Appendix I
Groundwater assessment report

Billabong Creek Regulators Groundwater Assessment

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NSW Department of Climate Change, Energy, the Environment and Water

Yanco Creek Modernisation Project - EIS
2 September 2024

Billabong Creek Regulators
Groundwater Assessment

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Executive summary

The NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) (formally known as Water Infrastructure NSW (WINSW)) is proposing to replace two existing weirs along Billabong Creek with new regulators (the proposal). The two existing weirs to be demolished are Hartwood Weir and Wanganella Weir. These are situated on Billabong Creek within the Yanco Creek system in south-west New South Wales (NSW) (refer Figure 1-1).

The weirs were built in the early 20th century and have been used to regulate flows through Billabong Creek, create weirs pools for irrigation and, in the case of Wanganella Weir, provide town water supply. The weirs are currently in states of declining condition and functionality, and are barriers to the movement of fish through the creek. Their condition limits their ability to regulate flows through the Yanco Creek system and leads to inefficiencies in how water is delivered to the environment and irrigators.

The new regulators would be fully automated and remotely operated meaning that operators could control the delivery of water more efficiently. The proposal is needed to improve the operator's ability to deliver the right amount of water to the right place at the right time. The new regulators would also feature fishways to support fish movement past the new structures.

The proposal is subject to environmental and planning approvals in accordance with the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The proposal is State significant infrastructure (SSI), and the Minister for Planning is the approval authority. An environmental impact statement (EIS) is required to accompany the application for approval of the proposal.

This assessment report has been prepared by Jacobs on behalf of 3Rivers (a JV between Jacobs Group (Australia) and GHD) as part of the EIS for the proposal. The EIS has been prepared to accompany the application for approval of the proposal and addresses the environmental assessment requirements of the Secretary of the Department of Planning, Housing and Infrastructure (the SEARs), issued on 8 December 2022.

The new Hartwood and Wanganella regulators, located immediately downstream of the existing weirs may alter the groundwater level in the adjacent floodplain, with an expanded operating range contributing to changed groundwater recharge and discharge. The objective of this report is to assess potential groundwater impacts from the construction and operation of the proposal, and where required, identify feasible and reasonable mitigation and management measures.

This assessment has found that the weir pools associated with the proposed regulators at Hartwood and Wanganella will have an insignificant to minor effect on groundwater. Billabong Creek is a losing disconnected watercourse in relation to groundwater and as such has only a small influence on groundwater behaviour. Accordingly, the proposed changes to the operating levels of Billabong Creek and the extent of the weir pools associated with the proposed regulators is predicted to have an insignificant effect on groundwater. Under the NSW Aquifer Interference Assessment Policy the impacts fall within the Level 1 category and the assessment is considered "Level 1 – Acceptable".

For the proposed Hartwood regulator the effects of the proposal are:

During Construction

- There will be no effect on groundwater as the base of the structure and likely excavation depths are above the recorded groundwater level at the site.

During Operation

- No discernible change in groundwater elevation or flow direction over the study area.

- Very minor watertable drawdown/mounding (0.5 to 1 cm) limited to 1 km from the weir pool and for periods of a few weeks associated with peak difference periods and insignificant changes on average. Whilst the effect will extend to this distance, the scale at this distance is very small, as other groundwater effects damp the changes in the watertable and reduce the effects with distance from the creek.
- Insignificant impact on water dependent ecosystems (high priority GDEs).
- Negligible increase in leakage from the weir pool to groundwater (of less than 0.1% of the estimated current seepage, amounting to around 4 m^3/day).
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given that the predicted change is a lowering in groundwater level, the watertable is around 5 mbgl and groundwater levels remain within the observed range of variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.

For the proposed Wanganella regulator the effects of the proposal are:

During Construction

- Groundwater drawdown in the vicinity of the construction area will be limited to a maximum of approximately 0.5 m with a peak possible radius of influence of 250 m and a likely maximum discernible radius of effect of less than 50 m. The expected rate of dewatering is less than 0.2 L/s.

During Operation

- No discernible change in groundwater elevation or flow direction over the study area.
- Minor watertable drawdown/mounding (1 to 2 cm) limited to 2 km from the weir pool and for periods of a few weeks associated with peak difference periods and insignificant changes on average. Whilst the effect will extend to this distance, the scale at this distance is very small, as other groundwater effects damp the changes in the watertable and reduce the effects with distance from the Creek.
- Very minor to insignificant increase in evapotranspiration and hence, insignificant impact on groundwater dependent ecosystems (high priority GDEs).
- Minor to insignificant change in leakage from the weir pool to groundwater as the overall leakage to groundwater and disconnected system remains.
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given the watertable is around 5 mbgl and groundwater levels remain within the expected range of natural variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.

The other projects planned in the study area were reviewed to determine if the proposal has the potential to result in significant cumulative impacts. No potential cumulative impacts relevant to groundwater were identified.

Groundwater level monitoring utilising the existing monitoring wells should be undertaken on a monthly basis at wells BH201 (Hartwood) and BH3 (Wanganella). The proposed regulators and associated operational changes are regarded as having a very low risk of adverse groundwater impacts.

ⓘ Important note about this report

The 3Rivers Joint Venture (3Rivers), a joint venture between Jacobs Group (Australia) Pty Limited and GHD Pty Ltd has been engaged to provide certain Engineering and Approvals Services for the NSW Sustainable Diversion Limit Adjustment Mechanism (SDLAM) program in accordance with the Agreement between 3Rivers and the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) (the client).

The sole purpose of this report and the associated services performed by Jacobs is to review the potential environmental effects associated with the construction and operation of the Billabong Creek Regulators in accordance with the scope of services set out in the contract between 3Rivers and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This assessment has been prepared in the timeframe and on the basis of the project description prepared by the client and within the limits of the budget approved for the work.

This report has been prepared on behalf of, and for the exclusive use of, the Client, and is subject to, and issued in accordance with, the provisions of the contract between 3Rivers and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

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Acronyms and abbreviations

Abbreviation	Definition
AHD	Australian height datum
AMLETT	Australia-wide Machine Learning Evapotranspiration for Trees
ANZECC	Australian and New Zealand Environment and Conservation Council
ANZG	Australian and New Zealand guidelines
AWRA	Australian Water Resources Assessment
AWS	Automatic weather station
BC	Boundary condition
BOM	Bureau of Meteorology
BTEXN	Benzene, toluene, ethylbenzene, xylenes and naphthalene
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water, formerly Water Infrastructure NSW
DGV	Default guideline values
EC	Electrical conductivity
EIS	Environmental impact statement
EPBC	Environment Protection and Biodiversity Conservation
ET	Evapotranspiration
FW	Freshwater
GDE	Groundwater dependant ecosystem
GH	General head
HEVAE	High Ecological Value Aquatic Ecosystems
LGA	Local government area
mbgl	Metres below ground level
PAH	Polycyclic aromatic hydrocarbons
PFAS	Per- and polyfluorinated substances
SDL	Sustainable diversion limit
SEAR	Secretary's Environmental Assessment Requirements
SSI	State significant infrastructure
TDS	Total dissolved solids
TRH	Total recoverable hydrocarbon
WINSW	Water Infrastructure NSW now renamed as NSW DCCEEW
WRP	Water resource plans
YCMP	Yanco Creek Modernisation Project

1. Introduction

As part of the 3Rivers joint venture with GHD, Jacobs Group (Australia) is currently engaged in the Yanco Creek Modernisation Project (YCMP), specifically focusing on the Billabong Creek Regulators Environmental Impact Assessment (EIS), commonly referred to as the "Billabong EIS". This task is being undertaken for the NSW Department of Climate Change, Energy, the Environment and Water (NSW DCCEEW) and is part of the broader scope of work conducted for the 3Rivers unincorporated Joint Venture.

The proposal involves the replacement of two existing weirs along Billabong Creek, namely Hartwood Weir, and Wanganella Weir, with new regulators. These proposed fully automated and remotely operable regulators would enable river operators to control flow remotely, enhancing the efficiency of flow control in Billabong Creek. Additionally, the new regulators will include fishways to facilitate fish movement past the structures. This proposal is integral to a wider array of water savings projects under the Murray-Darling Basin Plan Sustainable Diversion Limit Adjustment Mechanism.

1.1 Overview

NSW DCCEEW (formally known as Water Infrastructure NSW (WINSW)) is proposing to replace two existing weirs along Billabong Creek with new regulators (the proposal). The two existing weirs to be demolished are Hartwood Weir and Wanganella Weir. These are situated on Billabong Creek within the Yanco Creek system in south-west New South Wales (NSW) (refer Figure 1-1).

The weirs were built in the early 20th century and have been used to regulate flows through Billabong Creek, create weirs pools for irrigation and, in the case of Wanganella Weir, provide town water supply. The weirs are currently in states of declining condition and functionality, and are barriers to the movement of fish through the creek. Their condition limits their ability to regulate flows through the Yanco Creek system and leads to inefficiencies in how water is delivered to the environment and irrigators.

The new regulators would be fully automated and remotely operated meaning that operators could control the delivery of water more efficiently. The proposal is needed to improve the operator's ability to deliver the right amount of water to the right place at the right time. The new regulators would also feature fishways to support fish movement past the new structures.

The proposal is subject to environmental and planning approvals in accordance with the *NSW Environmental Planning and Assessment Act 1979* (EP&A Act) and the *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The proposal is State significant infrastructure (SSI), and the Minister for Planning is the approval authority. An environmental impact statement (EIS) is required to accompany the application for approval of the proposal.

1.2 Purpose and Scope of this Assessment Report

This assessment report has been prepared by Jacobs as part of the EIS for the proposal. The EIS has been prepared to accompany the application for approval of the proposal and addresses the environmental assessment requirements of the Secretary of the Department of Planning, Housing and Infrastructure (the SEARs), issued on 17 October 2024.

The new Hartwood and Wanganella regulators, located immediately downstream of the existing weirs may alter the groundwater level in the adjacent floodplain, with an expanded operating range contributing to changed groundwater recharge and discharge. The objective of this report is to assess potential groundwater impacts from the construction and operation of the proposal, and where required, identify feasible and reasonable mitigation and management measures.

1.3 Structure of this Assessment Report

The report is structured as follows:

Section 1 – Provides an introduction to the proposal and the assessment

Section 2 – Describes the methodology for the assessment

Section 3 – Describes the existing conditions

Section 4 – Assesses the impacts of the construction and operation of the proposal

Section 5 – Provides mitigation measures for the impacts identified

Section 6 – Conclusion

1.4 Summary of the proposal

1.4.1 Location

The proposed works are to be located on Billabong Creek, which is part of the Yanco Creek system in south-west New South Wales (NSW). The Yanco Creek system forms a part of the Murray-Darling Basin. An overview of the location of the proposal is shown in Figure 1-1.

The proposal is located within the local government area (LGA) of Edward River.

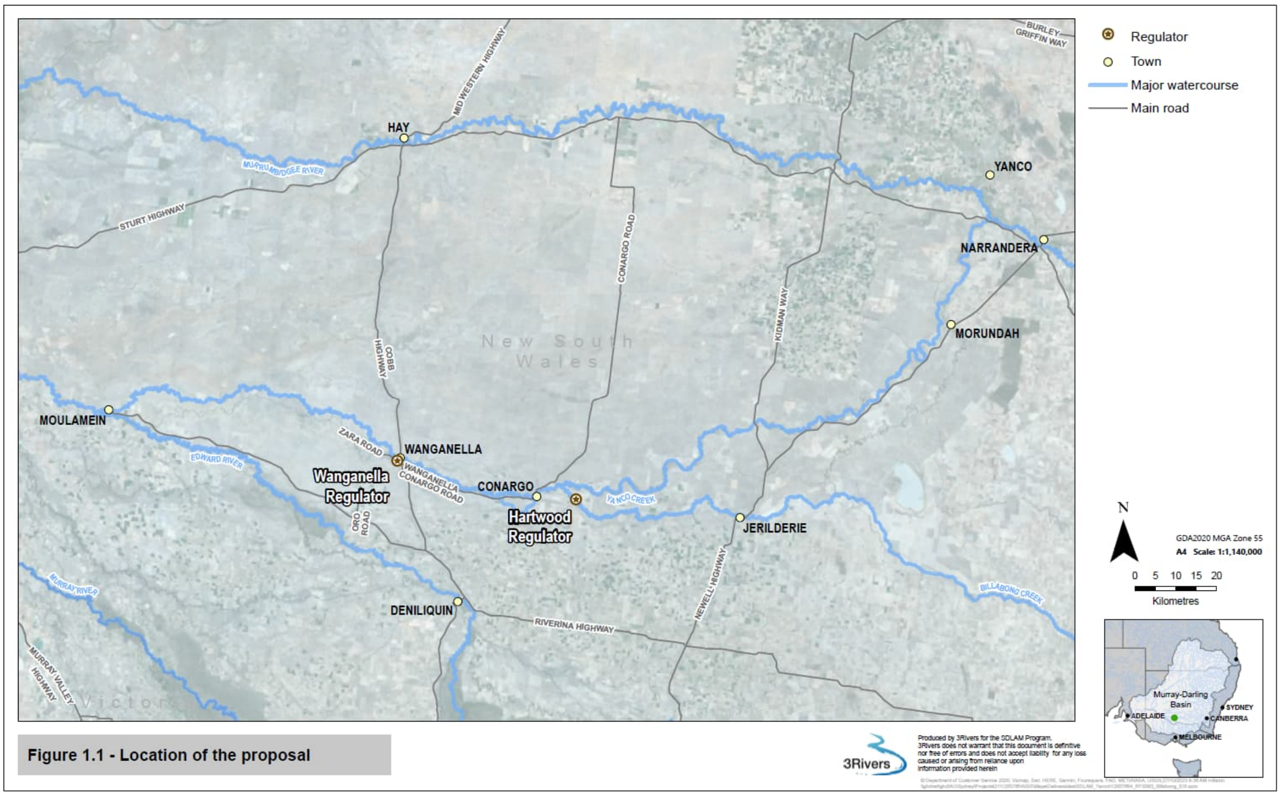

Figure 1-1. Location of the proposed new regulators that comprise the proposal

1.4.2 Key features of the proposal

The proposal involves replacing two existing weirs along Billabong Creek with (two) new regulators including fishways.

The core structure of the two regulators is similar and would include:

- concrete piers with maintenance bulkhead slots
- automated layflat gates across the crest of the structure to assist with flow management and downstream fish passage
- a low turbulence 'keyhole' type vertical slot fishway with allowances for variable headwater to provide upstream fish passage
- automated sidewinder gates within the vertical slot fishway to allow for variable headwater conditions
- fixed concrete crests on the opposite side of the gates to the vertical slot fishway
- concrete apron downstream of the structure
- concrete wingwalls upstream and downstream of the structure
- access from a trafficable deck for maintenance (Hartwood Regulator only)
- pedestrian walkway access part way across Wanganella Regulator structure to facilitate housing of gate actuators and for maintenance
- walkway grating over gates to facilitate operations and maintenance
- crushed rock maintenance pads, access and turnaround areas adjacent to the structure
- rip rap and rock beaching upstream and downstream of structure for erosion protection
- control house
- sheet pile cut-off walls beneath the structure
- fencing of the structures to prevent public access
- SCADA control system.

An indicative diagram of a regulator is shown in Figure 1-2. This figure provides an example of a five-gate regulator with a fishway and trafficable deck for maintenance vehicles.

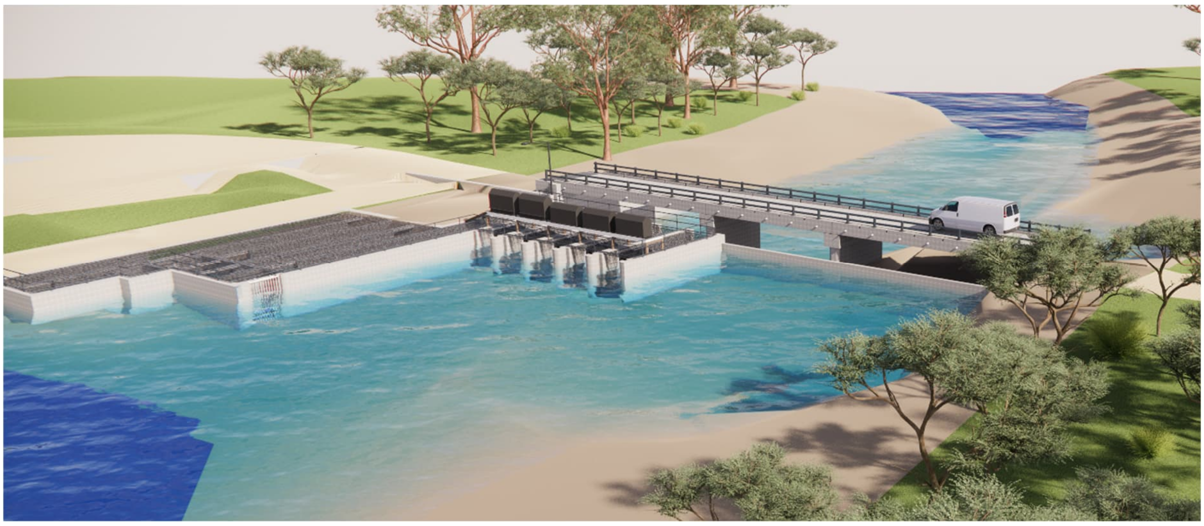

Figure 1-2. Indicative layout of proposed regulators

The proposal also involves the following elements:

- Power supply to the regulators would be provided by a mix of underground and overhead electricity cables connecting the structures to the grid.
- Access to the regulators would require permanent vehicle tracks for maintenance and some additional tracks to support construction only.
- The existing Forest Creek block bank, associated with the Hartwood Regulator, would be replaced with a similar earthen structure to the existing. This would include two concrete sills to define the upstream and downstream top of bank and armoured with rock beaching and crushed rock for erosion protection.
- A flood bypass channel would be constructed to reduce potential upstream flooding impacts from the Wanganella Regulator. The channel would enable flood waters to drain between the billabongs in the Wanganella Reserve during flood events. It would be 85 m long, around 40 m wide and 1.7 m deep and located north of the Wanganella Tip. Once completed, the channel sides and base would be naturalised and vegetated with appropriate local native species.
- An existing borrow pit on lot 56 / DP756322 near Hartwood Weir would be extended to provide material for the construction of Hartwood Regulator and Forest Creek block bank. Ancillary facilities, which would not form a permanent part of the proposal, would be required to construct the new regulators. These include site compounds, erosion control measures, sedimentation basins, temporary lay down areas and stockpile sites. In addition, there would be a need for spoil and materials handling areas, worker facilities and vehicle parking.

It is also expected that some road works would be needed to provide reliable access during construction. This could include road upgrades to provide all weather traffic, tree trimming or vegetation clearing to provide adequate clearance and new access roads.

During construction the existing weir structures would be partially or fully removed. Any remaining parts of the weirs would not affect flow or level in the Creek to any significant effect, so have not been assessed in this report.

The location of the existing weirs, proposed infrastructure, and the indicative construction footprints are shown on Figure 1-3 to Figure 1-4.

1.4.3 Timing

Construction of the proposal is anticipated to start in 2025, and be completed by 2026. The construction period is anticipated to be around 18 months. Construction would pause during periods of high flow.

1.4.4 Operation

The proposed regulators would be operated in accordance with operating rules established with the new asset owner WaterNSW and developed in consultation with key stakeholders. The rules, known as the Yanco Creek System Operations Plan, would take into account the regulation requirements at each regulator, as well as constraints such as limits to rates of rise and fall to accommodate fish breeding requirements. A draft of these operating rules (DPE, 2023a) and the associated source modelling (DPE, 2023b) has been used as the basis of this assessment.

The regulators would provide greater control of water levels than is possible with the existing weirs. The greater control would be utilised to meet environmental and water supply objectives.

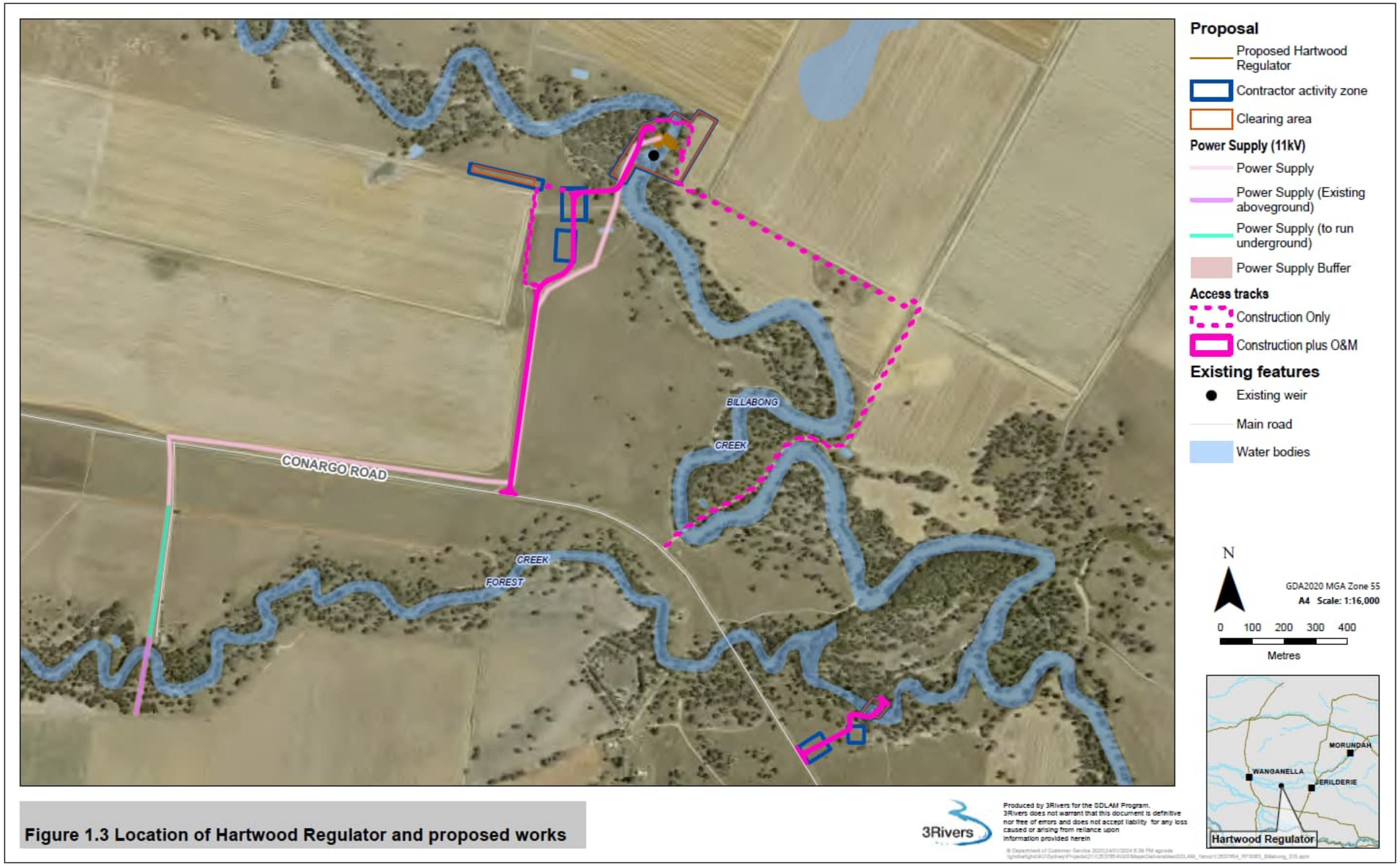

Figure 1-3. Location of Hartwood Regulator and proposed works

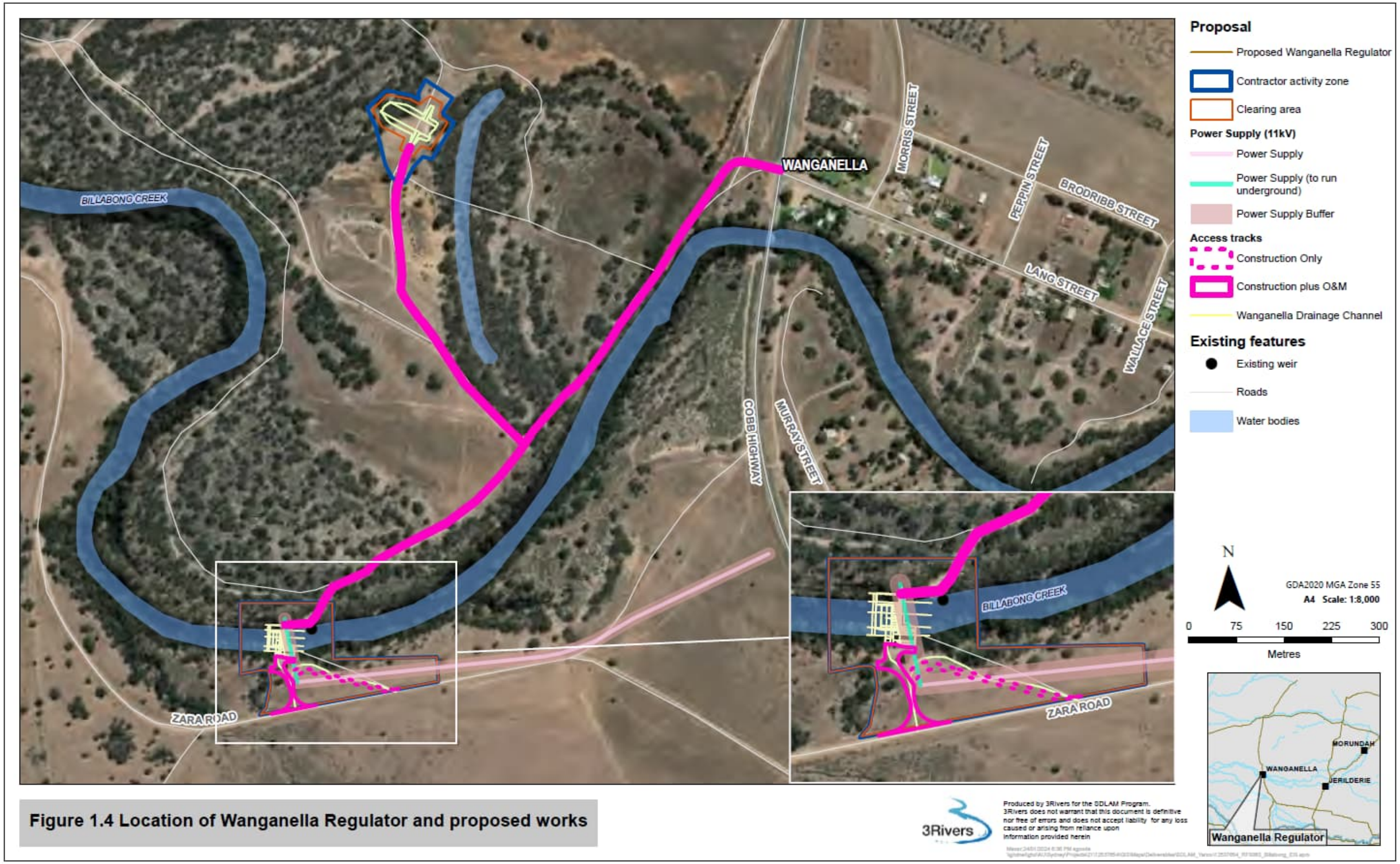

Figure 1.4 Location of Wanganella Regulator and proposed works

Figure 1-4. Location of proposed Wanganella Regulator and proposed works

A long-term water level series of existing and proposed conditions were required to characterise the impacts of the proposal on groundwater. Figure 1-5 presents the monthly average pool level (that is, the upstream water level) for the existing weir and the tested scenario for Hartwood regulator and Figure 1-6 presents the equivalent levels for Wanganella regulator.

The tested scenario is based on the proposed operating rules as per the Draft Yanco Creek System Operations Plan - Yanco Creek Modernisation Project (DPE, 2023a) and is documented in the Yanco Modernisation – Murrumbidgee Source Model Runs (DPE, 2023b). The long-term water level series was determined from Source modelling discharge results which were converted to water levels using a rating curve developed from hydraulic calculations and modelling results.

The existing conditions were based on operational flow results for flows less than 500ML/d at Hartwood and 400ML/d at Wanganella and flood scenarios for flows greater. In proposed conditions a compound rating table was used to represent the two different time periods and with the target operating levels outlined in the Operations Plan and listed in Table 1-1. It is noted that the above does not account for gate operations to maintain target water levels; however, as the groundwater assessment was on a monthly timestep and given the relatively small operational water level range and the general insensitivity of groundwater levels to small transient water level variations, this was not considered to be a significant issue.

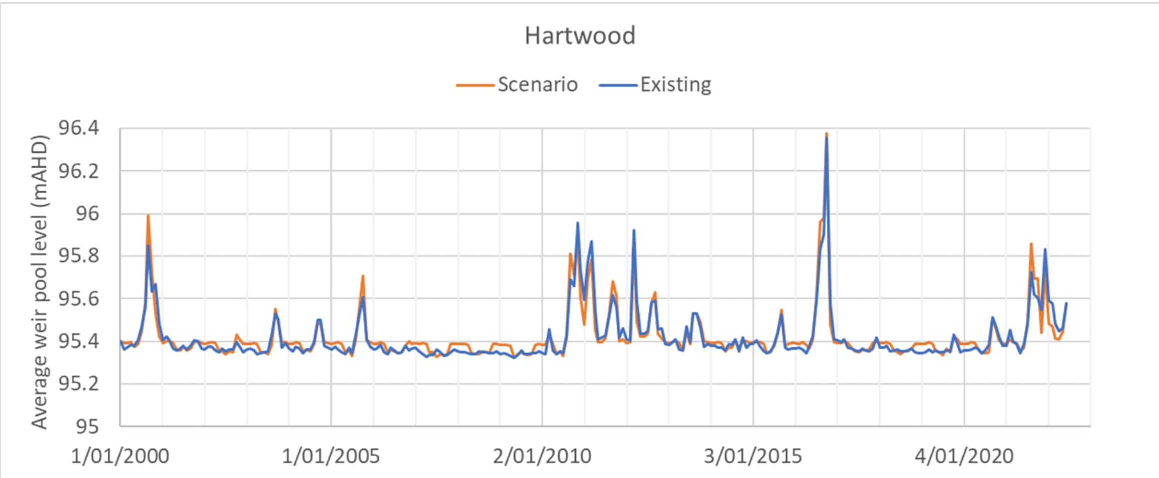

Figure 1-5. Hartwood monthly average weir and proposed regulator pool levels (upstream water level)

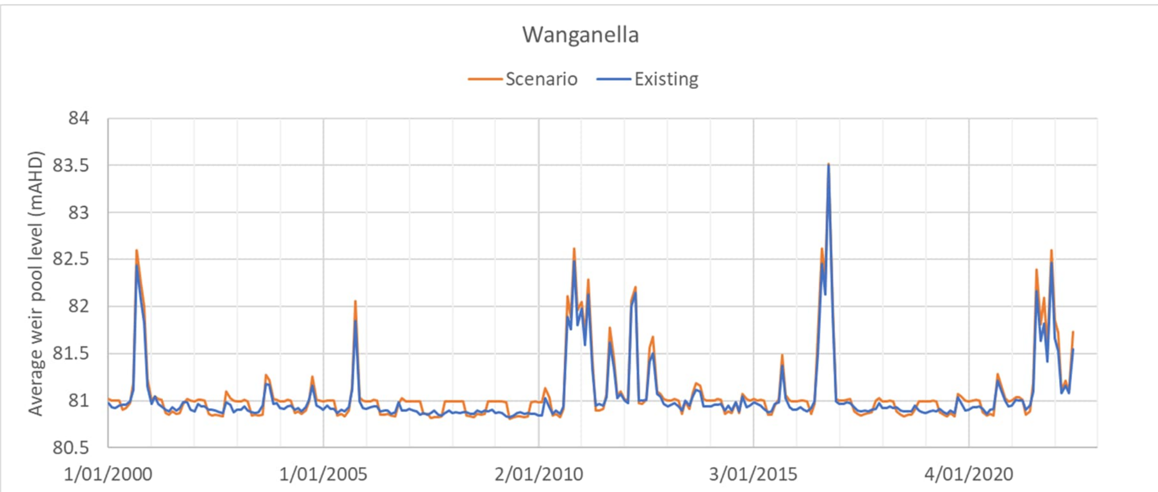

Figure 1-6. Wanganella monthly average weir and proposed regulator pool levels (upstream water level)

Table 1-1 Target operating levels from the Operations Plan (DPE, 2023a)

Time period	Hartwood - Regulator Pool Target Level (mAHD)	Wanganella - Regulator Pool Target Level (mAHD)
1 November to 30 April	95.44	80.99
1 May to 31 October	95.28	80.82

1.5 Secretary's environmental assessment requirements

This groundwater assessment has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs). Table 1-2 outlines the requirements relevant to this assessment.

Table 1-2 Relevant SEARs

Requirements	Where addressed in this report
3. Include a thorough description of the existing environmental conditions and hydrological regime to the extent of project influence up and down stream, including:	Chapter 3
a. Comprehensive mapping of baseline conditions of rivers, streams, wetlands, and groundwater potentially impacted by the project, inclusive of existing weirs, regulators, block banks, water allocations and operating conditions.	Chapter 3
c. A description of groundwater conditions that provides an understanding of groundwater level across the site under a range of wet and dry conditions.	Section 3.4.5 and 3.4.6
h. Water quality baseline data for the water resource likely to be impacted by the development. This should include relevant physical and chemical parameters such as temperature, EC, pH, turbidity, nutrients and dissolved oxygen as well as any available major ion and toxicant data.	Section 3.4.11 (for relevant groundwater related parameters)
i. Highly connected alluvial aquifers and their responses to river flows.	Section 3.4.8
4. Include a thorough assessment of the hydrological impacts of the project in comparison with existing hydrological conditions, to the extent of project influence up and down stream, including:	
c. Description of all works/activities that may intercept, extract, use, divert or receive surface water and/or groundwater. This includes the description of any development, activities or structures that will intercept, interfere with or remove surface water or groundwater, both temporary and permanent, ensuring compliance with regional Water Sharing Plans and Water Resource Plans, and with sustainable diversion limits of the Murray Darling Basin Plan.	Chapter 4
d. Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, groundwater dependent ecosystems, and ground water levels;	Chapter 4

Requirements	Where addressed in this report
including measures proposed to reduce and mitigate these impacts.	
g. Proposed surface and groundwater monitoring activities and methodologies.	Chapter 6
j. Assessment of impact on land salinization due to rising groundwater table induced by raised pool level in the storage, and mitigation of impacts.	Chapter 4

1.6 Assumptions

This assessment of effects of the proposal is based on the following assumptions:

- The footprint and depth of the proposed regulators is not materially different from the draft design drawings provided as of March 2024
- Groundwater levels and quality close to the creek are represented by the data collected from the observation wells constructed at each regulator site
- River operations will result in water levels that on average match the draft operating rules as modelled for this assessment
- Irrigation and groundwater extraction in the region continue to trend as for the period of 2000 to 2023
- No significant changes in land use or cover occur within close proximity to the weir pools.

2. Assessment approach and methodology

2.1 Legislative and policy context to the assessment

This section summarises the legislation, guidelines and/or policies driving the approach to the assessment.

- Water Act 2007
- Murray-Darling Basin Plan (2012)
- Murray Alluvium Water Resource Plan (2023)
- Murrumbidgee Alluvium Water Resource Plan (2023)
- Water Sharing Plan for the Murray Alluvial Groundwater Sources (2020)
- Water Sharing Plan for the Murrumbidgee Alluvial Groundwater Sources (2020)
- Water Management Act 2000
- Water Management Regulation 2018
- NSW Aquifer Interference Policy (2012)
- Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines and Water Quality Objectives in NSW (DEC 2006)
- Australian and New Zealand Guidelines (ANZG) for Fresh and Marine Water Quality (ANZG 2018).

The SEARs requirements relevant to groundwater and where these have been addressed in this report, are discussed in section 1.5 (above).

At the time of preparing this report the proposed works are not a controlled action under the EPBC Act. A referral to the Commonwealth Department is pending. This report may be updated pending the outcome of the referral decision.

2.2 Methodology

2.2.1 Study area

For the purposes of the assessment the proposal site and study area have been defined as follows:

- Proposal site – The area that would be directly affected by construction and the location of operational infrastructure.
- Study area – is the area investigated which includes the proposal site and surrounding area, with the potential to be directly or indirectly affected by the proposal. The area of investigation covered by this groundwater assessment comprised the shallow and intermediate aquifers surrounding Billabong Creek. The study area is shown in Figure 2-1 and Figure 2-2.

In deciding on the study area, the following factors were taken into account:

- The likely limits of any change in groundwater level that may result from the construction and operation of the proposal
- Controls on groundwater level, such as creeks, waterways, wetlands and rivers
- Land use, including irrigation and dryland areas
- Published groundwater contour and occurrence information

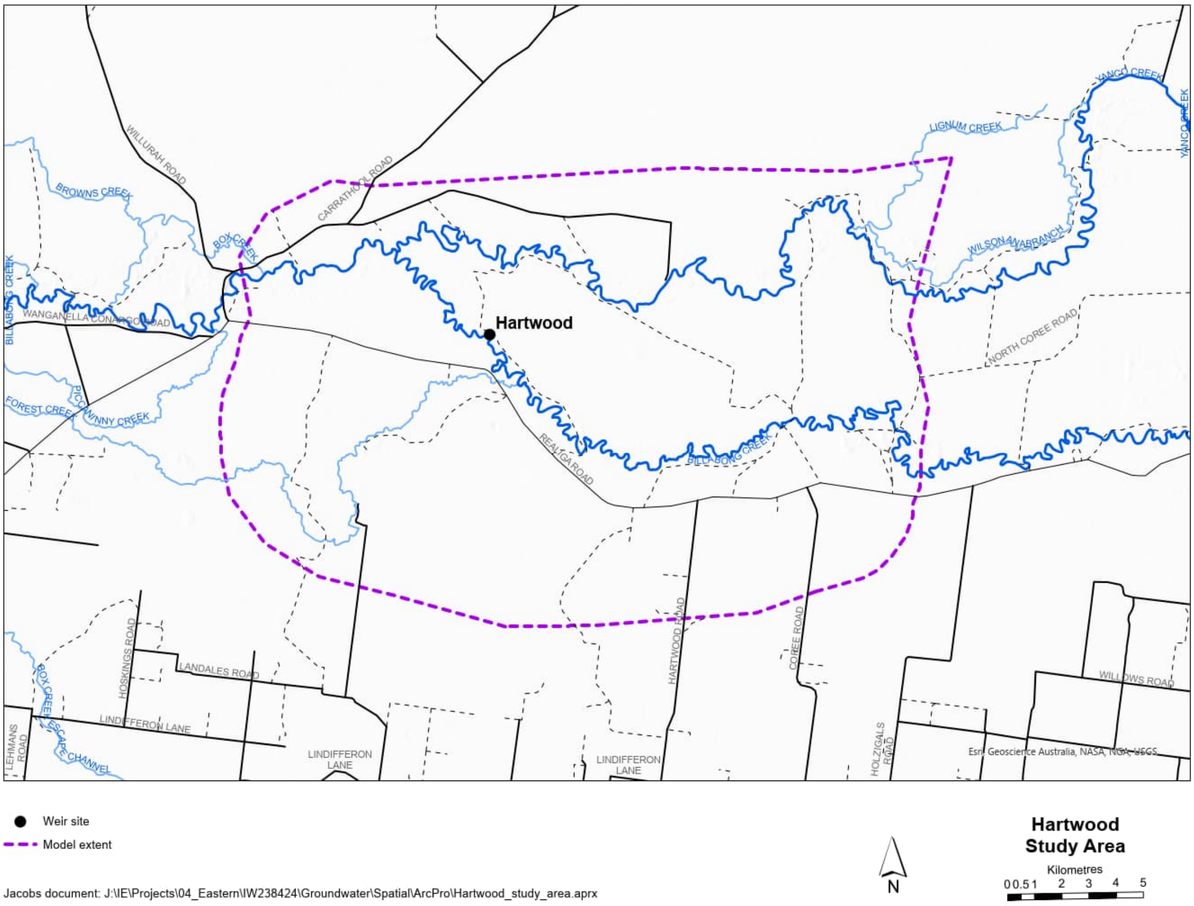

Figure 2-1. Hartwood study area used for this groundwater assessment

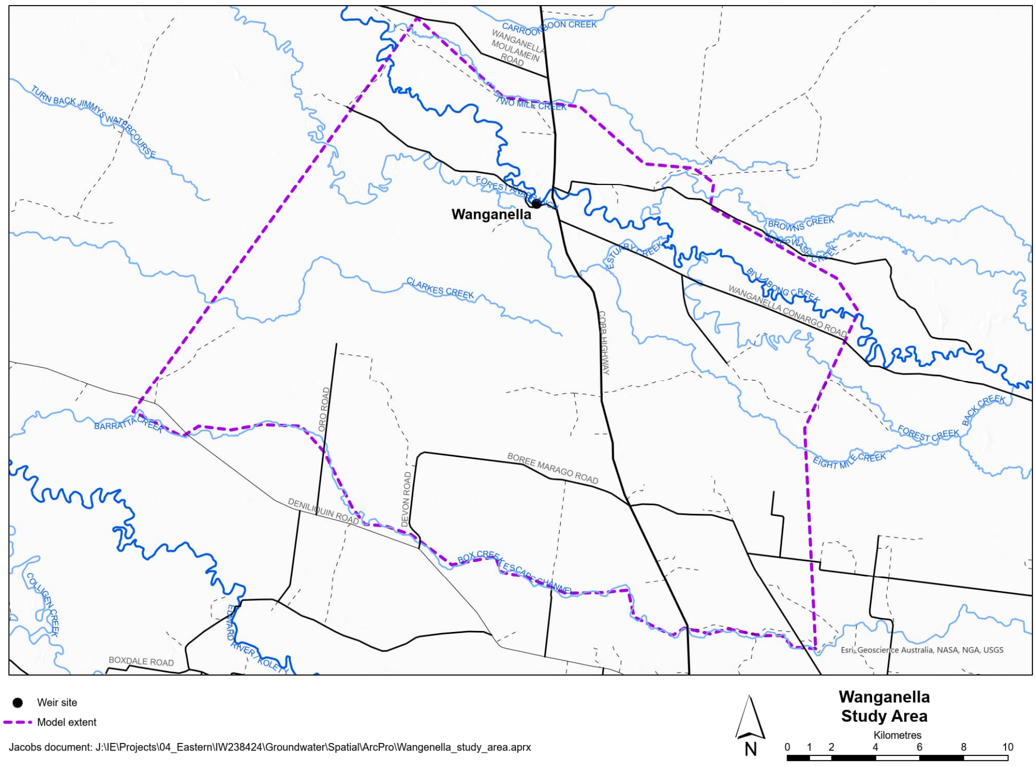

Figure 2-2. Wanganella study area used for this groundwater assessment

2.2.2 Groundwater quality and quantity assessment methodology

Potential groundwater related impacts which may occur due to the proposal have been assessed by:

- Characterising the existing environmental setting including climate, topography, geology, and groundwater occurrence, quality and use, including GDEs
- Installation of three monitoring wells (two at Wanganella and one at Hartwood) to characterise the hydrogeological conditions near the existing weirs. Water level monitoring, hydraulic testing and groundwater quality sampling were undertaken.
- Developing a conceptual groundwater model
- Assessing the potential for the proposal to interact with the watertable and underlying groundwater systems. This was undertaken by assessing the proposal's activities which could potentially intersect the watertable and comparing the likely depth of these activities to inferred groundwater elevations. The inferred groundwater elevations were assessed using groundwater levels from December 2023 from monitoring wells installed as part of this assessment.
- Assessing the impacts from operation by developing a numerical groundwater model and simulating the existing Hartwood and Wanganella weirs and the proposed operation of the regulators. Model boundary conditions were derived from an interpreted watertable surface developed from groundwater level data from public domain online databases and project wells. The tested scenario was based on the proposed operating rules as per the Draft Yanco Creek System Operations Plan - Yanco Creek Modernisation Project (DPE, 2023a) and is documented in the Yanco Modernisation – Murrumbidgee Source Model Runs (DPE, 2023b).
- Qualitative assessment of the potential for the proposal to impact on other groundwater users, baseflow to surface water drainage systems, and GDEs using the results from the numerical groundwater models.
- Providing recommendations for monitoring and management of identified potential impacts and risks, including management measures as appropriate.

2.2.3 Assessment of cumulative impacts

Cumulative impacts have the potential to occur when impacts from a proposal interact or overlap with impacts from other projects and can potentially result in a larger overall effect (positive or negative) on the environment, businesses or local communities. Cumulative groundwater impacts have been assessed through a qualitative analysis, taking into account the expected small effect of the proposed regulators.

3. Existing Environment

3.1 Groundwater catchment

The existing Hartwood and Wanganella weirs are located near the Murray and Murrumbidgee Water Sharing Plan Regions (Figure 3-1) and on the boundary of the Lower Murray Alluvium and Lower Murrumbidgee Alluvium groundwater sustainable diversion limit (SDL) resources units (Figure 3-2). These groundwater resources are managed under the Murrumbidgee and Murray Alluvium Water Resource Plans (WRP) which outline how NSW will meet its obligations under the Murray-Darling Basin Plan 2012 (Basin Plan) and the *Water Act 2007*. The catchment area and WRP areas are outlined on Figure 3-3 and Figure 3-4 respectively.

3.1.1 Groundwater management

Groundwater in the vicinity of the proposed regulators is managed and administered in accordance with WRP and through the use of Sustainable Diversion Limits (SDL) which apply to defined regions and aquifers.

The Murray Alluvium Water Resource Plan applies to all groundwater in the following groundwater sustainable diversion limit resource units within the WRP area (DPE, 2022a):

- Billabong Creek Alluvium (GS13)
- Upper Murray Alluvium (GS46)
- Lower Murray Shallow Alluvium (GS27a)
- Lower Murray Deep Alluvium (GS27b).

The following resource units are part of the Murrumbidgee Alluvium Water Resource Plan (DPE, 2022b):

- Lake George Alluvium (GS21)
- Mid Murrumbidgee Alluvium (GS31)
- Lower Murrumbidgee Shallow Alluvium (GS28a)
- Lower Murrumbidgee Deep Alluvium (GS28b).

The Lower Murray and Lower Murrumbidgee Shallow Alluvium and Deep Alluvium are relevant to the proposal (Figure 3-2). In the Murray Alluvium Water Resource Plan, the Shallow Alluvium is defined as the upper 20 m of sediments below ground surface and the Deep Alluvium extends from a depth of 20 m to a depth of approximately 350 m (DPE, 2022a). However, in the Murrumbidgee Alluvium Water Resource Plan the groundwater source boundary is identified by colour change in the sediments (DPE, 2022b). The Shallow Alluvium is approximately 40 m deep within the yellow/brown sands and clays of the Shepparton formation (DPE, 2022b). The deep groundwater source includes the older sediments of the Calivil Formation and the Renmark Group and is comprised of white sands and white/grey clays (DPE, 2022b).

For this groundwater assessment, the approach of the Murrumbidgee Alluvium WRP has been adopted. The shallow alluvium is limited to the upper most units of the Shepparton Formation, which are predominantly Clay and Silt with minor sand. In the vicinity of the proposal (see also later in this section) the shallow alluvium overlies a deeper more clay rich unit at about 40 m depth.

In contrast the Billabong Creek is the boundary between four SDL units, with the right bank of the creek located in the Lower Murrumbidgee Shallow Alluvium and the Left Bank located in the Lower Murray Shallow Alluvium. This means that effects of the proposal will be divided between the two shallow SDL units.

