Bunbury Outer Ring Road

Southern Section

Ministerial Statement 1191: M2.2

Hydrological Regime Report

Main Roads WA

Revision 0

15-Jul-22

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South West Gateway Alliance

Delivering the Bunbury Outer Ring Road

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1 Introduction

1.1 Overview and Scope

The Commissioner of Main Roads Western Australia (Main Roads) has been granted conditional approval for the Bunbury Outer Ring Road Southern Section (the Proposal) under Part IV Division 2 (section 45) of the *Environmental Protection Act 1986* by the Minster for Environment. The Proposal is subject to the implementation conditions of Ministerial Statement 1191 (MS 1191) which was issued on 31 May 2022 (Minister for Environment, 2022).

In their Report and Recommendations in relation to the Proposal (EPA Report 1714, October 2021), the EPA noted that in relation to Inland Waters, the potential for direct and indirect impacts to hydrological regimes and water quality in adjacent CC Category Wetlands (CCWs), RE Wetlands (REWs), the Five Mile Brook and black stripe minnow habitats.

To address these impacts, the EPA recommended Condition 2 requiring pre-disturbance monitoring of hydrological regimes and baseline conditions, and monitoring of these elements during and post-construction, with reporting requirements, to meet the objective that there are no project-attributable impacts to the hydrological regime and water quality of 'CC' category and 'resource enhanced' wetlands, Five Mile Brook or black-stripe minnow habitat.

Ministerial Statement 1191, therefore, includes the following conditions in relation to Inland Waters:

Condition 2-1(2)

> *No project attributable impacts to the hydrological regime and water quality of the following values when compared to preconstruction baseline conditions:*
>
> *(a) Five Mile Brook (incorporating MU Wetland UFI-1163 and CC Category Wetland UFI-931),*
>
> *(b) CC Category Wetland (UFI-14478),*
>
> *(c) RE Wetlands (UFI-1117 and UFI-15493), and*
>
> *(d) black-stripe minnow (Galaxiella nigrostriata) habitats defined and mapped in the proponent's Action Management Plan CC Significant Fauna (Revision 2 August 2021) that are within or adjoins the development envelope, except for the black-stripe minnow habitats permitted to be cleared in condition 4-1(1)(e).*

Condition 2-2

> *Prior to ground-disturbing activities, the proponent shall undertake monitoring of the hydrological regimes of the values listed in condition 2-1(2) and submit a report to the CEO about the preconstruction baseline conditions and predicted post-development hydrological regime.*

1.2 Proposal Context

Main Roads Western Australia (Main Roads) is proposing to construct a 27-kilometre highway, the Bunbury Outer Ring Road (BORR), that links Forrest Highway to Bussell Highway. The BORR (Southern Section) includes 11 kilometres (km) of dual carriageway connecting the South-Western Highway to Bussell Highway (Figure 1).

The Proposal area is located approximately 200 km south of Perth and occurs within the City of Bunbury and Shires of Capel, Dardanup and Harvey.

1.3 Purpose and Objective

The purpose of this report is to present the results of baseline hydrological surveys and describe the predicted post-development hydrologic regime pertaining to the sites defined in Condition 2-1(2) of MS 1191.

The report has been prepared to satisfy the requirements of Condition 2-2 of MS 1191, which states:

> *Prior to ground-disturbing activities, the proponent shall undertake monitoring of the hydrological regimes of the values listed in condition 2-1(2) and submit a report to the CEO about the preconstruction baseline conditions and predicted post-development hydrological regime.*

1.4 Key References and Reports

A number of key references and reports have informed the preparation of this report:

- Appeals Convenor (2022). Appeals Convenor's Report to the Minister for Environment: Appeals objecting to Report and Recommendations of EPA Report 1714 – Bunbury Outer Ring Road Southern Section. Appeal 045/21, April 2022. Office of the Appeals Convenor, Perth, Western Australia.
- Bunbury Outer Ring Road Integrated Planning Study BORR IPT (2019). Wetland Study (BORR-02-RP-EN-007, Jan 2019).
- Bunbury Outer Ring Road Integrated Planning Study BORR IPT (2020). Groundwater and Surface Water Quality Monitoring 2019-20 (BORR-00-RP-EN-005 Rev 1, August 2020).
- Environmental Protection Authority (2021). Bunbury Outer Ring Road Southern Section, Commissioner for Main Roads Western Australia. Report 1714, October 2021. Environmental Protection Authority, Perth, Western Australia.
- South West Gateway Alliance (2021). Bunbury Outer Ring Road Determination of Design Groundwater Levels (SWGA-00-270-00-REP-0001, September 2021).
- WRM (2021) Bunbury Outer Ring Road Southern Section: Targeted CC Significant Aquatic Fauna Monitoring 2021. Unpublished report by Wetland Research and Management to SWGA. December 2021.

1.5 Limitations

This Report has been prepared by South West Gateway Alliance (the Alliance) on behalf of Main Roads to satisfy Condition 2-2 of MS 1191. This report is limited to the sampling completed, to date, by other parties. This report is factual only, outlining methods used, data gathered, observations noted and results with statistics employed as required. The Alliance takes no responsibility for the accuracy, quality or reliability of the information or data provided by third parties.

33000 34000 35000 36000 37000

105000 104000 103000 102000 101000 100000

GELORUP

1

2

LEGEND

Proposal Area

Major Road

SLIP

Paper Size ISO A3

0 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 Perth Coastal Grid 1994

N

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BUNBURY OUTER RING ROAD | PLANNING AND DEVELOPMENT

Main Roads Western Australia
Bunbury Outer Ring Road Southern Section

Proposal Area

Date 13/06/2022

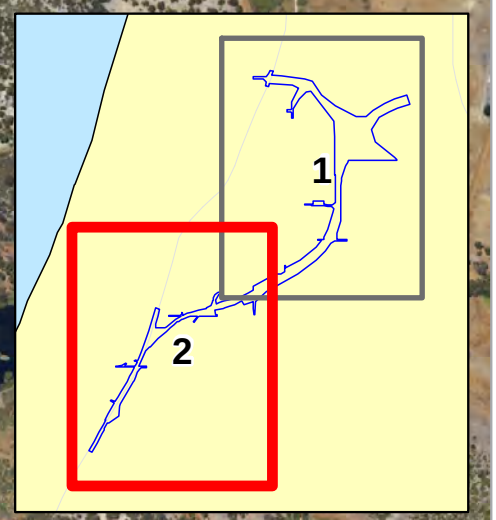
FIGURE 1

30000 31000 32000 33000

101000 100000 99000 98000 97000 96000

Bussell Highway

SLIP



LEGEND

Proposal Area

Major Road

Paper Size ISO A3

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Main Roads Western Australia
Bunbury Outer Ring Road Southern Section

Proposal Area

Date 13/06/2022

FIGURE 1

2 Site Information

2.1 Climate

The Proposal area falls within the Swan Coastal Plain, which is typically described as a warm Mediterranean climate, dominated by a hot, dry summer and a mild, wet winter. The Proposal area receives most of its annual rainfall during the winter months, with monthly rainfall peaking in July with 140.5 mm, and an annual average rainfall of 718 mm/yr (BORR IPT, 2020).

Precipitation predominantly occurs during winter months, with the possibility of some summer storms. Average annual rainfall recorded at the Bunbury meteorological station (ID 009965) is 718 mm/yr. A total of 964 mm fell in 2021, 30% more than the average rainfall (Figure 2).

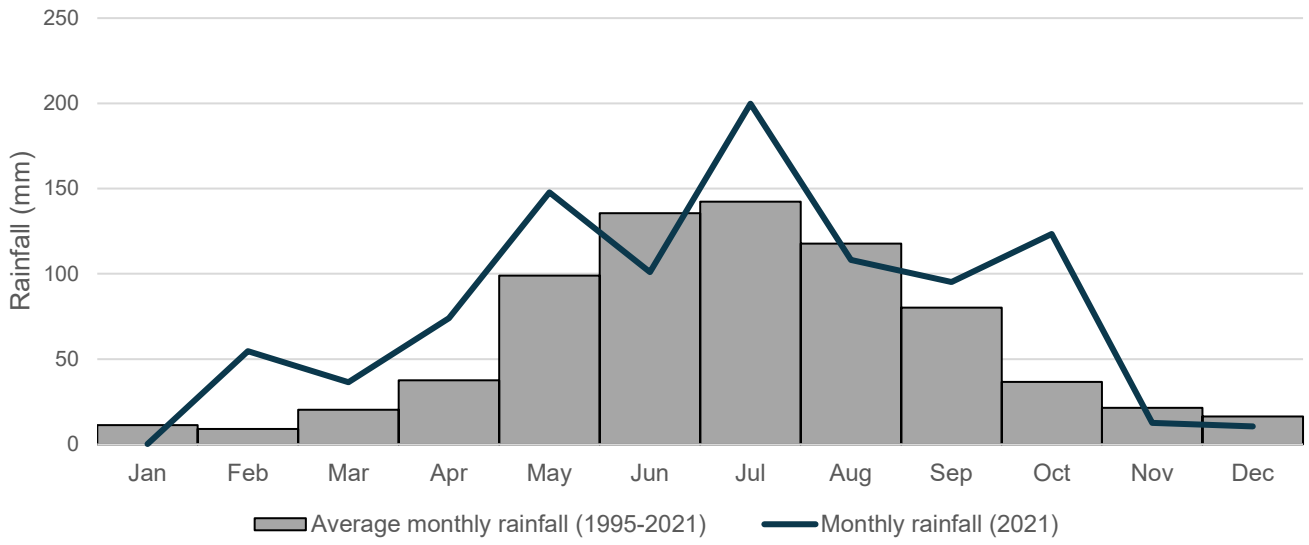

Figure 2. Bunbury rainfall (BOM Station 009965) for the period 1995-2021

Historically highest average monthly rainfall was recorded in June; however, more recent data indicates that July has tended to be the wetter month. Whereas winter rainfall has seen a general decreasing trend (May to July totals for the last 30 years significantly below the period average), summer rainfall in December and January has shown a slight increase with comparison to historic data.

2.2 Topography

Topography ranges from 5 – 39 m Australian Height Datum (AHD) with the more elevated areas associated with the Spearwood sands and Bassendean sands, and the least elevated areas associated with drainage lines (5 – 10 m AHD) (GoWA, 2021).

2.3 Hydrology

The Proposal area lies within the South West Drainage Division (GoWA, 2021) and intersects several watercourses, wetlands and other water bodies including Five Mile Brook.

Most wetlands within the Proposal area are seasonal and have a variable water regime depending on climate, filling with water during winter rainfall. The period of inundation, area of inundation and depth of water is determined primarily by how much rainfall is received and can vary from year to year. By the end of summer most of the ephemeral wetlands have dried.

2.4 Hydrogeology

2.4.1 Geological setting

The Proposal area lies within the southern extent of the Perth Basin, a deep linear trough of sedimentary rocks extending north south along the west Australian coast for around 1000 km. The basin is generally flat to gently undulating with exposures of the basin rocks generally being poor (Playford, 1976). The Perth Basin is essentially a half-graben bounded on the east by the north-trending Darling Fault, which separates the basin from the Archaean rocks of the Yilgarn Block. Phanerozoic sedimentary rocks in the Perth Basin may exceed 15,000 m in thickness.

The Proposal area is within the Bunbury Trough, a deep graben in the southern part of the Perth Basin. It is situated between the Darling Fault on the east and the Busselton and Schroeder Faults on the west. The total thickness of Phanerozoic sediments in the trough is probably at least 10,000 m. These include formations of Permian, Triassic, Jurassic, and Cretaceous age, overlain by a more recent sequence of sediments of Pliocene to Holocene age.

2.4.2 Hydrogeological units

The regional hydrogeology has been described, including various hydrogeological cross-sections and interpretations of the main aquifer units found in the region and coinciding with the Proposal area (Commander, 1984). DWER recently developed a numerical groundwater flow model of the region that encompasses the Proposal area. Development of the groundwater model has been based on detailed hydrogeological conceptualisation of all regional aquifer units. DWER provided the model layer geometry for use during this assessment. The following sections, and aquifer interpretations throughout this report, are developed with reference to the DWER model data and the interpretations made by Commander (Commander, 1984).

Three key regional aquifer units which are of relevance to the Proposal are present within the sedimentary units of the Bunbury Trough. A general description of each of these aquifers is presented below and summarised in Table 1. Further location-specific information on these aquifers is provided below.

The hydrogeology of the area is characterised by low relief and westerly draining system. Groundwater in the area occurs in the Superficial (unconfined), Leederville (confined) and Yarragadee (confined) Aquifers. Key characteristics of these regional aquifers is provided in the following sub-sections (Table 1; Figure 3).

2.4.3 Superficial Unconfined Aquifers

Unconfined groundwater is present in shallow deposits of interbedded clay and sandy clay of the Guildford Formation in elevated areas and sandy alluvium in the vicinity of the Collie River gully. Groundwater in elevated areas is recharged by rainfall infiltration and seasonally by irrigation water from the Harvey Water Irrigation Scheme. Along the Collie River, the alluvial aquifer receives recharge from the river under high flow conditions and from the Guildford Formation from elevated areas to the north and south. It may also receive recharge due to upward flow from sub-regional aquifers in the Guildford Formation and regional flow from the Leederville Formation.

As described above for the perched aquifer, groundwater discharges from the superficial unconfined aquifer via:

- lateral flow to local creeks, artificial drains
- downward vertical flow to deeper aquifers in elevated areas
- evapotranspiration from vegetation.

2.4.4 Shallow Partly Confined to Confined Aquifer

As groundwater flows down through the ground groundwater becomes increasingly confined as it enters deeper parts of the Guildford Formation. Flowpaths are inferred to be sandy lenses within the interbedded stratigraphy. The rate that groundwater enters and leaves this aquifer is smaller than unconfined intervals above because of the increasing dominance of clay in the hydraulics. Groundwater flow becomes increasingly horizontal as it enters the sub-regional flow system.

2.4.5 Deep confined Regional Aquifer

The Leederville Formation is present beneath most of the Swan Coastal Plain. The Leederville Aquifer is a collective term for several stratigraphic members of the formation including the Mowen, Upper Vasse and Lower Vasse units. It is confined beneath the Guildford Formation.

As a regional-scaled aquifer groundwater flows to the north-west towards the ocean and is used extensively as a water supply by licensed groundwater users across the Bunbury city and hinterland areas.

2.4.6 Connectivity between Superficial, Leederville and Yarragadee Aquifers

Groundwater connectivity between the aquifers is variable within the Proposal area. Information presented in Commander (Commander, 1984) suggests that an upward hydraulic head between the Leederville and Superficial Aquifers may be evident in the far northern part of the Proposal area, with a downward head expected for the remaining area. The downward head for the remainder of the area results in some recharge to the underlying formations (Commander, 1984). The presence and distribution of the clay dominant Guildford Formation would play an important role in limiting vertical flow between the superficial formation and underling units, and consequently confining the underlying aquifers.

In the Leederville formation, the highest heads are in the middle of the formation, with upward groundwater-flow to the superficial formations and downward groundwater flow to the Yarragadee Formation, in which the hydraulic head is generally much lower (Commander, 1984).

Table 1. Summary of key hydrogeological units within Proposal area

Unit	Distribution	Comment
Superficial	Entire project area	Saturated thickness of less than 30 m. Guildford clay dominant in north and east, with isolated shallow Bassendean Sand. Tamala sand n far south. Generally low yielding and an unsuitable groundwater target for the purposes of this Project.
Leederville	Majority of project area. Absent south-west of Bunbury airport	Formed of three key units – Mowen Group, Upper and Lower Vasse. Combined depth of up to 200 m. Due to overlying Guilford clays, generally considered to be a confined system. Mowen group present in isolated area in central area. Upper and Lower Vasse main groundwater targets. Lower Vasse generally is higher yielding but less utilised that Upper Vasse.
Yarragadee	Present beneath the Leederville in central and northern area (at depth) and beneath the superficial/ Bunbury Basalt in Southern extent of project area south/west of Bunbury airport	Deep sand dominant unit with shale bands, particularly in upper units. In southern most area the Yarragadee can be found at shallow depths immediately beneath the superficial. In remaining area it is found beneath the Leederville.

