ATP814P

Underground Water Impact Report

May 2023

REV	Date	Revision Description	Author	Checked	Approved
A	10/03/2023	Initial Draft for Internal Review	RDM Hydro Pty Ltd	MB	JP
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Executive Summary

The *Water Act 2000* requires that petroleum tenure holders adequately manage the potential impacts resulting from the exercise of underground water rights necessary to produce coal seam gas (CSG) and other petroleum. This Underground Water Impact Report (UWIR) has been prepared to satisfy the requirements of the *Water Act 2000* which requires that a UWIR is prepared, publicly notified and approved as triggered by the commencement of water production. This UWIR has been prepared to satisfy all requirements of the Act, including:

- Information about underground water extraction resulting from the exercising of the petroleum tenure holder's underground water rights,
- Information about the aquifers affected, or likely to be affected,
- Maps showing the area of the affected aquifer(s) where underground water levels are predicted to decline,
- Identification of impacts to environmental values,
- A water monitoring strategy, and
- A spring impact management strategy.

This UWIR relates to pilot activities which have occurred on and are proposed for ATP814P. ATP814P is located in the Bowen Basin, near Moranbah, and comprises seven non-contiguous areas. Pilot production was undertaken in the Monslatt block between 2011 and 2013. Pilot production commenced in the Sapphire block in December 2022 and is expected to run for one year. There is no other production currently planned on ATP814P until three strategically selected tenure blocks are transferred to Petroleum Leases.

Groundwater flow models were used to identify those areas where water level drawdown is predicted to exceed the *Water Act 2000* bore trigger threshold (5 m) and spring trigger threshold (0.2 m) due to the exercise of underground water rights.

The modelled drawdown predictions identify an Immediately Affected Area (IAA) and Long Term Affected Area (LTAA) for the Permian coal measures only. There is no IAA in for the Monslatt block as drawdowns were predicted to recover to less than the bore trigger threshold in 2013. No registered water supply bores that access the Permian coal measures are located within either the IAA or the LTAAs. No springs were identified within the spatial extents of the predicted spring trigger threshold exceedances. Model sensitivity analyses did not result in predicted drawdown that changes these outcomes.

This UWIR presents a Water Monitoring Strategy (WMS) for the Permian coal measures. Monitoring locations, schedules and the parameters to be tested have been detailed in the WMS and include monitoring of:

- water production rates,
- reservoir pressures, and
- produced water quality.

Monitoring data will be submitted to the Office of Groundwater Impact Assessment every six months.

A Spring Impact Management Strategy is not required as not springs are predicted to be impacted.

Drawdown maps will be reviewed annually.

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1 Introduction

Blue Energy Limited (Blue Energy) is the operator of Authority to Prospect (ATP) 814P, near Moranbah in the Bowen Basin.

The *Water Act 2000* requires that petroleum tenure holders adequately manage the impacts of underground water extraction necessarily associated with the extraction of coal seam gas (CSG), other petroleum resources, and mineral resources. Since 1 December 2010, the *Water Act 2000* has been amended to include, among other requirements, provisions for the preparation, consultation and submission of an Underground Water Impact Report (UWIR) – a requirement that is triggered by the exercise of underground water rights, corresponding to the extraction of water necessary for petroleum, gas or mineral production or testing. The key aspects of an UWIR include:

- Information about underground water extraction resulting from the exercising of the petroleum tenure holder's underground water rights,
- Information about the aquifers affected, or likely to be affected,
- Maps showing the area of the affected aquifer(s) where underground water levels are predicted to decline,
- A water monitoring strategy, and
- A spring impact management strategy.

A UWIR for ATP814P was initially approved in 2011 and with an update approved in 2016. Those UWIRs pertained only to the Monslatt block (formerly called the "East Block") (Blue Energy, 2016). Blue Energy has not exercised its underground water rights on ATP814P since January 2013.

Pursuant to Section 376 of the *Water Act 2000*, this document constitutes the updated UWIR for ATP814P. This UWIR considers all of the blocks that constitute ATP814P.

ATP814P is not within a declared Cumulative Management Area (CMA).

2 Legislation

Primary Queensland legislation that governs the management of resources, including groundwater, with respect to the CSG exploration and appraisal activities on ATP814P is summarised below.

2.1 Petroleum and Gas (Production and Safety Act) 2004

The Petroleum and Gas (Production and Safety) Act 2004 legislates for the safe and efficient exploration for, recovery of and transport of petroleum and fuel gas.

The Act establishes underground water rights for petroleum tenure holders. This allows the tenure holder to take or interfere with underground water in the spatial extent of the tenure, if that interference or take occurs while undertaking another authorised activity for the tenure. There is no volumetric limit to the amount of water that may be taken, however the tenure holder is subject to the provisions of Chapter 3 of the *Water Act 2000*. The associated water can be used for any authorised purpose, within or off tenure.

2.2 Water Act 2000

The *Water Act 2000* provides the regime for the planning and management of all water resources in Queensland. With respect to petroleum and gas production, Chapter 3 of the *Water Act 2000*:

- Identifies the obligations of CSG producers in relation to groundwater monitoring, reporting, impact assessment and management of impacts on other water users,
- Provides a framework and conditions for preparing a Baseline Assessment Plan and outlines the requirements of bore owners to provide information that the petroleum tenure holder reasonably requires to undertake a baseline assessment of the relevant bore,
- Sets out the process for assessing, reporting, monitoring, and negotiating with other water users regarding the impact of CSG production on aquifers.

The management of impacts on groundwater caused by the exercise of groundwater rights by petroleum tenure holders is achieved by providing a regulatory framework that requires:

- The preparation of UWIRs that establish underground water obligations, including obligations to monitor and manage impacts on aquifers and springs.
- Petroleum tenure holders to monitor and assess the impact of the exercise of underground water rights on water bores and to enter into "make good" agreements with the owners of potentially impacted bores,

The Queensland Government's Office of Groundwater Impact Assessment (OGIA) is responsible for managing these requirements in a declared Cumulative Management Area (CMA). Outside of the CMAs, individual tenure holders are responsible for the preparation of the UWIR. The requirements of a UWIR are specifically identified in the *Water Act 2000*, with additional description of the requirements provided in the UWIR guideline (DES, 2021). These requirements, and the conformance of this UWIR to those requirements are identified in Table 1.

A UWIR will identify whether an Immediately Affected Area or Long Term Affected Area will result from CSG activities. An Immediately Affected Area (IAA) is defined as an area where the predicted decline in water level within 3 years is greater than the bore trigger threshold. A Long Term Affected Area (LTAA) is defined as the area where bore trigger thresholds are exceeded at any time. The *Water Act 2000* defines the trigger thresholds as:

- Bore trigger threshold - 5 m for a consolidated aquifer,
- Bore trigger threshold - 2 m for an unconsolidated aquifer, and
- Spring trigger threshold - 0.2 m.

UWIRs are published to enable the community, including bore owners and other stakeholders, within the relevant area, to make submissions on the UWIR. These submissions are then required to be summarised by the petroleum tenure holder and submitted with the UWIR to DES for approval. The approved UWIR must then remain available on the petroleum tenure holder's website.

Table 1 Requirements of a UWIR (DES, 2021)

Reporting requirements (Water Act 2000)	Underground Water Impact Report Guidelines (DES, 2021)	Section(s) of this UWIR
Section 376		
For the area to which the report relates – (i) The quantity of water produced or taken from the area because of the exercise of any previous relevant underground water rights; and	PART A UNDERGROUND WATER EXTRACTION	Section 3.2 Table 2
(ii) an estimate of the quantity of water to be produced or taken because of the exercise of the relevant underground water rights for a 3 year period starting on the consultation day for the report		Section 3.3 Figure 1
For each aquifer affected, or likely to be affected, by the exercise of the relevant underground water rights –	PART B AQUIFER INFORMATION AND UNDERGROUND WATER FLOW	
(i) A description of the aquifer, and		Section 4.4
(ii) an analysis of the movement of underground water to and from the aquifer, including how the aquifer interacts with other aquifers; and		Section 4 Section 4.8
(iii) an analysis of the trends in water level change for the aquifer because of the exercise of the rights mentioned in paragraph (a)(i); and		Section 4.5
(iv) a map showing the area of the aquifer where the water level is predicted to decline, because of the taking of the quantities of water mentioned in paragraph (a), by more than the bore trigger threshold within 3 years after the consultation day for the report; and	PART C PREDICTED WATER LEVEL DECLINES FOR AFFECTED AQUIFERS	Section 6.4.1 Section 6.4.2 Figure 43

Reporting requirements (Water Act 2000)	Underground Water Impact Report Guidelines (DES, 2021)	Section(s) of this UWIR
(v) a map showing the area of the aquifer where the water level is predicted to decline, because of the exercise of relevant underground water rights, by more than the bore trigger threshold at any time		Figure 42 Figure 44
a description of the methods and techniques used to obtain the information and predictions under paragraph (b);		Section 6.1 Section 6.2 Section 6.3
a summary of information about all water bores in the area shown on a map mentioned in paragraph (b)(iv), including the number of bores, and the location and authorised use or purpose of each bore;		Section 6.4.3
(da) a description of the impacts on environmental values that have occurred, or are likely to occur, because of any previous exercise of underground water rights;		Section 6.4 Section 6.4.1
(db) a description of the impacts on environmental values that have occurred, or are likely to occur, because of the exercise of underground water rights-		Section 6.4.3 Section 6.4.4
(i) during the period mentioned in paragraph (a)(ii);		Section 6.4.3 Section 6.4.4
(ii) over the projected life of the resource tenure;		Section 6.4.3 Section 6.4.4
a program for –		
(i) conducting an annual review of the accuracy of each map prepared under paragraph (b)(iv) and (v); and		Section 7.3
(ii) giving the chief executive a summary of the outcome of each review, including a statement of whether there has been a material change in the information or predictions used to prepare the maps;		Section 7.3
a water monitoring strategy;	PART D WATER MONITORING STRATEGY	Section 7.1
a spring impact management strategy;	PART E SPRING IMPACT MANAGEMENT STRATEGY	Section 7.2
if the responsible entity is the office –		
(i) a proposed responsible tenure holder for each report obligation mentioned in the report; and		Not applicable
(ii) for each immediately affected area – the proposed responsible tenure holder or holders who must comply with any make good obligations for water bores within the immediately affected area;		Not applicable

Reporting requirements (Water Act 2000)	Underground Water Impact Report Guidelines (DES, 2021)	Section(s) of this UWIR
other information or matters prescribed under a regulation		Not applicable
Section 378	PART D WATER MONITORING STRATEGY	
1) A responsible entity's water monitoring strategy must include the following for each immediately affected area and long-term affected area identified in its underground water impact report or final report—		
(a) a strategy for monitoring— i) the quantity of water produced or taken from the area because of the exercise of relevant underground water rights; and ii) changes in the water level of, and the quality of water in, aquifers in the area because of the exercise of the rights;		Section 7.1 Section 7.1.1
(b) the rationale for the strategy;		Section 7.1
(c) a timetable for implementing the strategy;		Section 7.1
(d) a program for reporting to the office about the implementation of the strategy.		Section 7.1.2
(2) The strategy for monitoring mentioned in subsection (1)(a) must include—		
(a) the parameters to be measured; and		Section 7.1 Table 11
(b) the locations for taking the measurements; and		Section 7.1 Table 11
(c) the frequency of the measurements.		Section 7.1 Table 11
(3) If the strategy is prepared for an underground water impact report, the strategy must also include a program for the responsible tenure holder or holders under the report to undertake a baseline assessment for each water bore that is—		
(a) outside the area of a petroleum tenure; but		Not applicable
(b) within the area shown on the map prepared under section 376(b)(v).		Not applicable
(4) If the strategy is prepared for a final report, the strategy must also include a statement about any matters under a previous strategy that have not yet been complied with.		Not applicable

3 Petroleum Activities on ATP814P

3.1 Location and Layout

ATP814P comprises seven non-contiguous blocks[1] extending over a north-south distance of approximately 140 km and located around Moranbah in the northern Bowen Basin (Figure 2). Blue Energy has applied to convert three of the blocks (Sapphire (PLA1034), Lancewood (PLA1045) and Central (PLA1038)) to Petroleum Leases (PL). Blue Energy will ultimately relinquish the unnamed southwestern block[2].

The blocks comprising ATP814P are surrounded by existing PLs, ATPs and mining leases. There are a large number of operating coal mines interspersed with the ATP814P blocks. Arrow Energy is the operator of the surrounding ATPs and PLs. The only commercial CSG production is the Moranbah Gas Project (MGP) predominantly on PLs 191 and 196 immediately west of the Sapphire block, and comprising roughly 675 production and appraisal wells. The locations of operating mines are shown on Figure 2.

ATP814P extends across the Fitzroy and Burdekin Drainage Basins to the south and north respectively. The drainage divide aligns with the Lancewood block.

3.2 Historical Activities and Water Production

Prior to 2022, Blue Energy had drilled 17 CSG exploration and appraisal wells across ATP814P. Of these, four were in the Sapphire block, twelve were in the Monslatt block and one was in the Central block (Figure 2).

Historical exercise of underground water rights was via pilot (appraisal) testing in the Monslatt block between March 2011 and January 2013 and from the Sapphire 4 well from June to December 2012. Monthly water production from this period is included in Table 2.

Blue Energy undertook baseline assessments of thirteen water bores in July 2011. Twelve of these bores were in the Monslatt block and one was in the Sapphire block.

[1] Not graticular blocks
[2] Since this block will be relinquished it is not specifically considered in this UWIR

Table 2 Historical water production from ATP814P

Month Ending	Monthly water production (kL)				
	Monslatt 4	Monslatt 5P	Monslatt 6P	Monslatt 7	Sapphire 4
Mar-11	0.3	66	0	63	
Apr-11	0	166	0	38	0
May-11	0	220	0	51	0
Jun-11	0	270	0	60	0
Jul-11	0	513	0	89	0
Aug-11	0	501	0	55	0
Sep-11	0	464	0	15	0
Oct-11	0	48	0	81	0
Nov-11	0	0	0	0	0
Dec-11	0	3	0	1	0
Jan-12	0	49	9	3	0
Feb-12	0	326	10	63	0
Mar-12	0	72	2	19	0
Apr-12	0	140	6	21	0
May-12	0	537	2	84	0
Jun -12	0	506	0	73	5
Jul-12	0	514	0	53	6
Aug-12	0	172	0	49	3
Sep-12	0	0	0	48	0
Oct-12	0	0	0	55	0
Nov-12	0	0	0	45	6
Dec-12	0	0	0	16	16
Jan-13	0	0	0	27	0
TOTAL PER WELL	**0.3**	**2,868**	**29**	**1,011**	**35**

3.3 Planned activities and the quantity of water to be produced in the next three years

During 2022, Blue Energy drilled and constructed two sets of vertical-lateral intercept wells (Sapphire 5 and Sapphire 6). Each vertical has three or four lateral wells that target a different coal seam each. The laterals have an approximate in-seam length of 1,120 to 1,350 m. A pump is installed in the vertical well to enable water and gas extraction simultaneously from all of the connected laterals. Blue Energy will exercise its underground water rights through the pilot testing of these wells.

Blue Energy estimated the water production rates from the wells using a reservoir model and based on the company's understanding of the reservoir characteristics. The combined estimated water production rate from all laterals in the well is shown in Figure 1. This it the same water production curve used in the PL applications for the Sapphire, Lancewood and Central blocks (SLR, 2022).

Pilot testing commenced on 23 of December 2022, and is expected to run for 12 months. Following stabilisation of operations through January 2023, actual water production rates were found to be slightly different to the forecast rate. Figure 1 also shows the forecast rates for Sapphire 5 and Sapphire 6. These rates are a linear adjustment of the initial reservoir engineering estimate based on the actual production rate from February 2023, and show that the original estimate is a good approximation of the average forecast rate.

No other water production is currently planned for the current UWIR period (2023 to 2026) while operating under ATP814P. Future water production may occur within (Sapphire (PLA1034), Lancewood (PLA1045) and Central (PLA1038)) once Petroleum Leases (PL) have been granted. A UWIR specific to these PL areas will be prepared once approvals are granted.

Figure 1 Forecast water rates from the vertical well connected to lateral wells

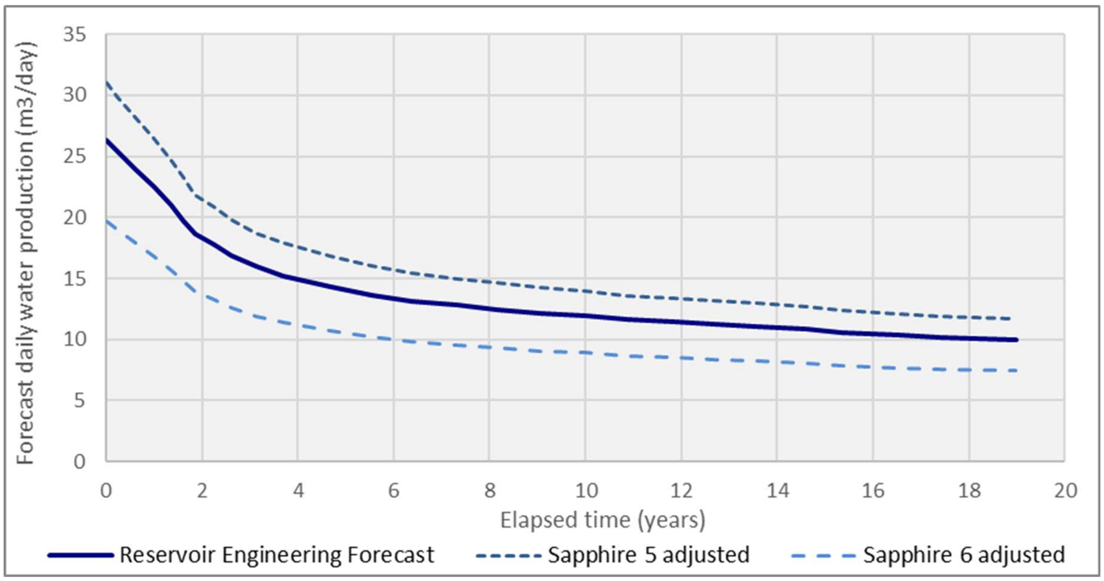
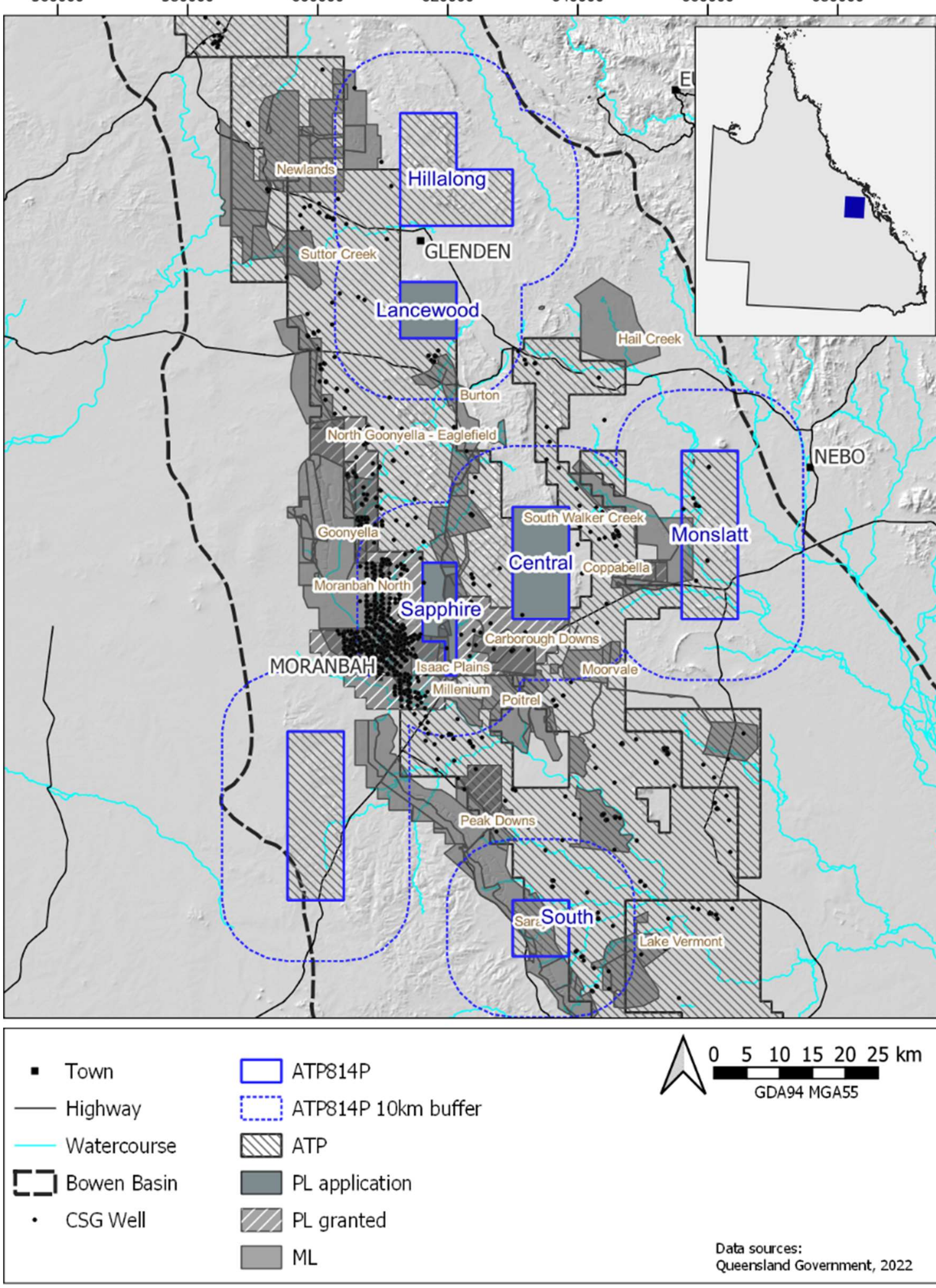


Figure 2 Location of ATP814P blocks, surrounding tenements and mines



4 Hydrogeological Regime

4.1 Drainage

ATP814P lies within the Burdekin River and Fitzroy River drainage basins (Figure 3). The drainage divide transects the Lancewood block with the Hillalong block entirely within the Burdekin Basin and the remaining blocks entirely within the Fitzroy Basin.

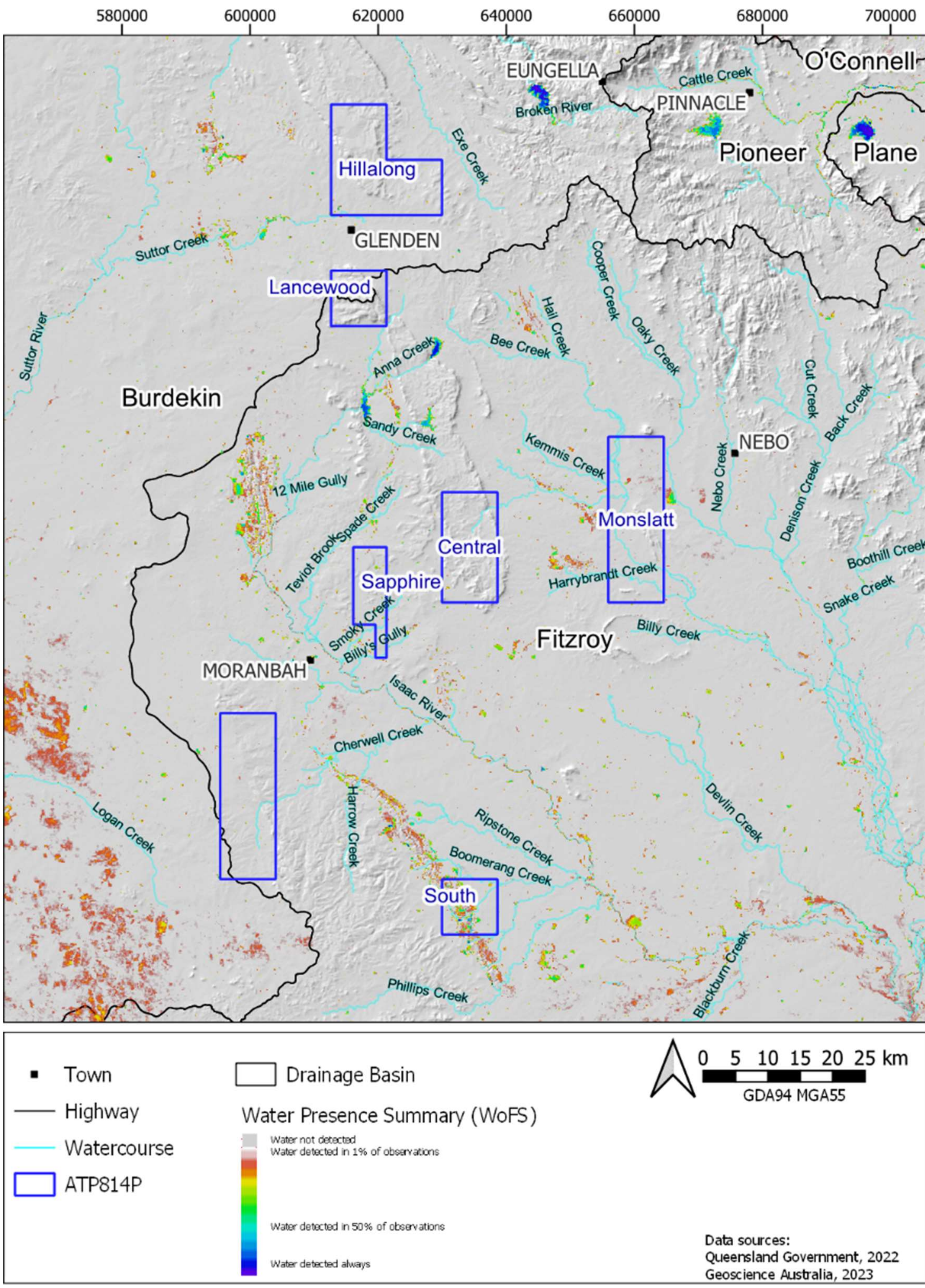
The major watercourses that drain each of the blocks are:

- Hillalong – Suttor Creek,
- Lancewood – Isaac River (headwaters),
- Sapphire – Smokey Creek and Billy's Gully,
- Central – Carborough Creek,
- Monslatt – Bee Creek and Harrybrandt Creek, and
- South – Hughes Creek and Boomerang Creek.

