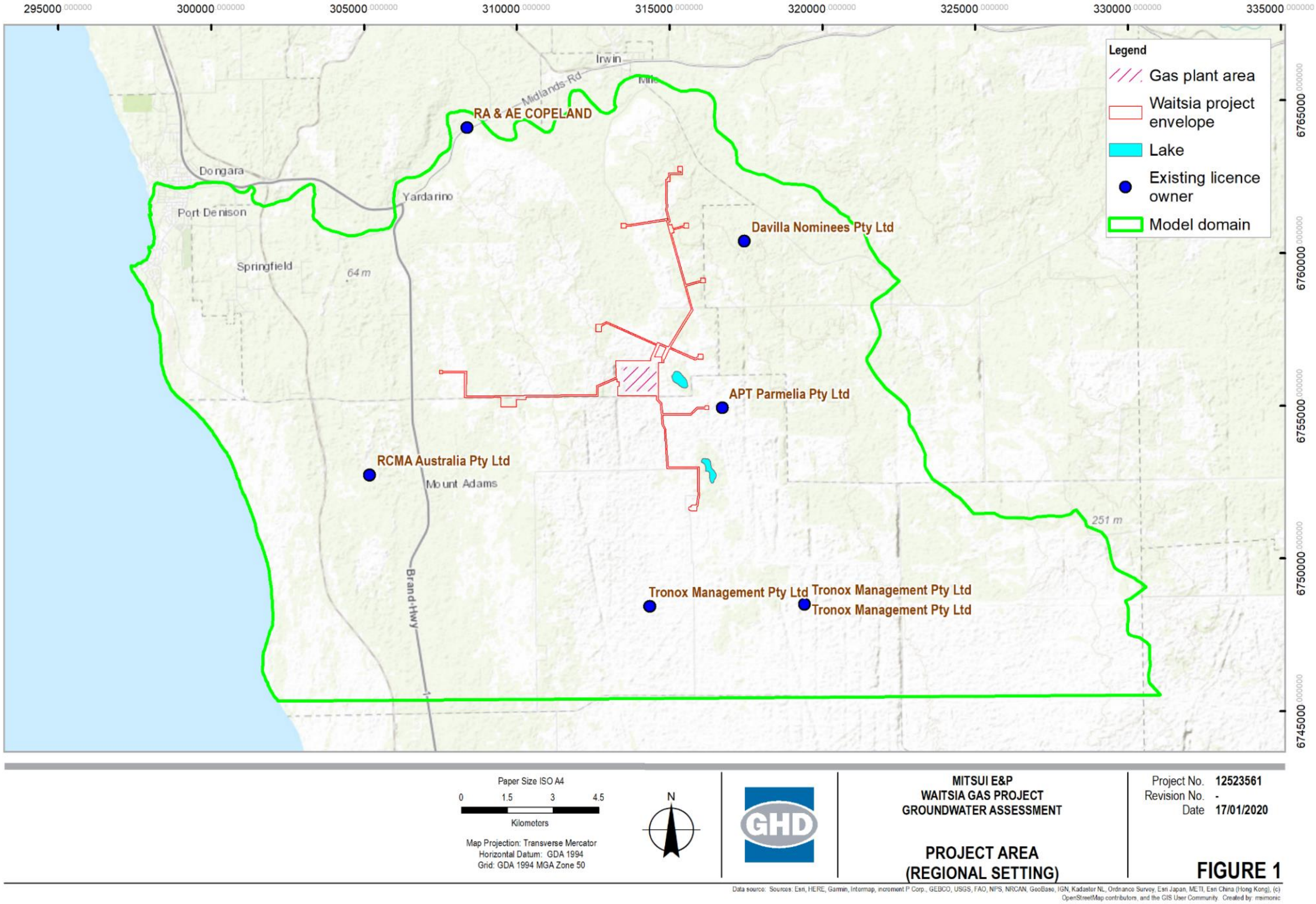

Figure 1-1 Project area (regional setting)

2. Review of Hydrogeological Conceptualisation

2.1 Desktop Review

A review of key information and available reports was carried out to formulate an understanding of the hydrogeology and establish the key aspects of the hydrogeological conceptualisation of the site.

The reports reviewed are presented in Table 2-1 and include aquifer reviews conducted for AWE, and regional modelling reports developed for the region, in particular the GARAMS (Gingin Arrowsmith Regional Aquifer Modelling System) model which was developed by GHD (2011) for Department of Water (now Department of Water and Environmental Regulation, the DWER), for the management of groundwater at a regional scale.

DWER also prepared an update of the hydrogeological conceptualisation of the region in 2017, based on new drilling and testing information.

Table 2-1 Information sources used for review

Document title	Author and date
Report for Gingin Arrowsmith Regional Aquifer Modelling System (GARAMS)	GHD, 2011
Hydrogeological Assessment of the Waitsia Reservoir Drilling Programme	Rockwater Hydrogeological & Environmental Consultants (2015)
The Hydrogeology of Groundwater Dependent Ecosystems in the Northern Perth Basin	Department of Environment (Now DWER) (2015)
Surface Water & Groundwater Monitoring Event Report - Waitsia 02 Location	GEMEC Environmental Consultants (2015)
Waitsia Gas Project Surveillance Monitoring Program - Senecio-03, Waitsia-01 & Waitsia-02 Well Sites	GEMEC Environmental Consultants (2016)
Northern Perth Basin: Geology, Hydrogeology and Groundwater Resources	DoW (2017)
Summary of Baseline Soil & Groundwater Assessments - Waitsia-04 Location	GEMEC Environmental Consultants (2018)
Annual Water Monitoring Report July to June 2018	Mitsui E&P Australia (2018)
Groundwater & Surface Water Monitoring Event Report - September 2019	GEMEC Environmental Consultants (2019)
Geology of the Mingenew-Dongara 1:100 000 Sheet. Western Australia Geological Survey, 1:100 000 Geological Series Explanatory Notes	Mory, AJ (1995)

The conceptual hydrogeological model of Waitsia Project site takes into account rainfall recharge, evaporation, drainage, abstraction and the interaction between the two major aquifers. The conceptual model was developed using regional information, as listed in Table 2-1.

2.2 Project Area Description

The project area centres on a proposed conventional gas plant located approximately 16 km east-south-east of Dongara in Western Australia (Figure 1), in a broader area of existing agricultural activities and oil and gas development. The region encompassing the site and used in this assessment is bound to the north and partly east by the Irwin River course, the Indian Ocean to the west, while to the south it is arbitrarily delineated by a line perpendicular to the ocean, 10 km distal to the site (Figure 1).

The gas plant area is located in a topographic depression or valley, between two ridges running in a north-north-west direction towards the Irwin River (Figure 2-2). The lowest ground elevation in the plant area is approximately 32 m AHD, with adjacent ridges reaching to over 120 m AHD.

The area is situated within the Irwin River catchment. The Irwin River flows at a distance of approximately 8 km to the northeast and north of the proposed gas plant. There are several recognised groundwater dependent ecosystems (GDEs) in the region including the Ejarno Spring (situated 500 m east of the gas plant area) and Yardanogo Nature Reserve (6 km south).

2.3 Rainfall and Evapotranspiration

The project area has a subtropical Mediterranean type climate with hot dry summers and mild wet winters. The average annual rainfall is approximately 400 mm (data from the closest Bureau of Meteorology station, Mingenew 008088) and occurs mainly between May and September (Figure 2-1). There is a strong rainfall gradient with rainfall decreasing with distance from the coast, so it is likely that rainfall at the site might be slightly higher based on its proximity to the coast.

Annual evaporation and evapotranspiration sums are approximately 2200 mm and 550 mm, respectively.

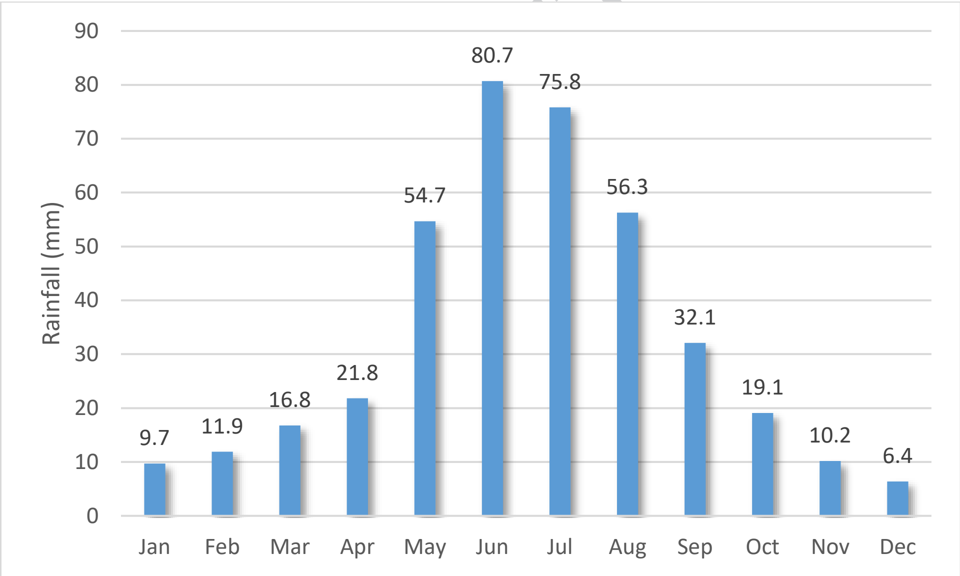

Figure 2-1 Mean rainfall for Mingenew (station 008088, source: BOM)