The Southern Section of the proposed BORR alignment occurs within the Bunbury Groundwater Area and Busselton-Capel Groundwater Area, both of which are proclaimed under the *Rights in Water and Irrigation Act 1914* (RIWI Act); and is located within the Bunbury West and Bunbury East groundwater sub-areas.

Areas on the western side of the development envelope overlap the Bunbury Water Reserve Public Drinking Water Source Area (Priority 3).

The primary groundwater units underlying the Southern Section of the proposed BORR alignment include the Superficial and Leederville aquifers.

There are no proclaimed rivers (under the RIWI Act) that intersect the Southern Section of the Proposal Area, however there are a number of minor drainage lines (including Five Mile Brook) which overlap the Proposal Area (BORR IPT, 2019b).

- Superficial aquifer: a thin (5 –40 m below ground level (bgl)) to absent, predominantly unconfined layer, which overlies the Leederville aquifer and is recharged by direct infiltration of rainfall
- Leederville aquifer: a confined formation ranging from 15 –300 m bgl, which is recharged by downward seepage from the overlying Superficial aquifer and direct infiltration in outcrop areas
- Yarragadee aquifer: a confined formation (within the Proposal area) underlying the Leederville aquifer and ranging from 600 m to 1200 m thick. The Yarragadee aquifer recharges by direct infiltration of rainfall where unconfined, and elsewhere through limited seepage from the overlying Leederville aquifer (Department of Water, 2009).

Water level data from telemetered and non-telemetered loggers confirmed that groundwater typically flows in a westerly direction towards the Indian Ocean (BORR IPT, 2020). Groundwater across the Proposal area is shallow, ranging (in wells monitored for the Proposal) from 0.6 –7.2 m bgl (5.48 –17.1 m AHD) (BORR IPT, 2020).

2.4.7 Groundwater Levels and Recharge Observations

Groundwater level responses in the shallow perched and unconfined aquifers typically show some instantaneous response to rainfall events. The local shallow aquifer has had measured groundwater levels at the ground surface during the winter over the past 12 months.

On the other hand, groundwater levels in the confined aquifer show a more regional response with more broadscale delayed groundwater level rise follow the early winter rainfall periods. They also indicate seasonal groundwater level rises that are close to the ground surface. Importantly, the seasonal rise in confined groundwater levels propagates to within the perched and unconfined aquifer zone and therefore it likely leads to a fully saturated aquifer system.

2.4.8 Groundwater sub-areas

The Proposal area lies entirely within the Bunbury Groundwater Area, and within a total of six groundwater sub-areas:

- Yarragadee South: the “Perth - Yarragadee South” sub area covers the whole of the BORR alignment and surrounding area. This subarea overlaps with the other 5 subareas (i.e. Yarragadee Aquifer underlies the entire Proposal area).
- Kemerton South (Leederville only): The Kemerton South subarea is present for the northern most section of the alignment for areas north of the Collie River. This subarea only includes the Leederville Aquifer.
- Australind (Superficial only): The Australind sub area is present for the northern most section of the alignment for areas north of the Collie River. This subarea only includes the Superficial Aquifer.
- Dardanup (Leederville and Superficial): The Dardanup sub area is present the Collie River and the Preston Rover. This sub area includes the Superficial Aquifer and the Leederville Aquifer.
- Bunbury East (Leederville and Superficial): The Bunbury East sub area is present between the Preston River in north to the eastern edge of Gelorup in the south. This sub area includes the Superficial Aquifer and the Leederville Aquifer.
- Bunbury West (Leederville and Superficial): The Bunbury West sub area is present for the far south of the alignment for the Area including Gelorup and to its south. This sub area includes the Superficial Aquifer and the Leederville Aquifer.

2.4.9 Groundwater chemistry

Groundwater quality (as salinity) in the Superficial Aquifer is generally fresh to marginally brackish (<500 to <2000 mg/L Total Dissolved Solids) within the area of the proposed road alignment. There is expected to be some localised variation as a result of poor drainage in clay rich areas (eastern areas), and the influence some of the drainage/rivers may have.

The Leederville Aquifer generally has fresh groundwater, particularly so for the upper more sandy parts. Deeper in the aquifer, salinities can increase somewhat, reported to be up to the region of 800 mg/L (Commander, 1984). The Yarragadee Aquifer (as found in the west and excluding where it is at significant depth beneath the Leederville Aquifer) generally has fresh groundwater toward higher up in its profile. However, at the base of the flow system there is a rapid salinity increase to 10,000 mg/L or more (Commander, 1984).

2.4.10 Groundwater receptors - general

An initial review of the data for considerations of a potential water supply source for the Proposal determined the unconfined Superficial Aquifer would not be suitable for abstraction for this Proposal. Based on various factors including:

- Limited depth of superficial formations
- Risks that abstraction may have on groundwater receptors
- Risk of not being able to meet the supply demands
- Allocation status

By not considering the Superficial Aquifer, the risks outlined above reduce, in particular the risk that abstraction may have had on other groundwater users such as Threatened Ecological Communities, Black-stripe minnow habitats and surface water features with connections to the Superficial Aquifer.

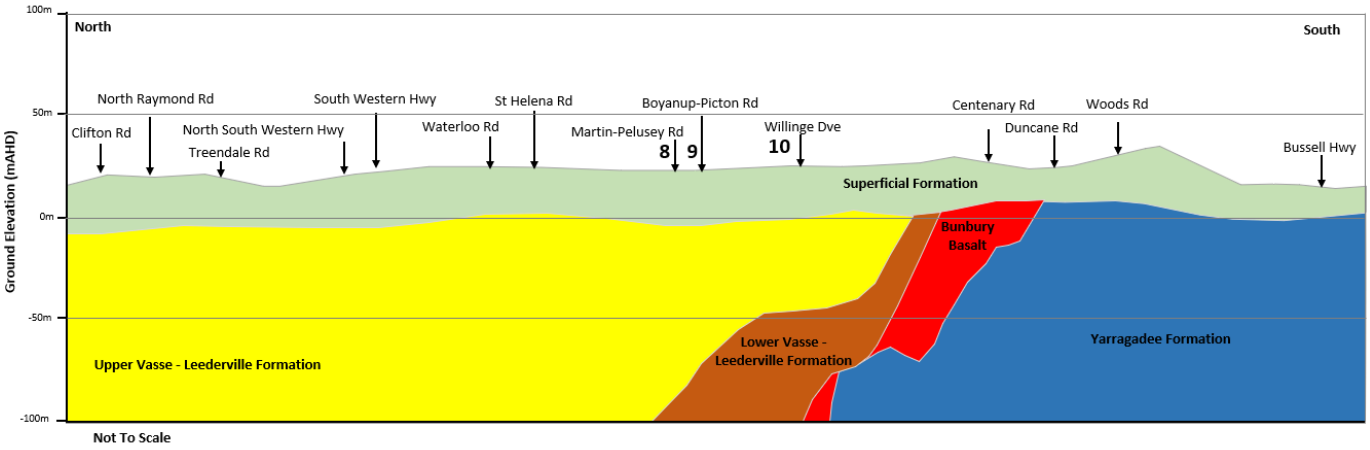

Figure 3. Hydro-stratigraphic schematic along the BORR alignment

2.5 Surface Water

2.5.1 Watercourses

Five Mile Brook intercepts the Proposal area, with the majority of the watercourse located outside of the Proposal area. The brook is seasonal, flowing only in winter months, discharging to Geographe Bay at Minninup Beach. Mean annual flow for Five Mile Brook is 5 GL/year.

2.5.2 Regional drainage

The Proposal area, to the east of Five Mile Brook, predominantly passes through rural/agricultural land, with the main drainage feature being Five Mile Brook. The area is characterised as palusplain, created by the thin sand layer overlying clay becoming saturated in the winter months, with associated wetlands including some Conservation Category and Resource Enhancement wetlands. Between Five Mile Brook and Bussell Highway the Proposal area is associated with the Gelorup area, which is characterised by low sand dunes. The depth to groundwater varies significantly with good separation at the top of the sand dunes and little separation in the low areas between the

dunes. There are no appreciable drains or creeks within the dunes. The proposed Centenary Road, which connects the Proposal area (near Lillydale Road) with Bussell Highway (at the existing Centenary Road intersection), traverses through low dunes at the Bussell Highway end transitioning into palusplain.

2.5.3 Wetlands

2.5.3.1 Wetlands of International Significance

No Ramsar wetlands (Ramsar Sites (DBCA-010)) are located within 10 km of the Proposal area. The Ramsar listed Peel-Yalgorup System is located approximately 20 km to the north of the Proposal and the Vasse-Wonnerup System is located approximately 19 km to the south west of the Proposal (GoWA, 2020).

2.5.3.2 Geomorphic Wetlands

Wetlands on the Swan Coastal Plain have been classified (Hill, Semeniuk, Semeniuk, & del Marco, 1996) using a geomorphic-hydrologic approach to wetland classification (Semeniuk & Semeniuk, 1995). Wetlands have also been evaluated and assigned an appropriate management category which provides guidance on the nature of wetland management and protection that the wetland should be afforded.

Much of the Proposal area comprises of MU category wetlands in the Southern section. The Proposal area intersects two CC Category Wetlands (CCW), two RE (RE), and 13 MU (MU) (Table 2). The Proposal area also runs adjacent to additional MU wetlands.

Table 2. Geomorphic wetlands within the Proposal area

Wetland Category	General Description	Potential Impact Area (ha)	UFI	Potential Impact Area (ha)
CC	Wetlands which support a high level of attributes and functions.	0.16	**931***	0.00
			14478*	0.16
RE	Wetlands which may have been modified or degraded, but still support substantial attributes and functions.	1.42	**1117***	1.42
			15493*	0.00
MU	Wetlands with few remaining important attributes and functions.	41.78	929	1.25
			932	0.48
			949	1.68
			1105	0.00
			1106	6.64
			1113	0.06
			1115	1.74
			1122	3.89
			1163*	1.32
			1165	0.57
			1167	0.85
			13228	21.44
			15500	1.85

* UFI listed under Condition 2-1(2) of MS 1191

The proposal has the potential to impact on inland waters from a total of 43.4 ha of geomorphic wetlands, including the following listed under Condition 2-1(2) of MS 1191:

- 0.16 ha of CCW (UFI-14478),
- 1.42 ha of REW (UFI-1117 and UFI-15493); and
- 41.78 ha of MUW (UFI-1163: 1.32 ha).

The proposal may impact on these wetlands, including through clearing of riparian vegetation, and changes to hydrological regimes and water quality.

The development envelope intersects a section of the Five Mile Brook where a vehicle bridge is proposed, and it is classified as a MU Wetland (Unique Feature Identifier UFI-1163). Directly downstream from the proposed bridge crossing, the Brook is classified as a CC Category Wetland (UFI-931) and contains suitable habitat for black stripe minnow.

The direct loss of 0.2 ha of a CCW (Unique Feature Identifier (UFI-14478) is not likely to be a significant residual impact given the clearing is located along the wetland edge and represents 0.003% of the total wetland.

Loss of 1.4 ha of REWs (UFI-1117 and UFI-15493) is also not considered to be significant because only partial clearance is proposed, and the drainage system will allow for hydrological regimes to be maintained. Given the low environmental values associated with MUWs, there is no significant residual impact to MUWs.

2.6 Black-stripe Minnow

2.6.1 Distribution

The black-stripe minnow is endemic to south-western Australia and is now rare throughout its distribution. Its main distribution lies within the Warren sub-region, where numerous populations are found between Albany and Augusta. However, there are isolated populations on the Swan Coastal Plain, including Lake Chandala (near Gingin), Melaleuca Park (north of Perth), and wetlands within the Kemerton Nature Reserve (north of Bunbury) (Morgan et al. 1998, Allen *et al.* 2002). In addition to the above occurrences on the Swan Coastal Plain, a survey by WRM in October 2018 of the BORR southern alternate investigation area recorded a population of black-stripe minnows in Gelorup (WRM 2019a). It is thought that the populations on the Swan Coastal Plain are remnants of a once wider distribution (Morgan et al. 1998).

The black-stripe minnow is capable of aestivating (burrowing) into soils to survive drying habitat and therefore tends to inhabit wetlands that dry over summer, appearing in pools within hours following first rains (Morgan *et al*. 2011). Black-stripe minnows inhabit ephemeral, tannin stained, vegetated wetlands of approximately 300 mm deep with a pH range of 3 – 8 (Morgan and Gill 2000; Galeotti *et al.* 2008). Other than these general observations, and anecdotal information, little is known about the preferred physio-chemical water properties of their habitats, with no correlations found between physio-chemical variables measured in wetlands across the south-west (Galeotti 2013). However, individual populations appear to be sensitive to sudden, localised changes in water quality variables (Knott *et* al. 2002).

2.6.2 Potential habitat areas in proximity to the Proposal area

The location and extent of potential black-stripe minnow habitat in proximity to the Proposal area, referenced in Condition 2-2(1)(d), are indicated in Figure 4. These potential habitat areas are reviewed in Table 3.

Confirmed black-stripe minnow sites within the Proposal area have a diversity of aquatic habitat types including large woody debris, emergent macrophyte, submerged macrophyte, trailing vegetation, floating macrophyte and detritus (Table 4). All sites had a sand substrate.

MU Wetland UFI-1106 was sampled by WRM in the 2018 and 2019 baseline surveys (WRM 2021). This is an extremely large seasonal wetland (over 24 hectares) that has a large area of intact native riparian vegetation, is fenced entirely and has minimal human/livestock disturbance. Black-stripe minnows were not recorded within this wetland despite extensive survey effort in both November 2018 and August 2019. The habitat and conditions at this

wetland (large, tannin-stained wetland with large areas of intact riparian vegetation) are similar to sites that black-stripe minnow were recorded in at nearby wetlands (e.g., wetlands within the BORR Northern and Central Section Proposal Area). It is considered likely that this wetland once supported black-stripe minnows, however, the population may have become isolated and subsequently died out due to land clearing practices. Given the close proximity of this wetland to other wetlands that support black-stripe minnows, and the high mobility of the species, it is possible that colonisation/recolonisation would occur after a large rainfall event if the wetlands become connected.