The Geoscience Australia (2023) *Water Observations from Space* (WoFS) displays historical surface water observations derived from satellite imagery for the period 1987 to present. Figure 3 includes the frequency that surface water is observed based on the WoFS product. It shows:

- Areas with permanent presence of water includes water supply dams such as Lake, Teviot Creek Dam, Elphinstone and the Burton Gorge Dam to the south of the Lancewood block, and farm dams spread around the region.
- Areas with the higher frequency of water presence is generally associated with open cut mine pit lakes. The most obvious of these is the Saraji mine that forms a linear feature transecting the South block, and the Goonyella mining complex to the northwest of the Sapphire block.
- The Isaac River is the only watercourse that shows the frequent presence of surface water. WoFS identifies that the Isaac River is ephemeral as water is generally only detected in 20-50% of the observations, with disconnection between the higher frequency stretches, suggesting the continued presence of pools for some time after the river flows.
- Water is detected in less than 1% of observations in most other watercourses except for small, disparate areas where pools may form after surface water flows.

Figure 3 Drainage and presence of water



4.2 Geological Setting

The geology within ATP814P comprises early Permian, Triassic, Tertiary and Quaternary sediments and volcanics (Table 3). Surface geology is mapped as Figure 4 and the underlying solid geology is mapped as Figure 5 (Sliwa et al, 2017). Figure 4 has been simplified from the 2018 detailed geological mapping data (DNRM, 2018). Table 4 summarises the mapped surface and solid geology within each of the ATP814P blocks.

The Bowen Basin is an elongated, north-south-trending basin extending over an area of 160,000 km^2 from central Queensland, south beneath the Surat Basin, and into New South Wales. ATP814P is in the northern portion of the Bowen Basin.

The depositional history of the Bowen Basin is complex due to varying rates of uplift and subsidence, hence the periods of sedimentation were not always consistent across the basin and the geological units are not always laterally extensive or correlatable (Draper, 2013). Deposition in the Bowen Basin commenced during the Early Permian, with fluvial and lacustrine sediments and volcanics being deposited in the east and a thick succession of coals and non-marine sediments in the west (Geoscience Australia, 2015). The basin then entered a thermal subsidence phase that extended from the mid Early Permian to the Late Permian, during which deltaic and shallow marine sediments and extensive coal measures were deposited (Mallet et al. 1995).

In the Late Permian, the basin entered an extensive period of foreland loading, resulting in accelerated subsidence that allowed the deposition of a thick succession of Late Permian marine and fluvio-deltaic sediments, including the Moranbah/German Creek, Fort Cooper and Rangal Coal Measures. In the Early to Middle Triassic fluvial and lacustrine sediments - Rewan Group, Clematis Group and Moolayember Formation (Draper, 2013) were deposited. Sedimentation in the Bowen Basin ceased in the Late Triassic, followed by a period of widespread erosion (Cadman, Pain & Vukovic 1998).

The tectonic history of the basin has resulted broad fold synclines of Permo-Triassic strata through the north-south extent of ATP814P (Figure 6). The western margins of the synclines are usually defined by faults associated with the Jellinbah Thrust Belt (Figure 5). The western limbs of the synclines dip steeply compared with the eastern limbs. The Jellinbah Thrust Belt is a northwest trending zone of thrust faults with throws in the order of 100 m to 500 m, but may be over 1,000 m. Individual faults are typically 10 to 80 km long. The majority of thrust faults dip at shallow angles to the east and propagate up into the Permian sediments. The thrust belt follows the northwest trending synclinal axis of the Basin as most of the fault segments trend northwest suggesting inheritance from earlier basement structure (Arrow, 2022). There is extensive small-scale faulting mapped throughout the Bowen Basin, with the mapped distribution concentrated around coal mines. In the vicinity of ATP814P, Sliwa et al. (2017) identify these to be in the order of 5 m to 30 m.

Igneous intrusions are extensively mapped, particularly in the Monslatt and Central blocks. Pattison (1990) suggested that they are predominantly early Cretaceous in age.

In the Tertiary, volcanic activity resulted in the widespread distribution of basalts and associated intermediate and acid rocks. This happened concordantly as with a period of deep weathering resulting in clay rick sediments intercalated with the basalt.

Scaled sections prepared from lithological and wireline logs obtained during exploration activities on the Monslatt block and Sapphire pilot are presented as Figure 7 and Figure 8. These show that the geology within the coal measures is effectively layer-cake (horizontal layering) at the block or pilot scale.

Table 3 Stratigraphic table with associated lithologies

Age	Stratigraphic Unit			Lithology
Quaternary	Alluvium Colluvium			Clay, silts, sand, gravel
Tertiary	Suttor Formation			Quartz sandstone, clayey sandstone, mudstone and conglomerate; fluvial and lacustrine sediments; minor interbedded basalt.
	Basalt			Olivine rich weathered basaltic sands, weathered basalt, and fresh basalt flows
	Duaringa Formation			Mudstone, sandstone, conglomerate, siltstone, oil shale, lignite and basalt
Triassic	Mimosa Group	Moolayember Formation		Mudstone, lithic sandstone, interbedded siltstone, mudstone, sandstone and thin coal seams
		Clematis Group		Cross-bedded quartz sandstone, some quartz conglomerate and minor red-brown mudstone
		Rewan Group		Green lithic sandstone, pebble conglomerate, red and green mudstone
Late Permian	Blackwater Group	Rangal Coal Measures		Coal seams, carbonaceous shale and mudstone, tuff, siltstone and mudstone
		Fort Cooper Coal Measures	Burngrove Formation	Coal, brown and green sandstone, conglomerate, carbonaceous shale, tuff
			Fairhill Formation	Labile sandstone, quartzose sublabile sandstone, siltstone, mudstone, calcareous and tuffaceous sandstone, volcanic conglomerate, carbonaceous mudstone, coal
		Moranbah Coal Measures		Quartzose to sublabile, locally argillaceous sandstone, siltstone, mudstone, carbonaceous mudstone and coal
Early to Middle Permian	Back Creek Group	Exmoor Formation		Quartzose to sublabile sandstone, siltstone, mudstone, rare limestone
		Blenheim Formation		Carbonaceous and micaceous sandstone, siltstone, shale, coquinite, minor conglomerate
		Gebbie Formation		Fine to coarse, quartzose and siltstone, shale, coquinite
		Tiverton Formation		Fine to medium bioturbated sandstone, siltstone, mudstone, shale, coquinite
		Lizzie Creek Volcanics		Andesite, basalt, andesitic rudite, sandstone, siltstone

Table 4 Geological summary of each block comprising ATP814P

Block	Surface Geology	Solid Geology
Hillalong	Quaternary alluvium, Tertiary basalt and sediments, Clematis Group and Rewan Formation, with small amounts of Rangal Coal Measures and Fair Hill Formation in the south-eastern corner	Primarily Clematis Group and Rewan Formation, with small amounts of Rangal Coal Measures and Fair Hill Formation in the south-eastern corner
Lancewood	Alluvium, Clematis Group and Rewan Formation	Clematis Group and Rewan Formation
Sapphire	Quaternary Alluvium, Tertiary sediments and basalt, small areas of Rewan Formation and Fort Cooper and Rangal Coal Measures,	Rewan Formation and Rangal Coal Measures. Large fault in the north-western corner
Central	Quaternary Alluvium, Moolayember Formation, Clematis Group and Rewan Formation	Moolayember Formation, Clematis Group and Rewan Formation
Monslatt	Quaternary and Tertiary alluvium, basalt, Fort Cooper and Moranbah Coal Measures	Predominantly Fair Hill Formation and Moranbah Coal Measures, with a Back Creek Group on the southern boundary. Intrusives on the western boundary and northern boundaries.
South	Predominantly Tertiary alluvium with small areas of Back Creek Group in the southwestern corner.	Fair Hill Formation, Moranbah Coal Measures and Back Creek Group.

Table 5 Coal measure stratigraphic depths of each block comprising ATP814P

Block	Top depth (m) – average		
	Rangal Coal Measures	Fort Cooper Coal Measures	Moranbah Coal Measures
Hillalong*	215	345.5	43
Lancewood*	466	622	Not encountered (wells to shallow)
Sapphire	166.2	335.8	552.0
Central	705.2	868.9	Not encountered (wells to shallow)
Monslatt	Not present	0 (where not covered by Tertiary strata)	32.2
South*	Not present	26	299

* No CSG wells within the block. Stratigraphic depths based on nearest offset well with stratigraphic records

Figure 4 Surface Geology (after DNRM, 2018)

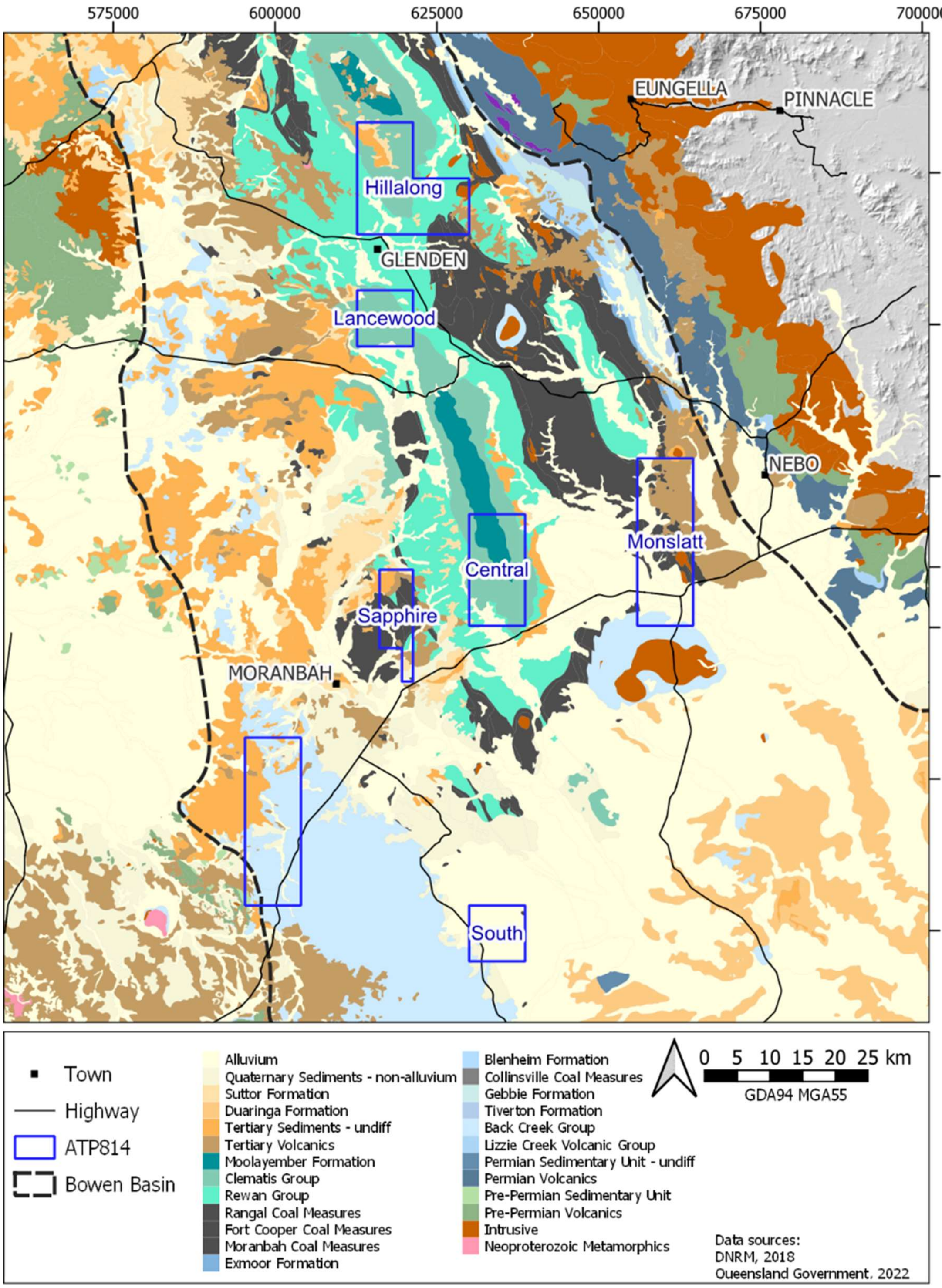


Figure 5 Solid Geology (Sliwa et al, 2017)

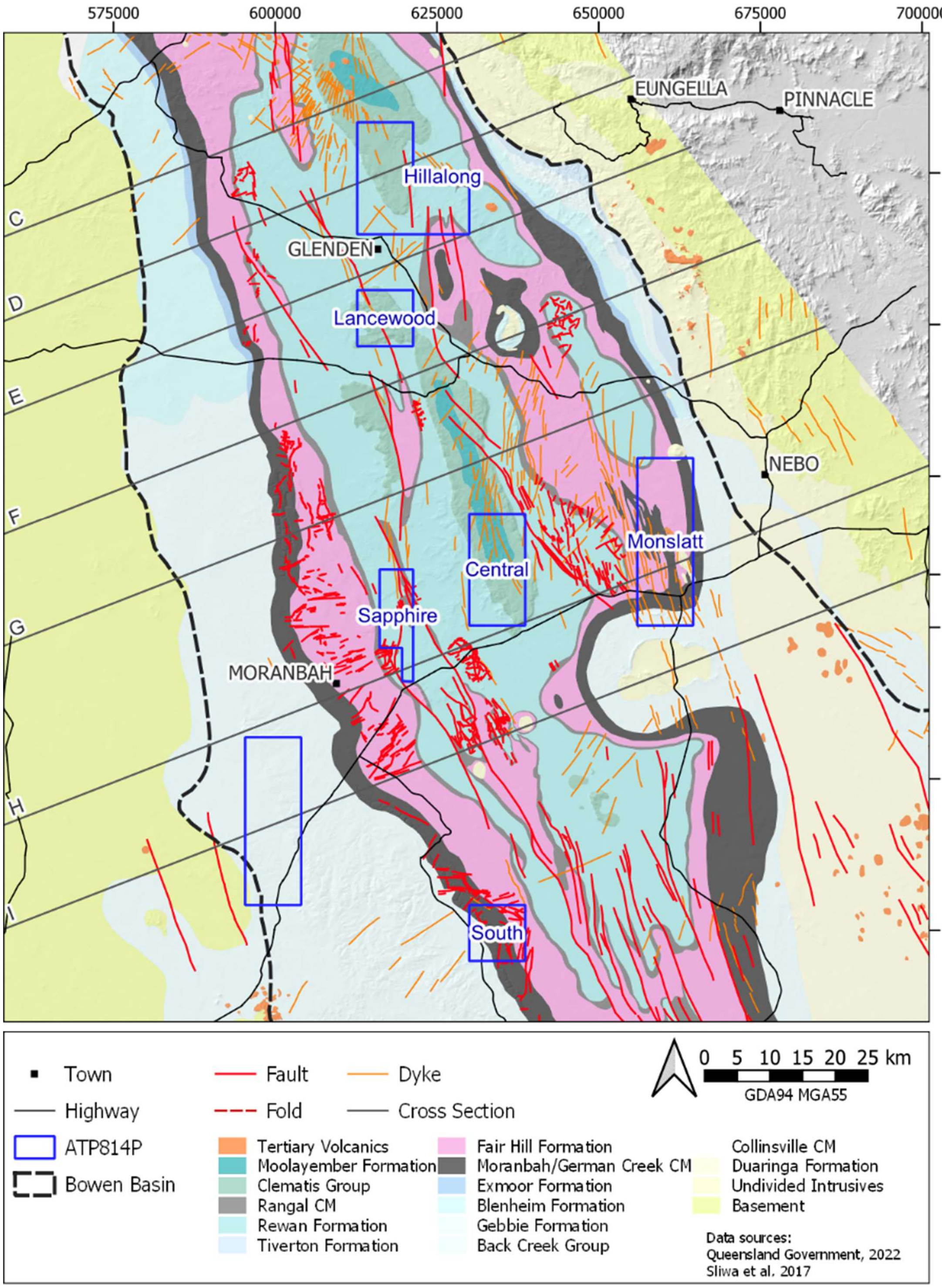


Figure 6 Regional Scale Geological Cross-Sections (Sliwa and Draper, 2003)

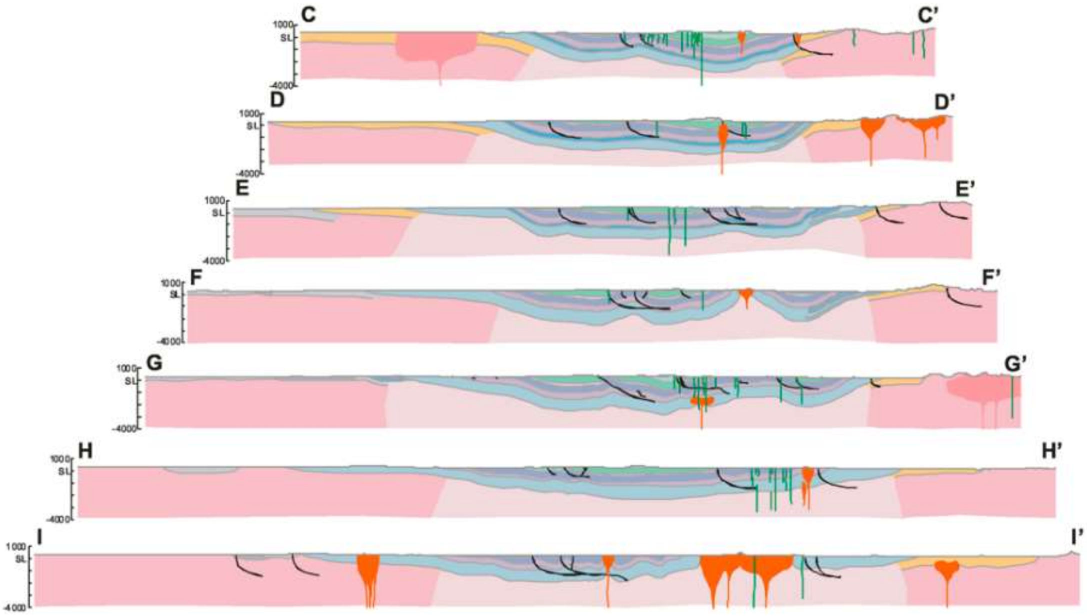


Figure 7 Monslatt Block - coal seam depths and correlation

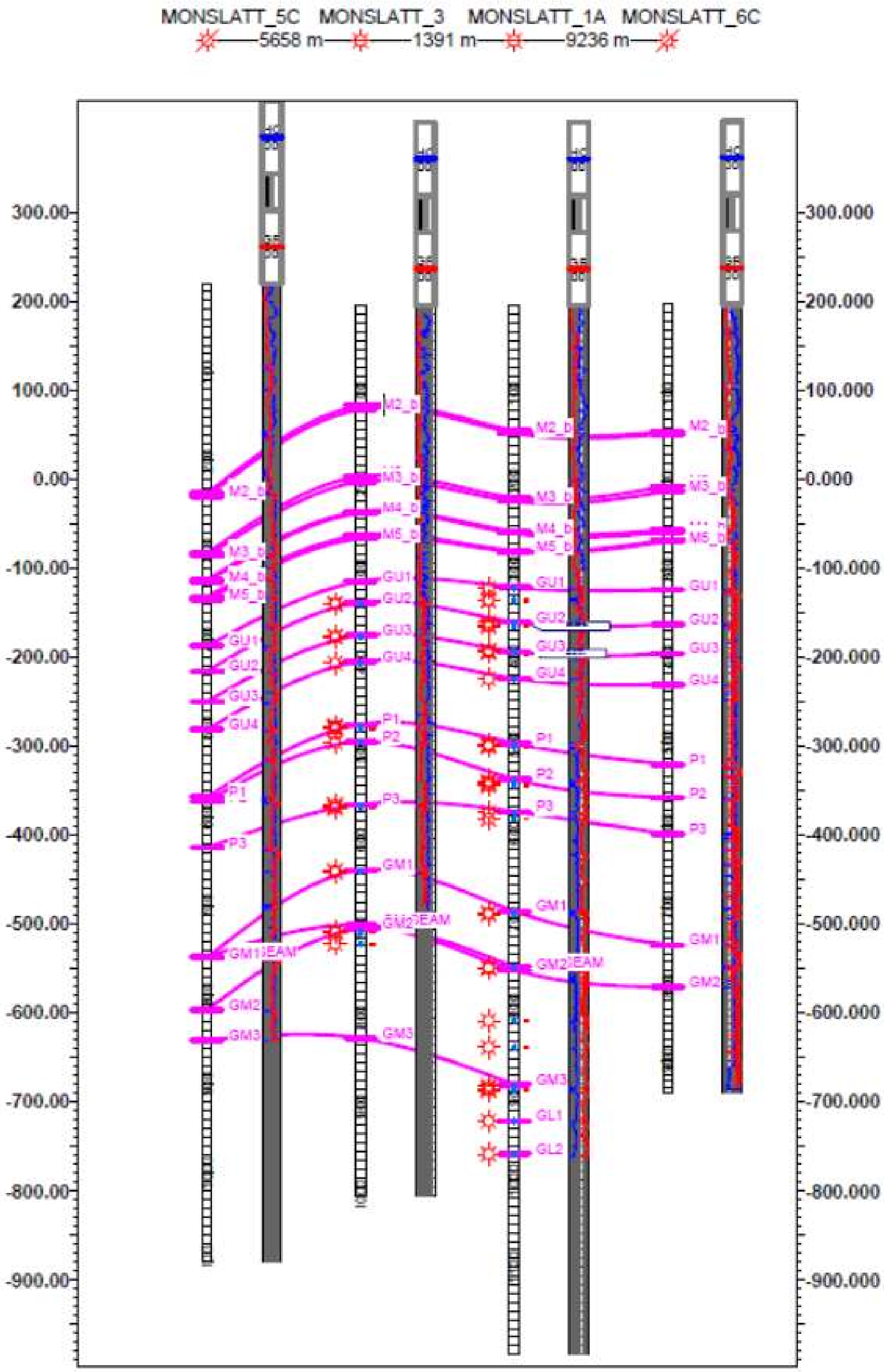
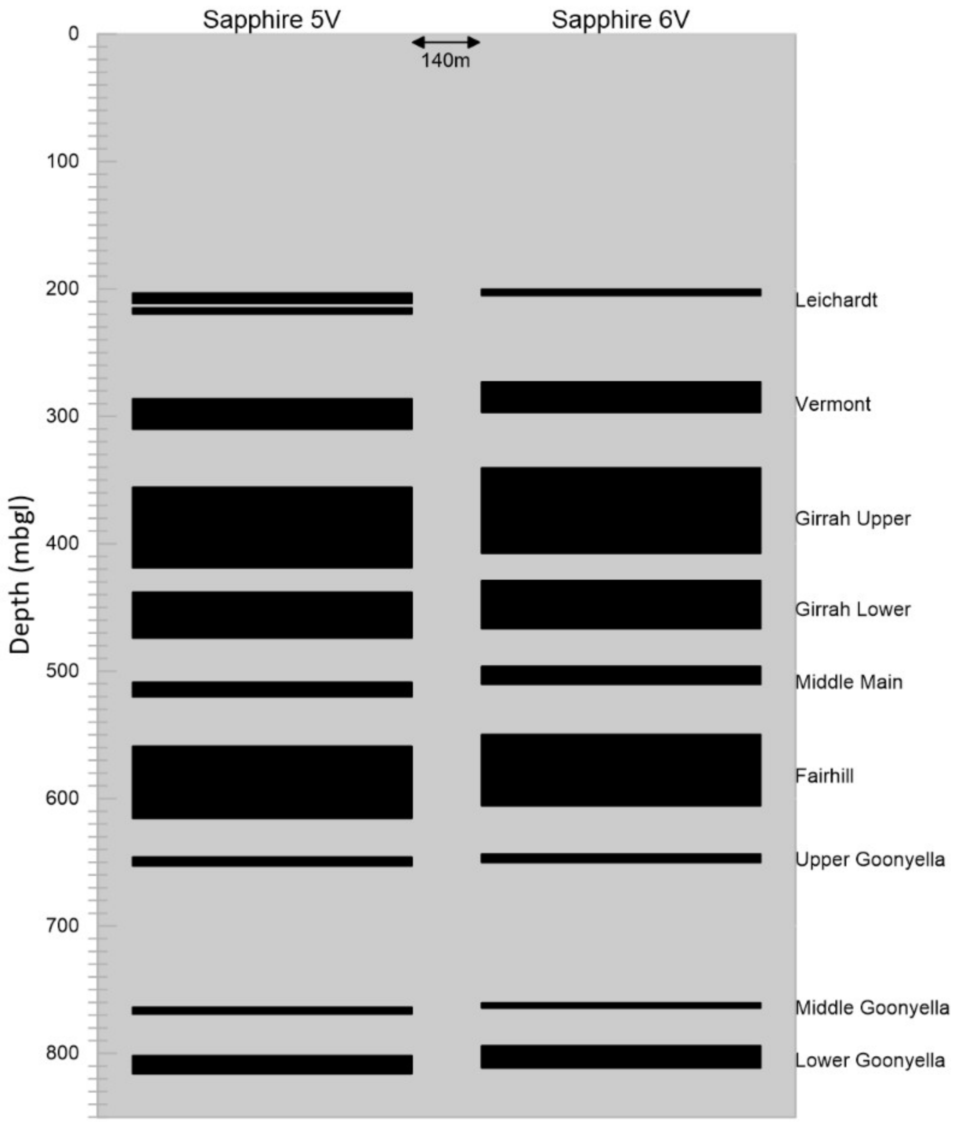


Figure 8 Sapphire pilot - coal seam depths and correlation



4.3 Target geological formations

In the Monslatt block, the P seam of the Moranbah Coal Measures was the production target.