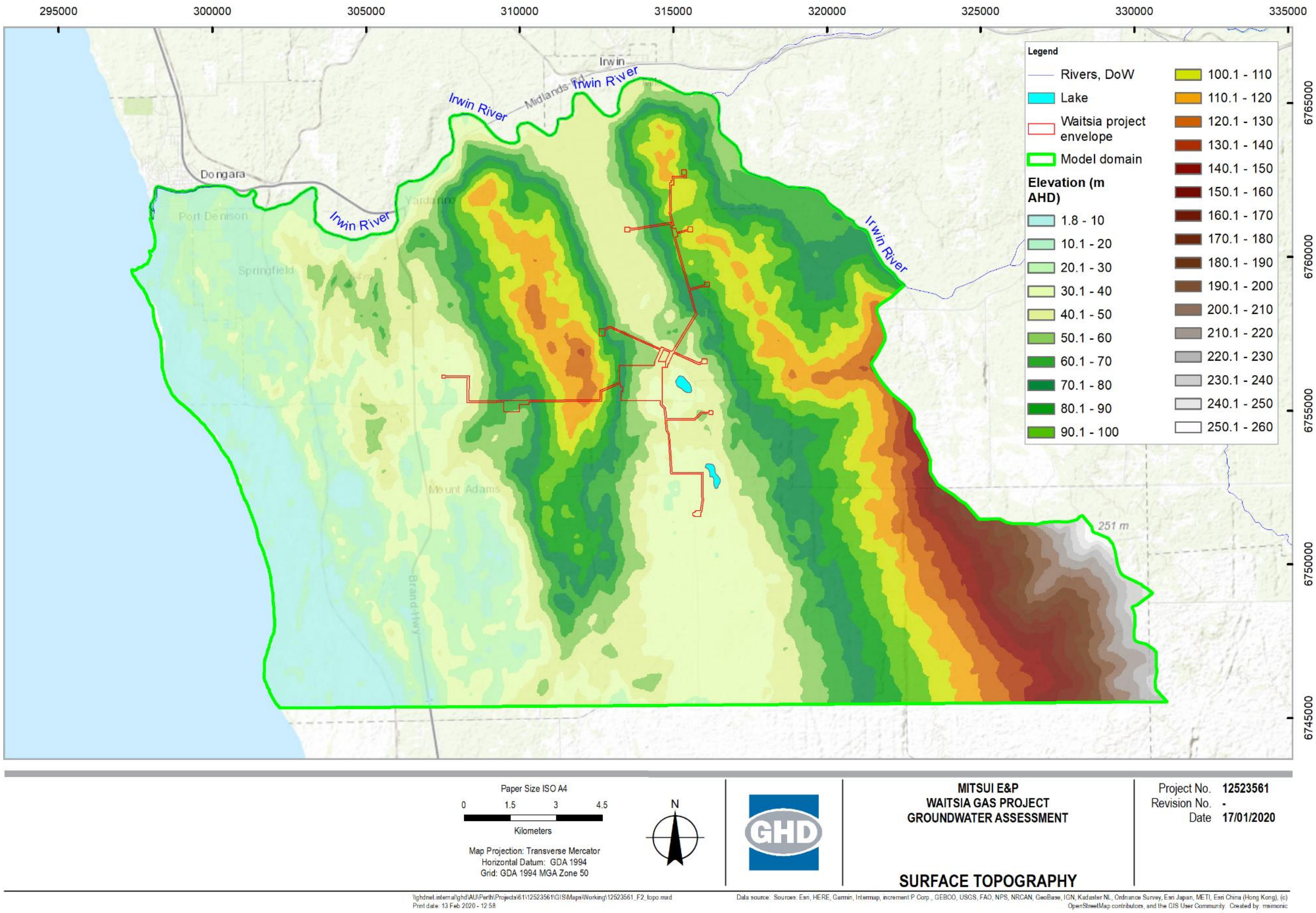

Figure 2-2 Surface topography

2.4 Hydrogeology

The Project site is situated in the North Perth Basin region which is geologically and hydrogeologically complex at a regional scale. The site conceptual hydrogeological model, comprises simplified geology and hydrogeology and a representation of major hydraulic processes within the model area.

In the project area the groundwater system comprises predominantly unconfined Superficial formations overlying the Yarragadee Aquifer. Superficial formations overlying the Yarragadee include alluvium, Tamala Limestone, Bassendean Sand, lateritic weathering residues and colluvium (Figure 2-4). These may be in direct hydraulic connection with the Yarragadee aquifer however some perched layers are known to exist in the area (DoW, 2017).

The main regional aquifer beneath the Waitsia Gas Field is the Yarragadee, which has the following characteristics in the Waitsia Reservoir area:

- composed of shale, siltstone and sandstone (Rockwater, 2015);
- standing water levels (SWLs) vary from 75 m Australian height datum (m AHD) to 15 m AHD, corresponding to 0 to 100 metres below ground surface (m bgs), depending on site topography;
- hydraulic gradient is broadly west-southwest toward the Indian Ocean (DoW, 2017);
- salinity is typically fresh to marginal near the surface and increases to brackish with depth.

The Yarragadee aquifer is overlain by Superficial formations in the site area, 18 to 20 m thick, with a less permeable unit at their base (possibly an equivalent of Becher Unit).

A review of groundwater levels in the Mitsui bores screened in the Yarragadee aquifer around the Project site, suggests that the aquifer is likely to be confined or partially confined, with upward component of groundwater flow in the Yarragadee aquifer.

Monitored groundwater levels in the region surrounding the project site indicate predominantly stable trends, suggesting that the groundwater system is in dynamic equilibrium. Seasonal variations in recorded water levels are observed within a 2 metre amplitude around a stable trend.

2.5 Groundwater Recharge

Groundwater recharge into the Yarragadee aquifers occurs by direct rainfall (in outcrops) as well as downward leakage from overlying aquifers i.e. the Superficial formations. In the area around the project site recharge is likely to be affected by:

- concentrated surface water infiltration within the river valleys, for example, the Irwin River system to the north that receives runoff from its catchment,
- restricted by clayey lithologies resulting in elevated groundwater salinity in the upper portion of the aquifer (Commander, 1981)
- alluvial depressions such as the one encountered to the east of the project site.

Localised siltstone and shale beds may support perched water table conditions in some areas. Low permeability lacustrine sediments are present in topographic depressions and result in the ponding of water in features such as the Ejarno Spring and the northern end of the Zeus Wetland to the south of the Ejarno Spring.

2.6 Groundwater Discharge

Groundwater discharges from the Yarragadee aquifer are likely to be via upward groundwater flow into the Superficial aquifer and potentially express at the ground surface, as is possibly occurring in the Ejarno Spring area. Other discharges from the Yarragadee aquifer enters portions of the Irwin River and offshore into the Indian Ocean (DoW, 2017).

2.7 Groundwater Use

Groundwater is also used for licensed and unlicensed abstraction. The latter is likely to include domestic and stock watering which extract relatively minor volumes of groundwater from the Superficial formation.

Abstraction of groundwater from the Yarragadee aquifer is licensed within the region and groundwater licences have been granted up to 3,500,000 kL/yr (Table 2-2). Abstraction licences with more than 60,000 kL/yr in proximity to the site are shown in Figure 1. The points of abstraction licences represent the centre of the lot that the abstraction licence is associated with and does not represent the actual abstraction location.

Table 2-2 Summary of groundwater abstraction licences

Number	Issue date	Expiry date	Allocation	Owner
109604	30/07/2015	29/07/2025	600,000 KL	RA & AE COPELAND
151360	15/01/2015	15/01/2025	500 KL	AWE Perth Pty Ltd
155141	25/06/2019	17/09/2023	20,600 KL	Lattice Energy Limited
161322	15/01/2015	15/01/2025	18,000 KL	AWE Perth Pty Ltd
161951	31/01/2017	30/01/2027	1,000 KL	AWE Perth Pty Ltd
162324	14/08/2014	14/08/2024	3,500,000 KL	Tronox Management Pty Ltd
162349	14/08/2014	14/08/2024	1,000,000 KL	Tronox Management Pty Ltd
171038	13/08/2013	13/08/2023	55,000 KL	APT Parmelia Pty Ltd
173435	8/02/2017	31/03/2024	18,500 KL	AWE Perth Pty Ltd
174989	14/08/2014	14/08/2024	2,000,000 KL	Tronox Management Pty Ltd
180269	15/01/2015	15/01/2025	3,000 KL	AWE Perth Pty Ltd
181277	30/07/2015	29/07/2025	10,000 KL	AWE (WA) Investment Company Pty Ltd
182409	17/12/2018	16/12/2028	99,300 KL	Davilla Nominees Pty Ltd
183759	18/01/2017	18/01/2022	3,500 KL	AWE Perth Pty Ltd
202619	28/03/2019	20/06/2025	12,800 KL	RCMA Australia Pty Ltd
202801	28/05/2019	27/05/2029	450,000 KL	RCMA Australia Pty Ltd

The closest regulated groundwater area, the Allanooka-Dongara Water Reserve, is located 16 km to the north from the project area. The reserve is listed as a ‘Priority One’ Public Drinking Water Source protection area but is unlikely within the influence of the Project activities.

2.8 Groundwater Dependent Ecosystems

The site is situated next to an alluvial depression (to the east of the Project site) which features surface expression of groundwater known as Ejarno Spring which is classified as a groundwater dependent ecosystem (GDE) otherwise referred to as the 6 Mile Swamp (GEMEC, 2019).

Similar features also occur further away to the southeast of the Project site in southbound continuation of the topographic depression and are known as the Zeus Wetland. They form part of the Beharra Spring consanguineous wetland suite which consists of a relict palaeo-lake system blanketed by Bassendean Sands forming dampland of irregular morphology (Strategen, 2012 in GEMEC, 2019). The hydrological connectivity between the Zeus wetlands and the underlying surficial aquifer varies between unconfined to perched (Strategen, 2012). The vegetation in and surrounding the Zeus wetland transitions from wetland to dryland vegetation and is considered to be partially dependent on groundwater, either as a perched water table or the surficial aquifer water table (Strategen, 2012). The Zeus Wetland is ephemeral.

Other GDEs in the area include (Figure 2-4):

- the Yardanogo Nature Reserve (2.5 km south of the gas plant area)
- Beekeepers Nature Reserve (10 km west of the gas plant area) along the coast
- Crown Reserves 27935 and 43543 (14 to 15 km ENE of the gas plant area) along the Irwin River

2.9 Conceptualisation Summary and Limitations

Groundwater flow at the site and in its immediate vicinity, especially in relation to the Ejarno Spring next to the Project site, is characterised by the following main features:

- Two main aquifers form the shallow aquifer system at the site, the shallower and unconfined Superficial aquifer overlying the top of the regionally extensive Yarragadee and largely confined aquifer. Their connectivity may be affected by the presence of a less permeable layer at the base of Superficial aquifer.
- Groundwater flow directions are generally towards the ocean, in the westerly to south-westerly direction. Groundwater levels show stable trends with only minor variations related to the seasonal cycle.
- There is a head difference between the Superficial and Yarragadee aquifers suggesting an upward component of groundwater flow at the Project site and in the area of the Ejarno Spring
- The Ejarno Spring has developed in the area of a topographic low and likely to be a combination of groundwater expression and rainfall/ surface water runoff ponding on the less permeable surface.
- Groundwater recharge consists of two main components, the direct diffuse rainfall and focused (river) recharge replenishing the Superficial aquifer and the lateral inflow from the regional system (from the east) in the Yarragadee aquifer.
- Groundwater eventually discharges from the aquifer system by outflow to the ocean, evapotranspiration in the topographic depressions or areas with shallow groundwater and potential discharge into the river system (Irwin River).
- Groundwater is extracted from the aquifer system and may include unlicensed extraction from the Superficial aquifer and licensed and regulated abstraction from the Yarragadee aquifer.