Table 3. Review of potential black-stripe minnow habitat areas in proximity to the Proposal area (refer Figure 4)

Figure Code	UFI	Wetland category	Data	Distance from proposal (m)	Comments
1a	15493	RE	2022	Within	In report, included as a monitoring site (BSM-S-PI-4)
1b	15500	MU		Within	In report, included as a site (unlikely to hold water)
1c	15500	MU		175	Small drain running through bushland site, unlikely to be impacted by proposal
2a	1103	CC	2019-Current	840	Reference site for BORR North/Central. Not impacted by Southern proposal
2b	14471	MU		550	Very shallow, seasonally inundated. Not impacted by proposal
2c	14471	MU		500	Could be seasonally connected to 3a,b,c,d. Not impacted by proposal
3a	14471	MU		400	Could be seasonally connected to 3b,d. Not impacted by proposal
3b	942	RE	2019	75	Sampled in 2019, no BSM. Excavated and disturbed wetland. Unlikely to be BSM but included in 2022 monitoring
3c	1165	MU		Within	Likely bushland, connected to seasonally damp paddock. Unlikely to be BSM habitat
3d	1167	MU		140	Seasonally damp paddock. Unlikely to be BSM habitat
4a	1106	MU	2019-20	Adjoin	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
4b	1106	MU	2019-20	Within	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
4c	1106	MU	2019-20	Adjoin	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
4d	1106	MU	2019-20	250	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
4e	1106	MU	2019-20	Adjoin	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
4f	1106	MU	2019-20	400	In report (refer Section 2.6.2 and 4.3). Potential BSM habitat
5a	1133	RE	2019	350	Dry in 2018. Potential BSM habitat and influence if downstream from Wetland 4 and connects to Wetland 5b,c.
5b	1112	RE	2019	Adjoin	Wet in 2018 (not sampled due to access). Potential BSM habitat and influence if downstream from Wetland 4
5c	1112	RE	2019	500	Dry in 2018. Potential BSM habitat and influence if downstream from Wetland 5b
5d	13228	MU	2019	140	Dry in 2018, potential but unlikely BSM habitat (bushland)
6	1117	RE	2022	Within	In report, included as a monitoring site (BSM-S-PI-5)
7a	13228	MU		75	Heavily degraded, part of mine. Unlikely BSM habitat
7b	13228	MU		Within	Heavily degraded, part of mine. Unlikely BSM habitat
7c	13228	MU		20	Heavily degraded, part of mine. Unlikely BSM habitat
8a	949	MU		700	Not in proximity to, or impacted by proposal
8b	949	MU		900	Not in proximity to, or impacted by proposal
8c	949	MU		900	Not in proximity to, or impacted by proposal
8d	949	MU		700	Not in proximity to, or impacted by proposal

Figure Code	UFI	Wetland category	Data	Distance from proposal (m)	Comments
8e	949	MU		1200	Not in proximity to, or impacted by proposal
9a	1090	MU		1200	Not in proximity to, or impacted by proposal
9b	1090	MU		1200	Not in proximity to, or impacted by proposal
10	949	MU		Within	Bushland, unlikely BSM habitat
11a	1093	RE		550	Bushland, unlikely BSM habitat. Not in proximity to, or impacted by proposal
11b	1093	RE		780	Not in proximity to, or impacted by proposal
11c	1093/ 1095	RE/MU		1100	Not in proximity to, or impacted by proposal
11d	1094	RE		500	Bushland, unlikely BSM habitat. Not in proximity to, or impacted by proposal
11e	1096	MU		500	Bushland, unlikely BSM habitat. Not in proximity to, or impacted by proposal
11f	1097	CC		800	Not in proximity to, or impacted by proposal
12	1159	MU		600	Bushland/farm dam. Unlikely habitat. Not impacted by proposal
13a	1163	MU	2019-Current	Within	Monitoring sites BSM-S-PI-1; BSM-S-PI-2
13b	931	CC		120	Downstream of impact. New site added downstream 2022
14a	1161	MU		1300	Not in proximity to, or impacted by proposal
14b	1164	RE		1300	Not in proximity to, or impacted by proposal
14c	1161	MU		1400	Not in proximity to, or impacted by proposal
15a	15821	RE		1500	Not in proximity to, or impacted by proposal
15b	15821	RE		1400	Not in proximity to, or impacted by proposal
15c	1004	CC		1100	Not in proximity to, or impacted by proposal
15d	1022	MU		1200	Not in proximity to, or impacted by proposal
15e	1023	CC		1400	Not in proximity to, or impacted by proposal
15f	1024	CC		1700	Not in proximity to, or impacted by proposal
15g	14502	MU		1800	Not in proximity to, or impacted by proposal
15h	14502	MU		1900	Not in proximity to, or impacted by proposal
15i	14502	MU		1500	Not in proximity to, or impacted by proposal
16a	1163	MU		2200	BSM habitat. Not in proximity to, and upstream of proposal. Not impacted by proposal
16b	1163	MU	2020	2200	Confirmed BSM. Not in proximity to, and upstream of proposal. Not impacted by proposal
16c	1163	MU		2200	BSM habitat. Not in proximity to, and upstream of proposal. Not impacted by proposal
17a	13852	Not assessed		1900	Bushland site. Not in proximity to, or impacted by proposal
17b	1172	RE		1800	Likely BSM habitat. Not in proximity to, or impacted by proposal
17c	1174	MU		1600	Bushland. Unlikely BSM habitat. Not in proximity to, or impacted by proposal
17d	1175	RE		2500	Likely BSM habitat. Not in proximity to, or impacted by proposal
17e	16093	CC	2018	2500	Confirmed BSM site. Not in proximity to, or impacted by proposal
17f	1179	MU		1900	Likely BSM habitat. Not in proximity to, or impacted by proposal
17g	1179	MU		1700	Likely BSM habitat. Not in proximity to, or impacted by proposal
18a	16077	CC	2018-Current	2700	Monitoring site BSM-S-R-1. Southern proposal reference site

Figure Code	UFI	Wetland category	Data	Distance from proposal (m)	Comments
18b	16079	CC	2018	2200	Potential BSM habitat. Not in proximity to, or impacted by proposal
18c	16079/ 10680	CC	2018	2400	Potential BSM habitat. Not in proximity to, or impacted by proposal
18d	16079	CC	2018	2000	Confirmed BSM site. Not in proximity to, or impacted by proposal
18e	16080	CC	2018	2100	Confirmed BSM site. Not in proximity to, or impacted by proposal
18f	1014	MU	2018	2000	Confirmed BSM site. Not in proximity to, or impacted by proposal
18g	1014	MU	2018	2000	Potential BSM habitat. Not in proximity to, or impacted by proposal
19a	1026	MU		400	Bushland. Unlikely BSM habitat or any impact from proposal
19b	1026	MU		400	Bushland. Unlikely BSM habitat or any impact from proposal
19c	1026	MU		400	Bushland. Unlikely BSM habitat or any impact from proposal
20a	1028	CC		350	Unlikely BSM habitat or any impact from proposal
20b	1026	MU		600	Unlikely BSM habitat or any impact from proposal
21a	14478	CC	2022	Adjoin	Monitoring site BSM-S-PI-6. Potential BSM habitat. Unlikely to be influenced by proposal
21b	14478	CC	2022	Adjoin	Monitoring site BSM-S-PI-6. Potential BSM habitat. Unlikely to be influenced by proposal
21c	1616/ 1015	MU		Adjoin	Monitoring site BSM-S-PI-6. Potential BSM habitat. Unlikely to be influenced by proposal
22	13229/ 1019	MU/CC		800	Not in proximity to, or impacted by proposal

Table 4. Average percentage of different habitat types of black-stripe minnow sites sampled in 2020 and 2021

Location ID	Year	Mineral substrate	Emergent macrophyte	Submerged macrophyte	Floating macrophyte	Algal cover	Detritus	Trailing vegetation	Large woody debris
BSM-S-R-1	2020	32.5	7.5	10	12.5	0	15	10	12.5
	2021	23.75	6.25	7.5	25	0.75	9.25	14.5	13
BSM-S-PI-1	2020	20	40	5	0	0	20	5	10
	2021	50	10	10	2.5	0	10	12.5	5
BSM-S-PI-2	2020	40	2.5	5	0	0	5	42.5	5
	2021	45	5	17.5	7.5	0	6.5	6	12.5

3 Methodology

3.1 Groundwater and Surface Water

3.1.1 Standards and Guidelines

The Proposal groundwater and surface water quality monitoring and analysis program were undertaken in accordance with the following standards and guidance documents:

- Australian and New Zealand Environment and CC Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000) Monitoring Guidelines Chapter 4.
- Australian Standard (1998) 5667.1 Water Quality – Sampling, Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples (AS 5667.1:1998).
- Department of Environment Regulation (DER – now DWER) Assessment and management of contaminated sites – Contaminated Sites Guidelines.
- Department of Health (2014), Contaminated Sites Ground and Surface Water Chemical Screening Guidelines, Department of Health.

3.1.2 Assessment Criteria

Water quality for physio-chemical parameters and nutrients have been compared against ANZECC/ARMCANZ (2000) freshwater guideline values for the protection of slightly/moderately disturbed wetland ecosystems in the south west of Western Australia as these are the most recent locally specific guidelines. It is noted that the ANZECC and ARMCANZ (2000) are now referred to as Australia and New Zealand Guidelines (ANZG) (2018) and came into effect on 4 September 2018 (ANZG, 2018). Preliminary review of these guidelines has identified that new default guideline values are not yet provided for SW WA. For the purposes of this wetland study, ANZECC and ARMCANZ (2000) criteria have been adopted until these values are updated. Results have also been compared to historical data from the pre-development monitoring program (BORR IPT 2020, SGWA 2021).

The following assessment criteria (adopted from the guidelines included in Section 3.1.1), were applied.

3.1.2.1 Groundwater criteria

- DER 2014 – Non-potable Use Groundwater (NPUG)
- ANZECC and ARMCANZ 2000 – Irrigation – Short-term trigger values

3.1.2.2 Surface water criteria

- ANZECC and ARMCANZ 2000 – Southwest Australia Lowland River Guidelines
- ANZECC and ARMCANZ 2000 – Freshwater Slight-Mod Disturbed.

3.1.3 Groundwater Monitoring

The methodology for monitoring of groundwater levels is contained within South West Gateway Alliance - Bunbury Outer Ring Road Determination of Design Groundwater Levels (SWGA-00-270-00-REP-0001, September 2021).

3.1.4 Groundwater Sampling

Refer to Table 3-1 of the *Bunbury Outer Ring Road Integrated Planning Study – Groundwater and Surface Water Quality Monitoring 2019-2020* (BORR IPT, 2020) as presented in Appendix C, for a summary of the groundwater sampling methodology.

3.1.5 Surface Water Sampling

Refer to Table 3-2 of the *Bunbury Outer Ring Road Integrated Planning Study – Groundwater and Surface Water Quality Monitoring 2019-2020* (BORR IPT, 2020) as presented in Appendix C, for a summary of the sampling methodology.

The fieldwork methodology is summarised in Table 5.

Table 5. Field work methodology

Activity / Item	Details
Groundwater Bore – Gauging	All monitoring bores were gauged using an interface probe to determine the depth to groundwater prior to the commencement of sampling.
Groundwater Bore – Sampling Method	All bores were sampled using low-flow technique (peristaltic pump). Ex-situ measurements of water quality parameters were taken on site using a multi-parameter instrument (YSI Pro DSS) fitted with a flow-through-cell. The parameters included pH, dissolved oxygen (DO), redox potential, temperature, and electrical conductivity (EC).
Surface Water – Sampling Method	The YSI Pro DSS was used to take in-situ measurements of water quality parameters, including the parameters taken at groundwater bores and water turbidity. Where water level permitted, the measurements were profiled at different depths. Quarterly *in situ* measurements of water quality parameters were undertaken using portable WTW and TPS field meters at a depth of approximately 10 cm below the surface. Undisturbed water samples were also collected for laboratory analysis of colour, total suspended solids and total recoverable hydrocarbons, from a depth of approximately 15 cm below the water surface. Laboratory analysis were conducted by a NATA accredited laboratory.
Sample Analysis	Primary samples were analysed by ALS, a NATA accredited laboratory, using standard methods. Laboratory QA/QC measures included duplicate and rinsate samples. Duplicate samples were taken at one groundwater bore and one surface water location each round, and rinsates were taken at a frequency of one per day of sampling.
Field Documentation	All field records were logged on standardised field forms and included the date and time, location, field personnel, quality assurance / quality control (QA/QC) sample information and details of the sampling observations.
Sample Preparation, Preservation and Transportation	Samples were placed in laboratory-supplied bottles containing appropriate preservatives. Samples for dissolved metals were not field filtered. Samples were labelled in accordance with the monitoring location, field personnel and date, placed in eskies chilled with ice and forwarded to the laboratory under standard chain of custody (COC) procedures.
Decontamination Procedure	Decontamination of all non-disposable equipment was completed between sample locations. Disposable equipment such as bladders and gloves were replaced between each location.
Equipment Calibration	All field equipment was calibrated by field staff or the vendor prior to use on-site (once per sample round).

3.2 Sampling Locations

Sampling locations for the BORR Southern section proposal area comprise:

- twelve (12) groundwater monitoring wells;
- three (3) surface water monitoring points (BSM);
- three (3) photo-point locations (BSM);
- four sampling locations have been added to the program incorporating CCWs UFI-931 and UFI-14478, and RE wetlands UFI-1117 and UFI-15493 as per Conditions 2.1 and 2.2. These locations are now included for collection of surface water quality and hydrology data.

Groundwater monitoring well locations are summarised in Table 6 and shown in Figure 5.

Surface water monitoring points are summarised in Table 7 and shown in Figure 6.

Table 6. Groundwater monitoring sites

Groundwater Monitoring Well Location ID	Easting (MGA94 Zone 50)	Northing (MGA94 Zone 50)	Top of Collar (m AHD)
BORR MW04	370118	6297060	9.45
BORR MW05	370681	6298315	12.24
BORR MW06	371109	6299068	11.62
BORR MW07	372078	6300142	15.62
BORR MW08a	373588	6300392	15.95
BORR MW09	374241	6301013	16.45
BORR MW10	374848	6301753	19.35
BORR MW11	375286	6302605	20.80
BORR MW12	375843	6304181	19.63
BORR MW46	373883	6305094	7.03
MR MW05	375313	6302185	20.51
BH 27.1	371426	6299584	12.30

Table 7. Surface water monitoring sites

Surface Water Location ID	Description	UFI	Wetland Category	Easting (MGA94 Zone 50)	Northing (MGA94 Zone 50)
BSM-S-PI-1	Five Mile Brook (u/s)	UFI-931	CC	373282	6330053
BSM-S-PI-2	Five Mile Brook	UFI-1163	MU	373652	6300375
BSM-S-PI-3*	Five Mile Brook (d/s)	UFI-1163	MU	373737	6301748
BSM-S-R-1	Reference site			373383	6298152
BSM-S-PI-4*	Centenary Rd	UFI-15493	RE	373559	6305160
BSM-S-PI-5*	Lilydale Rd	UFI-1117	RE	375536	6303883
BSM-S-PI-6*	Bussell Hwy South	UFI-14478	CC	370834	6298013

* New monitoring locations

3.3 Black-stripe Minnow

Quarterly monitoring for black-stripe minnows was undertaken in May, August and October of 2020 and January, May, August and October 2021, with annual population monitoring of black-stripe minnows undertaken in August 2020 and October 2021 (WRM, 2021), and is consistent with methodology used by others in similar surveys across Australia, including the sampling of wetlands of the Swan Coastal Plain, and included:

- quarterly water quality monitoring including in situ parameters (pH, oxygen-reduction potential, dissolved oxygen, electrical conductivity, turbidity and temperature) and laboratory analysis of total suspended solids, hydrocarbons and colour;
- quarterly photopoint monitoring;
- detailed habitat characteristics including mineral substrate and aquatic habitat composition;
- one targeted black-stripe minnow population survey.

4 Hydrological Status

4.1 Groundwater

Sampling of groundwater monitoring locations to inform the baseline *Groundwater and Surface Water Quality Monitoring Report 2019-2020* (BORR IPT, 2020) report was conducted between August 2019 to July 2020.

Groundwater monitoring has been conducted by SWGA during 2021 and 2022.

Table 8 provides the groundwater elevation data for the groundwater monitoring locations.

Representative hydrographs from bores in Table 8 are presented in Appendix A.

Groundwater elevations (m AHD) and depth to groundwater (m bgl) modelled for the proposal area (SWGA, 2021b) are displayed in Appendix B.

Groundwater levels in the Proposal area appear to be consistent with the regional trends of an elevated groundwater table associated with high winter rainfall in 2021.