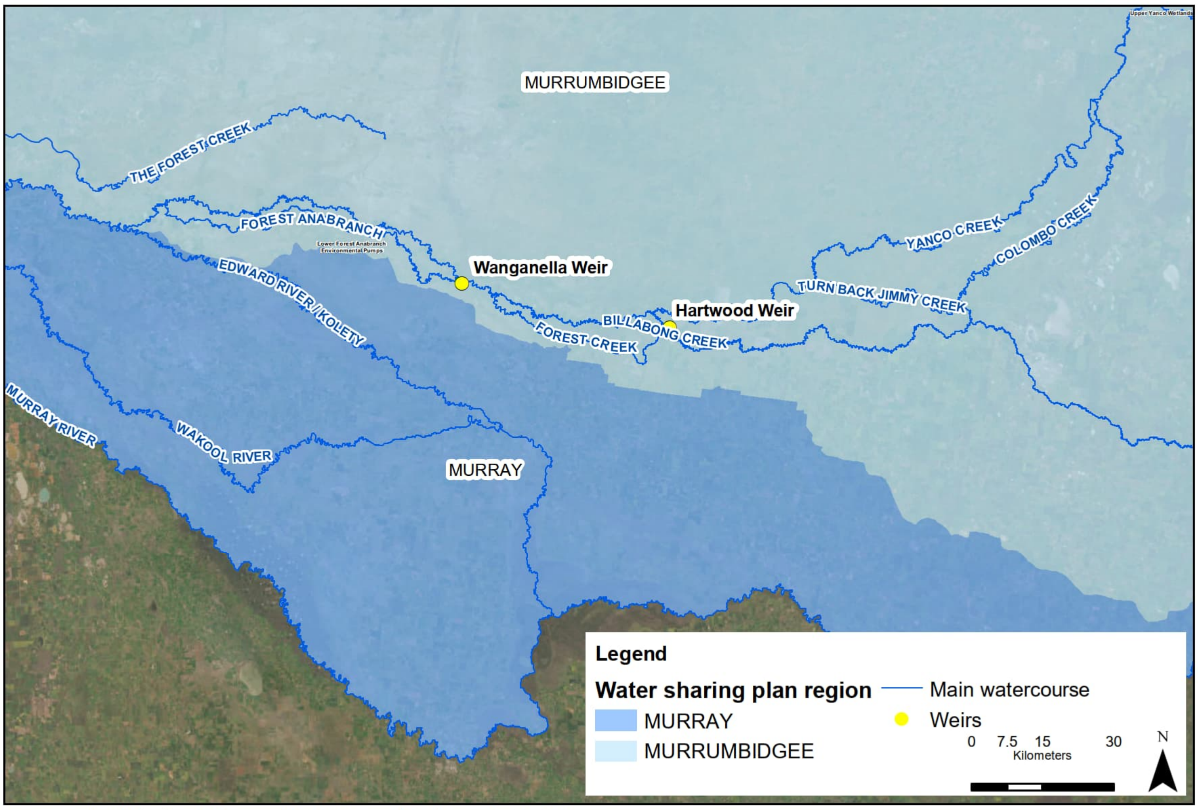

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Figure 3-1. Water sharing plan region (NSW office of Water, 2013)

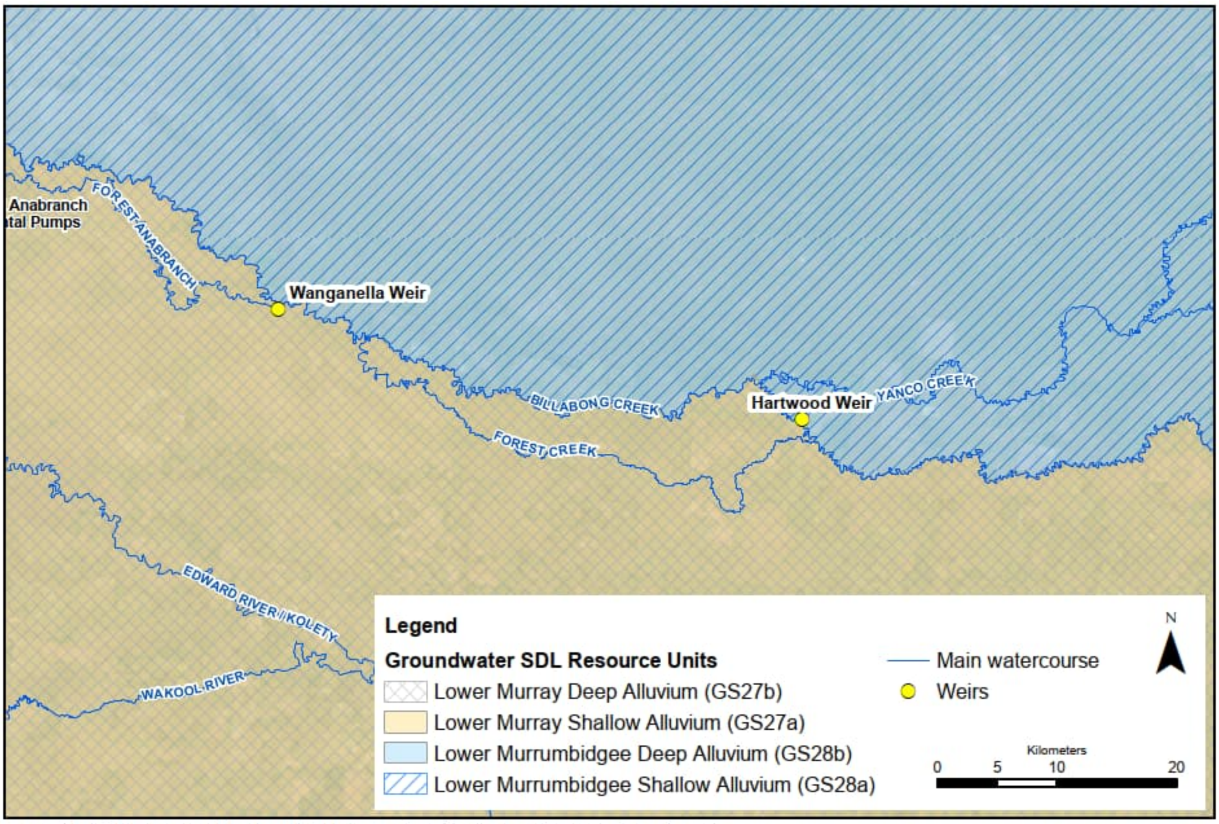

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Figure 3-2. Groundwater SDL resource units (Murray Darling Basin Authority, 2023)

Billabong Creek in the vicinity of the proposal is in a topographic area characterised by relatively low elevation and relatively flat and low slope. The topography is typical of the lower reaches of the Murray Catchment where distributary floodplains have formed in the region of confluence of the Murray and Murrumbidgee Rivers. Figure 3-3 and Figure 3-4 show the elevation range in the catchment areas surrounding the sites of the two proposed regulators. The primary feature of this landscape is the flat landscape and low gradient. This tends to emphasise small variations in topography, which can have an effect on groundwater level and depth. The gentle and flat topography is reflected in groundwater elevation patterns.

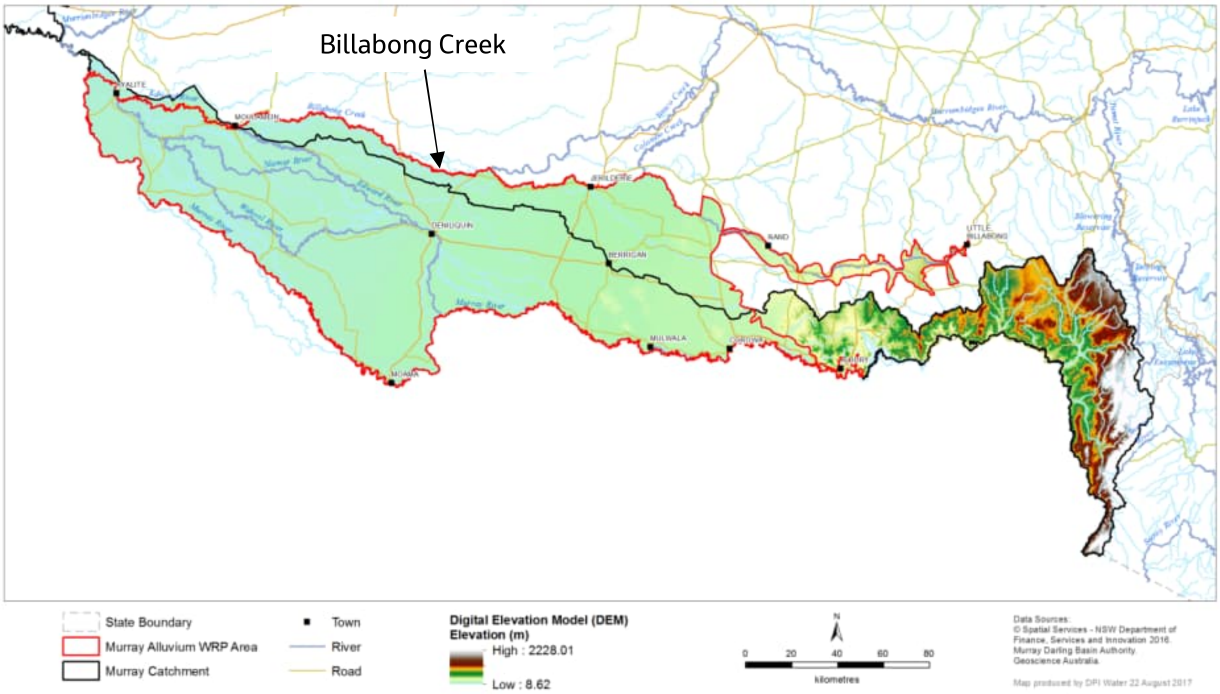

Figure 3-3. Topography and elevation map of the Murray catchment (DPI, 2019a)

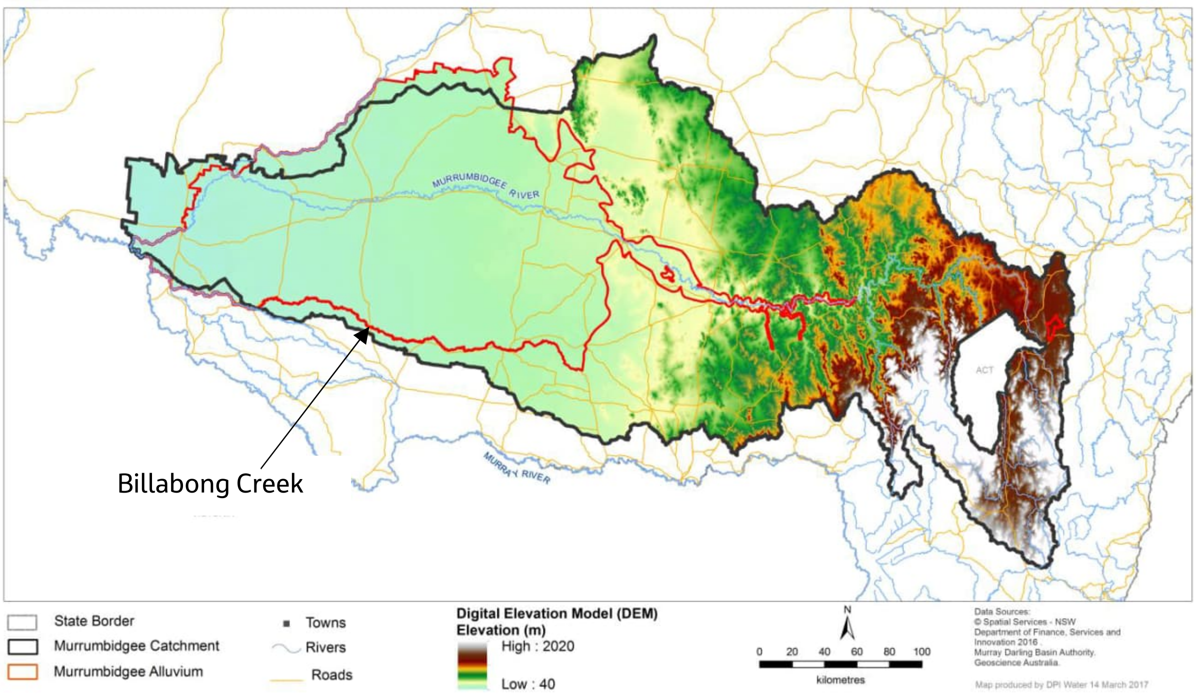

Figure 3-4. Topography and elevation map of the Murrumbidgee catchment (DPI, 2019b)

3.2 Topography in the study area

The topography in the vicinity of the Hartwood site is generally flat with an elevation of approximately 96 mAHD to 101 mAHD. The topography within the vicinity of the existing Wanganella Weir is generally flat with an elevation of approximately 87 to 91 mAHD. Topography near Wanganella regulator is presented on Figure 3-6 and the topography near Hartwood regulator is presented in Figure 3-5.

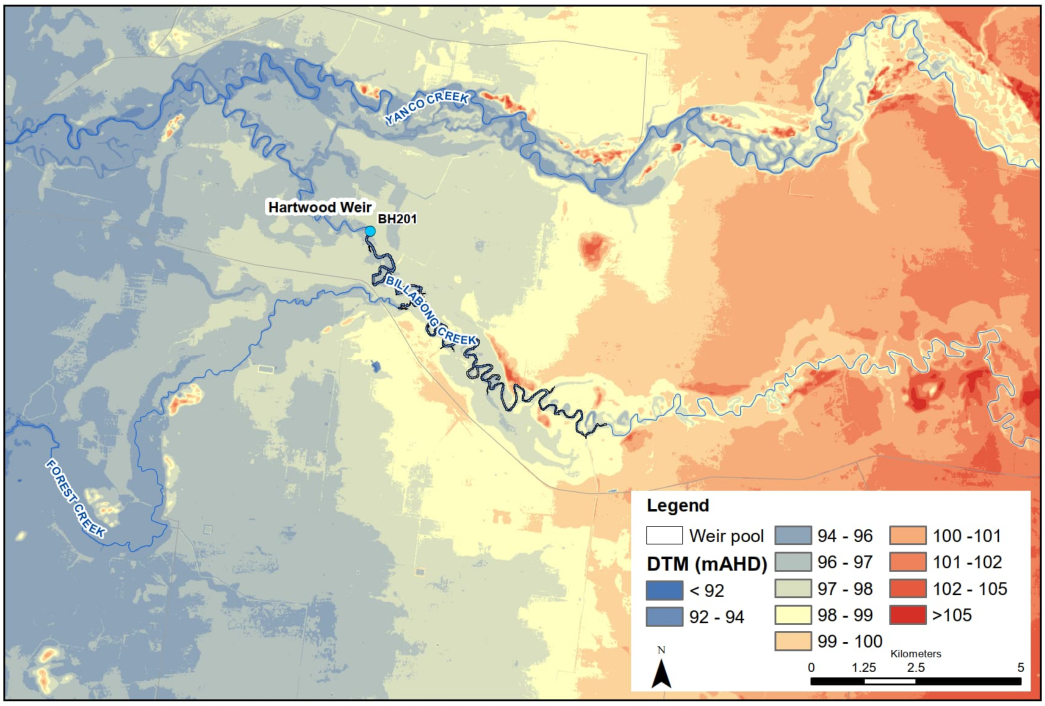

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Figure 3-5. Topography near Hartwood (Data sourced from DPI, analysis by Jacobs)

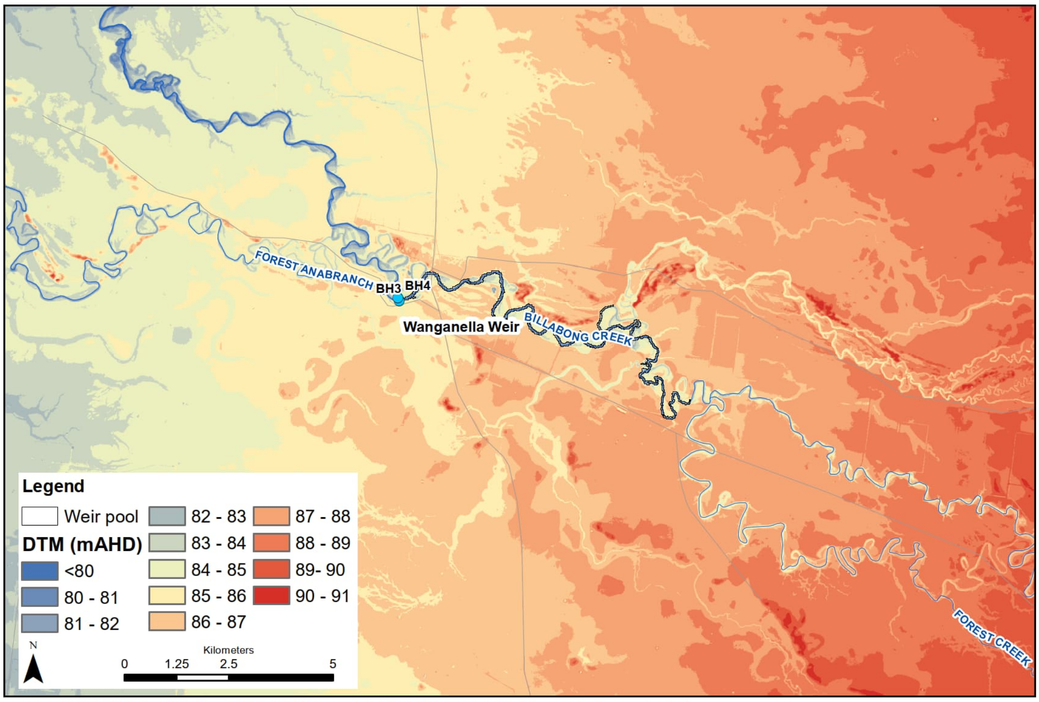

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Figure 3-6. Topography near Wanganella (Data sourced from DPI, analysis by Jacobs)

3.3 Climate

3.3.1 Rainfall and temperature

Review of data available through the Bureau of Meteorology (BOM) (BOM, 2024b) indicates the nearest BOM weather station for rainfall and temperature data is the Deniliquin Airport automatic weather station (AWS) Weather Station (#074258) located approximately 40 km southwest of the existing Hartwood Weir and 40 km south of the existing Wanganella Weir.

Utilising the BOM climate database, the average total rainfall for each calendar month from 1997 to 2024 (27 years) was calculated and is summarised in Table 3-1 and presented in Figure 3-7. Analysis of the available rainfall data presented in Figure 3-7 shows there is only a moderate level of seasonality within the study area, and that rainfall is typically low in most months. Lowest average rainfall was recorded in January (24.8 mm) and March (26.3 mm), followed by February (26.5 mm). Highest monthly rainfall was recorded in November (48.8 mm) followed by October (41.8 mm) and September (33.6 mm). Between April and August there is very little variation between monthly rainfalls.

Table 3-1 Average total monthly rainfall recorded at Deniliquin Airport AWS Weather Station (#074258)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rainfall (mm)	24.8	26.5	26.3	28.2	27.1	30.8	28	33.3	33.6	41.8	48.8	29.9	380.1

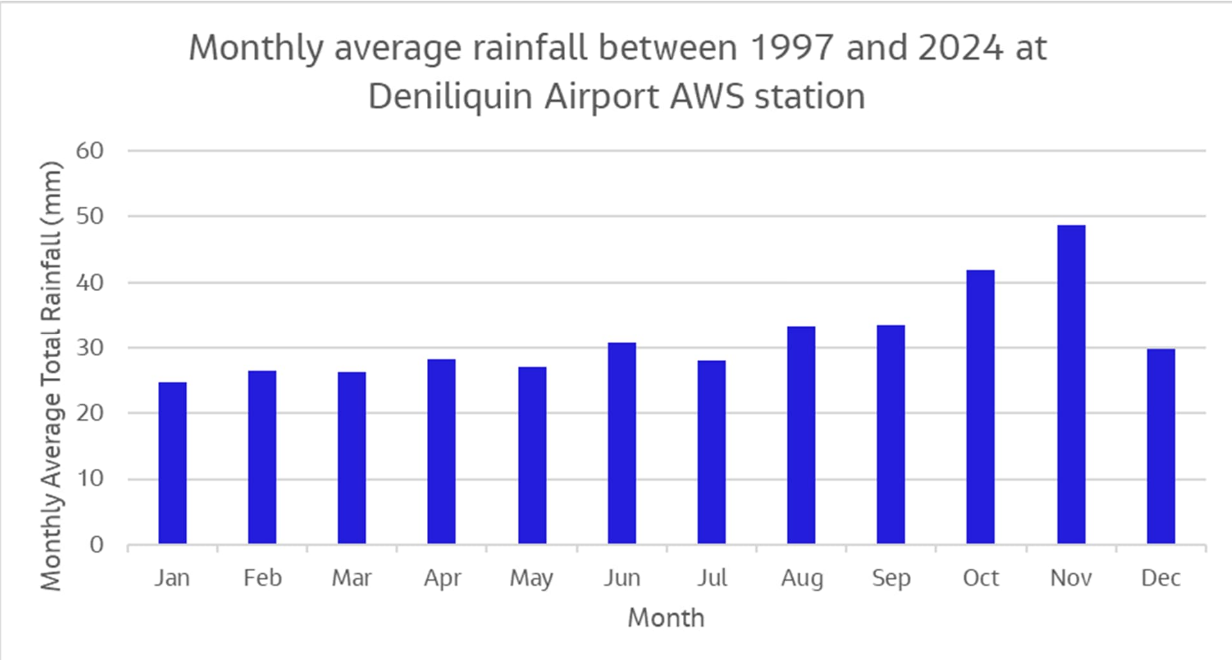

Figure 3-7. Average total monthly rainfall between 1996 and 2021, as recorded by Yanco Agricultural Institute Weather Station (#74037)

Long-term temperature data from Deniliquin Airport AWS Weather Station (BOM, 2024b) was reviewed and is presented in Figure 3-8. This data demonstrates the average monthly maximum and minimum temperature ranges between 1971 to 2024. The analysis of available temperature data indicates that the proposal areas are positioned within a temperate climatic region characterised by warm summers and cool winters. Average minimum and maximum temperatures range from approximately 3 to 14°C (July) and 16 to 33°C (January) seasonally, with predominately mild to moderate autumn and spring months.

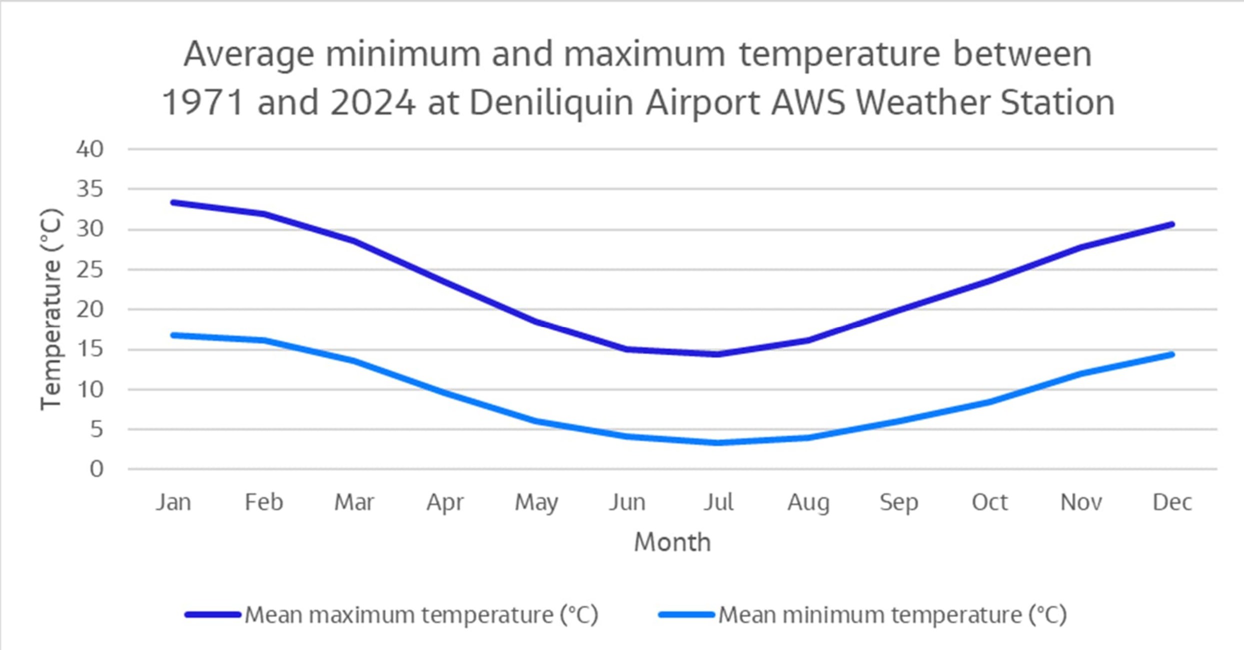

Figure 3-8. Average monthly minimum and maximum temperature between 2000 and 2021, as recorded at Deniliquin Airport AWS Weather Station (#074258)

3.4 Hydrogeology

3.4.1 Hydrostratigraphy

The Deniliquin Hydrogeological Map 1:250,000 (William and Woolley, 1992) indicates Quaternary aged sediments (QA) are present at the existing Wanganella and Hartwood weirs. The Quaternary aged sediments consist of unconsolidated, grey, brown, micaceous silty clay, silt, polymictic sand and gravel. These sediments are associated with Billabong Creek and align with the creek on a regional scale. The alluvial sediments are underlain by the Shepperton Formation (TQs) which consists of unconsolidated to poorly consolidated clay and silty clay with lenses of polymictic coarse to fine sand.

In accordance with the Deniliquin Hydrogeological Map (William and Woolley, 1992) the hydrogeological units within the basin are characterised by the below hydrogeological sequences:

- Quaternary Alluvial Aquifer
  - Commonly unsaturated, local watertable or perched watertable
- Shepparton Formation Aquifer System
  - Unconsolidated to poorly consolidated mottled, variegated clay, silty clay with lenses of poly mictic, coarse to fine sand and gravel; partly modified by pedogenesis, includes intercalated red-brown palaeosols
- Pliocene Sand Aquifer System
  - Calivil Formation: poorly consolidated pale grey, poorly sorted, coarse to granular quartz sand conglomerate, white kaolinitic matrix; includes thick intercalations of kaolin, thin lenses of carbonaceous clay; grain size diminishes westward
- Renmark Group Aquifer System
  - Only present in some areas of the basin. The Warina Formation is part of the Renmark Group.

A simplified cross section illustrating the relative thickness of each sequence in Figure 3-9.

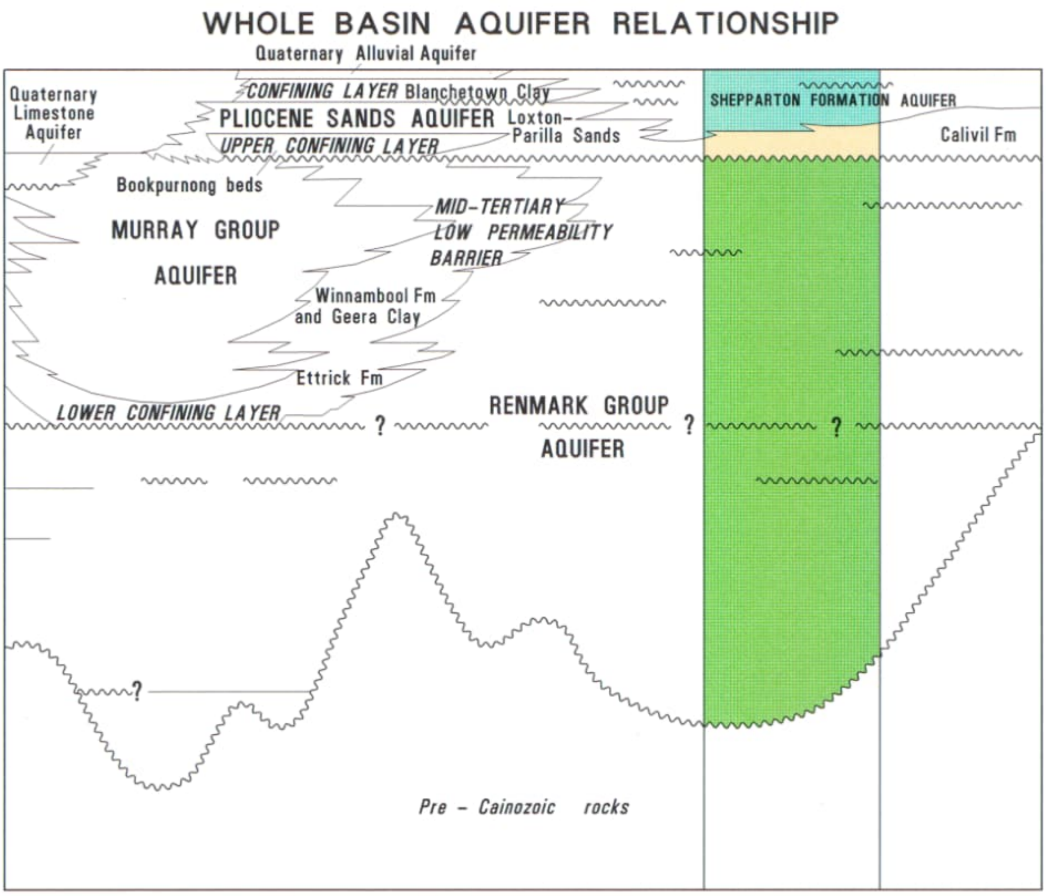

Figure 3-9. Hydrogeological cross section (William and Woolley, 1992)

In the Lower Murrumbidgee region that includes the study area it is common for a separation to be made within the Shepparton Formation. There is usually a recognisable more clay rich horizon at the base of the Shepparton Formation, above the Pliocence Sand. This "lower Shepparton Formation" is regarded as a barrier to vertical flow and is a local retarding layer between the Pliocene (Calivil Formation) and the surface aquifer. This unit is not recognised across the whole Murray Basin, has been identified in Victoria but not formally identified as a sub-unit in NSW (Brown and Stephenson, 1991). Nevertheless there is recognition of a coarsening upward sequence in which the upper Calivil Formation or lower Shepparton Formation is clay rich grading into a mixed clay and sand sequence with significant variability controlled by the specific depositional environment.

3.4.2 Regional Stratigraphy

Stratigraphic information was obtained from registered bores within 20 km of the proposed Wanganella and Hartwood regulators (summarised in Table 3-2). Three formations were identified: the Shepparton Formation, Calivil Formation and Warina Sand/ Renmark Group. The Shepparton Formation occurs from surface to around 40-50 m below ground level (bgl), followed by the Calivil Formation to a depth of approximately 130 mbgl and Warina Sand/ Renmark Group to the depth of termination.

Table 3-2 Available regional stratigraphic information (BoM, 2024a)

Location/ Bore	Stratigraphy
GW500029.1.1 (18 km south-east of Wanganella Regulator)	Shepparton Formation (0 – 40.5) Calivil Formation (40.5 – 146 m) Lower Renmark Group (146 – 313 m)
GW500491.1.1 (18 km south-west of Wanganella Regulator)	Shepparton Formation (0 – 56 m) Calivil Formation (56 – 131. 5m) Warina Sand (131.5– 241.5 m)
GW503717.1.1 (19 km south of Wanganella Regulator)	Shepparton Formation (0 – 37 m) Calivil Formation (37 – 132 m) Warina Sand (132– 200.3 m)
GW504186.1.1 (3 km south-west of Hartwood Regulator)	Shepparton Formation (0 – 51 m) Calivil Formation (51 – 130 m) Warina Sand (130– 22 6m)
GW500080.1.1 (18 km south of Hartwood Regulator)	Shepparton Formation (0 – 36 m) Calivil Formation (36 – 124 m) Warina Sand (124– 251 m)
GW029889.1.1 (15 km west of Hartwood Regulator)	Shepparton Formation (0 – 40.84 m) Calivil Formation (40.84 – 115.82 m) Warina Sand (115.82– 146.3 m)

3.4.3 Site-specific lithology

Lithological logs from geotechnical investigation drilled to support the design of the proposed Hartwood and Wanganella regulators were reviewed to further develop the understanding of site-specific geology (GTS, 2022 and GTS, 2023). Borehole locations are shown on Figure 3-12 and Figure 3-15.

Four boreholes were drilled in the vicinity of the new regulators (GTS, 2022 and GTS, 2023). At Wanganella two boreholes (BH3 and BH4) were converted to groundwater monitoring wells and one borehole (BH201) at Hartwood. A summary of the predominant lithology and well construction details for boreholes drilled as part of this study are provided in Table 3-3 below (GTS, 2022 and GTS, 2023). Additional borehole logs are available in the 2004 NSW Department of Commerce Hartwood Weir Geotechnical Investigation Report. While the predominant lithology is described as sand in the table below, Jacobs' interpretation is that the sand contains a proportion of fine sediments (e.g. silts and clays).

Table 3-3 Available site-specific geological information

Location/ Bore	Depth of bore (m)	Predominant Lithology (m)	Well Construction (m)	Inferred screened unit
Wanganella BH1	10.5	Fill: 0 - 0.2 Clay: 0.2 – 2.7 Sand: 2.7 – 4.0 Clay: 4.0 – 9.1 Sand: 9.1 – 9.2 Clay: 9.2 – 10.5	N/A	N/A
Wanganella BH2	10.0	Fill: 0 - 0.2 Clay: 0.2 – 2.2 Sand: 2.2 – 7.1 Clay: 7.1 – 10.0	N/A	
Wanganella BH3	10.0	Fill: 0 - 0.1 Clay: 0.1 – 2.6 Sand: 2.6 – 7.0 Clay: 7.0 – 8.0 Sand: 8.0 – 9.0 Clay: 9.0 – 10.0	Casing: 0 – 5.7 Screen: 5.7 – 8.7 Hole collapsed: 8.7 – 10.0	Quaternary Alluvium/ Shepparton Formation
Wanganella BH4	10.0	Fill: 0 - 0.2 Clay: 0.2 – 3.3 Sand: 3.3 – 5.0 Clay: 5.0 – 8.0 Silt: 8.0 – 8.8 Sand: 8.8 – 10.0	Casing: 0 – 2.2 Screen: 2.2 – 8.2	Quaternary Alluvium/ Shepparton Formation
Hartwood BH201	18.0	Fill: 0 – 0.3 Clay: 0.3 – 5 Sand: 5.0 – 6.5 Clay: 6.5 – 7.4 Sand: 7.4 – 9.6 Clay: 9.6 – 18.0	Casing: 0 – 5.0 Screen 5.0 – 7.0 Sump: 7.0 – 9.0	Quaternary Alluvium/ Shepparton Formation
Hartwood BH202	18.0	Fill: 0 – 0.1 Clay: 0.1 – 4.5 Sand: 4.5 – 5.0 Clay: 5.0 – 6.5 Sand: 6.5 – 9.1 Clay: 9.1 – 18.0	N/A	N/A
Hartwood BH203	5.0	Fill: 0 - 0.5 Clay: 0.05 – 5.0	N/A	N/A
Hartwood BH204	18.0	Fill: 0 – 0.1 Clay: 0.1 – 3.7 Sand: 3.7 – 10.6 Clay: 10.6 – 18.0	N/A	N/A

3.4.3.1 Particle Size Distribution

Particle size distribution from samples collected during drilling at Hartwood in Figure 3-10 and from Wanganella are presented in Figure 3-11 (3Rivers, 2022). Additional particle size distribution data for boreholes recently drilled at Hartwood are available in the GTS 2023 Yanco Modernisation Phase 2 Geotechnical Investigation Report. At the Hartwood site, the silt and clay component is less, with fine to medium sand predominant. These analyses indicate that at Wanganella site, the sediments are predominantly silt or fine sand, however, at around 7 to 10 m there is a dominantly sand interval, which we interpret to be sand directly associated with the current Billabong Creek. Near surface, the sediments are much finer grained, reflecting floodplain deposits.

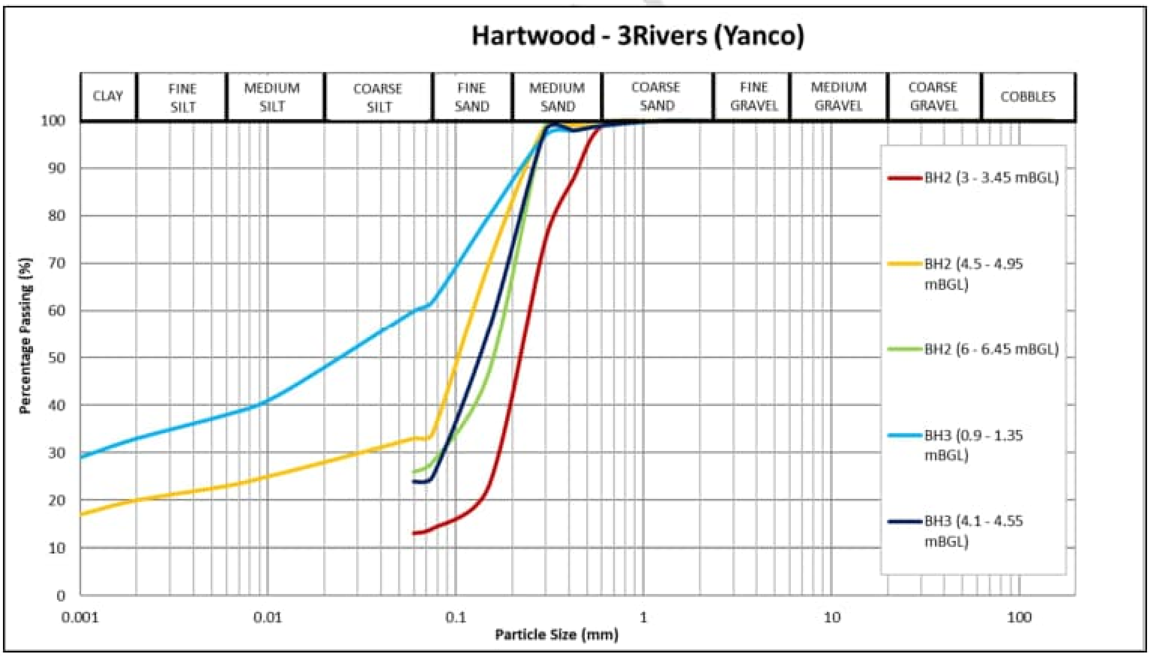

Figure 3-10. Particle size distributions from samples recovered at Hartwood weir (3Rivers, 2022)

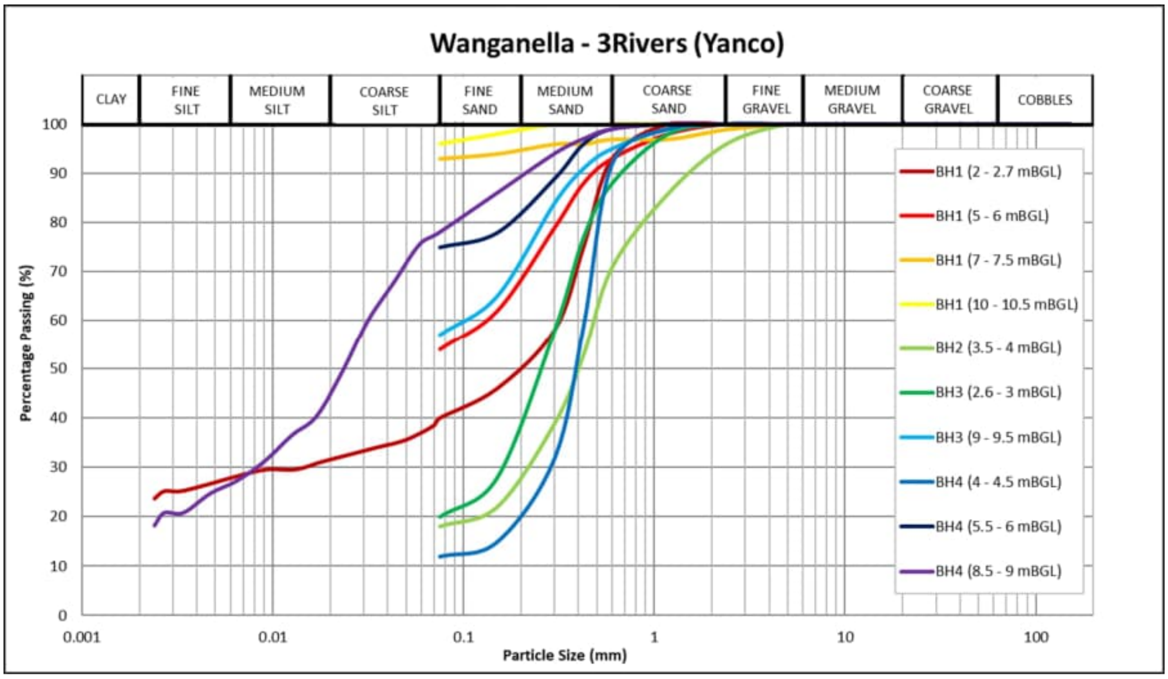

Figure 3-11. Particle size distributions from samples recovered at Wanganella weir (3Rivers, 2022)

3.4.4 Hydraulic conductivity

Hydraulic conductivity testing including rising and falling head tests was completed at a total of three groundwater monitoring wells within the vicinity of the existing Hartwood and Wanganella weirs between 14/12/23 and 15/12/23. The results are provided in Table 3-4 and are within the typical range expected for alluvial sediments. Further information on the hydraulic conductivity testing is provided in Appendix A.

Table 3-4 Hydraulic conductivity testing results of bores within the vicinity of Hartwood and Wanganella

Test ID	Test type	Test duration	K (m/d)	Average (m/d)
BH201 – Test 1	Falling head test	12 mins	0.33	0.5
	Rising head test	6 mins	0.69	
BH201 – Test 2	Falling head test	9 mins	0.46	
	Rising head test	6 mins	0.58	
BH3	Falling head test[1]	30 mins	0.002	0.002
BH4 – Test 1	Falling head test	19 mins	0.05	0.1
	Rising head test	20 mins	0.15	
BH4 – Test 2	Falling head test	20 mins	0.04	
	Rising head test	14 mins	0.13	
	Rising head test	6 mins	0.69	
	Rising head test	6 mins	0.58	

Notes: 1 – Test terminated after 30 minutes after minimal recovery observed

3.4.5 Groundwater levels

3.4.5.1 Regional groundwater levels

Groundwater level data for a select number of registered bores in the vicinity of the existing Hartwood weir are provided in Figure 3-13 and Figure 3-14. A location map of wells with groundwater observations are presented in Figure 3-12.

Water levels in the Shepparton Formation in the vicinity of the existing Hartwood weir represent the watertable generally between 10 mbgl and 20 mbgl, approximately 84 mAHD to 94 mAHD. Groundwater elevations generally increase between1970's to 2002 and then decline with time until monitoring records cease around 2006 and 2013 with a small increase around 2010/2011. This water level increase correlates with the rapid expansion of the irrigation industry by the 1970s (DPI, 2019a). In addition, NSW water reforms commencing in 1994 including the release of the Water Management Act 2000 and the NSW State Groundwater Dependent Ecosystems Policy released in 2002 (DPI, 2019a) are expected to have had an influence on reduced water extraction rate, mostly in the upper catchment. There is expected to be muted response to extraction controls in the study areas because of the limited number of groundwater extraction wells. Reduced groundwater extraction and flood events between 2010-2011 are expected to have had an influence on groundwater levels as observed in Figure 3-13. Overall groundwater levels generally fluctuate around 0.1-0.2 m based on monitoring well hydrographs.

Water levels within the Calivil Formation and Warina Sands Formation in the vicinity of the existing Hartwood weir indicate a generally steady water level from 1975 to 1995, water level (mAHD) then begins to decrease until approximately 2011 before generally increasing until 2023 with a period of decease in 2020. These fluctuating water levels are expected to be directly influenced by extraction in the region from the deeper (Calivil) aquifer.

Shallow and deep well pairs (GW036053 and GW040977) indicate there is downward hydraulic gradient between the Shepparton and Calivil Formation (GW036053) and the Calivil Formation and Warina Sand (GW040977). It is interpreted that this downward gradient is supported by the fine grained lower Shepparton Formation.

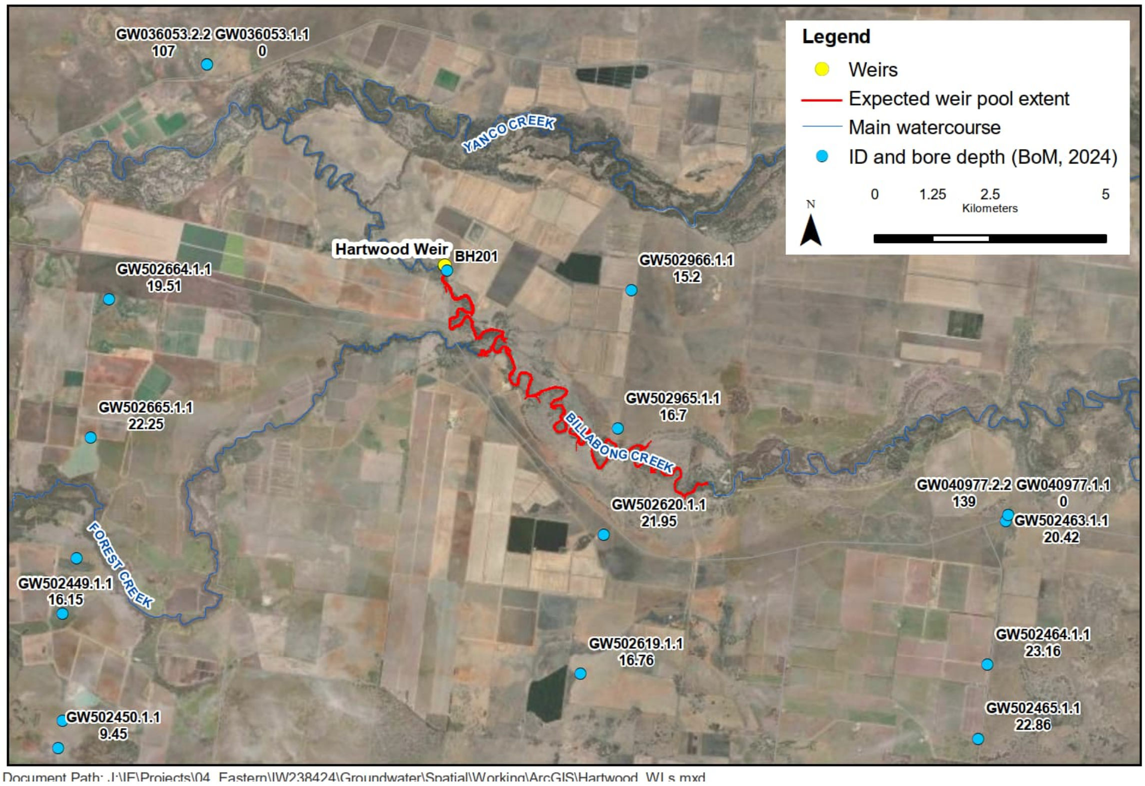

Figure 3-12. Groundwater observations near Hartwood

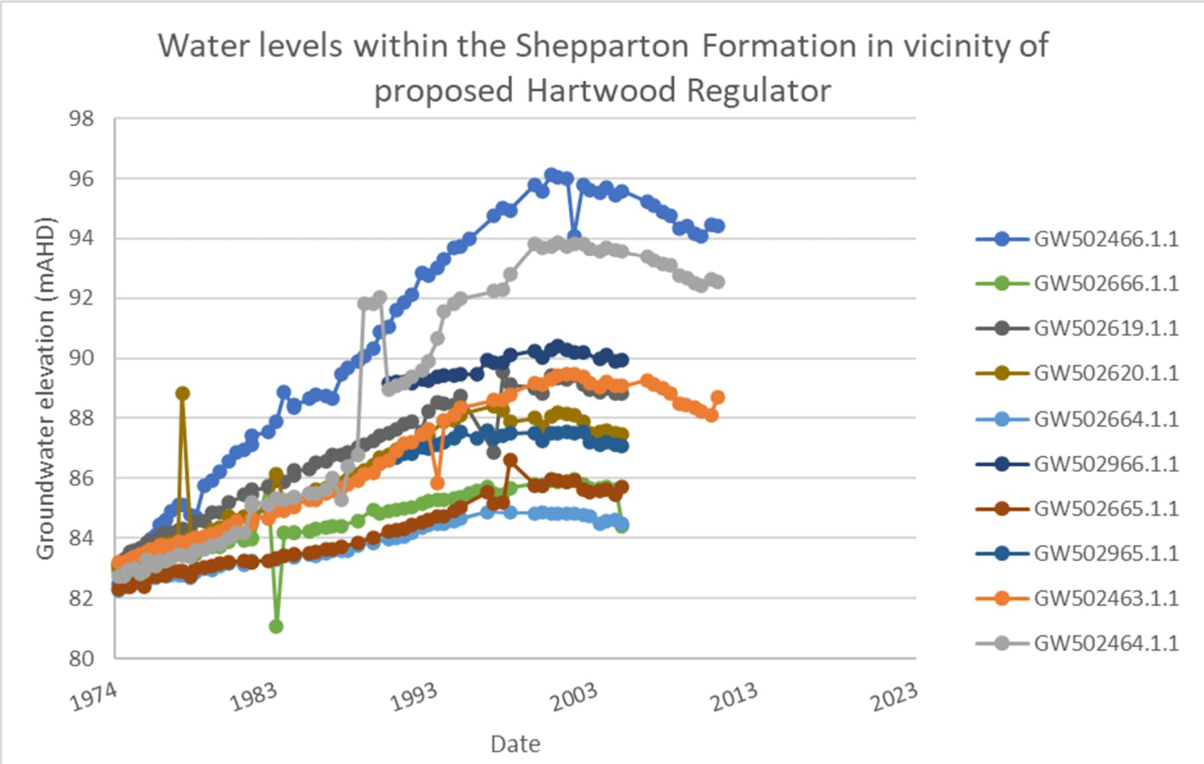

Figure 3-13. Water levels of registered bores screened within the Shepparton Formation in the vicinity of Hartwood

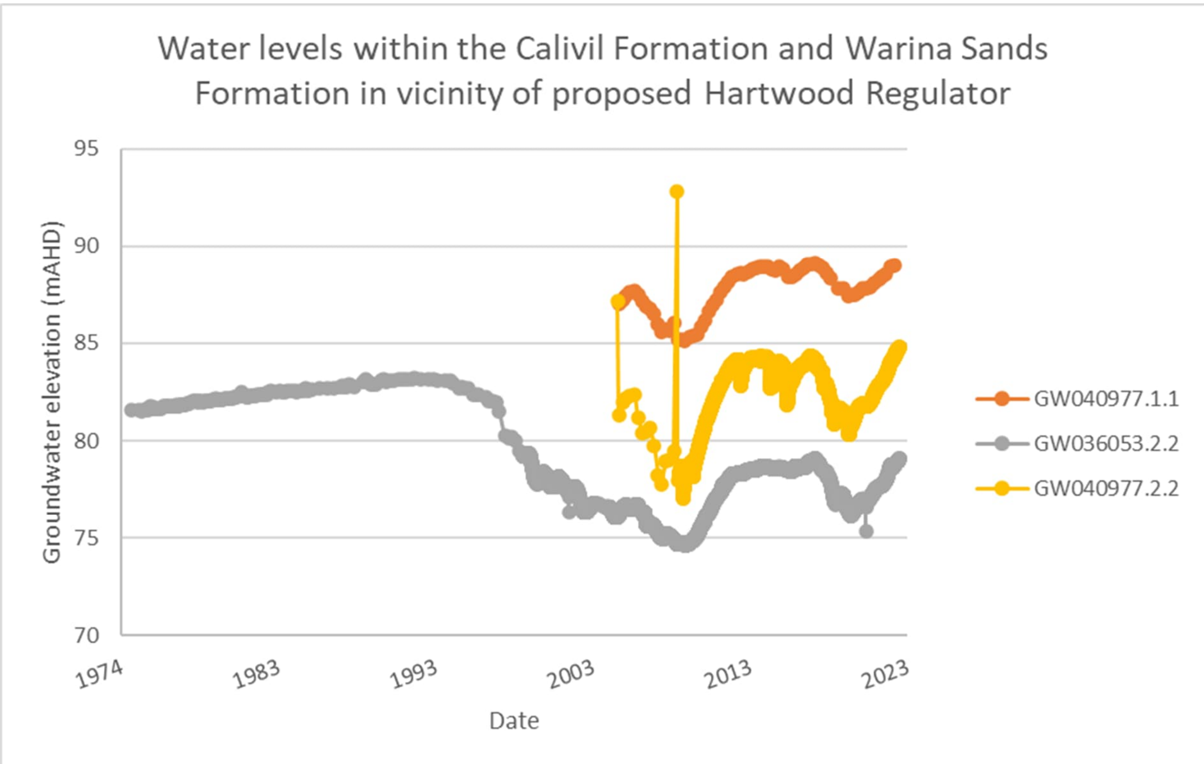

Figure 3-14. Water levels of registered bores screened within the Calivil Formation and Warina Sands Formation in the vicinity of Hartwood

Hydrographs for wells screened in the Shepparton Formation in the vicinity of Wanganella is presented in Figure 3-16 and in the Calivil Formation / Warina Sands in Figure 3.17. The large increase in water level in GW501876 compared to other wells reflects that that this monitoring well is located around 9.5 km south east of the other monitoring wells in a large irrigation area. The groundwater elevation increases in 1991 and 1993 at GW501898.1.1 may be associated with increased flows to Wanganella and Eight Mile Creek. Groundwater levels in the deeper Calivil Formation and Warina respond to pumping.