The hydrogeological conceptualisation summary for the Project site and the Ejarno Spring is depicted in Figure 2-3.

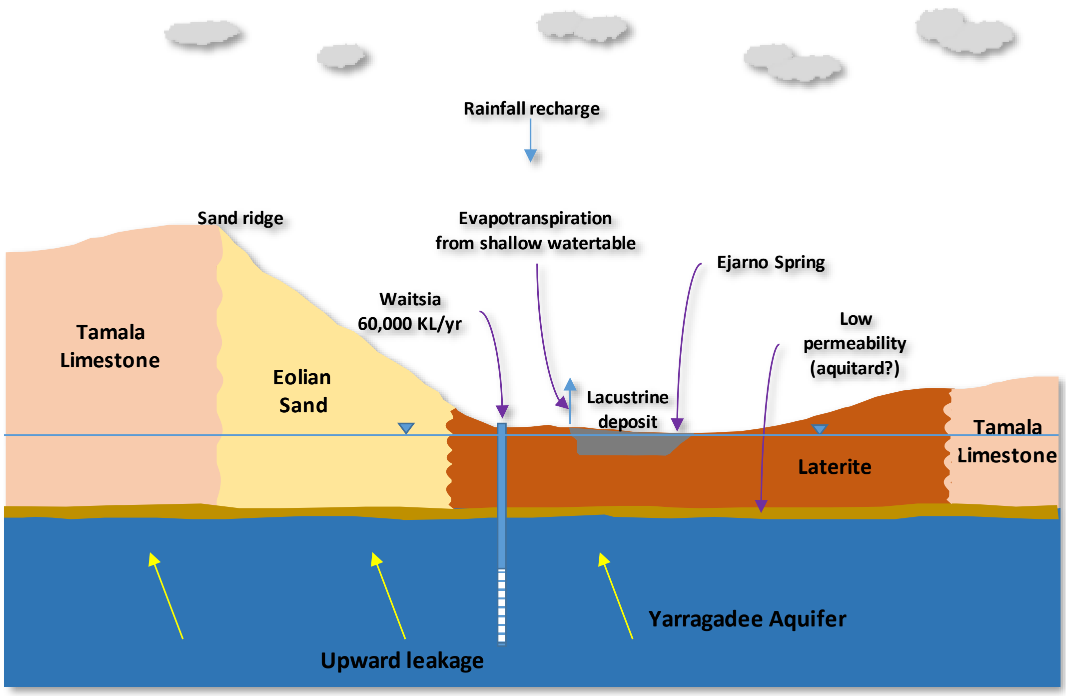

Figure 2-3 Conceptual section across the project area and Ejarno Spring

The geological details at the Project Site and Ejarno Spring are interpreted from regional geological information and bore logs around the Project site as there has been no hydrogeological drilling in the spring area.

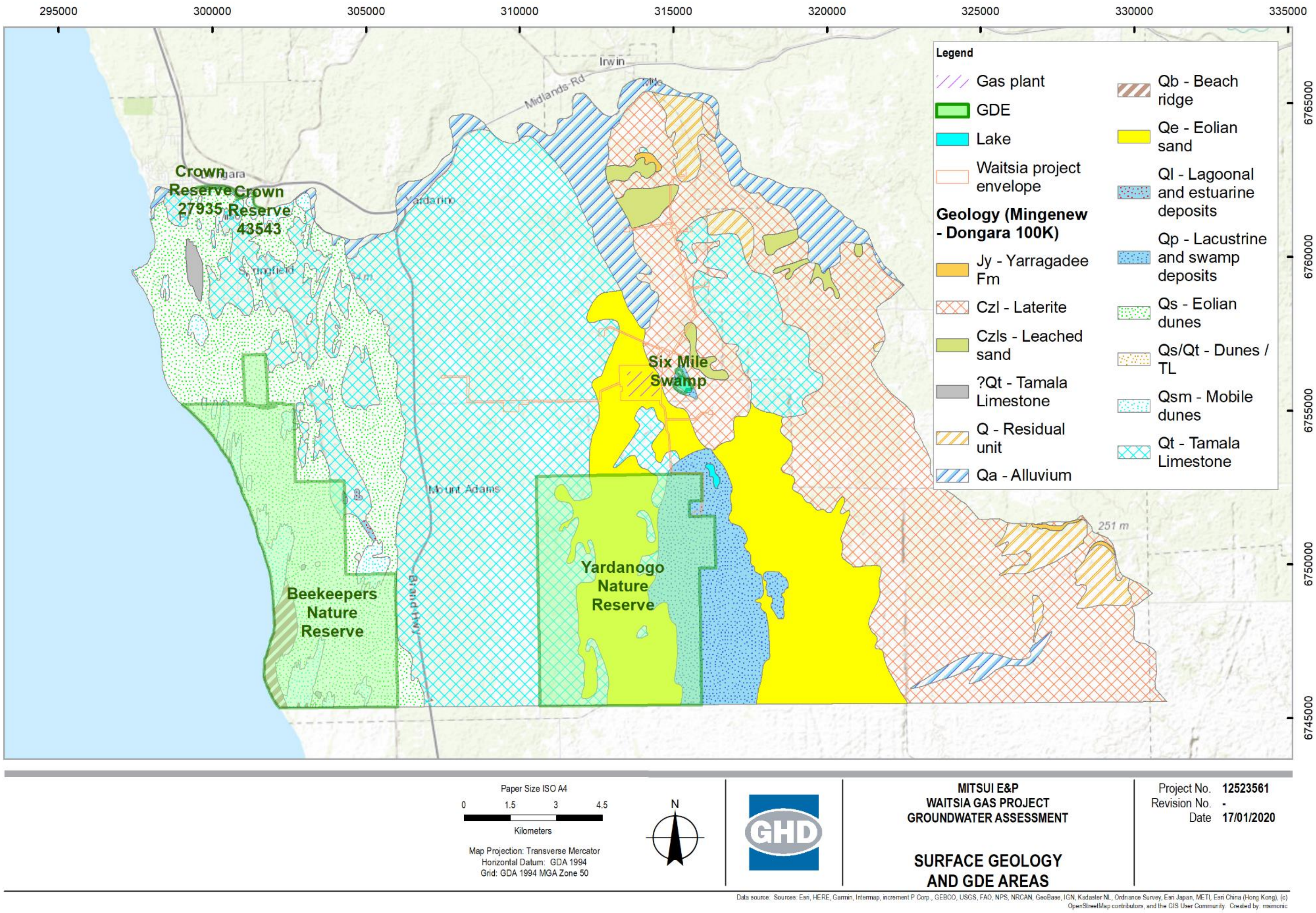

Figure 2-4 Surface geology and GDE mapping

3. Numerical Modelling

3.1 Model Construction

The numerical model was developed to simulate groundwater flow at a subregional scale, based on the conceptual hydrogeological model described in Section 2. Data and maps from the previous hydrogeological investigations were reviewed and captured using GIS and modelling tools. Groundwater level and abstraction data was collected from the DoW databases. The numerical model was constructed using MODFLOW-USG software which allows for efficient grid refinement in the area of interest (Figure 3-1).

The model comprises the following components and approaches:

3.1.1 Model Domain and Spatial Discretisation

In alignment with hydrogeological conceptualisation, the numerical model domain comprises the two major aquifers, and extends to the Irwin River in the north and north east, follows the surface catchment divide in the east and Indian Ocean coast to the west. The southern boundary of the model is arbitrary in absence of any hydrologically relevant features.

The model was vertically discretised into four layers:

- two base layers (Layer 3 and 4) representing the **Yarragadee Aquifer**
- Yarragadee aquifer overlain by a thin **clay-rich layer** (Layer 2) observed at the base of Superficial Formation and the overlying Superficial Formation.
- Layer 1 (top layer) representing the **Superficial formations**, divided into an 'alluvial' unit (that includes the Ejarno Spring) and Tamala Limestone. It also includes, to the east of the site, the subcropping Yarragadee aquifer (Figure 3-2) since the Superficial formations may be thin and largely unsaturated.

The layer elevations were implemented as follows:

- The base of layer 1 was derived from previous studies (Figure 3-3).
- The bases of layers 2 to 4 were derived by applying uniform thicknesses of 2 m, 50 m and 100 m, respectively.
- The model does not represent the full thickness of Yarragadee aquifer since only the top section of the formation is required for this assessment.

An example of the model layer setup in a W-E section across the project and Ejarno Spring area is presented in Figure 3-4.

3.1.2 Boundary Conditions

The boundary conditions implemented in the numerical model are as follows:

- The model domain is bounded in the north and north east by MODFLOW RIV boundary, representing the Irwin River in the top model layer (Layer 1).
- The eastern boundary in layers representing the Yarragadee aquifer (Layer 3 and 4) are CHD (fixed head or water level) simulating regional groundwater throughflow. Head information for this boundary was taken from GARAMS and Rockwater (2015).
- The southern boundary is considered 'no flow' as is aligned in the generally east to west direction of groundwater flow with no additional flow inputs expected along this boundary.

- The western boundary is a general head boundary (GHB) with set level of 0.3 m AHD representing the ocean. The setup and locations of the boundary conditions are presented in Figure 3-1.

3.1.3 Aquifer parameters

The initial aquifer parameters assigned to the model hydrogeological zones were sourced from GARAMS (2011) and DoW (2017). Some modifications to these parameters were made during the steady state and transient calibration to achieve a better fit between the observed and simulated groundwater levels.

3.1.4 Recharge

The recharge rate estimate implemented in the model was obtained from regional studies (and set at 55 mm/year (e.g. DOW, 2017). For the purposes of this assessment this estimate was uniformly applied across the model domain.

Since the water level observations in the area show a consistently stable trend, temporal variations in the recharge rate were not considered necessary for the purposes of this assessment.

3.1.5 Abstraction

Groundwater abstractions were represented within the model domain (in locations shown in Figure 1) for annual rates greater than 60 kL/yr, based on the current licenced groundwater allocation rate specified in the DWER databases.

A review of groundwater levels in the area suggested that there has been no substantial abstraction associated with the Tronox abstraction licence (3.5M kL/yr), as there is no evidence of drawdown that would be expected with this abstraction volume. Therefore, the Tronox licenced abstraction was not represented in the model.