In the Sapphire block, the lateral wellbores at each wellsite target one of each of the following coal seams:

- Rangal Coal Measures – Leichardt Seam
- Rangal Coal Measures - Vermont Coal Seam
- Fort Cooper Coal Measures – Middle Main Coal Seam
- Fort Cooper Coal Measures – Fair Hill Seam
- Moranbah Coal Measures - Upper Goonyella Coal Seal

4.4 Hydrostratigraphic summary

The small number of groundwater supply bores across ATP814P attests to the poor aquifer development in the region. The geology across ATP814P can be divided into the following hydrostratigraphic units:

- **Quaternary alluvium** – present along drainage lines and most extensive is association with the Isaac-Connors river system in the Fitzroy Basin. The alluvium reaches a maximum thickness in the range of 10 m to 30 m. Likely to be unconfined to semi-confined with intermittent connection to the surface water. Local-scale aquifers may be perched and not connected to the regional water table.
- **Tertiary Strata including basalts and sediments and weathered rock** – up to nearly 200 m thick in the vicinity of the Lancewood block and more akin to an aquitard due to the high clay content of original lithologies. Groundwater flow is predominantly within the secondary porosity (fractures and joints), and as such this type of aquifer tends to have a low storage capacity. The aquifer is compartmentalised due to the presence of low permeability weathered horizons between basalt flows, and the presence of massive (unfractured) low permeability basalt in the centre of the flows or low permeability sedimentary deposits.
- **Coal seams** – although they are of low permeability, the coal seams form the primary aquifers in the Bowen Basin. They are laterally extensive and continuous, and are confined by the regolith, overburden, interburden and under burden. They comprise less than 10% of the total thickness of the coal bearing packages. This hydrostratigraphic unit may contain coal seams of the Rangal, Fort Cooper or Moranbah Coal Measures
- **Overburden and interburden** – the overburden and interburden comprise very low permeability sandstone, siltstone, mudstone and shale of the Permo-Triassic Formations. It forms the aquitards that separates and confines the coal seams.
- **Basement** - the Back Creek Group and Lizzie Creek volcanics form the hydrogeological basement to the Bowen Basin sequence.

4.5 Water level trends

The GWBD was interrogated to identify bores within 10km of the ATP814P block boundaries with sufficient water level data to assess temporal water level trends. The locations of these bores are shown on Figure 9, with the timeseries data presented as Figure 10 to Figure 19. The hydrographs include a rainfall residual mass/cumulative difference from the mean curve, which can be used to help understand the effect of rainfall on the water level response. Where the residual mass curve shows a rising trend, rainfall was above average, and vice versa.

No bores with timeseries water level data were identified in the vicinity of the Lancewood and Hillalong blocks, and only selected water level data in the vicinity of the Sapphire block are presented due to the large number of bores available. The temporal water level trends are summarised in Table 6.

To assess spatial water level trends, a composite potentiometric surface was generated for the Bowen Basin using water level data from the GWBD augmented with data sourced from the literature. Where multiple water levels were available for the same bore, the most recent value was used. The surface elevation of the bore was obtained from the Shuttle Radar Topography Mission (SRTM) 1 second Digital Elevation Model (SRTM 1S DEM). The reduced water level was calculated by subtracting the measured water level from the ground surface elevation at each point, and then the point data was interpolated using the Kriging algorithm in the Surfer© surface modelling software. It is acknowledged that this surface includes data from different formations and differing hydraulic connectivity, and temporally disparate data, however the potentiometric surface is considered likely to be representative at the regional scale at which it was generated. There are likely to be significant discrepancies in areas of disturbance, such as in the immediate vicinity of mines.

The potentiometric surface is presented as Figure 20. It shows a general correlation between groundwater flow directions and topography. Groundwater elevations are highest in the vicinity of the Hillalong block. To the north of the drainage divide between the Burdekin and Fitzroy Basins and aligning roughly with the Lancewood block, groundwater flows to the north, whereas south of the divide, the general flow direction appears to be to the south. There is an area of elevated head to the southwest of Moranbah, driving an easterly flow direction through the South block. The potentiometric surface indicates that the Isaac-Connors River system is likely to be discharge feature.

The potentiometric surface was converted to a depth to water map by subtracting it from the SRTM 1S DEM. This is presented as Figure 21. The depth to water across the APT814P blocks is highly variable and generally dependent on the surface topography. For example, in the Lancewood Block, which has elevated topography, the depth to water is estimated to be up to 200 mbgl, whereas within the southern extent of the Sapphire block, the water level may be less than 10 mbgl.

Table 6 Summary of temporal water level trends

Block	Unit	Figure	Description
Monslatt	Alluvium	Figure 10	Data from 2 bores constructed within the Bee Creek alluvium is available which show trends that correlate to rainfall, i.e. declining trends over a period of below average rainfall. The two bores are separated by a distance of approximately 6.5 km, but show almost identical trends and water levels. The water levels in the alluvium are greater than 14 mbgl.
	Blackwater Group	Figure 11	Water level data is available for 3 bores. RN13040312 shows a strong correlation to rainfall, whereas the other two bores do not appear to respond to rainfall, yet are shallower. Water levels in the Blackwater Group are between 7 mbgl and 28 mbgl.
	Fort Cooper Coal Measures	Figure 12	Only one hydrography is available for the Fort Cooper Coal Measures. The water level is between 10 mbgl and 12 mbgl and shows a subdued response to rainfall.
Sapphire	Alluvium	Figure 13	Timeseries data is available for 2 bores screened in the alluvium associated with Billy's Gully. The bores show a subdued correlation to rainfall. Water levels in the alluvium are approximately 10 mbgl.
	Tertiary Basalts and Sediments	Figure 14	There are many bore screened in the Tertiary strata particularly to the east of the Sapphire block. These hydrographs show water levels varying between 3 mbgl and 37 mbgl, and temporal variability with seasonal responses (RN141421, RN141812), and some correlation to rainfall (RN131003, RN141813, RN141812) to an inverse relationship to rainfall (i.e. a rising trend when rainfall is below average – RN141456).
	Blackwater Group	Figure 15	Water level data for one bore is available, which shows a strong correlation between the water level response and rainfall. The bore is only 19 m deep and is constructed in fracture sandstone.
	Rangal Coal Measures	Figure 16	Hydrographs are available for 11 bores constructed in the Rangal Coal Measures. The hydrographs show little correlation to rainfall. Standing water levels mostly range from 13 mbgl to 35 mbgl, but the water level in RN182391 is ~62 mbgl and in RN162565 is ~82 mbgl. These bores are downdip of the mine pits and the water levels are likely influenced by mining. RN182392 and RN182390 were within the current extent of the mine pit and show a declining trend, likely related to pit progression towards their location. The difference in response with RN182391,

Block	Unit	Figure	Description
			which is in close proximity, suggest limited internal lateral and vertical connectivity within the Rangal Coal Measures. RN182078 shows a strong declining trend through 2018/2019, likely due to mining progressing towards its location. It is nested (co-located) with RN182079, which is constructed in the Tertiary Strata, and which shows no indication of a declining trend, suggesting a low degree of hydraulic connectivity between the monitored zones.
Central	Alluvium	Figure 17	2 bores with hydrographs are available, with water levels showing a strong correlation to rainfall, and a fluctuation of ~ 3 m. The water levels in the alluvium are between 3 mbgl and 7 mbgl.
	Rangal Coal Measures	Figure 18	Timeseries water level data is available for 3 bores. RN162241 and RN162242 are constructed to similar depth (~15m) and are immediately adjacent to each other and are on the bank of Walker Creek. The water level depth and response in these bores is almost identical and shows a slight correlation to rainfall. The shallow water level (3 -5 mbgl) suggests the upper weathered zone of the Rangal Coal Measures is in hydraulic connection to the creek at this location. RN162243 shows a declining water level trend from 2014 to 2022. The original water level was 13 mbgl, declining to 20 mbgl. The bore is 135m deep, with the water level decline likely due to mining at the nearby South Walker Creek mine.
South	Back Creek Group	Figure 19	Timeseries data is only available for one bore, which shows a flat then rising trend. The water level response is not directly correlatable to rainfall, but the rise may a delayed response to above average rainfall in 2011/2012.

Figure 9 Bores with timeseries water level data

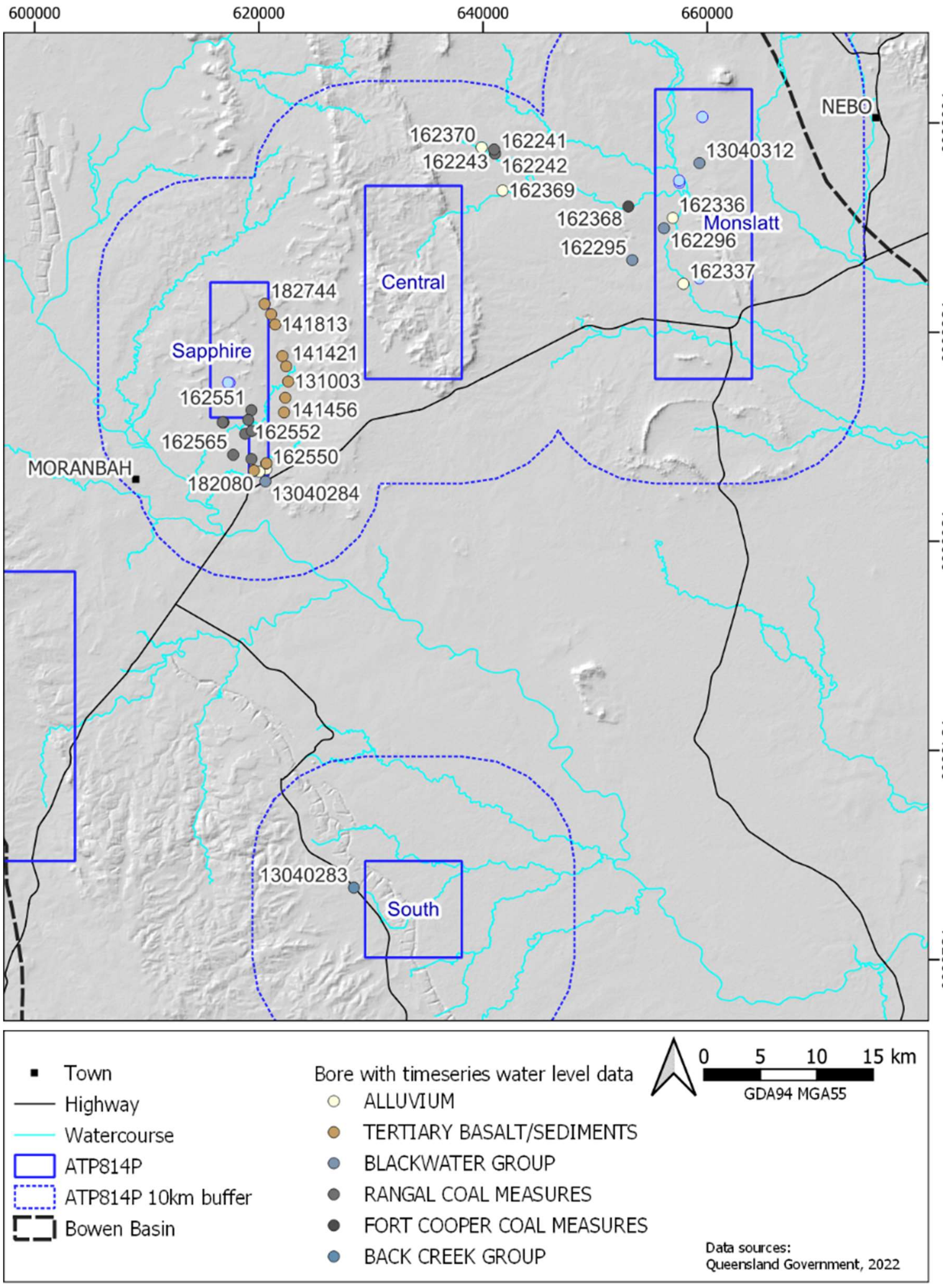


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Figure 10 Timeseries water levels: Monslatt Block - Alluvium

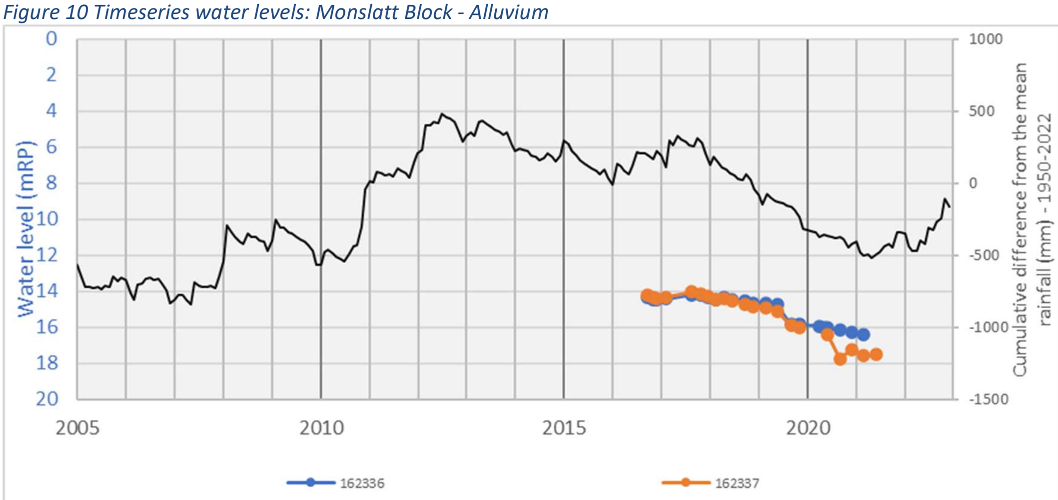


Figure 11 Timeseries water levels: Monslatt Block - Blackwater Group

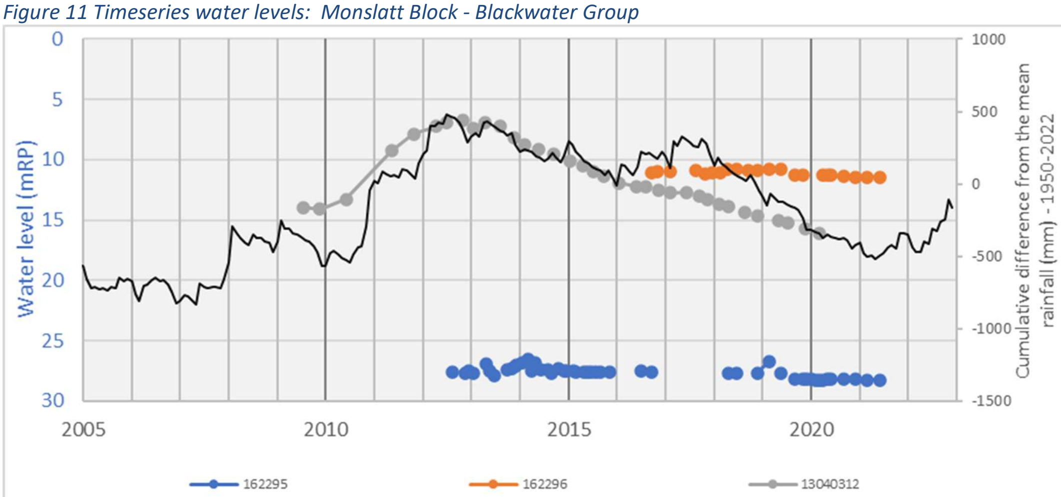


Figure 12 Timeseries water levels: Monslatt Block - Fort Cooper Coal Measures

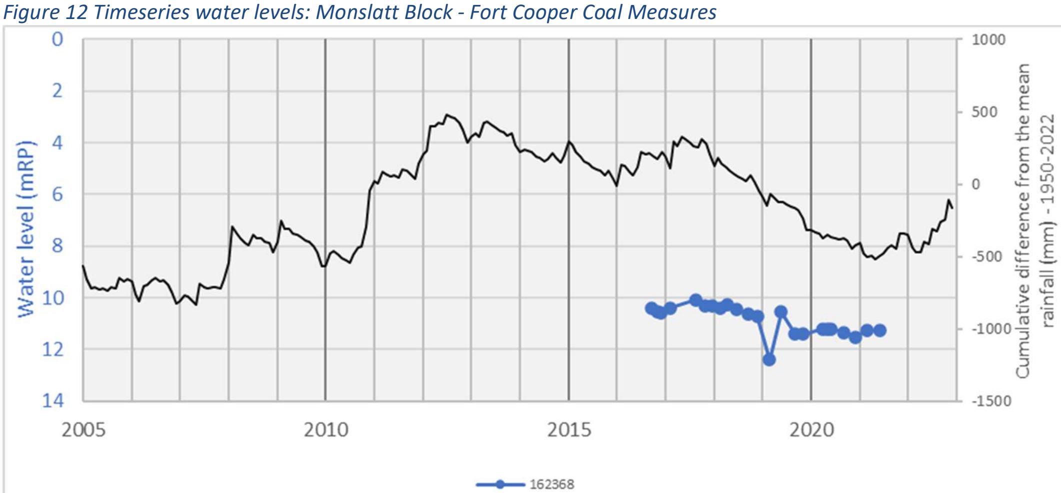


Figure 13 Timeseries water levels: Sapphire Block - Alluvium

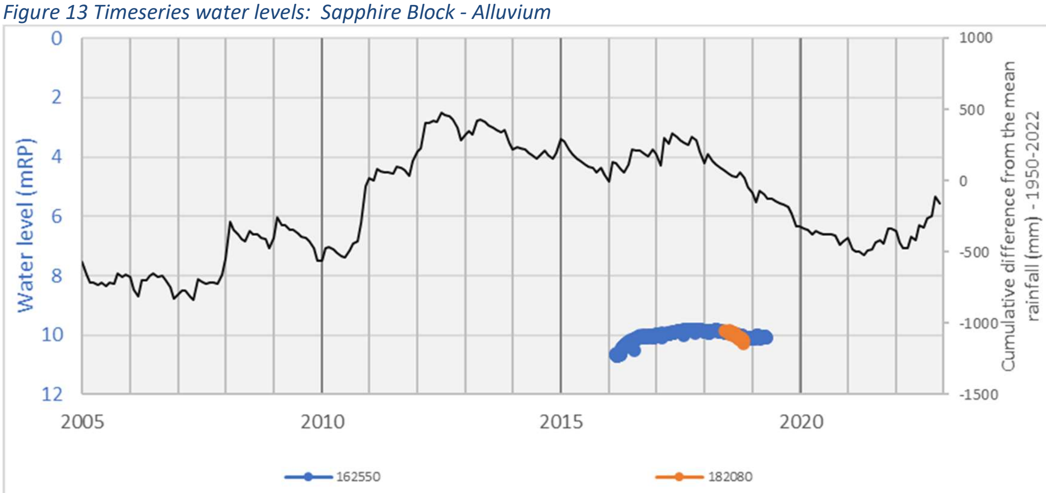


Figure 14 Timeseries water levels: Sapphire Block -Tertiary Basalts and Sediments