Table 8. Groundwater elevations

BORR IPT Location ID	Casing Level (m AHD)	Groundwater Depth (m b TOC)			Groundwater Elevation (m AHD)			
		Aug '19 – Jul '20	Jul 2021	Jun 2022	Aug '19 – Jul '20	Jul 2021	Aug '18 – Aug '21	Jun 2022
BORR MW04	9.45	3.88 – 4.81	3.94	4.22	5.57 – 4.64	5.51	5.60 – 4.60	5.23
BORR MW05	12.24	5.63 – 6.78	-	-	6.61 – 5.45	-	6.65 – 6.10	-
BORR MW06	11.62	5.31 - 6.73	5.34	5.61	6.31 - 4.89	6.28	6.50 – 5.90	6.01
BORR MW07	15.62	9.99 -10.09	10.2	-	5.62 - 5.52	5.42	5.62 - 5.52	-
BORR MW08a	15.95	2.07 - 4.28	1.87	3.01	13.88 - 11.66	14.08	13.88 - 11.66	12.94
BORR MW09	16.45	3.14 – 4.55	3.60	4.07	13.30 – 11.90	12.85	14.10 – 11.90	12.38
BORR MW10	19.35	1.36 – 2.31	1.19	1.76	17.99 – 17.03	18.16	18.30 – 17.00	17.59
BORR MW11	20.80	0.95 – 3.98	0.82	-	19.84 – 16.82	19.98	19.84 – 16.82	-
BORR MW12	19.63	1.49 – 2.46	-	1.32	18.13 – 17.16	19.63	18.50 – 17.10	18.31
BORR MW46	7.03	3.49 – 4.63	3.51	3.48	3.47 – 2.45	3.52	3.55 - 2.40	3.55
MR MW05	20.51	2.23 – 3.74	2.28	2.54	18.28 – 16.77	18.23	18.50 – 16.77	17.97
BH 27.1	-	-	6.08	6.15	-	-		-

4.2 Surface Water

Surface water quality and depth will be monitored at CC Wetland UFI-14478, and RE wetlands UFI-1117 and UFI-15493 over winter of 2022. These sites were not part of the survey programme for previous years, but have been added to meet the requirements of Condition 2 of MS1191. A preliminary site investigation in May 2022 revealed that all sites could potentially hold water, however, this will need to be confirmed during the winter period 2022. A summary of this information, as well as the current status of the other UFI sites listed under Condition 2-1(2) of MS1191 can be found in Table 9.

Table 9. Surface water monitoring sites status

UFI	Surface Water Location ID	BSM	Comments
UFI-931	BSM-S-PI-1	Yes	BSM found during annual monitoring in 2021. Monitoring will continue in October 2022, and throughout the development of the project.
UFI-1163	BSM-S-PI-2 BSM-S-PI-3	Yes	BSM found during annual monitoring in 2021. Monitoring will continue in October 2022, and throughout the development of the project. A new site is proposed downstream of the Proposal area.
UFI-15493	BSM-S-PI-4	N/A	Potential to hold water, initial surveys during May 2022 indicate vegetation likely to hold water at some stages of the year. Follow up surveys for surface water and BSM presence.
UFI-1117	BSM-S-PI-5	N/A	Unlikely to hold water, initial surveys during May 2022 show old, decaying wetland vegetation. Topography also unsuited for wetland. Follow up surveys for surface water and BSM presence.
UFI-14478	BSM-S-PI-6	N/A	Likely to hold water, initial surveys during May 2022 indicate healthy, wetland habitats. Follow up surveys for surface water and BSM presence.

4.3 Black-stripe Minnow

Three sites inhabited by black-stripe minnow in the Proposal area, one reference (BSM-S-R-1) and two potential impact sites (BSM-S-PI-1 and BSM-S-PI-2), are routinely monitored quarterly for water quality from May 2020. BSM-S-PI-1 was dry in May 2020, October 2020, January 2021 and May 2021. BSM-S-PI-2 was dry in May 2020, January 2021 and May 2021. BSM-S-R-1 held water on all sampling occasions. Maximum water depth at all sites was highest in August in 2020 and October in 2021 (both BSM-S-R-1 and BSM-S-PI-2 had a maximum water depth >1.8 m at August and October 2021 sampling). This is likely due to later and extended seasonal rainfall in 2021.

In situ water quality within the black-stripe minnow sites was characterised by acidic to neutral pH, low dissolved oxygen levels, and fresh to brackish electrical conductivities (EC). During sampling in August and October 2021, all sites were fresher than the same time in 2020, likely due to higher rainfall in 2021. pH was below the trigger values (ANZECC 2000) for the protection of slightly/moderately disturbed wetland ecosystems in the southwest of W.A. (pH 7 – 8.5) at BSM-S-R-1 and BSM-S-PI-2 in October 2020 and BSM-S-R-1 in May and October 2021. Similar to 2020, dissolved oxygen concentrations in 2021 were below the trigger value of 90% at all sites on all sampling occasions (Table 10).

Total recoverable hydrocarbons were recorded at all sites on at least one sampling occasion, with values for both F2 hydrocarbons (>C10-C16) and F3 hydrocarbons (>C16-C34). All sites have influences from road and/or farmland runoff, which are likely sources of hydrocarbons (Table 11).

A one-off dissolved metals sample was collected at each site in August 2020. Background levels of dissolved aluminium (0.092 – 0.1 mg/L) were greater than the DGVs (for 99% species protection) for aluminium (ANZG 2018) at all sites. Relatively high background levels of dissolved copper and dissolved zinc (>10x the DGV at BSM-S-PI-1 and BSM-S-PI-2 and >2x at BSM-S-R-1) were recorded at all sites compared to the DGV for 99% species protection. Concentrations of all other measured dissolved metals were below ANZG DGVs.

Table 10. *In situ* water quality results from all black-stripe minnow sites sampled in 2020 and 2021

Location ID	Date	Temp	Cond	pH	Redox	Turbidity	DO	DO
		(°C)	(µS/cm)	(H^+)	(mV)	(NTU)	(%)	(mg/L)
ANZECC Guidelines			**300 - 1500**	**7 - 8.5***		**10 - 100**	**90 - 120**	
BSM-S-R-1	29/05/2020	Not sampled						
	7/08/2020	13.1	820	7.15	-19.8	4.9	72.1	7.88
	28/10/2020	18.8	1056	6.71	18.8	4.86	31	2.2
	28/01/2021	16.4	2610	7.26	8.5	10.64	31.4	9.91
	25/05/2021	11	2810	5.58	7.96	2.76	48.7	5.56
	27/08/2021	8.2	619.6	7.82	-40.2	2.13	48.4	5.68
	13/10/2021	11.5	742.7	6.89	10.1	3.25	55.5	5.97
	31/01/2022	21.1	1360	6.75	27.5	8.96	5	0.51
	1/06/2022	8.5	1947	5.02	118.1	6.8	54.4	6.12
BSM-S-PI-1	29/05/2020	DRY						
	7/08/2020	14.1	837	7.24	-24.9	1.52	72.2	7.55
	28/10/2020	DRY						
	28/01/2021	DRY						
	25/05/2021	DRY						
	27/08/2021	10.2	520.9	7.36	-14.7	6.61	63.5	7.09
	14/10/2021	13.9	778.9	7.12	-1.5	5.95	83	8.34
	31/01/2022	DRY						
	1/06/2022	DRY						
BSM-S-PI-2	29/05/2020	DRY						
	8/08/2020	11	846	7.41	-34.8	3.55	76.9	8.47
	28/10/2020	20.5	1125	6.96	5.3	26.57	34.4	3.35
	28/01/2021	DRY						
	25/05/2021	DRY						
	27/08/2021	10.1	528.1	7.74	-36	6.78	55	6.78
	14/10/2021	16.6	716.1	7.31	-13.5	4.87	83.5	8.43
	31/01/2022	DRY						
	1/06/2022	DRY						

*ANZECC (2000) recognises that pH can typically range between 4.5 and 6.5 in highly coloured wetlands, such as those in the study area.

Note: default ANZECC (2000) water quality guideline values. Values outside of ANZECC guideline values are highlighted in orange.

Table 11. Laboratory analysed water quality results from all black-stripe minnow sites sampled in 2020 and 2021

Location ID	Date	Colour	TSS	TRH				
		(TCU)	(mg/L)	F1*	F2*	F3*	F4*	Total TRH
				(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
BSM-S-R-1	29/05/2020	Not sampled						
	7/08/2020	700	17	<25	<25	<100	<100	<250
	28/10/2020	790	130	<25	110	650	100	860
	28/01/2021	520	9	<25	48	340	<100	<250
	25/05/2021	200	1	<25	<25	140	<100	<250
	27/08/2021	670	3	<25	<25	<100	<100	<250
	13/10/2021	560	6	<25	400	130	<100	530
	31/01/2022	740	18	<25	<25	180	<100	<250
	1/06/2022	390	16	<25	<25	180	<100	<250
BSM-S-PI-1	29/05/2020	DRY						
	7/08/2020	640	1	<25	<25	<100	<100	<250
	28/10/2020	DRY						
	28/01/2021	DRY						
	25/05/2021	DRY						
	27/08/2021	650	4	<25	<25	<100	<100	<250
	14/10/2021	560	4	<25	<25	130	<100	<250
	31/01/2022	DRY						
	1/06/2022	DRY						
BSM-S-PI-2	29/05/2020	DRY						
	8/08/2020	640	1	<25	<25	<100	<100	<250
	28/10/2020	800	22	<25	<25	140	<100	<250
	28/01/2021	DRY						
	25/05/2021	DRY						
	27/08/2021	650	7	No sample taken				
	14/10/2021	590	3	<25	48	120	<100	<250
	31/01/2022	DRY						
	1/06/2022	DRY						
*F1: C6-C10, F2: >C10-C16, F3:C16-C34, F4: >C34-C40								

Note: (F: fraction number, C: carbon number range).

MU Wetland (UFI-1106) was sampled in both 2018 and 2019 as part of the Proposal area baseline surveys. *In situ* water quality recorded within this site is present in Table 12 below, and had similar physio-chemical properties to sites where black-stripe minnows have been recorded.

Black-stripe minnow habitat sites within the Proposal area that were surveyed pre-2020 will be revisited. Limitations that included access from landholders, and a reduced habitat availability due to rainfall events may have influenced the presence and extent of black-stripe minnows in these areas.

Table 12. *In situ* water quality results from UFI-1106 sampled in 2018 and 2019.

Location ID	Date	Temp	Cond	pH	DO	DO
		(°C)	(µS/cm)	(H^+)	(%)	(mg/L)
ANZECC Guidelines			**300 - 1500**	**7 - 8.5***	**90 - 120**	
UFI-1106	21/11/2018	21.2	1913	7.52	92.2	8.05
	21/11/2018	21.2	1913	7.52	92.2	8.05
	21/11/2018	29.7	2350	7.48	145.5	11.96
	26/08/2019	26.4	1517	7.78	108.8	8.51
	27/08/2019	20.6	2020	7.98	102.8	9.54

*ANZECC (2000) recognises that pH can typically range between 4.5 and 6.5 in highly coloured wetlands, such as those in the study area.

4.4 Vegetation and Drainage Monitoring

Ecoedge (2021) baseline monitoring results over the 2019 and 2020 years are summarised as follows:

- No change in vegetation structure between any of the rounds of monitoring.
- No change in vegetation condition between any of the rounds of monitoring.
- Weed cover increased at 35 of the boundary photopoint sites and five of nine transect sites. Increase in weeds affected all vegetation types in both reference and potential impact sites. This was attributed to increased rainfall in 2020 when compared to 2019.
- No change in native cover for boundary photopoint monitoring sites.
- Non-significant increase in native herbaceous species recorded at six of the nine transect sites. Likely attributed to higher rainfall in 2020 when compared to 2019.
- Plant stress recorded at boundary photopoint sites and claypan reference site CP-NS-R-1 in spring 2020. Unlikely to be Phytophthora dieback.
- No signs of damage, or abnormal stress at any sites due to drainage impacts.
- No changes in erosion, inundation/flooding or abnormal drying issues.

5 Post-Development Hydrological Regime

5.1 Overview

The Alliance notes and is cognisant that in its Report and Recommendation to the Minister for Environment (EPA Report 1714, October 2021), the EPA noted that in relation to Inland Waters, the potential for direct and indirect impacts to hydrological regimes and water quality in adjacent CC Category Wetlands (CCWs), RE Wetlands (REWs), the Five Mile Brook and black-stripe minnow habitats.

To address these impacts, the EPA recommended Condition 2 of MS 1191 requiring pre-disturbance monitoring of hydrological regimes and baseline conditions, and monitoring of these elements during and post-construction, with reporting requirements, to meet the objective that there are no project-attributable impacts to the hydrological regime and water quality of 'CC' category and 'resource enhanced' wetlands, Five Mile Brook or black-stripe minnow habitat.

The Alliance is committed to ensuring that the design and construction of the Proposal will not result in an alteration to the hydrological regimes that supports significant environmental values within the local area.

The proposal aims to minimise impacts through the following:

- Design of a transverse drainage system to maintain the pre-development hydrological processes of the proposal area and to minimise potential drainage shadow effects on surrounding wetlands and waterways (black-stripe minnow habitat), vegetation and agricultural properties.
- Establishment of baseline surface and groundwater quality.
- Monitoring for evidence of erosion and run-off during construction and operations, and surface water monitoring during construction of the bridge over Five Mile Brook.
- Construction of detention and infiltration basins where there is potential for discharge of hazardous spills into waterways.
- Implementation of a Construction Environmental Management Plan including measures such as:
  - procedures for handling and storage of hydrocarbons and spill response,
  - no storage or refuelling within 200 metres of a natural watercourse or within 50 metres of a CCW or REW,
  - erosion and sediment controls, to ensure no direct run-off during construction to protect water quality in Five Mile Brook and wetlands.
- Implementation of an Acid Sulfate Soils Management Plan and Dewatering Management Plan to ensure correct dewatering methods, effluent monitoring and management, effluent treatment, effluent disposal and monitoring requirements.
- Installation of erosion protection measures and a clear span bridge over Five Mile Brook to minimise riparian disturbance and maintain fish passage for black-stripe minnow.
- Installation of biological filters where possible as part of the revegetation and landscape design to protect water quality from operational run-off.
- Investigation of alternate sources of water to reduce the reliance on groundwater for construction and dust suppression purposes.
- Dewatering and water abstraction activities associated with construction will be temporary and impacts are likely to be spatially restricted and not significant.

5.2 Drainage Strategy

The proposal has been designed with drainage infrastructure that maintains the existing water balance of the proposal area in order to not impact on hydrological regimes or water quality of adjoining CCWs, REWs, black-stripe minnow and the Five Mile Brook.

The road drainage strategy is based on at source detention and infiltration with preference for surface flows where practical in accordance with the DWER requirements and expectations. This generally consists of passive sheetflow that is collected by adjacent vegetated surfaces or open channels and basins at the toe of the embankment for detention and some infiltration. Where overland flow of road runoff is not possible, particularly in kerbed locations or

in high fill situations, pit and pipe or kerb openings are proposed. The erosion potential from the outlets of pipework or kerb openings will be managed with rock protection.

The majority of road runoff will be directed into proposed shallow water quality management basins or existing localised depressions. These storage areas are designed to overtop during major events and flows are directed to existing natural flow paths, creeks and rivers after management of common rainfall events. For the management of transverse drainage systems and major waterways, the strategy is to maintain the hydrologic regime of all crossings where they may be interrupted by the proposed works. Coordination with the asset owners of the existing crossings is ongoing through the development of the design to understand and appreciate their requirements and ultimately to gain acceptance of the design.

The drainage strategy for the southern section of the Proposal area is to adopt an unkerbed profile to allow the runoff to sheet off the highway, through the vegetated embankment to the adjacent verge. Where the highway and associated interchanges require kerbing for delineation/to meet road design standards or for the control of scour, the outlet of the drainage networks shall either be directed to retention/detention basins sized for the small frequent rainfall event (defined by DWER as up to 15mm of rainfall) or to the adjacent vegetated verge areas to spread out and infiltrate or to flow into the local drainage systems. Basins are likely to be provided upstream of sensitive receptors or where large networks and/or those featuring steeper grades are being discharged.

The drainage strategy for local roads is to adopt a generally unkerbed profile, reflective of the existing local road network. Where kerbing is required, e.g. at intersections/roundabouts, these should be drained by kerb openings or small pit and pipe networks to the adjacent verge/local drains. The existing area is generally a seasonally inundated palusplain, which results in relatively high levels of runoff from rainfall events in the winter months. As such, the change in land use to a highway is not likely to result in a significant change in runoff. The disconnection of the drainage system will further aid with flood mitigation by slowing the runoff from the highway thereby reducing peak flows and promoting infiltration during drier months. The water quality basins proposed for pit and pipe networks where kerbing is required will also aid in reducing the peak flows from these networks, even in major events, particularly for shorter duration storms that are of concern for localised flooding.