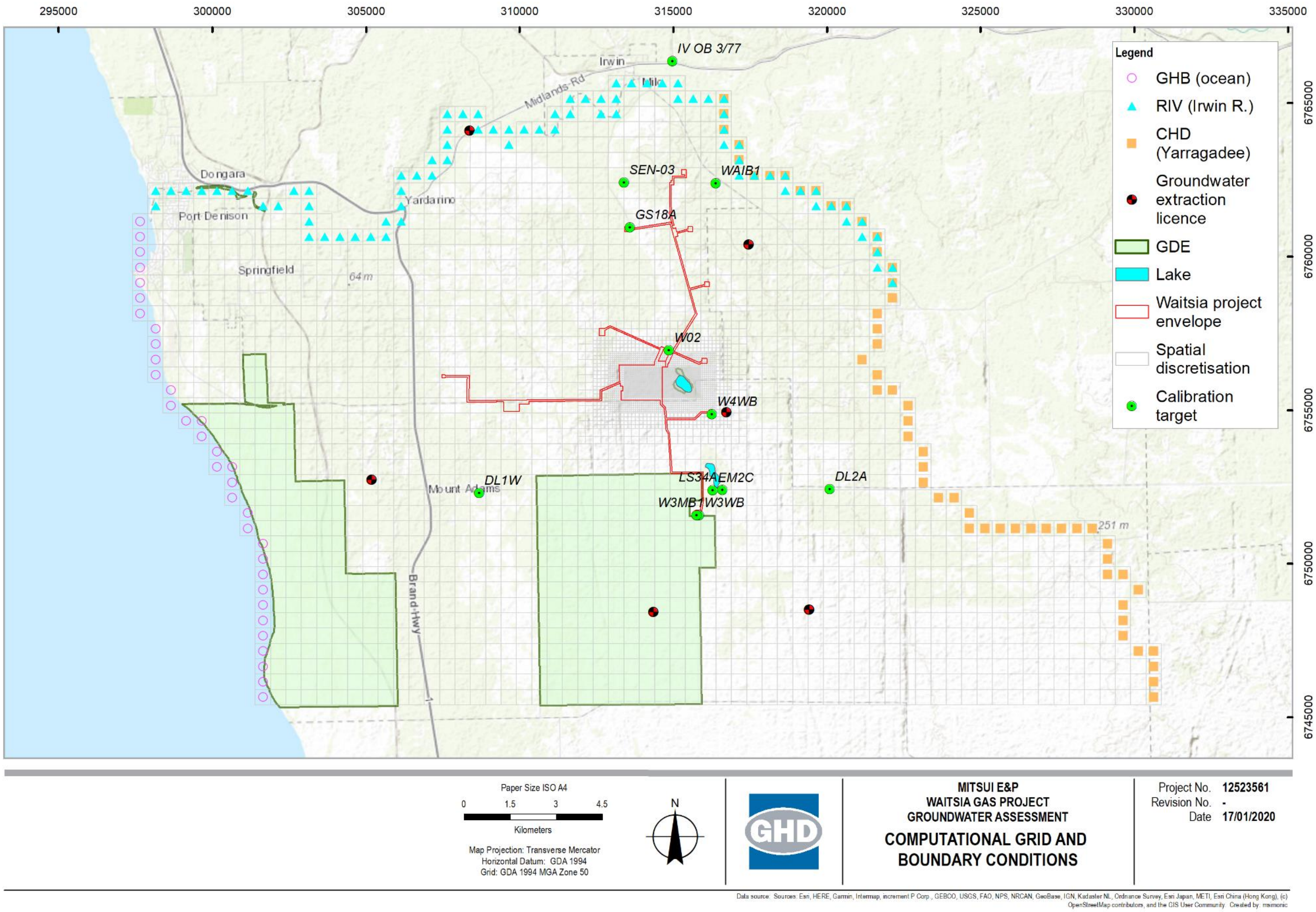

Figure 3-1 Model computational grid and boundary conditions

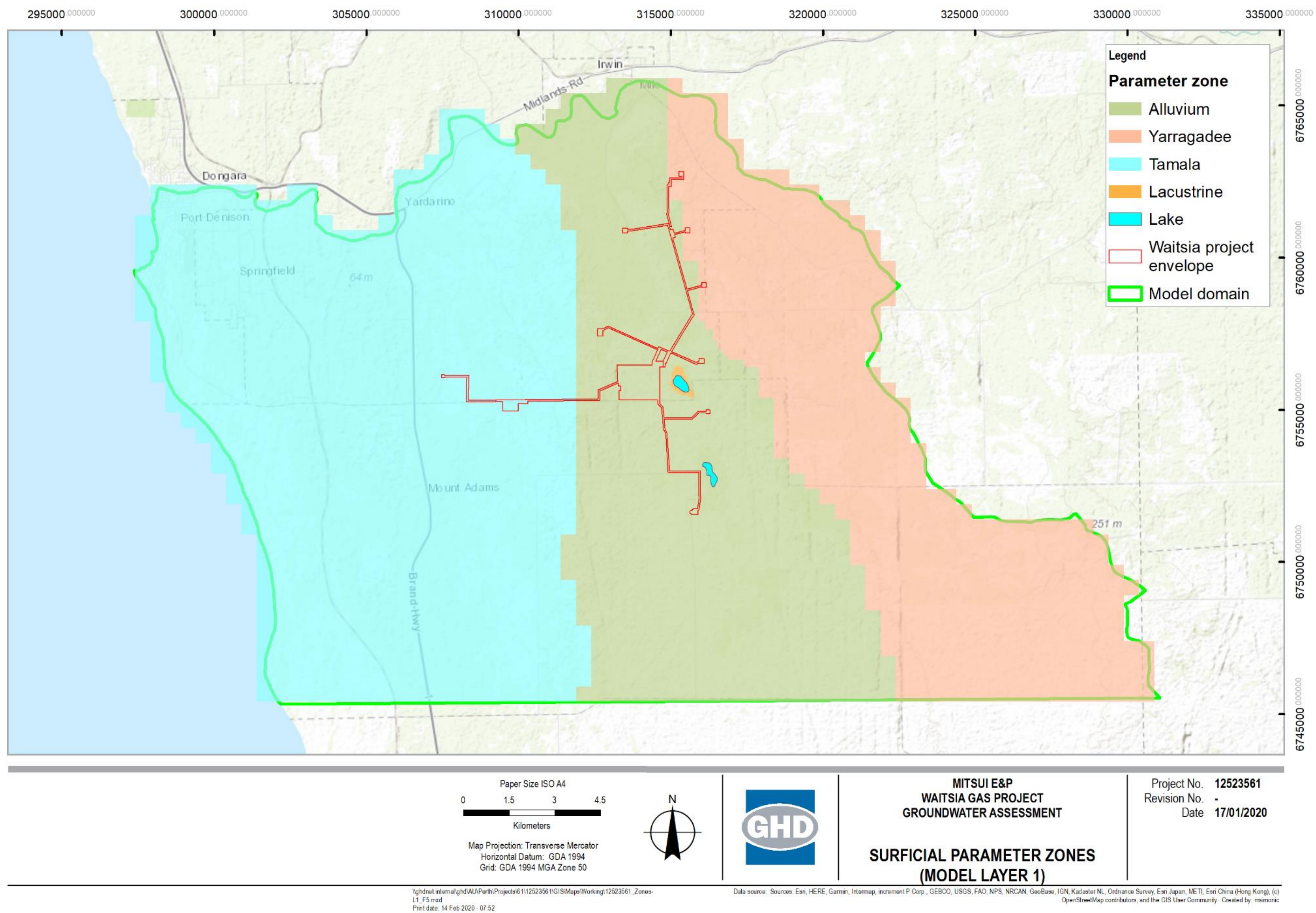

Figure 3-2 Model parameter zones, layer 1 (Surficial formations)