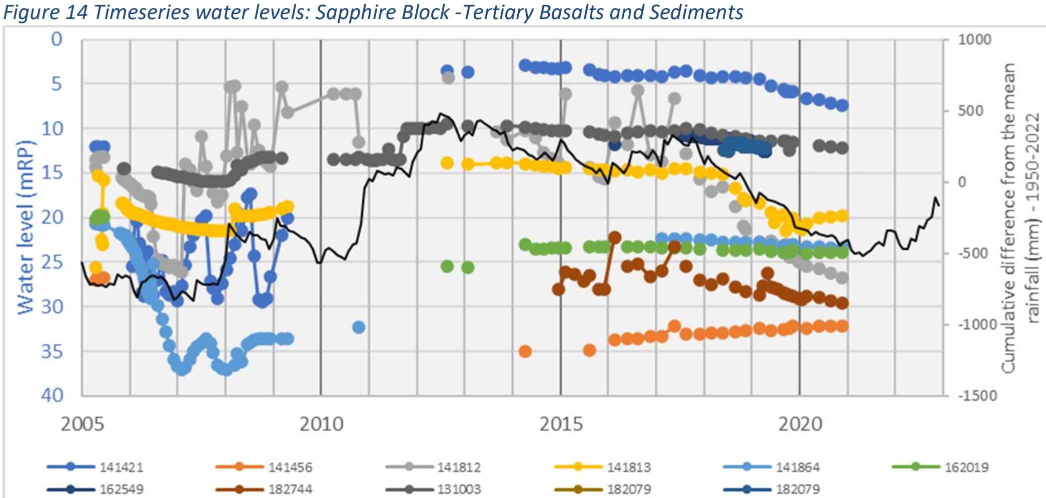


Figure 15 Timeseries water levels: Sapphire Block - Blackwater Group

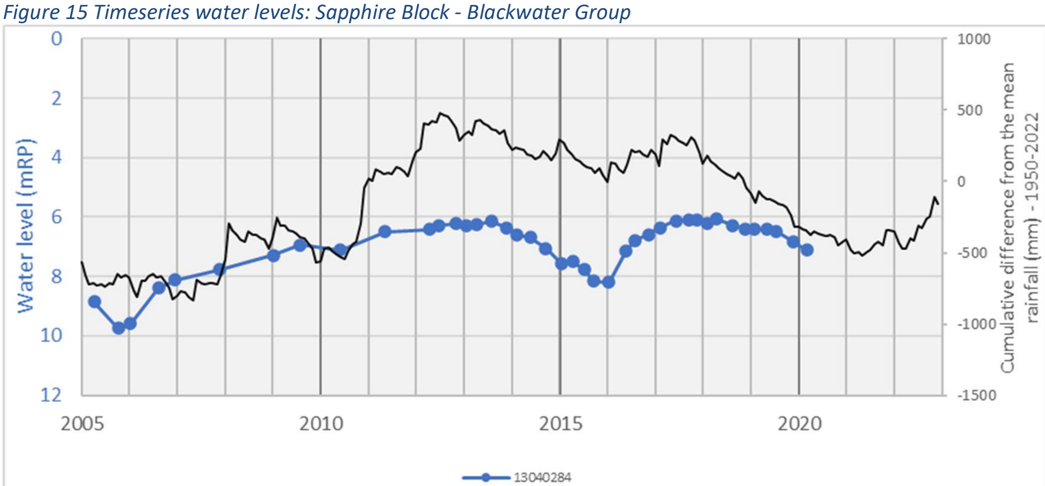


Figure 16 Timeseries water levels: Sapphire Block - Rangal Coal Measures

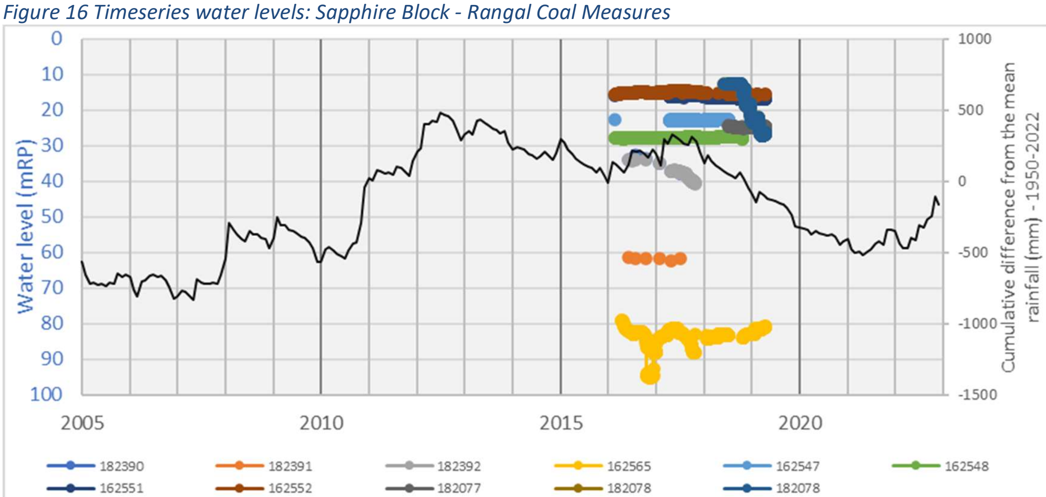


Figure 17 Timeseries water levels: Central Block – Alluvium

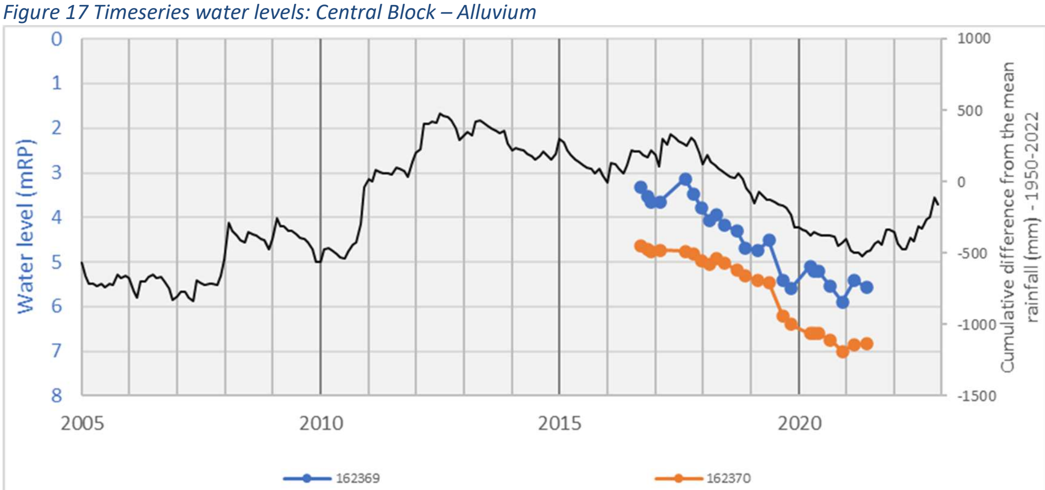


Figure 18 Timeseries water levels: Central Block – Rangal Coal Measures

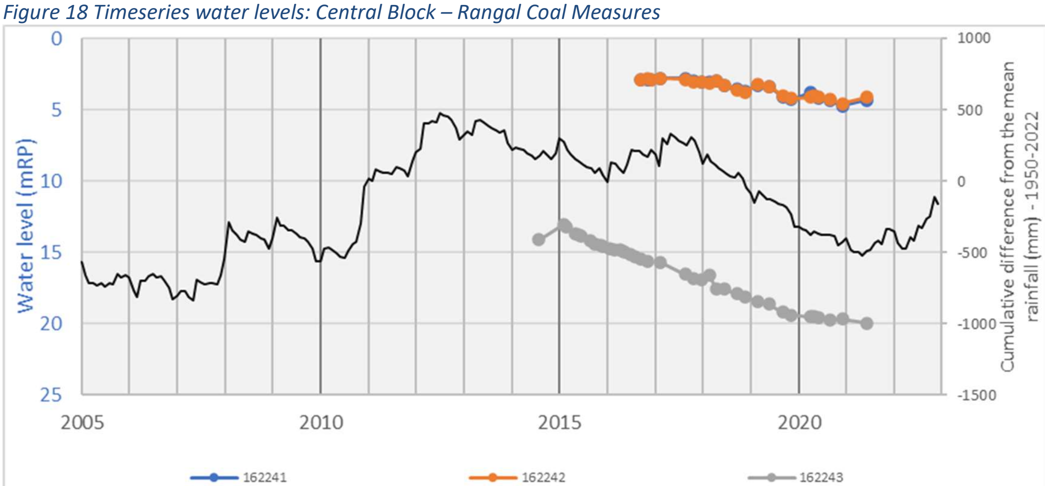


Figure 19 Timeseries water levels: South Block – Back Creek Group

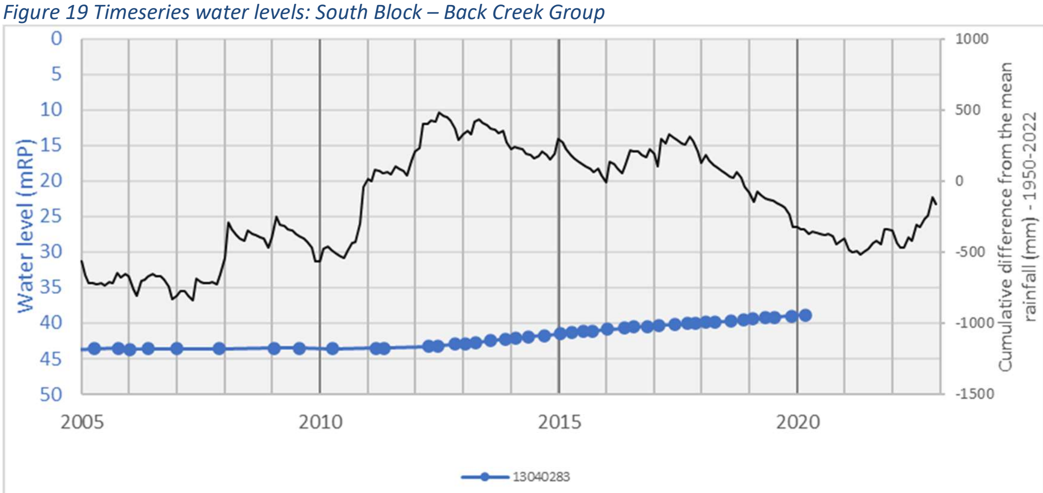


Figure 20 Composite potentiometric surface

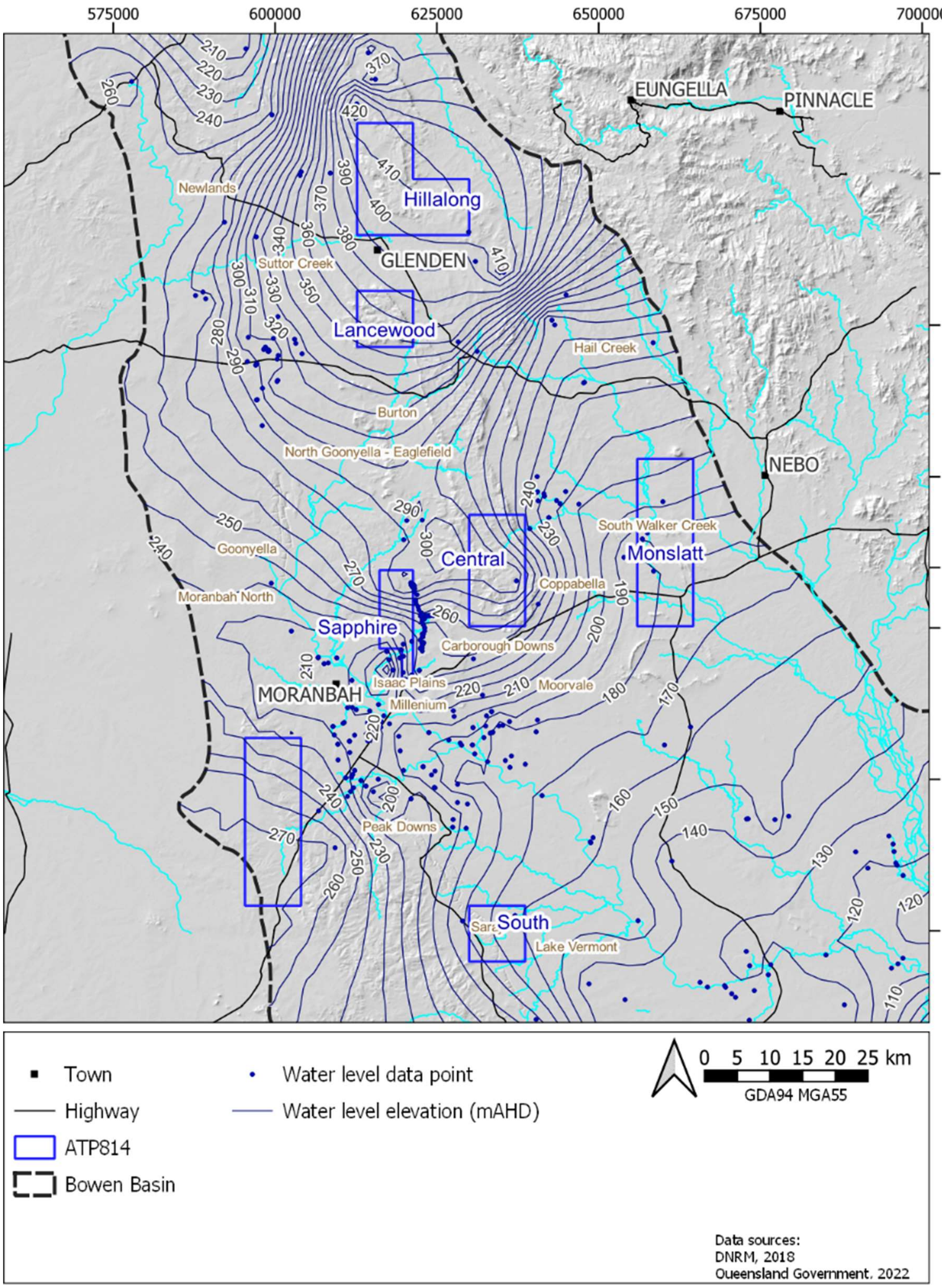
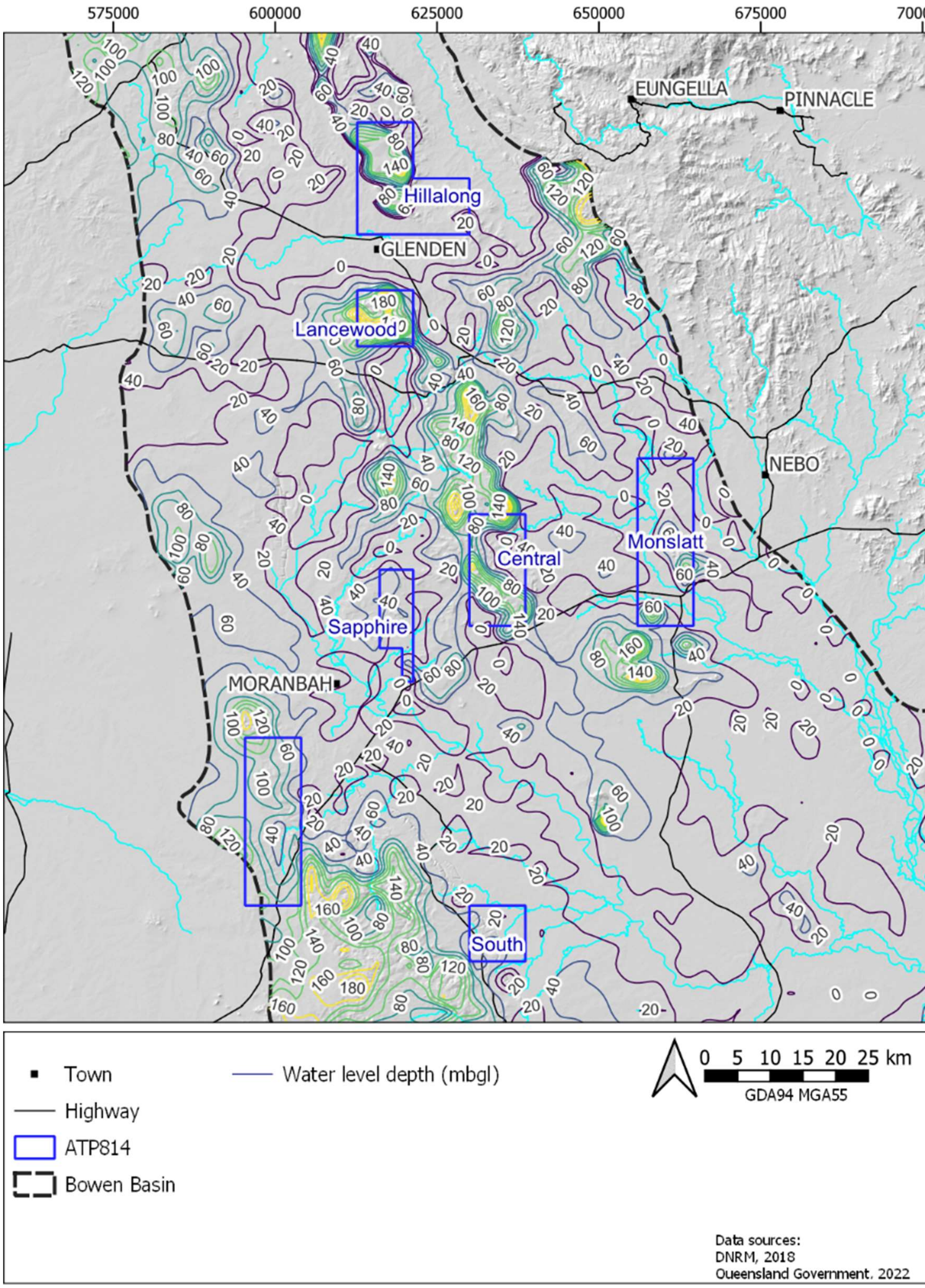


Figure 21 Depth to groundwater



4.6 Groundwater quality

Groundwater quality data has been sourced from the Blue Energy baseline assessments, the chemistry data from the GWBD and from a literature review of hydrogeological assessments of surrounding mines and the Arrow Energy Moranbah Gas Project (Arrow, 2022).

Figure 22 presents a piper tri-linear diagram that shows the relative proportion of the major ions using the most recently available sample from each bore. The diagram has been prepared using a method based on Peeters (2014) whereby the position on the trilinear diagram is represented by a specific colour. This same colour has then been used on Figure 23 to elucidate any spatial trends in the major ion chemistry and groundwater salinity.

Figure 22 shows that the majority of groundwater exhibit a sodium-chloride-bicarbonate water type, but with a wide range particularly of the relative cation concentrations. There does not appear to be a consistent water type or trend to the water types by unit. Figure 23 (and Figure 24) supports the piper diagram, by indicating that there are wide ranges in salinities for each of the units, and the only apparent large-scale spatial trend is an increase in salinity (as measured by electrical conductivity) to the south of the study area. In relatively data-rich areas, such as to the southeast of the Lancewood block, to the south of Sapphire block and in the South block, significant intraformational variability can be observed over short distances. This suggests poor hydraulic connectivity within and between groundwater units.

Electrical conductivities vary widely within each unit (Figure 24), with most units hosting groundwater electrical conductivities of greater than 5,000 µS/cm to in excess of 40,000 µS/cm.

Figure 22 Piper tri-linear diagram of major ion chemistry

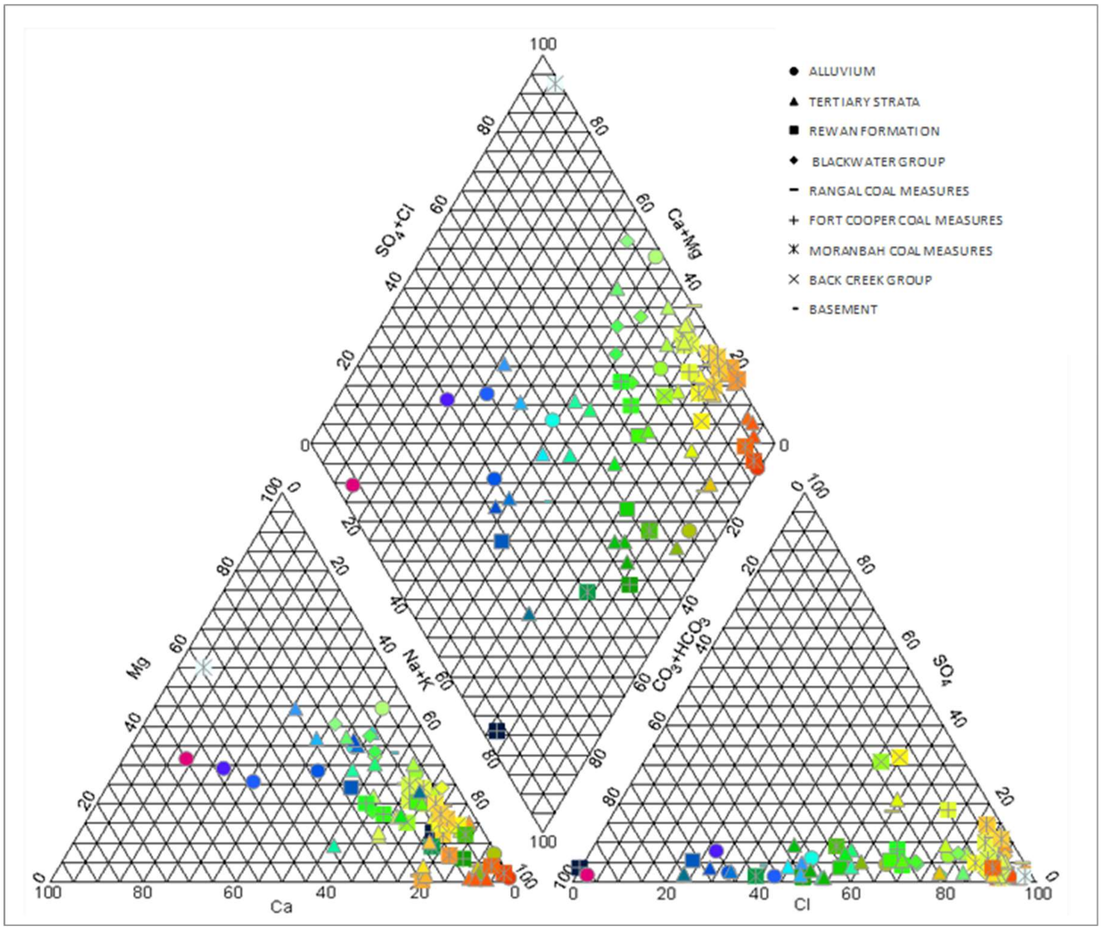
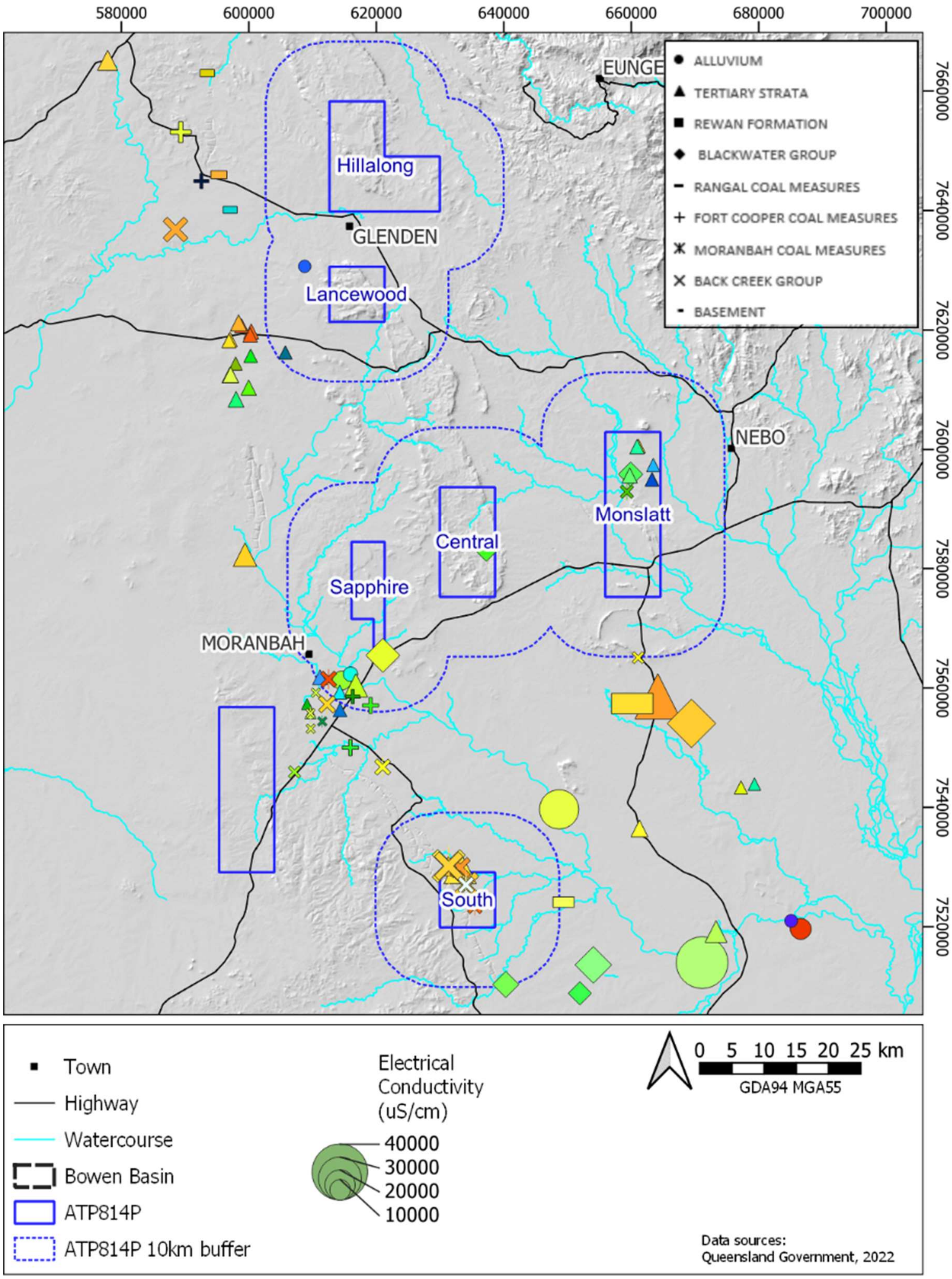


Figure 23 Spatial distribution of water type and electrical conductivity



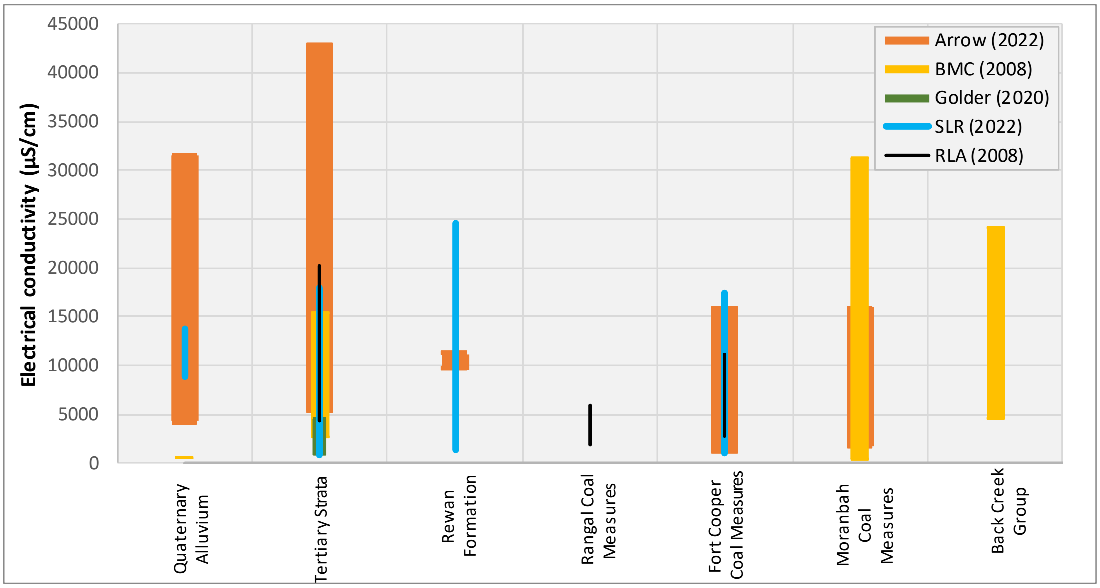
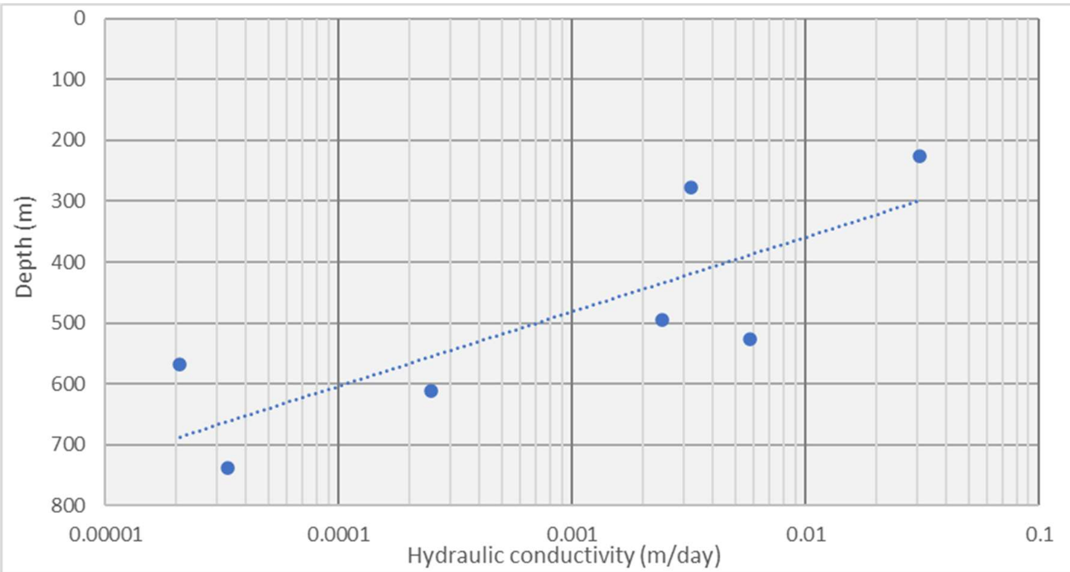


Figure 24 Comparison of electrical conductivities

4.7 *Hydraulic parameters*

Blue Energy undertook drill stem test (DST) permeability testing during the drilling of the Sapphire 2, 3 and 4 wells, with results shown in Figure 25. These results show a clear decrease in hydraulic conductivity[3] with depth, of approximately three orders of magnitude over a 500 m depth interval.

Figure 25 Depth versus hydraulic conductivity from DSTs in the Sapphire block



In preparing the environmental impact assessment for the Isaac Plains coal mine located to the south of the Sapphire block, AGE (2020) compiled the results of hydraulic conductivity field tests, which are reproduced in Table 7. The wide range in the horizontal hydraulic conductivity of the basalt (in particular) is reflective of the fractured rock nature of the formation. Higher hydraulic conductivities in the coal measures are also likely to be related to fracturing rather than the intrinsic permeability of the rock matrix, but also show a decrease in permeability with depth.

Blue Energy also performed drill stem tests during exploration and appraisal activities in the Monslatt block. Permeability measurements of the Permian coals in Monslatt were mostly less than $1x10^{-4}$ m/day, with a maximum measurement of 0.025 m/day.

Limited vertical hydraulic conductivity (Kv) data has been identified in literature for the Bowen Basin. Most models utilised a 0.1 multiplier of vertical to horizontal hydraulic conductivity (Kh) (i.e. vertical is ten time less than horizontal). OGIA (2019), using numerical permeameters to

[3] Intrinsic permeability converted to hydraulic conductivity using a conversion factor of 0.831 m/day = 1,000 millidarcies (Bouwer, 1978)

upscale data, derived Kh/Kv ratios of ranging from ~0.5 to 1 x 10^6 for the coal measures, and 0.5 to 5 x 10^{-4} for the clastic formations.

Specific storage represents the volume of water a formation releases from storage per unit change in hydraulic head under fully saturated conditions and relates to the expansion of the water (decompression) or compression of the aquifer as a result of the change in pressure. It imparts influence on the rate and extent of drawdown propagation and recovery. Arrow (2022) explored the uncertainties relating to the adopted specific storage values and tested the following ranges in this parameter:

- Coal Measures – $2x10^{-5}$ m^{-1} to $1x10^{-6}$ m^{-1}
- Interburden - $1x10^{-6}$ m^{-1} to $4x10^{-6}$ m^{-1}
- Tertiary - $1x10^{-6}$ m^{-1} to $2x10^{-5}$ m^{-1}

Table 7 Estimates of hydraulic conductivity (after AGE, 2020)

Unit	Hydraulic conductivity (m/day)	
	Horizontal	Vertical
Alluvium	0.01 - 8.1	
Tertiary Sediments	0.04 – 2	
Basalt	0.1 – 6.4	
Moolayember Formation	1.8 x 10^{-6}	5.1 x 10^{-10}
Clematis Group	0.01	3.7 x 10^{-5}
Rewan Group	1.8 x 10^{-6} – 0.004	7.8 x 10^{-7} – 1.1 x 10^{-5}
Weathered Permian	0.004 – 0.1	
Rangal Coal Measures – coal	0.03 – 4.2	
Rangal Coal Measures – interburden	6.2 x 10^{-7} – 6 x 10^{-3}	3.1 x 10^{-7} – 4.5 x 10^{-6}
Fort Cooper Coal Measures – Fairhill Seam	8.4 x 10^{-5} – 8.4 x 10^{-4}	
Fort Cooper Coal Measures	0.03 – 2.5	
Moranbah Coal Measures – Goonyella Middle Seam	8.4 x 10^{-4} – 0.3	

4.8 Aquifer interactions

Interaction between aquifers in the Bowen Basin is limited. Evidence for this is provided by the following:

- Despite being of relatively low permeability, the coal seams form the primary aquifers within the Permian-aged sequence. The individual coal seams may be laterally extensive, but they are separated by thick packages of low permeability interburden.
- Higher hydraulic conductivities in the coal measures are likely to be related to fracturing rather than the intrinsic permeability of the rock matrix, and also show a decrease in permeability with depth.
- Water levels in similar depth bore in close proximity show differing responses to rainfall. Correlation of water level responses to rainfall appear to be primarily related to proximity to

watercourses and shallow bore depth. There is no indication of rainfall recharge to the deeper coal measures.