5.3 Black-stripe Minnow

The proposal traverses a number of wetlands and waterways, including the Five Mile Brook, and would result in the direct loss of habitat for black-stripe minnow. In addition, the EPA considered that the potential indirect impacts from the proposal were to hydrological regimes, hydrological connectivity and degradation of water quality, given the construction of the road and bridges within or near to black-stripe minnow habitats.

Where the proposal crosses water courses inhabited by black-stripe minnows, such as Five Mile Brook, culverts will be constructed to provide connectivity between wetlands upstream and downstream of the alignment to prevent isolation of populations. They are a highly mobile species, and will move through wetlands as conditions allow. Excerpt from WRM report(s) below:

Surveys conducted within the Kemerton region have shown that black-stripe minnow populations will disperse in years of high rainfall and black-stripe minnows were declared extinct in one of the pools, only to be recorded in subsequent surveys (MBS Environmental 2009). Due to the high mobility of the species and increased connectivity between wetlands in wetter years, it is possible that black-stripe minnows have migrated between wetlands and are likely more abundant and widespread in the local area. It is also possible that seasonal fluctuations of presence/abundance of black-stripe minnows may occur, with the highest activity occurring between late June/early July and late September/early October (Smith et al. 2002). Currently, little is known about the biology of the black-stripe minnow however changes to water inundation extent, connectivity and duration could adversely impact reproduction and breeding success. Black-stripe minnows were recorded moving downstream between BSM-N-PI-1 and BSM-N-PI-2 through the culvert at Centenary Road. This suggests that black-stripe minnows will use artificial structures to move between connected wetlands, although the length, depth, water velocity and issues such as light conditions will likely influence fish movements.

Drainage design for the Proposal has sought to maintain the existing surface water hydrology, both within the Proposal Area and surrounds. The sizing and design of surface water drainage structures for the Proposal will be sufficient to maintain the existing hydrological flows through the mapped watercourse / wetland areas. Accordingly,

a significant indirect impact to black-stripe minnow habitat or individuals through altered hydrological regimes is not expected. The drainage design specifies that the elevation of the base of culverts is consistent with or below the base of the current drainage line to allow for water movement, and the use of suitably sized and shaped (flat based) culverts to minimise the velocity of water movement.

Key design requirements will minimise indirect impacts on hydrology that supports suitable habitat on either side of the development envelope at Five Mile Brook and south of Manea Park, and that hydrological modelling of surface water will ensure bridge and culvert design would minimise impacts on and maintain surface water flow.

5.4 Summary and Conclusions

Existing hydrological regime and water quality of the proposal area will be maintained during construction and operation of the proposal, to ensure environmental values are protected. The potential indirect impacts to hydrological regimes and water quality will be managed so that upon completion, the hydrological regimes will be maintained and no significant impacts attributable to the Proposal will occur.

Drainage design for the Proposal has sought to maintain the existing surface water hydrology, both within the Proposal Area and surrounds. The sizing and design of surface water drainage structures for the Proposal will be sufficient to maintain the existing hydrological flows through the mapped watercourse / wetland areas. Accordingly, a significant indirect impact to black-stripe minnow habitat or individuals through altered hydrological regimes is not expected.

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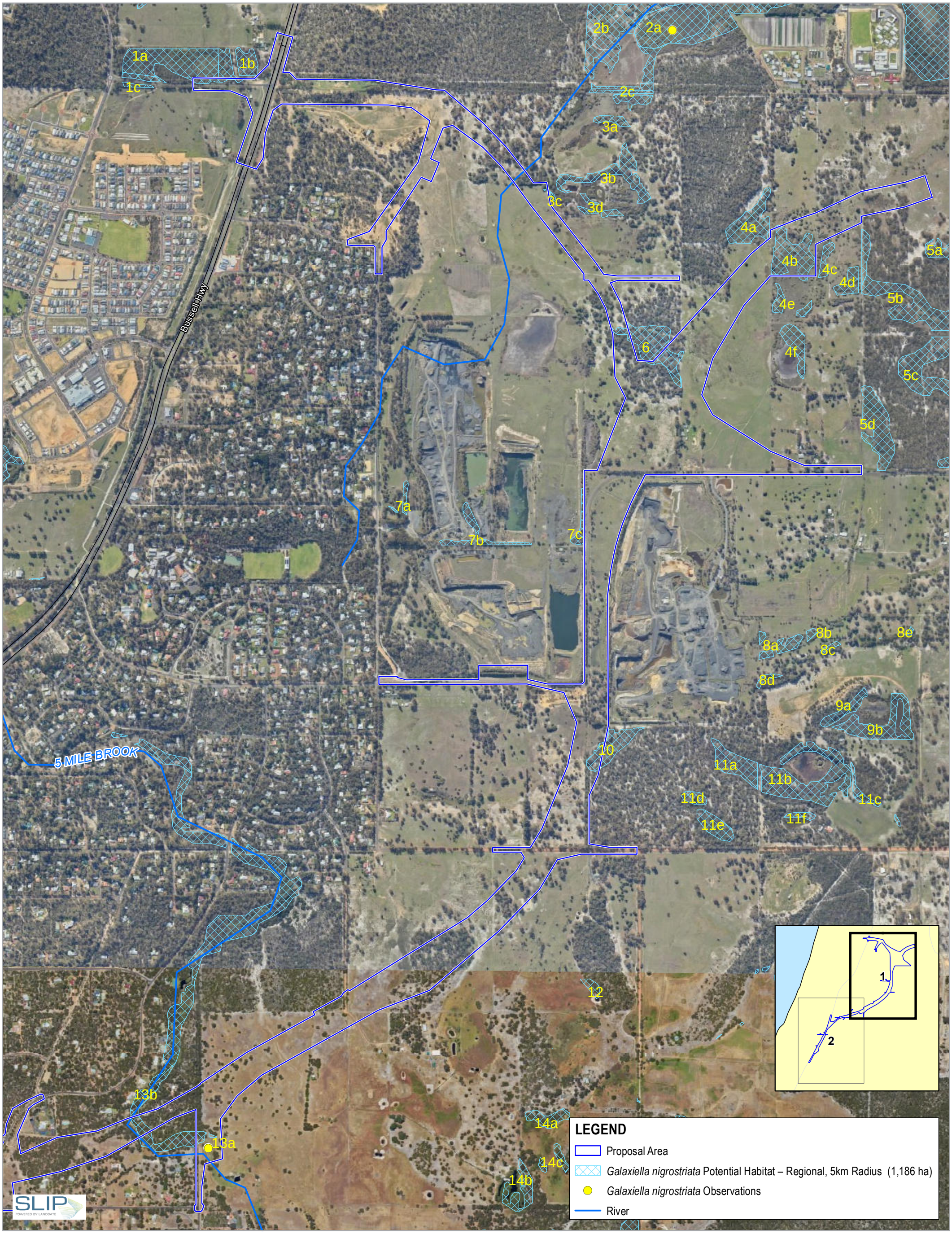
7 Figures



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BORR Team

Australian Government
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mainroads WESTERN AUSTRALIA
BUNBURY OUTER RING ROAD | PLANNING AND DEVELOPMENT

Main Roads Western Australia
Bunbury Outer Ring Road Southern Section

Black-stripe Minnow observations and habitat extent within and adjacent to the Proposal Area

Project No. **61-37041**
Revision No. **1**
Date **2/09/2020**

FIGURE 4

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LEGEND

- Proposal Area
- *Galaxiella nigrostriata* Potential Habitat – Regional, 5km Radius (1,186 ha)
- *Galaxiella nigrostriata* Observations
- River

SLIP POWERED BY LANDGATE

Paper Size ISO A3

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Black-stripe Minnow observations and habitat extent within and adjacent to the Proposal Area

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FIGURE 4

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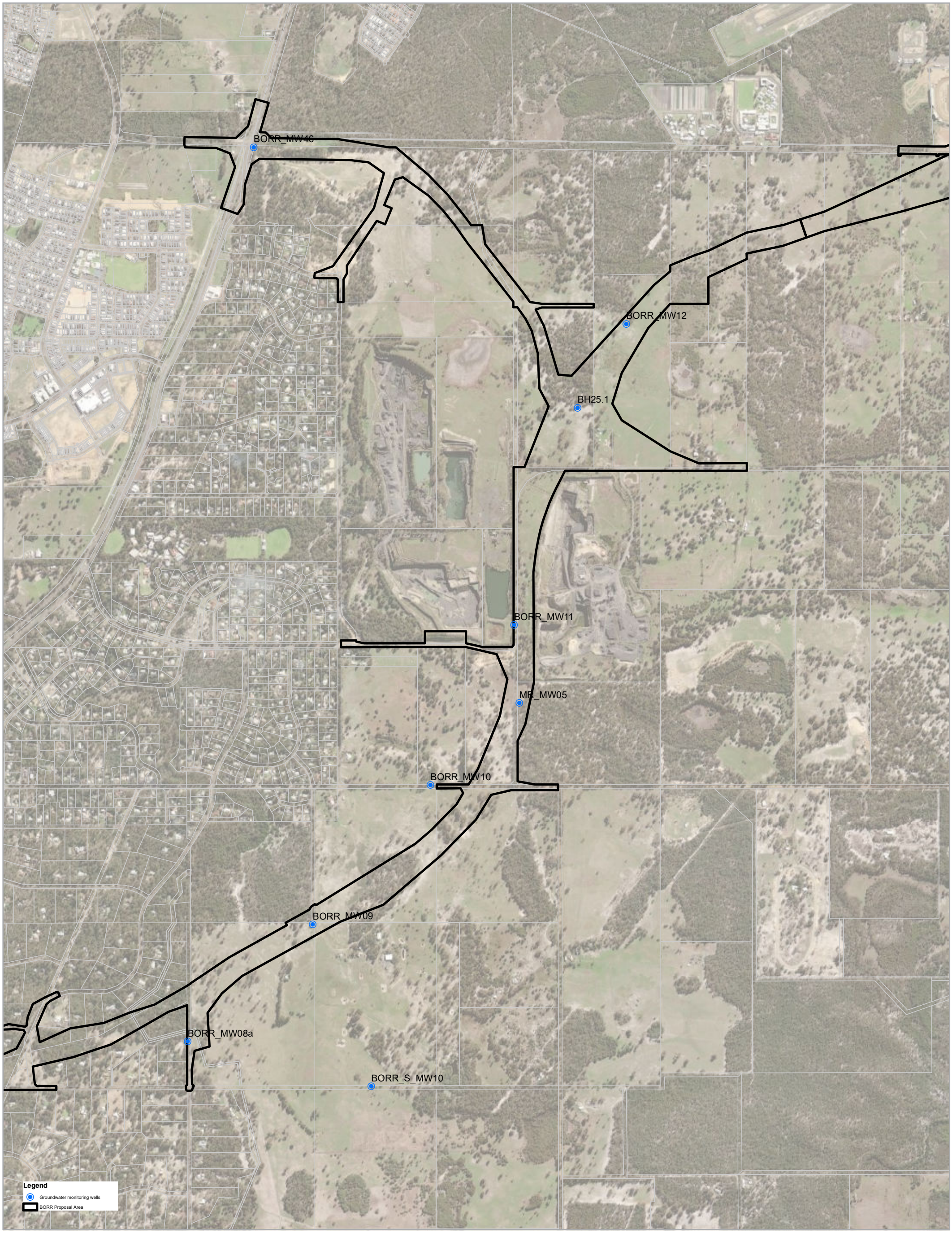

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Main Roads Western Australia
Bunbury Outer Ring Road

Groundwater Monitoring Locations

Project No. **60644786**
Revision No. **Rev A**
Date **21/04/2021**

Figure 5

Paper Size ISO A3

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Map Projection: Transverse Mercator
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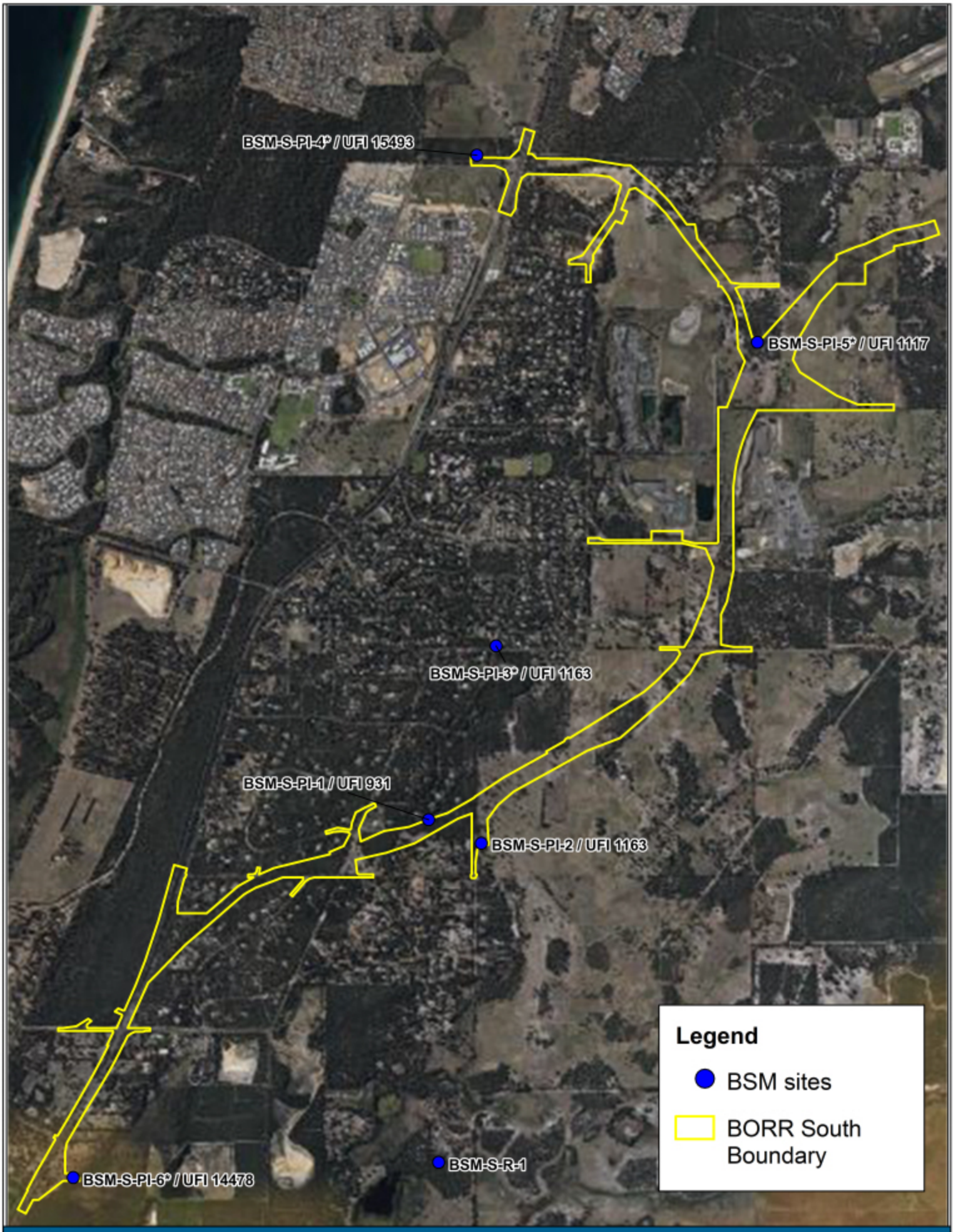
Main Roads Western Australia
Bunbury Outer Ring Road

Groundwater Monitoring Locations

Project No. **60644786**
Revision No. **Rev A**
Date **21/04/2021**

Figure 5

Data source: BORR Team: BORR Alignment, Sinks - 201903; Landgate: Roads, Localities - 2018, Imagery: WA Now accessed 20190620. Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: gary.brophy