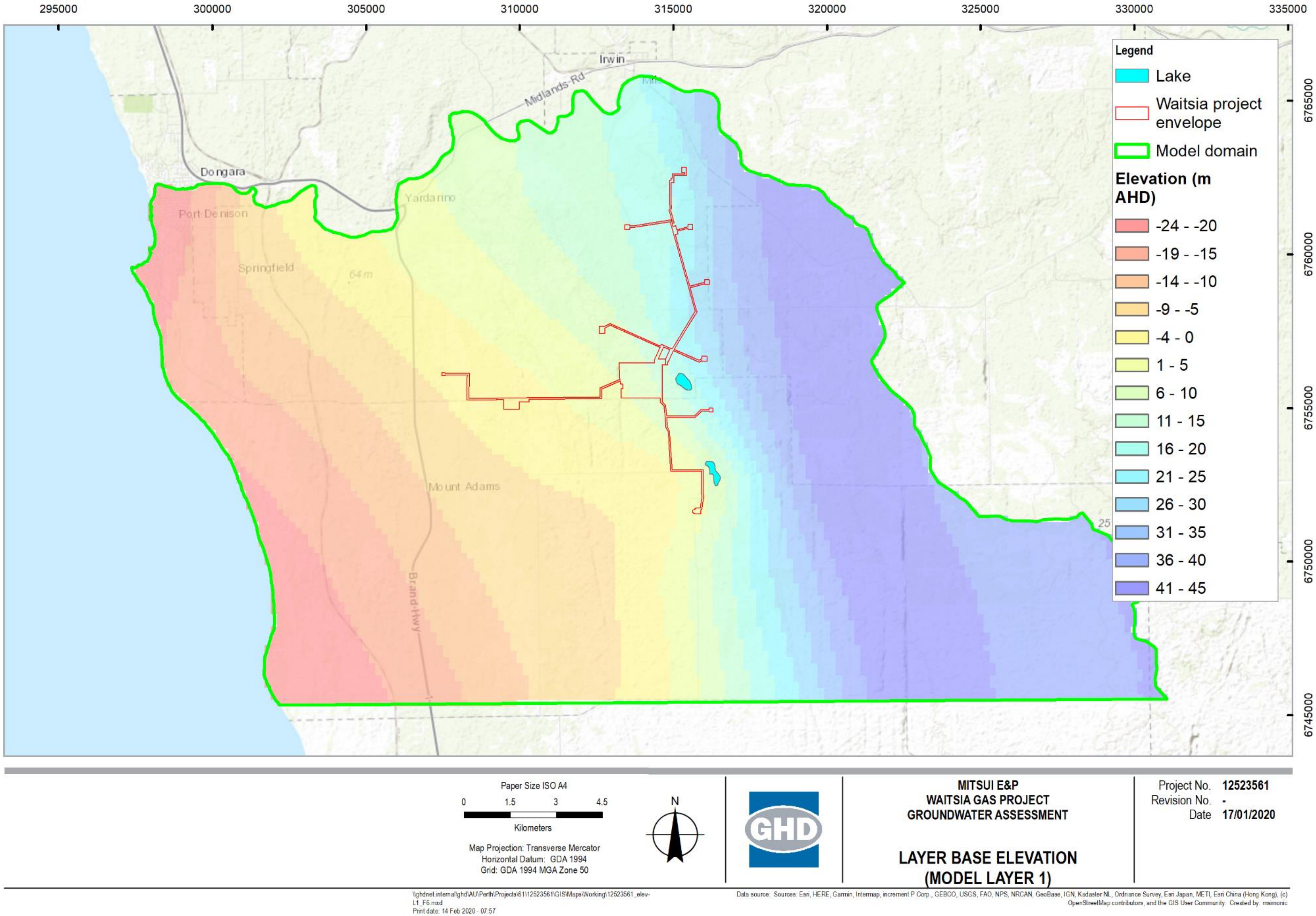

Figure 3-3 Model layer 1, base elevation

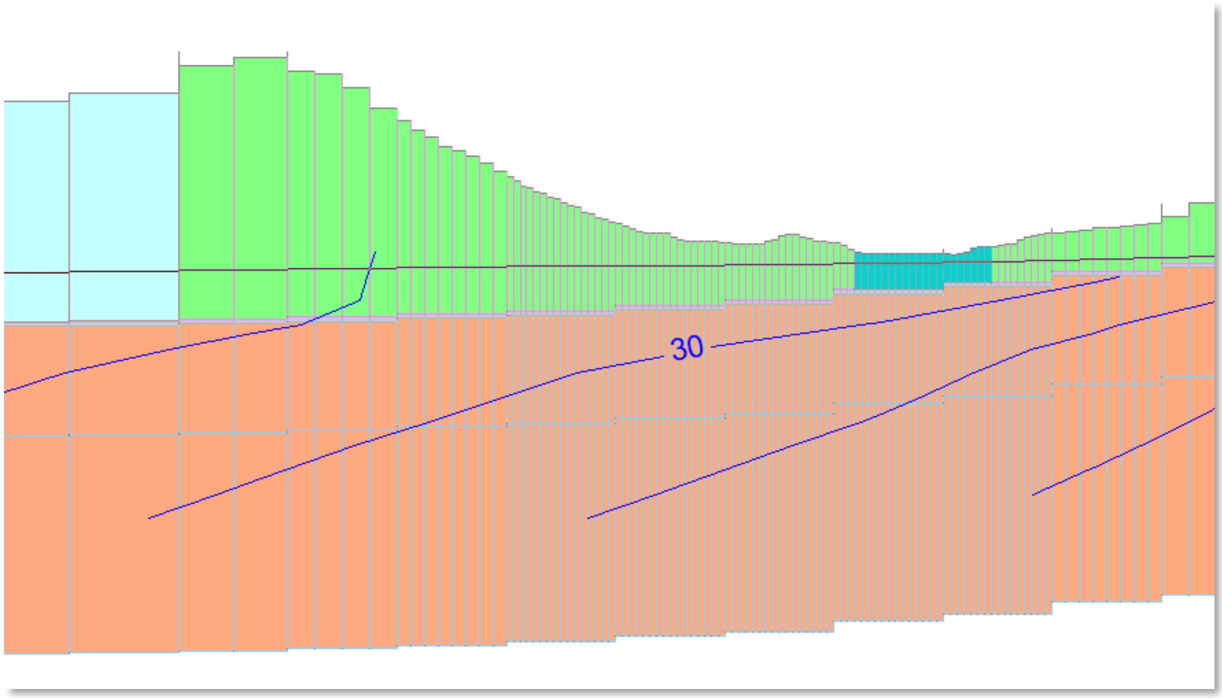

Figure 3-4 Example model section (W-E) across the project area and Ejarno Spring

3.2 Model Calibration

3.2.1 Approach

The approach to undertaking model calibration was by performing an iterative adjustment of selected aquifer parameters (hydraulic conductivities) to minimise the difference between observed and modelled groundwater levels at monitoring bore locations. Locations of groundwater targets for which water levels were computed are shown in Figure 3-1.

SMS solver was used to obtain the simulation results from the MODFLOW-USG numerical model, with head and residual convergence criteria of 0.001. Since the available water level data is not detailed enough to show seasonal variation in groundwater levels (Figure 3-6 and Figure 3-7), the model was calibrated in the transient state using time-averaged variables (recharge, evapotranspiration, pumping, throughflow) for the period 2014 to 2019. Seasonal variations are assumed to be in order of a 1-2 metres so this approximation is considered appropriate.

For comparison the model constructed for the purposes of this assessment was also run with GARAMS-derived hydraulic parameters for the regional DWER model.

3.2.2 Calibration Results

Hydrographs from ten selected representative bore locations were compared to computed water levels hydrographs and are presented in Figure 3-6. The location of the bores used for calibration is presented in Figure 3-1.

The comparison of real versus simulated levels suggests an acceptable calibration, with matches particular valid around the project site (bore W02), but also in locations further from the site, with one exception for WAIB1 which is over 6 km NNW of the project site. The WAIB1 location is not far from the Irwin River (Figure 3-1) and may be affected by recharge from the river via infiltration in this area, or different (less permeable) hydraulic conditions. Due to the distance from the Project site, the difference in actual and simulated water levels at WAIB1 is not considered to impact the representativeness of the ‘local’ model in the area of interest (Project site).

A scaled mean square error (SRMS) of 7.4% was achieved for the calibration period. When comparing the modelled and observed heads, the majority of the wells were within the 95% confidence interval. Existing differences between observed and modelled values may have been caused by the parameters and predictions adopted to represent average conditions within the 0.5 km^2 model grid cells; or by the assumed uniform aquifer parameters for the hydrogeological formations. The SRMS value is also affected by the lack of calibration for bore location WAIB1, if this was not considered the SRMS value would be 4.3%.

The match between observed and computed hydrographs for the case with GARAMS regional model derived parameters is shown in Figure 3-7. This suggests a generally less acceptable fit when compared with the results of the ‘local’ model. It is therefore concluded that local model is a more adequate representation of the project site conditions.

Storage parameters adopted are consistent with the GARAMS regional model (GHD 2011), as they have been found less sensitive to changes. The GARAMS regional model and this local model calibration confirmed that modelled water levels are more sensitive to lateral hydraulic conductivity values, in this case of the Superficial aquifer and to a smaller degree to hydraulic conductivity of the Yarragadee aquifer. Hydraulic conductivity values were optimised for site-specific conditions and compared to the GARAMS regional model parameterisation.

Calibrated parameters for locally calibrated model are tabulated in Figure 3-5:

Figure 3-5 Summary of calibrated parameters

Zone	Hydraulic conductivity Kh/Kv (m/d)	Specific storage / specific yield (Ss/Sy)
Alluvium (L1)	15/1.5	0.0001/0.2
Yarragadee subcrop (L1)	6/0.6	0.00001/0.1
Tamala Limestone (L1)	200/100	0.00001/0.2
Base of Superficials (L2)	3/0.01	0.00001/0.1
Yarragadee (L3, L4)	3/0.01	0.00001/0.1

3.2.3 Parameter Sensitivity

Sensitivity of the model results was also tested to assess the assumption regarding the presumed low permeability of the surficial sediments potentially present beneath the Ejarno Spring. The overall local model calibration was not affected by perturbations of the permeability of the surficial sediments (within layer 1).

A conservative approach was taken in the base case model, with permeability of these sediments assumed to be equal to the rest of alluvial sediments.

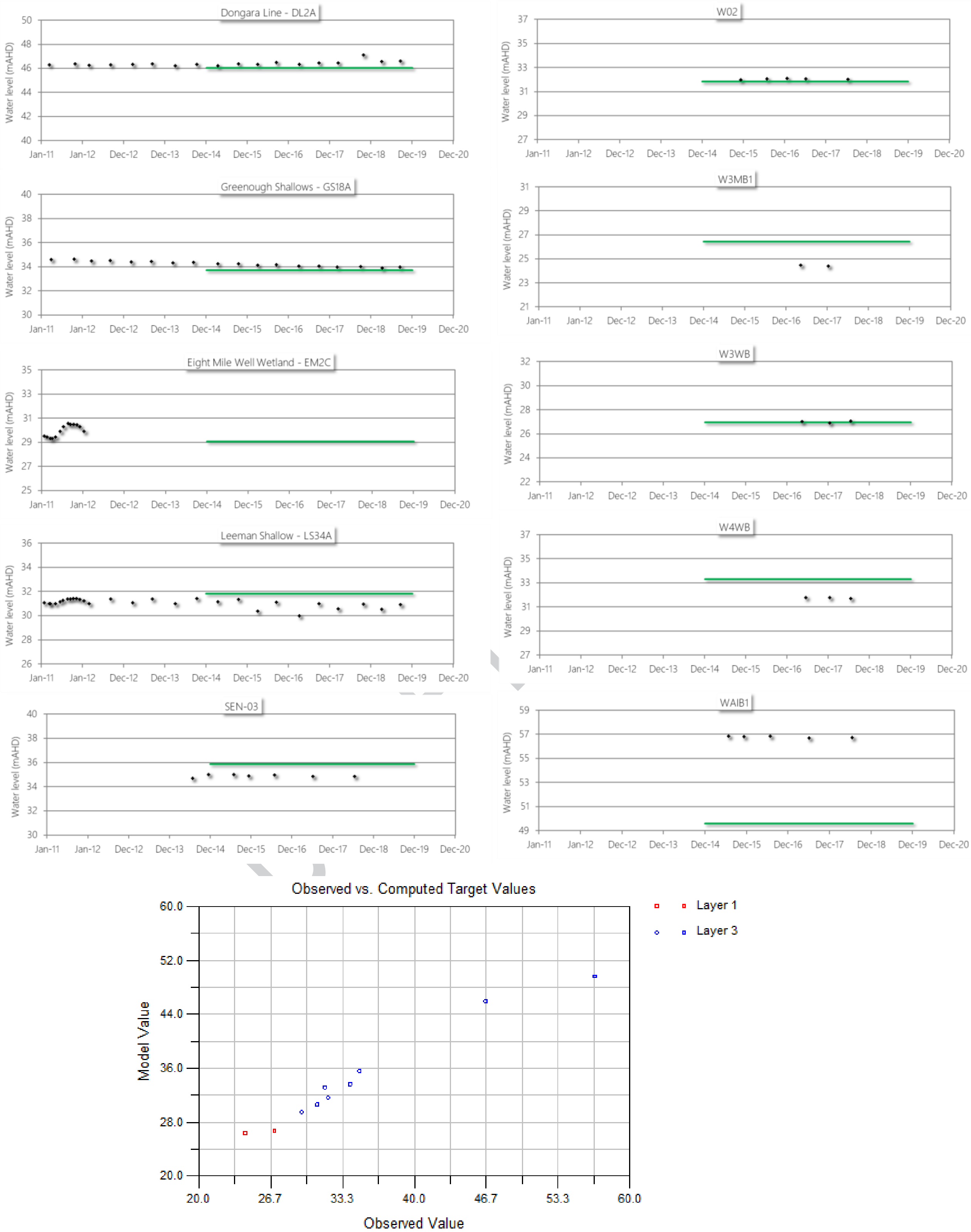

Figure 3-6 Comparison between observed (black dots) and computed hydrographs (green) of the calibration targets, base case