Shallow and deep well pair GW040977.1.1 and GW040977.1.2 indicate there is downward hydraulic gradient between the Calivil Formation and Warina Sands.

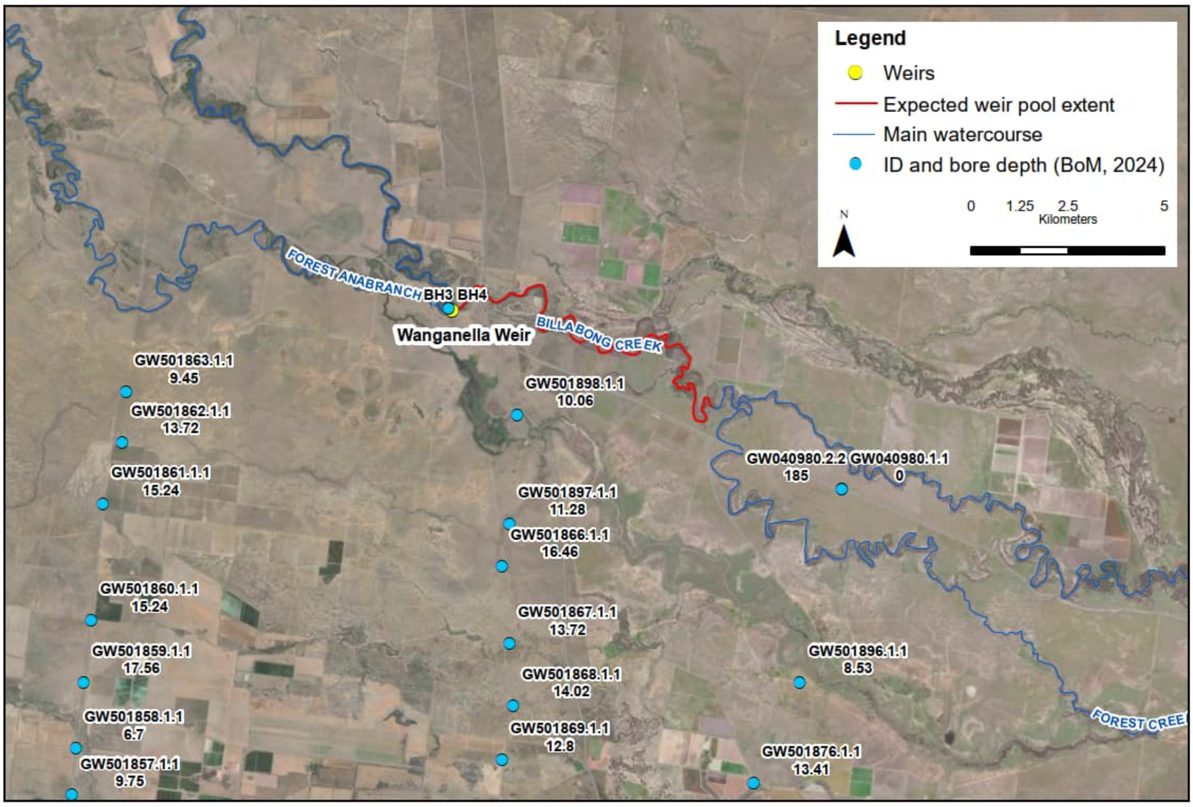

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Figure 3-15. Groundwater observations near Wanganella

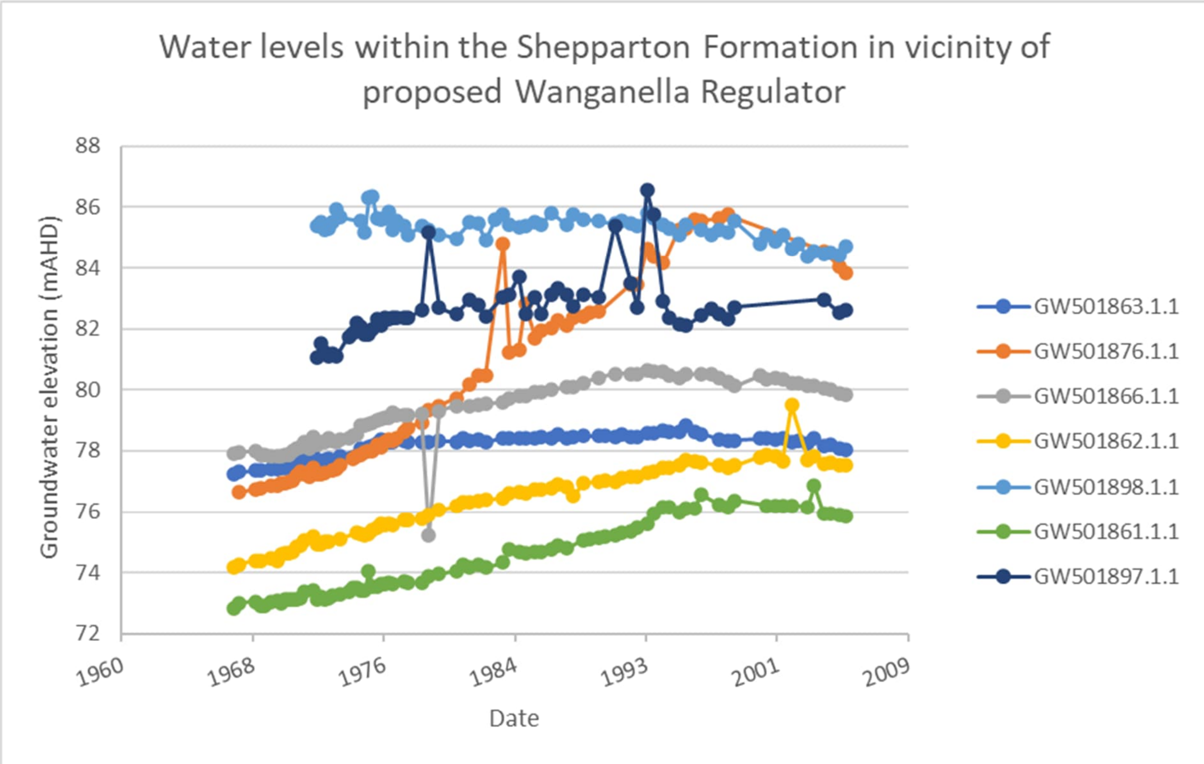

Figure 3-16. Water levels of registered bores screened within the Shepparton Formation in the vicinity of Wanganella

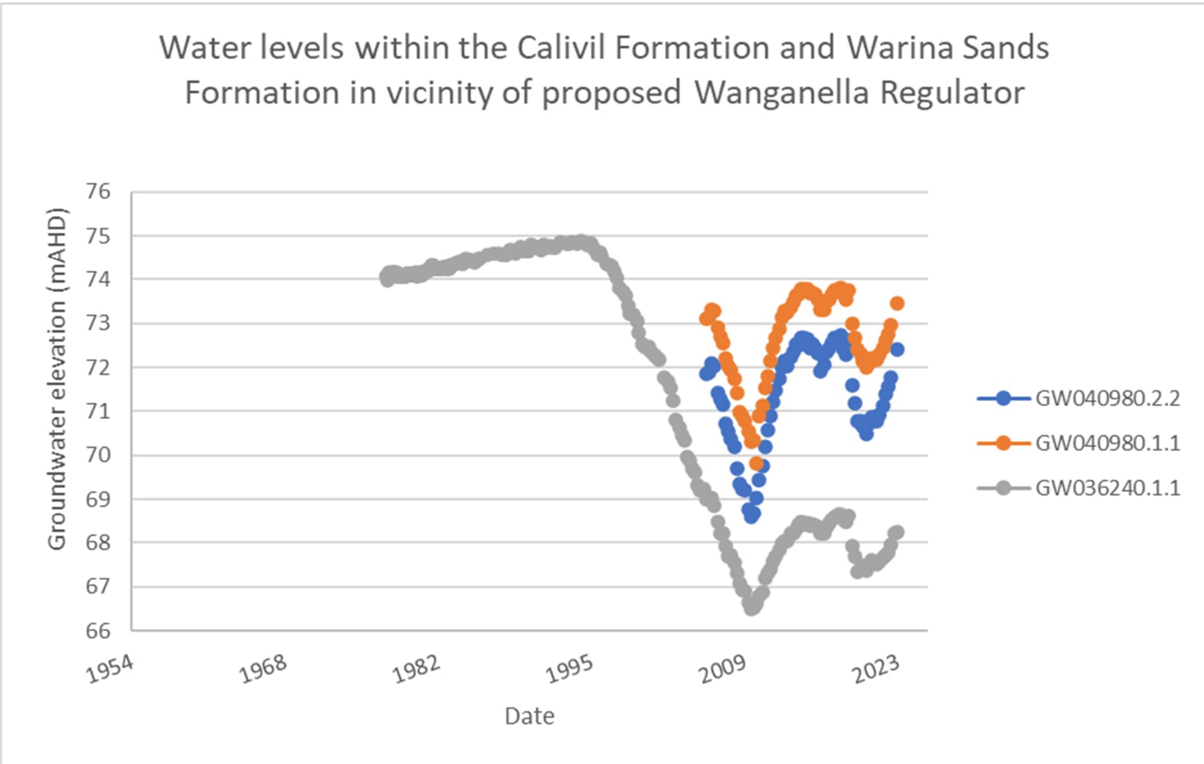

Figure 3-17. Water levels of registered bores screened within the Calivil Formation and Warina Sands Formation in the vicinity of Wanganella

3.4.5.2 Site-specific groundwater levels

Table 3-5 presents the estimated groundwater elevations in December 2023 from monitoring wells installed near Hartwood and Wanganella weirs (shown on Figure 3-12 and Figure 3-15). The groundwater elevation in monitoring well BH201 (around 89.6 mAHD), installed 85 m downstream from the existing weir pool crest, is below the minimum weir pool elevation of 95.3 mAHD and hence, it is interpreted that Billabong Creek is losing to groundwater in this area. This is supported by interpreted regional groundwater elevations which also suggest the creek is losing near Hartwood and by field investigations conducted in 2004 where the watertable was encountered at 4.9 mbgl in boreholes drilled in the right and left abutments of the weir and approximately 1.8 m below the creek bed level (NSW Department of Commerce, 2004). The estimated groundwater elevations at BH3 and BH4 (~78.4 mAHD) located within 55 to 80 m downstream of the existing Wanganella weir pool (~80.1 mAHD) suggest that Billabong Creek is losing to groundwater locally at the weir pool.

Table 3-5. Estimate of groundwater elevations in December 2023

Well	Easting	Northing	Water level (mbgl)	Estimate of ground surface elevation (mAHD)*	Estimate of groundwater elevation (mAHD)*
BH201	344323	6091220	5.23	94.8	89.6
BH3	300371	6100560	5.71	84.0	78.3
BH4	300336	6100628	4.24	82.7	78.5

*Ground surface elevation estimated from 15 m pixel resolution terrain model.

3.4.6 Groundwater flow direction

The interpreted regional watertable elevation contours near Hartwood and Wanganella are presented in Figure 3-18 and Figure 3-19 respectively. Watertable elevations at Hartwood range from 93 mAHD in the east / upstream Billabong Creek to 80 mAHD in the south. The watertable elevation near the existing Hartwood Weir is around 90 mAHD with the average (surface) water level in the weir around 95.4 mAHD. Groundwater flow is away from Billabong Creek with groundwater flow to both the south and to the north west.

Watertable elevations at Wanganella range from 85 mAHD in the east to 73 mAHD in the west. The watertable elevation near the existing Wanganella Weir is around 78.5-80 mAHD with the average weir pool elevation around 81.05 mAHD. This indicates that Billabong Creek is losing to groundwater with the surface water groundwater interaction discussed further in Section 3.4.8. The groundwater flow direction near the existing Wanganella Weir is generally west towards Billabong Creek. The groundwater gradient flattens out in the downstream section of Billabong Creek with large gradients interpreted near Wanganella. These large gradients and elevated groundwater elevations (around 80-83 mAHD) are likely to be associated with seepage out of Wanganella Swamp / Eight Mile Creek.

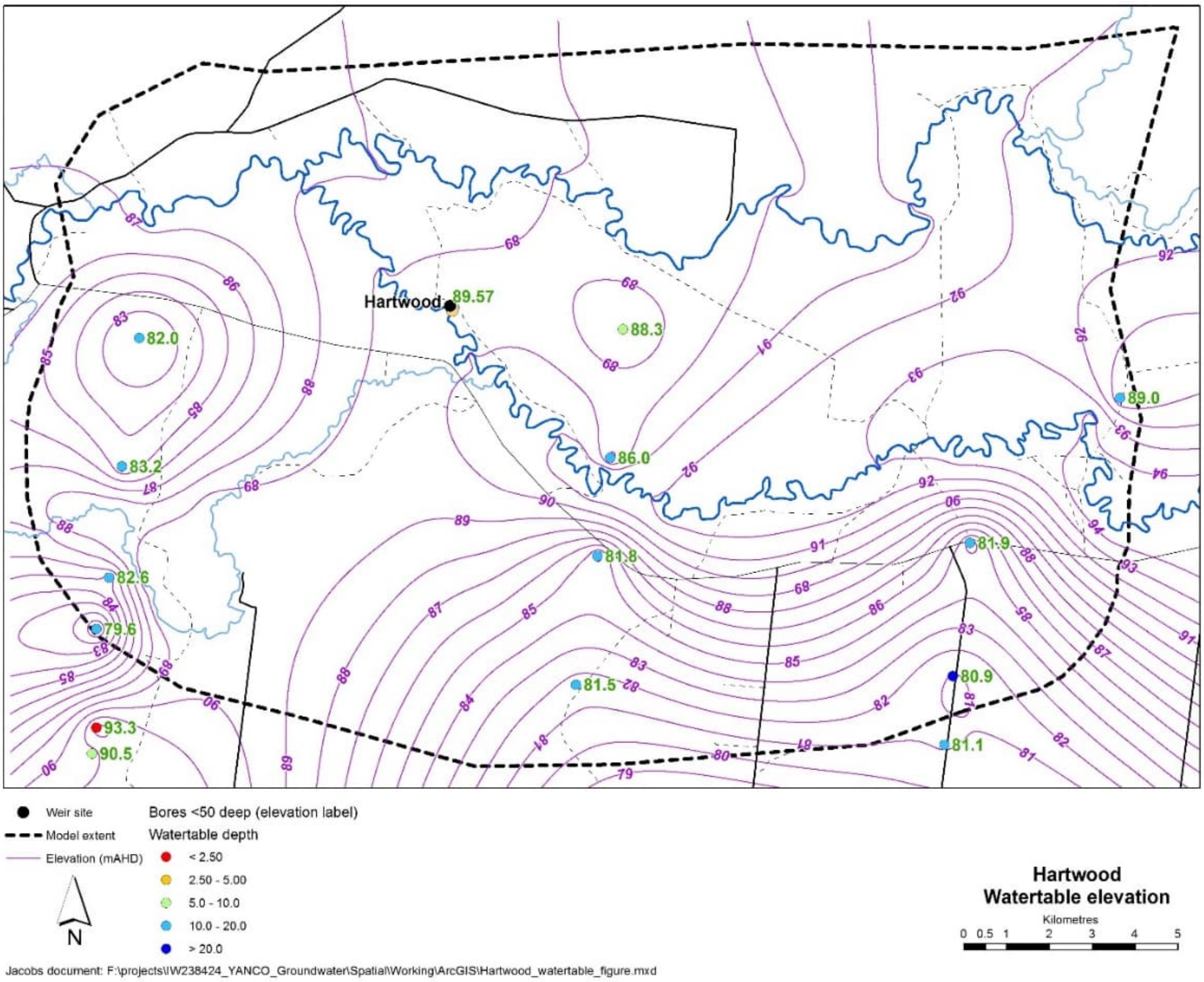

Figure 3-18. Interpreted watertable elevation near Hartwood

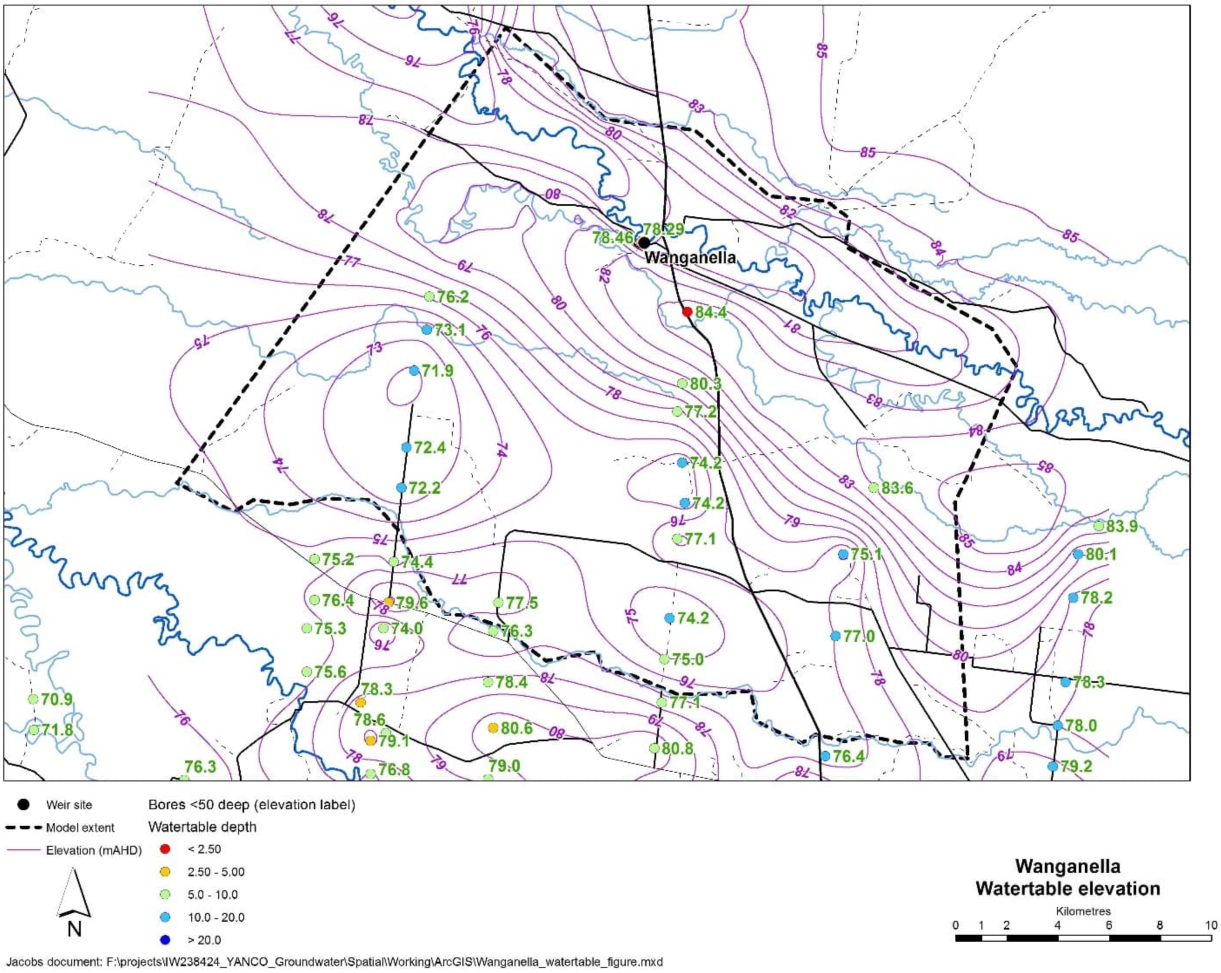

Figure 3-19. Interpreted watertable elevation near Wanganella

3.4.7 Recharge and Discharge

DPI (2019a, 2019b) states that the primary recharge processes for the Lower Murray Alluvium and the Murrumbidgee Alluvium catchments involve direct rainfall infiltration, leakage from irrigation activities and Murray River/ Murrumbidgee River and tributaries seepage. Extraction for irrigation and through-flow to the west are the main discharge methods, along with base flow into the Wakool River downstream of Deniliquin and evaporation occurring near the surface watertable.

Irrigation and environmental watering are anthropogenic sources of recharge. Figure 3-20 and Figure 3-21 presents areas classified as irrigated plantation forests, irrigated cropping, irrigated perennial horticulture and irrigated seasonal horticulture in the NSW Landuse 2017 (DCCEEW, 2017). These areas are expected to have higher recharge rates than adjacent areas.

Following European settlement, altered flow regimes led to Wanganella Swamp becoming predominately inundated (instead of ephemeral) before drying out in 2006 when flows were suspended due to water shortages (Hutton, 2020). Since 2020 Wanganella Swamp and Eight Mile Creek have received environmental water via a private irrigation channel (Hutton, 2020). The extent of inundation in 2020 is presented in Figure 3-22. The high groundwater elevation at GW501898 (84.5 mAHD) suggests that groundwater mounding was present adjacent to Wanganella Swamp in 2005.

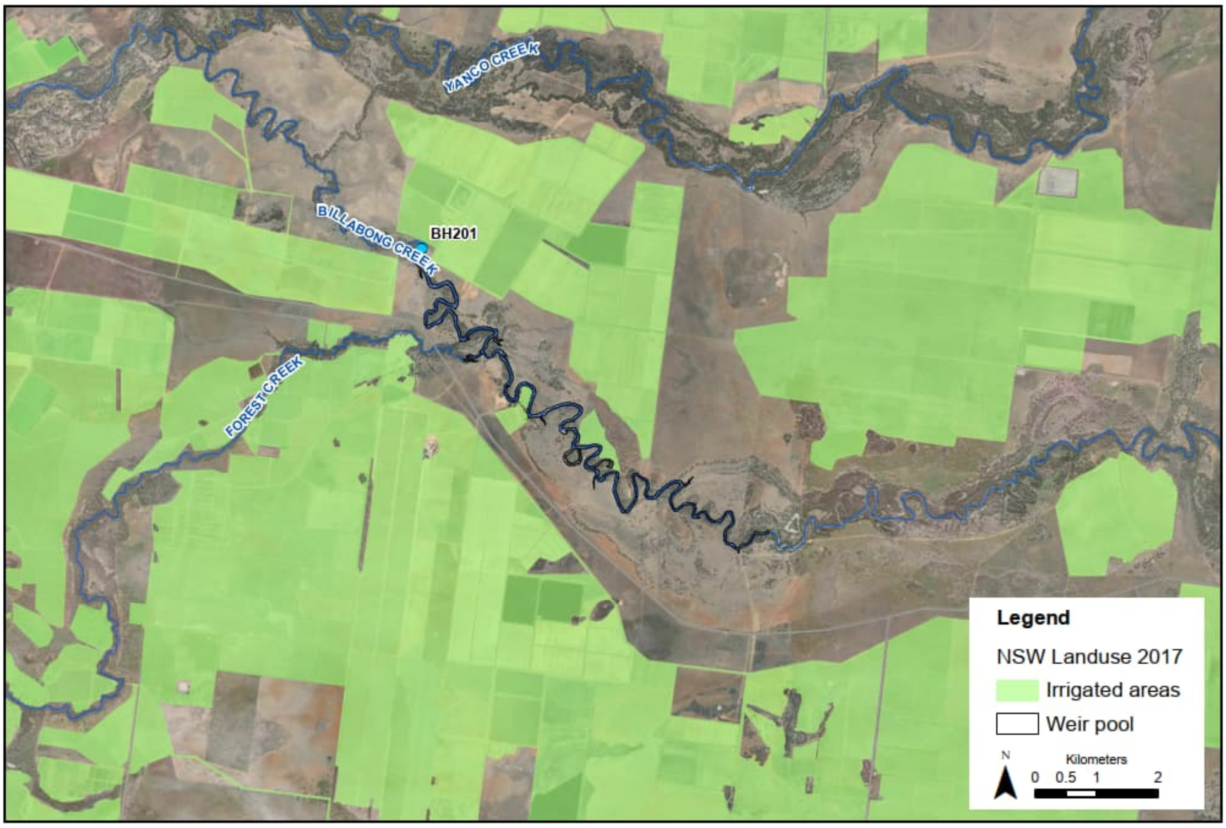

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Figure 3-20. Irrigated areas need Hartwood (NSW Landuse 2017)

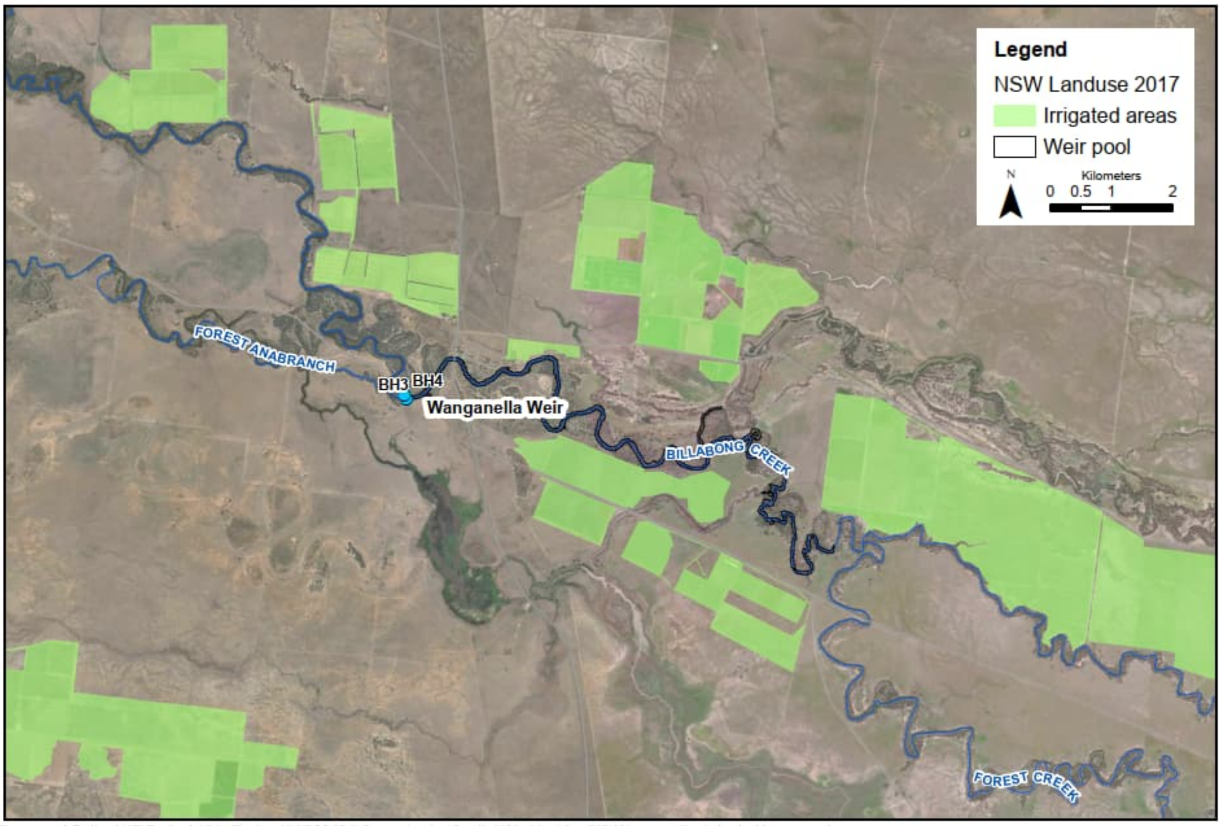

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Figure 3-21. Irrigated areas need Wanganella (NSW Landuse 2017)

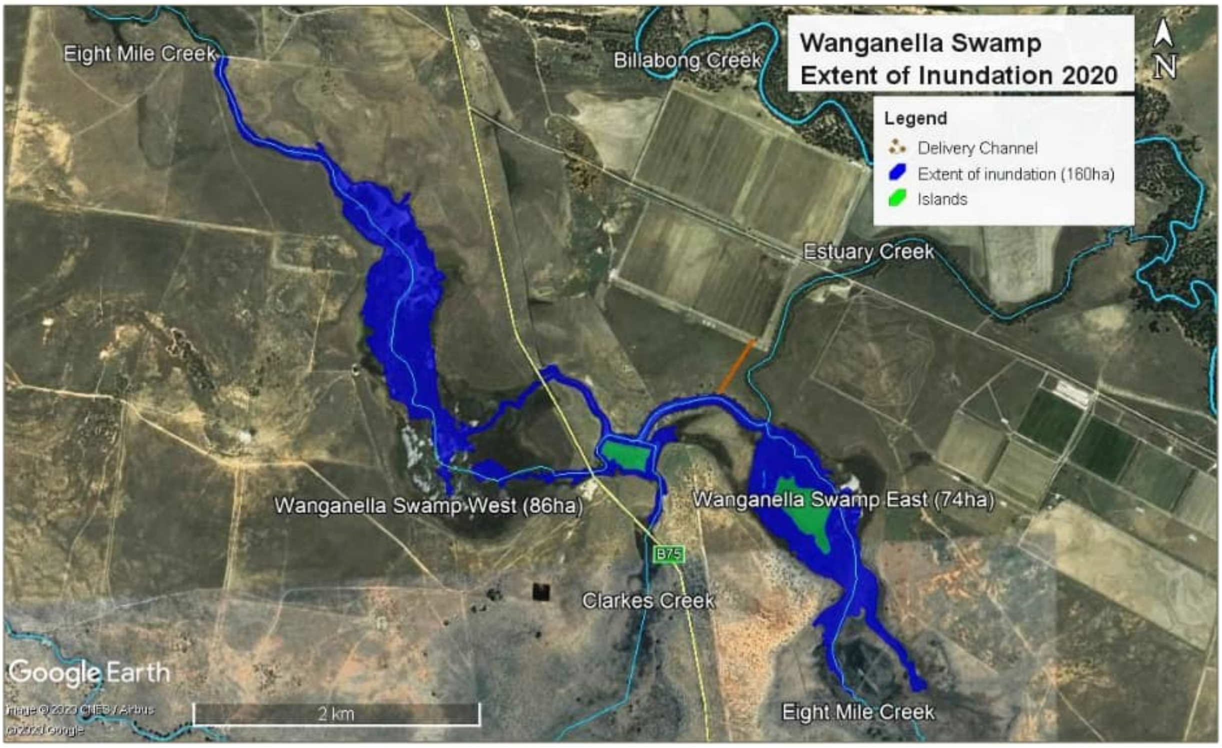

Figure 3-22. Extent of inundation in 2020 at Wanganella Swamp (Hutton, 2020)

3.4.8 Surface water – groundwater interaction

The degree and type of interaction between groundwater and surface water is largely dependent on topography, watercourse geomorphology and the underlying groundwater systems, particularly the depth of groundwater levels relative to watercourse levels. The CSIRO groundwater-surface water connectivity mapping (Crosbie et al., 2019) indicates that Billabong Creek is predominantly losing to groundwater at Hartwood and Wanganella (Figure 3-23). This dataset contains a classification of the stream reaches in the Murray Darling Basin by their proportion of bores predicting losing or gaining conditions within the network of the Australian Water Resources Assessment River (AWRA-R) model and is based on data from 1/6/1970 to 31/5/2019 (49 years).

Local groundwater gauging results from monitoring wells adjacent to Billabong Creek (Section 3.4.5.2) indicate Billabong Creek is a disconnected creek and is losing to groundwater at both Hartwood and Wanganella. The groundwater elevation in monitoring well BH201 (around 89.6 mAHD) is around 5.7 m below the minimum weir pool elevation of 95.3 mAHD and 2.9 m below the base of Billabong Creek. This conceptualisation is supported by interpreted regional groundwater elevations which also suggest the creek is losing near Hartwood and by field investigations conducted in 2004 (NSW Department of Commerce, 2004).

The groundwater elevation at BH3 and BH4 (around 78.4 mAHD) is 2.6 m below the average weir pool elevation at Wanganella (81.05 mAHD) and 1 m below the base of Billabong Creek (79.4 mAHD). This indicates that Billabong Creek is losing to groundwater locally at the weir pool.

At both proposed regulator sites the groundwater level is below the base of the creek. This can only occur if seepage from the creek is small, such that recharge does not cause the watertable to rise to intersect the bed of the creek. It is therefore interpreted that seepage from Billabong Creek has only a minor effect on groundwater levels at both regulator sites. Lateral flow gradients and fluxes appear to be sufficient to avoid a groundwater mound from the existing weir pools. This is an important conclusion when the changes in weir pool level proposed with the new regulators is considered (see later sections).

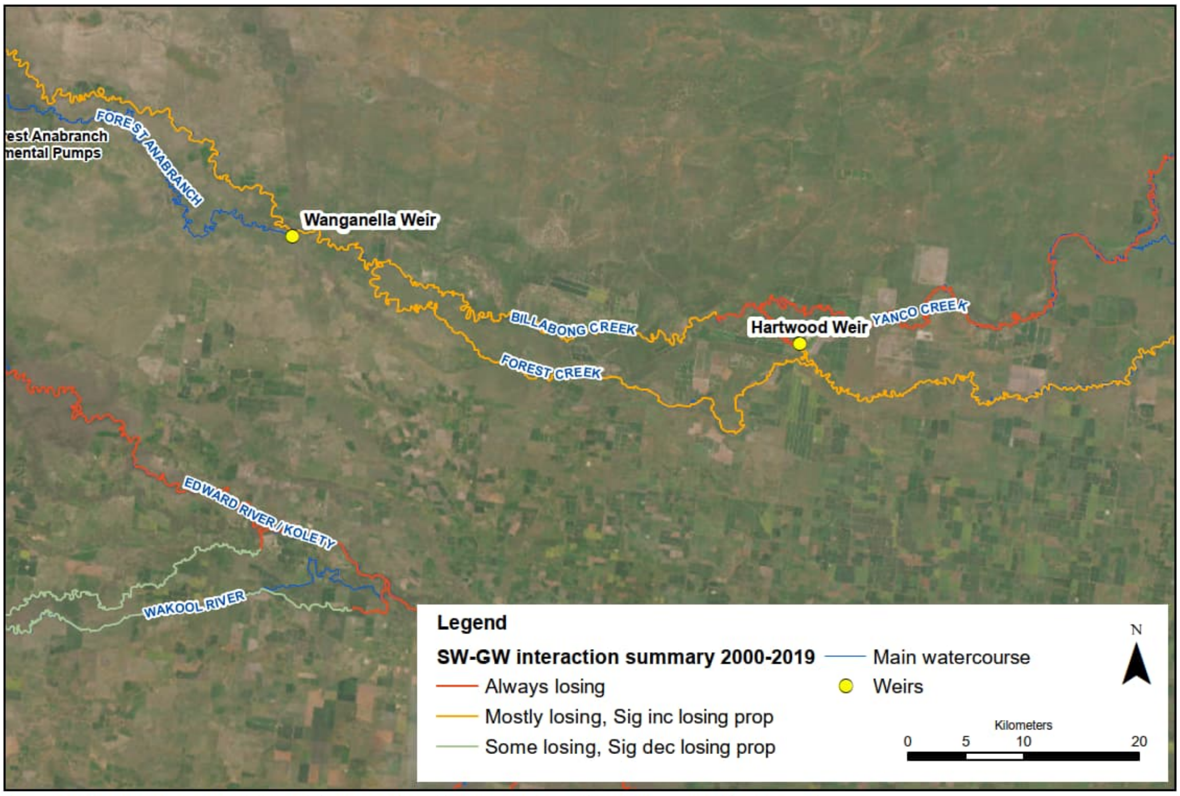

Figure 3-23. Summary of groundwater interaction summary 2000-2019 (Crosbie et al 2019)

3.4.9 Groundwater Dependent Ecosystems (GDEs)

GDEs are ecological communities that are dependent, either entirely or in part, on the presence of groundwater for their health or survival. The NSW Department of Primary Industries Water methodology (Kuginis et al., 2016) adopts the definition of a GDE as:

"Ecosystems which have their species composition and natural ecological processes wholly or partially determined by groundwater".

GDEs might rely on groundwater for the maintenance of some or all of their ecological functions, and that dependence can be variable, ranging from partial and infrequent dependence, i.e., seasonal or episodic, to total continual dependence.

The Bureau of Meteorology's GDE Atlas (BOM, 2024c) was reviewed to investigate the potential for GDEs to exist within the study area. The terrestrial and aquatic GDEs identified within 500 m of the existing Wanganella and Hartwood weirs are identified below.

13 terrestrial GDEs are identified within 500 m of the existing Hartwood Weir with two within 100 m and two aquatic GDEs are identified within 500 m, both of which are less than 100 m from the existing Hartwood Weir (BOM, 2024c). Potential terrestrial GDEs with a high potential for groundwater interaction and listed as High Priority in the High Ecological Value Aquatic Ecosystems (HEVAE) framework (DCCEEW, 2018) are shown on Figure 3-24.

26 potential terrestrial GDEs are identified within 500 m of the existing Wanganella Weir with six within 100m and four potential aquatic GDEs are identified within 500 m of existing Wanganella Weir with two within 100m (BOM, 2024c). Potential terrestrial GDEs with a high potential for groundwater interaction and listed as High Priority in the High Ecological Value Aquatic Ecosystems (HEVAE) framework (DCCEEW, 2018) are shown on Figure 3-25. Terrestrial vegetation with a high potential for groundwater interaction located 1.1 km

south of the Wanganella Weir is associated with Wanganella Swamp which receives water through managed environmental watering events. These managed environmental watering events are likely to recharge the groundwater in this area and support mapped high priority vegetation. Likewise, the Wanganella weir pool is conceptualised as losing to groundwater.

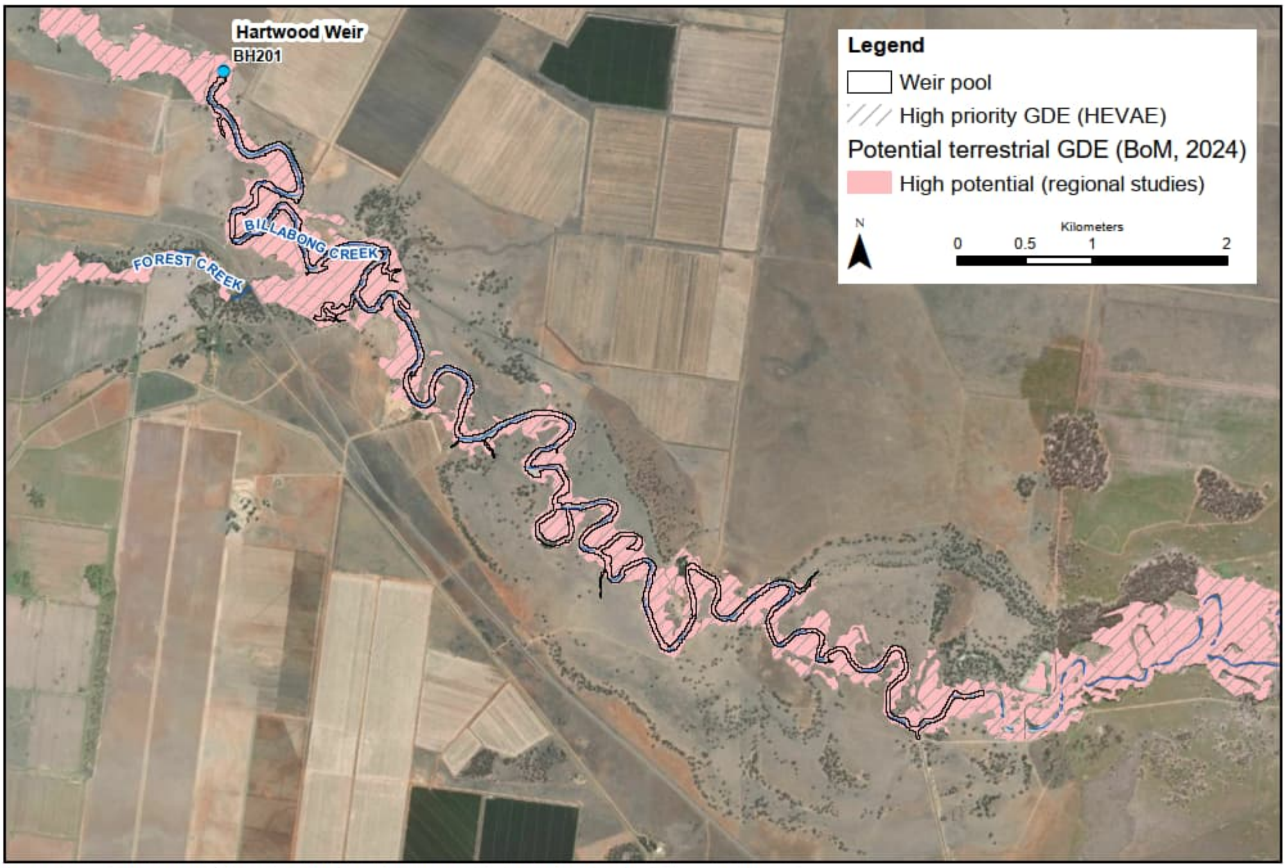

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Figure 3-24. Potential GDEs from the BoM GDE Atlas (low potential not shown) (BoM, 2024) and high priority GDEs from the High Ecological Value Aquatic Ecosystems (HEVAE) framework (DCCEEW, 2018) near Hartwood Weir.

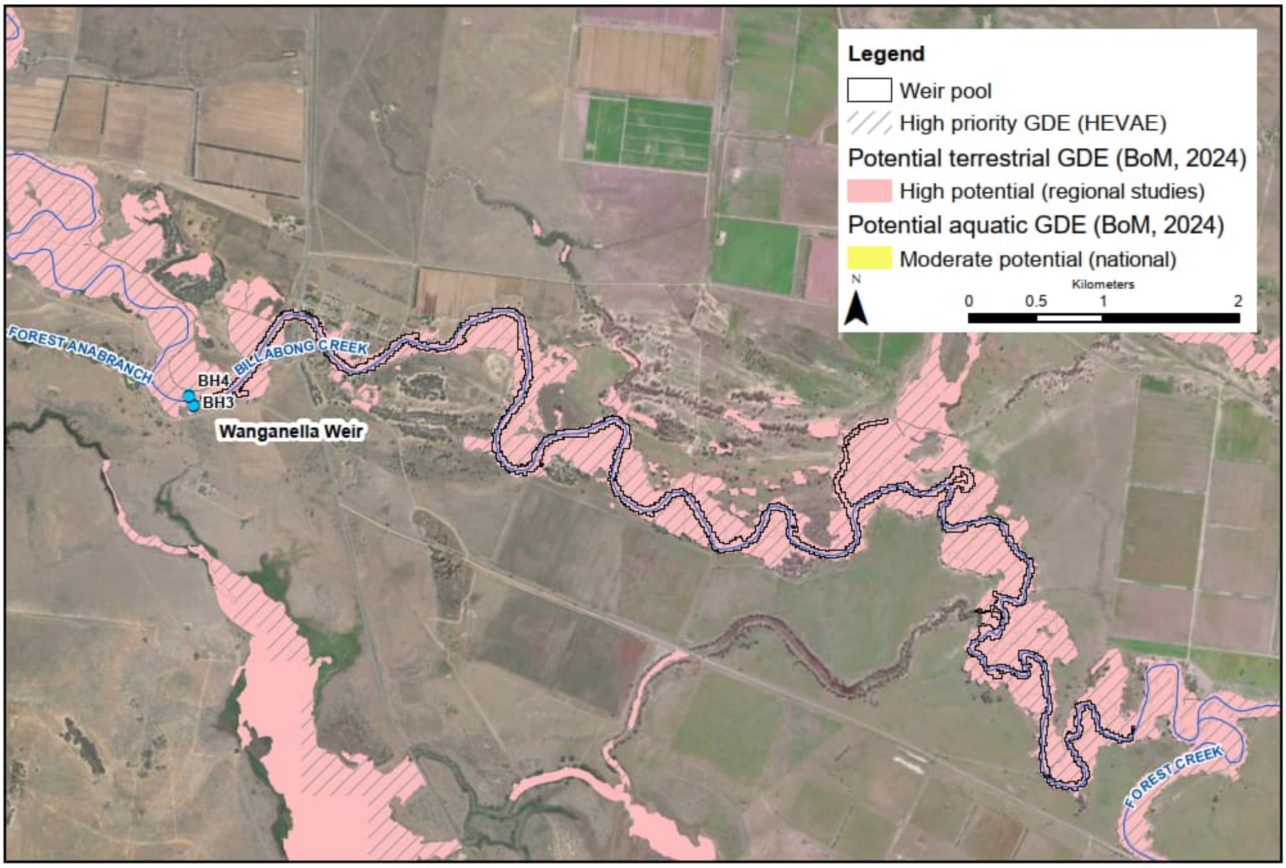

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Figure 3-25. Potential GDEs from the BoM GDE Atlas (low potential not shown) (BoM, 2024) and high priority GDEs from the High Ecological Value Aquatic Ecosystems (HEVAE) framework (DCCEEW, 2018) near Wanganella Weir.

Given that the interpretation presented in earlier sections of this assessment has identified that Billabong Creek is a losing stream either partially or fully disconnected from the groundwater system, there is some uncertainty that arises when considering the mapping of GDE's as presented here. The location of the potential GDE's along the length of the weir pools combined with the close proximity to the creek suggests that this vegetation is responding to weir pool seepage rather than directly from regional groundwater. It is difficult to separate the effects of soil moisture storage from groundwater use in the methods used to map GDE's. A direct assumption that the mapped vegetation is dependent on groundwater rather than river recharge cannot be made in light of the understanding of regional watertable depth and quality.

3.4.9.1 Evapotranspiration

Figure 3-26 and Figure 3-27 presents the January 2022 evapotranspiration dataset from the Australia-wide Machine Learning Evapotranspiration for Trees (AMLETT) model for Murray-Darling Basin wetlands (Doody, 2023) for Hartwood and Wanganella respectively. This is a Murray Basin spatial model that uses field data and machine learning to estimate floodplain tree evapotranspiration (*Eucalyptus camaldulensis* (River Red Gum) and *E. largiflorens* (Black Box)). There is reasonable correlation between the high priority GDEs (DCCEEW, 2018) and high evapotranspiration estimates near Billabong Creek and environmental watering at Wanganella Swamp.