WRM
Wetland Research & Management

BSM Sites Southern Alighnment 2022

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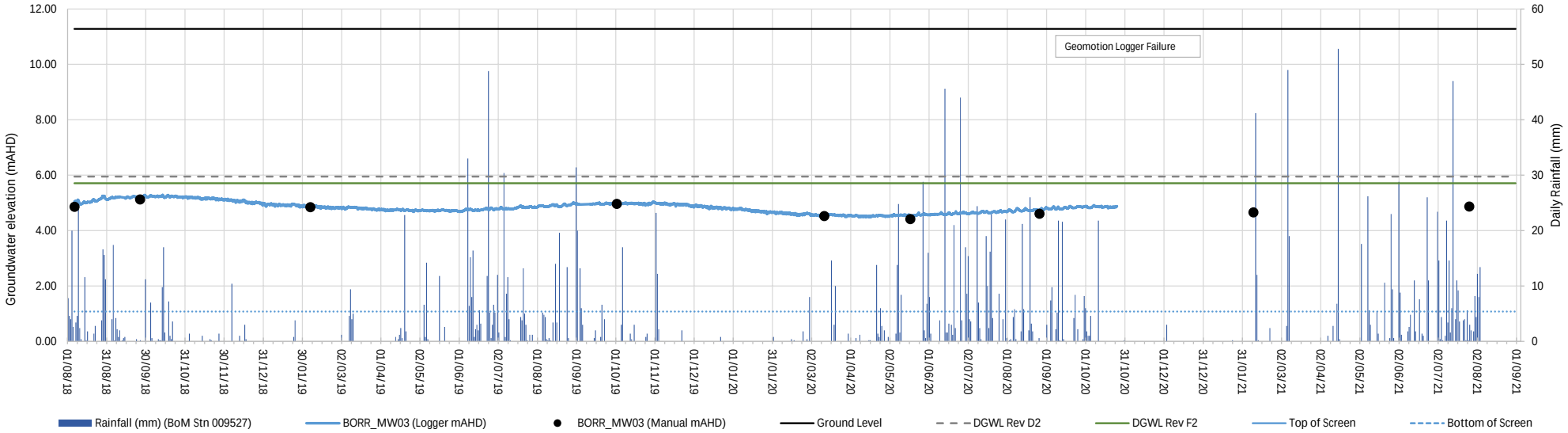
Appendix A

Groundwater Monitoring Well Hydrographs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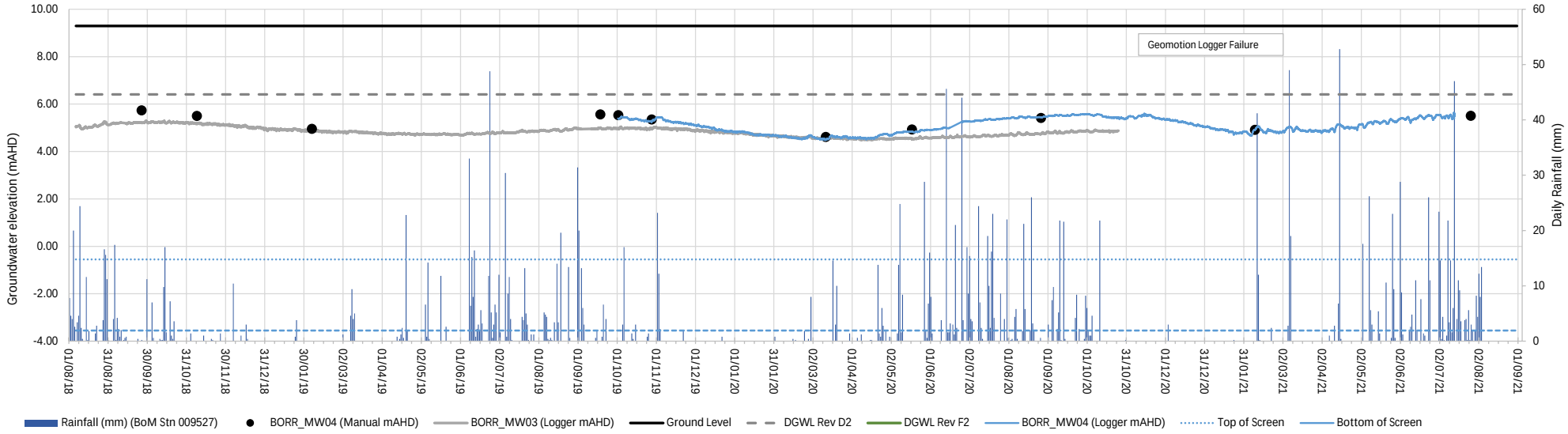
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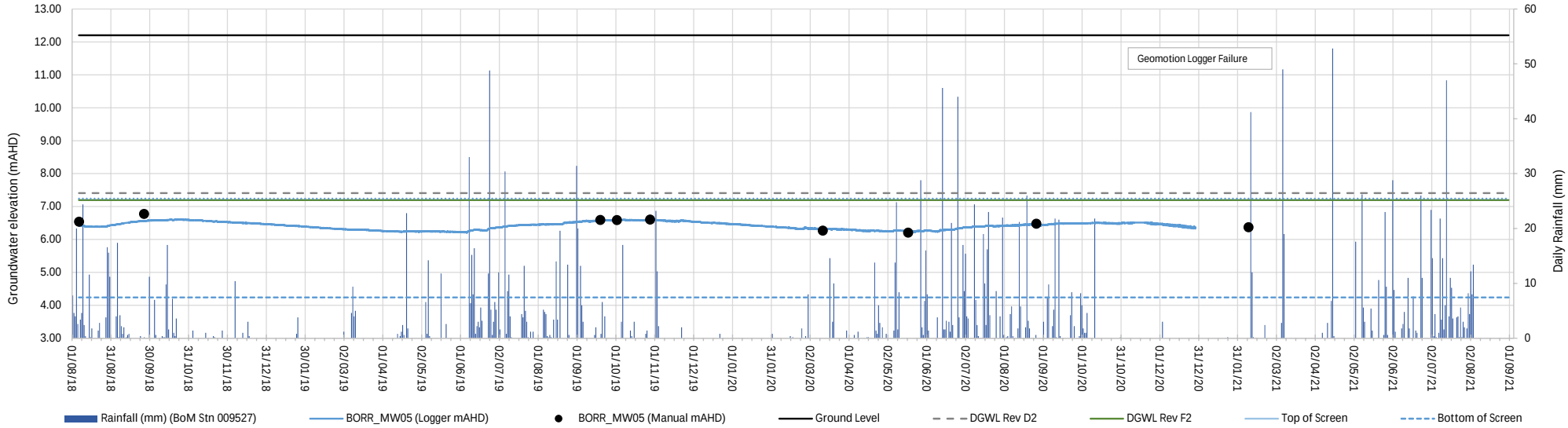
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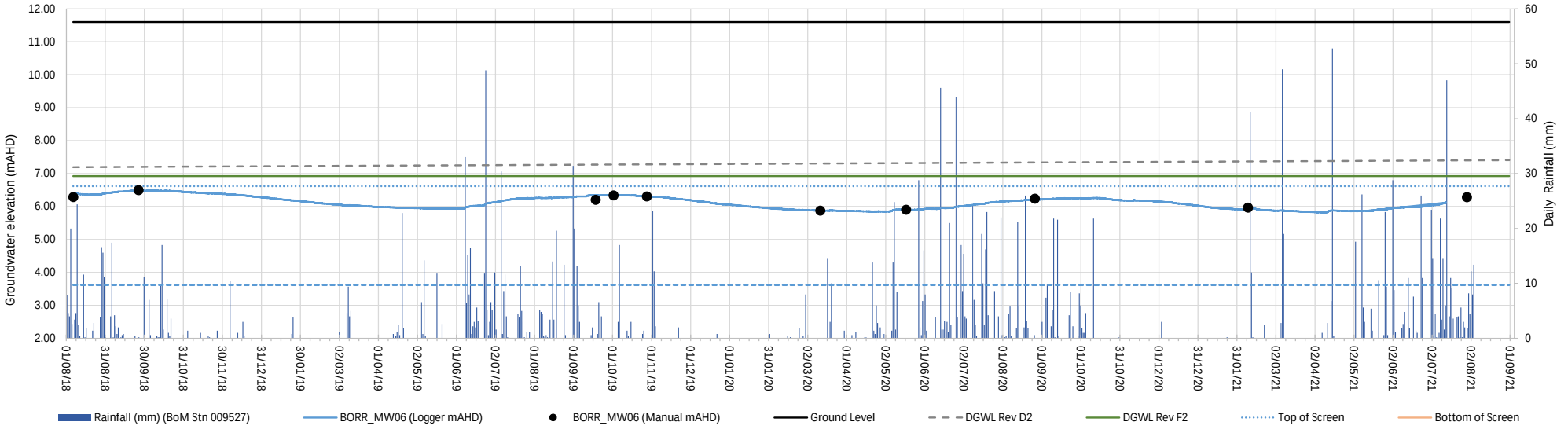
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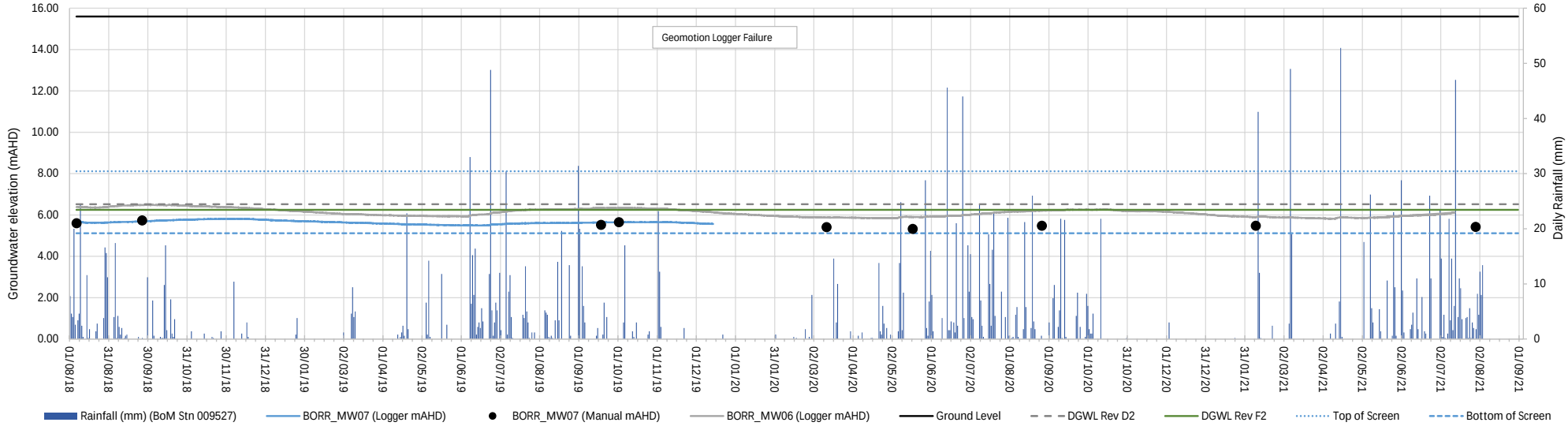
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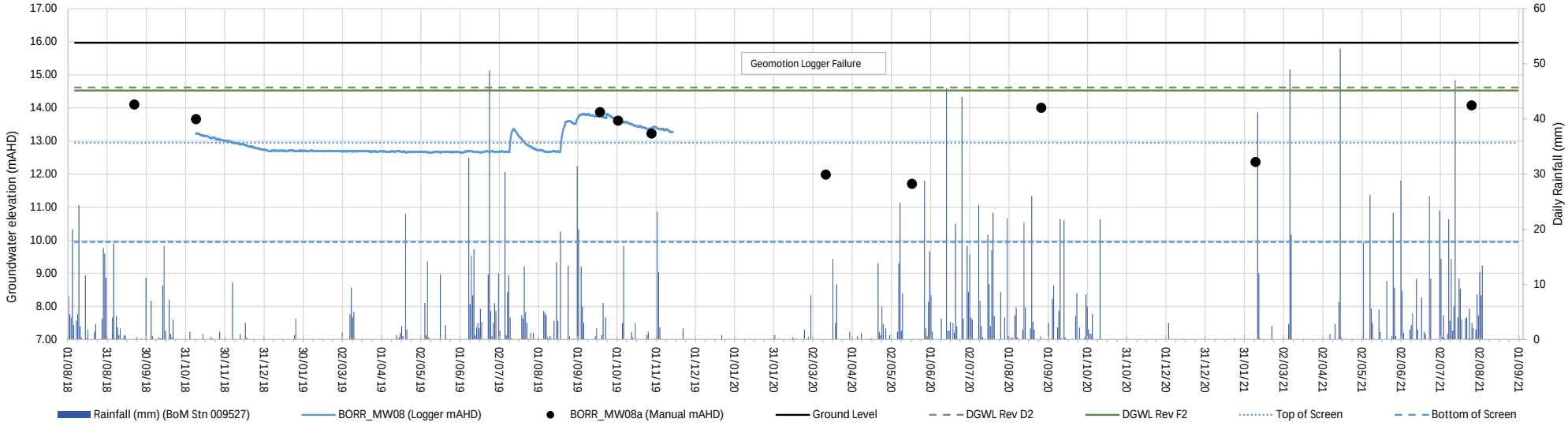
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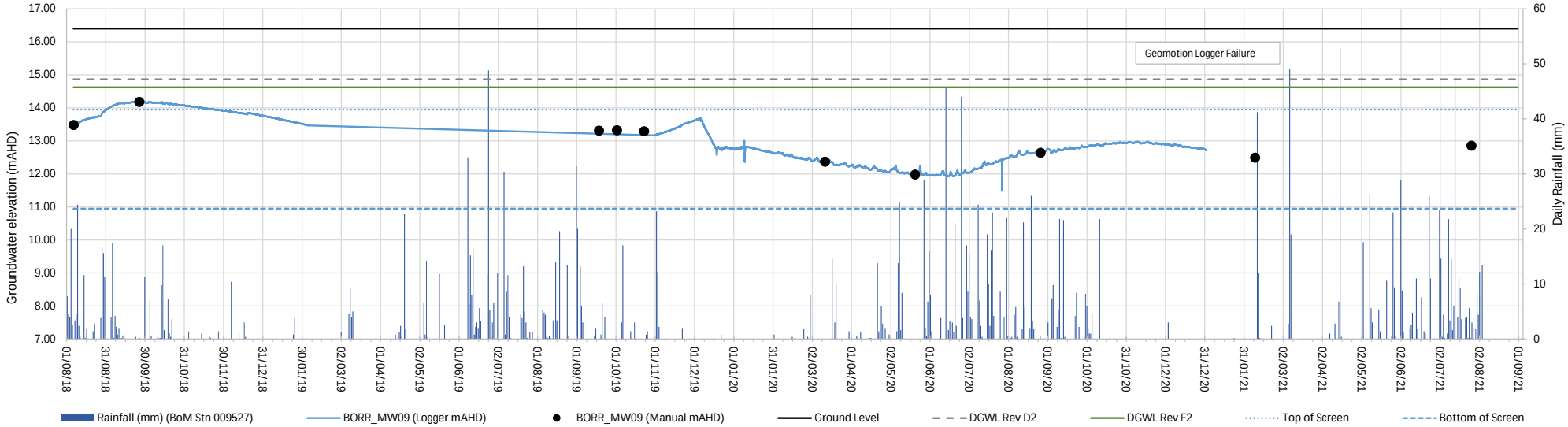
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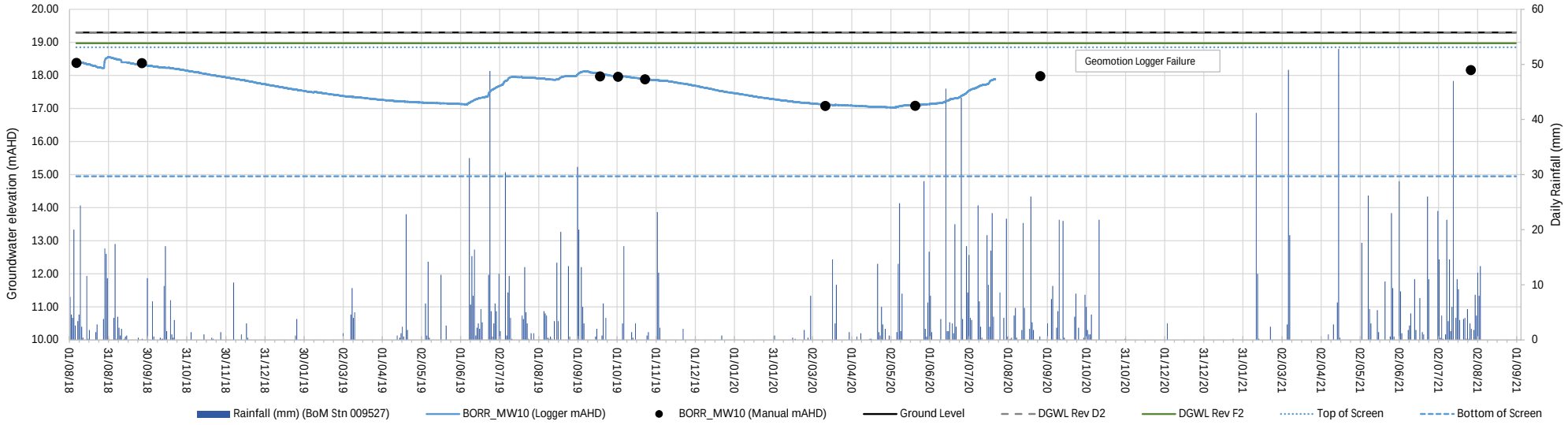
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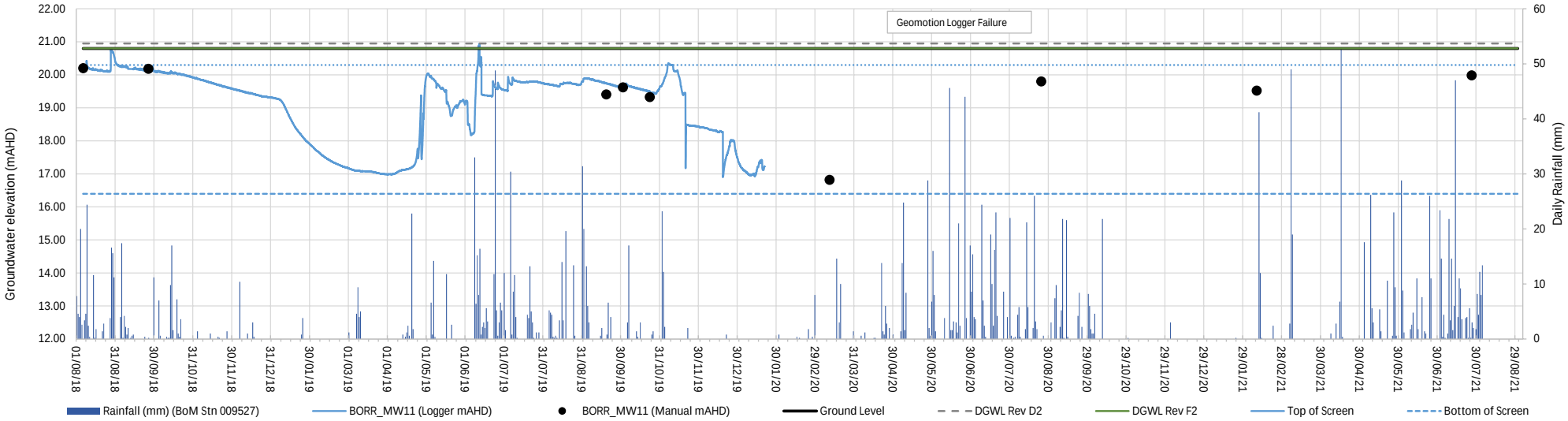
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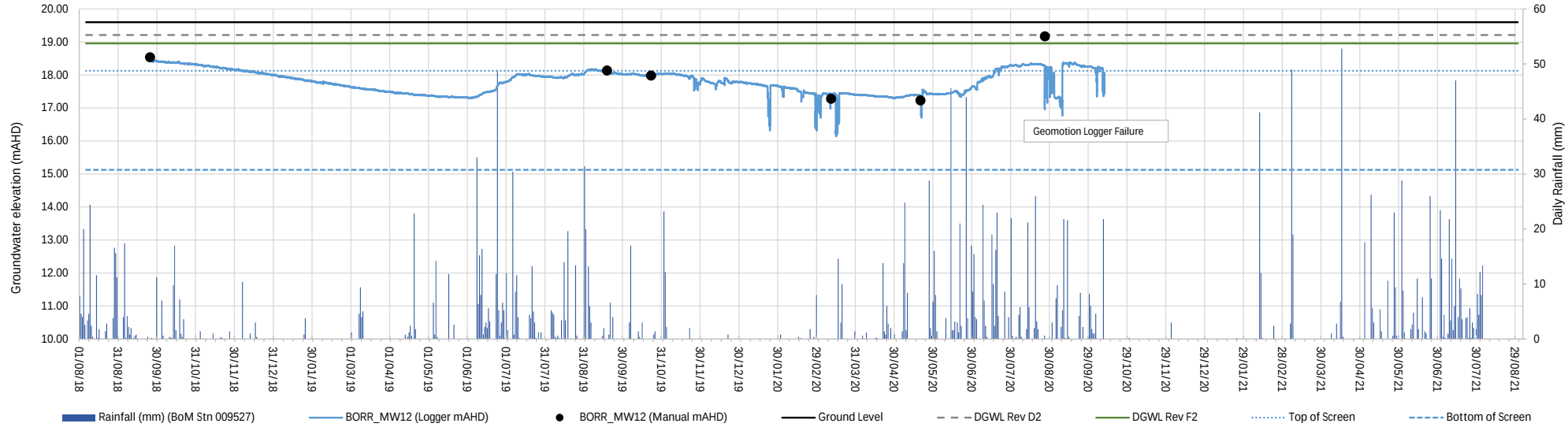
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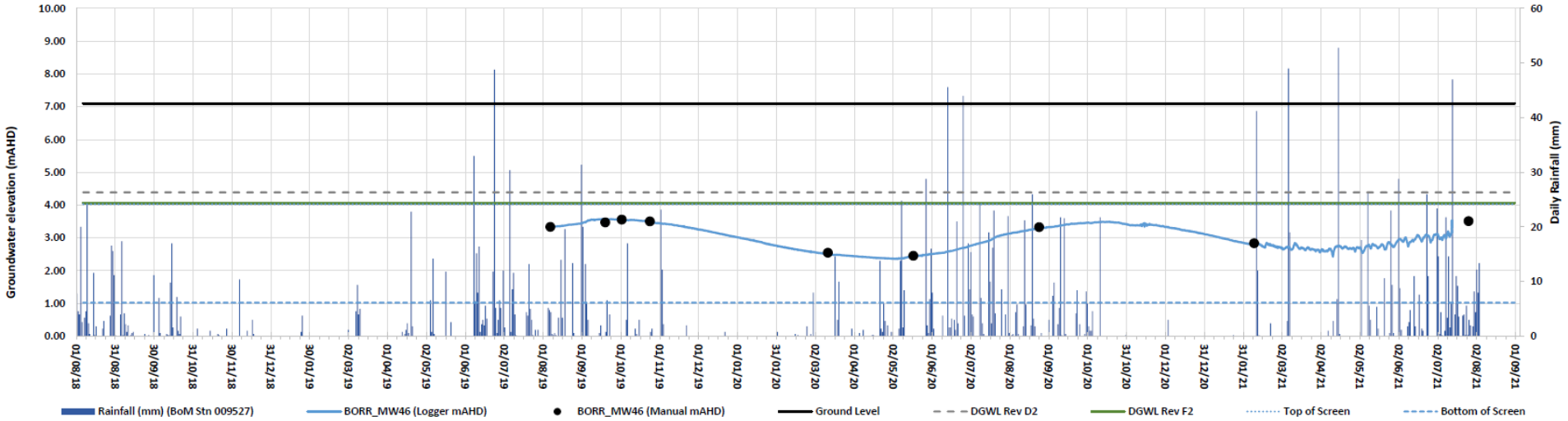
Groundwater Monitoring Well Hydrograph – BORR_MW46