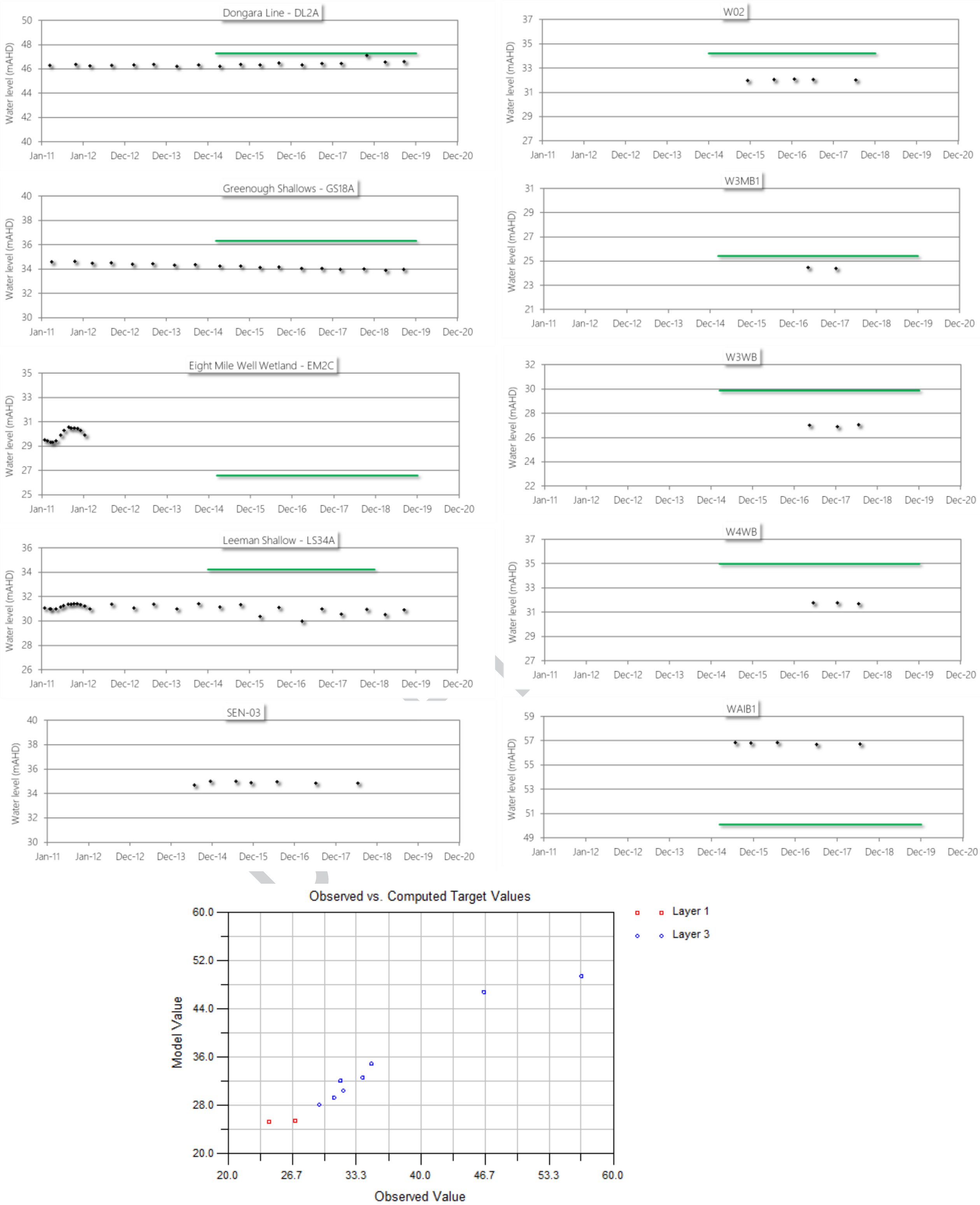

Figure 3-7 Comparison between observed (black dots) and computed hydrographs (green) of the calibration targets, GARAMS parameters

3.3 Predictive Modelling of Proposed Abstraction

3.3.1 Evaluated Cases

The potential impact of the proposed abstraction at 60,000 kL/yr from the gas plant area was assessed by examining the water level change induced by pumping, specifically on the Ejarno Spring (GDE) and third party licensed users in the area.

The water level change (referred to as drawdown) is defined as the difference between the water level before abstraction commences and five years after continuous abstraction.

Simulations of abstraction were undertaken from a theoretical production bore set in the top section of Yarragadee aquifer and located along the eastern boundary of the Waitsia processing area (approximately 500 west of the Ejarno Spring).

Three conceptual scenarios were evaluated:

1. '**Base case (BC)**' – the model with locally calibrated parameters
2. '**GARAMS parameterisation case (GPC)**' – as above but with hydraulic parameters taken from the GARAMS regional model
3. '**Lacustrine low K case (LLKC)**" – as BC but with a low hydraulic conductivity unit beneath the Ejarno Spring.

The impact of the abstraction on water levels was evaluated using delineation of drawdown for both the Yarragadee and Superficial aquifers.

3.3.2 Results

Drawdown contours (representing reduction in water level) presented in Figure 3-8 to Figure 3-13 suggest negligible to minor water level changes attributable to abstraction from a theoretical bore at the Waitsia processing area.

The modelled changes in Superficial aquifer at the western edge of the lake at Ejarno Spring represent show a maximum reduction in water levels of 6, 0 and 5 cm after five years of pumping for scenarios (1) to (3) respectively.

The modelled changes in Yarragadee aquifer water levels are predicted to show a decrease by up to 19 cm at the Ejarno Spring. Predicted drawdown estimates of water levels are within the order of magnitude previously determined in the Mitsui WMP using the analytical solution (Theis equation) and reflects the relatively minor abstraction rate of 2 L/s. the Project site.