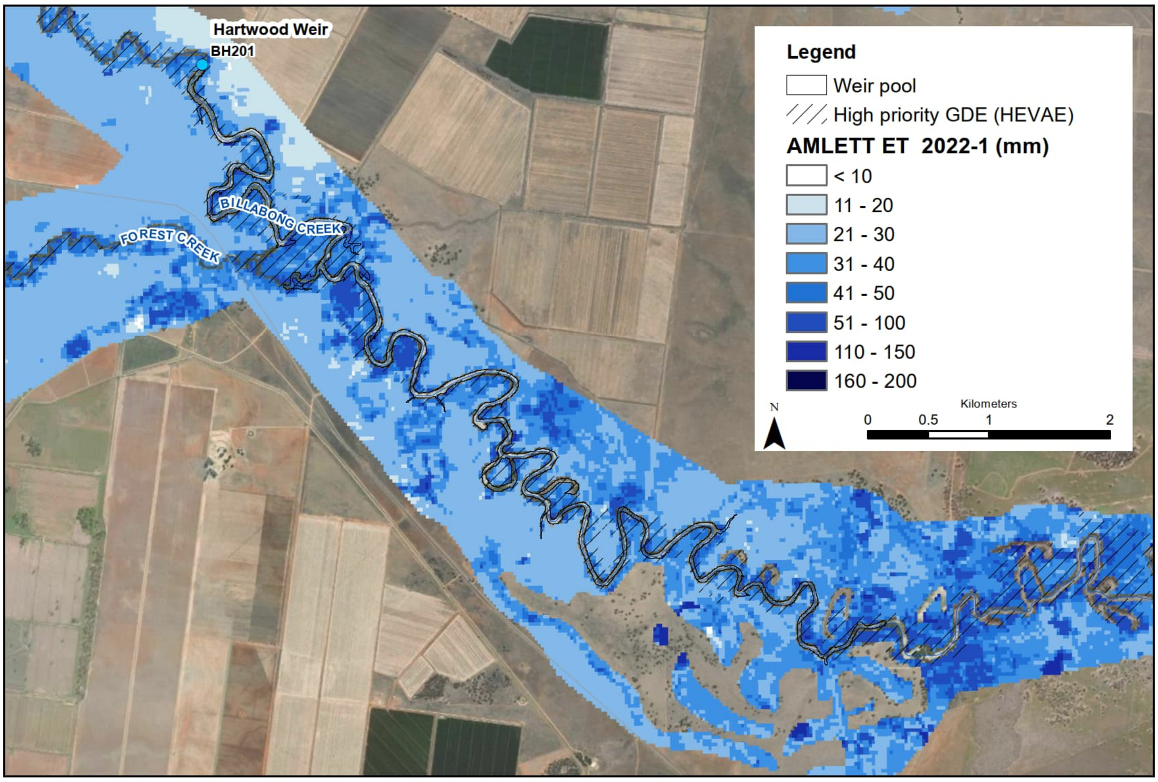

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Figure 3-26. Hartwood AMLETT evapotranspiration estimate for January 2022 (Doody, 2023).

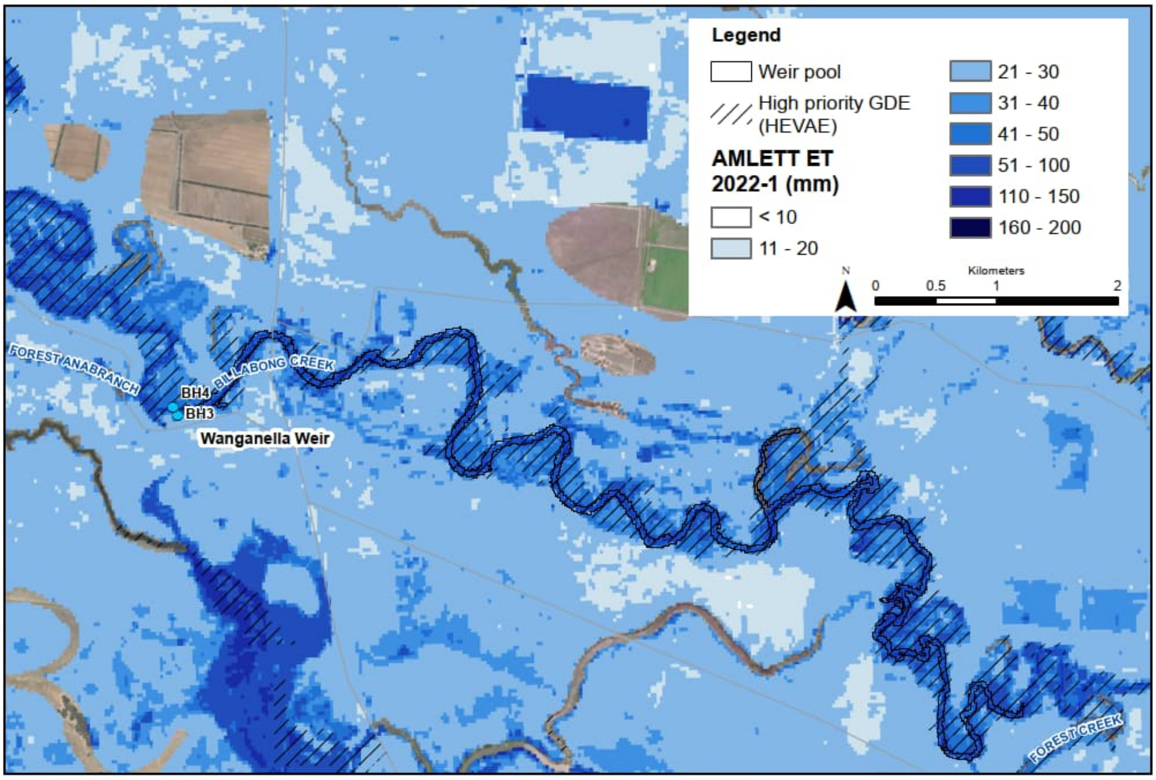

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Figure 3-27. Wanganella AMLETT evapotranspiration estimate for January 2022 (Doody, 2023).

3.4.10 Registered groundwater bores

The Bureau of Meteorology's (BOM) Australian Groundwater Explorer (BOM, 2024a) was reviewed to investigate registered groundwater bores and associated groundwater level records in the region of the proposal. The review identified 155 registered bores within 20 km and 4 registered bore within 2 km of the existing Hartwood Weir. 73 registered bores were identified within 20km and 2 registered bores within 2 km of the existing Wanganella Weir.

To assess the potential impact to registered bores within close proximity to the existing Hartwood and Wanganella weirs, the bores within 2 km have been assessed further as identified within Table 3-6 and shown on Figure 3-28 and Figure 3-29. Italicised bore IDs have a status of proposed or removed.

Four registered bores are within 2 km of the existing Hartwood Weir. This includes two irrigation bores, one monitoring well and one bore with unknown use. Based on publicly available borelogs, GW504186.1.1 is inferred to be screened in the Warina Sand Aquifer. GW047296.1.1 is likely to be screened in the Calivil Formation, however, the status of the bore is unknown with the status listed as proposed. The two remaining bores are inferred to be screened in the upper Shepparton Formation.

The two registered bores within 2 km of the existing Wanganella Weir have a purpose of 'unknown'. Based on borelogs publicly available, GW005449.1.1 is inferred to be accessing the Calivil Formation and GW501898.1.1 is inferred to be accessing the Shepparton Formation.

Table 3-6 Registered groundwater bores within 2 km of the existing Hartwood and Wanganella weirs

Bore ID	Bore Depth (m)	Screened Depth (m)	Screened Lithology	Drilled Date	Purpose	Status
Hartwood						
GW504186.1.1	226	190 – 226	Sand (Warina Sand)	30/11/2008	Irrigation	Functioning
GW502965.1.1	16.7	16.2-16.7	-	12/8/2000	Unknown	Functioning
GW502260.1.1	5.2	4.6-5.2	-	20/11/2000	Monitoring	Functioning
GW047296.1.1	67	Unknown	-	1/4/1979	Irrigation	Proposed
Wanganella						
GW005449.1.1	55.2	39.62 - 55.17	Drift fine coarse seams (Calivil Formation)	1/1/1909	Unknown	Unknown
GW501898.1.1	10.06	8.54 - 10.06	Unknown (Shepparton Formation)	20/11/2000	Unknown	Functioning

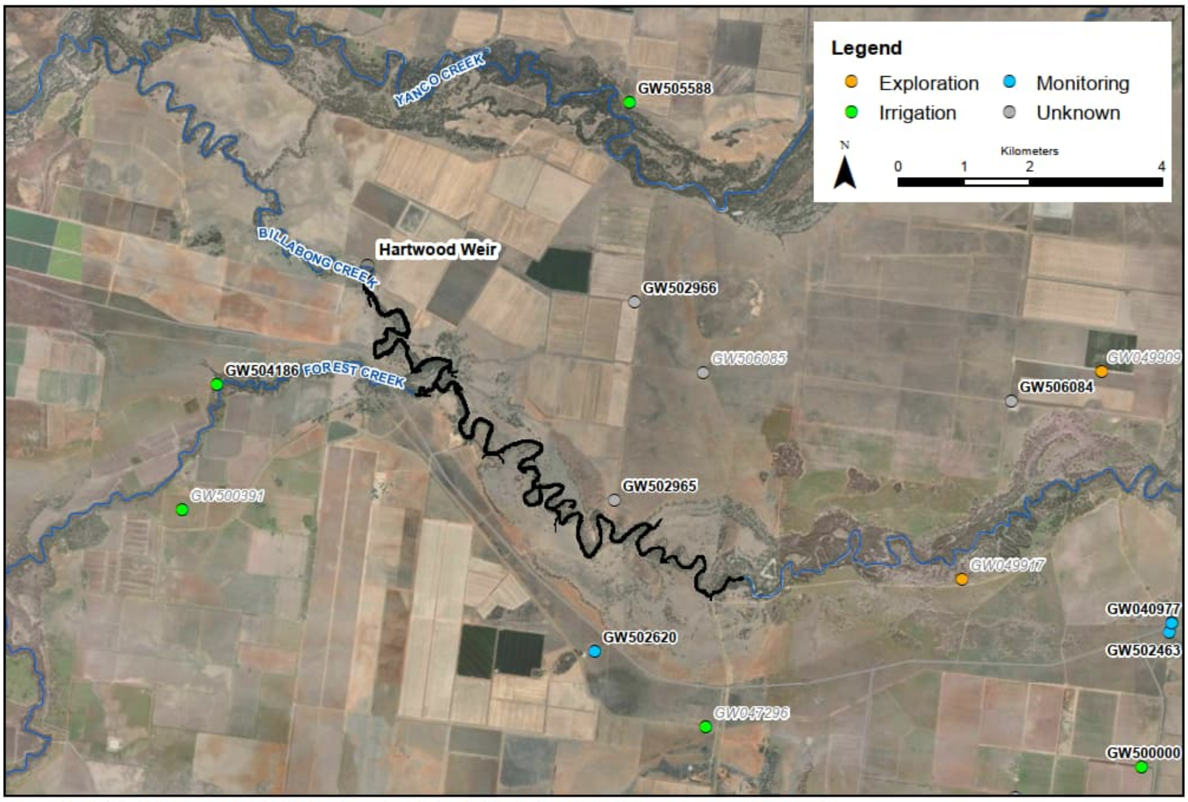

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Figure 3-28. Registered groundwater bores near Hartwood (italicised bore ID have a status of proposed or removed)

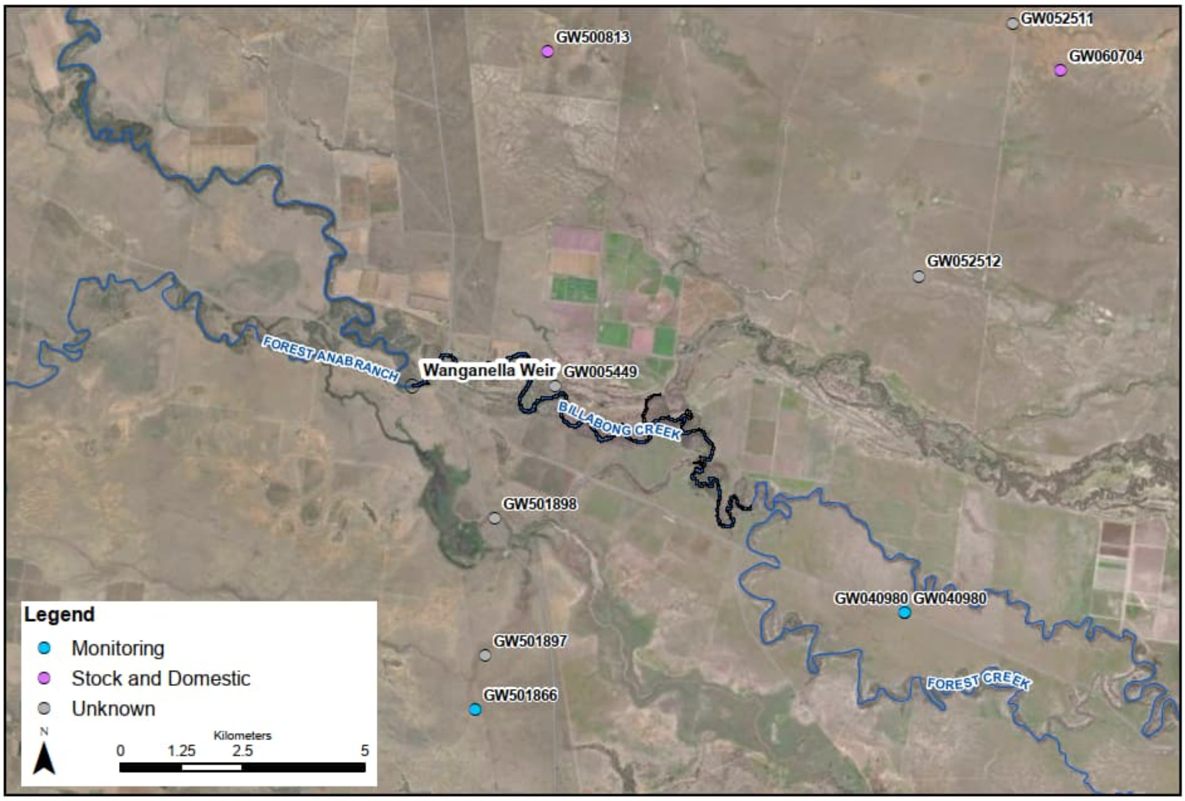

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Figure 3-29. Registered groundwater bores near Wanganella

3.4.11 Water Quality

3.4.11.1 Regional

Groundwater salinity in the Lower Murray Shallow Alluvium is presented in Figure 3-30 (DPE, 2022a) and in the Murrumbidgee Shallow Alluvium in Figure 3-31 (DPE, 2022b).

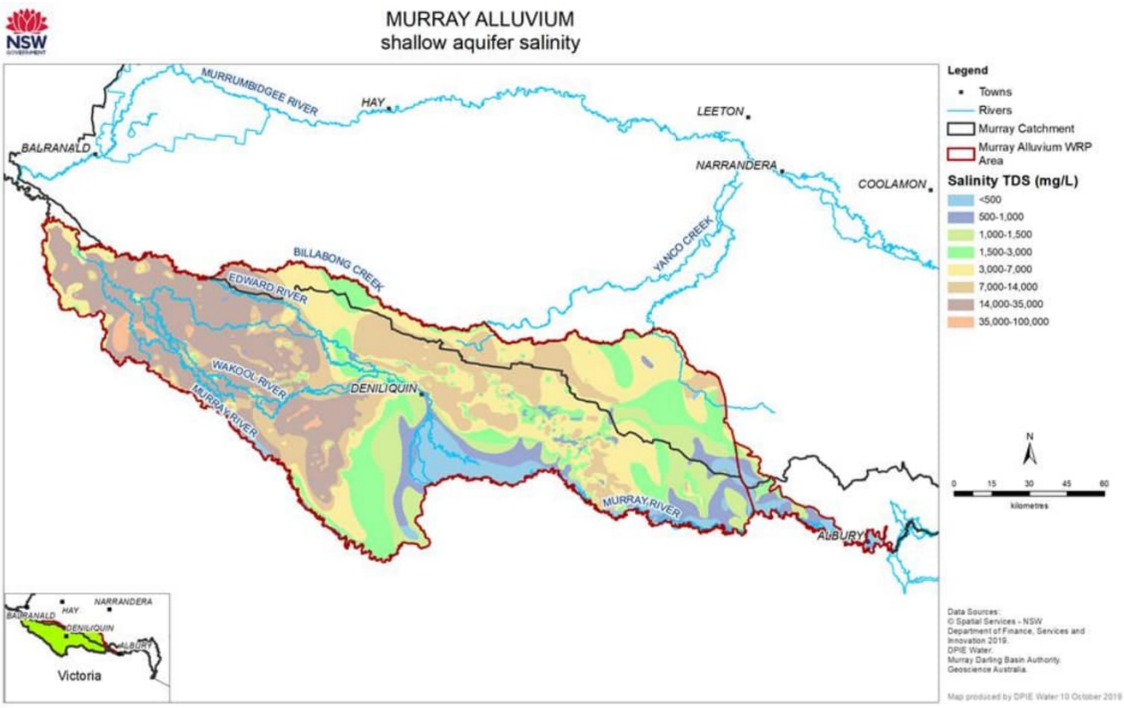


Figure 3-30. Groundwater salinity in the Lower Murray Shallow Alluvium (DPE, 2022a)

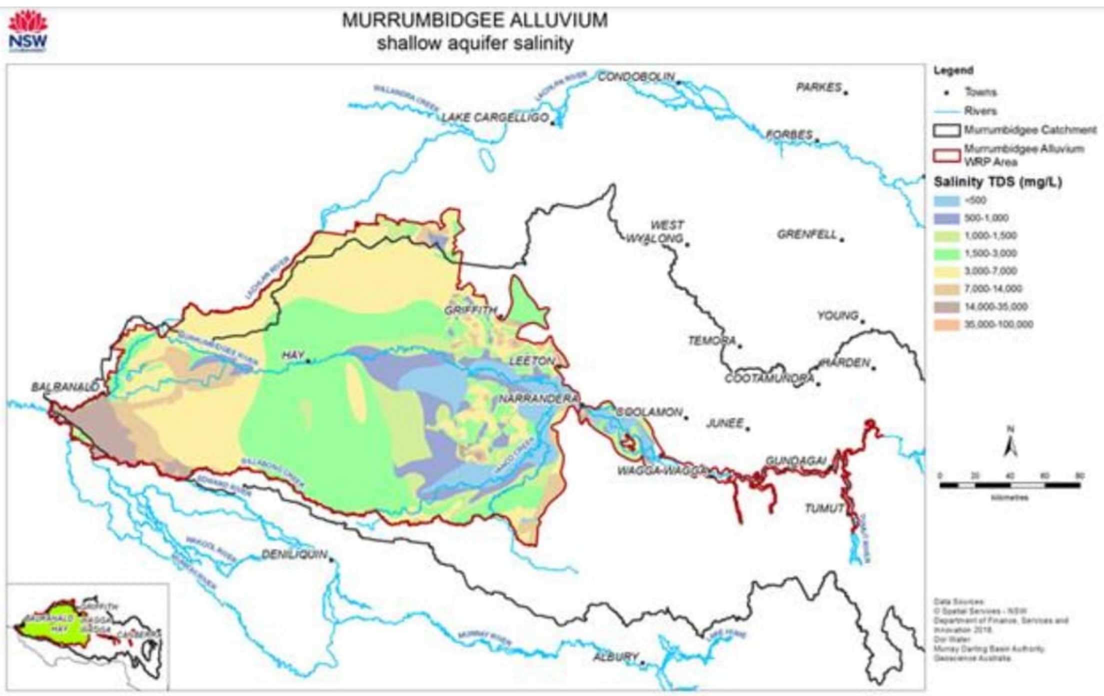


Figure 3-31. Groundwater salinity in the Murrumbidgee Shallow Alluvium (DPE, 2022b)

3.4.11.2 Monitoring bore water quality data

Three groundwater monitoring bores (BH3, BH4 and BH201) in the vicinity of Hartwood (BH3 and BH4) and Wanganella (BH201) were sampled between 14/12/2023 and 16/12/2023. Analytes included dissolved metals, major cations and anions, nutrients, total dissolved solids (TDS), nutrients, Per- and Polyfluorinated Substances (PFAS), total recoverable hydrocarbon (TRH), benzene toluene ethylbenzene xylenes and naphthalene (BTEXN) and polycyclic aromatic hydrocarbons (PAHs). Field parameters were taken using a water quality probe at the time of sampling.

Groundwater quality results and laboratory certificate of analysis are presented in Appendix A. This report includes a comparison of analyte concentrations to the ANZECC 2000 Stock Watering, ANZECC 1992 Industrial Water Use, AS2159-2009 Piling – Design and Installation (Buildings & Structures) ANZG (2018) Freshwater (FW) 95% toxicant default guideline values (DGVs) and ANZECC PFAS FW 95% National Guidelines.

Based on the data collected, the following general key points are noted:

- ANZECC 2000 Stock Watering criteria was exceeded for sodium (BH4).
- ANZG (2018) Freshwater 95% toxicant DGVs criteria was exceeded for copper (BH3, BH4, BH201), lead (BH4), nickel (BH4, BH201), zinc (BH4, BH201). As the aquifer is mostly disconnected from the Creek, the Freshwater guideline values are used as a reference point and do not indicate a suitable guideline for groundwater quality.
- Total dissolved solids ranged from 650 mg/L to 2,900 mg/L.

3.5 Conceptual groundwater model

The conceptual groundwater model for the study area is summarised below:

- Localised deposits of Quaternary aged alluvial sediments which comprise interbedded sands, clays and silts are presents near Billabong Creek. The watertable lies within Quaternary Alluvium at around 5 mbgl near the existing Wanganella and Hartwood weirs. The alluvium is incised into and underlain by the Shepparton Formation.
- The Shepparton Formation contains the shallow regional aquifer system. The Quaternary Alluvium is incised into the Shepparton Formation in the near vicinity of Billabong Creek and other significant watercourses. The Shepparton Formation is around 40-50 m thick and consists of variegated clay, silty clay with lenses of poly mictic, coarse to fine sand and gravel. The basal part of the Shepparton Formation is typically finer grained sediments than the upper part, although this is variable regionally. The deeper more clay rich units form a barrier to (downward) vertical groundwater flow and help to maintain the water elevation separation between units (see below).
- The Calivil Formation underlies the Shepparton Formation and consists of poorly consolidated, poorly sorted, coarse to granular quartz sand conglomerate with thin lenses of carbonaceous clay. Based on regional hydrostratigraphy data the Calivil Formation is present at a depth of about 50 m below surface with a thickness of approximately 80-100 m.
- The regional watertable elevation has been affected by land use change and particularly irrigation activities from the early 1970s. Altered surface water flow regimes (e.g. at Wanganella Swamp and Eight Mile Creek) and water reform implementation in the 1990s-2000s and flooding in more recent years have all had an influence on the watertable depth. These influences have had only minor or localised effects on groundwater quality.
- The watertable elevation near the existing Hartwood Weir is around 90 mAHD with the average water level in the weir around 95.4 mAHD. Groundwater flow is generally from north east to south west, supplemented by minor recharge out of the creek. Flow in the shallow aquifer system is mildly affected by recharge from the creek but is overall to the south and west, with a component to the north west. As

the hydraulic conductivity of the Shepparton Formation is typically low and gradients are low, the regional flow rate is small.

- Watertable elevations at Wanganella range from 85 mAHD in the east to 73 mAHD in the west. The watertable elevation near the existing Wanganella Weir is around 78.5-80 mAHD with the average weir pool elevation around 81.05 mAHD. Elevated groundwater levels (around 80-83 mAHD), with groundwater closer to the surface than is typical for the region has been identified to the south, and is likely associated with recharge from surface water at Wanganella Swamp / Eight Mile Creek.
- Billabong Creek is a mostly disconnected creek and is losing to groundwater at both Hartwood and Wanganella. Whilst creek seepage contributes to recharge to groundwater, groundwater does not affect surface water levels nor contribute to flow in the creek. Accordingly, groundwater variation has no effect on creek flow or quality.
- Hydraulic conductivity in the aquifer surrounding the creek is anticipated to be low for clay dominant alluvium and moderate to high for the lenses of sandy alluvial material. Slug testing has been undertaken at three monitoring wells installed at Hartwood and Wanganella. The hydraulic conductivity ranges from 0.002 m/d at BH3 to 0.5 m/d at BH201. This indicates that although there is a moderate to high proportion of sand and coarser material, that this is combined with clays and silts and that a low to moderate overall permeability is expected. Whilst there will be sand seams present, especially in the Quaternary Alluvium, these are variable in extent and thickness and do not appear to constitute a widespread sand seam that extends over the study area. Accordingly, higher permeability zones are expected in the immediate vicinity of the creek, but these are not expected to create zones of connection to the surrounding area, outside of the immediate floodplain of the creek.
- Recharge occurs via direct rainfall infiltration, seepage from rivers / creeks (localised recharge) and from anthropogenic sources such as irrigation and environmental watering. The recharge rate is expected to be higher in irrigation areas compared to areas without irrigation.
- Groundwater discharge occurs via extraction from deep bores and rare shallow extraction wells for irrigation. Through-flow to the west is likely to be the main discharge mechanism for the shallow aquifer, along with base flow into the Wakool River downstream of Deniliquin and evaporation occurring near the surface of the watertable.
- Potential terrestrial GDEs with a high potential for groundwater interaction and listed as High Priority in the High Ecological Value Aquatic Ecosystems (HEVAE) framework (DCCEEW, 2018) are mapped adjacent to Billabong Creek. Whilst these areas are mapped as potential GDE's, the methodology used to define this is based on recognising enhanced evapotranspiration (ET). It is not clear that the dominant source of water for ET in the vicinity of the two weir pools is actually groundwater. This is because the groundwater is relatively deep and nearing the limit of accessibility by deep rooted vegetation. Immediately adjacent to the creek bank seepage and soil water could provide a significant water source, one that is not strictly from groundwater. It is considered likely that vegetation water use is dominated by river leakage and flood recharge rather than direct groundwater use.
- Groundwater in the proposal area is generally fresh to slightly brackish. From the limited bore records it is interpreted that the groundwater immediately adjacent to the creek is slightly fresher than the surrounding groundwater. This is expected to be a result of long term creek and flood recharge over decades or longer.

3.6 Concepts of creek connection with groundwater

Groundwater – surface water interaction is often characterised by the relationship between groundwater level and surface water level. In the two weir pool extents of Billabong Creek that are associated with the current weirs and the slightly extended pools that are proposed to result from the regulators, groundwater level is always below surface water level. This means that the interaction is classified as "losing disconnected". The principles of interaction were outlined by Winter *et al.* 1998. Figure 3-32 illustrates the concept of a losing disconnected river as defined by Winter *et al.* 1998.

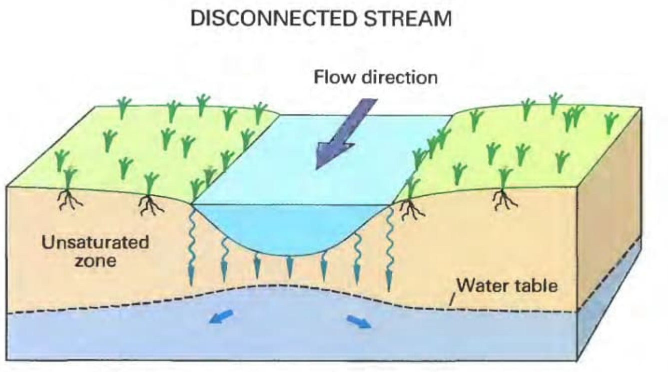


Figure 3-32. Illustration of a Disconnected Stream as defined by Winter et al. 1998.

The National Water Commission refined the definition of this interaction (SKM 2011) as “non-contiguous connected stream”. More recently, Crosbie *et al*. 2019 in a review of stream aquifer interaction in the Murray Basin defined the concept of a “losing – disconnected” stream, which is the condition that is understood to occur with Billabong Creek at the two sites for this assessment.

The various descriptions cited above apply to the Billabong Creek in the region of Hartwood and Wanganella weirs and around the sites of the proposed regulators. These features are:

- Groundwater level below the base of the creek
- A likely partially-saturated or un-saturated zone between the creek bed and the watertable
- A creek that is always losing to groundwater
- No effect on creek level or flow imparted by groundwater
- Some effect of creek derived recharge on groundwater mediated by the intervening unsaturated zone

4. Impact assessment

4.1 Construction impacts

4.1.1 Hartwood

The groundwater elevation at Hartwood is around 89.6 mAHD. The base of fixed crest weir structure is 91.26 mAHD with sheet piles expected to extend to 84.9 mAHD. Based on the design provided 27 February 2024, the groundwater elevation is well below the base of Hartwood Regulator structure (~1.6 m) and hence, groundwater dewatering will not be required. Water removal from inside of the sheet pile wall is expected to control seepage through the sheet pile wall, but this will not be groundwater.

4.1.2 Wanganella

The groundwater elevation at Wanganella is around 78.4 mAHD (average of BH3/BH4). The base of fixed crest weir structure is 78.6 mAHD with sheet piles expected to extend to 72.7 mAHD. The assumed excavation depth is 0.5 m below the base of structure. Based on the design provided 27 February 2024 and the assumed excavation depth, the groundwater elevation is above the base of Wanganella Regulator structure by around 0.3 m and minor dewatering is expected.

Groundwater impacts from construction have been assessed using an analytical approach developed by 3Rivers to assess excavations near watercourses. It has been assumed that the sheet piles will penetrate 7.5 m below the depth of the structure and that drawdown will occur to a depth of 0.5 m below the base of the structure. An aquifer thickness of 20 m and a length and width of 40 m by 20 m of the structure was assumed. A hydraulic conductivity of 0.15 m/d was adopted based on the slug test result at BH4. It is estimated that the groundwater inflow rate will be around 0.16 L/s.

Groundwater drawdown in the vicinity of the construction area will be limited to a maximum of approximately 0.5 m. At the expected rate of less than 0.2 L/s the groundwater level can be controlled by a surface mounted pump utilising a sump in the base of the excavation. No groundwater well is required and drawdown will be achieved by infiltration through the floor of the excavation.

Groundwater drawdown will be restricted to a distance of 250 m from the excavation at maximum (estimated using the Theis equation). This maximum distance has been calculated on the basis of an infinite aquifer without allowance for the seepage from the surrounding creek and over the full period of construction. It is anticipated that the limit of effect will be no more than 50 m because:

- Seepage into the bank and bed of the creek immediately around the construction area will mitigate drawdown,
- Construction dewatering will only be required for short periods within construction of the two halves of the regulator, once the structure is above groundwater level, dewatering will not be required. The floor of the regulator is just above groundwater level.

The key parameters and results from the analytical assessment are illustrated in Figure 4-1.

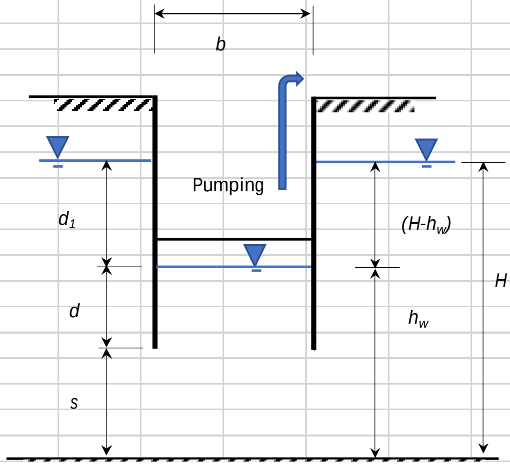
Location being assessed: Wanganella regulator (Billabong Creek)

Use for excavations adjacent to a river where sheet piling is proposed.

Case 1 - Uniform Soil Conditions

Case 1 Inputs

Soil Permeability, *k*	0.15	m/day
Sheet pile excavation length, *l*	40	m
Width of excavation / sheet piles, *b*	25	m
Sheet pile depth below lowered groundwater level in the excavation, *d*	6	m
Lowered water table level in aquifer, *hw*, (above aquifer base)	9.5	m
Initial water table level in the aquifer, *H*, (above aquifer base)	14	m
Tip of sheet pile from aquifer impermeable base, *s*	3.5	m
Drawdown within the excavation, *d1*	4.5	m



		0.075	0.15	0.225	0.3	1.5
	flow per unit length m3/day	0.170679	0.341357	0.512036	0.682715	3.413574
	Total Flow (m3/day)	6.827149	13.6543	20.48145	27.30859	136.543
Case 1 Results:	Total Flow (L/s)	0.079	0.158	0.237	0.316	1.58

Figure 4-1. Key parameters and conceptual layout of the analytical approach for assessing inflow.

4.2 Operational impacts

4.2.1 Hartwood

4.2.1.1 Model overview and conceptualisation

A numerical groundwater model was developed to provide estimates of groundwater impacts for the operation of the replacement Hartwood Regulator. Numerical groundwater modelling has been undertaken using MODFLOW-USG to quantify potential changes to groundwater levels and water balance associated with the Draft Yanco Creek System Operations Plan. The modelling is informed by the hydrogeological conceptualisation presented in the preceding sections.

The model is a Class 1 model as defined by the Groundwater Modelling Guidelines (Barnett et al. 2012). This status recognises that the proposed changes to the hydraulic regime associated with the proposed regulator is minor and that they likely present a low risk to aquifers and GDE. Further, based on the available groundwater observations and aquifer detail, a more detailed model is unlikely to provide greater certainty than a class one model for the study area.

The model covers a domain approximately 27 km by 16 km, as illustrated in Figure 4-2. It comprises three layers: Alluvium/Upper Shepperton, Lower Shepperton, and Calivil Formation, detailed in a three-dimensional, three-layer structure shown in Figure 4-3. The definition of the units and description is provided in section 3.4 above.

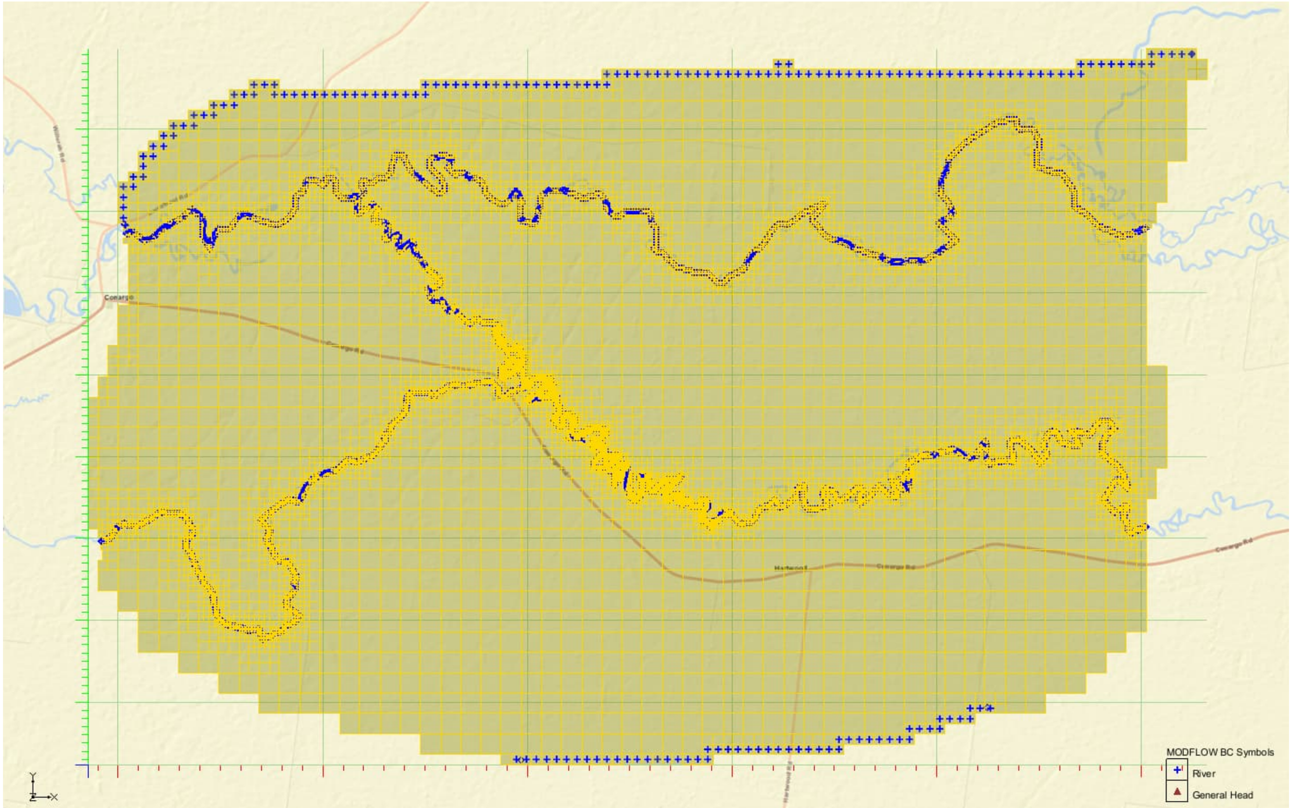


Figure 4-2. Hartwood model domain, centred on Billabong Creek and the Hartwood Weir

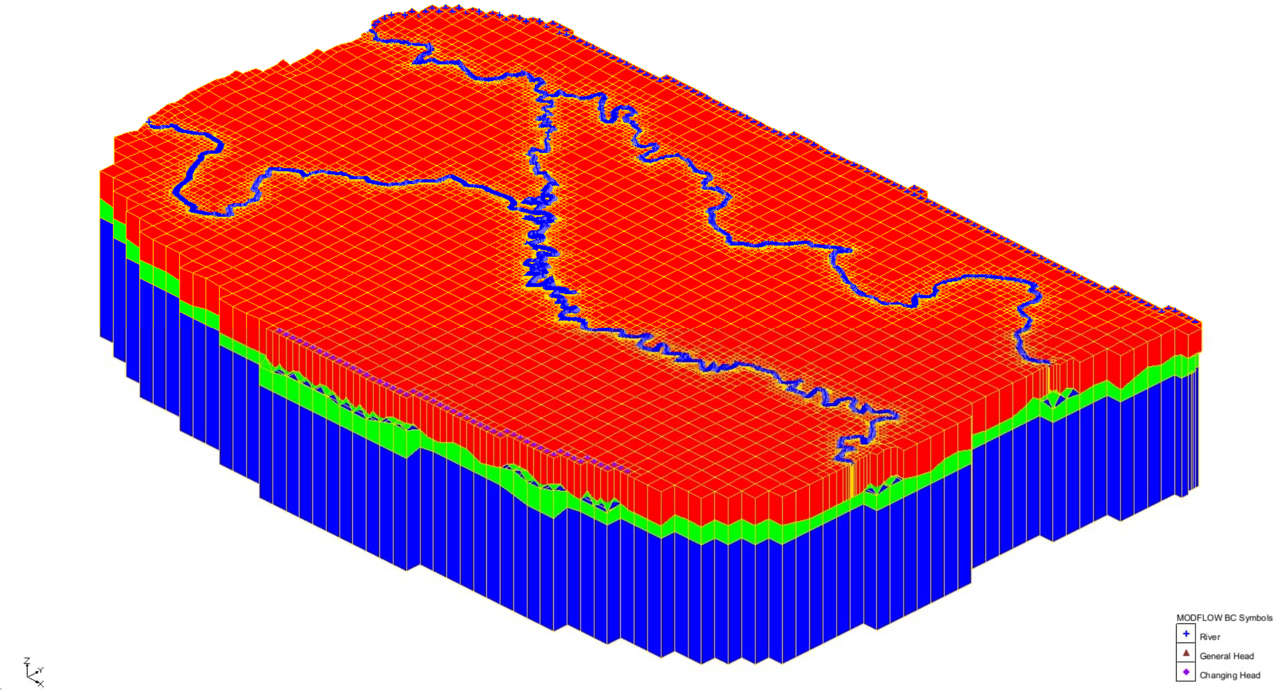


Figure 4-3. 3D 3-Layer Hartwood model (27x16 km)

Hydrogeological properties relevant to the model derived from literature used as the starting point for the numerical model are presented in Table 4-1 with calibration parameters highlighted in italic fonts. The range of parameters considered is enclosed in curly braces ({}).

Table 4-1. Initial hydrogeological properties considered in the Hartwood numerical model

Parameter	Layer 1 (Upper Shepparton Fm)	Layer 2 (Lower Shepparton Fm)	Layer 3 (Calivil Fm)
Horizonal Hydraulic conductivity (m/d)	{0.05 to10}	{0.005 to 5}	{5 to 60}
Vertical Hydraulic conductivity (m/d)	{0.005 to 5}	{0.00001 to 0.001}	{0.5 to 20}
Specific Yield (-)	0.05	-	-
Specific Storage (1/m)	1E-6	1E-6	1E-6
Potential ET rate (m/d) – riparian/tree zone	6.57E-3 [2400 mm/yr]	-	-
ET extinction depth (m) - riparian/tree zone	5	-	-
Potential ET rate (m/d) - developed land	3.27E-3 [1200 mm/yr]	-	-
ET extinction depth (m) – developed land	3	-	-
Rainfall Recharge (m/d)	2.738E-5 [10 mm/yr]	-	-
Approximate layer Thickness (m)	40-45	20-30	180
Billabong Ck and Yanco Ck River boundary condition (BC) head (m)/ Conductance (m^2/d)	94-87, pool level/ {1E-3 to1E-1}	-	-
Model North general head (GH) BC head (m)/ Conductance (m^2/d)	90-87/ {1E-3 to1E+2}	-	-
Model South GH BC head (m)/ Conductance (m^2/d)	80/ {1E-3 to1E+2}	-	-
Recharge Irrigated Lands (m/d)	{3E-5 to 5E-4} [11 to 183 mm/yr]		
Model East GH BC head (m)/ Conductance (m^2/d)	-	82/ {1E-3 to1E+2}	82/ {1E-3 to1E+2}
Model West GH BC head (m)/ Conductance (m^2/d)	-	72/ {1E-3 to1E+2}	72/ {1E-3 to1E+2}

Boundary conditions for the model include General Head or River (refer to Figure 4-2), with all other boundaries considered as no-flow conditions. The heads for these boundary conditions were estimated from approximate groundwater level contours. Watercourses including Billabong Creek, Yanco Creek, and Forest Creek were modelled as River Boundary Conditions in which groundwater exchange with the watercourses is simulated as a head dependent boundary condition where river stage elevation is defined along with a boundary conductance term that can regulate the transfer of water between groundwater and the watercourses.

The model applies a recharge rate of 10 mm/year on unirrigated lands. Recharge on irrigated lands is adjustable and treated as a calibration parameter. The irrigated land cells are shown in Figure 4-4.

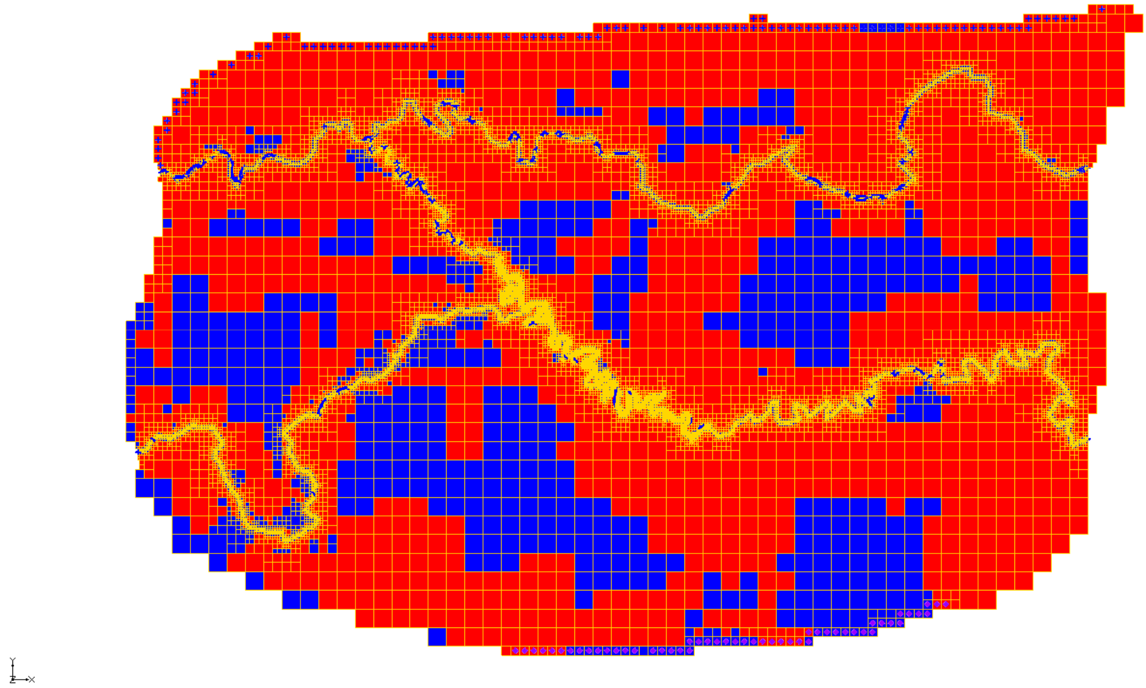


Figure 4-4. Irrigated land cells shown as dark blue

Two distinct zones with evapotranspiration (ET) are considered. The first zone has a potential ET rate of 1,200 mm/year and a root extinction depth of 3 m, indicating moderate water use and limited root depth. This evaporation zone is used for cleared and developed land, including irrigation, but where there is a low proportion of deep rooted vegetation such as trees. Conversely, the riparian zone is characterized by a higher potential ET rate of 2,400 mm/year and a deeper root extinction depth of 5 m. The riparian zone is based on the high priority GDEs (Section 3.4.9) The rates of potential ET were set considering the observed pan evaporation data for the area and using the rates provided in the AMLETT dataset for the riparian zones.

The model domain contains nine groundwater monitoring bores. Data from these bores, specifically the average measured head from 2000 to 2023, were used for steady-state calibration. To account for spatial variation in river conductance, different segments of the creeks within the domain were distinguished. The river conductance zones are shown in Figure 4-5. Calibration results, including the parameters used, are summarized in Table 4-2. A comparison between the measured and modelled heads, highlighting the accuracy of the model, is depicted in Figure 4-6.