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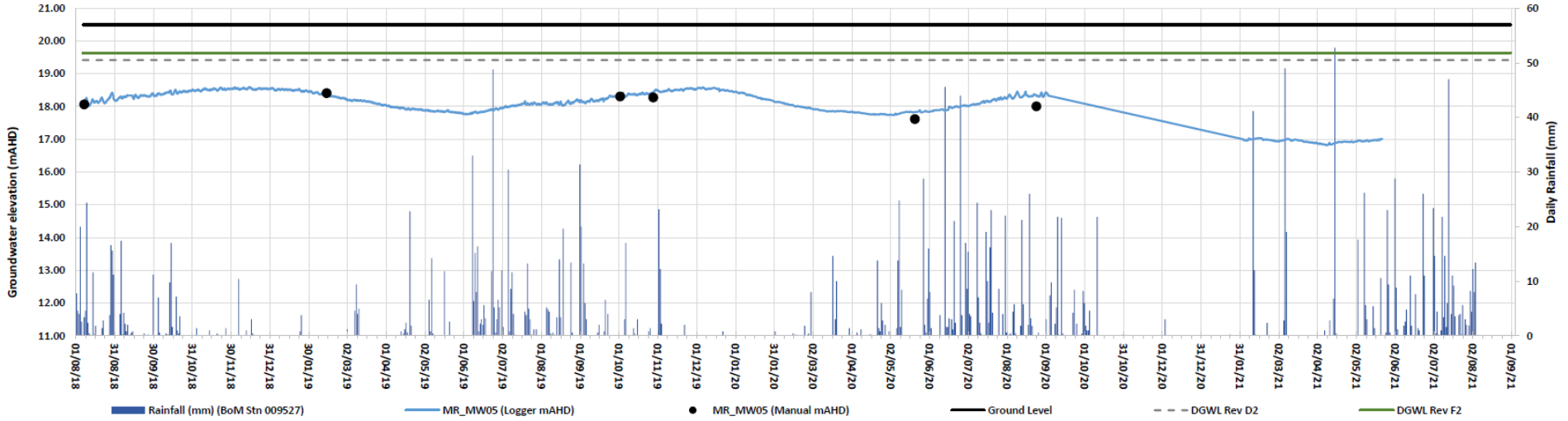
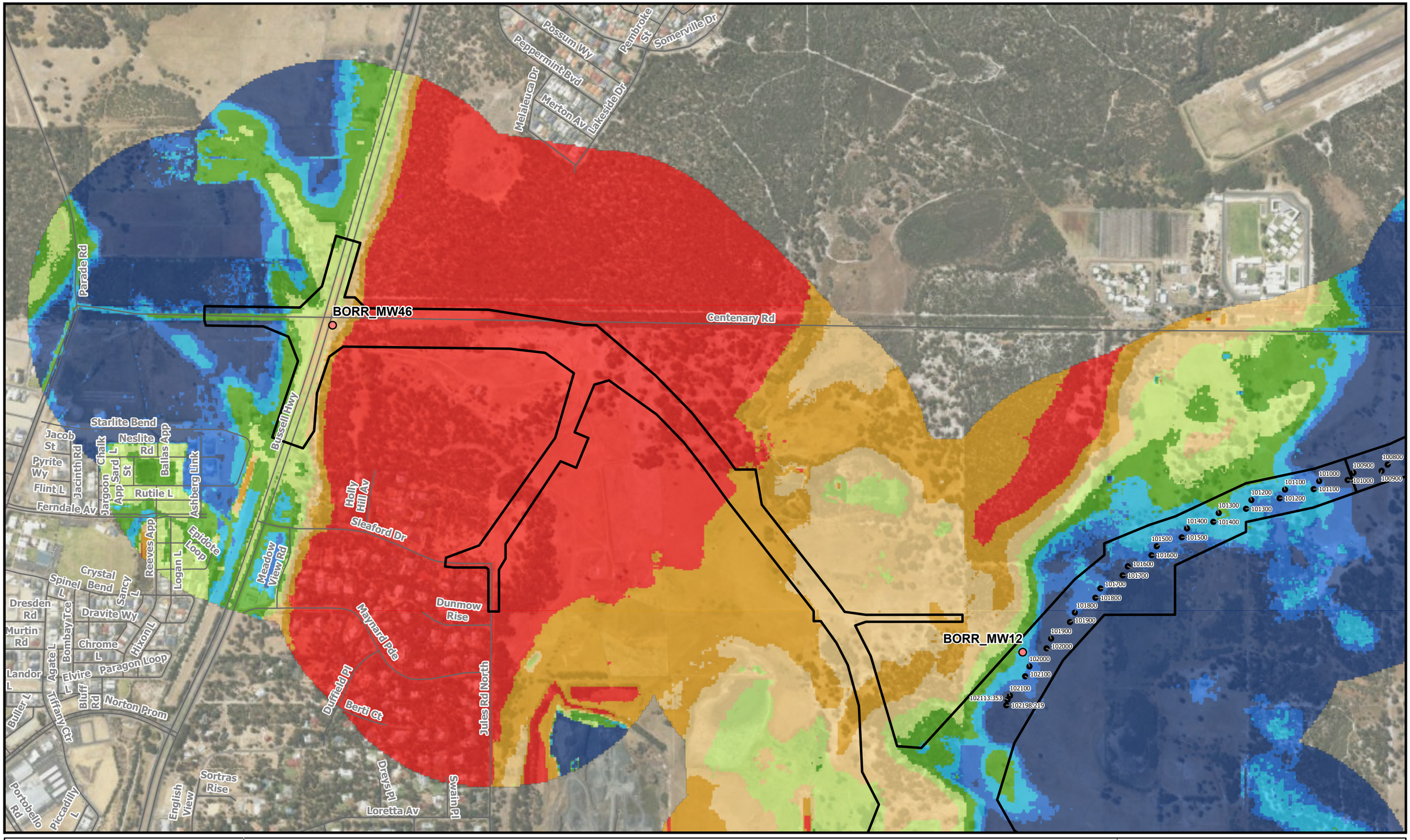


Appendix B

Groundwater Elevations (m AHD) and Depth to Groundwater (m bgl) Modelled for the Proposal Area



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APPROVED BY	G.BROPHY
LAST MODIFIED	07 SEP 2021

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N

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DATUM

0 100 200 300 400

metres

Data sources:

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LEGEND

- BORR Alignment
- New Bores (Feb 2021)
- DGWL E2 Constraint Bores (Nov 2020)
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- Major Chainage

DGWL F2 m bgl

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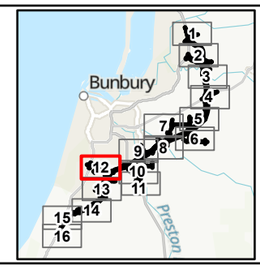
- 4.3 - 6.7
- 6.7 - 37.8