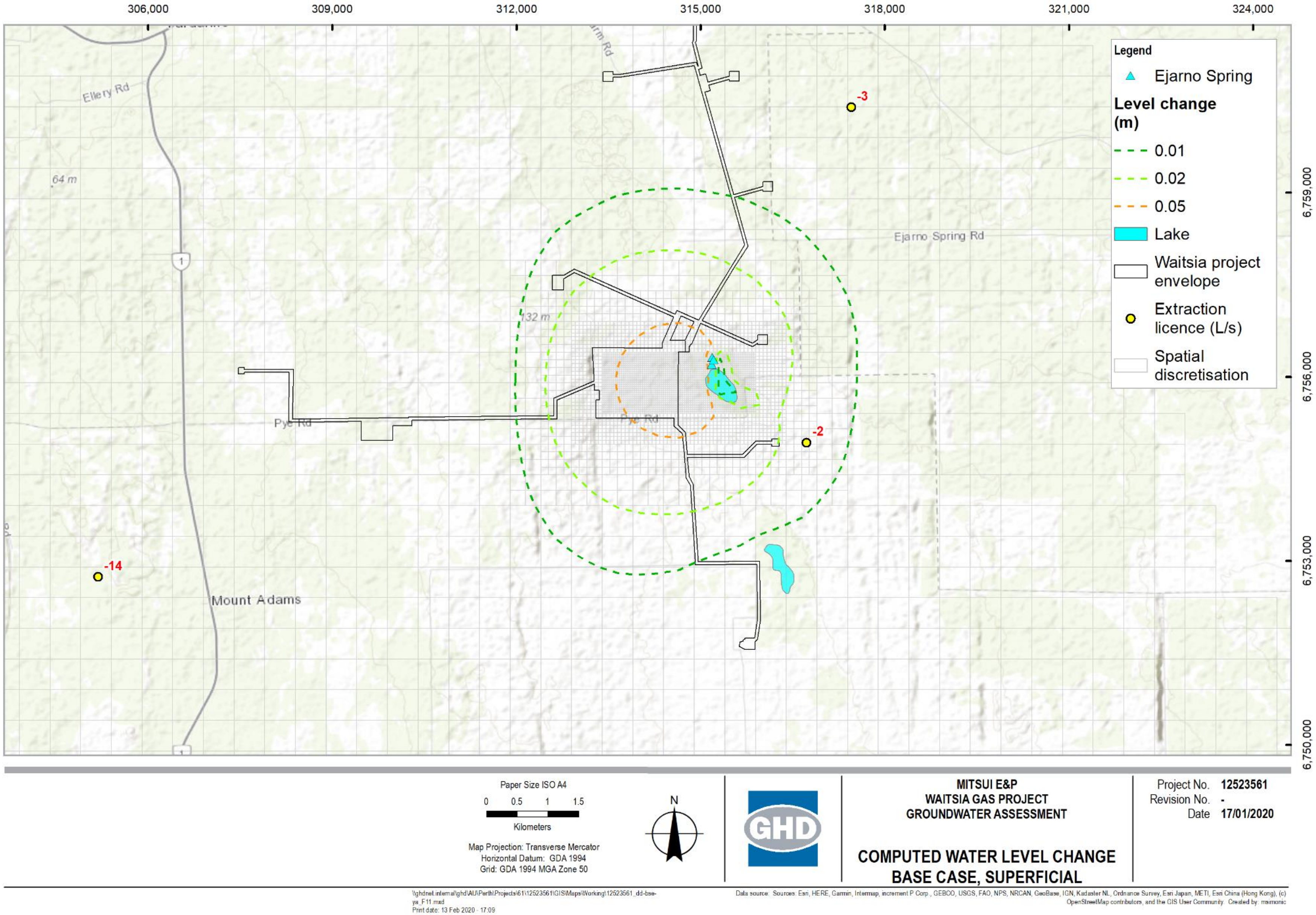

Figure 3-8 Computed water level change, base case, Superficial aquifer

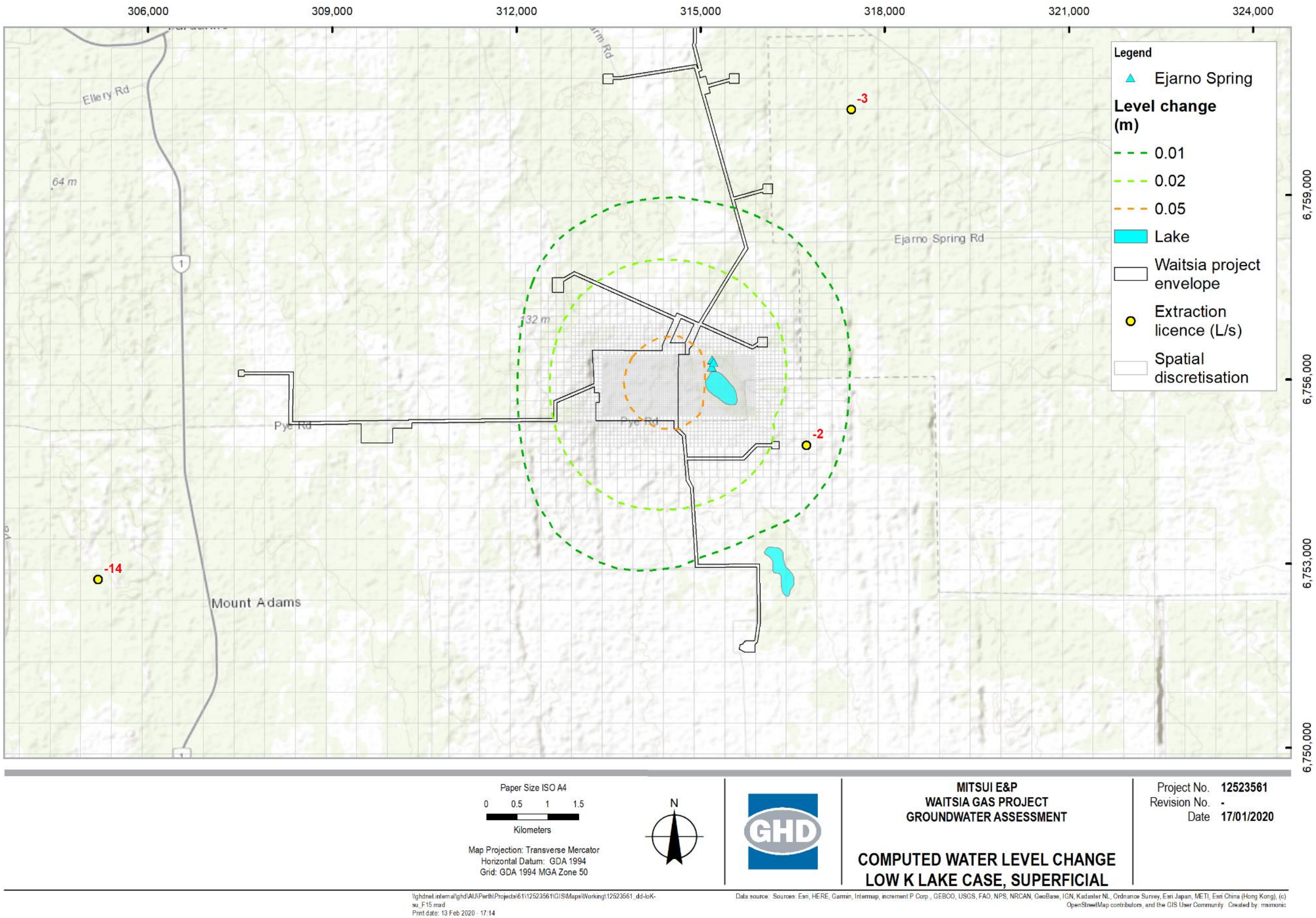

Figure 3-9 Computed water level change, lacustrine low K case, Superficial aquifer

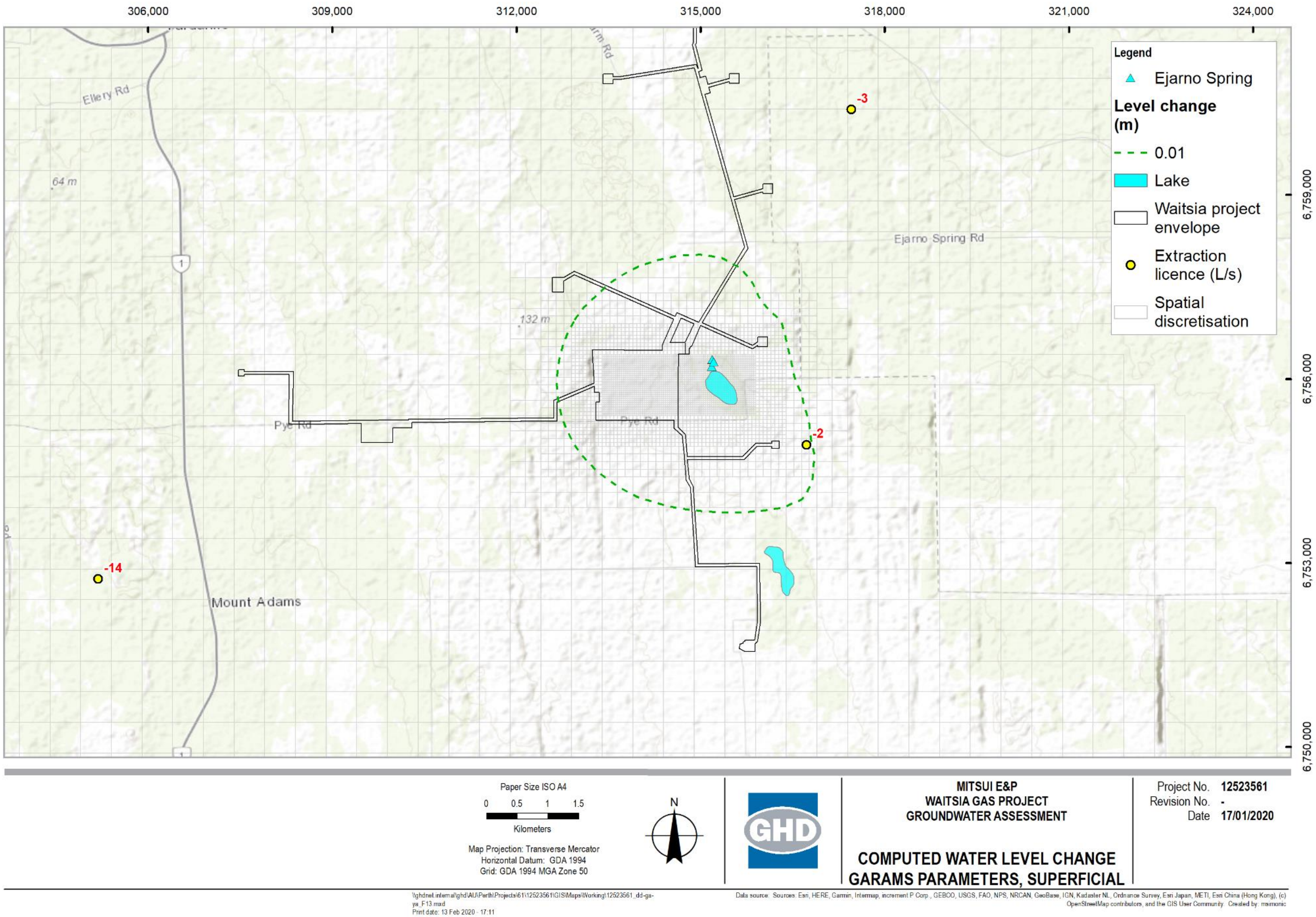

Figure 3-10 Computed water level change, GARAMS parameter case, Superficial aquifer