Table 4-2. Calibrated parameter values

Parameter	Name	Value
Horizonal Hydraulic conductivity (m/d) – Layer 1	HK_10	5.5
Vertical Hydraulic conductivity (m/d) - Layer 1	VK_11	2.3
Horizonal Hydraulic conductivity (m/d) - Layer 2	HK_20	5.0
Vertical Hydraulic conductivity (m/d)- Layer 2	VK_21	0.0007
Horizonal Hydraulic conductivity (m/d) - Layer 3	HK_30	14.7
Vertical Hydraulic conductivity (m/d) - Layer 3	VK_31	0.50
Recharge Irrigated Lands (m/d)	RCH_100	2.69E-04
North-side River BC Conductance (m^2/d)	RIV_209	20.1
South-side River BC Conductance (m^2/d)	RIV_208	0.001

Parameter	Name	Value
West-side GH BC Conductance (m^2/d)	GHB_302	4.9
East-side GH BC Conductance (m^2/d)	GHB_301	0.100
Internal River/Creek BC Conductance (m^2/d)	RIV_201	0.001
	RIV_202	0.001
	RIV_203	0.001
	RIV_204	0.100
	RIV_205	0.02
	RIV_200	0.100
	RIV_206	0.016
	RIV_207	0.100

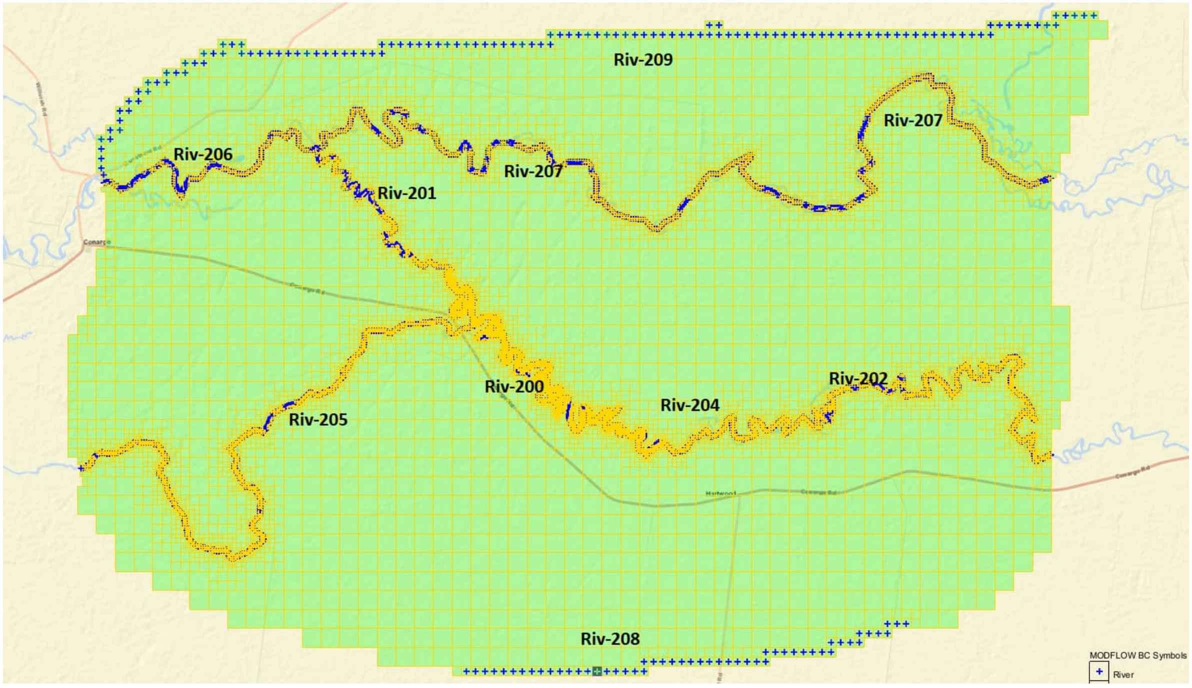


Figure 4-5. River conductance zones used in the Hartwood model

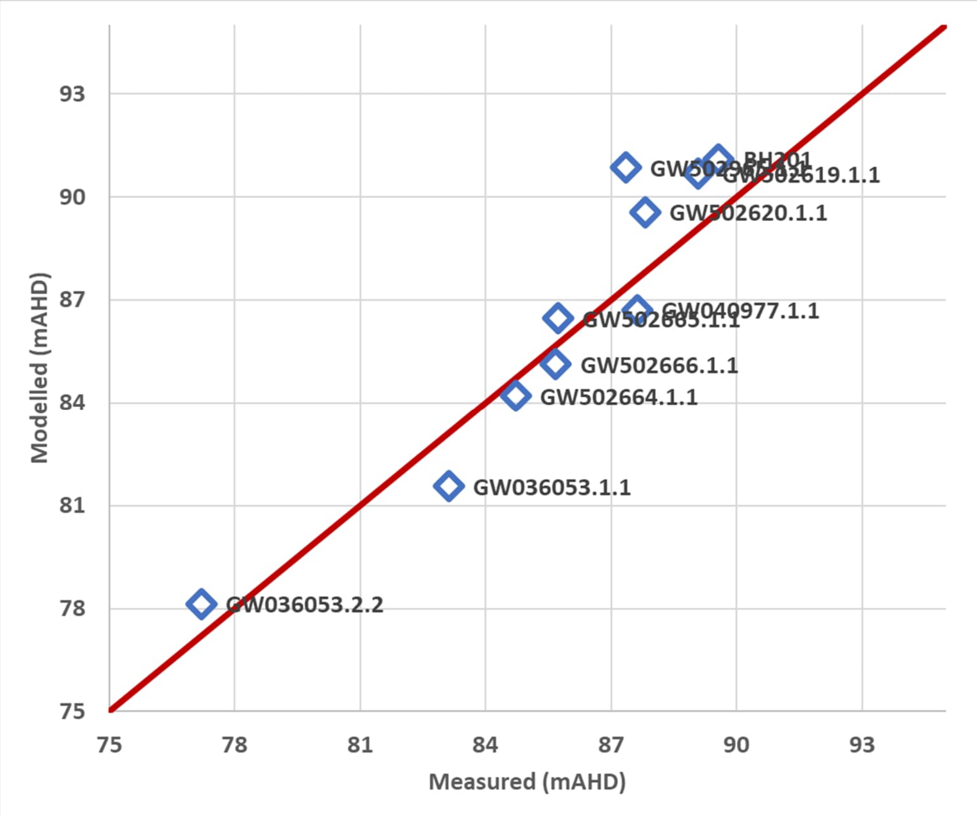


Figure 4-6. Modelled versus measured head of monitoring bores.

4.2.1.2 Model scenarios

Transient simulations have been undertaken for the existing and tested scenario (the proposed regulator operation) for the period 2000 to 2022. The tested scenario is based on the proposed operating rules as per the Draft Yanco Creek System Operations Plan - Yanco Creek Modernisation Project dated September 2023 (DPE, 2023a) and is described further in Section 1.4.4. Weir pool stage elevations adopted are shown in Figure 4-7 and applied to the maximum weir pool extent. The key observation to be drawn from this figure is that there is a very minor difference in water elevation between the current condition and the tested scenario; the average and maximum difference is 0.006 m and 0.15 m respectively. Clearly such a small difference leads to an expectation of minor variation in groundwater as a result of the proposal.

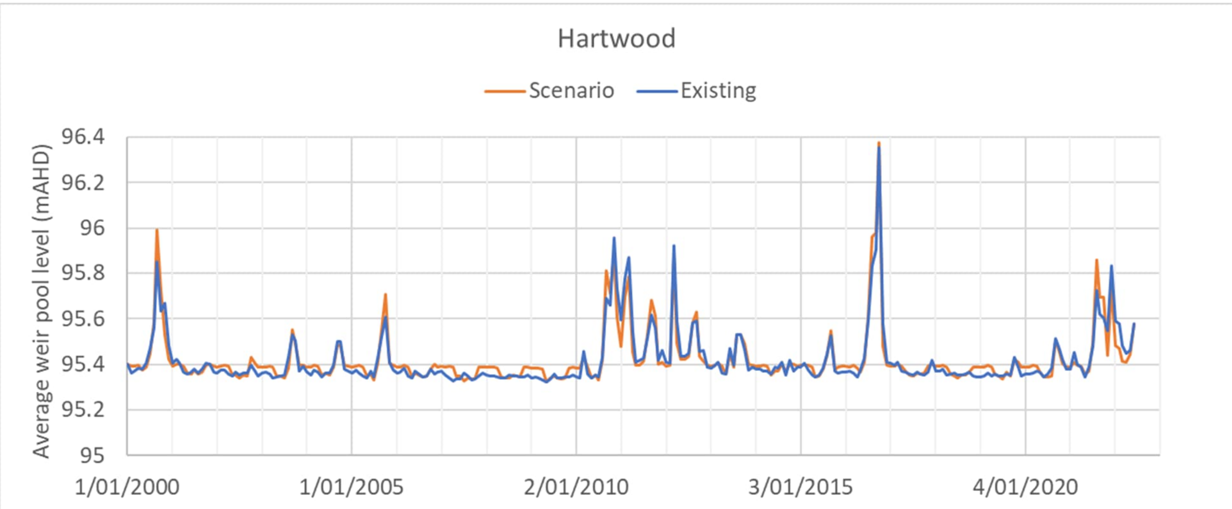


Figure 4-7. Hartwood weir pool levels (existing and scenario)

4.2.1.3 Groundwater elevation

The predicted watertable elevation in 2022 for the existing and tested scenario across the model domain are presented in Figure 4-8 and Figure 4-9. There is no discernible change in groundwater elevation or flow direction at 1 mAHD contour intervals. This is supported by the conceptualisation which indicates Billabong Creek is a disconnected creek. This watertable represents the conditions after 22 years of the proposal and illustrates the long term effect on groundwater.

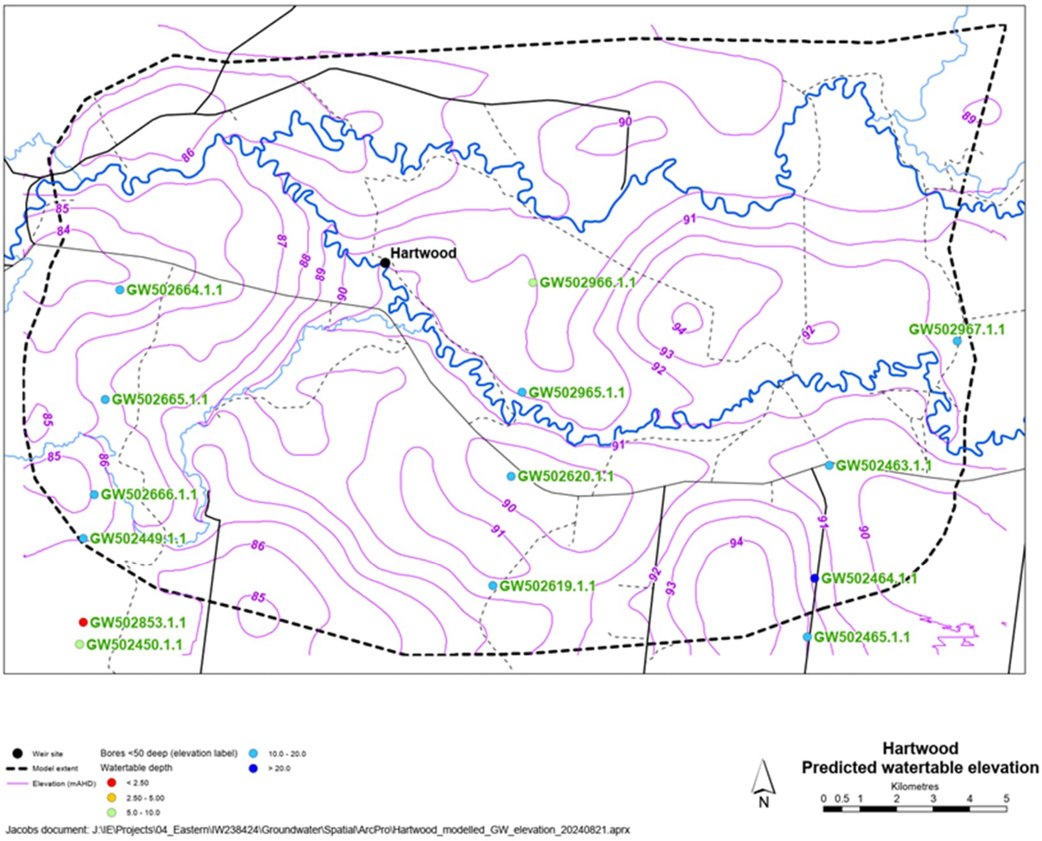


Figure 4-8. Predicted watertable elevation 1/1/2022 (existing)

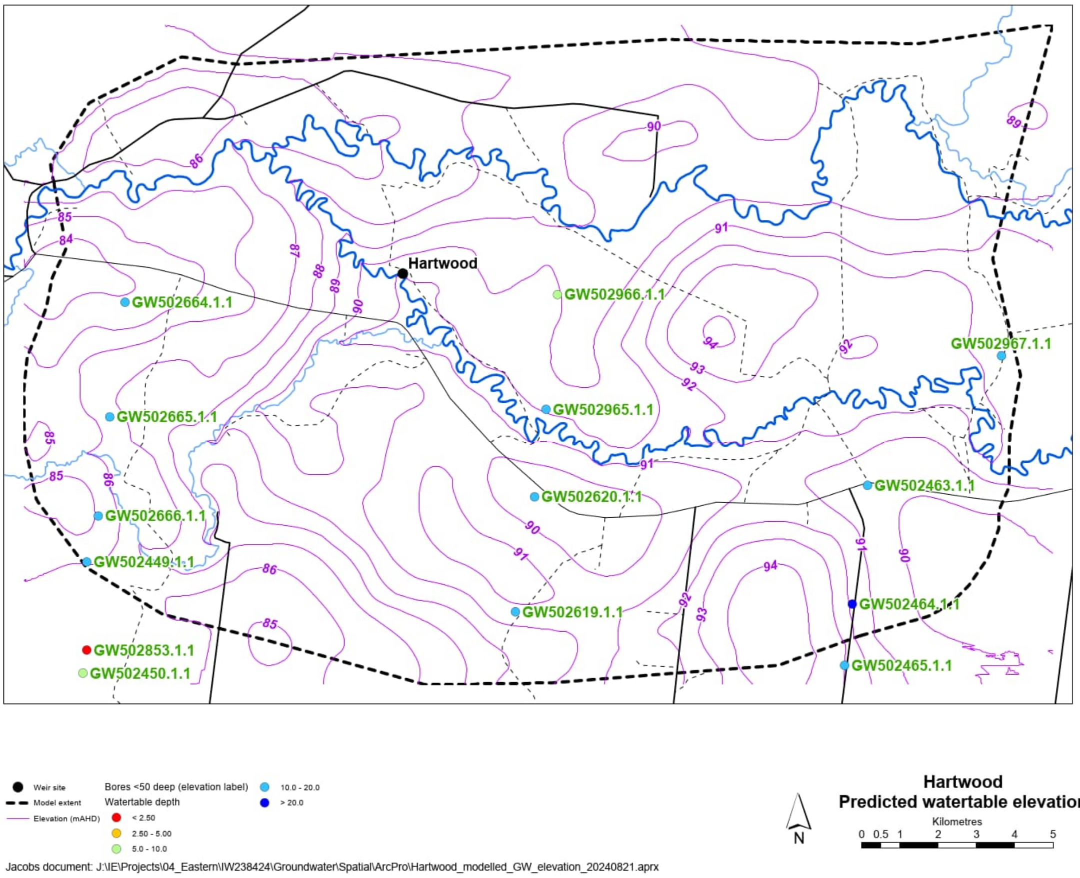


Figure 4-9. Predicted watertable elevation 1/1/2022 (scenario)

4.2.1.4 Drawdown resulting from the proposal

Predicted groundwater drawdown and mounding contours associated the proposed Hartwood regulator is presented in Figure 4-10 to Figure 4-13. Drawdown and mounding contours were derived by subtracting the predicted groundwater elevations in the scenario from the existing case. The minimum and maximum difference between the weir pool level for the existing and tested scenario are -0.15 meters and 0.14 m, occurring in September 2000 and November 2000 respectively. The resulting mounding at these times are presented in Figure 4-10 and Figure 4-11. These values are peak differences in weir pool values and are similar to the long-term average effect with additional times shown in Figure 4-12 and Figure 4-13. Figure 4-12 and Figure 4-13 illustrate the differences in water levels (head differences) in January 2022, and July 2022 which represents the conditions after 22 years of the proposal and the long term effect on groundwater. Drawdown is predicted in January 2022 and July 2022 as the existing weir pool levels are marginally above the tested scenario weir pools levels at those times.

The predicted drawdown and mounding associated with the tested scenario is negligible during operation (around <0.01m) and most likely will not be distinguishable in monitoring well hydrographs in the area. This is because the watertable measurement generally fluctuates around 0.1-0.2 m over the seasons and the predicted drawdown is close to the limit of accuracy of measurement. Based on a search of the registered bores in the region, there were no irrigation or basic rights bores located in proximity to the predicted drawdown. The likelihood of irrigation or stock bores and the Lower Murray Groundwater Source being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.

Given the limit of the forecast drawdown no interaction between the regulators in the proposal has been identified and so no cumulative effect is expected.

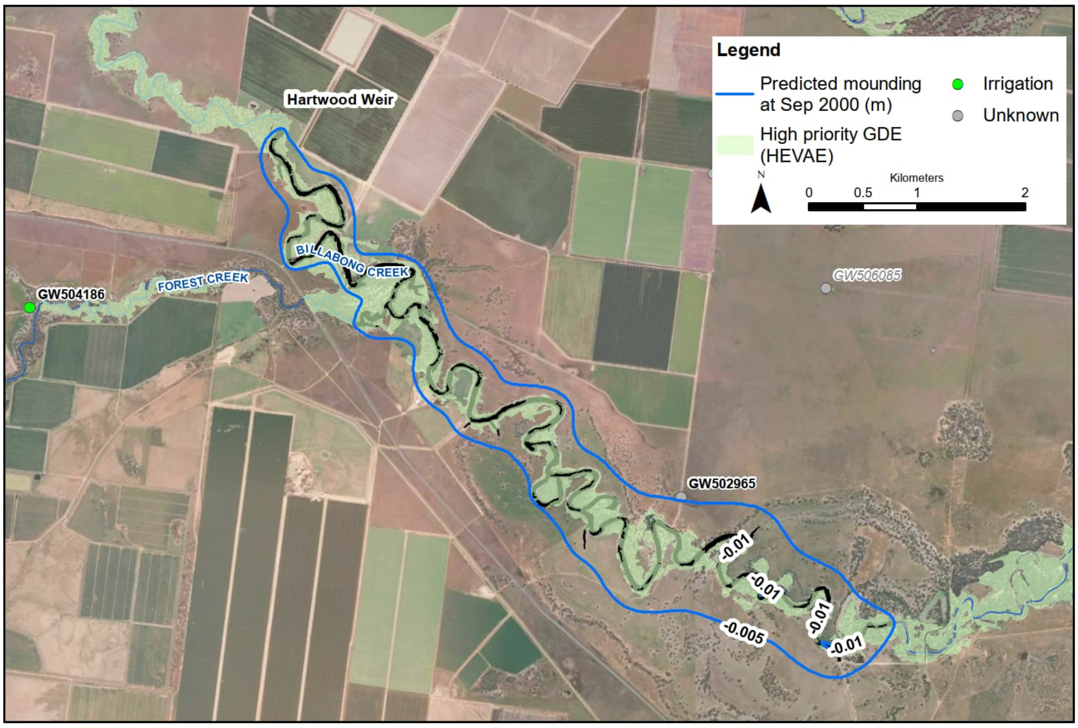


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Figure 4-10. Predicted groundwater mounding at Hartwood at 1/9/2000

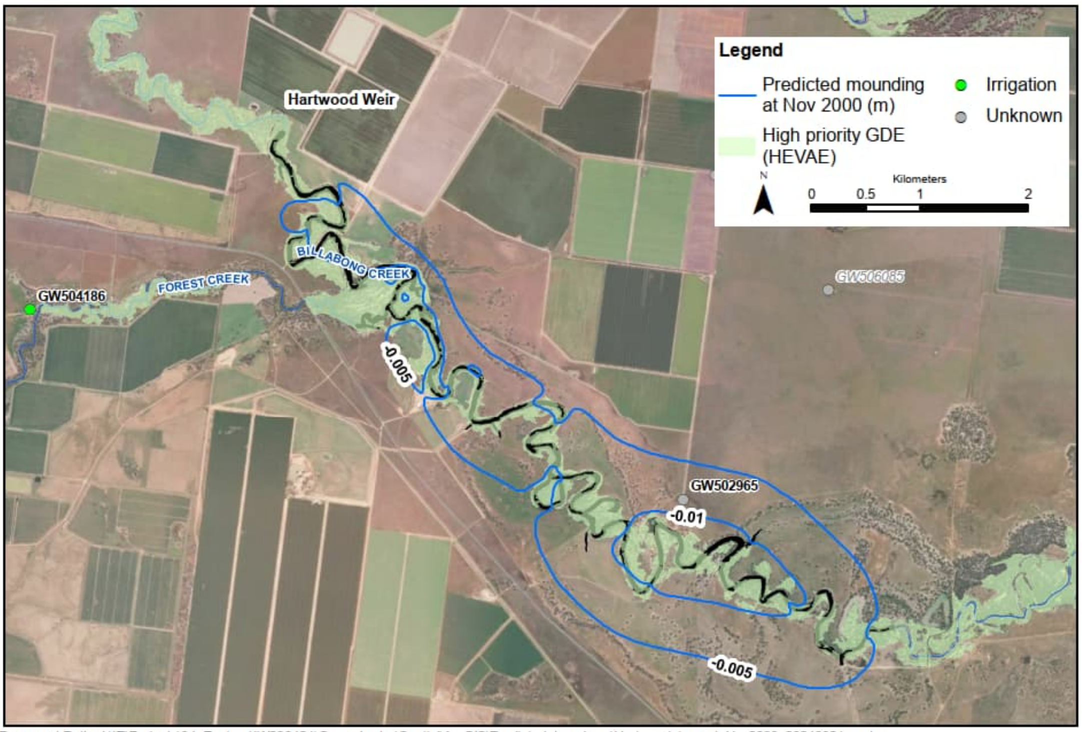

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Figure 4-11. Predicted groundwater mounding at Hartwood at 1/11/2000

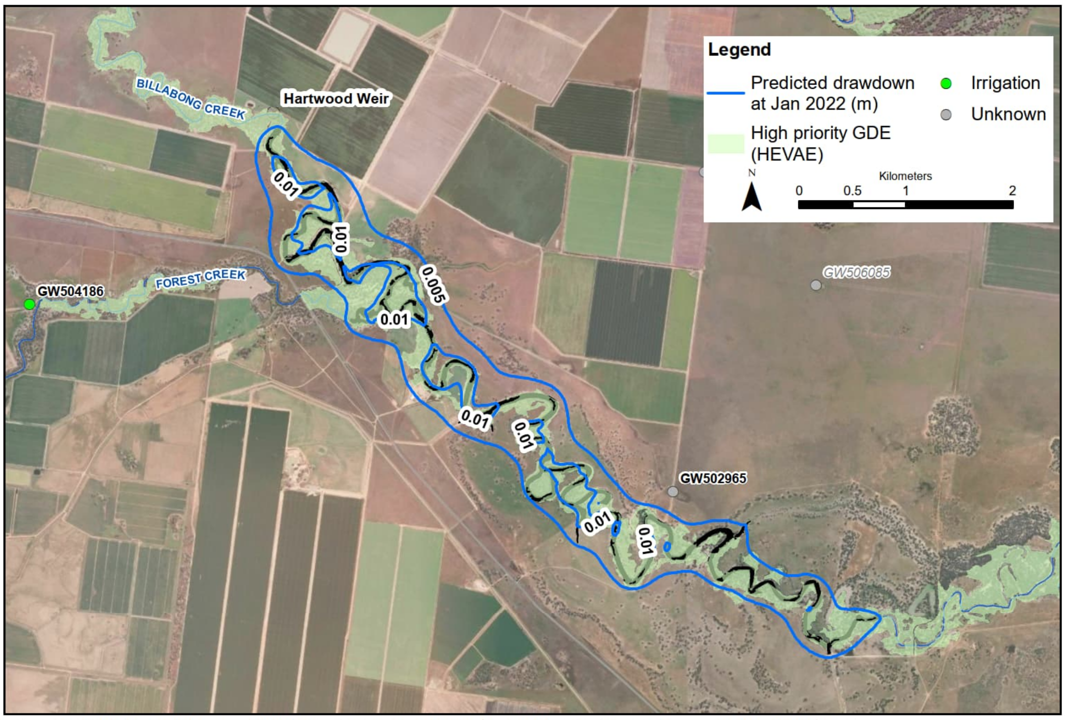

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Figure 4-12. Predicted groundwater drawdown at Hartwood at 1/1/2022

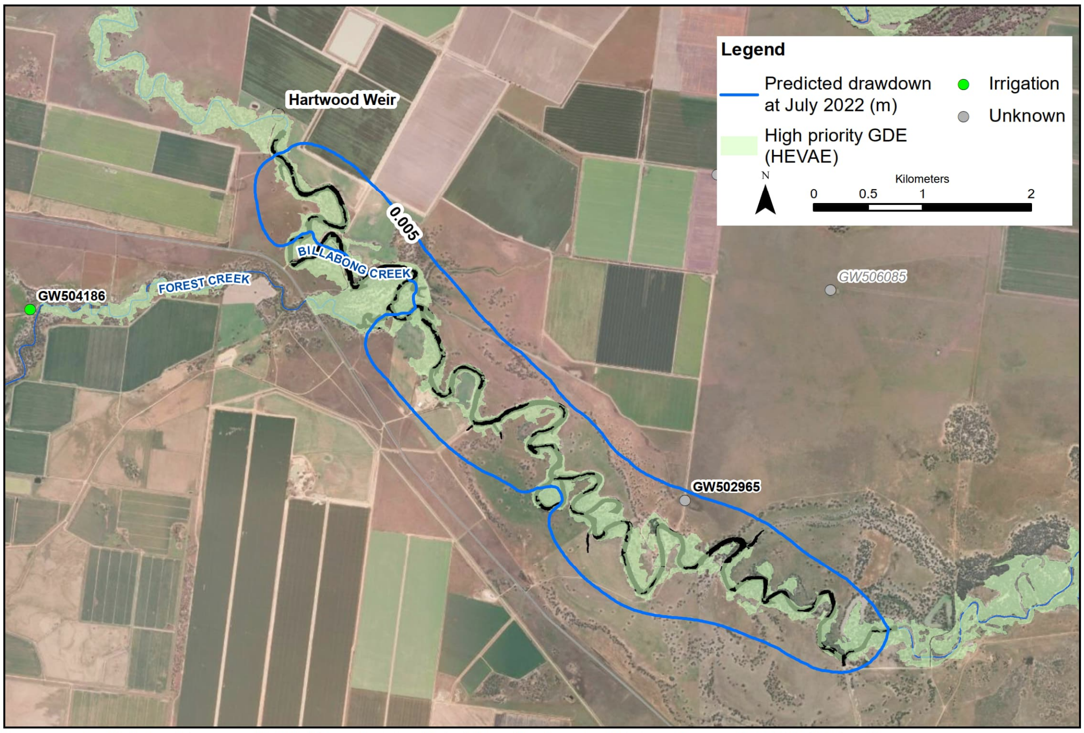

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Figure 4-13. Predicted groundwater drawdown at Hartwood at 1/7/2022

4.2.1.5 Weir pool flux

The predicted discharge from the weir pool to groundwater for the existing and tested scenario are shown on Figure 4-14. Overall, there is a very minor increase in the weir pool flux to groundwater for the scenario tested compared to the existing case. The average increase is 4 m^3/day with a maximum difference of 90 m^3/day which is less than 3% of the average total flux to groundwater. This is a negligible change and within the uncertainty of the model. The risk of saline groundwater discharging to Billabong Creek is considered to be nil as the creek is predicted to remain always losing to groundwater.

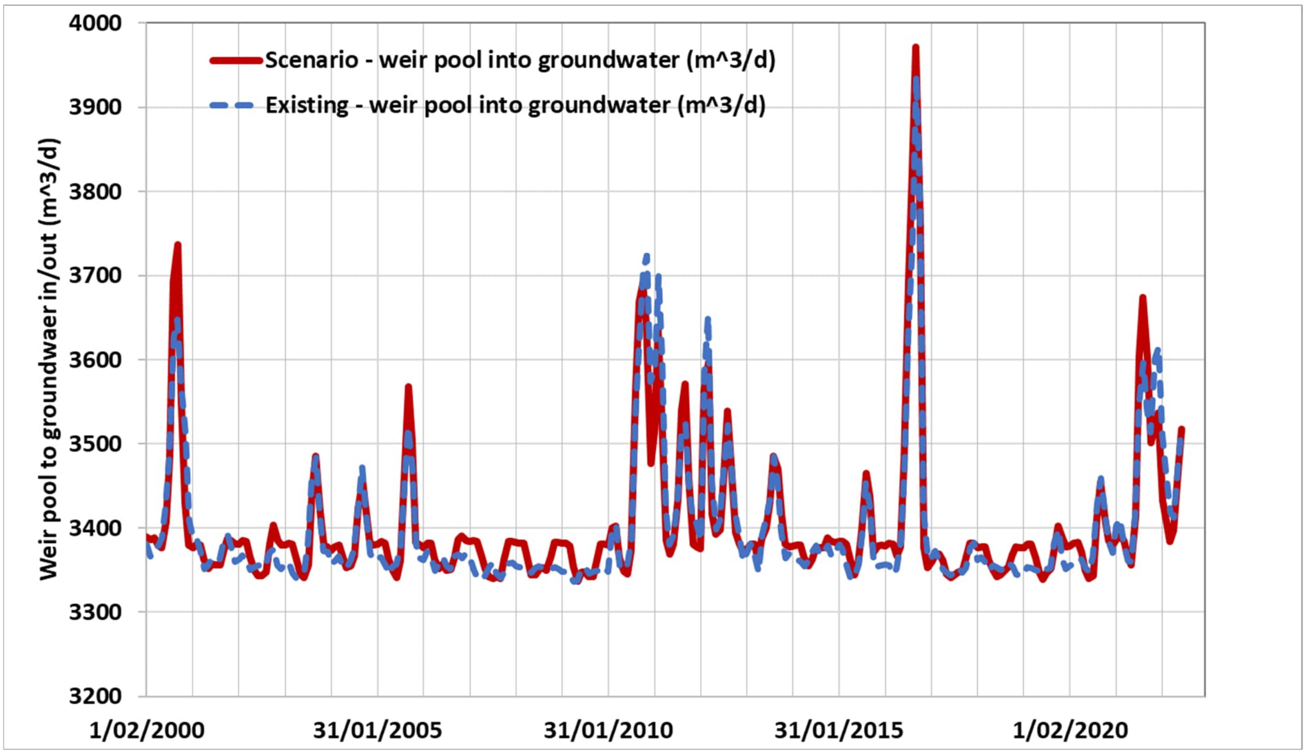

Figure 4-14. Flux from weir pool to groundwater for the existing and tested scenario.

4.2.1.6 Evapotranspiration

Figure 4-15 illustrates the volumetric rate of water extracted from groundwater due to evapotranspiration (ET) for both existing and tested scenario. There is negligible change in the rate at which water is extracted from groundwater due to ET between the existing and tested scenario. This indicates there can be expected to be negligible impact to water dependent ecosystems (high priority GDEs) in the vicinity of Billabong Creek as a result of the proposal.

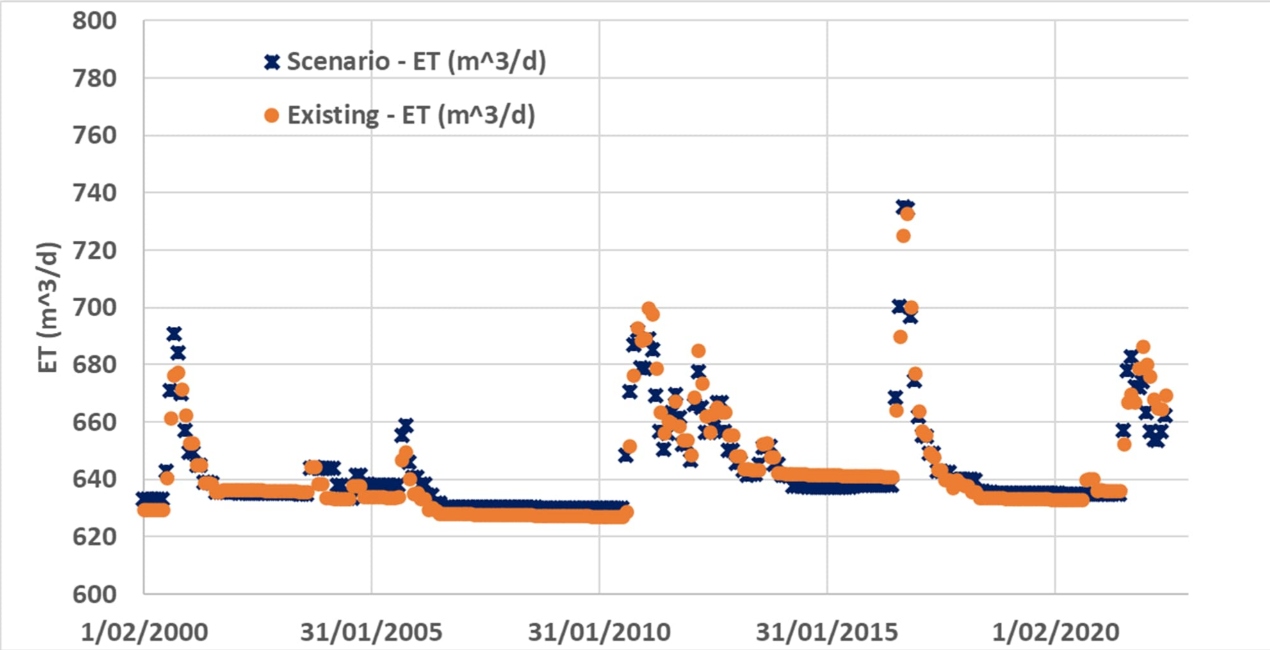

Figure 4-15. Evapotranspiration (ET) for the existing and tested scenario.

4.2.1.7 Summary of expected groundwater impacts

The expected groundwater impacts include:

- No discernible change in groundwater elevation or flow direction over the study area.
- Very minor watertable drawdown/mounding (0.5 to 1 cm) limited to 1 km from the weir pool and for periods of a few weeks associated with peak difference periods, and insignificant changes on average. Whilst the effect will extend to this distance, the scale at this distance is very small, as other groundwater effects damp the changes in the watertable and reduce the effects with distance from the creek.
- Insignificant impact on water dependent ecosystems (high priority GDEs).
- Negligible increase of leakage from the weir pool to groundwater (of less than 0.1% of the estimated current seepage, amounting to around 4 m^3/day).
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given that the predicted change is a lowering in groundwater level, the watertable is around 5 mbgl and groundwater levels remain within the observed range of variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.
- Under the NSW Aquifer Interference Assessment Policy the predicted impacts fall within the Level 1 category and the assessment is considered "Level 1 – Acceptable" (documented in Appendix B).

4.2.2 Wanganella

4.2.2.1 Model overview and conceptualisation

A numerical groundwater model was developed to provide estimates of groundwater impacts for the operation of the replacement Wanganella Regulator. Numerical groundwater modelling has been undertaken using MODFLOW-USG to quantify potential changes to groundwater levels and water balance associated with the Draft Yanco System Operations Plan proposal operation. The modelling is informed by the hydrogeological conceptualisation presented in Chapter 3.

The model is a Class 1 model as defined by the Groundwater Modelling Guidelines (Barnett et al. 2012). This status recognises that the proposed changes to the hydraulic regime associated with the proposed regulators is minor and that they likely present a low risk to aquifers and GDE. Further, based on the available groundwater observations and aquifer detail, a more detailed model is unlikely to provide greater certainty than a class one model for the study area.

The model covers a domain approximately 31 km by 21 km, as illustrated in Figure 4-16. It comprises three layers: Alluvium/Upper Shepperton, Lower Shepperton and Calivil Formation, detailed in a three-dimensional, three-layer structure shown in Figure 4-17. The model boundaries are located approximately along watercourses where this was feasible.

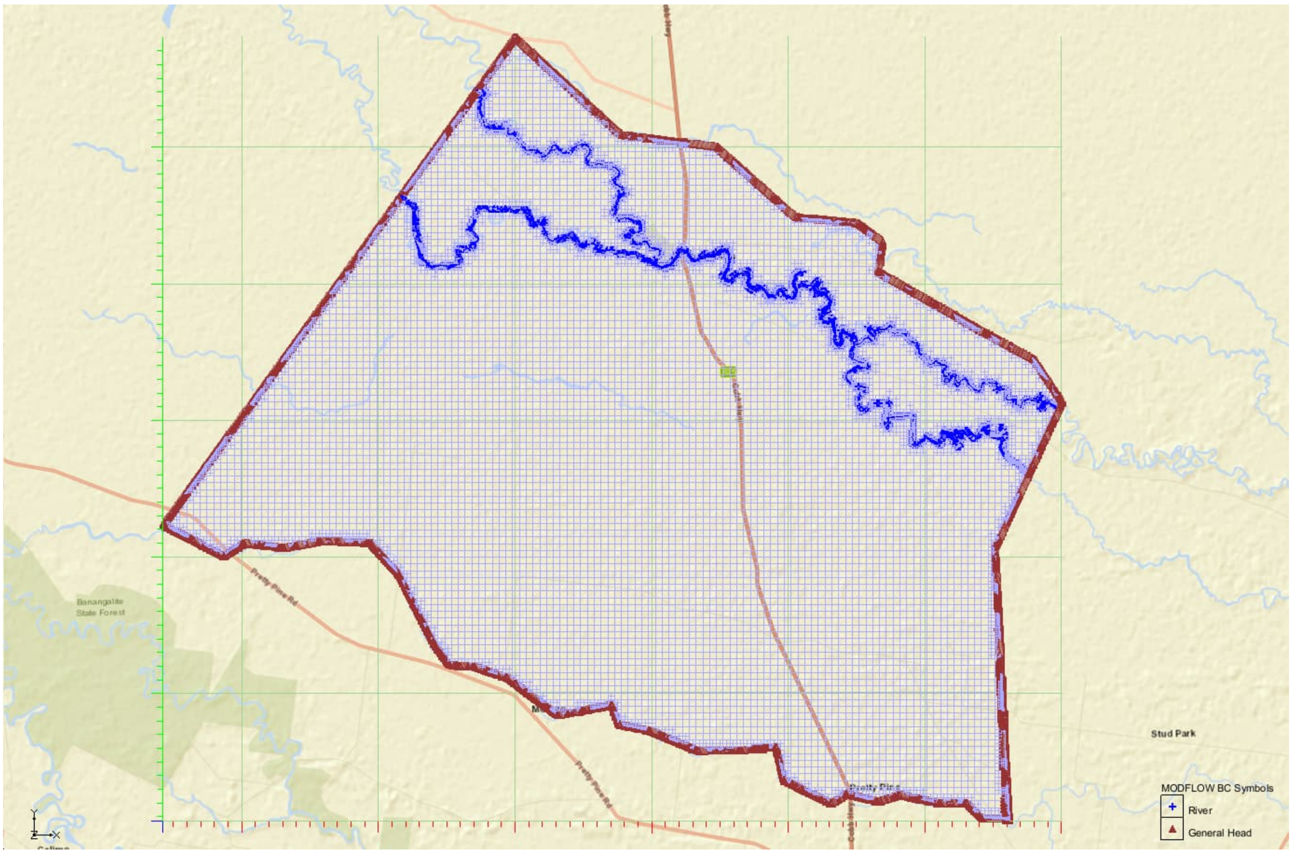

Figure 4-16. Wanganella model domain

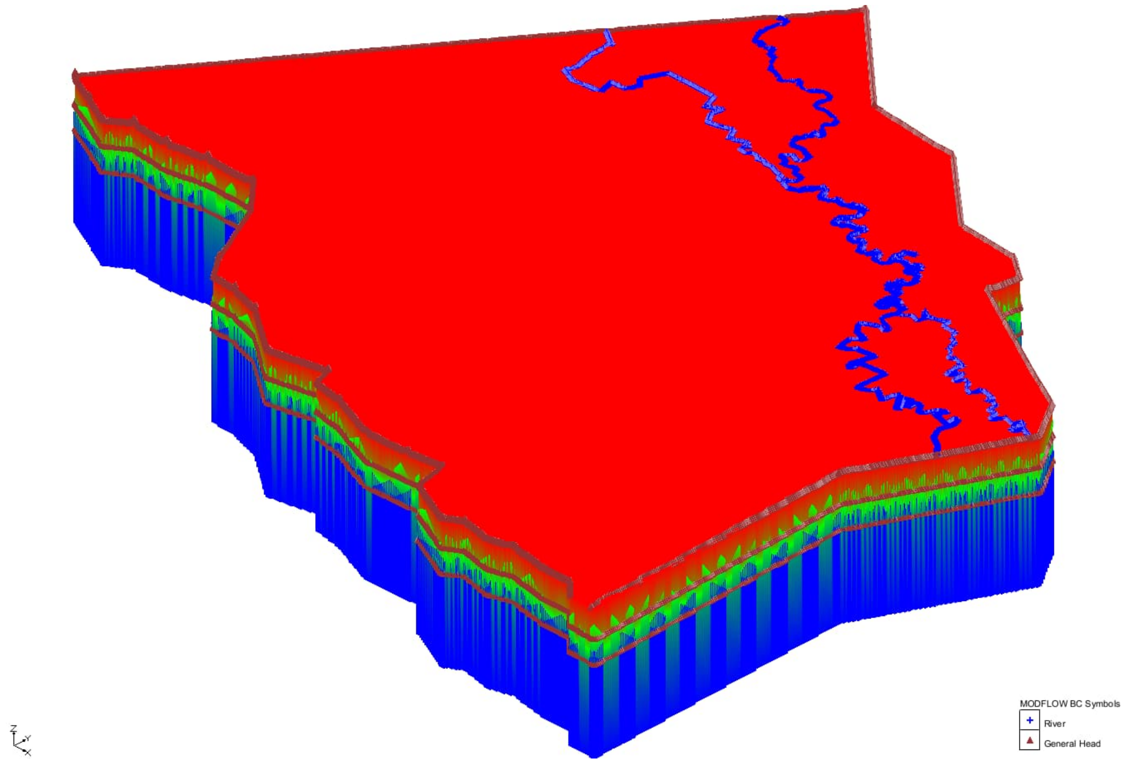

Figure 4-17. 3D 3-Layer Wanganella model

Hydrogeological properties were gathered from literature and the initial value ranges for the model are presented in **Table 4-3**, with calibration parameters highlighted in italic fonts. The range of parameters considered is enclosed in curly braces ({}).

Table 4-3. Hydrogeological properties considered in the Wanganella numerical model

Parameter	Layer 1 (Upper Shepparton Fm)	Layer 2 (Lower Shepparton Fm)	Layer 3 (Calivil Fm)
Horizonal Hydraulic conductivity (m/d)	***{0.05 to10}***	***{0.01 to 10}***	***{0.5 to 60}***
Vertical Hydraulic conductivity (m/d)	***{0.001 to 5}***	***{0.00001 to 1}***	***{0.05 to 20}***
Specific Yield (-)	0.05	-	-
Specific Storage (1/m)	1E-6	1E-6	1E-6
Potential ET rate (m/d) – riparian/tree zone	6.57E-3 [2400 mm/yr]	-	-
ET extinction depth (m)- riparian/tree zone	5	-	-
Potential ET rate (m/d) – developed land	3.27E-3 [1200 mm/yr]	-	-
ET extinction depth (m) – developed land	3	-	-
Rainfall Recharge (m/d)	2.738E-5 [10 mm/yr]	-	-
Approximate layer Thickness (m)	40-45	20-30	180
Model Southern GH BC head (m)	80		
River/Creek BC head (m)/ ***Conductance*** (m^2/d)	94-87, pool level/ ***{1E-3 to1E+3}***	-	-
North-side GH BC head (m)/ ***Conductance*** (m^2/d)	80-83/ ***{1E-3 to1E+3}***	76-80/ ***{1E-3 to1E+3}***	76-80/ ***{1E-3 to1E+3}***
South-side GH BC head (m)/	72-79/	69-76/	69-76/

Parameter	Layer 1 (Upper Shepparton Fm)	Layer 2 (Lower Shepparton Fm)	Layer 3 (Calivil Fm)
Conductance (m^2/d)	***{1E-3 to1E+3}***	***{1E-3 to1E+3}***	***{1E-3 to1E+3}***
Recharge Irrigated Lands (m/d)	***{3E-5 to 2.7E-4}*** ***[10 to100 mm/yr]***		
Recharge Swamp Area (m/d)	***{3E-5 to 5.5E-4}*** ***[10 to 200 mm/yr]***		
East-side GH BC head (m)/ ***Conductance*** (m^2/d)	75-79/ ***{1E-3 to1E+3}***	76-80/ ***{1E-3 to1E+3}***	76-80/ ***{1E-3 to1E+3}***
West-side GH BC head (m)/ ***Conductance*** (m^2/d)	75-80/ ***{1E-3 to1E+3}***	72-76/ ***{1E-3 to1E+3}***	72-76/ ***{1E-3 to1E+3}***

Boundary conditions for the model include General Head or River, with all other boundaries considered as no-flow conditions. Notably, River boundary conditions are a specific type of General Head boundary condition. The heads for these boundary conditions were estimated from approximate groundwater level contours. The model applies a recharge rate of 10 mm/year on unirrigated lands. Recharge on irrigated lands is adjustable and treated as a calibration parameter. The irrigated land cells are shown in Figure 4-18. An additional recharge area was considered around Wanganella Swamp and Eight Mile Creek with the recharge rate determined in the calibration process. This area was determined from the assessment of existing conditions, where higher than typical groundwater levels were observed in the vicinity of the wetlands.

Two distinct zones with evapotranspiration (ET) are considered. The first Zone has an ET rate of 1,200 mm/year and a root extinction depth of 3 m, indicating moderate water use and root depth. This zone was used to represent the developed land and areas where deep rooted vegetation (such as trees) is sparse. Conversely, the riparian zone is characterized by a higher ET rate of 2,400 mm/year and a deeper root extinction depth of 5 m, representing an area with a high percentage of deep-rooted vegetation.

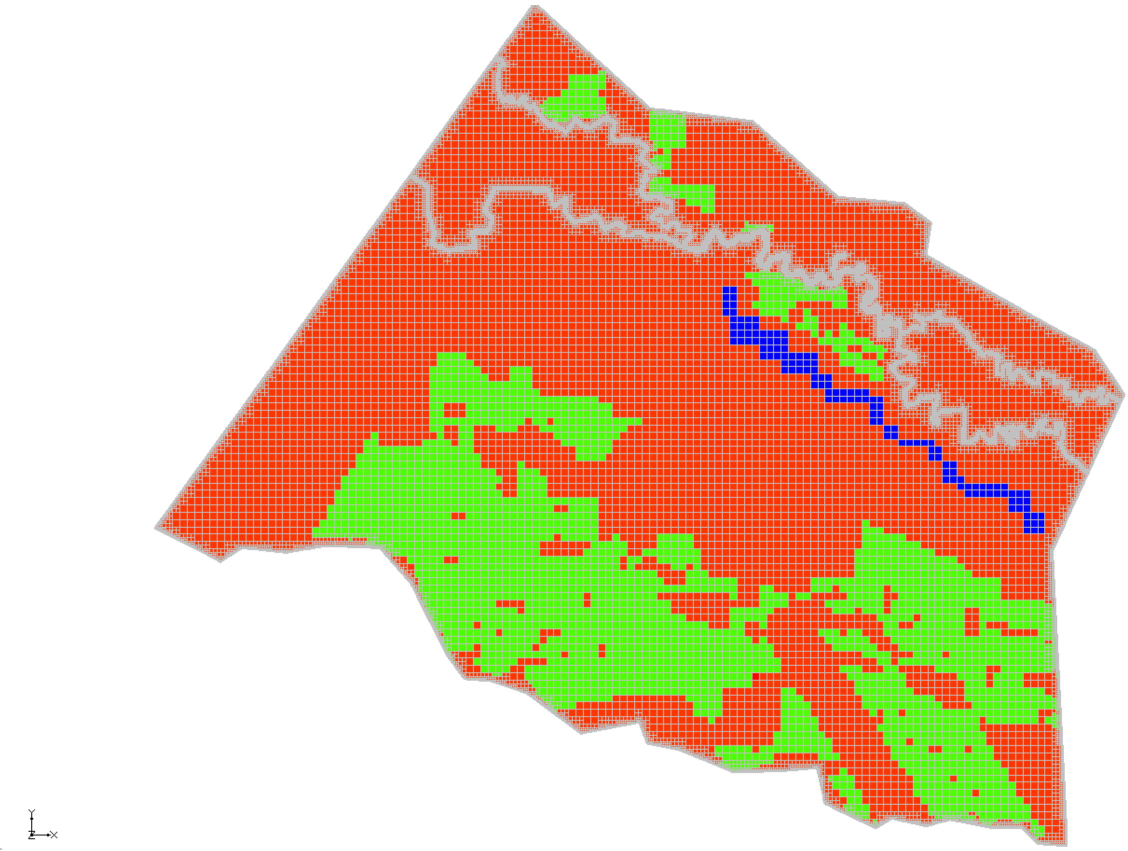

Figure 4-18. Irrigated land cells are shown as green and the zone with additional recharge as blue.

The model domain contains ten groundwater monitoring bores. Data from these bores, specifically the average measured head from 2000 to 2023, were used for steady-state calibration. To account for spatial variation in river conductance, different segments of the creeks within the domain were distinguished (Figure 4-19). Calibration results, including the parameters used, are summarized in Table 4-4. A comparison between the measured and modelled heads, highlighting the accuracy of the model, is depicted in Figure 4-20.