- There is significant intraformational variability in water quality over short distances.
- Wide ranges in the horizontal hydraulic conductivity of the basalt (in particular) is reflective of the fractured rock nature of the formation. The hydraulic testing data will be biased to the higher permeability parts (fractures) of the tested zone. The fractures are separated by low permeability material, resulting in a water bearing zones of limited lateral and vertical connectivity and an overall low bulk hydraulic conductivity.

5 Environmental Values

The environmental values (EVs) of water are the qualities that make it capable of supporting aquatic ecosystems and human uses. The Queensland Government's *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water and Wetland Biodiversity) is the primary vehicle through which the EVs of waterways in Queensland are protected. The following EVs are listed under Section 6(2) of the EPP Water and Wetland Biodiversity:

- Aquatic ecosystems associated with high ecological value, slightly disturbed, moderately disturbed and highly disturbed waters,
- Aquaculture,
- Agriculture,
- Recreation (primary, secondary and visual),
- Drinking water,
- Industrial use, and
- Cultural and spiritual values.

The exercise of underground water rights has the potential to impact on these EVs through the degradation the reduction in water availability through depressurisation. The EVs are supported by either groundwater supply bores (e.g. aquaculture, agriculture, drinking water and industrial use) or through the surface expression of groundwater via springs and baseflow to surface water bodies and their associated wetlands (all identified EVs). Aquatic ecosystems also include terrestrial groundwater dependent ecosystems, for which there may not be a surface expression of the groundwater.

The environmental values within the vicinity of ATP814P are described in the following sections.

5.1 Groundwater Bores

The GWBD was used to identify potentially active water supply bores on and within 10 km of the ATP814P blocks. Potentially active water supply bores includes all those registered bores that are not identified as "Abandoned and Destroyed" or that can be readily identified as exploration, monitoring or investigation bores via the Queensland Globe mine monitoring bore layer, their listed purpose, original names or construction details. Where there was any uncertainty, the bores were assumed to be water supply bores.

The GWBD search identified 647 registered water bores on or within 10 km of ATP814P, with the Blue Energy baseline assessments identifying an additional 12 unregistered bores. The locations of the bores and their purpose is shown on Figure 26. Of the 659 bores:

- 72 were identified as Abandoned or Destroyed.
- 15 were identified to be for mineral or petroleum exploration.
- 454 were identified to be for monitoring or investigation purposes.
- 112 were identified to exist for water supply.

The formation accessed by the bore was interpreted from the strata logs for the bores and the mapped surface and solid geologies at the bore location. The assigned formations for each of the water bores is listed in Appendix A and is mapped on Figure 27. The majority of the bores are interpreted to access the Tertiary Strata or the Triassic formations, such as the Rewan Group or the Clematis Group, or undifferentiated early to mid Permian formations, that may include the coal seams.

Figure 26 Groundwater bore locations and purpose

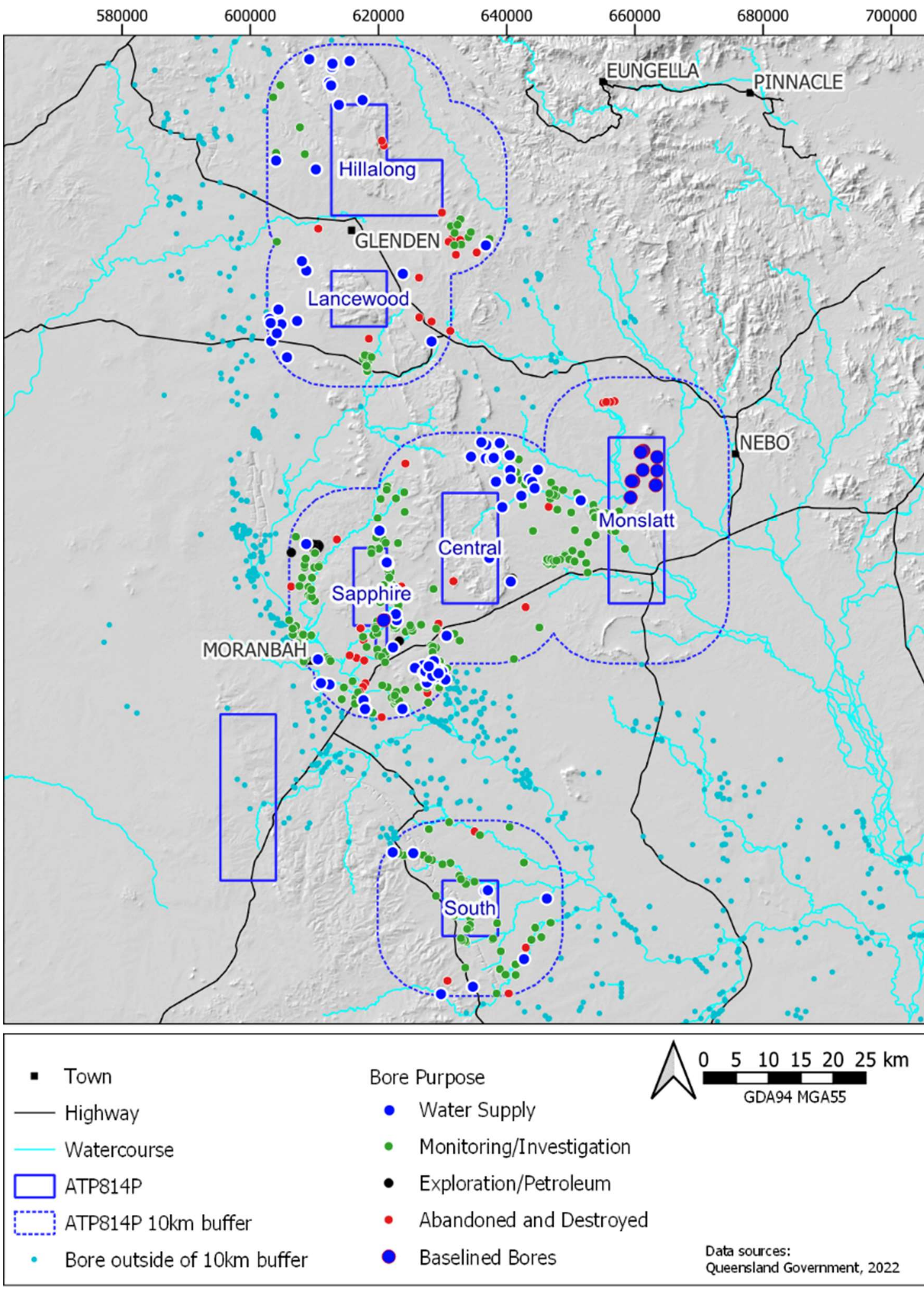
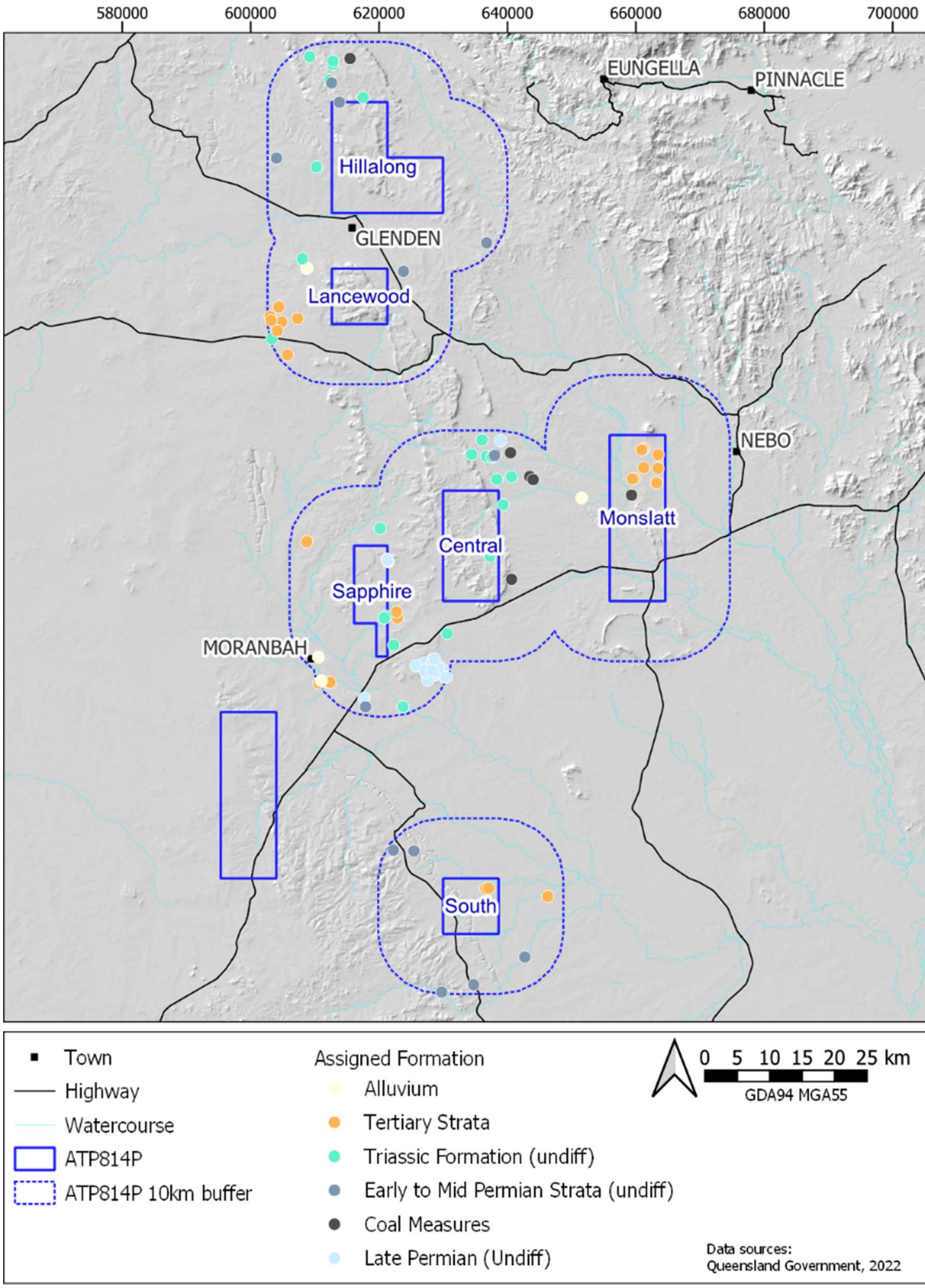


Figure 27 Water supply bores and assigned formation



5.2 Groundwater Dependent Ecosystems

Doody et al. (2019) defines groundwater dependent ecosystems (GDEs) as natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services. The broad types of GDEs are (Eamus et al., 2006):

- Ecosystems dependent of surface expression of groundwater – springs, groundwater fed wetlands or baseflow fed streams or rivers,
- Ecosystems dependent on sub-surface expression of groundwater – terrestrial GDEs, and
- Subterranean ecosystems – stygofauna

Figure 17 presents the location of potential GDEs in the vicinity of the ATP814P blocks, with a description provided in Table 8.The data was sourced from the BoM GDE Atlas (BoM, 2023).

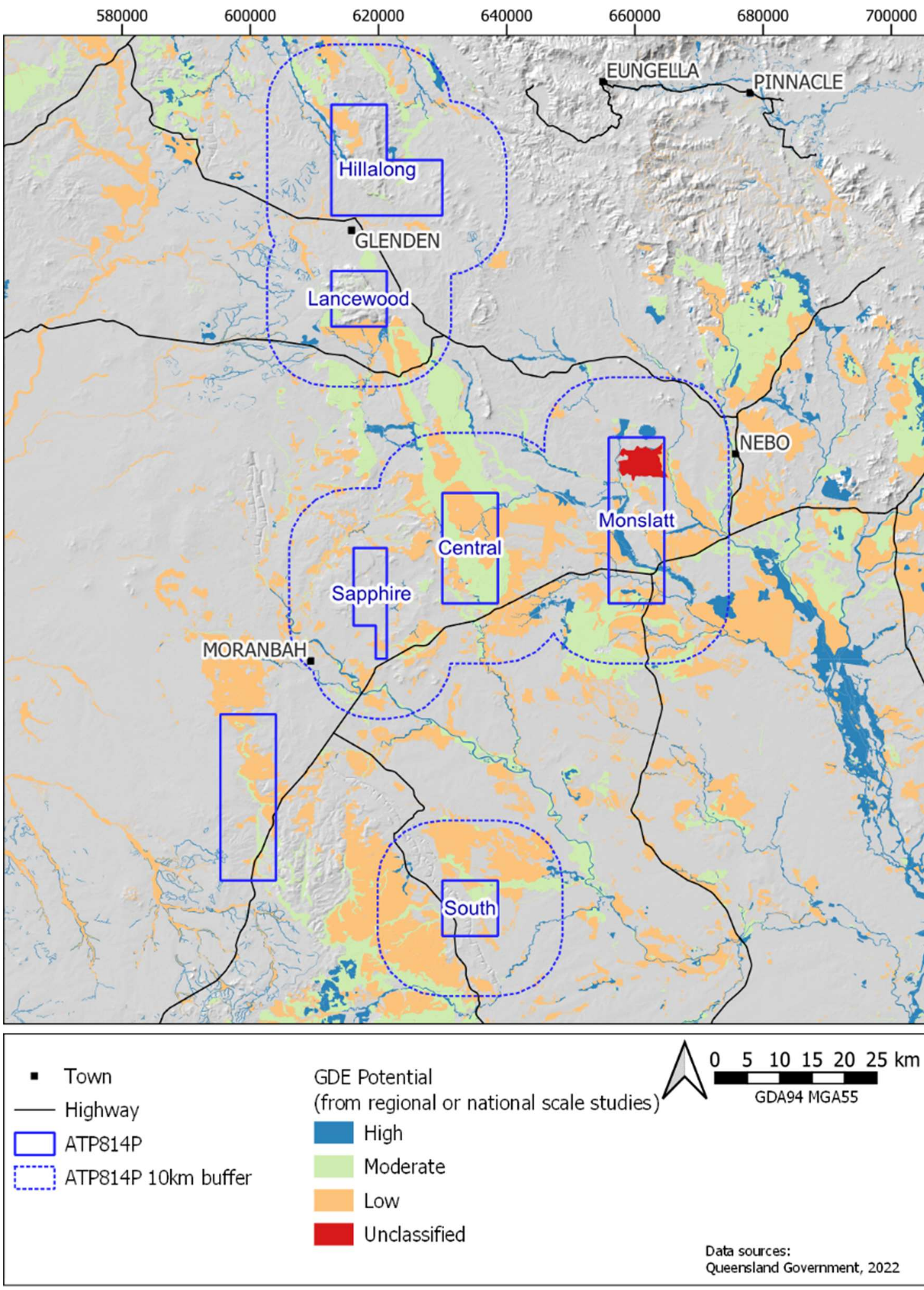
There are no mapped springs within 80 km of any of the blocks that constitute ATP814P.

Table 8 Summary of mapped potential GDE distribution

Block	Potential GDE Distribution
Hillalong	High potential GDEs associated with the break in slope of the western margin of the elevated plateau of the Clematis Sandstone outcrop. Moderate and low potential GDEs associated with the plateaus and Cattle Creek to the northeast of the block. Small area of high potential GDE to the northeast corner associated with the plateau of Clematis Group outcrop.
Lancewood	Moderate potential terrestrial GDEs associated with small ephemeral drainage lines through the north of the block. The GDE Atlas identifies these as intermittent, persisting for the medium term. Low and moderate potential terrestrial GDEs mapped around the southern boundary of the block, associated with the alluvial plains of the Isaac River.
Sapphire	Low potential terrestrial GDEs in the north and the south aligned with mapped alluvium of the ephemeral Teviot Brook in the north and an unnamed watercourse in the south. The mapped area in the south area includes parts of the Isaac Plains mine pits. There are also some small areas of moderate potential terrestrial GDEs in the south. High potential terrestrial GDEs are mapped in association with the Isaac River to the southwest of the block, and in a small area associated with Smoky Creek to the east of the block.
Central	Most of the Central block is mapped with low and moderate potential terrestrial GDEs. These areas are underlain by the elevated landscape of the Triassic-aged Clematis Group and Moolayember Formations. High potential terrestrial GDEs associated with Carborough and Spring Creeks.
Monslatt	The mapped potential GDEs in the Monslatt block varies from low to high potential, with relatively large area in the north identified as unclassified. The unclassified area is underlain by Tertiary basalt, and appears to be land cleared for agriculture.

Block	Potential GDE Distribution
	The high potential areas are associated with riparian vegetation along the ephemeral Bee Creek on the block, and Cooper Creek to the east of the block. The classification of GDE potential is based on regional scale assessment, and artefacts of this can be seen with the potential changing on either side of roads, with no change in underlying geology or topography.
South	The south block is dominated by the Saraji coal mine, although there are large swathes of moderate and low potential terrestrial GDE mapped in the north of the block and to the west of the mine. The northeast corner of the block is mapped as moderate potential terrestrial GDE. The potential GDEs are mapped in associated with the alluvial sediments of the Isaac-Connors river system.

Figure 28 Mapped GDEs (after BoM, 2023)



6 Prediction of Groundwater Impacts

Groundwater flow models were constructed to enable the prediction of groundwater level drawdown due to the exercise of underground water rights on ATP814P. The objective of the modelling was to identify the extent of drawdown exceeding the *Water Act 2000* trigger thresholds as follows:

- Bore trigger threshold for a consolidated aquifer – 5 m
- Bore trigger threshold for an unconsolidated aquifer – 2 m
- Spring trigger threshold - 0.2 m

6.1 General Method

Underground water rights have only been exercised in the Monslatt and Sapphire blocks, which are 35 km apart. Individual groundwater flow models have been constructed for each of the blocks using the two-dimensional groundwater flow modelling package MLU for Windows (Hemker and Post, 2020).

MLU can perform transient drawdown calculations in layered aquifer systems. It assumes all layers are homogeneous, isotropic and of infinite extent, however the hydraulic characteristics of individual layers can be independently parameterised. It assumes lateral flow through aquifers and vertical flow through aquitards. Only groundwater flow resulting from pumping from bores can be simulated, i.e. it does not consider recharge, non-bore discharge and cross- or through-flow, however these are not relevant within the area predicted to be potentially impacted. Over the spatial and temporal scale of the pilot activities within ATP814P, the effectively layer-cake geology and the intraformational consistency in the lithologies, at the scale of the pilot activities and the predicted extent of the pressure changes, these limitations are considered appropriate for the purposes of predicting water level declines associated with the pilot activities. MLU is a single-phase (water only) groundwater flow simulator.

6.2 Monslatt Block

Pilot testing of four wells was performed in the Monslatt block from March 2011 through to January 2013. All four wells targeted the P seam of the Moranbah Coal Measures. The actual extraction rates are provided in Table 2.

A 4-layer MLU model was constructed to simulate the exercise of underground water rights in the Monslatt block (Table 10). The depths and thickness of the layers are based on the averages the Monslatt 4, Monslatt 5P, Monslatt 6P and Monslatt 7 wells. Actual extraction rates were applied to each of the wells in model aquifer number 2.

A 4-layer numerical groundwater flow model was constructed for the previous Blue Energy UWIR for ATP814P (Blue Energy, 2015) The hydraulic parameterisation for the MLU model was based on the calibrated model values from the previous model as show in Table 9. The basalt aquifer was assumed to be confined, to provide a more conservative estimate of potential drawdown compared with an unconfined aquifer.

To enable timeseries data extraction, monitoring bores were assumed to be located coincident with the production wells. A monitoring bore was assigned to both model aquifers at each well location.

Table 9 Monslatt Block – model layering and base case parameterisation

Layer Name	Aquifer number	Layer base depth (m)	Layer thickness (m)	Horizontal hydraulic conductivity (m/day)	Vertical hydraulic conductivity (m/day)	Storage coefficient (-)
Basalt Aquifer	1	32	32	0.0143	-	0.0001
Overburden	-	526	494	-	0.000001	-
P Seam	2	538	12	0.01	-	0.00001
Basement	-	1038	1000	-	0.000001	-

6.2.1 Predicted magnitude and extent of groundwater level decline

Figure 29 provides the timeseries drawdown from the each of the production well locations. This figure shows:

- Maximum predicted drawdown occurs concurrently with and proportionally to the maximum water extraction rate. A maximum predicted drawdown in the P Seam of 219 m was predicted to occur in Monslatt 5P. Drawdown in Monslatt 4 and Monslatt 6P was not predicted to exceed 10 m at a maximum at any time. The relative magnitudes of drawdown between the wells is driven by their water extraction rates.
- All drawdowns were predicted to recover to less than 5 m within 940 days after the *start* of production. This is the equivalent of September 2013.
- The maximum predicted drawdown at any time for the basalt aquifer was less than 0.1 m.

Figure 31 is a map showing the composite of the maximum magnitude and extent of drawdown in the P Seam at the end of the month of maximum water production each pilot well. The maximum extent of predicted drawdown (assumed to be 0.2 m) is teardrop in shape and incorporates Monslatt 5P, Monslatt 7 and Monslatt 4. It extends a maximum of approximately 18.5 km in the north-south orientation and 13.8 km in the east-west orientation. An area with a radius of approximately 1 km was predicted to be drawn down by more than 0.2 m surrounding Monslatt 6P.

6.2.2 Model sensitivity analysis

Sensitivity of the drawdown predictions was assessed by varying the hydraulic parameters used in the model. The intent of varying the parameters was to increase the predicted drawdown, particularly of the surficial Basalt aquifer which local water supply bores access and would support GDEs. Four scenarios were assessed:

- **Case 1** – Increase the vertical hydraulic conductivity by a factor of 10. This would increase the leakage between the P Seam and the surficial basalt aquifer.

- **Case 2** – decrease the horizontal hydraulic conductivity by a factor of 10. This would increase the drawdown in the P Seam resulting in greater hydraulic gradients and potential for induced leakage from other layers.
- **Case 3** – decrease the storativity of the coal seams to $5x10^{-6}$. This would increase the drawdown in the P Seam resulting in greater hydraulic gradients and potential for induced leakage from other layers.
- **Case 4** – all of the above.

The maximum predicted drawdown for each case is shown on Figure 30. This shows that:

- Decreasing the horizontal hydraulic conductivity and combining all the changes results in maximum predicted drawdowns in the P Seam of 1,930 m and 1,749 m respectively. These predicted drawdowns are significantly greater than the depth of the P Seam (538 m in the model - Table 9) and are therefore the parameterisation is unrealistic in the real world. The base case adopted parameters provide a reasonable estimate of the potential drawdowns.
- All sensitivity analyses result in greater predicted drawdown in the Basalt aquifer. Of the realistic scenarios, the increase in the vertical hydraulic conductivity (Case 1) is predicted to increase the drawdown in the Basalt aquifer to 0.8 m and decreasing the storativity (Case 3) would increase the maximum predicted drawdown to 0.12 m. For Case 1, the drawdown is not predicted to exceed 0.2 m

The extent of the 5 m drawdown contour for the P Seam and the 0.2 m contour for the Basalt aquifer for Case 1 and Case 3 at the end of production (458 days) is compared with the Base Case on Figure 32. This shows that while Case 1 is predicted to result in a greater magnitude of drawdown, the extent of the predicted drawdown will contract in the Basalt aquifer. For the P Seam, an increase in the vertical hydraulic conductivity (Case 1) results in a contraction in the extent of the 5 m predicted drawdown contour, whereas a decrease in the storativity will increase the extent of the 5 m predicted drawdown contour. The changes are as expected for the direction of change for the hydraulic parameters.