- Harvey Water Pipelines
- Rivers
- Roads

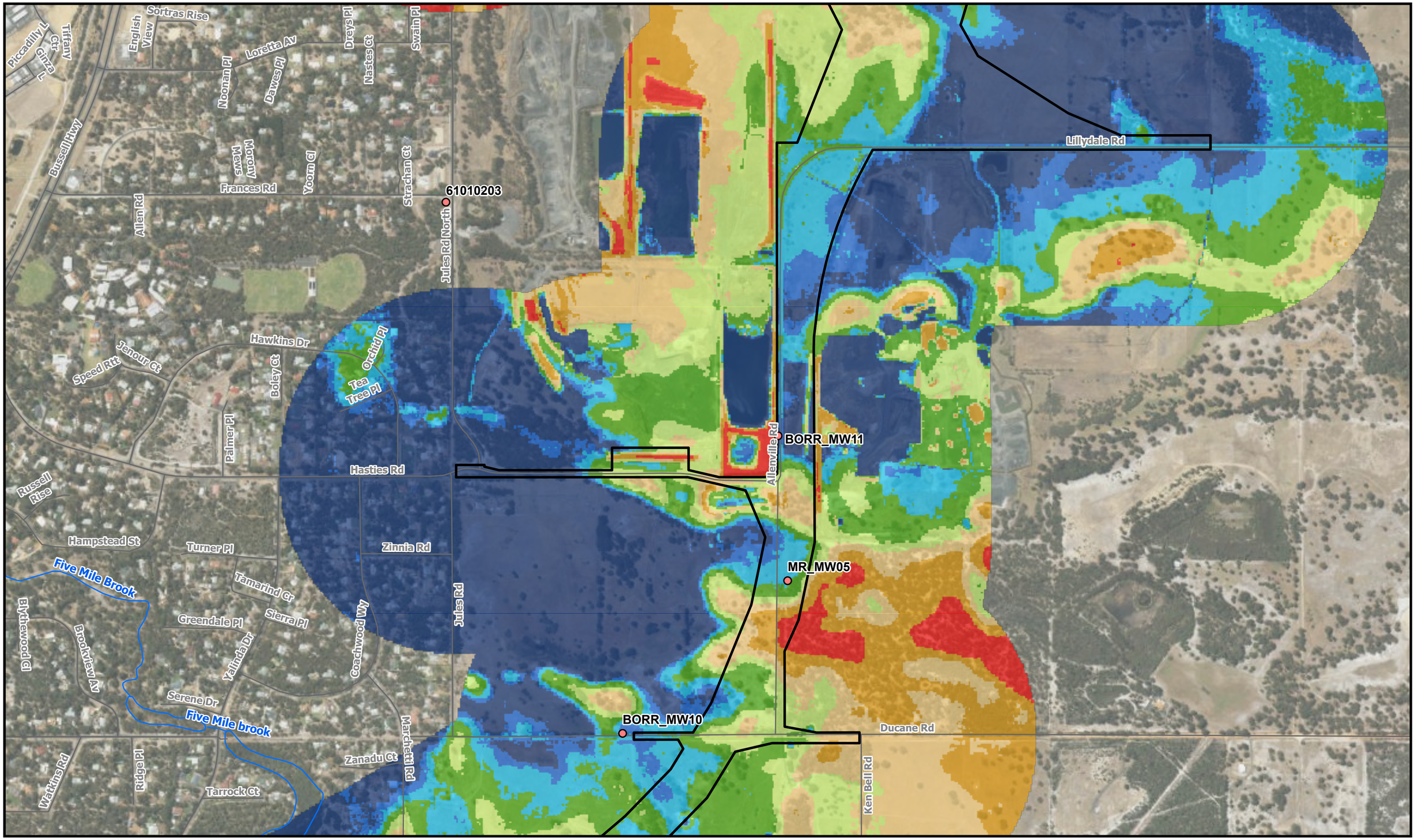


Depth to groundwater (m BGL)

Main Roads Western Australia
Bunbury Outer Ring Road

Figure
Appendix B2

A3 size



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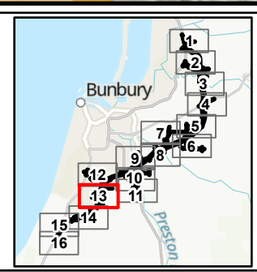
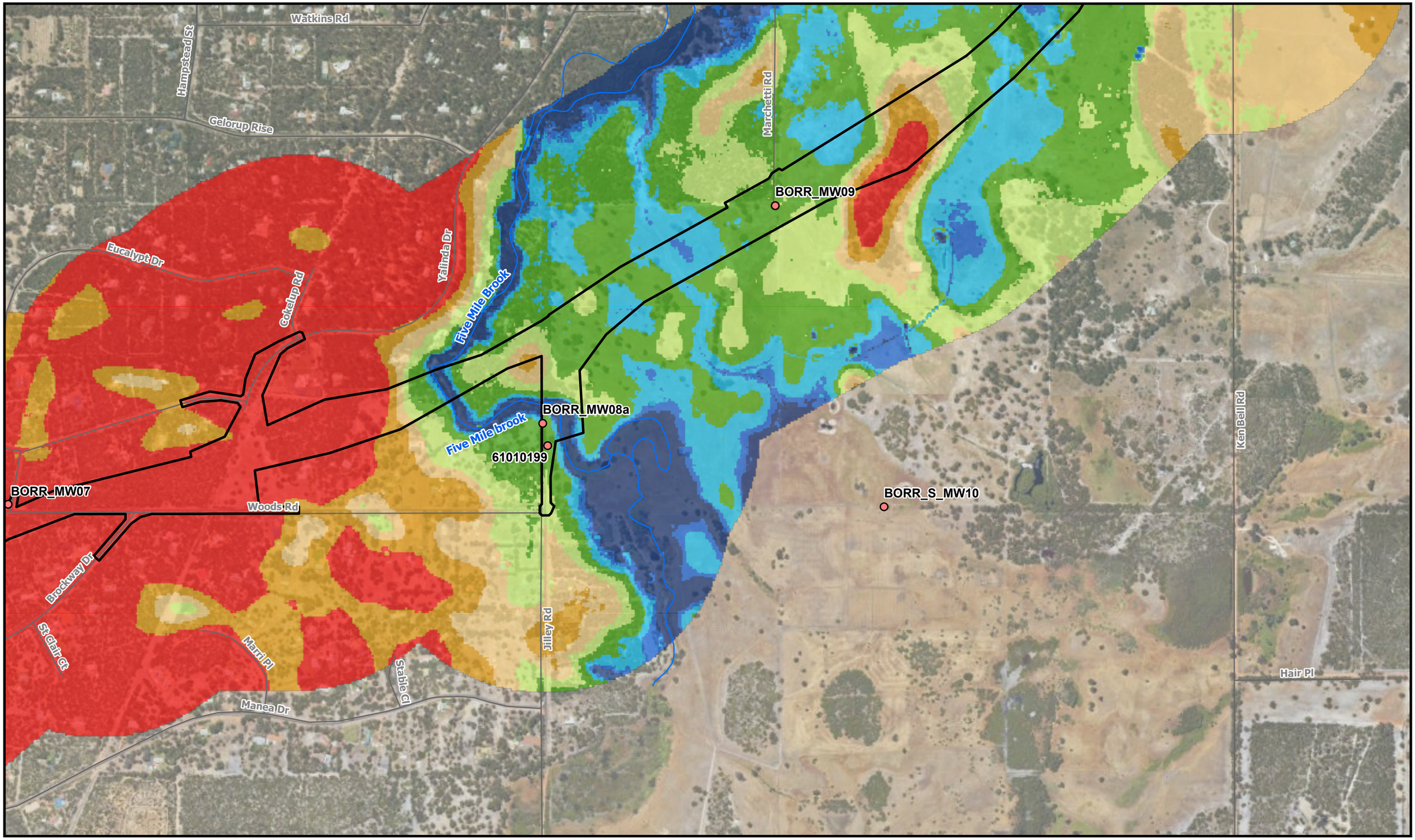


Depth to groundwater (m BGL)

Main Roads Western Australia
Bunbury Outer Ring Road

Figure
Appendix B2

A3 size



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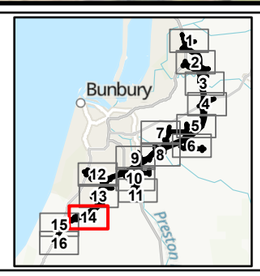

Depth to groundwater (m BGL)

Main Roads Western Australia
Bunbury Outer Ring Road

Figure
Appendix B2

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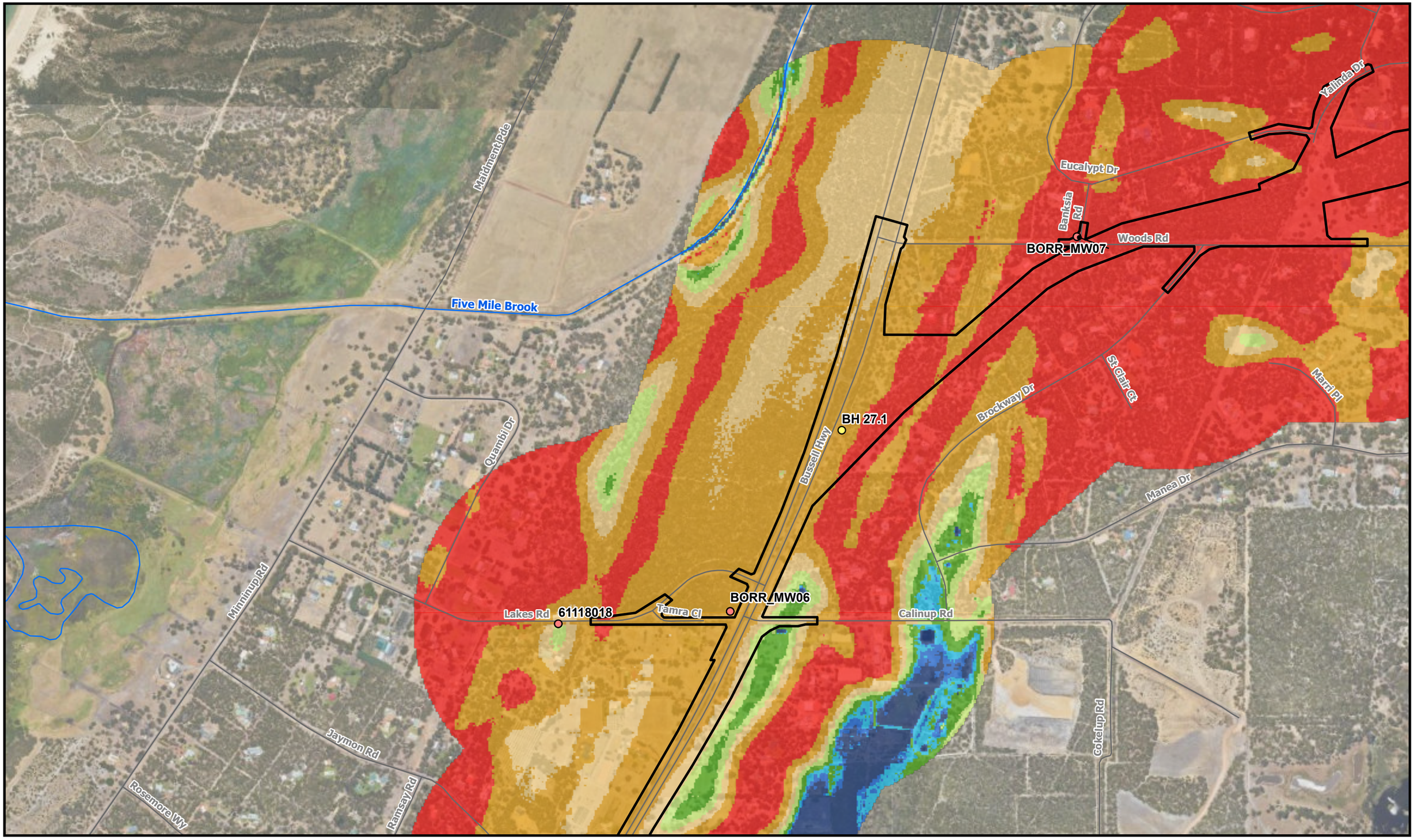

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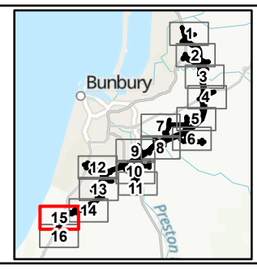

Depth to groundwater (m BGL)

Main Roads Western Australia
Bunbury Outer Ring Road

Figure
Appendix B2

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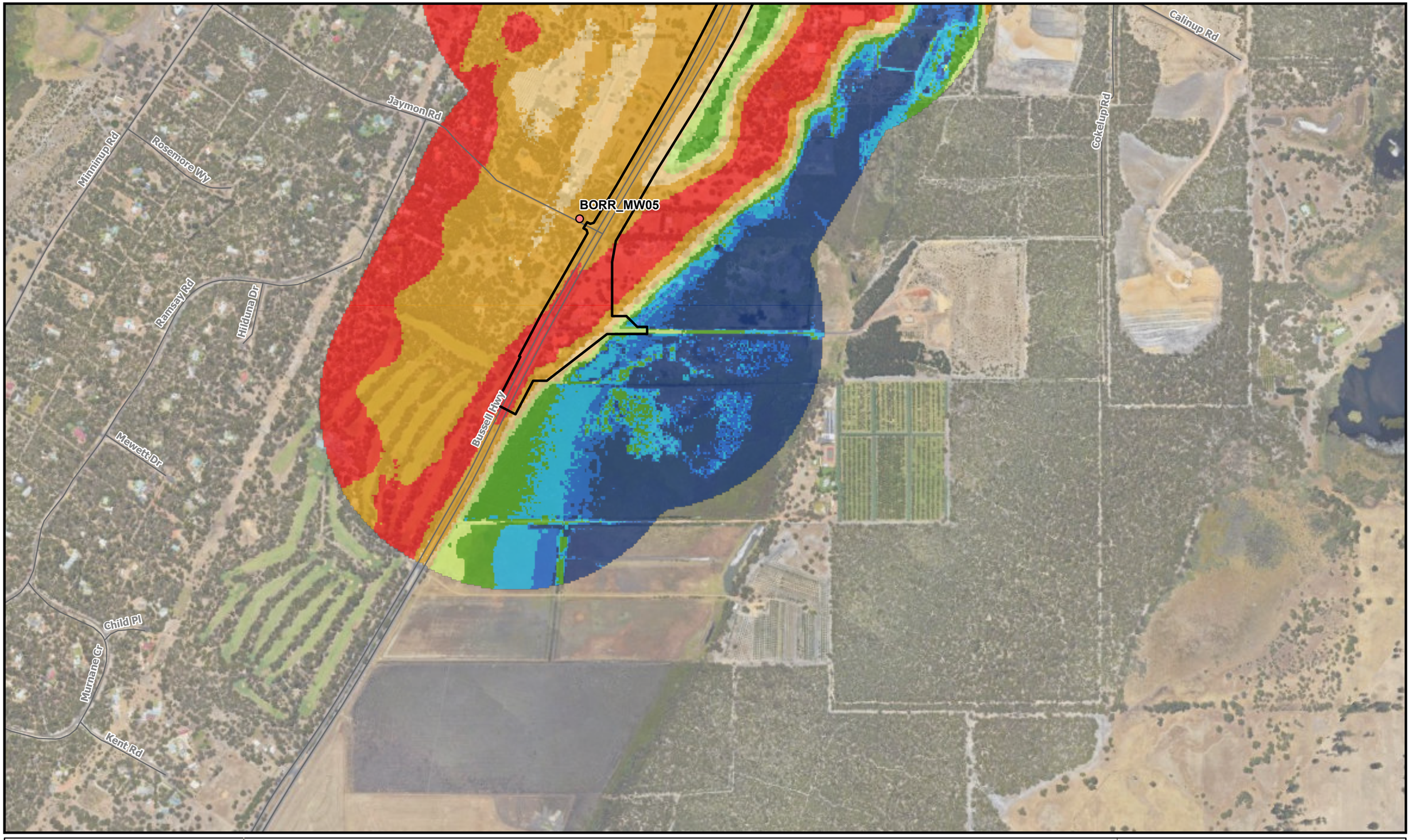

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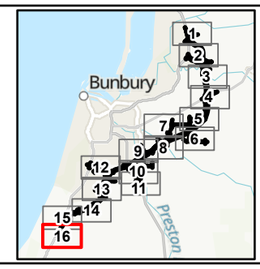

Depth to groundwater (m BGL)

Main Roads Western Australia
Bunbury Outer Ring Road

Figure
Appendix B2

A3 size

Appendix C

Bunbury Outer Ring Road Integrated Project Team- Groundwater and Surface Water Monitoring 2019-2020 (BORR IPT, 2020)

South West Gateway Alliance
Suite 3, 3 Craig Street, Burswood
Western Australia 6100

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