Table 4-4. Calibrated parameter values

Parameter	Name	Value
Horizonal Hydraulic conductivity (m/d) – Layer 1	HK_10	4.86
Vertical Hydraulic conductivity (m/d) - Layer 1	VK_11	0.08
Horizonal Hydraulic conductivity (m/d) - Layer 2	HK_20	0.02
Vertical Hydraulic conductivity (m/d)- Layer 2	VK_21	0.0006
Horizonal Hydraulic conductivity (m/d) - Layer 3	HK_30	60
Vertical Hydraulic conductivity (m/d) - Layer 3	VK_31	0.78
Recharge Irrigated Lands (m/d)	RCH_1	2.22E-04
Recharge Swamp Area (m/d)	RCH_2	5.48E-04
North GH BC Conductance (m^2/d)	GHB	0.003-10
South GH BC Conductance (m^2/d)	GHB	10-250
West GH BC Conductance (m^2/d)	GHB	10-180

Parameter	Name	Value
East GH BC Conductance (m^2/d)	GHB	0.02-10
Internal River/Creek BC Conductance (m^2/d)	RIV-200	0.98
	RIV-202	1.45
	RIV-226	0.01
	RIV-223	0.16
	RIV-201	0.85
	RIV-221	10.00

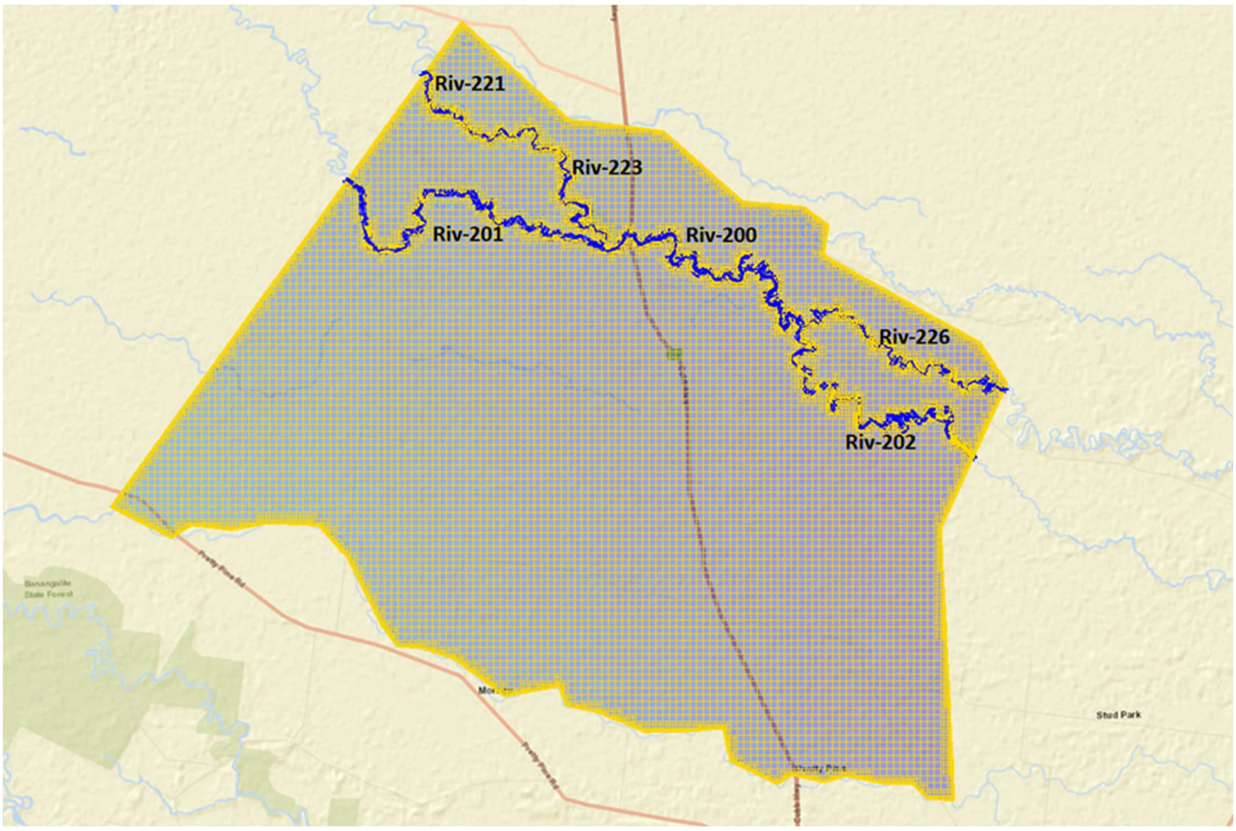

Figure 4-19. River conductance zones used in the Wanganella model

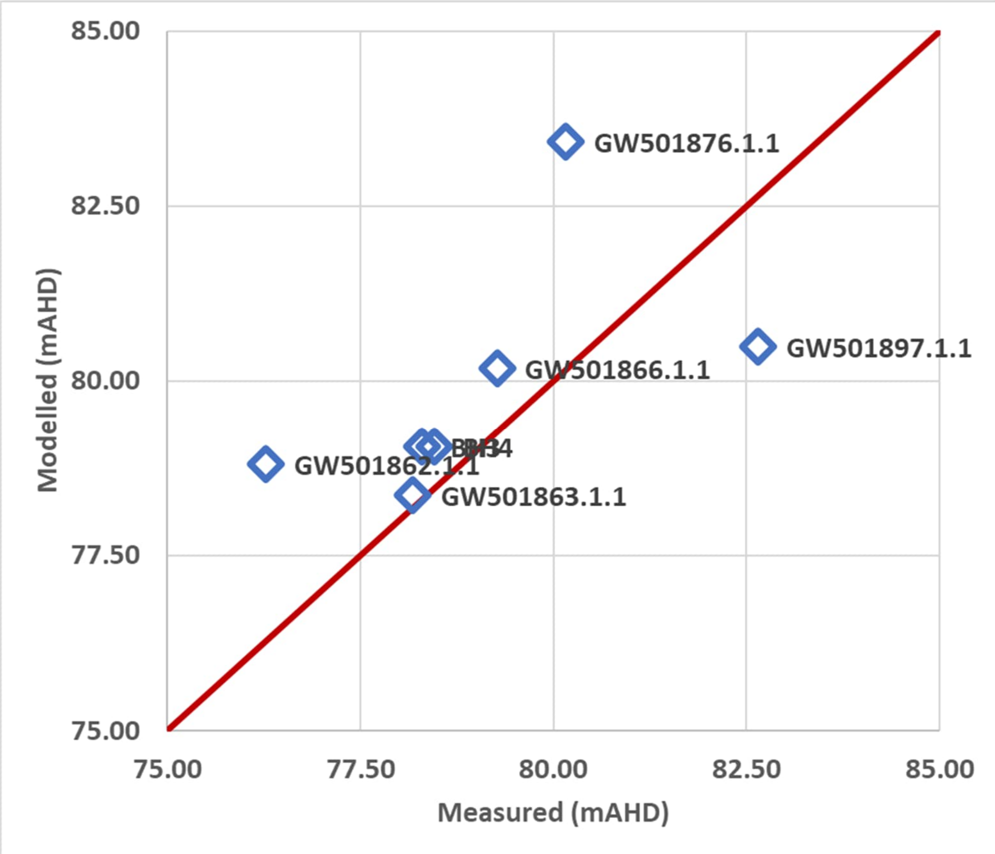

Figure 4-20. Modelled versus measured head of monitoring bores.

4.2.2.2 Model scenarios

A numerical groundwater model was developed to provide estimates of groundwater impacts for the upgraded environmental regulator at Wanganella. Scenarios have been run for the existing and tested scenario for 22 years (2000-2022). The tested scenario is based on the proposed operating rules as per the Draft Yanco Creek System Operations Plan - Yanco Creek Modernisation Project dated September 2023 (DPE, 2023a) and is described further in Section 1.4.4. Time series of weir pool stage adopted for Wanganella are shown in Figure 4-21. The key observation to be drawn from this figure is that there is a very minor difference in water elevation between the current condition and the tested scenario; there is an average and maximum difference of 0.04 and 0.3 m respectively. Clearly such a small difference leads to an expectation of minor variation in groundwater as a result of the proposal.

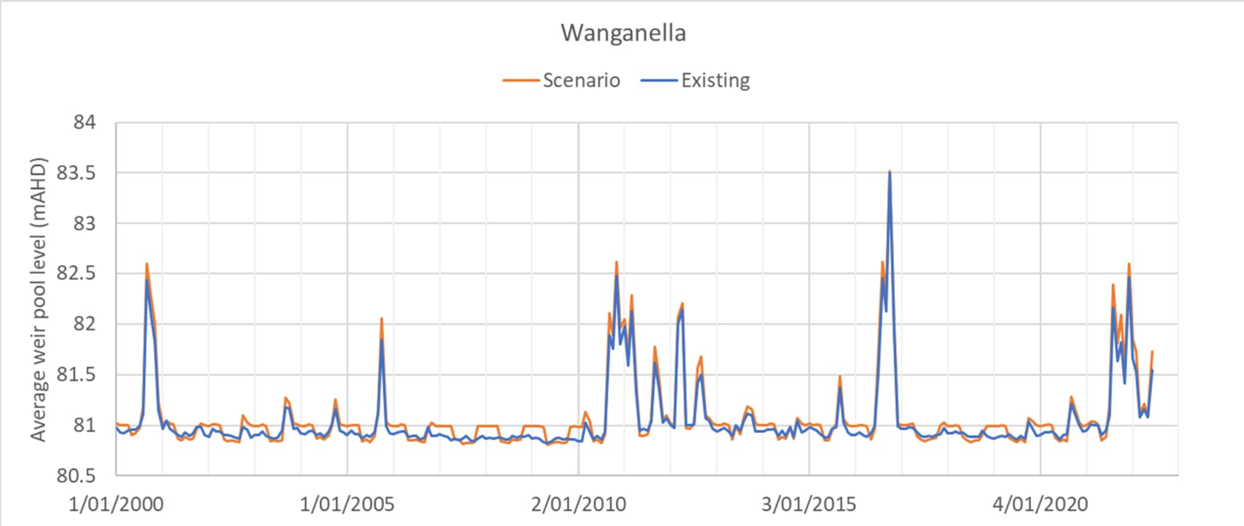

Figure 4-21. Wanganella weir pool levels (existing and scenario)

4.2.2.3 Groundwater elevation

The predicted watertable elevation in 2022 for the existing and tested scenario across the model domain are presented in Figure 4-22 and Figure 4-23. There is no discernible change in groundwater elevation or flow direction at 1 mAHD contour intervals. The predicted drawdown is presented in Section 4.2.2.4. This watertable represents the conditions after 22 years of the proposal and illustrates the long term effect on groundwater.

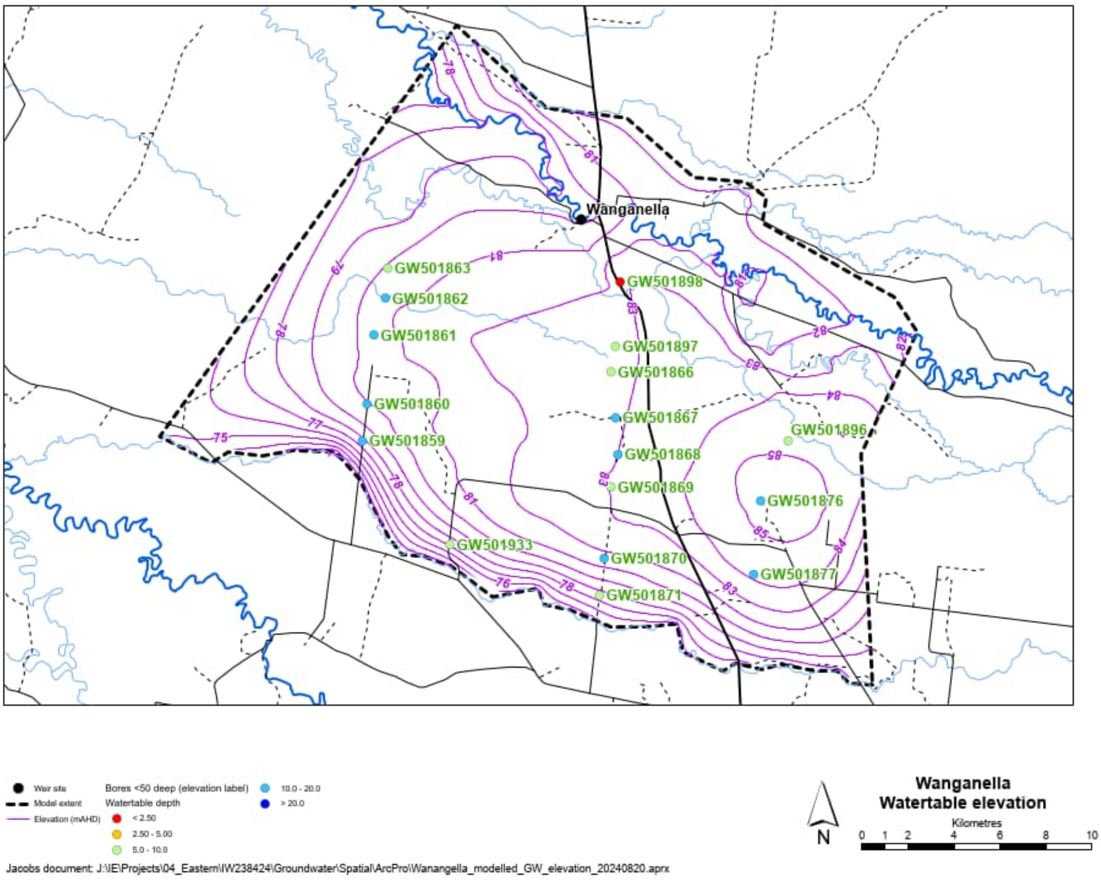

Figure 4-22. Wanganella predicted watertable January 2022 (existing)

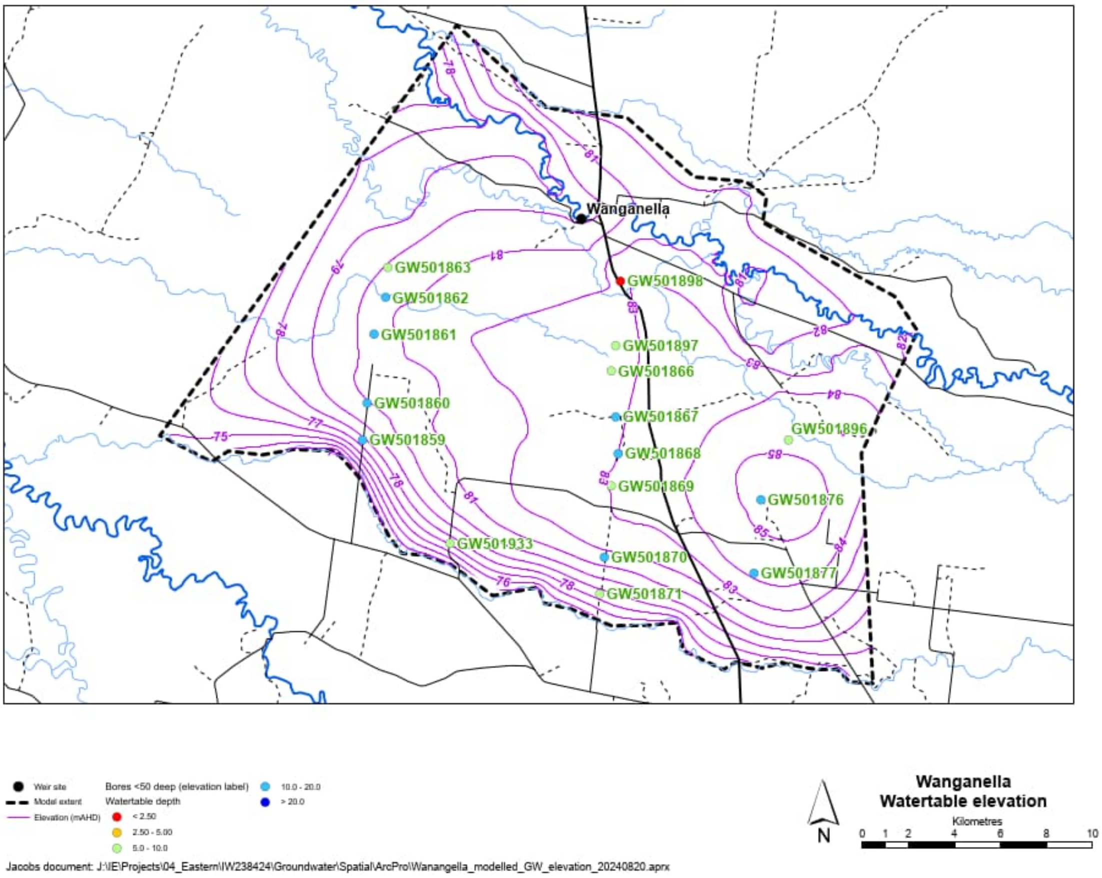

Figure 4-23. Wanganella predicted watertable January 2022 (scenario)

4.2.2.4 Drawdown resulting from the proposal

Predicted groundwater drawdown contours associated with the tested scenario at four dates are presented in Figure 4-24 to Figure 4-27. Drawdown contours were calculated by subtracting the predicted groundwater elevations of the scenario from the existing case. The minimum and maximum difference between the existing and tested scenario weir pool elevations are a reduction of 0.1 m and an increase of 0.3 m, occurring on August 2003 (Figure 4-24) and October 2021 (Figure 4-25) respectively.

These values are peak differences in the weir pool values and are similar to the long-term average effect with additional times shown Figure 4-26 and Figure 4-27. These figures illustrate the difference in groundwater levels (head differences) in January 2022 and July 2022 which represents the conditions after 22 years of the proposal and the long-term effects on groundwater.

The predicted watertable mounding and drawdown associated with the scenario will largely be indistinguishable from the natural variability with groundwater levels generally fluctuating around 0.1-0.2 m based on monitoring well hydrographs (Section 3.4.5.1). Drawdown is predicted to occur (up to 0.05 m) close to the weir pool in August 2003 for a few weeks. Drawdown, of a smaller magnitude, is also predicted to occur seasonally when the tested scenario weir pool levels are lower than the existing weir pool levels (Figure 4-21).

Based on a search of the registered bores in the region, there were no irrigation or stock and/or domestic bores located in proximity to the predicted drawdown. The likelihood of basic rights bores and the Lower Murray Groundwater Source being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation. There is one bore with unknown use within the vicinity of predicted drawdown (GW005449), however, the impact is considered negligible based on the predicted change.

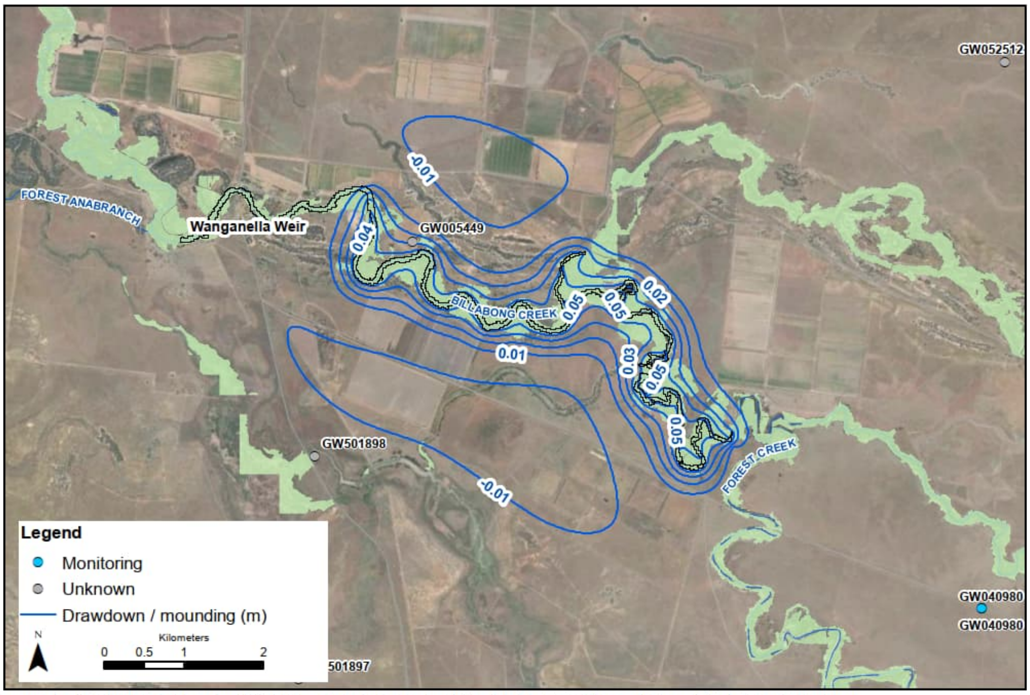

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Figure 4-24. Wanganella predicted watertable drawdown and mounding August 2003

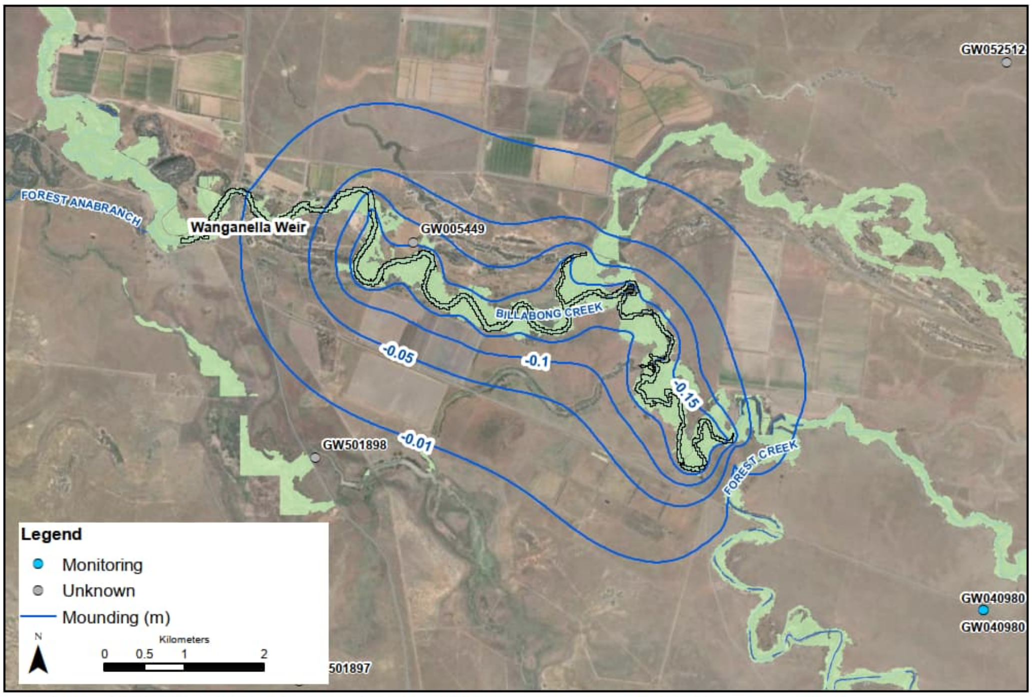

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Figure 4-25. Wanganella predicted watertable drawdown October 2021

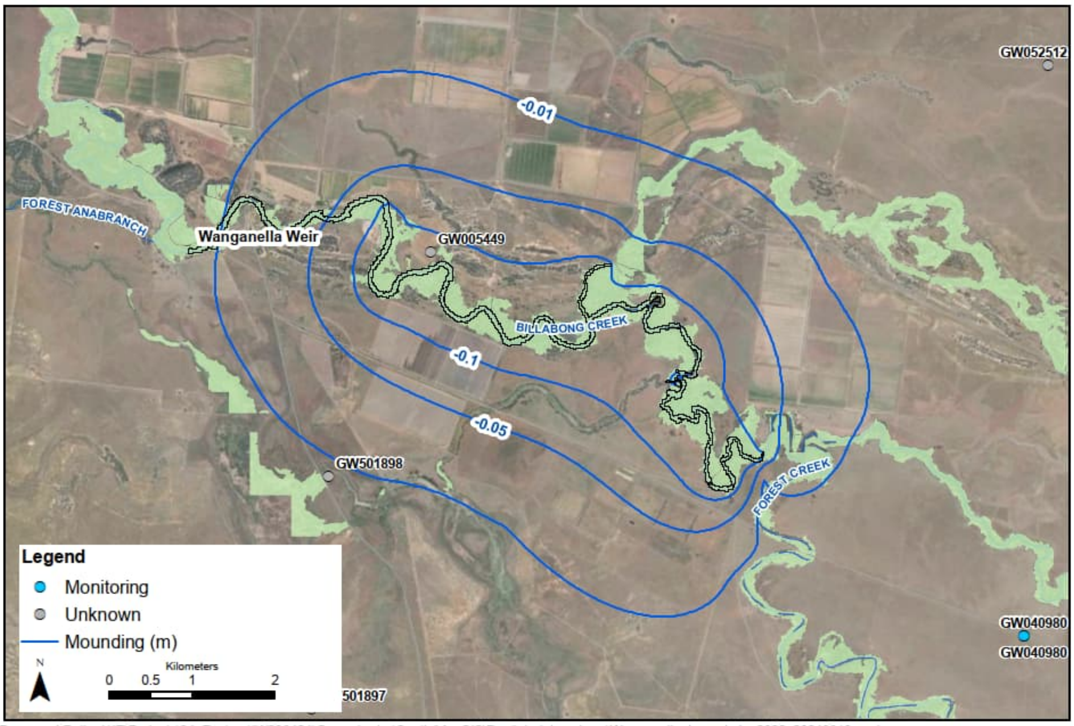

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Figure 4-26. Wanganella predicted watertable mounding January 2022

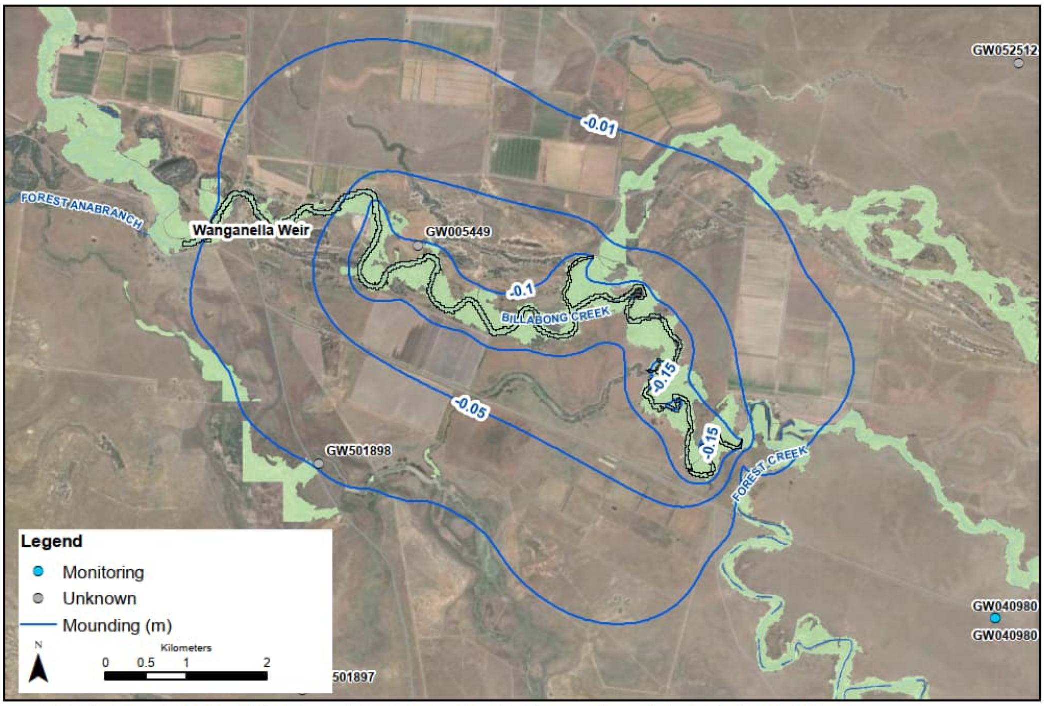

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Figure 4-27. Wanganella predicted watertable mounding June 2022

4.2.2.5 Weir pool flux

The predicted discharge from the weir pool to groundwater for the existing and tested scenario are shown in Figure 4-28. Overall, there is minimal difference between the weir pool flux to groundwater for the existing and scenario tested. The average difference is 210 m^3/day which represents an increased outflow from the weir pool to the groundwater for the tested scenario. The average of the negative difference is -520 m^3/day and the average increased outflow is 300 m^3/day. The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to remain always losing to groundwater.

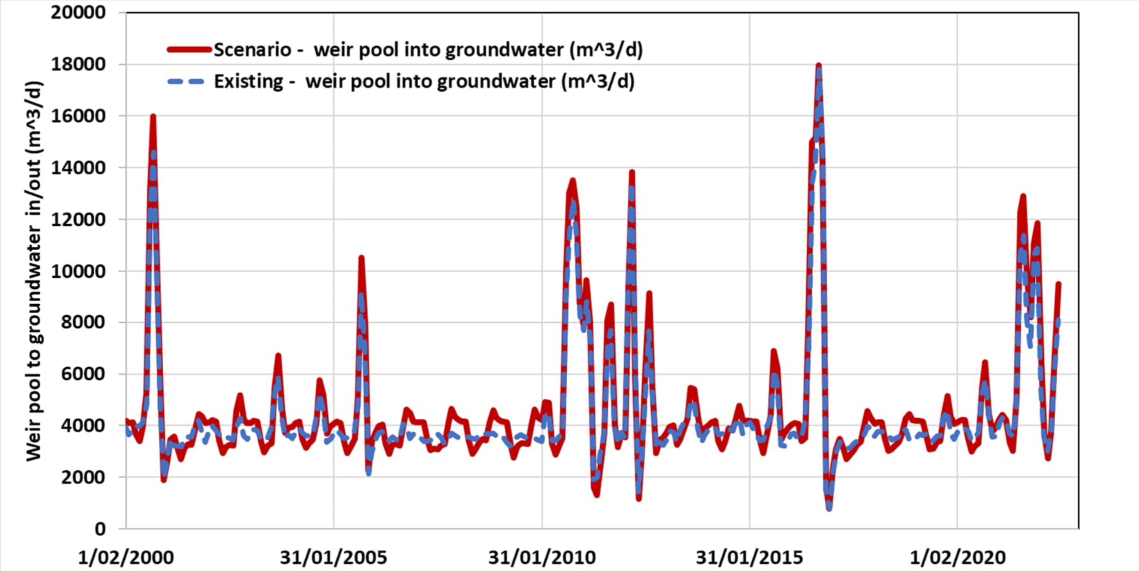

Figure 4-28. Wanganella predicted flux from weir pool to groundwater

4.2.2.6 Evapotranspiration

Figure 4-29 illustrates the volumetric rate of water extracted from groundwater due to evapotranspiration (ET) for both existing and tested scenario. There is a minor change in the rate of ET for both the existing and tested scenario with an increase of around 120 m^3/day in the scenario tested. This indicates there will be negligible impact to water dependent ecosystems (high priority GDEs) which are mapped in the vicinity of Billabong Creek.

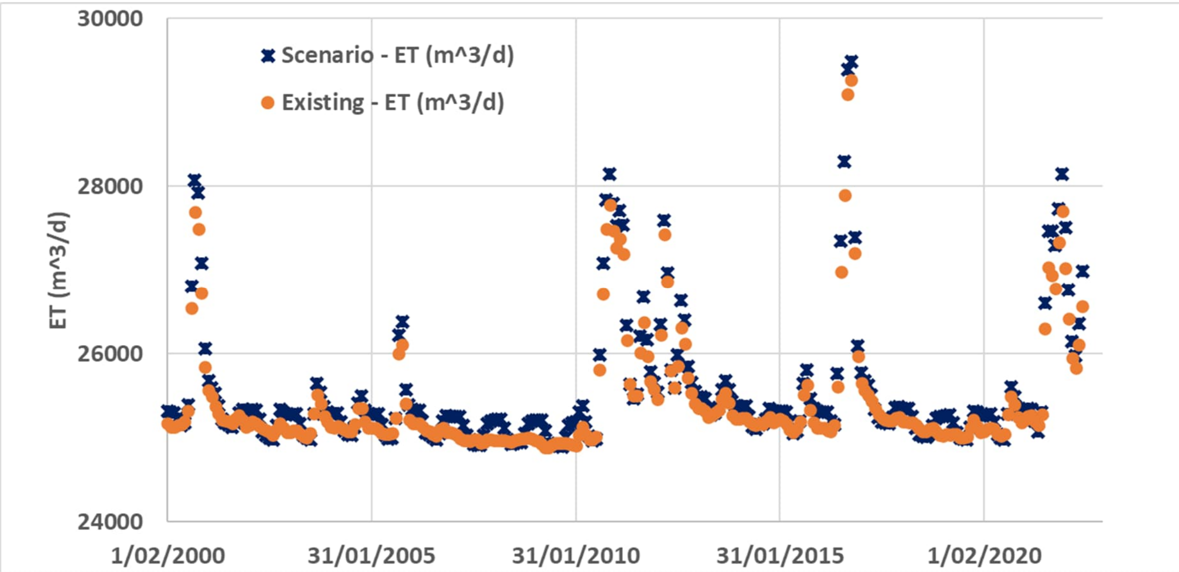

Figure 4-29. Wanganella predicted evapotranspiration

4.2.2.7 Summary of expected groundwater impacts

The expected groundwater impacts include:

- No discernible change in groundwater elevation or flow direction over the study area, but with expected mounding or drawdown of groundwater by 1 or 2 cm limited to 2 km from the weir pool.
- Minor watertable drawdown/mounding associated with short term (in the order of a few weeks) peak difference periods and insignificant changes on average.
- Very minor increase in evapotranspiration and insignificant impact on water dependent ecosystems (high priority GDEs).
- Minor to insignificant change in leakage from the weir pool to groundwater as the overall leakage to groundwater and disconnected system remains.
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given the watertable is around 5 mbgl and groundwater levels remain within the expected range of natural variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.
- Under the NSW Aquifer Interference Assessment Policy the predicted impacts fall within the Level 1 category and the assessment is considered “Level 1 – Acceptable” (documented in Appendix B).

4.3 Cumulative impacts

The other projects planned in the study area were reviewed to determine if the proposal has the potential to result in significant cumulative impacts. No potential cumulative impacts relevant to groundwater were identified.

5. Mitigation and management of impacts

As the groundwater effects are at worst only localised, short term and minor and in most cases negligible, there is no specific mitigation measures that should be applied. Ongoing monitoring to confirm the scale of the changes in response to operation is recommended in the next section.

6. Proposed Monitoring

Given the small scale of expected impacts only limited groundwater monitoring is recommended.

Groundwater level monitoring utilising the existing monitoring wells should be undertaken on a monthly basis at wells BH201 (Hartwood) and BH3 (Wanganella).

Given the small change in groundwater levels expected and the absence of any threatening process for water quality, only limited water quality monitoring is required. Annual salinity (as electrical conductivity (EC)) and pH is recommended in the above mentioned monitoring wells.

Groundwater monitoring should be reviewed after five years of operation to determine whether there is a requirement for ongoing monitoring. If consistent level and water quality is observed after five years, then the monitoring could be ceased, subject to environmental regulator approval.

7. Conclusions

This assessment has found that the weir pools associated with the proposed regulators at Hartwood and Wanganella will have an insignificant to minor effect on groundwater. Under the NSW Aquifer Interference Assessment Policy, the impacts fall within the Level 1 category and the assessment is considered "Level 1 – Acceptable". Billabong Creek is a losing disconnected watercourse in relation to groundwater and as such has only a small influence on groundwater behaviour. Accordingly, the proposed changes to the operating levels of Billabong Creek and the extent of the weir pools associated with the proposed regulators have an insignificant effect on groundwater.

For the proposed Hartwood regulator the effects of the proposal are:

During Construction

- There will be no effect on groundwater as the base of the structure and likely excavation depth is above the recorded groundwater level at the site.

During Operation

- No discernible change in groundwater elevation or flow direction over the study area.
- Very minor watertable drawdown/mounding (0.5 to 1 cm) limited to 1 km from the weir pool and for periods of a few weeks associated with peak difference periods and insignificant changes on average. Whilst the effect will extend to this distance, the scale at this distance is very small, as other groundwater effects damp the changes in the watertable and reduce the effects with distance from the Creek.
- Insignificant impact on water dependent ecosystems (high priority GDEs).
- Negligible increase of leakage from the weir pool to groundwater (of less than 0.1% of the estimated current seepage, amounting to around 4 m^3/day).
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given that the predicted change is a lowering in groundwater level, the watertable is around 5 mbgl and groundwater levels remain within the observed range of variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.

For the proposed Wanganella regulator the effects of the proposal are:

During Construction

- Groundwater drawdown in the vicinity of the construction area will be limited to a maximum of approximately 0.5 m with a peak possible radius of influence of 250m and a likely maximum discernible radius of effect of less than 50 m. The expected rate of dewatering is less than 0.2 L/s.

During Operation

- No discernible change in groundwater elevation or flow direction over the study area.
- Minor watertable drawdown/mounding associated with peak difference periods limited to 2 km from the weir pool and insignificant changes on average. The greatest effect is close to the Creek, with the scale of the effect reducing rapidly with increasing distance for the Creek. Other effects on the watertable provide a damping effect on the watertable response that considerably reduces the overall effect with distance.
- Very minor to insignificant increase in evapotranspiration and hence, insignificant impact on groundwater dependent ecosystems (high priority GDEs).

- Minor to insignificant change in leakage from the weir pool to groundwater as the overall leakage to groundwater and disconnected system remains.
- The likelihood of irrigation or stock bores and the Lower Murray or Lower Murrumbidgee groundwater sources being adversely impacted by operation is considered negligible due to the lack of bores identified in the area and the negligible change in groundwater elevation.
- Land salinisation is not expected to occur given the watertable is around 5 mbgl and groundwater levels remain within the expected range of natural variability.
- The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to always remain losing to groundwater.

The other projects planned in the study area were reviewed to determine if the proposal has the potential to result in significant cumulative impacts. No potential cumulative impacts relevant to groundwater were identified.

Groundwater level monitoring utilising the existing monitoring wells should be undertaken on a monthly basis at wells BH201 (Hartwood) and BH3 (Wanganella).

The proposed regulators and associated operational changes are regarded as having a very low risk of adverse groundwater impacts.

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Appendix A. Billabong Creek 14/12/2023 – 16/12/2023 Groundwater Monitoring Factual Report

A.1 Introduction and purpose

This report has been prepared by Jacobs to support the Billabong Creek Regulators Groundwater Assessment. Jacobs was engaged to complete a groundwater investigation adjacent to the existing Hartwood and Wanganella Weirs. The purpose was to provide factual information on the groundwater levels, baseline groundwater quality and hydraulic conductivity from monitoring wells installed near the existing Hartwood and Wanganella weirs. This factual report summaries the results of field investigations.

Field work was undertaken at the proposed Wanganella and Hartwood sites from 14/12/2023 to 16/12/2023. During the field work two wells were assessed in the vicinity of the existing Wanganella Weir, shown in Section A.5, and one well assessed in the vicinity of the existing Hartwood Weir, shown below in Section A.5. The location and design of each bore is summarised below in Table A-1. Well construction diagrams for each of the assessed wells have been provided in Section A.6.

Table A-1. Summary of assessed bore locality and design

Bore ID	Easting	Northing	Area	Bore Depth (mBTOC)	Screened Interval (mBTOC)	Screened Lithology(s)
BH201	344323	6091220	Hartwood	9	5 – 7	Sand / Silty Sand
BH3	300371	6100560	Wanganella	8.7	5.7 – 8.7	Silty Sand / Clayey Sand
BH4	300336	6100628	Wanganella	8.2	2.2 – 8.2	Silty Clay / Sandy Clay / Sand

A.1.1 Scope

The scope included the following:

- Groundwater level gauging of three monitoring bores installed in the vicinity of existing Hartwood and Wanganella Weirs (BH201, BH3 and BH4)
- Groundwater bore development of BH3 and BH4
- Slug testing of groundwater monitoring wells to ascertain hydraulic conductivity
- Groundwater sampling and comparison to groundwater investigation criteria.

A.2 Methodology

A.2.1 Groundwater gauging

Groundwater gauging was conducted using an interface probe to measure the depth to water, depth to light non-aqueous phase liquid (LNAPL) if present, and the overall bore depth. Groundwater levels were gauged at each well prior to well development, sampling and slug testing.

A.2.2 Well development

The objective of well developing is to displace the drilling water with formation groundwater in the well casing and filter pack, as well as to remove fine sediments from within the filter pack and base of well. BH3 and BH4 (not previously developed) were developed by bailer prior to sampling and hydraulic testing.

Monitoring well BH201 was developed after installation and therefore not subject to development procedures. Field parameters were recorded during groundwater sampling using a YSI Water Quality Probe.

Well development is assessed to have been completed once;

- A minimum of three (3) well volumes (and typically 10 well volumes) have been removed and/or;
- Groundwater quality field parameters have stabilised (recorded during development using a YSI Water Quality Probe).

Table A-2. Well development details

ID	Date	Volume purged (L)	Comments
BH3	14/12/2023	10	Initially clear, becoming turbid with increasing silt content
	15/12/2023	4	Turbid, brown
	16/12/2023	2	Clear
BH4	14/12/2023	25	Initially turbid and rich in organic matter with sulphide odour, becoming clear with some fines
	15/12/2023	35	Initially silty, no odour, increasing in transparency

A.2.3 Hydraulic testing

Slug testing of groundwater monitoring wells was completed on the 14/12/2023 and 15/12/2023. Testing was undertaken using a solid PVC slug to displace water in the bore and a groundwater level logger to record the change in groundwater head. Two falling head tests and two rising head tests were each completed at BH4 and BH201. One slug test was conducted at BH3 but was terminated after 30 minutes due to minimal recovery observed by manual measurements over the test duration.

A Solinst Level Logger was used to log the changes in groundwater head during slug testing. For BH4 and BH201 data loggers were set to measure at an interval of eight readings per second (at 0.125 second intervals). Due to slow recharge observed during development, data loggers for BH3 were set to measure at a 0.5 second interval. Manual measurements were also taken using an interface meter at regular intervals during the slug testing.

Change in water level data recorded during the tests was processed using the Aqtesolv software package to estimate hydraulic conductivity (K) for the screened section of aquifer at each well. The determination of a K value for each test was undertaken using a visual match on a log-log displacement/time curve using the Bouwer and Rice (1976) analytical solution for unconfined aquifers. A hydraulic conductivity anisotrophy ratio (Kvertical/Khorizontal) of 0.1 was used in all analyses.

A summary of parameters used in each slug test are summarised below in Table A-3 and curve fitting graphs undertaken as part of this analysis are included in Section A.7.

Table A-3. Slug test parameters

Parameter	BH3	BH4	BH201
Initial standing water level (m TOC)	7.69	5.12	5.14
Diameter of slug (mm)	40	40	40
Depth of logger (m TOC)	9.68	8.09	8.65
SWL after logger installation (m TOC)	7.67	5.11	5.14
Height of water column (m)	1.99	3.78	2.77
Assumed aquifer thickness (m)	15	15	15

Parameter	BH3	BH4	BH201
K anisotropy ratio	0.1	0.1	0.1
Well casing radius (m)	0.025	0.025	0.025

A.2.4 Groundwater sampling

Groundwater sampling was undertaken using a grab sample (disposable bailer) methodology. Three bores (BH3, BH4, and BH201) were sampled, with a total of four primary samples taken. Field parameters were recorded during groundwater sampling using a YSI Water Quality Probe to monitor for stabilisation.

2.0 L bailers were used to retrieve groundwater at the base of the water column in each monitoring bore. Samples were collected between 14/12/2023 and 16/12/2023. Samples were taken from BH201 on both 14/12/2023 (Sample ID: BH201a) and 15/12/2023 (Sample ID: BH201b).

Samples for dissolved metals (Ar, Cd, Cr, Cu, Pb, Hg, Ni, Zn) were field filtered using syringe filter units and then decanted into laboratory supplied sterile bottles containing relevant preservatives. All other samples were dispensed directly from the disposable bailer into the relevant bottles.

All samples were sent to Australian Laboratory Services (ALS), with relevant chain of custody documents in Section A.8 and lab certificates included in Section A.9. ALS are accredited by the National Association of Testing Authorities (NATA) for the analyses undertaken.

Samples were analysed for the following suite of analytes:

- Total and Dissolved Metals (Ar, Ca, Cr, Cu, Pb, Hg, Ni, Zn only)
- Cations and Anions: (Cd, Mg, Na, K, Cl, SO4, Alkalinity and Ionic Balance)
- Nutrients: Total Nitrogen, TKN, NOx, NO2, NO3, NH3
- Total Dissolved Solids (TDS) – Standard Level
- pH
- Volatile Organic Compounds (VOCs) and Semi Volatile Organic Compounds (SVOCs)
- Per- and Poly-fluoroalkyl Substances (PFAS) – Short suite of 12 analytes.

Field and laboratory controls were conducted in accordance with EPA NSW groundwater sampling guidelines (NEPC, 2013). On the 15 December the following QA/QC samples were collected;

- One (1) duplicate / triplicate samples analysed for each of the analytes specified above
- One (1) trip blank sample analysed for each of the analytes specified above
- One set of duplicate/triplicate samples (interlab/intralab) (DUP-1/TRIP-1), were taken in tandem with primary sample BH201a for quality assurance and control (QA/QC) purposes

All quality control measures completed as part of this sampling program where reviewed, with the complete QA/QC assessment included in Section A.3.4.3 of this factual report.

A.3 Results

A.3.1 Groundwater levels

Table A-6 summarises the groundwater gauging results at each bore. Groundwater levels at BH3 were noted to have very slow recovery during and after well development and had not fully recovered to initial levels by the following day. This is supported by the low interpreted hydraulic conductivity from slug tests conducted at BH3 which is discussed further below.

Table A-4. Representative monitoring bore gauging results

Well	Date	Time	Casing Stickup (+) (mAGL)	Water level (mbTOC)	Water level (mbgl)	Bore depth (mbTOC)
BH201	15/12/2023	4:21 PM	-0.08	5.15	5.23	9.15
BH3	14/12/2023	5:52 PM	0.70	6.41	5.71	9.58
BH4	14/12/2023	4:45 PM	0.70	4.94	4.24	8.56

A.3.2 Well development

Well development records are summarised in Table A-2. Well development details and field water quality parameters are the end of development summarised in Table A-5 below. BH4 was developed successfully with rapid recharge to the well noted, and water quality parameters stabilising rapidly. BH3 was observed during development to be low yielding with the bore going dry after 10 L was removed on the 14/12/2023. The bore was left to recover overnight to allow groundwater levels to recover before being bailed dry again the following day (15/12/2023). A sample was collected on the 16/12/2023 after an additional 2 L was removed.

It should be noted that field parameters did not stabilise at BH3 over the available development time, therefore values noted below may not be representative of groundwater conditions in the vicinity of the well.

Table A-5. Summary of field parameters and observations

Bore ID	Date	T (°C)	DO (mg/L)	pH	EC (uS/cm)	ORP (mV)
BH3	16/12/2023	17.1	4.98	6.35	585.5	-38.2
BH4	14/12/2023	19.0	4.35	6.59	5785	-84.2

A.3.3 Hydraulic testing

Slug test results are summarised in Table A-6 AQTESOLV (v4.50.002) curve fitting graphs are included in Section A.7. The derived hydraulic conductivity from tested wells varied from 0.002 to 0.7 m/d. The results are provided are within the typical range expected for alluvial sediments. Where multiple tests at each well were undertaken, an average of the resulting estimates of K was used to give an overall estimate of hydraulic conductivity for the tested interval.

Table A-6. Slug test results

Test ID	Test type	Test duration	K (m/d)	Average (m/d)
BH3 – Test 1	Falling head test[1]	30 mins	0.002	0.002
BH4 – Test 1	Falling head test	19 mins	0.05	0.1
	Rising head test	20 mins	0.15	
BH4 – Test 2	Falling head test	20 mins	0.04	
	Rising head test	14 mins	0.13	
BH201 – Test 1	Falling head test	12 mins	0.33	0.5
	Rising head test	6 mins	0.69	
BH201 – Test 2	Falling head test	9 mins	0.46	
	Rising head test	6 mins	0.58	

Notes: 1 – Test terminated after 30 min due to minimal recovery

A.3.4 Groundwater quality

A.3.4.1 Field parameters

Water quality parameters measured prior to sampling are summarised in Table A-7. The groundwater quality sample collected from BH201 on the 15/12/2023 is considered more reliable as more than 10 well volumes were removed and groundwater quality parameters had stabilised prior to sampling. BH3 was allowed to recover overnight after being bailed dry on the 14/12/2023 and 15/12/2023 before a sample was collected on the 16/12/2023, however, water quality parameters had not stabilised.

Table A-7. Field water quality parameters (sampling)

Bore ID	Date	T (°C)	DO (mg/L)	pH	EC (uS/cm)	ORP (mV)
BH3	16/12/2023	19.5	17.1	4.98	585	-38.2
BH4	15/12/2023	19.5	2.83	6.47	5621	-74.8
BH201a	14/12/2023	30.7	12.2	6.50	1493	-92.0
BH201b	15/12/2023	18.0	1.59	6.44	1189	-96.3

A.3.4.2 Laboratory Analysis

Analytes were assessed against adopted guidelines for this field investigation. Analyte concentrations in all samples were compared to ANZECC 2000 Stock Watering, ANZECC 1992 Industrial Water Use, AS2159-2009 Piling – Design and Installation (Buildings & Structures) ANZG (2018) Freshwater (FW) 95% toxicant DGVs and ANZECC PFAS FW 95% National Guidelines. Exceedances against adopted guideline values are summarised in Table A-8 and Table A-9 below. A complete summary of all analytical results has been provided in Section A.10. All other analytes were found to be within the adopted investigation guidelines.