Figure 29 Monslatt Block – base case timeseries predicted drawdown

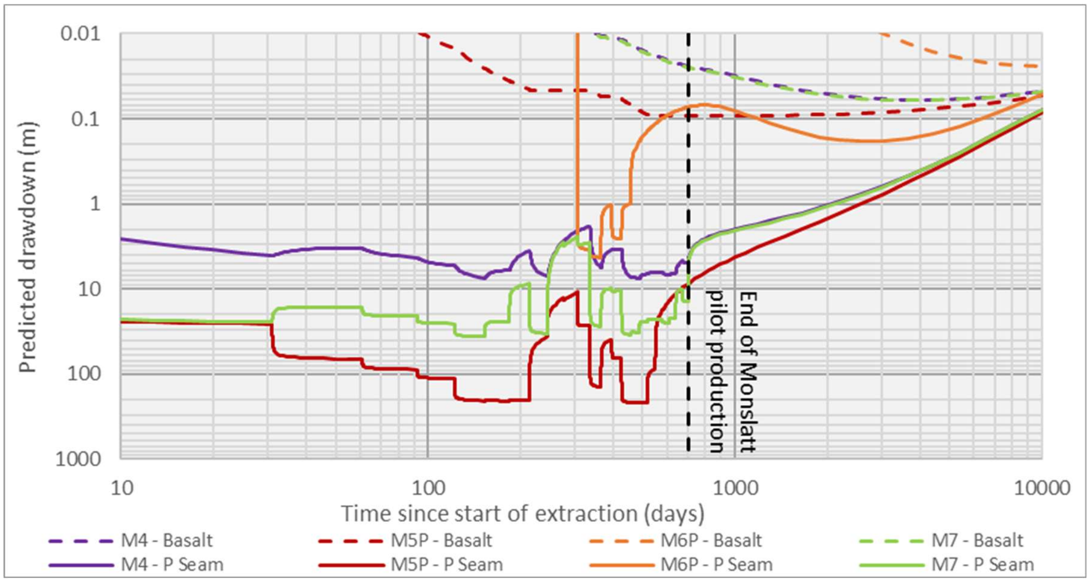


Figure 30 Monslatt Block - model parameter sensitivity analysis: maximum predicted drawdown

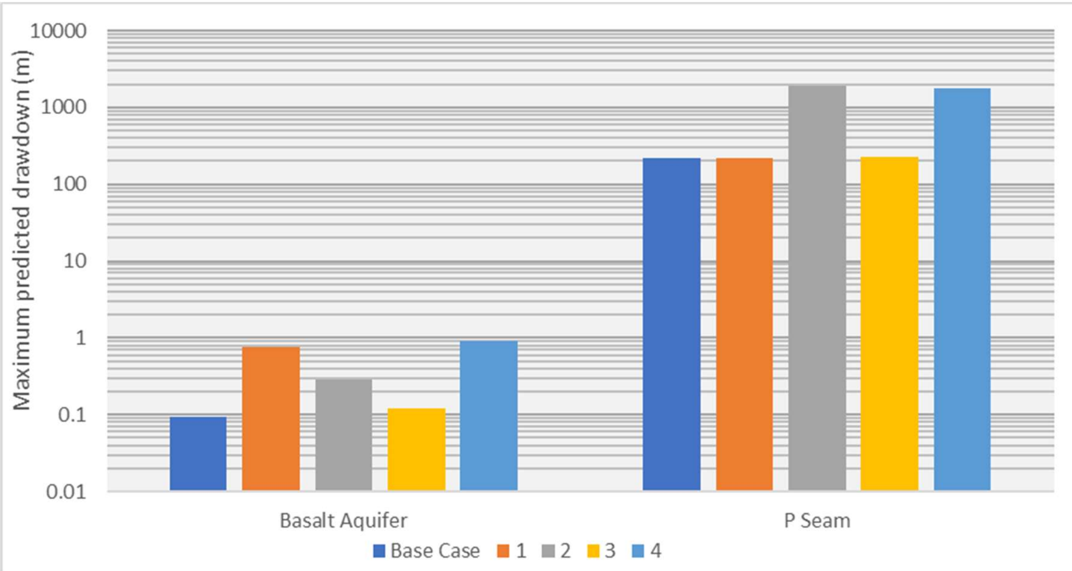


Figure 31 Monslatt Block – predicted drawdown at end of maximum water production (composite)

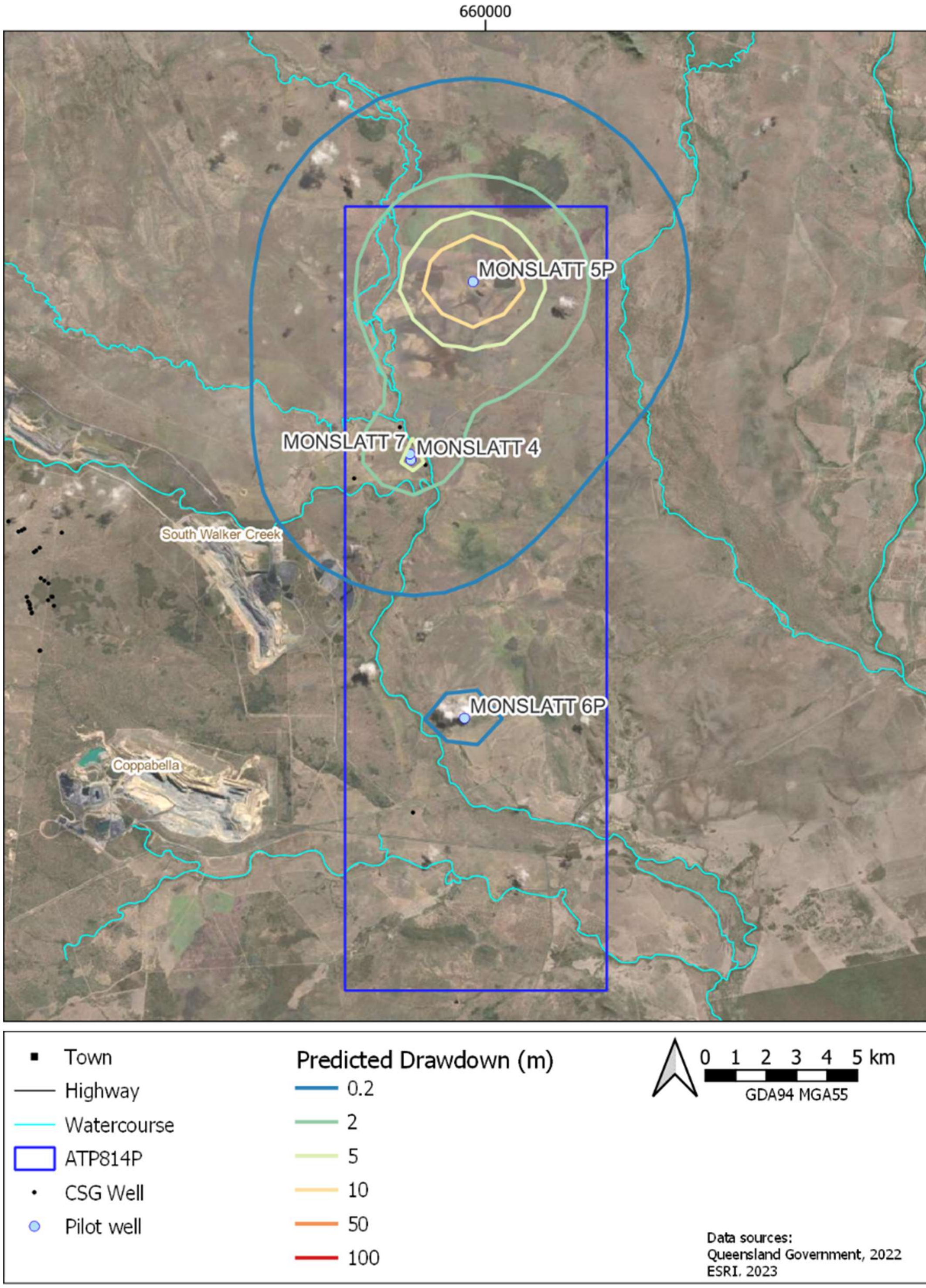
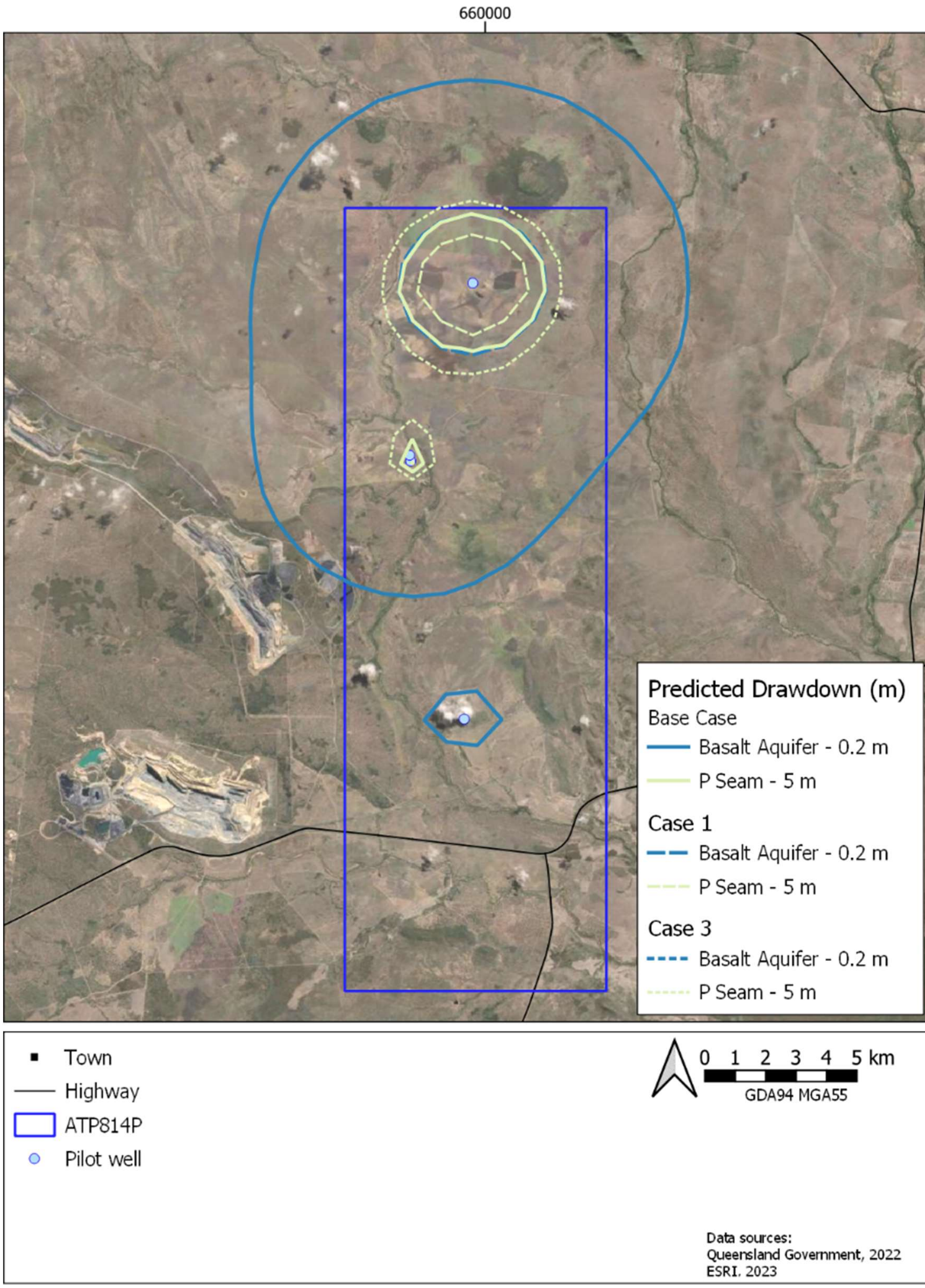


Figure 32 Monslatt Block - comparison of predicted drawdown contours for Base Case and sensitivity analyses



6.3 *Sapphire Block*

Blue Energy has historically exercised its underground water rights and is currently exercising its underground water rights on the Sapphire block .

In 2012, Sapphire 4 well was on pilot production for approximately 6 months (Table 2).

For the current appraisal activities, two sets of wells have been drilled in the Sapphire block. Sapphire 5 has four laterals constructed in the Leichardt, Vermont, Middle Main and Upper Goonyella coal seams. Sapphire 6 has three laterals constructed in the Leichardt, Vermont and Fair Hill coal seams. Each set of lateral wells has an associated vertical well in which the pump is installed.Pilot production commenced on 23 December 2022 and is anticipated to run for one year. The assumed extraction rates are shown on Figure 1.

A 12-layer MLU model was constructed to simulate the exercise of underground water rights in the Sapphire block (Table 10). The depths and thickness of the layers are based on the average from the Sapphire 5 and Sapphire 6 vertical wells. Surface geology mapping identifies that Tertiary strata are not present the vicinity of the pilot (Figure 4) and MLU does not provide predictions for aquitard layers, thus a nominal 10m thick surficial aquifer was included in the model to enable simulation of the potential drawdown of the water table.

The horizontal hydraulic conductivity for each of the coal seams was calculated based on the depth of the model layer and the relationship between hydraulic conductivity and depth show in Figure 25. A uniform vertical hydraulic conductivity value of $1x10^{-5}$ m/day was assigned to the interburden layers. A storativity of $1x10^{-5}$ was assigned to the coal seams, and a specific yield 0.1 was assigned to the surficial aquifer. Sensitivity of the predictions to changes in the hydraulic parameters was assessed.

For the Sapphire 4 pilot, the single was assigned to MLU aquifer number 4, representing the Middle Main seam of the Fort Cooper Coal Measures. Due to the short duration of this pilot production, the small volume of water produced, and the significant time interval between that production ceasing and the current pilot activities, the Sapphire 4 production was modelled as a discrete event.

For the current Sapphire 5 and Sapphire 6 pilot and since MLU cannot simulate horizontal wellbores, the average trajectory of the laterals for each set of wells was evenly discretised into four pseudo-wells per lateral well group. The pseudo-wells were assigned to extract from the model layers of associated with that well group's target seams. Water extraction was evenly divided between the pseudo-wells. A location central to the eight pseudo-wells was used for to extract timeseries predictions from the model. The locations of the pseudo-wells and the point where timeseries data was extracted are shown on Figure 35 to Figure 39.

6.3.1 *Predicted magnitude and extent of groundwater level decline*

Figure 33 provides the predicted timeseries drawdown at the location of the Sapphire 4 well during the production in 2012. This figure shows:

- Maximum drawdown of 26 m occurred in the Middle Main seam, corresponding to the end of the production pilot (December 2012).

- Water level drawdown was predicted to recover to less than 5 m within three days of water extraction ceasing.
- Predicted drawdown did not exceed 5 m in any of the other aquifers.

The magnitude and extent of drawdown associated with the Sapphire 4 pilot in 2014 has not been mapped because the extent of drawdown exceeding 5 m was not predicted to extend beyond 100 m from the Sapphire 4 well. Drawdown associated with the Sapphire 4 pilot production has not been further considered in this UWIR.

Figure 34 provides the predicted timeseries drawdown from the assumed monitoring location central to the Sapphire 5 and Sapphire 6 production wells. This figure shows:

- Maximum predicted drawdown occurs at the end of pilot production for all coal seams except the Upper Goonyella seam when extraction ceases. There is a lag to the when the maximum drawdown occurs in the Upper Goonyella seam and the surficial aquifer after production ceases, of 126 and 199 days respectively.
- The maximum predicted drawdown in the surficial aquifer is less than 1 cm.
- The maximum predicted drawdown in the coal seams ranges from 13.1 m in the Upper Goonyella seam to 54.4 m in the Vermont seam. This is predominantly related to the decrease in hydraulic conductivity with depth. The Vermont seam has the greatest predicted drawdown despite being deeper than the Leichardt seam due its greater thickness, and therefore greater ability to supply water to the well.

Figure 35 to Figure 39 shows the magnitude and extent of drawdown in each of the coal seams at the end of pilot production. A similar figure has not been prepared for the surficial aquifer as the maximum magnitude of predicted drawdown is so small (less than 1 cm). These figures show maximum extents of drawdown (assumed to be 0.2 m) as a radius from the centre of the production wells (same location as the timeseries predictions):

- Leichardt seam – 6.1 km
- Vermont seam – 6.3 km
- Middle Main seam – 5.1 km
- Fair Hill seam – 4.8 km
- Upper Goonyella seam – 3.1 km

Table 10 Sapphire Block – layering and base case parameterisation

Layer Name	Aquifer number	Layer base depth (m)	Layer thickness (m)	Horizontal hydraulic conductivity (m/day)	Vertical hydraulic conductivity (m/day)	Storage coefficient (-)	Production Zones	
							Sapphire 5	Sapphire 6
Surficial Aquifer	1	10	10	1	-	0.1		
Overburden	-	208	198	-	0.00001	-		
Leichardt Seam	2	213	5	0.02	-	0.00001	✓	✓
Interburden	-	280	67	-	0.00001	-		
Vermont Seam	3	290	10	0.014	-	0.00001	✓	✓
Interburden	-	503	213	-	0.00001	-		
Middle Main Seam	4	516	13	0.002	-	0.00001	✓	
Interburden	-	554	38	-	0.00001	-		
Fair Hill Seam	5	610	56	0.0003	-	0.00001		✓
Interburden	-	1255	645	-	0.00001	-		
Upper Goonyella Seam	6	1262	7	0.0001	-	0.00001	✓	
Underburden	-	1263	1	-	0.00001	-		

Figure 33 Sapphire 4 - timeseries predicted drawdown

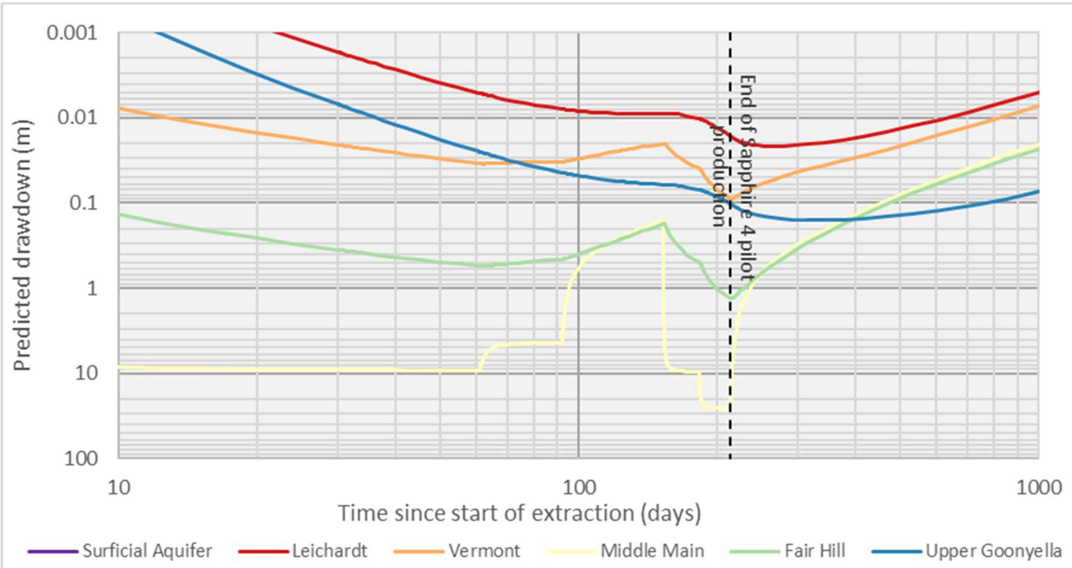


Figure 34 Sapphire Block current pilot activities - base case timeseries predicted drawdown.

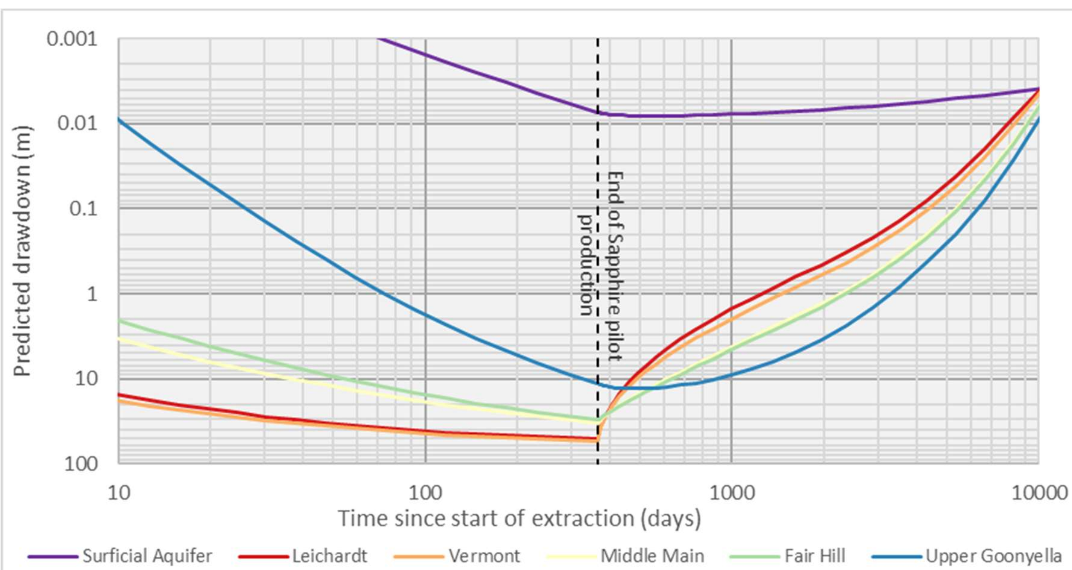


Figure 35 Sapphire Block – predicted drawdown at the end of production (365 days) in the Leichardt Seam (Aquifer 2)

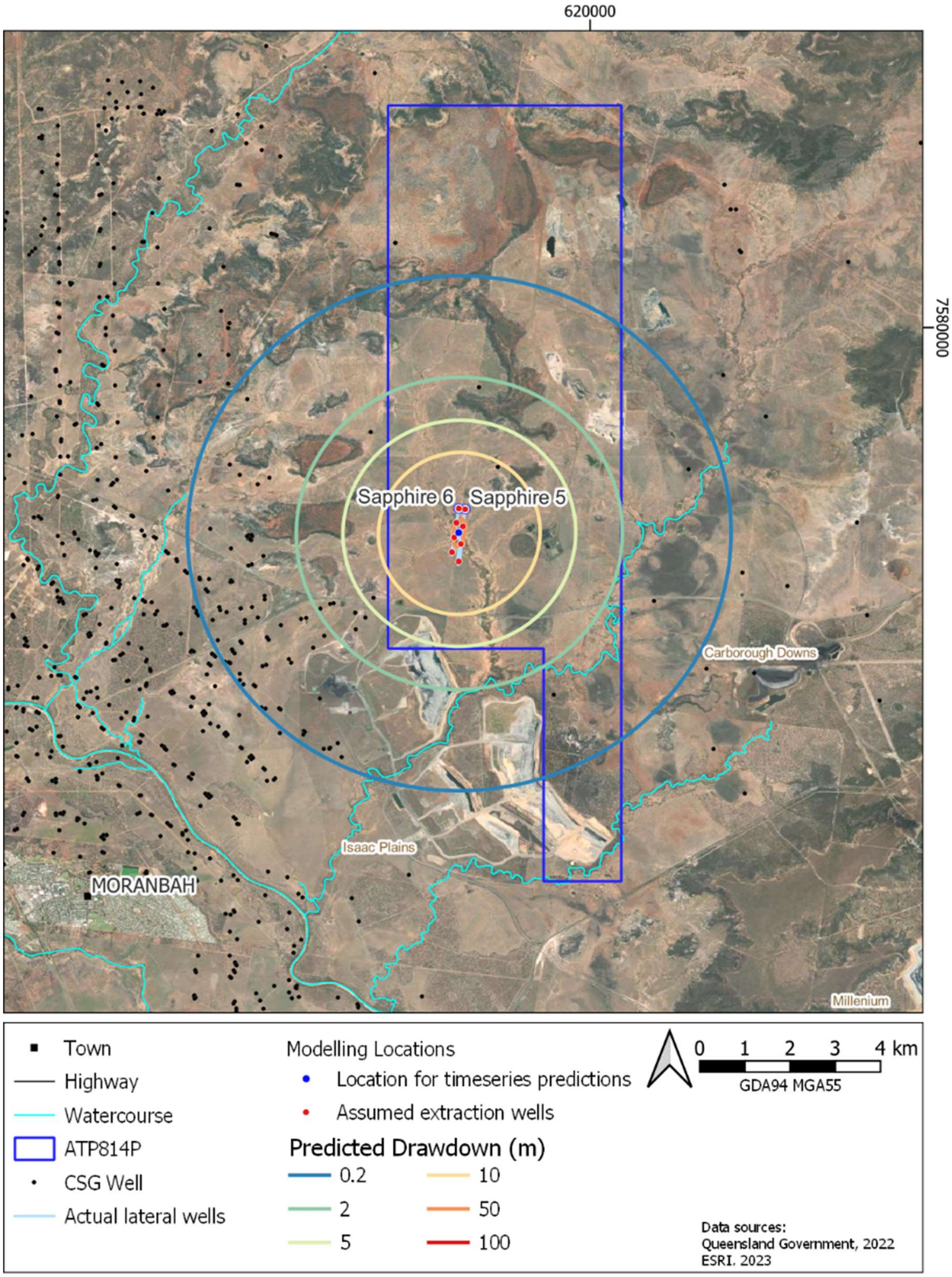


Figure 36 Sapphire Block – predicted drawdown at the end of production in the Vermont Seam (Aquifer 3)

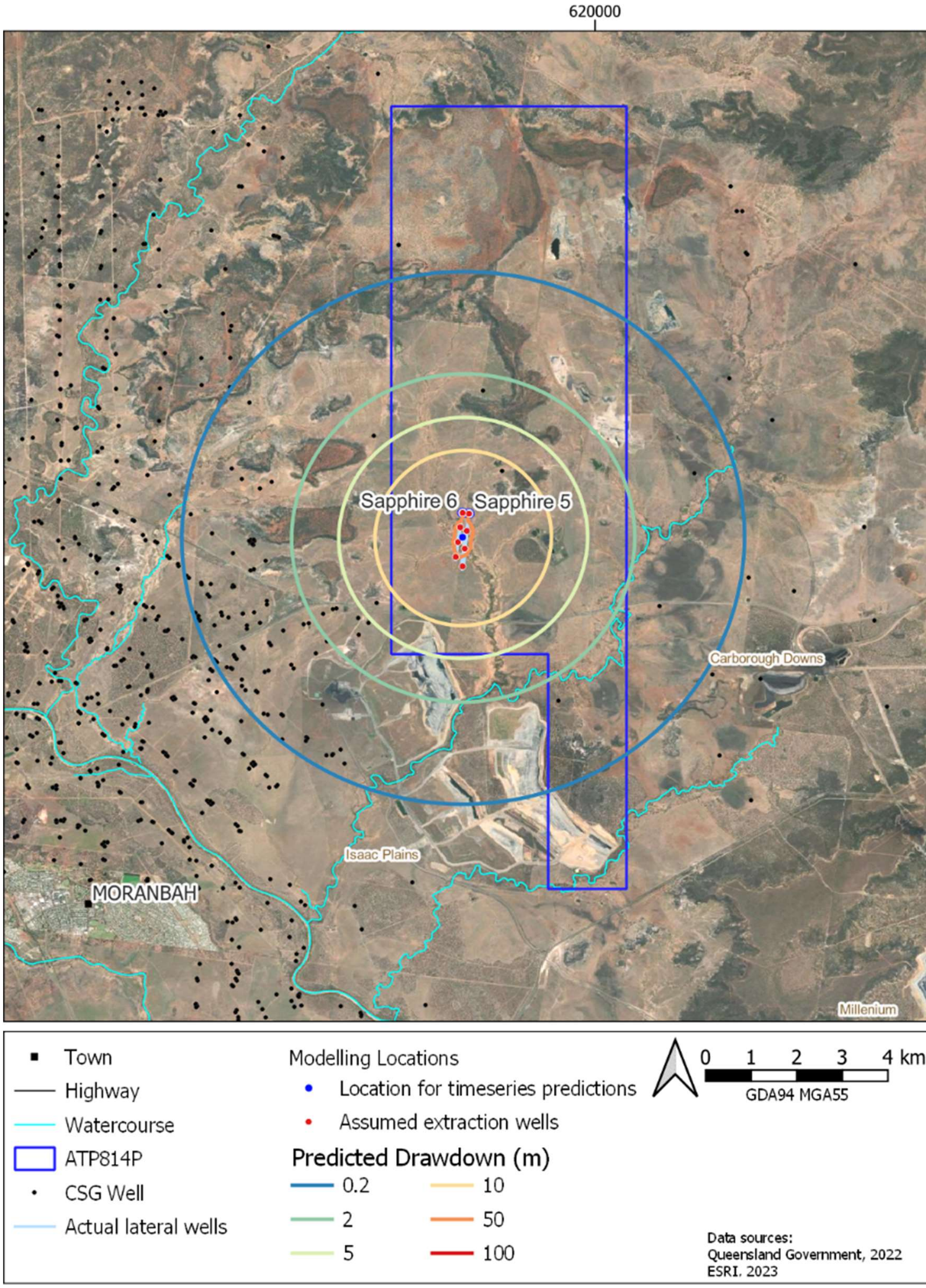


Figure 37 Sapphire Block – predicted drawdown at the end of production in the Middle Main Seam (Aquifer 4)