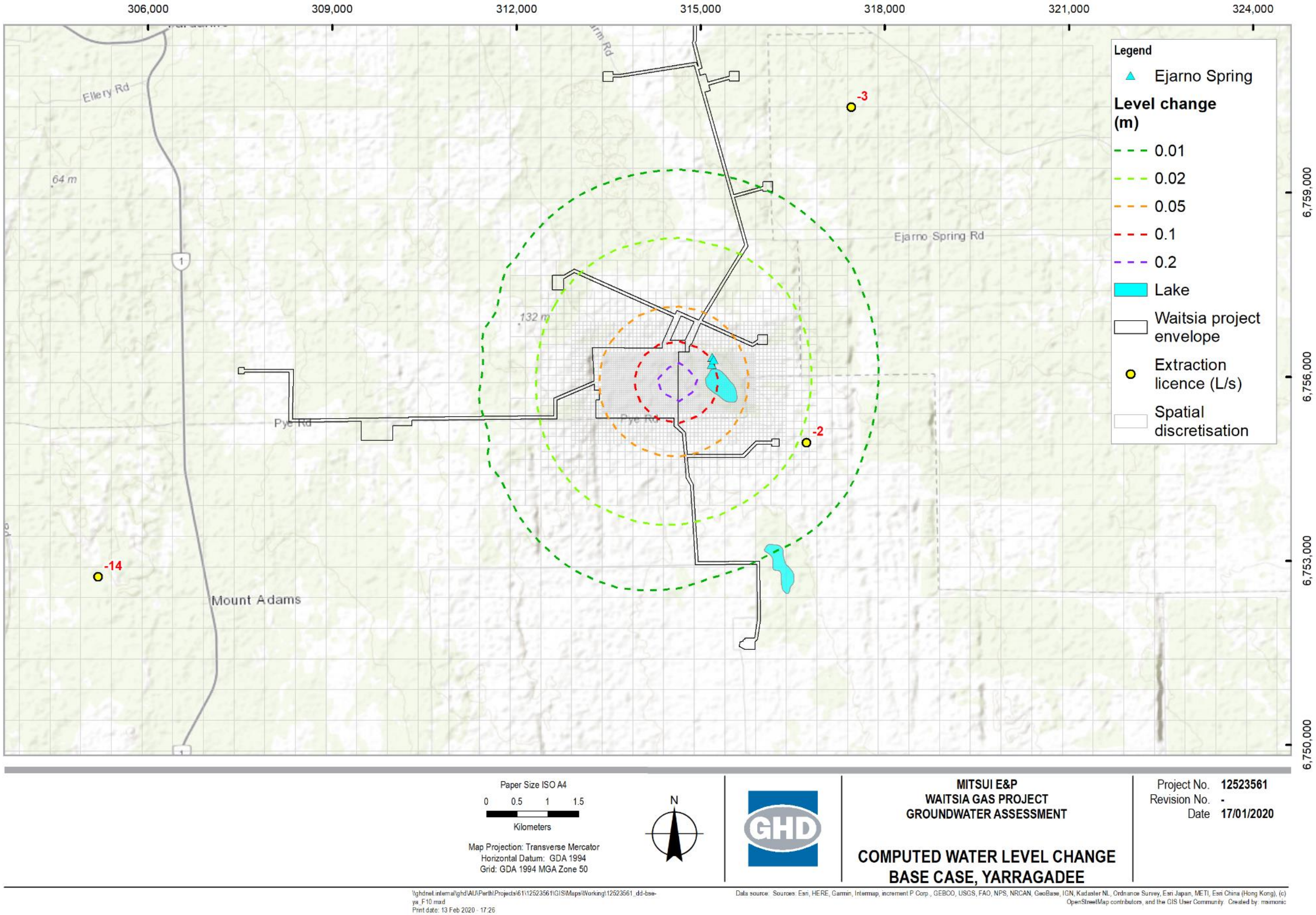

Figure 3-11 Computed water level change, base case, Yarragadee aquifer

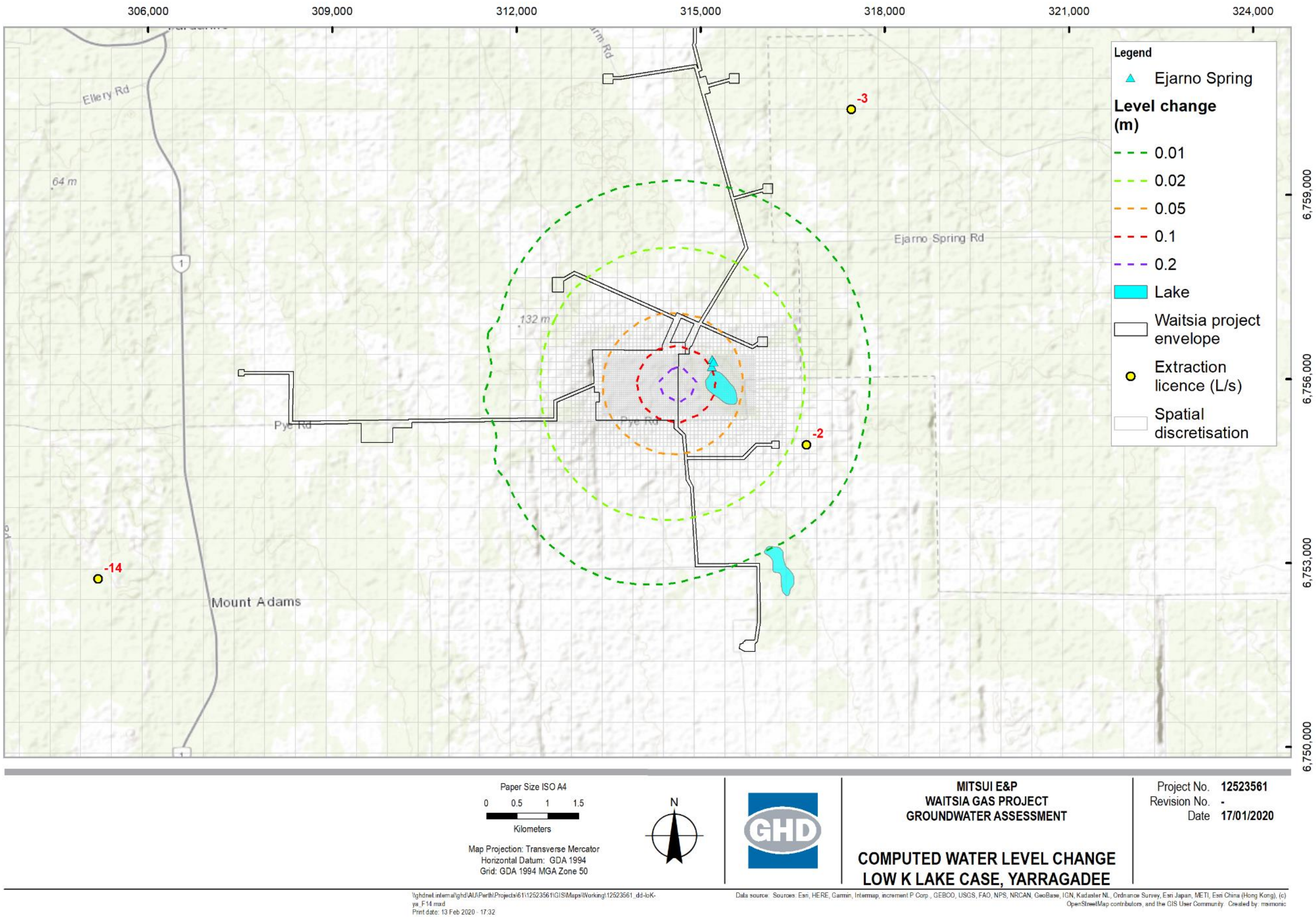

Figure 3-12 Computed water level change, lacustrine low K case, Superficial aquifer

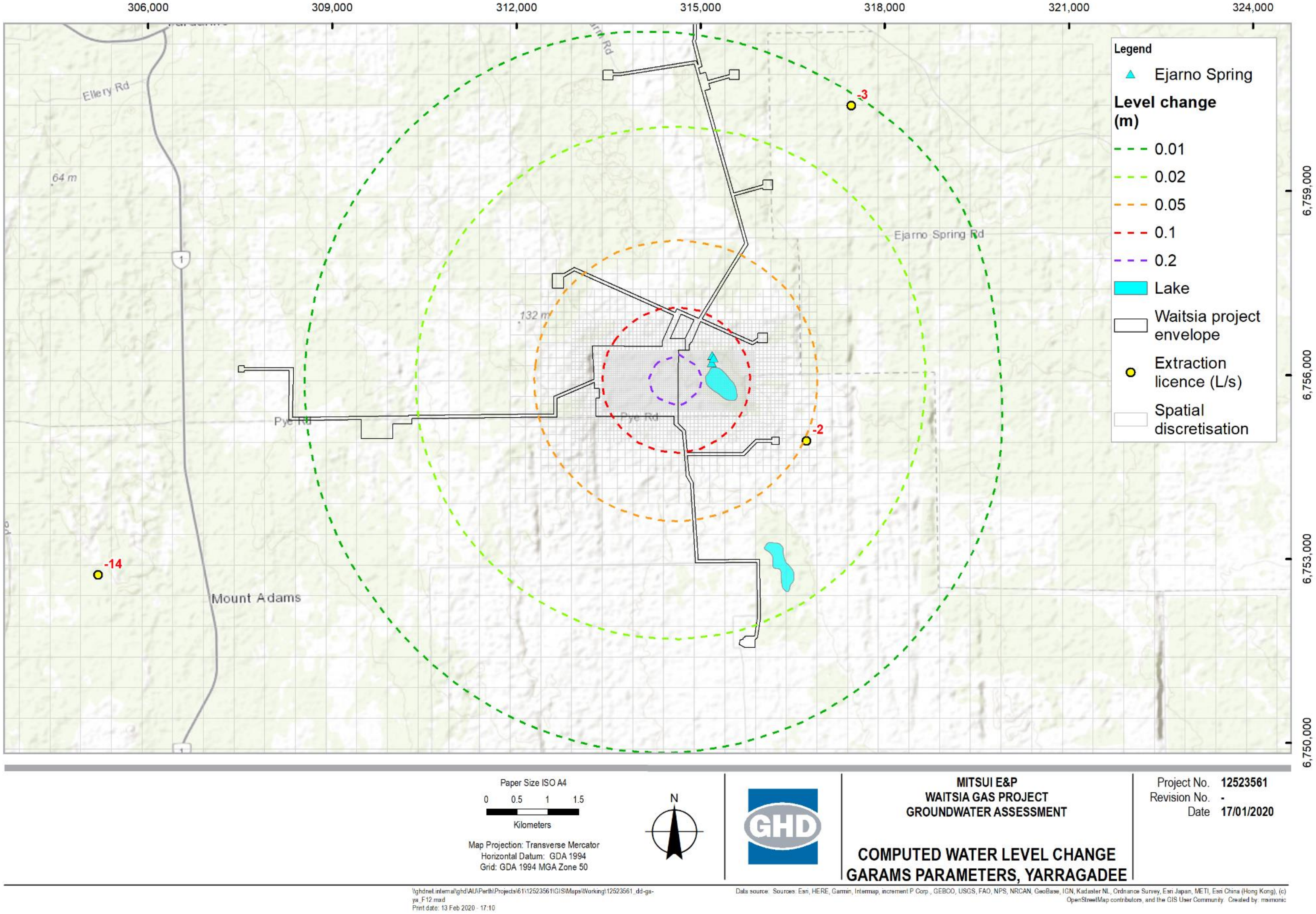

Figure 3-13 Computed water level change, GARAMS parameter case, Yarragadee aquifer

3.4 Impact Assessment

Simulated results of water level change attributable to pumping from the gas plant area are summarised in Table 3-1. These suggest that there would be a very minor impact on groundwater levels on the area of the Ejarno Spring as a result of the proposed Project abstraction. This very minor impact would be difficult to distinguish from the natural (seasonal variations) of water levels in the area, which are assumed in the order of 1 to 2 m within a year.

The model results need to be considered in light of the high degree of conservatism adopted. For example, conservative assumptions were made by discounting the potential presence of perched groundwater or the presence of lower permeability layers which would reduce the hydraulic connectivity between the two aquifers and with the Ejarno Spring, by preventing or reducing the upward flow of groundwater from the Yarragadee aquifer into the Superficial layers.

Table 3-1 Predicted drawdown in water levels at western side of Ejarno Spring after 5 years

Scenario	Superficial Drawdown (m)	Yarragadee Drawdown (m)
1 Base case	0.06	0.15
2 GARAMS parameterisation case	0.00	0.19
3 Lacustrine low K case	0.05	0.13

The water level change at the GDE (Yardanogo Nature Reserve) to the south of the Project site is predicted in the order of 1 to 2 cm after five years of pumping and therefore is not considered to have a significant impact on groundwater levels.

The only licensed site within the predicted drawdown (of 2 cm) from abstraction at the proposed gas plant is APT Parmelia. Therefore the anticipated impact on water levels for neighbouring licensed abstractions is predicted to be negligible or very minor due to the limited drawdown impact and distance from the Project site.

3.5 Assessment and Model Limitations

The numerical model is a simplified representation of the hydrogeological system and assumptions have been applied to the model which can present limitations and impact confidence in the model results. These limitations have to be carefully considered when assessing model outputs and impact assessments. The model is considered appropriate based on the information available and within the context of the purpose of the modelling.

To improve the predictive capacity of the numerical model, additional improvement on conceptual understanding could be considered. There are areas with gaps in the hydrogeological understanding, specifically in the Ejarno Spring area. There is limited data available on the base elevation of the Superficial aquifer and its connectivity with the Yarragadee aquifer in the Ejarno Spring area. To address this data gap conservative assumptions were made by discounting the potential presence of perched groundwater or the presence of lower permeability layers, which would restrict or prevent the upward flow of groundwater from the Yarragadee aquifer into the Superficial layers.

In the current numerical model, each hydrogeological unit was assigned a uniform hydraulic conductivity. However, hydraulic conductivity can vary significantly across individual hydrogeological units. At the local scale the match between observed and simulated water levels in available monitoring bores suggests that the model is sufficiently representative of local conditions and appropriate to assess the level of drawdown associated with the proposed Project abstraction rate.

There is limited information on the pumping abstraction records from the DWER – Water Resource Licensing allocation database for licensed abstractions. Any subsequent data update would improve future model revisions and the associated predictions.

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