Table A-8. Summary of groundwater quality exceedances - ANZECC 2000 Stock Watering

Analyte	Sodium (filtered) (mg/L)
Guideline exceeded	ANZECC 2000 Stock Watering
Guideline value (mg/L)	230
BH4	**526**

Table A-9. Summary of groundwater quality exceedances - ANZG (2018) Freshwater 95% toxicant DGVs

Analyte	Copper (filtered)	Lead (filtered)	Nickel (filtered)	Zinc (filtered)
Guideline exceeded	ANZG (2018) Freshwater 95% toxicant DGVs			
Guideline value (ug/L)	1.4	3.4	11	8
BH3	2	<1	5	8
BH4	13	18	14	35
BH201a	13	2	22	18
BH201b	1	<1	19	<5

A.3.4.3 Laboratory Analysis Quality Control (QA/QC)

One (1) duplicate pair and four (4) primary samples were collected as part of the routine groundwater monitoring program. The sample and QAQC results were reported in laboratory reports from the primary laboratory (ALS) and from the secondary laboratory (Eurofins).

The complete list of RPDs is provided at the conclusion of this report in Section A.11. In summary:

- 3 of 73 blind duplicate RPDs did not meet acceptance limits (95.8% completeness)
- 4 of 57 split duplicate RPDs did not meet acceptance limits (92.9% completeness)
- Overall, 7 of 130 duplicate RPDs did not meet acceptance limits (94.6% completeness)

For blind and split duplicates, the RPDs outside acceptance limits were inorganic analytes (phosphorus and TRHs), with additional exceedances noted for Nitrate (as N) and turbidity. For the remaining outliers, the intralab duplicates were within acceptance limits, therefore no material impact is expected in this investigation.

The data quality assessment reported no significant issues that may have any weight on the wider field investigation. The assessment is based upon the results reported in these laboratory certificates and associated QC reports in Section A.9 of this factual report. The complete QA/QC assessment if included as Section A.11 of this report.

A.4 References

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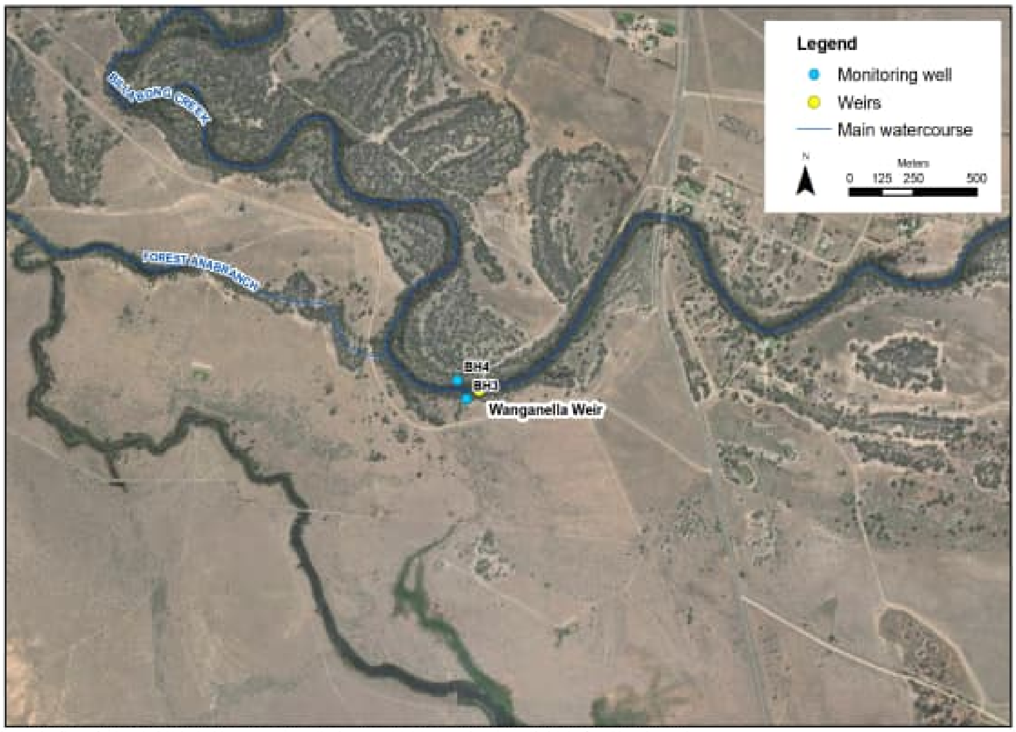
A.5 Figures



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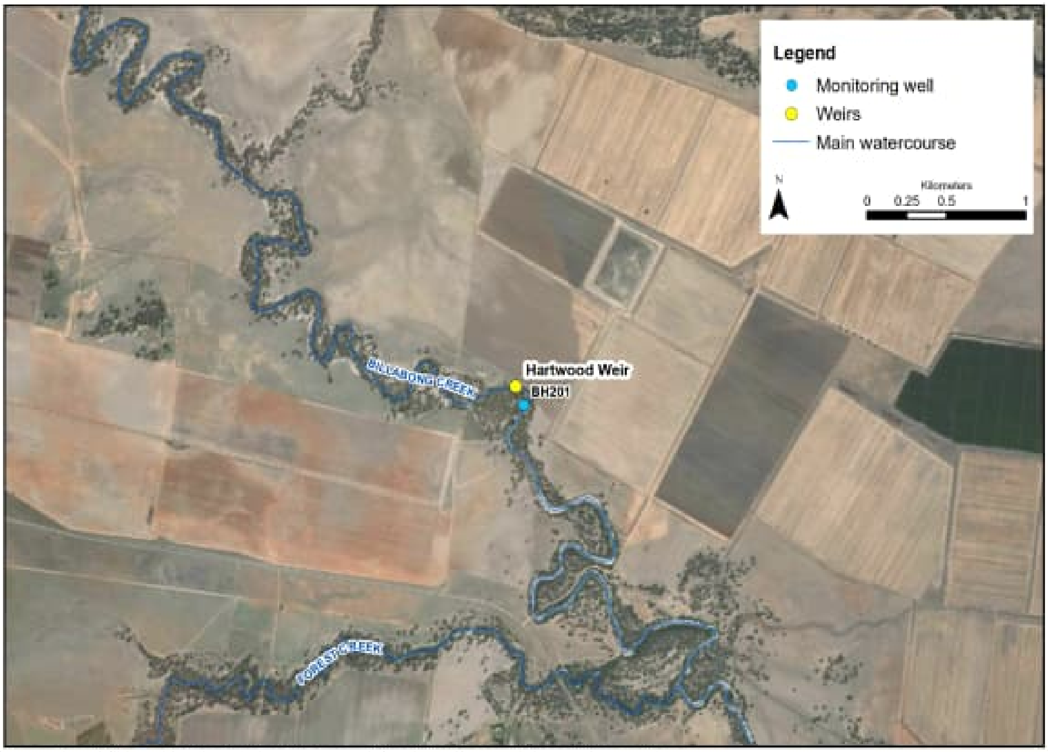
Location of existing Wanganella weir and monitoring well location



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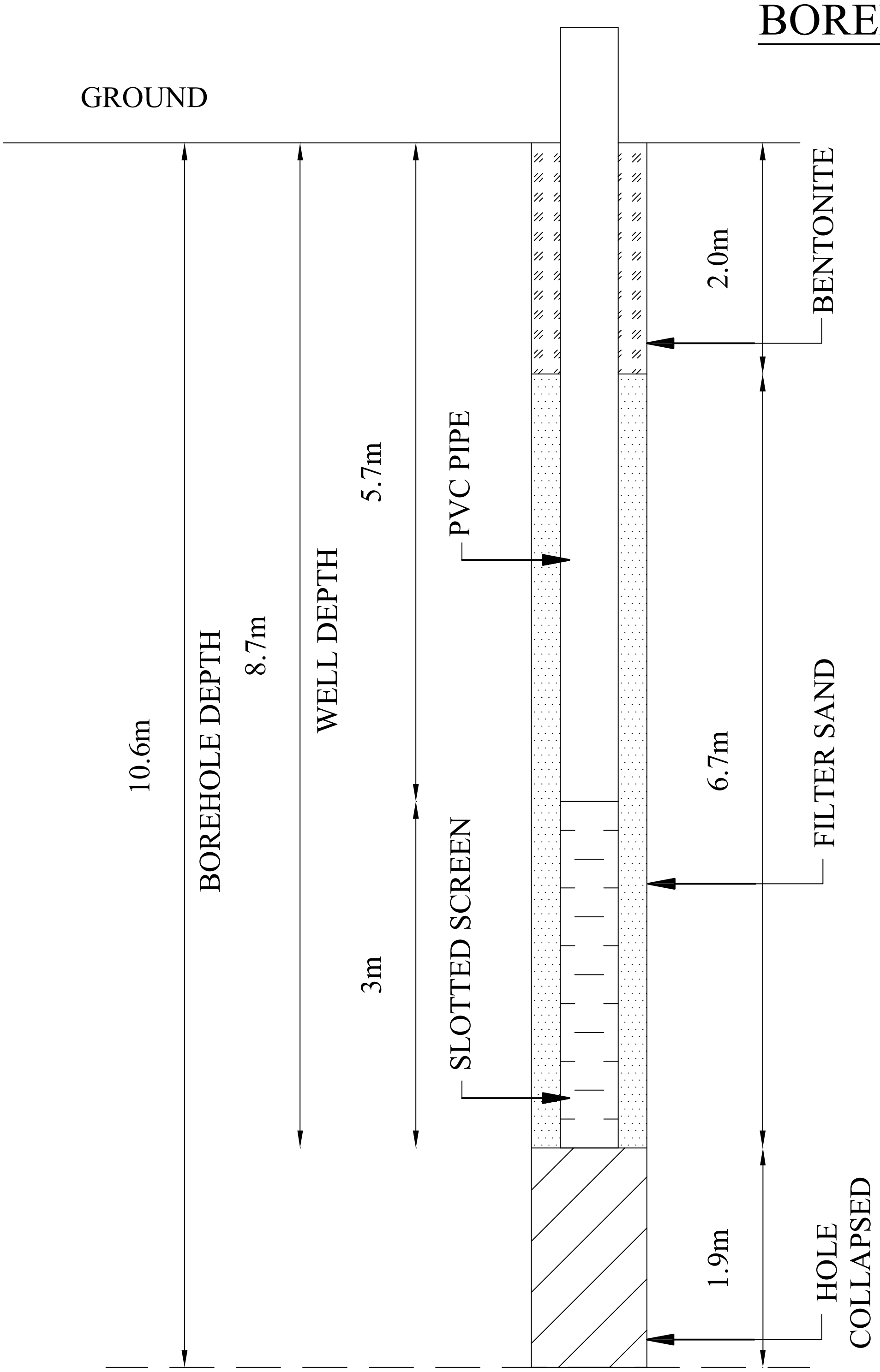
Location of existing Hartwood weir and monitoring well location

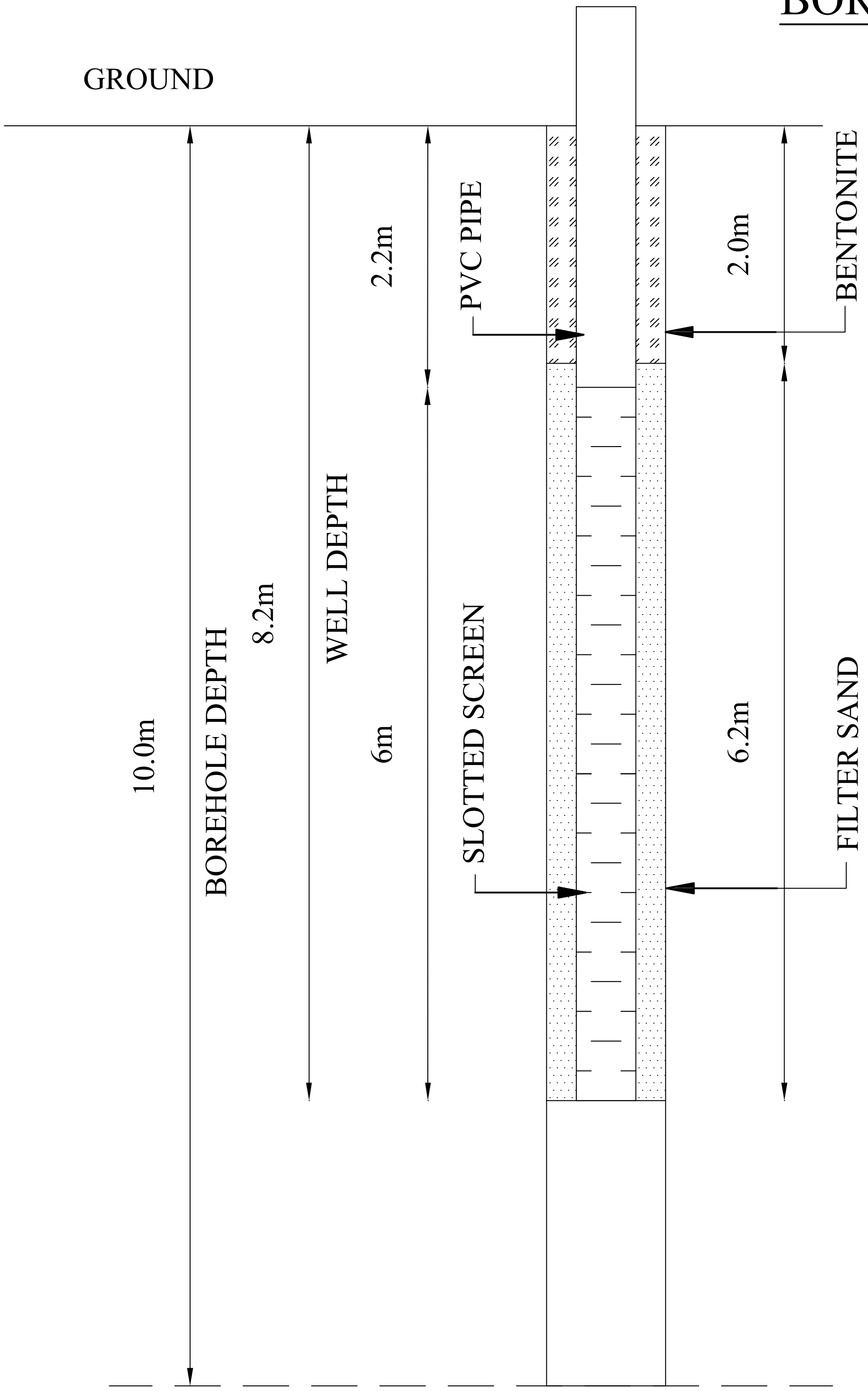
A.6 Bore construction diagrams

BOREHOLE 3



GTS GEOTECHNICAL TESTING SERVICES	**GEOTECHNICAL INVESTIGATION**	**CLIENT:** JACOBS GROUP (AUSTRALIA) PTY LTD **PROJECT:** WANGANELLA WEIR, WANGANELLA	
	APPROXIMATE LOCATIONS NOT TO SCALE	GTS REF: 22C 0012	DATE: 31 MARCH 2022

BOREHOLE 4



GEOTECHNICAL INVESTIGATION

APPROXIMATE LOCATIONS NOT TO SCALE

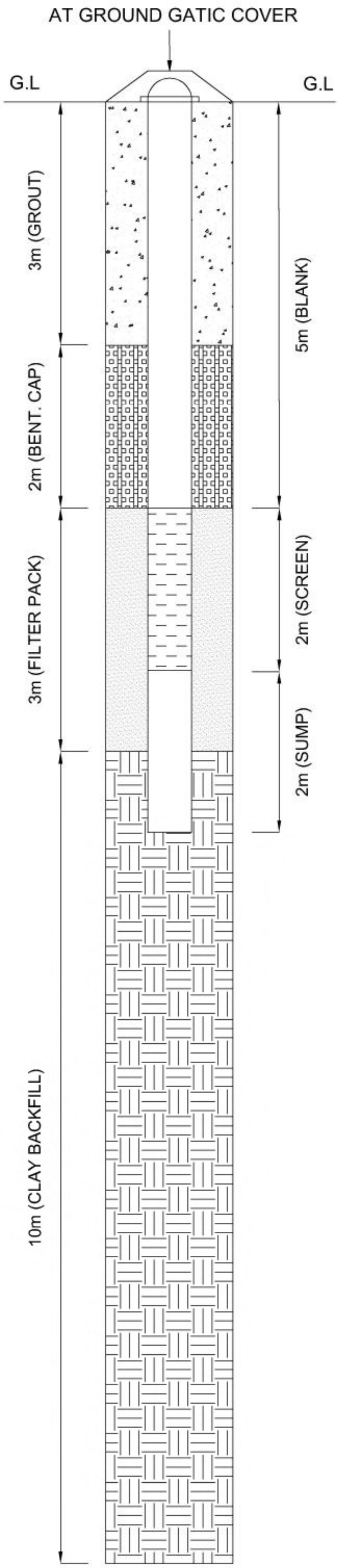
CLIENT: JACOBS GROUP (AUSTRALIA) PTY LTD

PROJECT: WANGANELLA WEIR, WANGANELLA

GTS REF: 22C 0012

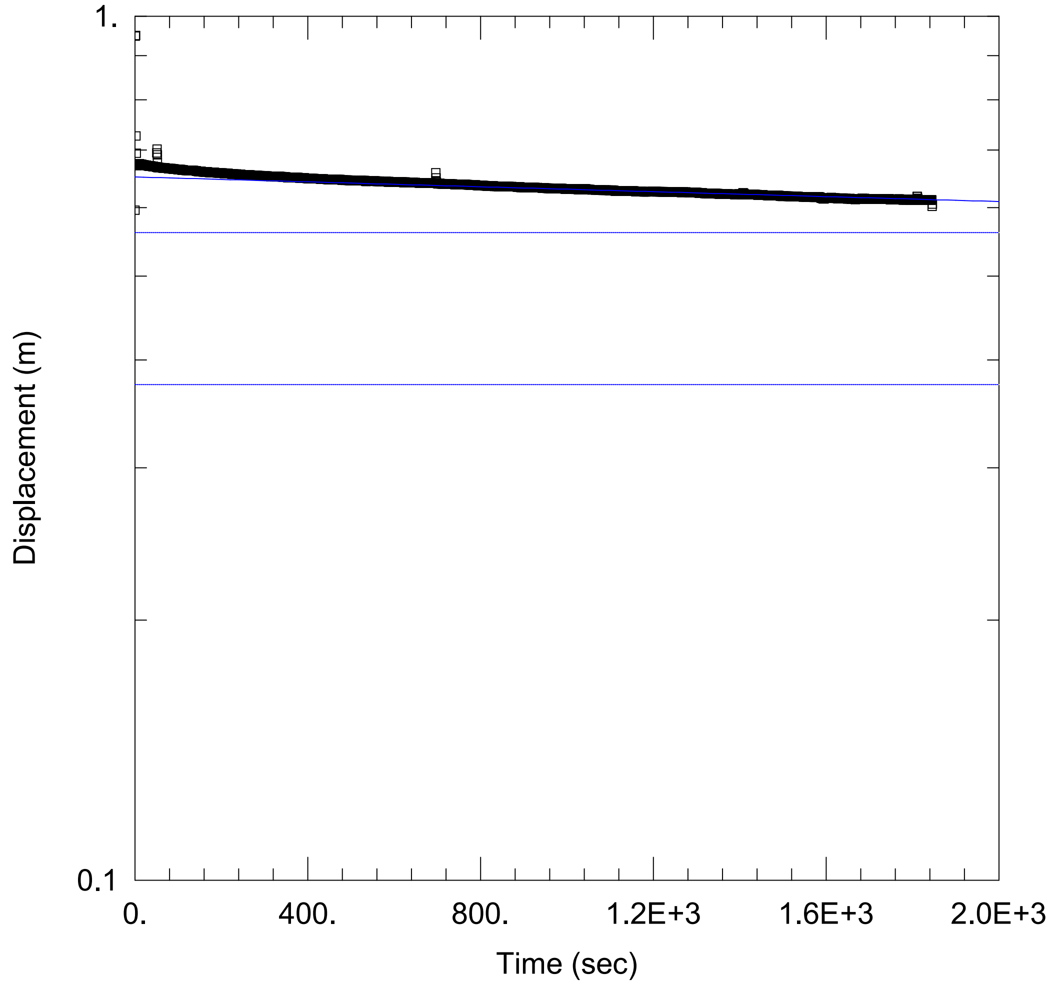
DATE: 31 MARCH 2022

BOREHOLE 201



GTS GEOTECHNICAL TESTING SERVICES	GEOTECHNICAL INVESTIGATION	CLIENT: JACOBS AUSTRALIA PROJECT: HARTWOOD REGULATOR - BH201 WELL DIAGRAM	
	APPROXIMATE LOCATIONS NOT TO SCALE	GTS REF: 23C 0508-2 CLIENT REF:	DRAWN BY: ED DATE: 1 NOVEMBER 2023

A.7 Slug test results



BH3 FHT 1

Data Set: C:\...\BH3_FHT_1.aqt
Date: 02/19/24 Time: 11:07:33

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Wanganella, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH3 FHT 1)

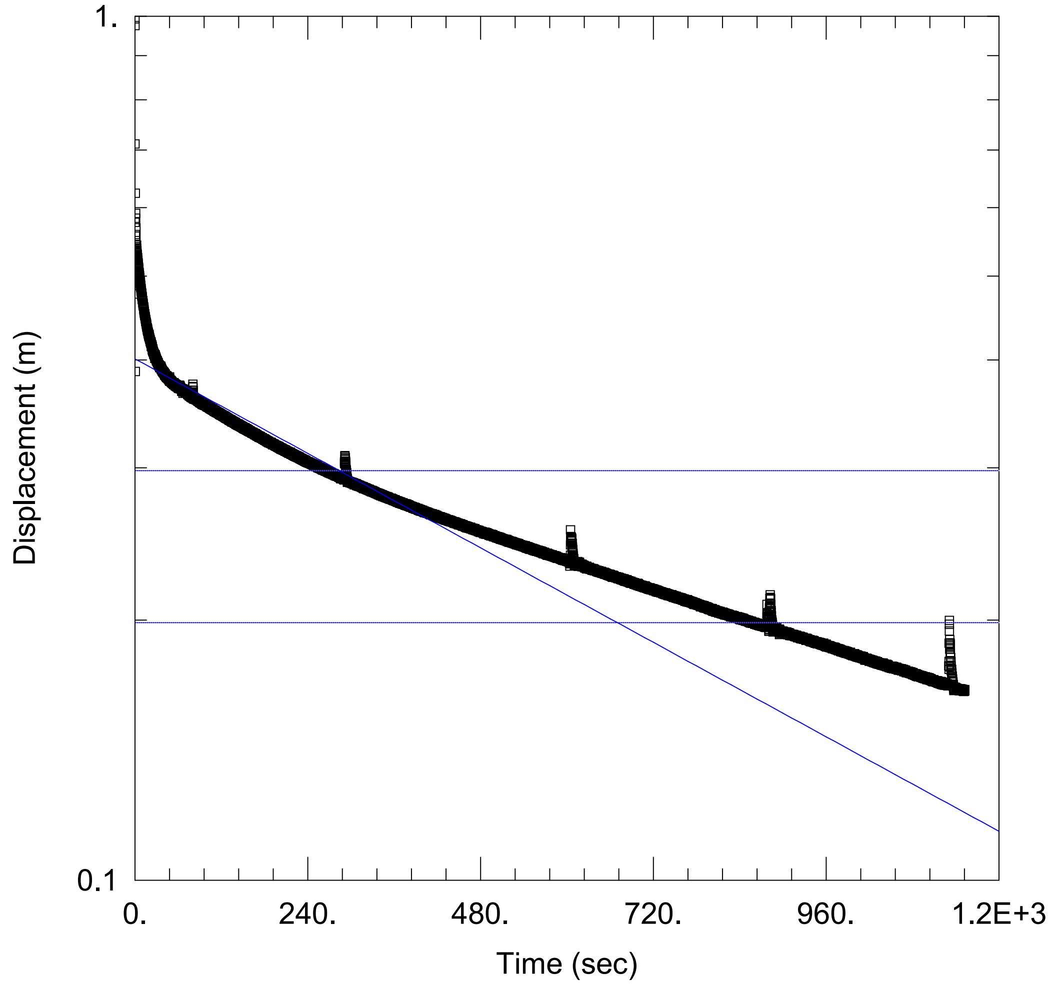
Initial Displacement: 1.872 m
Total Well Penetration Depth: 1.99 m
Casing Radius: 0.025 m

Static Water Column Height: 1.99 m
Screen Length: 1.99 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.00242 m/day y0 = 0.6514 m



BH4 FHT 1

Data Set: C:\...\BH4_FHT_1.aqt
Date: 02/18/24 Time: 16:44:56

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Wanganella, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH4)

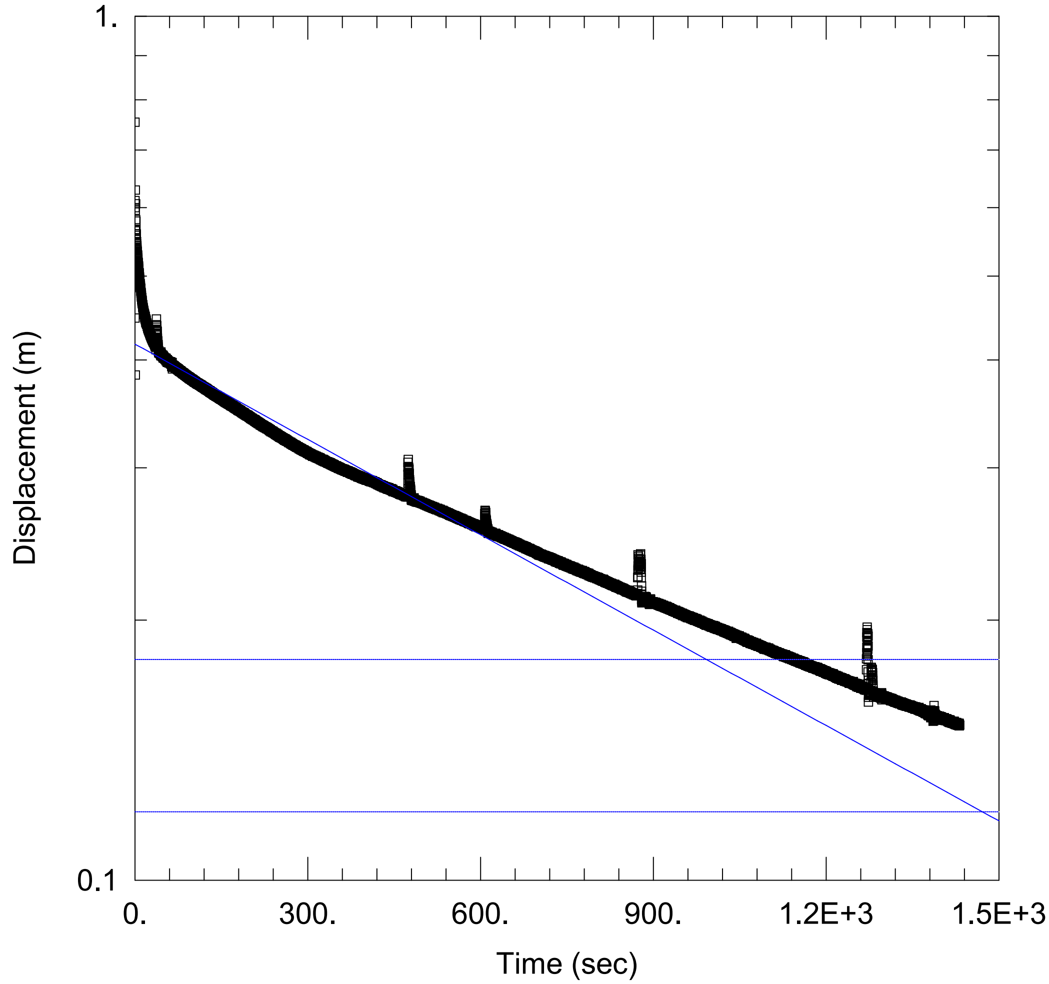
Initial Displacement: 0.9929 m
Total Well Penetration Depth: 3.78 m
Casing Radius: 0.025 m

Static Water Column Height: 3.78 m
Screen Length: 3.78 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.04791 m/day y0 = 0.4011 m



BH4 FHT 2

Data Set: C:\...\BH4_FHT_2.aqt
Date: 02/18/24 Time: 16:45:15

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Wanganella, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 0.1

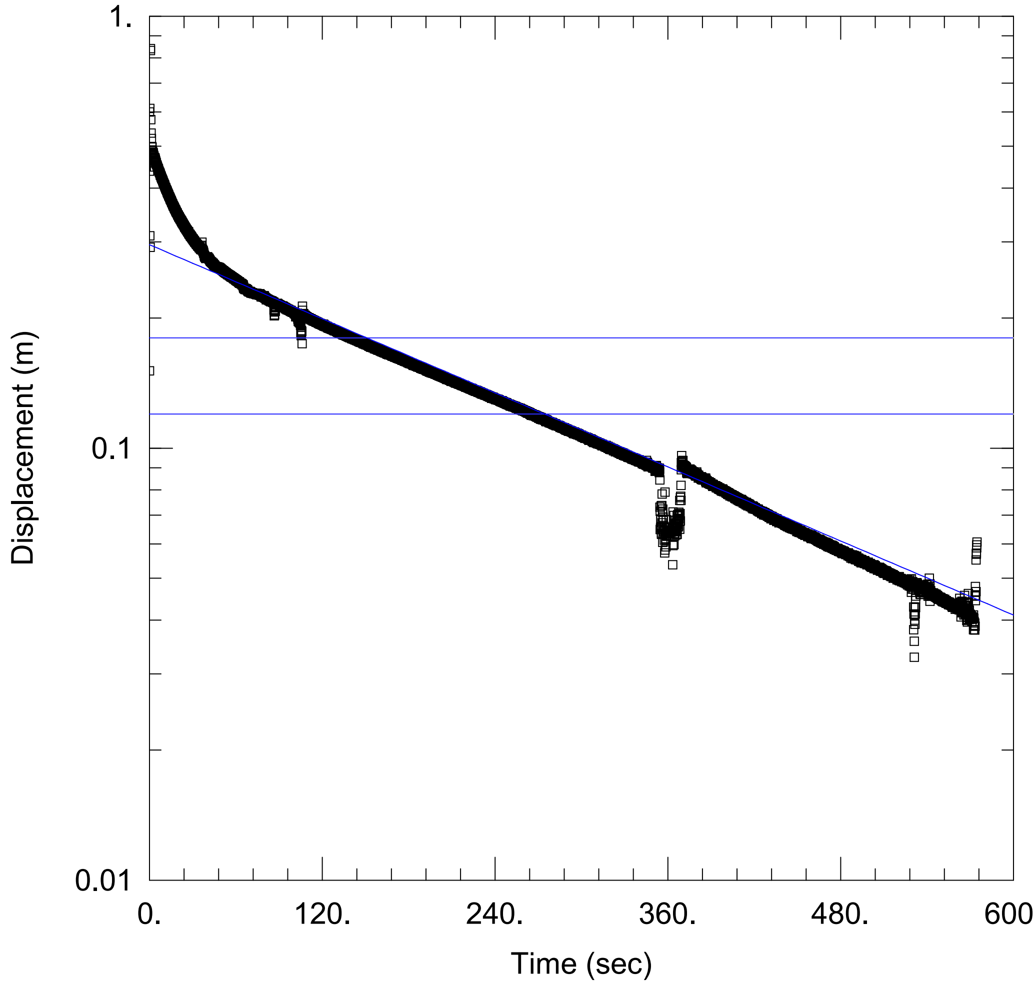
WELL DATA (BH4)

Initial Displacement: 0.6 m
Total Well Penetration Depth: 3.78 m
Casing Radius: 0.025 m
Static Water Column Height: 3.78 m
Screen Length: 3.78 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.03869 m/day y0 = 0.4172 m



BH4 RHT 1

Data Set: C:\...\BH4_RHT_1.aqt
Date: 02/18/24
Time: 16:45:33

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Wanganella, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m
Anisotropy Ratio (Kz/Kr): 0.1

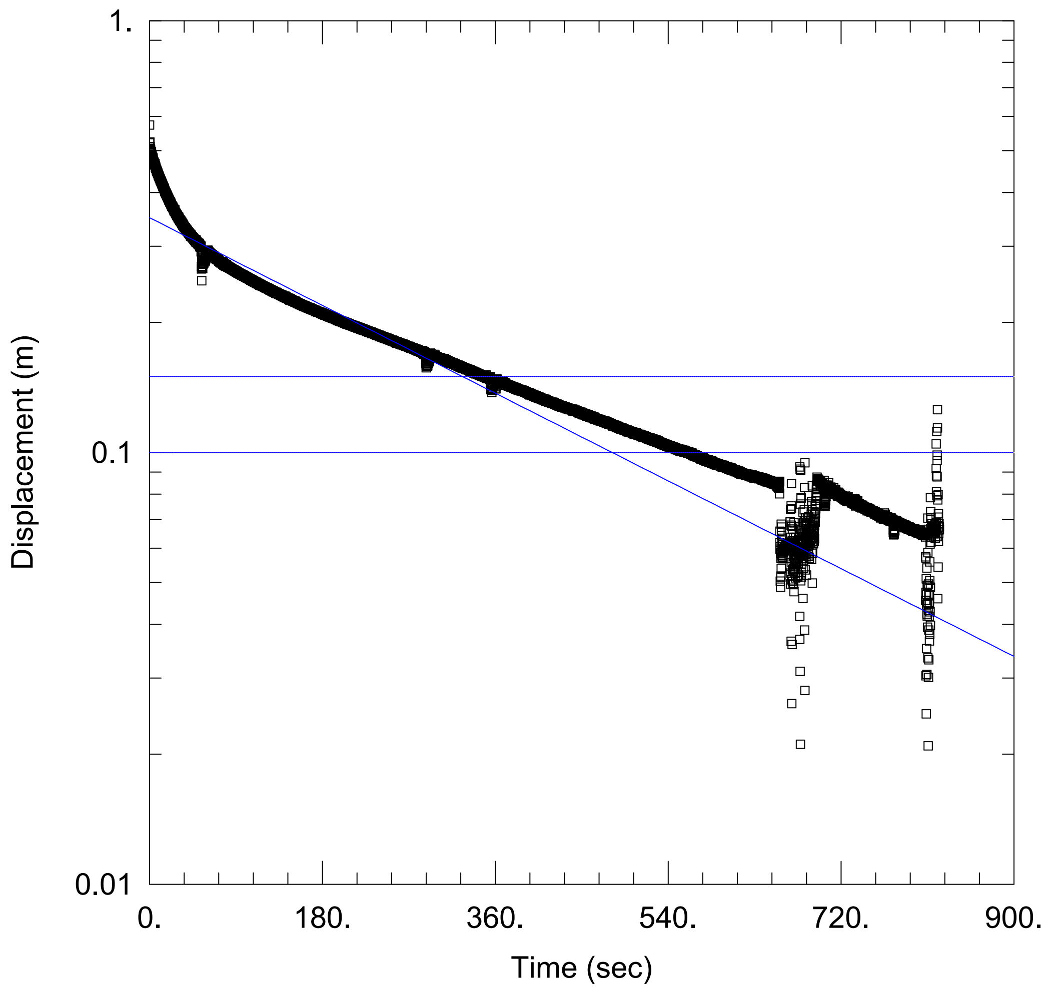
WELL DATA (BH4)

Initial Displacement: 0.6 m
Total Well Penetration Depth: 3.78 m
Casing Radius: 0.025 m
Static Water Column Height: 3.78 m
Screen Length: 3.78 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1503 m/day
y0 = 0.2957 m



BH4 RHT 2

Data Set: C:\...\BH4_RHT_2.aqt
Date: 02/18/24
Time: 16:45:51

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Wanganella, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m
Anisotropy Ratio (Kz/Kr): 0.1

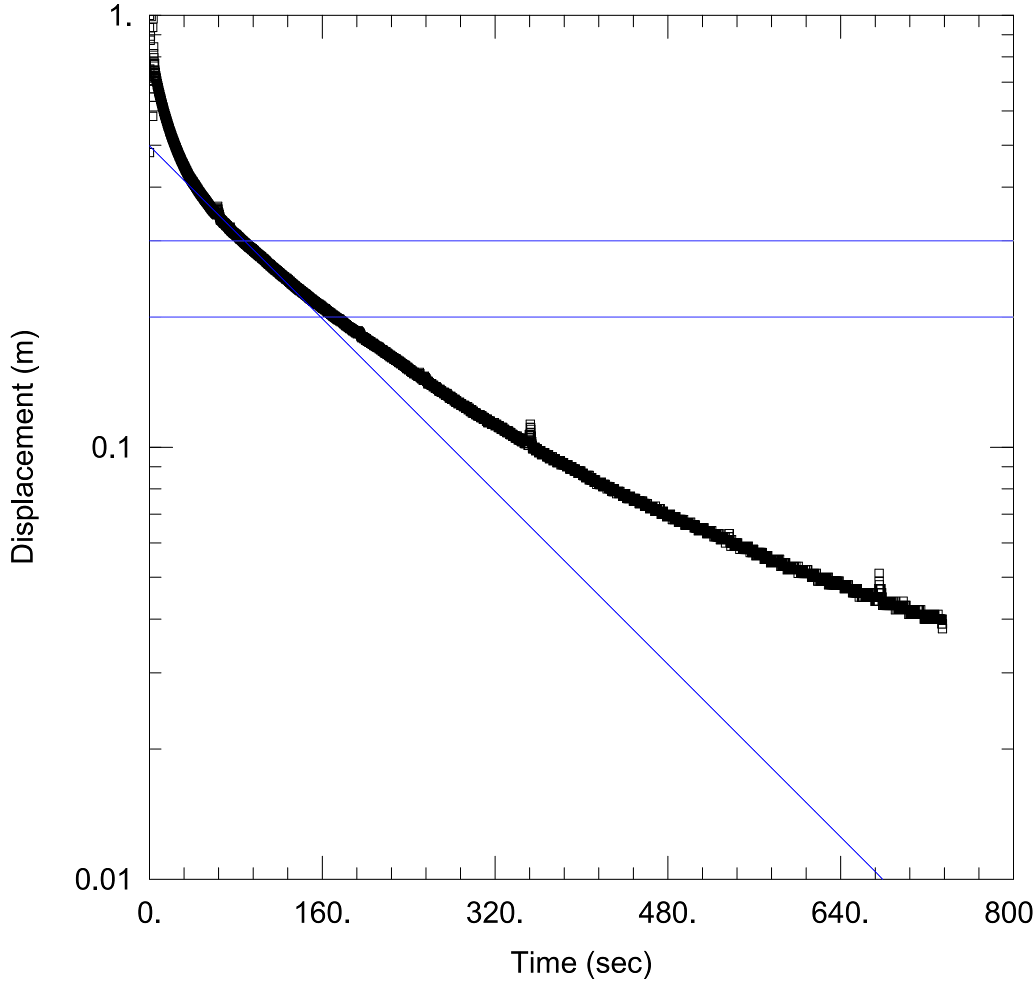
WELL DATA (BH4)

Initial Displacement: 0.5 m
Total Well Penetration Depth: 3.47 m
Casing Radius: 0.025 m
Static Water Column Height: 3.47 m
Screen Length: 3.47 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.1266 m/day
y0 = 0.3496 m



BH201 FHT 1

Data Set: C:\...\BH201_FHT_1.aqt
Date: 02/18/24
Time: 16:43:08

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Hartwood, NSW
Test Well: BH201
Test Date: 14/12/23

AQUIFER DATA

Saturated Thickness: 15. m
Anisotropy Ratio (Kz/Kr): 0.1

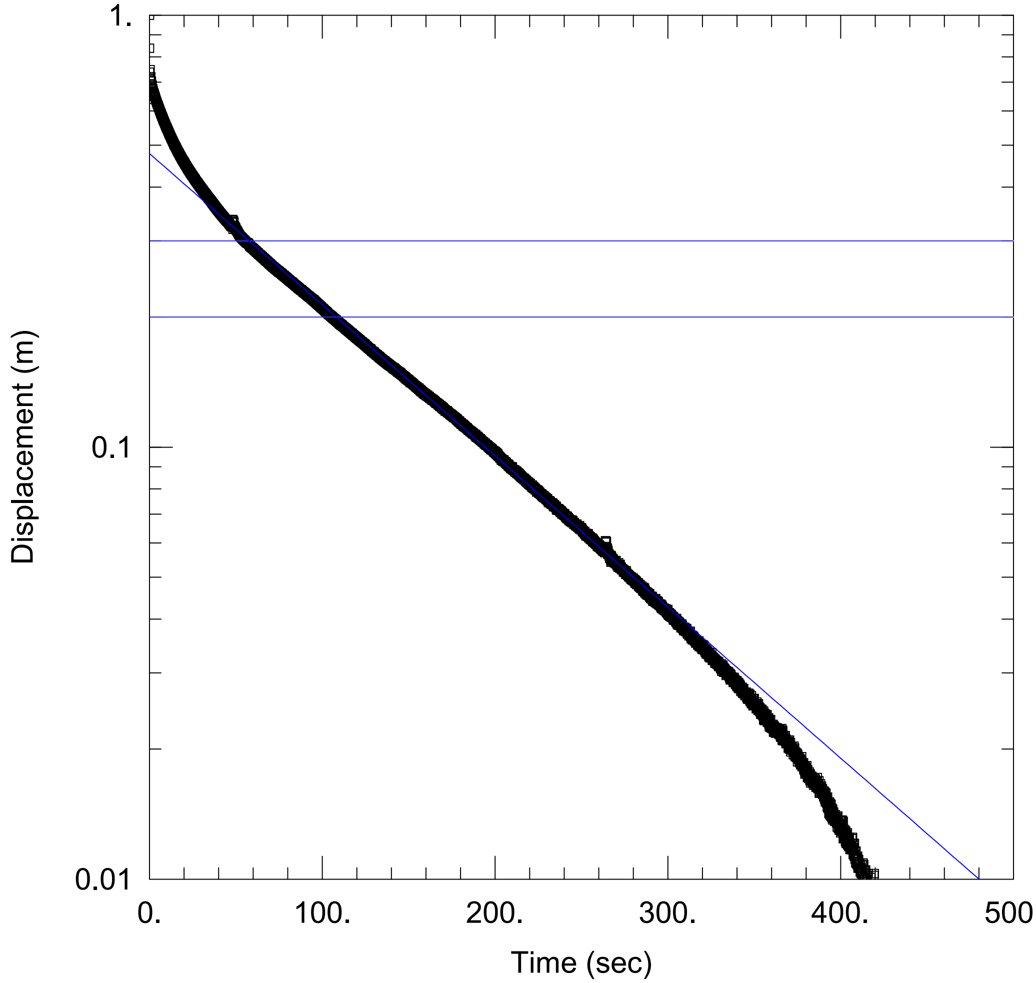
WELL DATA (BH201)

Initial Displacement: 1. m
Static Water Column Height: 2.77 m
Total Well Penetration Depth: 2.77 m
Screen Length: 2.77 m
Casing Radius: 0.025 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.3323 m/day
y0 = 0.4983 m



BH201 FHT 2

Data Set: C:\...\BH201_FHT_2.aqt
Date: 02/18/24 Time: 16:43:28

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Hartwood, NSW
Test Well: BH201
Test Date: 14/12/23

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 0.1

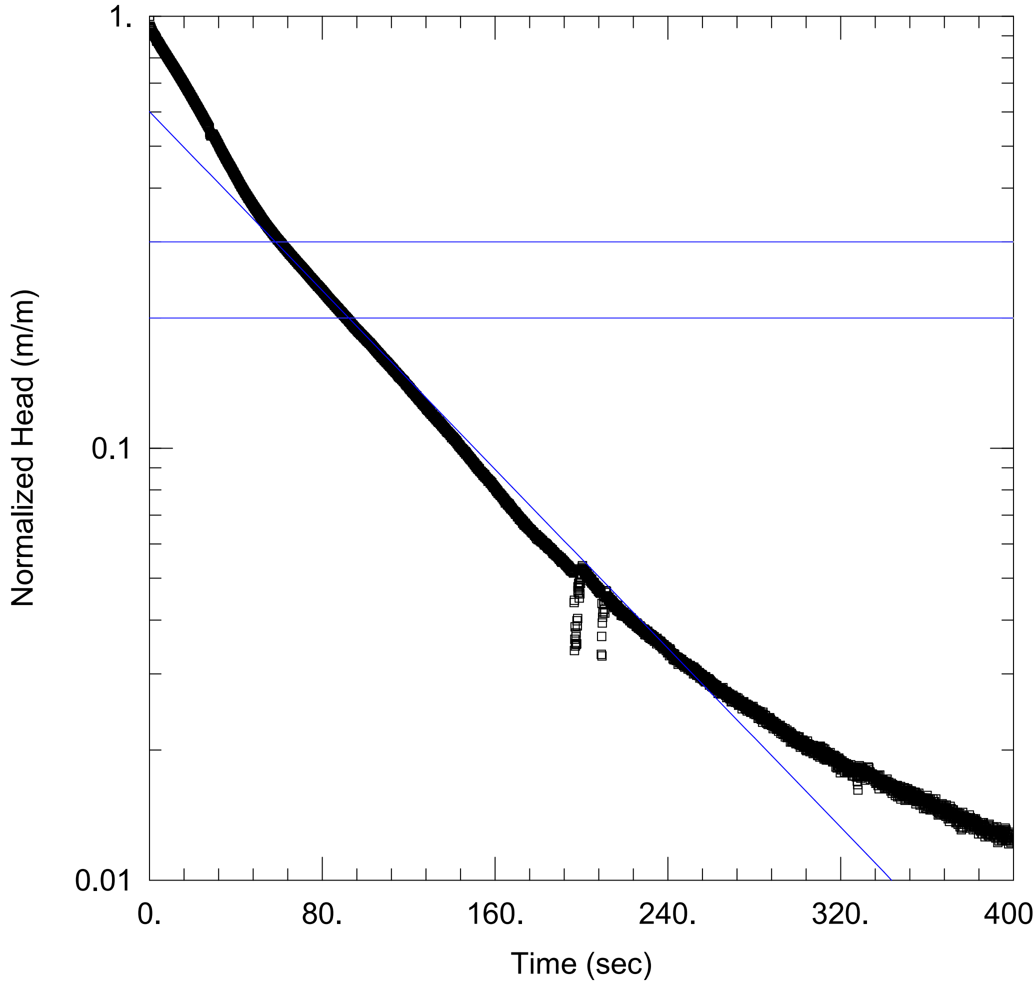
WELL DATA (BH201)

Initial Displacement: 1. m
Total Well Penetration Depth: 2.77 m
Casing Radius: 0.025 m
Static Water Column Height: 2.77 m
Screen Length: 2.77 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.4651 m/day y0 = 0.4781 m



BH201 RHT 1

Data Set: C:\...\BH201_RHT_1.aqt
Date: 02/19/24
Time: 11:13:36

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Hartwood, NSW
Test Well: BH4
Test Date: 15/12/23

AQUIFER DATA

Saturated Thickness: 15. m
Anisotropy Ratio (Kz/Kr): 0.1

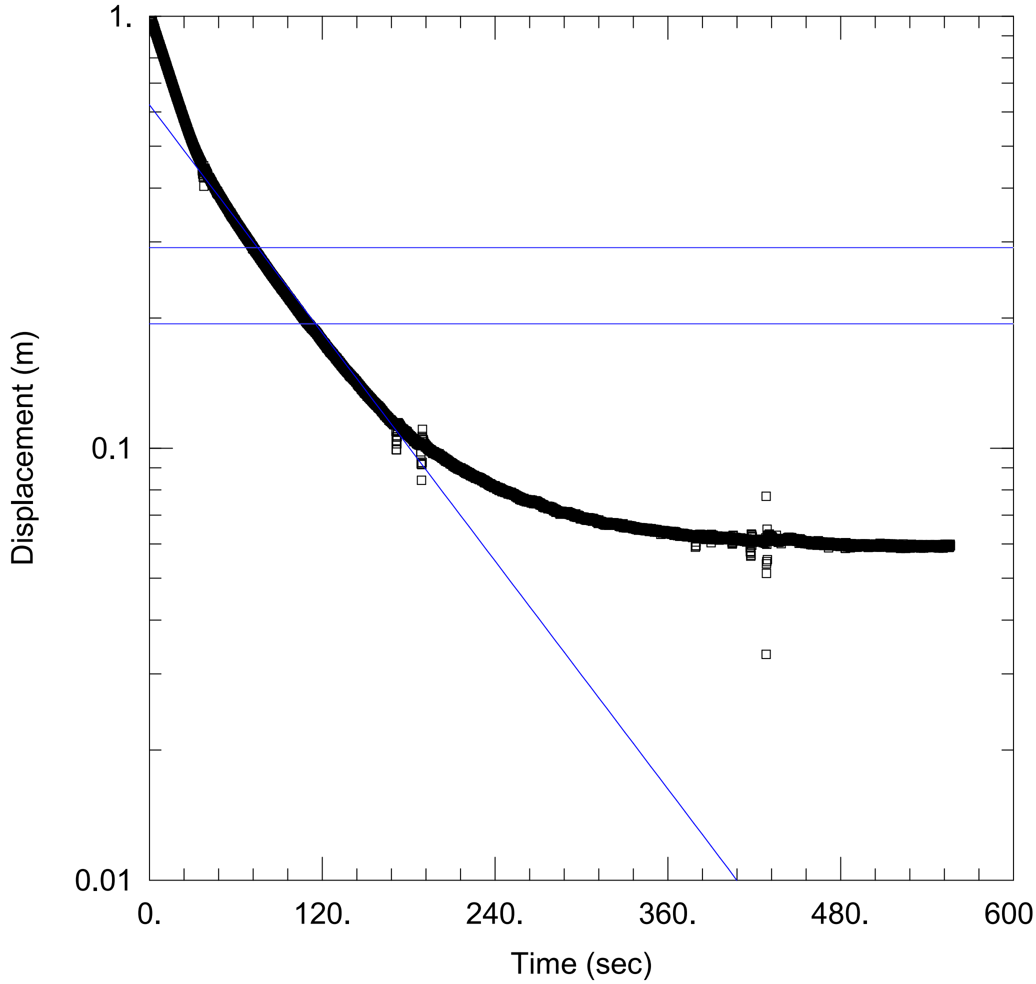
WELL DATA (BH201)

Initial Displacement: 1.039 m
Total Well Penetration Depth: 2.77 m
Casing Radius: 0.025 m
Static Water Column Height: 2.77 m
Screen Length: 2.77 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 0.688 m/day
y0 = 0.6246 m



BH201 RHT 2

Data Set: C:\...\BH201_RHT_2.aqt
Date: 02/18/24 Time: 16:44:14

PROJECT INFORMATION

Company: Jacobs Group (Australia)
Client: DPE
Project: IW238436
Location: Hartwood, NSW
Test Well: BH4
Test Date: 14/12/23

AQUIFER DATA

Saturated Thickness: 15. m Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (BH201)

Initial Displacement: 0.97 m
Total Well Penetration Depth: 2.77 m
Casing Radius: 0.025 m

Static Water Column Height: 2.77 m
Screen Length: 2.77 m
Well Radius: 0.05 m
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Bouwer-Rice

K = 0.5846 m/day y0 = 0.6227 m

A.8 Chain of Custody

ALS Environmental

CHAIN OF CUSTODY

ALS Laboratory: please tick →

☐ADELAIDE 21 Burma Road Pooraka SA 5095 Ph: 08 8359 0890 E: adelaide@alsglobal.com
☐BRISBANE 32 Shand Street Stafford QLD 4053 Ph: 07 3243 7222 E: samples.brisbane@alsglobal.com
☐GLADSTONE 46 Callemondah Drive Clinton QLD 4680 Ph: 07 7471 5600 E: gladstone@alsglobal.com
☐MACKAY 78 Harbour Road Mackay QLD 4740 Ph: 07 4944 0177 E: mackay@alsglobal.com
☐MELBOURNE 2-4 Westall Road Springvale VIC 3171 Ph: 03 8549 9600 E: samples.melbourne@alsglobal.com
☐MUDGEE 27 Sydney Road Mudgee NSW 2850 Ph: 02 6372 6735 E: mudgee.mail@alsglobal.com
☐NEWCASTLE 5/585 Maitland Rd Mayfield West NSW 2304 Ph: 02 4014 2500 E: samples.newcastle@alsglobal.com
☐NOWRA 4/13 Geary Place North Nowra NSW 2541 Ph: 024423 2063 E: nowra@alsglobal.com
☐PERTH 10 Hod Way Malaga WA 6090 Ph: 08 9209 7655 E: samples.perth@alsglobal.com
☐SYDNEY 277-289 Woodpark Road Smithfield NSW 2164 Ph: 02 8784 8555 E: samples.sydney@alsglobal.com
☐TOWNSVILLE 14-15 Desma Court Bohle QLD 4818 Ph: 07 4796 0600 E: townsville.environmental@alsglobal.com
☐WOLLONGONG 99 Kenny Street Wollongong NSW 2500 Ph: 02 4225 3125 E: portkembla@alsglobal.com

CLIENT: Jacobs
OFFICE:
PROJECT: IW238424
ORDER NUMBER:
PROJECT MANAGER:
CONTACT PH:
SAMPLER: Jacobs
SAMPLER MOBILE:
COC emailed to ALS? (YES) / NO
EDD FORMAT (or default):
Email Reports to (will default to PM if no other addresses are listed): tom.cocks@jacobs.com *1
Email Invoice to (will default to PM if no other addresses are listed): *
COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: *1 erin.mcintosh@jacobs.com & nim.udawatta@jacobs.com

TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)

Custody Seal Intact?	Yes	No	N/A
Free ice / frozen ice bricks present upon receipt?	Yes	No	N/A
Random Sample Temperature on Receipt:		°C	
Other comment:			

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
[signature]			Richard Baez
DATE/TIME: 18/12/2023	DATE/TIME:	DATE/TIME:	DATE/TIME: 18/12/23 – 12:21

ALS USE	SAMPLE DETAILS MATRIX: SOLID (S) WATER (W)			CONTAINER INFORMATION		ANALYSIS REQUIRED including SUITES (NB. Suite Codes must be listed to attract suite price) Where Metals are required, specify Total (unfiltered bottle required) or Dissolved (field filtered bottle required)								Additional Information
LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	[crossed out]	TRH, BTEXN PAH	8 metals (dissolved)	TDS	major cations & anions	Nutrients	PFAS (short suite)		Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.
1	BH201	14/12/2023	W		8		✓	✓	✓	✓	✓	✓		
2	Dup_1	14/12/2023	↓		↓		↓	↓	↓	↓	↓	↓		
→ 3	Trip_1	14/12/2023												* Send to Eurofins
4	BH4	15/12/2023												lab QC
5	QC_1	14/12/2023												lab QC
6	QC_2	15/12/2023												lab QC
7	QC_3	15/12/2023												
8	BH201	15/12/2023												
9	BH3	16/12/2023	↓		↓		↓	↓	↓	↓	↓	↓		Sample bottles labelled as 15/12/2023 (this is incorrect)

Environmental Division
Melbourne
Work Order Reference
EM2322584
Telephone : + 61-3-8549 9600

Samples sent to lab fc
Micro (Nitrate) BOD pH
Colour Turbidity RP
Other
Date 18/12, BL

* All samples were taken in December not october as send on sample bottles

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserv... m Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Pres... rved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag ...