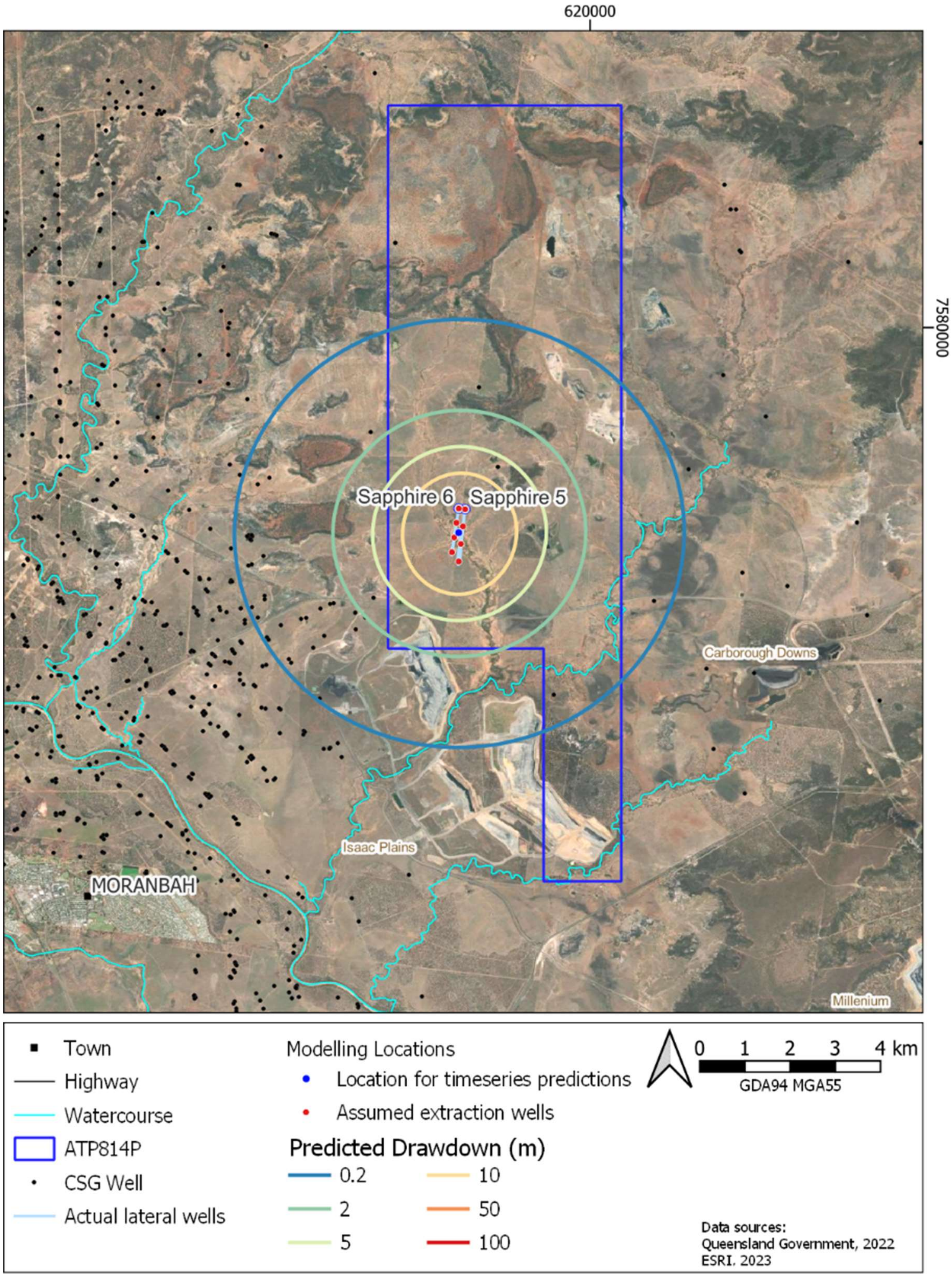


Figure 38 Sapphire Block – predicted drawdown at the end of production in the Fair Hill Seam (Aquifer 5)

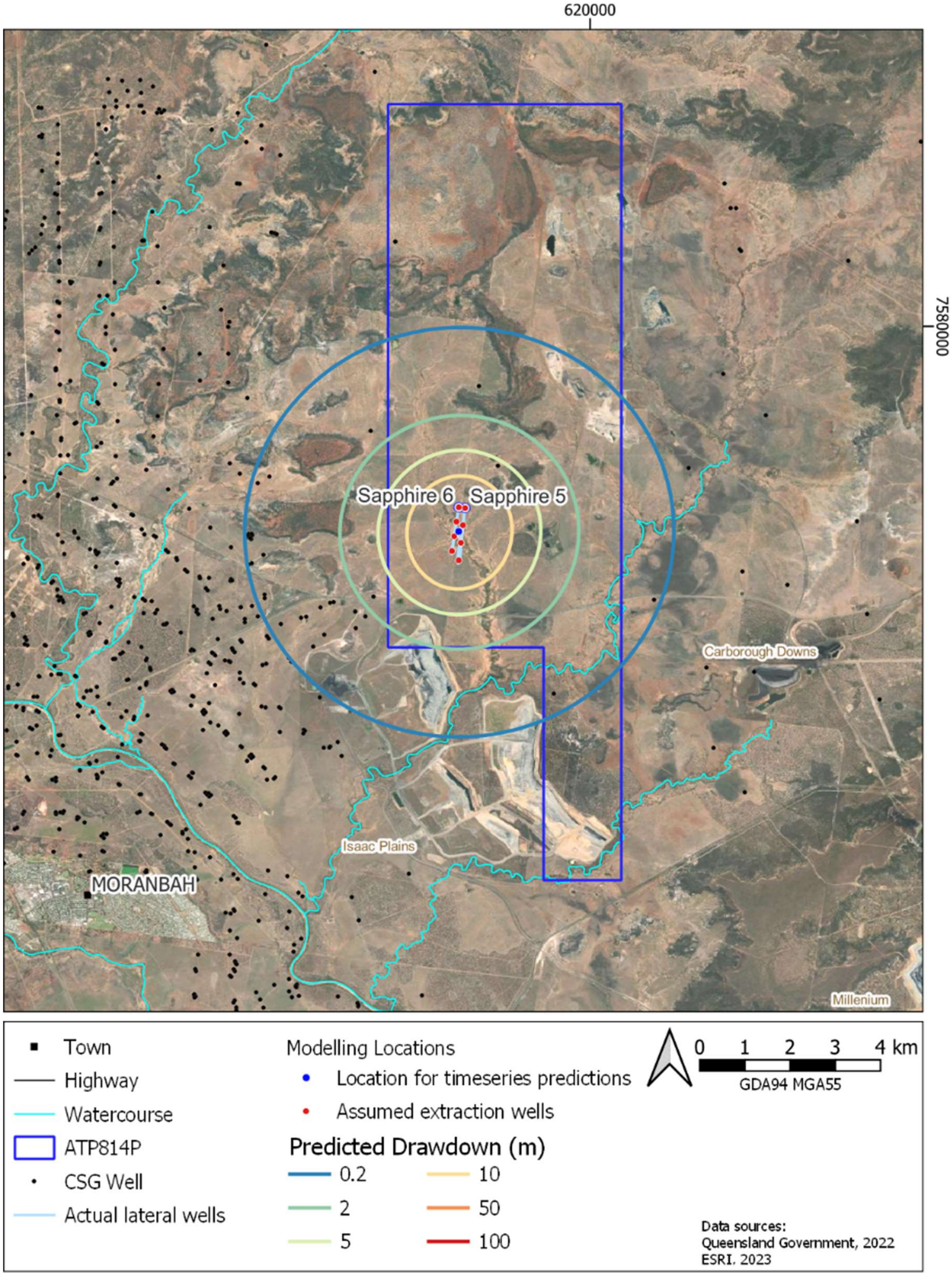
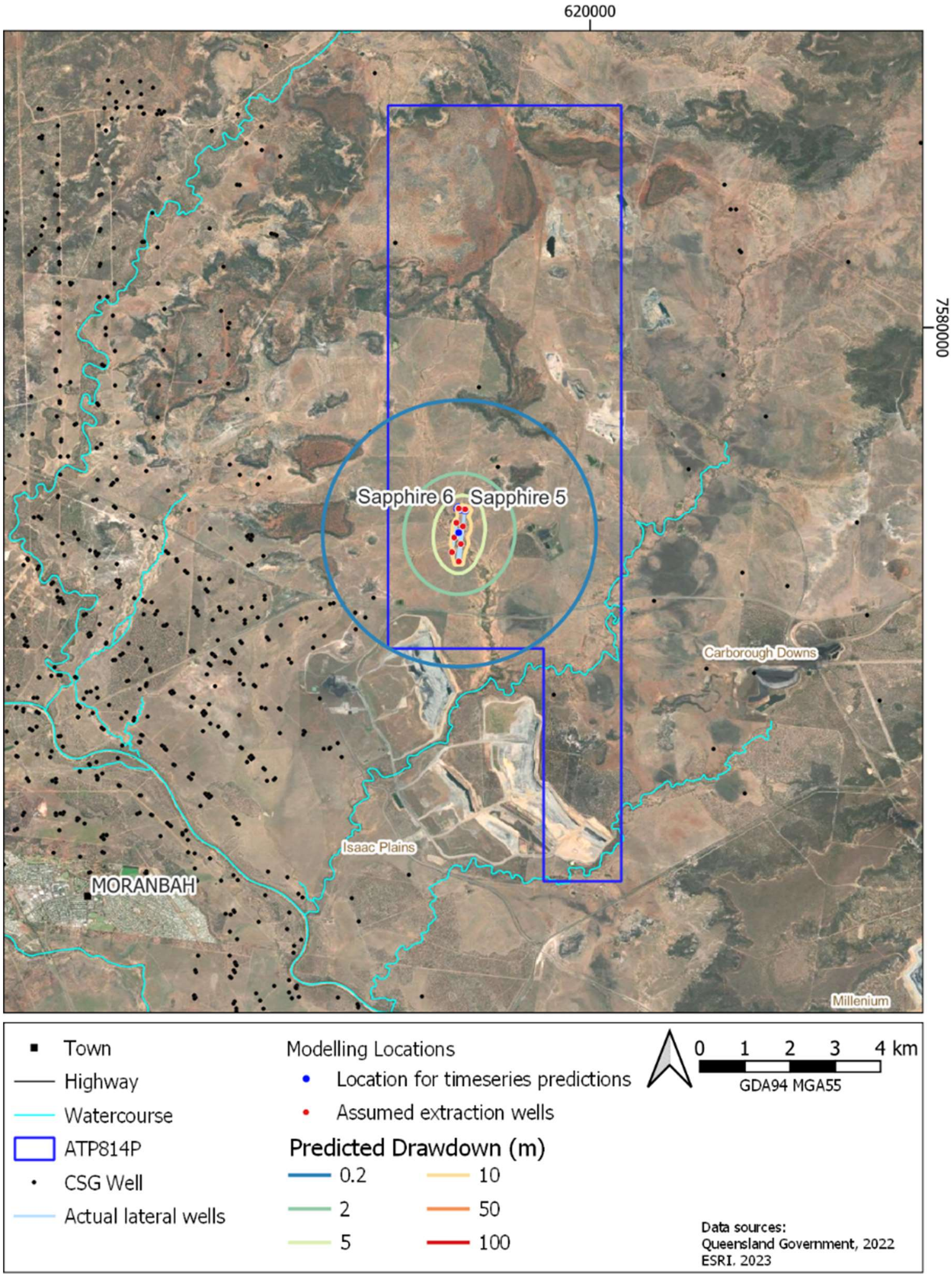


Figure 39 Sapphire Block – predicted drawdown at the end of production in the Upper Goonyella Seam (Aquifer 6)



6.3.2 *Model sensitivity analysis*

Sensitivity of the drawdown predictions was assessed by varying the hydraulic parameters used in the model. The intent of varying the parameters was to increase the predicted drawdown, particularly of the surficial aquifer which would support GDEs. Four scenarios were assessed:

- **Case1** – Increase the vertical hydraulic conductivity by a factor of 10. This would increase the leakage between the coal seams and the surficial aquifer.
- **Case 2** – decrease the horizontal hydraulic conductivity by a factor of 10. This would increase the drawdown in the coal seams resulting in greater hydraulic gradients and potential for induced leakage from other layers.
- **Case 3** – decrease the storativity of the coal seams. This would increase the drawdown in the coal seams resulting in greater hydraulic gradients and potential for induced leakage from other layers.
- **Case 4** – all of the above

The maximum predicted drawdown for each case is shown on Figure 40. This shows that most cases resulted in an increase in the maximum magnitude of predicted drawdown relative to the base case. The maximum increase is drawdown was for Case 2 where the horizontal hydraulic conductivity of the coal seams was decreased by an order of magnitude, resulting in maximum predicted drawdowns of 109 m to 268 m as compared with the 13 m to 54 m in the coal seams for the Base Case. This may be more realistic for CSG production, suggesting that the permeability relationship used for the Base Case may provide an overestimate of the hydraulic conductivity. The extent of the 5 m drawdown contour for Case 2 at the end of production is compared with the Base Case on Figure 41. This shows a significant contraction in the relative extent of the drawdown despite the increased magnitude of drawdown. This would be expected from a lower hydraulic conductivity.

None of the sensitivity cases resulted in greater than 0.2 m drawdown predicted in the Surficial Aquifer.

Figure 40 Sapphire Block - model parameter sensitivity analysis: maximum predicted drawdown

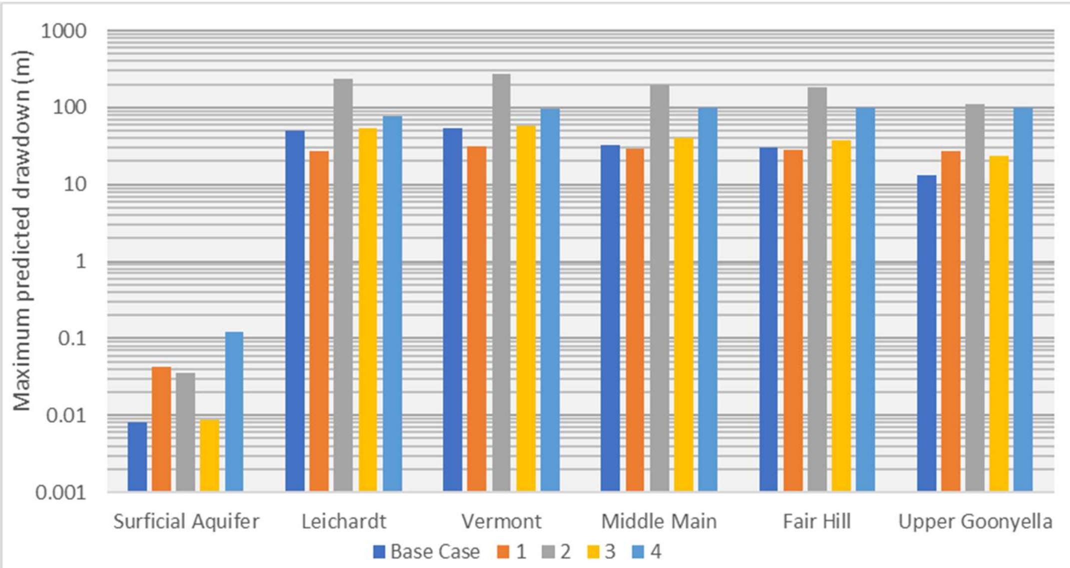
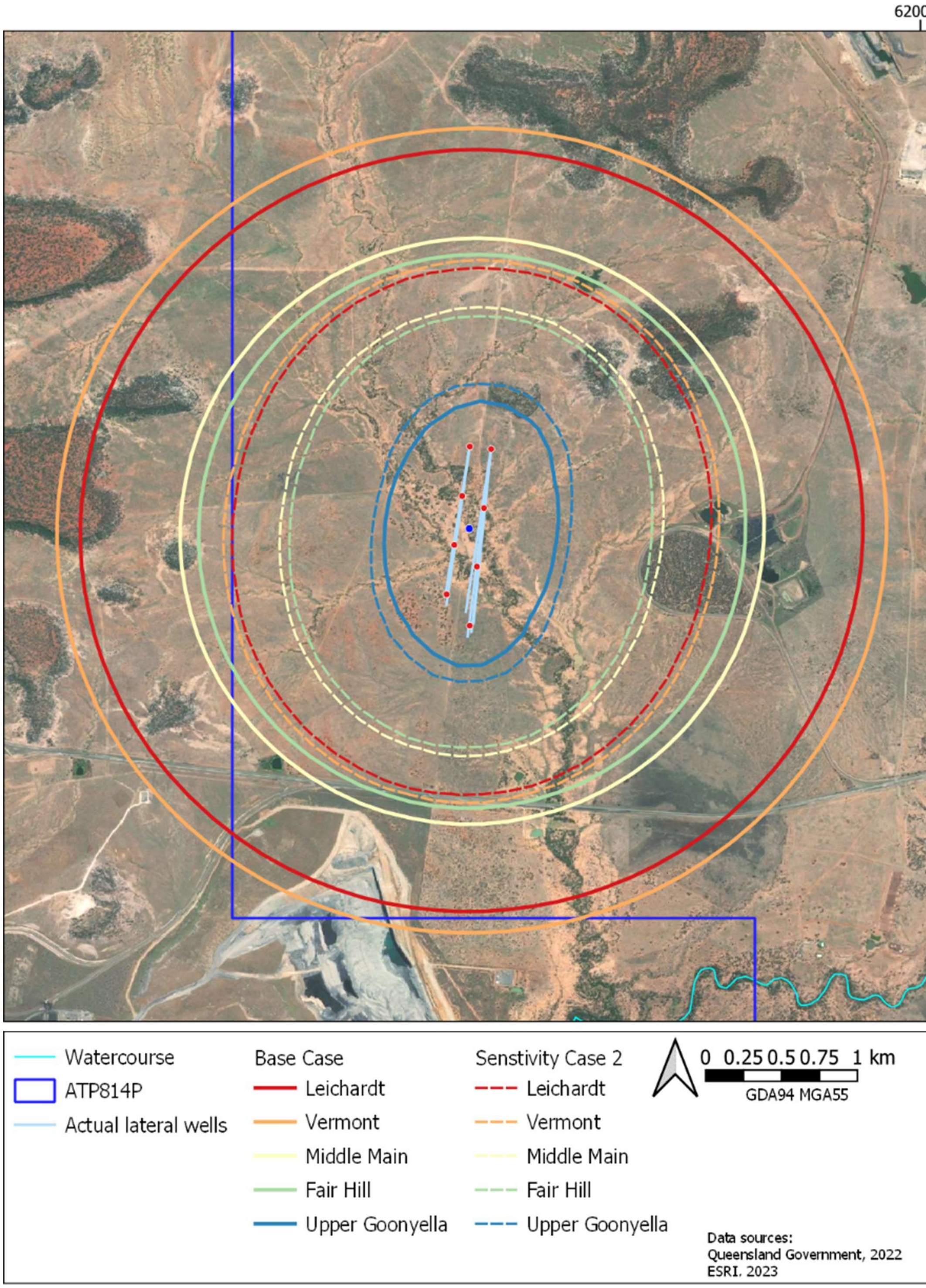


Figure 41 Sapphire Block - comparison of 5m drawdown contours for Base Case and Case 2



6.4 *Predicted impacts to environmental values*

The *Water Act 2000* identifies the bore trigger threshold for water level decline as 5 m for a consolidated aquifer and 2 m for an unconsolidated aquifer. The area in which the water level is predicted to decline by more than the bore trigger threshold within 3 years of the consultation date of the UWIR is termed the Immediately Affected Area (IAA), and the area in which the bore trigger threshold is exceed at any time is termed the Long Term Affected Area (LTAA).

The Tertiary basalt, and Permo-Triassic sediments of the Bowen Basin are all consolidated aquifers, therefore 5 m has been adopted as the relevant bore trigger threshold.

For spring impacts, the *Water Act 2000* the trigger threshold is defined as a water level decline of 0.2 m. Since the *Water Act 2000* does not define a trigger threshold for terrestrial GDEs, the spring trigger threshold has been used.

6.4.1 *Monslatt Block – IAA and LTAA*

Blue Energy last exercised its underground water rights in the Monslatt Block in January 2013.

There is no IAA for the Monslatt block as drawdown is predicted to have recovered to less than 5 m prior to March 2026 (the end of the current UWIR period) – refer to Figure 29 which shows all predicted drawdowns to have recovered to less than 5 m within 940 days of production commencing, the equivalent of September 2013.

The LTAA for the Monslatt block is limited to the P Seam of the Moranbah Coal Measures and is shown on Figure 42. It encompasses a radius of approximately 2.4 km around the Monslatt 5 well and a radius of less than 500 m centred on Monslatt 7 and Monslatt 4. The predicted exceedance of the trigger threshold is historical, with all drawdown predicted to have recovered to less than 5 m by September 2013.

6.4.2 *Sapphire Block – IAA and LTAA*

Since planned current pilot production in the Sapphire block is for one year only, both the IAA and LTAA are predicted to occur within the current UWIR period (2023 – 2026).

Water levels are predicted to recover within all model layers to less than the adopted bore trigger threshold (5 m) within less than three years. The IAA is therefore the predicted extent of the bore trigger threshold at the end of production (1 year), whereas the LTAA incorporates the time lag in the maximum magnitude of drawdowns observed in Figure 34.

The IAA and LTAA for the Sapphire block are shown on Figure 43 and Figure 44 respectively.

Figure 42 Monslatt Block – LTAA

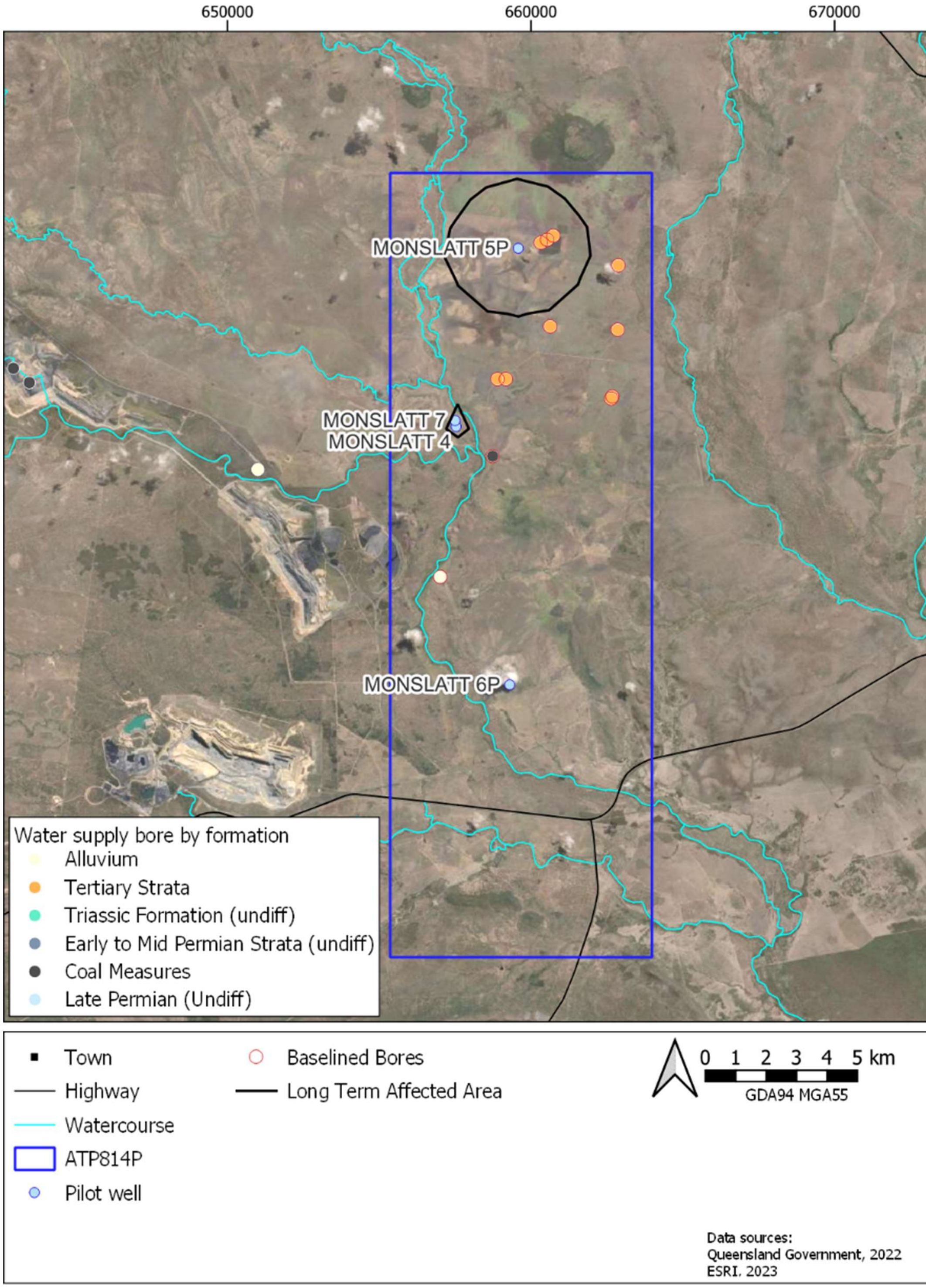


Figure 43 Sapphire Block Immediately Affected Area (IAA)

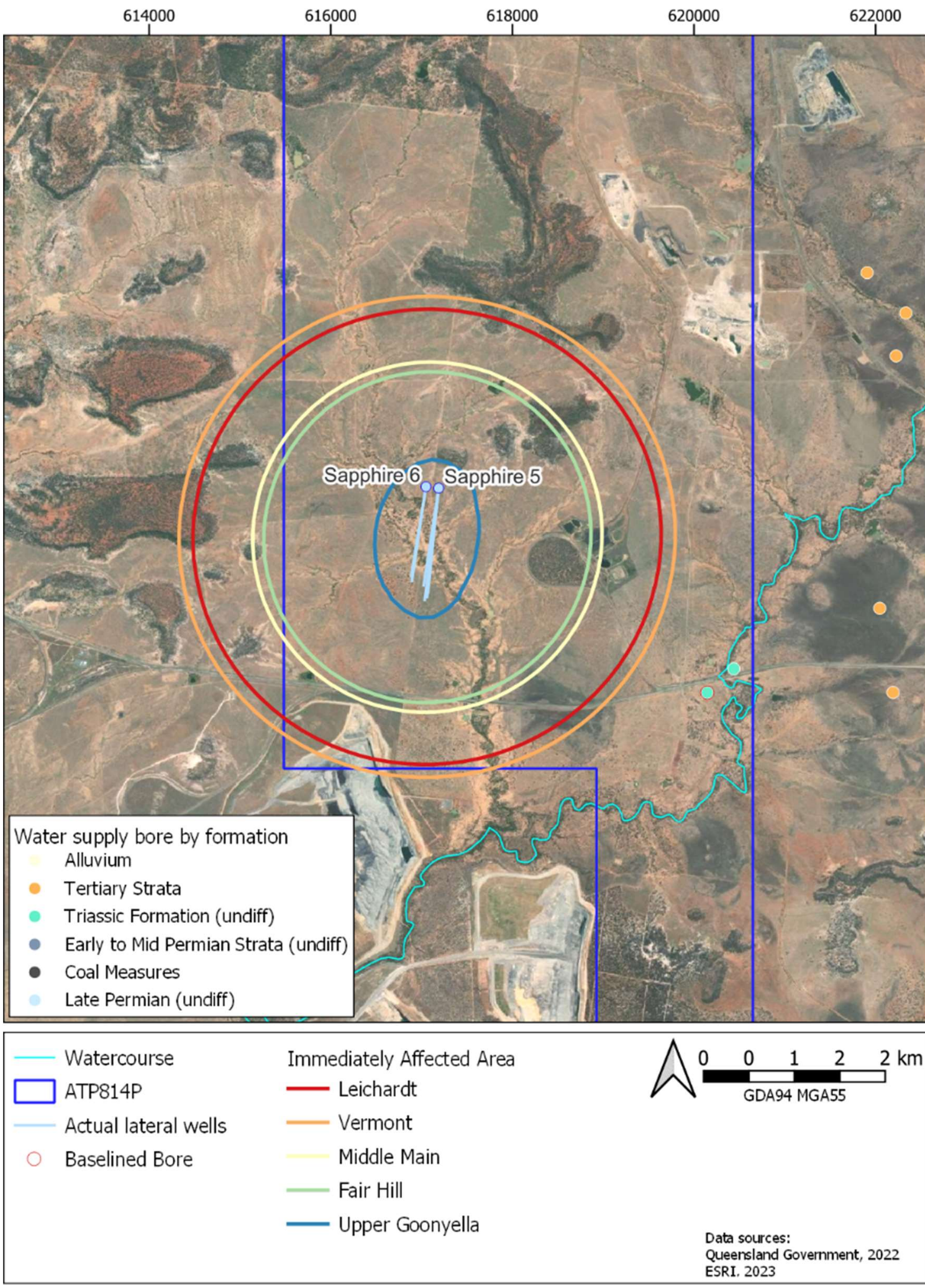
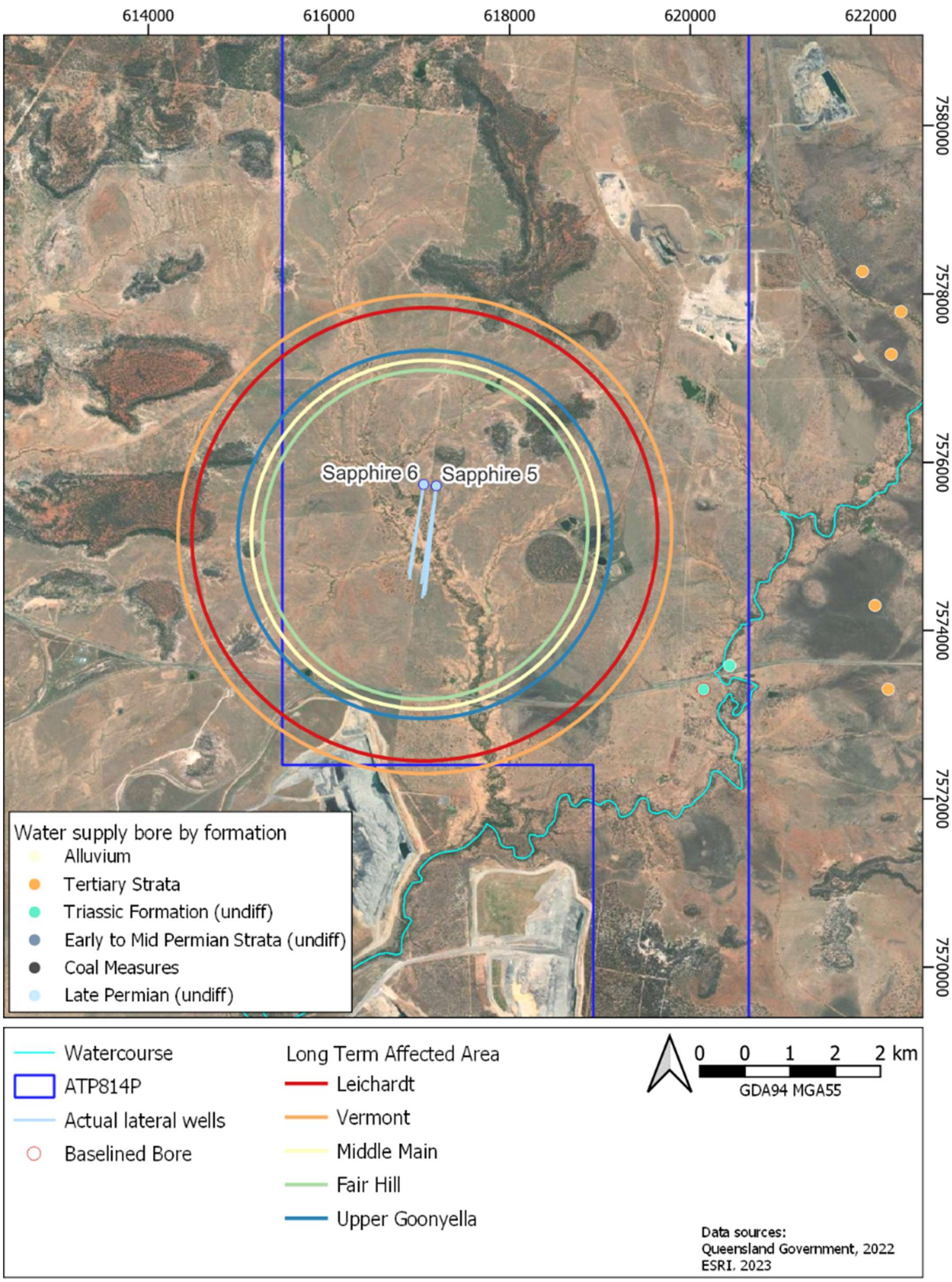
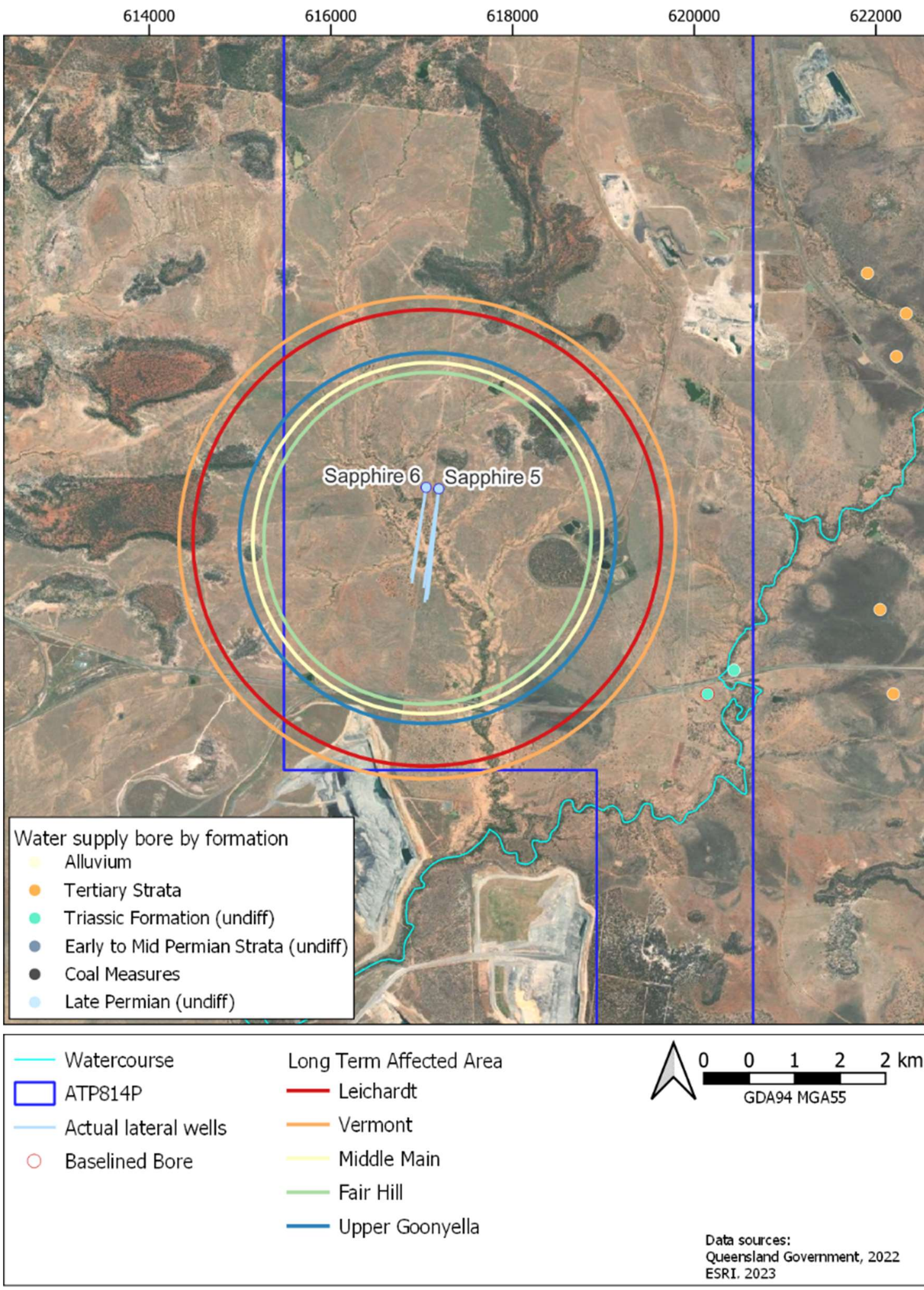


Figure 44 Sapphire Block Long Term Affected Area (LTAA)




614000
616000
618000
620000
622000
7580000
7578000
7576000
7574000
7572000
7570000
Sapphire 6
Sapphire 5
Water supply bore by formation
Alluvium
Tertiary Strata
Triassic Formation (undiff)
Early to Mid Permian Strata (undiff)
Coal Measures
Late Permian (undiff)
Watercourse
ATP814P
Actual lateral wells
Baselined Bore
Long Term Affected Area
Leichardt
Vermont
Middle Main
Fair Hill
Upper Goonyella
0 0 1 2 2 km
GDA94 MGA55
Data sources:
Queensland Government, 2022
ESRI. 2023

6.4.3 Potential Impacts to Groundwater bores

Figure 42 and Figure 44 show the LTAAs for the Monslatt and Sapphire blocks respectively. The LTAAs apply to the coal seams within the Permian coal measures (Rangal, Fort Cooper and Moranbah) and no LTAA applies to the shallow aquifers. These maps include the locations and formations of identified water supply bores.

There are no identified water supply bores that target the coal measures identified within the spatial extents of the LTAAs. The model sensitivity analysis performed does not change this outcome.

Three water supply bores were identified within the spatial extent of the LTAA of the P Seam in the Monslatt block. These bores underwent baseline assessments in 2011/2012 and were identified to access the Tertiary basalts. They are not predicted to be impacted by the previous exercise of underground water rights.

There are no identified water supply bores within the spatial extent of the LTAAs associated with the exercise of underground water rights in the Sapphire block.

No water supply bores will be impacted by Blue Energy’s exercise of underground water rights.

6.4.4 Potential Impacts to Groundwater Dependent Ecosystems

Base case models do not predict drawdown exceeding 0.2 m in a surficial aquifer for either the Monslatt block or the Sapphire block.

The model sensitivity analyses performed did not result in predicted drawdown exceeding 0.2 m for the water table for the Sapphire block.

One realistic model sensitivity analysis performed for the Monslatt block indicated that drawdown may exceed 0.2 m in the surficial Basalt aquifer in the north of the Monslatt block (Figure 41). Comparison of timeseries actual evapotranspiration data (McVicar et. Al., 2023) for the approximate area in sensitivity Case 1 encompassed by the 0.2 m predicted drawdown contour (Figure 32) is presented as Figure 45. Also shown on Figure 45, is the average evapotranspiration calculated for the month with the lowest actual evapotranspiration from before and after the commencement of underground water rights. This graph shows:

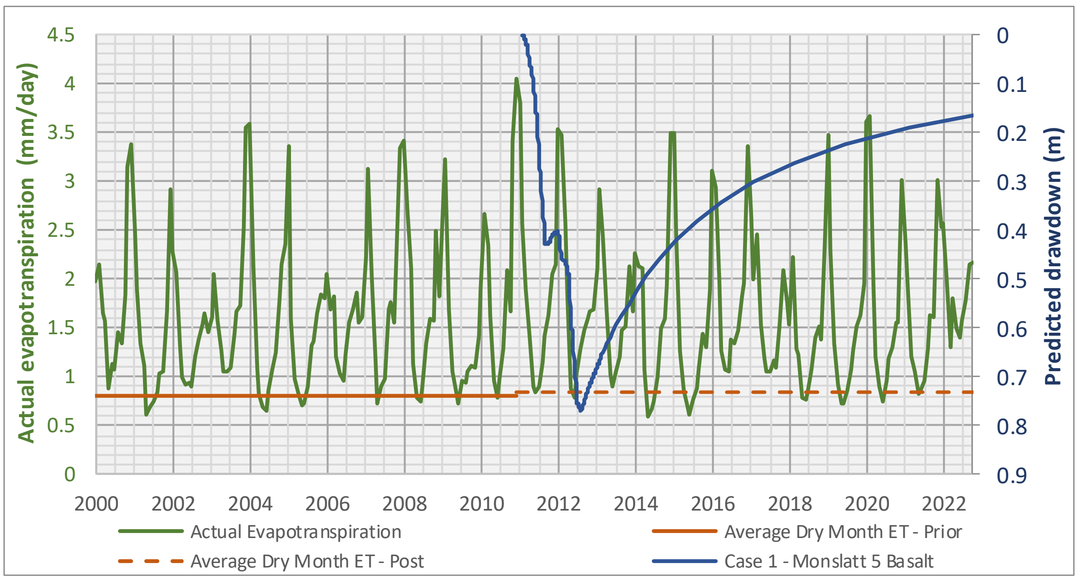
- Predicted drawdown exceeding 0.2 m occurred between July 2011 and March 2021, with the maximum drawdown predicted occur in September 2012.
- The average actual driest month evapotranspiration prior to water production commencing is marginally less than after production commenced, thus there is no indication that vegetation did not have access to water due to the predicted drawdown.

Based on this evidence, there has been no impact on the health of terrestrial GDEs due to the exercise of underground water rights.

There are no mapped springs within 80 km of any of the blocks that constitute ATP814P. All of the watercourses within ATP814P and its immediate vicinities are ephemeral and are therefore not groundwater fed. No springs or watercourse springs were identified within the spatial extent of drawdown (as defined by the 0.2 m drawdown contour) for any model layer.

The previous, current or future exercise of underground water rights on ATP814P will not impact springs or other GDEs.

Figure 45 Comparison of timeseries predicted drawdown and actual evapotranspiration



6.5 Predicted Impacts to Formation Integrity and Surface Subsidence

The extraction of water and gas from the subsurface will result in compaction of the strata from which they are produced. The magnitude and extent of the compaction are influenced by the magnitude and extent of the drawdown, the geomechanical properties of the coal, interburden and overburden, and the total thickness of the coal in which the drawdown occurs. It can be conservatively assumed that any compaction of the coal seams will directly translate to subsidence at the surface.

OGIA (2021) suggests that for hundreds of meters of drawdown of pressure in the coal seams, only a few centimetres of subsidence will occur at the surface. CSG companies operating in the Surat Basin predicted surface subsidence of 80 mm to 280 mm OGIA (2021).

Figure 31 and Figure 35 to Figure 39 show the areas where more than 100 m of drawdown is predicted to occur. Only a very small portion of the areas influenced by the exercise of underground water rights experience sufficient drawdown to induce compaction which on the assumption of hundreds of meters of drawdown is likely to be in the order of a few centimetres. This is unlikely to affect formation integrity and if the compaction were to manifest as surface subsidence, would be unlikely to affect surface water hydrology.

7 Monitoring, management and reporting

This section describes the water monitoring strategy (WMS), spring impact management strategy (SIMS) planned under this UWIR and the program for annual review of the accuracy of each map of the IAA and LTAA.

7.1 Water Monitoring Strategy

An underground water monitoring strategy (WMS) is required for the IAA and the LTAA. IAAs and LTAAs have only been defined for the coal seams as water levels are not predicted to decline in excess of the bore trigger threshold in the overlying aquifers. The monitoring strategy does not include the Monslatt block as the LTAA was historical and predicted water level drawdown has now recovered to less than the adopted trigger threshold.

The primary purpose of the monitoring is to provide information to improve the understanding of the groundwater system and changes induced by the exercise of underground water rights.

The WMS is summarised in Table 11.

Table 11 Summary of the WMS

Item	Sites	Frequency
Produced water volumes	Each production well	Monthly
Reservoir pressure	Each production well	Monthly
Produced water quality (field analysis)	Each production well	Quarterly
Produced water quality (laboratory analysis)	Each production well	Annually

7.1.1 Monitoring methodology

All water monitoring will be undertaken in accordance with the *Queensland Monitoring and Sampling Manual* (DES, 2018).

The volume of water produced at each well will be constantly measured by individual electronic water flow meters installed in accordance with the manufacturer's specifications. The SCADA system will continuously record the data and calculate the total daily volume produced from each well.

Reservoir pressures in each well will either be measured or will be extrapolated from measured surface pressures at least monthly while the well is on production.

A sample for water quality analysis will be collected annually from each pilot well while it is on production. The samples will be collected from a valve on the wellhead, directly into laboratory supplied bottles.

Field parameters will be measured at the time of sampling using a calibrated field water meter and include:

- Electrical conductivity (EC)
- pH

- Temperature

Field parameters will also be measured quarterly.

Samples for laboratory analysis will be:

- Collected in new, laboratory supplied sample containers, with appropriate preservatives.
- Stored in a chilled esky or refrigerator prior to delivery to the laboratory.
- Submitted under Chain-of-Custody protocols.
- Submitted to a laboratory accredited with the National Association of Testing Authorities (NATA) for the analyses to be conducted.

The analytical suite shown in Table 12 is based on the suite identified in the WMS (OGIA, 2021a) for the Surat CMA UWIR (OGIA, 2021) and is considered appropriate to meet the purpose of the monitoring. Dissolved methane has been excluded from the OGIA (2021a) suite as methane concentrations are expected to be at saturation due to gas production.

Table 12 Analytical suite for laboratory analysis

Category	**Parameters**	
Physiochemical parameters	Electrical conductivity Total dissolved solids pH	
Major ions	*Cations*	*Anions*
	Calcium	Chloride
	Magnesium	Carbonate
	Sodium	Bicarbonate
	Potassium	Sulphate
Dissolved metals and minor/trace elements	Arsenic	Lead
	Barium	Manganese
	Boron	Mercury
	Cadmium	Nickel
	Chromium	Selenium
	Cobalt	Strontium
	Copper	Zinc
	Iron	
Other analytes	Fluoride	

7.1.2 Data submission

The *Water Act 2000* requires a program for reporting to the OGIA about the implementation of the WMS under a UWIR.

Data collected under the WMS will be compiled and provided to OGIA every 6 months to align with the delivery dates for the Surat CMA UWIR (1 April and 1 October).

7.2 Spring Impact Mitigation Strategy

Since there are no springs located within the predicted extents of the exceedance of the spring trigger thresholds (0.2 m) a spring impact management strategy is not required.

7.3 Annual Review of the UWIR

The *Water Act 2000* requires that the accuracy of the IAA and LTAA is reviewed annually. This review will consist of a review of the monitoring data against the assumptions incorporated into the predictions. Where the assumptions of the model(s) are significantly different to the results of the WMS, the model will be revised and the UWIR updated.

The review will include a summary and will include a statement of whether there has been a material change in the information or predictions used to prepare the maps.

The annual reviews will be provided to the Chief Executive (DES) within 20 business days of the anniversary date of the approval of this UWIR.

The UWIR will be updated every three years. An annual review will not be prepared when a revised UWIR is issued.

8 References

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Appendix A – Water Supply Bore Characteristics

Registered Number	Year Drilled	Assigned Formation
17269	1966	Early to Mid Permian Strata (undiff)
46582	1978	Late Permian (Undiff)
46916	1980	Triassic Formation (undiff)
63154	1930	Alluvium
63155	1930	Alluvium
63156	1920	Triassic Formation (undiff)
63157	1920	Triassic Formation (undiff)
81696	1992	Tertiary Strata
81908	1996	Triassic Formation (undiff)
81909	1994	Triassic Formation (undiff)
84538	1954	Early to Mid Permian Strata (undiff)
85051	1937	Rangal Coal Measures
85054	1973	Triassic Formation (undiff)
85055	1973	Triassic Formation (undiff)
85056	1982	Triassic Formation (undiff)
85057	1973	Triassic Formation (undiff)
85058	1971	Triassic Formation (undiff)
85059	1981	Early to Mid Permian Strata (undiff)
85060	1982	Early to Mid Permian Strata (undiff)
85078	1987	Rangal Coal Measures
85100	1987	Tertiary Strata
85403	1992	Alluvium
85414	1990	Tertiary Strata
85417	1990	Triassic Formation (undiff)
85419	1990	Tertiary Strata
85420	1990	Tertiary Strata
85444	1990	Tertiary Strata
85445	1990	Tertiary Strata
85446	1990	Tertiary Strata
103210	1999	Late Permian (Undiff)
105427	2004	Triassic Formation (undiff)
105479	2001	Late Permian (Undiff)
105480	2001	Late Permian (Undiff)
105481	2002	Late Permian (Undiff)
105482	2001	Late Permian (Undiff)
105483	2002	Late Permian (Undiff)
105484	2001	Late Permian (Undiff)
105485	2002	Late Permian (Undiff)
105486	2002	Late Permian (Undiff)
105487	2002	Late Permian (Undiff)
105488	2003	Late Permian (Undiff)
105489	2001	Late Permian (Undiff)
105490	2003	Late Permian (Undiff)
105491	2003	Late Permian (Undiff)
105492	2003	Late Permian (Undiff)
105493	2003	Late Permian (Undiff)
105494	2002	Late Permian (Undiff)
105495	2003	Late Permian (Undiff)
105496	2003	Late Permian (Undiff)
105497	2003	Late Permian (Undiff)
105498	2001	Late Permian (Undiff)
105499	2003	Late Permian (Undiff)
105500	2002	Late Permian (Undiff)
105501	2001	Late Permian (Undiff)

Registered Number	Year Drilled	Assigned Formation
105525	2003	Late Permian (Undiff)
105526	2003	Late Permian (Undiff)
105676	2005	Tertiary Strata
105677	2005	Tertiary Strata
122458	2006	Tertiary Strata
131000	2005	Tertiary Strata
131001	2005	Tertiary Strata
131002	2005	Tertiary Strata
131612	2006	Late Permian (Undiff)
131613	2006	Late Permian (Undiff)
131614	2006	Late Permian (Undiff)
131615	2006	Late Permian (Undiff)
132631	2007	Tertiary Strata
136092	2002	Early to Mid Permian Strata (undiff)
136689	2007	Tertiary Strata
141247	2007	Early to Mid Permian Strata (undiff)
162263	Drilled da	Rangal Coal Measures
162264	1966	Rangal Coal Measures
162265	1978	
162266	1980	
162271	1930	
162272	1930	Triassic Formation (undiff)
162273	1920	
162274	1920	Triassic Formation (undiff)
162276	1992	
162278	1996	Triassic Formation (undiff)
162506	1994	Early to Mid Permian Strata (undiff)
162554	1954	Alluvium
162810	1937	Triassic Formation (undiff)
162817	1973	Triassic Formation (undiff)
162818	1973	Triassic Formation (undiff)
162908	1982	
165163	1973	Early to Mid Permian Strata (undiff)
182164	1971	Tertiary Strata
182166	1981	Alluvium
182335	1982	Late Permian (Undiff)
182336	1987	Early to Mid Permian Strata (undiff)
182337	1987	Early to Mid Permian Strata (undiff)
182338	1992	Triassic Formation (undiff)
182455	1990	Early to Mid Permian Strata (undiff)
182871	1990	
182872	1990	Early to Mid Permian Strata (undiff)
199098	1990	Early to Mid Permian Strata (undiff)
BMA1	Unknown	Alluvium
Broadlea 2	Unknown	Triassic Formation (undiff)
Brogabri Bore	Unknown	Moranbah Coal Measures
Bull Paddock Bore	Unknown	Tertiary Strata
Main Gully Bore	Unknown	Tertiary Strata
Mountain Paddock Bore	Unknown	Tertiary Strata
New Windmill Bore	Unknown	Tertiary Strata
Old Main Gully Bore	Unknown	Tertiary Strata
Old Windmill Bore	Unknown	Tertiary Strata
Paul 1	Unknown	Tertiary Strata
Paul 2	Unknown	Tertiary Strata

Registered Number	Year Drilled	Assigned Formation
Paul 3	Unknown	Tertiary Strata
Paul4	Unknown	Tertiary Strata