Report: 1055286
19/12 BF

CHAIN OF CUSTODY

ALS Laboratory: please tick →

294

CLIENT: Jacobs
OFFICE:
PROJECT: IW238424
ORDER NUMBER:
PROJECT MANAGER:
SAMPLER: Jacobs
COC emailed to ALS? (YES) / NO
Email Reports to (will default to PM if no other addresses are listed): tom.cocks@jacobs.com *1
Email Invoice to (will default to PM if no other addresses are listed): #

TURNAROUND REQUIREMENTS: (Standard TAT may be longer for some tests e.g.. Ultra Trace Organics)
☐ Standard TAT (List due date):
☐ Non Standard or urgent TAT (List due date):
ALS QUOTE NO.:
CONTACT PH:
SAMPLER MOBILE:
EDD FORMAT (or default):

COC SEQUENCE NUMBER (Circle)
COC: 1 2 3 4 5 6 7
OF: 1 2 3 4 5 6 7

FOR LABORATORY USE ONLY (Circle)
Custody Seal Intact? Yes No N/A
Free ice / frozen ice bricks present upon receipt? Yes No N/A
Random Sample Temperature on Receipt: °C
Other comment:

RELINQUISHED BY: [signature]
DATE/TIME: 18/12/2023
RECEIVED BY:
DATE/TIME:
RELINQUISHED BY:
DATE/TIME:
RECEIVED BY: Richard Baez
DATE/TIME: 18/12/23 - 12:2

COMMENTS/SPECIAL HANDLING/STORAGE OR DISPOSAL: *1 erin.mcintosh@jacobs.com & nim.udawatta@jacobs.com

ALS USE LAB ID	SAMPLE ID	DATE / TIME	MATRIX	TYPE & PRESERVATIVE (refer to codes below)	TOTAL CONTAINERS	TRH, BTEXN, PAH	8 metals (dissolved)	TDS	major cations & anions	Nutrients	PFAS (short suite)	Additional Information (Comments on likely contaminant levels, dilutions, or samples requiring specific QC analysis etc.)
1	BH201	14/12/2023	W		8	✓	✓	✓	✓	✓	✓	
2	Dup_1	14/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	
→ 3	Trip_1	14/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	*Send to Eurofins
4	BH4	15/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	lab QC
5	QC_1	14/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	lab QC
6	QC_2	15/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	lab QC
7	QC_3	15/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	
8	BH201	15/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	
9	BH3	16/12/2023	↓		↓	↓	↓	↓	↓	↓	↓	Sample bottles labelled as 15/12/2023 (this is incorrect)

*All samples were taken in December not October as sent on sample bottles

Environmental Division
Melbourne
Work Order Reference
EM2322584

Telephone: + 61-3-8549 9600

DATE: 19/12/23
TIME: 930
COURIER:
TEMPERATURE: 8.2
ATTEMPT TO CHILL: YES NO
SD

18/12, 13L

Water Container Codes: P = Unpreserved Plastic; N = Nitric Preserved Plastic; ORC = Nitric Preserve...
V = VOA Vial HCl Preserved; VB = VOA Vial Sodium Bisulphate Preserved; VS = VOA Vial Sulfuric Pres...
Z = Zinc Acetate Preserved Bottle; E = EDTA Preserved Bottles; ST = Sterile Bottle; ASS = Plastic Bag...
...m Hydroxide Preserved Plastic; AG = Amber Glass Unpreserved; AP - Airfreight Unpreserved Plastic
...rved Amber Glass; H = HCl preserved Plastic; HS = HCl preserved Speciation bottle; SP = Sulfuric Preserved Plastic; F = Formaldehyde Preserved Glass;

A.9 Laboratory reports

CERTIFICATE OF ANALYSIS

Work Order	: **EM2322584**	Page	: 1 of 13
Client	: **JACOBS GROUP(AUSTRALIA)PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MS ERIN MCINTOSH	Contact	: Peter Ravlic
Address	: PO BOX 312 FLINDERS LANE MELBOURNE VIC AUSTRALIA 8009	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 07 3026 7100	Telephone	: +6138549 9645
Project	: IW238424	Date Samples Received	: 18-Dec-2023 12:21
Order number	: IW238424	Date Analysis Commenced	: 19-Dec-2023
C-O-C number	: ----	Issue Date	: 27-Dec-2023 16:03
Sampler	: JACOBS		
Site	: ----		
Quote number	: EN/000		
No. of samples received	: 9		
No. of samples analysed	: 8		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Laboratory Coordinator	Melbourne Inorganics, Springvale, VIC
Nancy Wang	2IC Organic Chemist	Melbourne Organics, Springvale, VIC

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contract for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EP080: Particular samples EM2322584_001 shows positive hit of C6-C9/C6-C10 band due to 2-Butanone (MEK).
- EP075 (SIM): Where reported, Benzo(a)pyrene Toxicity Equivalent Quotient (TEQ) per the NEPM (2013) is the sum total of the concentration of the eight carcinogenic PAHs multiplied by their Toxicity Equivalence Factor (TEF) relative to Benzo(a)pyrene. TEF values are provided in brackets as follows: Benz(a)anthracene (0.1), Chrysene (0.01), Benzo(b+j) & Benzo(k)fluoranthene (0.1), Benzo(a)pyrene (1.0), Indeno(1.2.3.cd)pyrene (0.1), Dibenz(a.h)anthracene (1.0), Benzo(g.h.i)perylene (0.01). Less than LOR results for 'TEQ Zero' are treated as zero.
- EP231X - Per- and Polyfluoroalkyl Substances (PFAS): Samples received in 20ml or 125ml bottles have been tested in accordance with the QSM5.3 compliant, NATA accredited method. 60mL or 250mL bottles have been tested to the legacy QSM 5.1 aligned, NATA accredited method.
- EP080: Where reported, Total Xylenes is the sum of the reported concentrations of m&p-Xylene and o-Xylene at or above the LOR.
- EP075(SIM): Where reported, Total Cresol is the sum of the reported concentrations of 2-Methylphenol and 3- & 4-Methylphenol at or above the LOR.
- As per QWI – EN55-3 Data Interpreting Procedures, Ionic balances are typically calculated using Major Anions - Chloride, Alkalinity and Sulfate; and Major Cations - Calcium, Magnesium, Potassium and Sodium. Where applicable and dependent upon sample matrix, the Ionic Balance may also include the additional contribution of Ammonia, Dissolved Metals by ICPMS and H+ to the Cations and Nitrate, SiO2 and Fluoride to the Anions.
- ED041G: EM2322584 #1 and #2, Samples have been diluted prior to analysis and LOR have been raised accoridngly.
- EA015H: EM2322584 #1-2 TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.
- Ionic Balance out of acceptable limits for sample #2 due to analytes not quantified in this report.
- Sodium Adsorption Ratio (where reported): Where results for Na, Ca or Mg are <LOR, a concentration at half the reported LOR is incorporated into the SAR calculation. This represents a conservative approach for Na relative to the assumption that <LOR = zero concentration and a conservative approach for Ca & Mg relative to the assumption that <LOR is equivalent to the LOR concentration.
- EP231: Stable isotope enriched internal standards are added to samples prior to extraction. Target compounds have a direct analogous internal standard with the exception of PFPeS, PFHpA, PFDS, PFTrDA and 10:2 FTS. These compounds use an internal standard that is chemically related and has a retention time close to that of the target compound. The DQO for internal standard response is 50-150% of that established at initial calibration. PFOS is quantified using a certified, traceable standard consisting of linear and branched PFOS isomers. These practices are in line with recommendations in the National Environmental Management Plan for PFAS (Australian HEPA) and also conform to QSM 5.3 (US DoD) requirements.
- ED045G: The presence of Thiocyanate, Thiosulfate and Sulfite can positively contribute to the chloride result, thereby may bias results higher than expected. Results should be scrutinised accordingly.

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH201	DUP_1	BH4	QC_1	BH201
			Sampling date / time	14-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00
Compound	CAS Number	LOR	Unit	EM2322584-001	EM2322584-002	EM2322584-004	EM2322584-005	EM2322584-008
				Result	Result	Result	Result	Result
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**1060**	**1100**	**2900**	----	**650**
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	<1	----	<1
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	<1	----	<1
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**517**	**537**	**371**	----	**477**
Total Alkalinity as CaCO3	----	1	mg/L	**517**	**537**	**371**	----	**477**
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<5	<5	**51**	----	**3**
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**104**	**127**	**1380**	----	**70**
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**60**	**59**	**226**	----	**61**
Magnesium	7439-95-4	1	mg/L	**42**	**41**	**145**	----	**44**
Sodium	7440-23-5	1	mg/L	**119**	**118**	**526**	----	**85**
Potassium	7440-09-7	1	mg/L	**6**	**6**	**12**	----	**7**
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.041**	**0.040**	**0.010**	----	**0.004**
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	<0.0001
Chromium	7440-47-3	0.001	mg/L	**0.003**	**0.003**	**0.006**	----	<0.001
Copper	7440-50-8	0.001	mg/L	**0.013**	**0.011**	**0.013**	----	**0.001**
Lead	7439-92-1	0.001	mg/L	**0.002**	**0.003**	**0.018**	----	<0.001
Nickel	7440-02-0	0.001	mg/L	**0.022**	**0.023**	**0.014**	----	**0.019**
Zinc	7440-66-6	0.005	mg/L	**0.018**	**0.016**	**0.035**	----	<0.005
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	----	<0.0001
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.06**	**0.05**	**0.39**	----	**0.06**

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH201	DUP_1	BH4	QC_1	BH201
			Sampling date / time	14-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00
Compound	CAS Number	LOR	Unit	EM2322584-001	EM2322584-002	EM2322584-004	EM2322584-005	EM2322584-008
				Result	Result	Result	Result	Result
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	<0.01	----	<0.01
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	**0.02**	**0.02**	----	**0.02**
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.01**	**0.02**	**0.02**	----	**0.02**
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**31.6**	**33.0**	**1.9**	----	**2.6**
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**31.6**	**33.0**	**1.9**	----	**2.6**
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.30**	**0.30**	**0.81**	----	**0.42**
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	**0.19**	**0.23**	<0.01	----	<0.01
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**13.3**	**14.3**	**47.4**	----	**11.6**
ø Total Cations	----	0.01	meq/L	**11.8**	**11.6**	**46.4**	----	**10.5**
ø Ionic Balance	----	0.01	%	**5.92**	**10.4**	**1.07**	----	**4.64**
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	**2.3**	**3.2**	<1.0	----	<1.0
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Acenaphthene	83-32-9	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Fluorene	86-73-7	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Phenanthrene	85-01-8	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Anthracene	120-12-7	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Fluoranthene	206-44-0	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Pyrene	129-00-0	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	<1.0	<1.0	----	<1.0

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Sample ID	BH201	DUP_1	BH4	QC_1	BH201
				Sampling date / time	14-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00
Compound	CAS Number	LOR	Unit		EM2322584-001	EM2322584-002	EM2322584-004	EM2322584-005	EM2322584-008
					Result	Result	Result	Result	Result
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued									
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	<0.5	----	<0.5
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	<1.0	----	<1.0
^ **Sum of polycyclic aromatic hydrocarbons**	----	0.5	µg/L		**2.3**	**3.2**	<0.5	----	<0.5
^ **Benzo(a)pyrene TEQ (zero)**	----	0.5	µg/L		<0.5	<0.5	<0.5	----	<0.5
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		**20**	<20	<20	----	<20
C10 - C14 Fraction	----	50	µg/L		**14000**	**12200**	<50	----	**9560**
C15 - C28 Fraction	----	100	µg/L		**6860**	**6380**	<100	----	**3570**
C29 - C36 Fraction	----	50	µg/L		**420**	**480**	<50	----	**240**
^ **C10 - C36 Fraction (sum)**	----	50	µg/L		**21300**	**19100**	<50	----	**13400**
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
C6 - C10 Fraction	C6_C10	20	µg/L		**20**	<20	<20	----	<20
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L		<20	<20	<20	----	<20
>C10 - C16 Fraction	----	100	µg/L		**20100**	**17800**	<100	----	**12700**
>C16 - C34 Fraction	----	100	µg/L		**1420**	**1520**	<100	----	**790**
>C34 - C40 Fraction	----	100	µg/L		<100	<100	<100	----	<100
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L		**21500**	**19300**	<100	----	**13500**
^ **>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L		**20100**	**17800**	<100	----	**12700**
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	<1	----	<1
Toluene	108-88-3	2	µg/L		**2**	**2**	<2	----	<2

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH201	DUP_1	BH4	QC_1	BH201
			Sampling date / time	14-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00
Compound	CAS Number	LOR	Unit	EM2322584-001	EM2322584-002	EM2322584-004	EM2322584-005	EM2322584-008
				Result	Result	Result	Result	Result
EP080: BTEXN - Continued								
Ethylbenzene	100-41-4	2	µg/L	<2	<2	<2	----	<2
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	<2	----	<2
ortho-Xylene	95-47-6	2	µg/L	<2	<2	<2	----	<2
^ Total Xylenes	----	2	µg/L	<2	<2	<2	----	<2
^ Sum of BTEX	----	1	µg/L	**2**	**2**	<1	----	<1
Naphthalene	91-20-3	5	µg/L	<5	<5	<5	----	<5
EP231A: Perfluoroalkyl Sulfonic Acids								
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	<0.02	<0.02	----	<0.02
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	<0.01	<0.01	----	<0.01
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	<0.01	<0.01	----	<0.01
EP231B: Perfluoroalkyl Carboxylic Acids								
Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	<0.1	<0.1	----	<0.1
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	<0.02	<0.02	----	<0.02
Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	<0.02	<0.02	----	<0.02
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	<0.02	<0.02	----	<0.02
Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	<0.01	<0.01	----	<0.01
EP231D: (n:2) Fluorotelomer Sulfonic Acids								
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	<0.05	<0.05	----	<0.05
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	<0.05	<0.05	----	<0.05
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	<0.05	<0.05	----	<0.05
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	<0.05	<0.05	----	<0.05
EP231P: PFAS Sums								
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L	<0.01	<0.01	<0.01	----	<0.01

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH201	DUP_1	BH4	QC_1	BH201
			Sampling date / time	14-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00	14-Dec-2023 00:00	15-Dec-2023 00:00
Compound	CAS Number	LOR	Unit	EM2322584-001	EM2322584-002	EM2322584-004	EM2322584-005	EM2322584-008
				Result	Result	Result	Result	Result
EP231P: PFAS Sums - Continued								
Sum of PFAS (WA DER List)	----	0.01	µg/L	<0.01	<0.01	<0.01	----	<0.01
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	36.5	31.8	29.8	----	32.8
2-Chlorophenol-D4	93951-73-6	1.0	%	79.2	74.1	78.9	----	83.9
2.4.6-Tribromophenol	118-79-6	1.0	%	89.0	82.5	83.6	----	94.1
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	44.7	41.7	81.4	----	51.2
Anthracene-d10	1719-06-8	1.0	%	82.8	74.7	79.1	----	79.9
4-Terphenyl-d14	1718-51-0	1.0	%	79.4	74.1	81.2	----	82.3
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	95.5	90.8	94.0	----	95.1
Toluene-D8	2037-26-5	2	%	99.8	106	101	----	102
4-Bromofluorobenzene	460-00-4	2	%	108	115	110	----	114
EP231S: PFAS Surrogate								
13C4-PFOS	----	0.02	%	107	109	97.3	100	104
13C8-PFOA	----	0.02	%	97.9	94.1	96.2	92.5	98.7

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH3	----	----	----	----
			Sampling date / time	16-Dec-2023 00:00	----	----	----	----
Compound	*CAS Number*	*LOR*	*Unit*	EM2322584-009	--------	--------	--------	--------
				Result	----	----	----	----
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Total Dissolved Solids @180°C	----	10	mg/L	**257**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**172**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**172**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**2**	----	----	----	----
ED045G: Chloride by Discrete Analyser								
Chloride	16887-00-6	1	mg/L	**53**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**31**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**20**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**37**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**2**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.010**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	**0.002**	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.005**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.008**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.04**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH3	----	----	----	----
			Sampling date / time	16-Dec-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EM2322584-009	--------	--------	--------	--------
				Result	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	14797-65-0	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	**0.01**	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**0.01**	----	----	----	----
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**0.5**	----	----	----	----
EK062G: Total Nitrogen as N (TKN + NOx) by Discrete Analyser								
^ Total Nitrogen as N	----	0.1	mg/L	**0.5**	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.10**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	----	----	----	----
EN055: Ionic Balance								
ø Total Anions	----	0.01	meq/L	**4.97**	----	----	----	----
ø Total Cations	----	0.01	meq/L	**4.85**	----	----	----	----
ø Ionic Balance	----	0.01	%	**1.22**	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Naphthalene	91-20-3	1.0	µg/L	<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L	<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L	<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L	<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L	<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L	<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L	<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L	<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L	<1.0	----	----	----	----

Analytical Results

Sub-Matrix: WATER
(Matrix: WATER)

				Sample ID	BH3	----	----	----	----
				Sampling date / time	16-Dec-2023 00:00	----	----	----	----
	Compound	CAS Number	LOR	Unit	EM2322584-009	--------	--------	--------	--------
					Result	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued									
	Chrysene	218-01-9	1.0	µg/L	<1.0	----	----	----	----
	Benzo(b+j)fluoranthene	205-99-2 205-82-3	1.0	µg/L	<1.0	----	----	----	----
	Benzo(k)fluoranthene	207-08-9	1.0	µg/L	<1.0	----	----	----	----
	Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	----	----	----	----
	Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L	<1.0	----	----	----	----
	Dibenz(a.h)anthracene	53-70-3	1.0	µg/L	<1.0	----	----	----	----
	Benzo(g.h.i)perylene	191-24-2	1.0	µg/L	<1.0	----	----	----	----
^	**Sum of polycyclic aromatic hydrocarbons**	----	0.5	µg/L	<0.5	----	----	----	----
^	**Benzo(a)pyrene TEQ (zero)**	----	0.5	µg/L	<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
	C6 - C9 Fraction	----	20	µg/L	<20	----	----	----	----
	C10 - C14 Fraction	----	50	µg/L	<50	----	----	----	----
	C15 - C28 Fraction	----	100	µg/L	<100	----	----	----	----
	C29 - C36 Fraction	----	50	µg/L	<50	----	----	----	----
^	**C10 - C36 Fraction (sum)**	----	50	µg/L	<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions									
	C6 - C10 Fraction	C6_C10	20	µg/L	<20	----	----	----	----
^	**C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L	<20	----	----	----	----
	>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
	>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
	>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^	**>C10 - C40 Fraction (sum)**	----	100	µg/L	<100	----	----	----	----
^	**>C10 - C16 Fraction minus Naphthalene (F2)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN									
	Benzene	71-43-2	1	µg/L	<1	----	----	----	----
	Toluene	108-88-3	2	µg/L	<2	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH3	----	----	----	----
			Sampling date / time	16-Dec-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EM2322584-009	--------	--------	--------	--------
				Result	----	----	----	----
EP080: BTEXN - Continued								
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ Total Xylenes	----	2	µg/L	<2	----	----	----	----
^ Sum of BTEX	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP231A: Perfluoroalkyl Sulfonic Acids								
Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	----	----	----	----
Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	----	----	----	----
Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	----	----	----	----
EP231B: Perfluoroalkyl Carboxylic Acids								
Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	----	----	----	----
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	----	----	----	----
Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	----	----	----	----
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	----	----	----	----
Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	----	----	----	----
EP231D: (n:2) Fluorotelomer Sulfonic Acids								
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	----	----	----	----
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	----	----	----	----
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	----	----	----	----
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	----	----	----	----
EP231P: PFAS Sums								
Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L	<0.01	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Sample ID	BH3	----	----	----	----
			Sampling date / time	16-Dec-2023 00:00	----	----	----	----
Compound	CAS Number	LOR	Unit	EM2322584-009	--------	--------	--------	--------
				Result	----	----	----	----
EP231P: PFAS Sums - Continued								
Sum of PFAS (WA DER List)	----	0.01	µg/L	<0.01	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	1.0	%	31.0	----	----	----	----
2-Chlorophenol-D4	93951-73-6	1.0	%	78.7	----	----	----	----
2.4.6-Tribromophenol	118-79-6	1.0	%	85.4	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	1.0	%	81.6	----	----	----	----
Anthracene-d10	1719-06-8	1.0	%	77.8	----	----	----	----
4-Terphenyl-d14	1718-51-0	1.0	%	78.9	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	2	%	106	----	----	----	----
Toluene-D8	2037-26-5	2	%	106	----	----	----	----
4-Bromofluorobenzene	460-00-4	2	%	99.7	----	----	----	----
EP231S: PFAS Surrogate								
13C4-PFOS	----	0.02	%	100	----	----	----	----
13C8-PFOA	----	0.02	%	96.5	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**		Recovery Limits (%)	
Compound	*CAS Number*	*Low*	*High*
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10	51
2-Chlorophenol-D4	93951-73-6	30	114
2.4.6-Tribromophenol	118-79-6	26	133
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	35	127
Anthracene-d10	1719-06-8	44	122
4-Terphenyl-d14	1718-51-0	44	124
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	73	129
Toluene-D8	2037-26-5	70	125
4-Bromofluorobenzene	460-00-4	71	129
EP231S: PFAS Surrogate			
13C4-PFOS	----	65	140
13C8-PFOA	----	71	133

Certificate of Analysis

Environment Testing

NATA Accredited
Accreditation Number 1261
Site Number 1254

Accredited for compliance with ISO/IEC 17025 – Testing
NATA is a signatory to the ILAC Mutual Recognition Arrangement for the mutual recognition of the equivalence of testing, medical testing, calibration, inspection, proficiency testing scheme providers and reference materials producers reports and certificates.

Jacobs Group (Australia) P/L VIC
PO Box 312 Flinders Lane
Melbourne
VIC 8009

Attention: **Erin McIntosh**

Report **1055286-W**
Project name
Project ID IW238424
Received Date Dec 19, 2023

Client Sample ID			**TRIP_1**
Sample Matrix			**Water**
Eurofins Sample No.			**M23-De0044213**
Date Sampled			**Dec 14, 2023**
Test/Reference	LOR	Unit	
Total Recoverable Hydrocarbons			
TRH C6-C9	0.02	mg/L	< 0.02
TRH C10-C14	0.05	mg/L	17
TRH C15-C28	0.1	mg/L	11
TRH C29-C36	0.1	mg/L	0.6
TRH C10-C36 (Total)	0.1	mg/L	28.6
TRH C6-C10	0.02	mg/L	< 0.02
TRH C6-C10 less BTEX (F1)[N04]	0.02	mg/L	< 0.02
TRH >C10-C16	0.05	mg/L	27
TRH >C10-C16 less Naphthalene (F2)[N01]	0.05	mg/L	27
TRH >C16-C34	0.1	mg/L	5.0
TRH >C34-C40	0.1	mg/L	< 0.1
TRH >C10-C40 (total)*	0.1	mg/L	32
BTEX			
Benzene	0.001	mg/L	< 0.001
Toluene	0.001	mg/L	0.002
Ethylbenzene	0.001	mg/L	< 0.001
m&p-Xylenes	0.002	mg/L	< 0.002
o-Xylene	0.001	mg/L	< 0.001
Xylenes - Total*	0.003	mg/L	< 0.003
4-Bromofluorobenzene (surr.)	1	%	97
Total Recoverable Hydrocarbons - 2013 NEPM Fractions			
Naphthalene[N02]	0.01	mg/L	< 0.01
Polycyclic Aromatic Hydrocarbons			
Acenaphthene	0.001	mg/L	< 0.001
Acenaphthylene	0.001	mg/L	< 0.001
Anthracene	0.001	mg/L	< 0.001
Benz(a)anthracene	0.001	mg/L	< 0.001
Benzo(a)pyrene	0.001	mg/L	< 0.001
Benzo(b&j)fluoranthene[N07]	0.001	mg/L	< 0.001
Benzo(g.h.i)perylene	0.001	mg/L	< 0.001
Benzo(k)fluoranthene	0.001	mg/L	< 0.001
Chrysene	0.001	mg/L	< 0.001
Dibenz(a.h)anthracene	0.001	mg/L	< 0.001
Fluoranthene	0.001	mg/L	< 0.001
Fluorene	0.001	mg/L	< 0.001

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Client Sample ID			TRIP_1
Sample Matrix			Water
Eurofins Sample No.			M23-De0044213
Date Sampled			Dec 14, 2023
Test/Reference	LOR	Unit	
Polycyclic Aromatic Hydrocarbons			
Indeno(1.2.3-cd)pyrene	0.001	mg/L	< 0.001
Naphthalene	0.001	mg/L	0.004
Phenanthrene	0.001	mg/L	< 0.001
Pyrene	0.001	mg/L	< 0.001
Total PAH*	0.001	mg/L	0.004
2-Fluorobiphenyl (surr.)	1	%	86
p-Terphenyl-d14 (surr.)	1	%	67
Ammonia (as N)	0.01	mg/L	0.06
Chloride	1	mg/L	120
Nitrate & Nitrite (as N)	0.05	mg/L	< 0.05
Nitrate (as N)	0.02	mg/L	0.02
Nitrite (as N)	0.02	mg/L	< 0.02
Organic Nitrogen (as N)*	0.2	mg/L	33.94
Sulphate (as SO4)	5	mg/L	< 5
Total Dissolved Solids Dried at 180 °C ± 2 °C	10	mg/L	1800
Total Kjeldahl Nitrogen (as N)	0.2	mg/L	34
Total Nitrogen (as N)*	0.2	mg/L	34
Phosphate total (as P)	0.01	mg/L	0.11
Alkalinity (speciated)			
Bicarbonate Alkalinity (as CaCO3)	20	mg/L	450
Carbonate Alkalinity (as CaCO3)	10	mg/L	< 10
Hydroxide Alkalinity (as CaCO3)	20	mg/L	< 20
Total Alkalinity (as CaCO3)	20	mg/L	450
Heavy Metals			
Arsenic (filtered)	0.001	mg/L	0.039
Cadmium (filtered)	0.0002	mg/L	< 0.0002
Chromium (filtered)	0.001	mg/L	0.003
Copper (filtered)	0.001	mg/L	0.012
Lead (filtered)	0.001	mg/L	0.002
Mercury (filtered)	0.0001	mg/L	0.0001
Nickel (filtered)	0.001	mg/L	0.020
Zinc (filtered)	0.005	mg/L	0.010
Alkali Metals			
Calcium	0.5	mg/L	54
Magnesium	0.5	mg/L	40
Potassium	0.5	mg/L	4.8
Sodium	0.5	mg/L	120
Per- and Polyfluoroalkyl Substances (PFASs) - Short			
1H.1H.2H.2H-perfluorooctanesulfonic acid(6:2 FTSA)[N11]	0.05	ug/L	< 0.05
13C2-6:2 FTSA (surr.)	1	%	174
Perfluorohexanesulfonic acid (PFHxS)[N11]	0.01	ug/L	< 0.01
Perfluorooctanesulfonic acid (PFOS)[N11]	0.01	ug/L	< 0.01
18O2-PFHxS (surr.)	1	%	101
13C8-PFOS (surr.)	1	%	139
Perfluorooctanoic acid (PFOA)[N11]	0.01	ug/L	< 0.01
13C8-PFOA (surr.)	1	%	122
Sum (PFHxS + PFOS)*	0.01	ug/L	< 0.01

Client Sample ID			TRIP_1
Sample Matrix			Water
Eurofins Sample No.			M23-De0044213
Date Sampled			Dec 14, 2023
Test/Reference	LOR	Unit	
Per- and Polyfluoroalkyl Substances (PFASs) - Short			
Sum of US EPA PFAS (PFOS + PFOA)*	0.01	ug/L	< 0.01
Sum of enHealth PFAS (PFHxS + PFOS + PFOA)*	0.01	ug/L	< 0.01

Sample History

Where samples are submitted/analysed over several days, the last date of extraction is reported.

If the date and time of sampling are not provided, the Laboratory will not be responsible for compromised results should testing be performed outside the recommended holding time.

Description	Testing Site	Extracted	Holding Time
Total Recoverable Hydrocarbons - 1999 NEPM Fractions	Melbourne	Dec 20, 2023	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Dec 20, 2023	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
Total Recoverable Hydrocarbons - 2013 NEPM Fractions	Melbourne	Dec 20, 2023	7 Days
- Method: LTM-ORG-2010 TRH C6-C40			
BTEX and Naphthalene			
BTEX	Melbourne	Dec 20, 2023	14 Days
- Method: LTM-ORG-2010 BTEX and Volatile TRH			
Polycyclic Aromatic Hydrocarbons	Melbourne	Dec 20, 2023	7 Days
- Method: LTM-ORG-2130 PAH and Phenols in Soil and Water			
Phosphate total (as P)	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Metals M8 filtered	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-MET-3040 Metals in Waters, Soils & Sediments by ICP-MS			
Eurofins Suite B11C: Na/K/Ca/Mg	Melbourne	Dec 20, 2023	180 Days
- Method: LTM-MET-3010 Alkali Metals by ICP-AES			
Per- and Polyfluoroalkyl Substances (PFASs) - Short	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-ORG-2100 Per- and Polyfluoroalkyl Substances (PFAS)			
Eurofins Suite B19D: Total N, TKN, NOx, NO2, NO3, NH3, Total P			
Ammonia (as N)	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4450 Determination of Nitrogen Species by Discrete Analyser			
Nitrate & Nitrite (as N)	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4450 Determination of Nitrogen Species by Discrete Analyser			
Nitrate (as N)	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4450 Determination of Nitrogen Species by Discrete Analyser			
Nitrite (as N)	Melbourne	Dec 20, 2023	2 Days
- Method: LTM-INO-4450 Determination of Nitrogen Species by Discrete Analyser			
Organic Nitrogen (as N)*	Melbourne	Dec 19, 2023	7 Days
- Method: APHA 4500 Organic Nitrogen (N)			
Total Kjeldahl Nitrogen (as N)	Melbourne	Dec 20, 2023	28 Days
- Method: APHA 4500-Norg B,D Total Kjeldahl Nitrogen by FIA			
Eurofins Suite B11E: Cl/SO4/Alkalinity			
Chloride	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
Sulphate (as SO4)	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4270 Anions by Ion Chromatography			
Alkalinity (speciated)	Melbourne	Dec 20, 2023	14 Days
- Method: LTM-INO-4250 Alkalinity by Electrometric Titration			
Total Dissolved Solids Dried at 180 °C ± 2 °C	Melbourne	Dec 20, 2023	28 Days
- Method: LTM-INO-4170 Total Dissolved Solids in Water			

Company Name:	Jacobs Group (Australia) P/L VIC	**Order No.:**		**Received:**	Dec 19, 2023 9:30 AM
Address:	PO Box 312 Flinders Lane Melbourne VIC 8009	**Report #:**	1055286	**Due:**	Jan 5, 2024
		Phone:	03 8668 3000	**Priority:**	10 Day
		Fax:	03 8668 3001	**Contact Name:**	Erin McIntosh
Project Name:					
Project ID:	IW238424				

Eurofins Analytical Services Manager : Savini Suduweli

Sample Detail						Phosphate total (as P)	Polycyclic Aromatic Hydrocarbons	Metals M8 filtered	BTEX and Naphthalene	Total Recoverable Hydrocarbons	Eurofins Suite B19D: Total N, TKN, NOx, NO2, NO3, NH3, Total P	Eurofins Suite B11E: Cl/SO4/Alkalinity	Per- and Polyfluoroalkyl Substances (PFASs) - Short	Eurofins Suite B11C: Na/K/Ca/Mg	Total Dissolved Solids Dried at 180 °C ± 2 °C
Melbourne Laboratory - NATA # 1261 Site # 1254						X	X	X	X	X	X	X	X	X	X
External Laboratory															
No	**Sample ID**	**Sample Date**	**Sampling Time**	**Matrix**	**LAB ID**										
1	TRIP_1	Dec 14, 2023		Water	M23-De0044213	X	X	X	X	X	X	X	X	X	X
Test Counts						1	1	1	1	1	1	1	1	1	1

Internal Quality Control Review and Glossary

General

1. Laboratory QC results for Method Blanks, Duplicates, Matrix Spikes, and Laboratory Control Samples follow guidelines delineated in the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended May 2013. They are included in this QC report where applicable. Additional QC data may be available on request.
2. All soil/sediment/solid results are reported on a dry weight basis unless otherwise stated.
3. All biota/food results are reported on a wet weight basis on the edible portion unless otherwise stated.
4. For CEC results where the sample's origin is unknown or environmentally contaminated, the results should be used advisedly.
5. Actual LORs are matrix dependent. Quoted LORs may be raised where sample extracts are diluted due to interferences.
6. Results are uncorrected for matrix spikes or surrogate recoveries except for PFAS compounds.
7. SVOC analysis on waters is performed on homogenised, unfiltered samples unless noted otherwise.
8. Samples were analysed on an 'as received' basis.
9. Information identified in this report with blue colour indicates data provided by customers that may have an impact on the results.
10. This report replaces any interim results previously issued.

Holding Times

Please refer to the 'Sample Preservation and Container Guide' for holding times (QS3001).

For samples received on the last day of holding time, notification of testing requirements should have been received at least 6 hours before sample receipt deadlines as stated on the SRA.

If the Laboratory did not receive the information in the required timeframe, and despite any other integrity issues, suitably qualified results may still be reported.

Holding times apply from the date of sampling; therefore, compliance with these may be outside the laboratory's control.

For VOCs containing vinyl chloride, styrene and 2-chloroethyl vinyl ether, the holding time is 7 days; however, for all other VOCs, such as BTEX or C6-10 TRH, the holding time is 14 days.

Units

mg/kg: milligrams per kilogram	**mg/L:** milligrams per litre	**ppm:** parts per million
µg/L: micrograms per litre	**ppb:** parts per billion	**%:** Percentage
org/100 mL: Organisms per 100 millilitres	**NTU:** Nephelometric Turbidity Units	**MPN/100 mL:** Most Probable Number of organisms per 100 millilitres
CFU: Colony forming unit	**Colour:** Pt-Co Units	

Terms

APHA	American Public Health Association
CEC	Cation Exchange Capacity
COC	Chain of Custody
CP	Client Parent - QC was performed on samples pertaining to this report
CRM	Certified Reference Material (ISO17034) - reported as percent recovery.
Dry	Where moisture has been determined on a solid sample, the result is expressed on a dry weight basis.
Duplicate	A second piece of analysis from the same sample and reported in the same units as the result to show comparison.
LOR	Limit of Reporting.
LCS	Laboratory Control Sample - reported as percent recovery.
Method Blank	In the case of solid samples, these are performed on laboratory-certified clean sands and in the case of water samples, these are performed on de-ionised water.
NCP	Non-Client Parent - QC performed on samples not pertaining to this report, QC represents the sequence or batch that client samples were analysed within.
RPD	Relative Percent Difference between two Duplicate pieces of analysis.
SPIKE	Addition of the analyte to the sample and reported as percentage recovery.
SRA	Sample Receipt Advice
Surr - Surrogate	The addition of a similar compound to the analyte target is reported as percentage recovery. See below for acceptance criteria.
TBTO	Tributyltin oxide (*bis*-tributyltin oxide) - individual tributyltin compounds cannot be identified separately in the environment; however, free tributyltin was measured, and its values were converted stoichiometrically into tributyltin oxide for comparison with regulatory limits.
TCLP	Toxicity Characteristic Leaching Procedure
TEQ	Toxic Equivalency Quotient or Total Equivalence
QSM	US Department of Defense Quality Systems Manual Version 5.4
US EPA	United States Environmental Protection Agency
WA DWER	Sum of PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFBS, PFHxS, PFOS, 6:2 FTSA, 8:2 FTSA

QC - Acceptance Criteria

The acceptance criteria should only be used as a guide and may be different when site-specific Sampling Analysis and Quality Plan (SAQP) have been implemented.

RPD Duplicates: Global RPD Duplicates Acceptance Criteria is ≤30%; however, the following acceptance guidelines are equally applicable:

Results <10 times the LOR:	No Limit
Results between 10-20 times the LOR:	RPD must lie between 0-50%
Results >20 times the LOR:	RPD must lie between 0-30%

NOTE: pH duplicates are reported as a range, not as RPD

Surrogate Recoveries: Recoveries must lie between 20-130% for Speciated Phenols & 50-150% for PFAS. SVOCs recoveries 20 – 150%, VOC recoveries 70 – 130%

PFAS field samples containing surrogate recoveries above the QC limit designated in QSM 5.4, where no positive PFAS results have been reported or reviewed, and no data was affected.

QC Data General Comments

1. Where a result is reported as less than (<), higher than the nominated LOR, this is due to either matrix interference, extract dilution required due to interferences or contaminant levels within the sample, high moisture content or insufficient sample provided.
2. Duplicate data shown within this report that states the word "BATCH" is a Batch Duplicate from outside of your sample batch but within the laboratory sample batch at a 1:10 ratio. The Parent and Duplicate data shown are not data from your samples.
3. pH and Free Chlorine analysed in the laboratory - Analysis on this test must begin within 30 minutes of sampling. Therefore, laboratory analysis is unlikely to be completed within holding time.Analysis will begin as soon as possible after sample receipt.
4. Recovery Data (Spikes & Surrogates) - where chromatographic interference does not allow the determination of recovery, the term "INT" appears against that analyte.
5. For Matrix Spikes and LCS results, a dash "-" in the report means that the specific analyte was not added to the QC sample.
6. Duplicate RPDs are calculated from raw analytical data; thus, it is possible to have two sets of data.

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Quality Control Results

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Method Blank							
Total Recoverable Hydrocarbons							
TRH C6-C9	mg/L	< 0.02			0.02	Pass	
TRH C10-C14	mg/L	< 0.05			0.05	Pass	
TRH C15-C28	mg/L	< 0.1			0.1	Pass	
TRH C29-C36	mg/L	< 0.1			0.1	Pass	
TRH C6-C10	mg/L	< 0.02			0.02	Pass	
TRH >C10-C16	mg/L	< 0.05			0.05	Pass	
TRH >C16-C34	mg/L	< 0.1			0.1	Pass	
TRH >C34-C40	mg/L	< 0.1			0.1	Pass	
Method Blank							
BTEX							
Benzene	mg/L	< 0.001			0.001	Pass	
Toluene	mg/L	< 0.001			0.001	Pass	
Ethylbenzene	mg/L	< 0.001			0.001	Pass	
m&p-Xylenes	mg/L	< 0.002			0.002	Pass	
o-Xylene	mg/L	< 0.001			0.001	Pass	
Xylenes - Total*	mg/L	< 0.003			0.003	Pass	
Method Blank							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	mg/L	< 0.01			0.01	Pass	
Method Blank							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	mg/L	< 0.001			0.001	Pass	
Acenaphthylene	mg/L	< 0.001			0.001	Pass	
Anthracene	mg/L	< 0.001			0.001	Pass	
Benz(a)anthracene	mg/L	< 0.001			0.001	Pass	
Benzo(a)pyrene	mg/L	< 0.001			0.001	Pass	
Benzo(b&j)fluoranthene	mg/L	< 0.001			0.001	Pass	
Benzo(g.h.i)perylene	mg/L	< 0.001			0.001	Pass	
Benzo(k)fluoranthene	mg/L	< 0.001			0.001	Pass	
Chrysene	mg/L	< 0.001			0.001	Pass	
Dibenz(a.h)anthracene	mg/L	< 0.001			0.001	Pass	
Fluoranthene	mg/L	< 0.001			0.001	Pass	
Fluorene	mg/L	< 0.001			0.001	Pass	
Indeno(1.2.3-cd)pyrene	mg/L	< 0.001			0.001	Pass	
Naphthalene	mg/L	< 0.001			0.001	Pass	
Phenanthrene	mg/L	< 0.001			0.001	Pass	
Pyrene	mg/L	< 0.001			0.001	Pass	
Method Blank							
Ammonia (as N)	mg/L	< 0.01			0.01	Pass	
Chloride	mg/L	< 1			1	Pass	
Nitrate & Nitrite (as N)	mg/L	< 0.05			0.05	Pass	
Nitrate (as N)	mg/L	< 0.02			0.02	Pass	
Nitrite (as N)	mg/L	< 0.02			0.02	Pass	
Sulphate (as SO4)	mg/L	< 5			5	Pass	
Total Kjeldahl Nitrogen (as N)	mg/L	< 0.2			0.2	Pass	
Phosphate total (as P)	mg/L	< 0.01			0.01	Pass	
Method Blank							
Alkalinity (speciated)							
Bicarbonate Alkalinity (as CaCO3)	mg/L	< 20			20	Pass	
Carbonate Alkalinity (as CaCO3)	mg/L	< 10			10	Pass	

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Environment Testing

Test	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Hydroxide Alkalinity (as CaCO3)	mg/L	< 20			20	Pass	
Total Alkalinity (as CaCO3)	mg/L	< 20			20	Pass	
Method Blank							
Heavy Metals							
Arsenic (filtered)	mg/L	< 0.001			0.001	Pass	
Cadmium (filtered)	mg/L	< 0.0002			0.0002	Pass	
Chromium (filtered)	mg/L	< 0.001			0.001	Pass	
Copper (filtered)	mg/L	< 0.001			0.001	Pass	
Lead (filtered)	mg/L	< 0.001			0.001	Pass	
Mercury (filtered)	mg/L	< 0.0001			0.0001	Pass	
Nickel (filtered)	mg/L	< 0.001			0.001	Pass	
Zinc (filtered)	mg/L	< 0.005			0.005	Pass	
Method Blank							
Alkali Metals							
Calcium	mg/L	< 0.5			0.5	Pass	
Magnesium	mg/L	< 0.5			0.5	Pass	
Potassium	mg/L	< 0.5			0.5	Pass	
Sodium	mg/L	< 0.5			0.5	Pass	
Method Blank							
Per- and Polyfluoroalkyl Substances (PFASs) - Short							
1H.1H.2H.2H-perfluorooctanesulfonic acid(6:2 FTSA)	ug/L	< 0.05			0.05	Pass	
Perfluorohexanesulfonic acid (PFHxS)	ug/L	< 0.01			0.01	Pass	
Perfluorooctanesulfonic acid (PFOS)	ug/L	< 0.01			0.01	Pass	
Perfluorooctanoic acid (PFOA)	ug/L	< 0.01			0.01	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons							
TRH C6-C9	%	80			70-130	Pass	
TRH C10-C14	%	123			70-130	Pass	
TRH C6-C10	%	84			70-130	Pass	
TRH >C10-C16	%	114			70-130	Pass	
LCS - % Recovery							
BTEX							
Benzene	%	123			70-130	Pass	
Toluene	%	104			70-130	Pass	
Ethylbenzene	%	102			70-130	Pass	
m&p-Xylenes	%	96			70-130	Pass	
Xylenes - Total*	%	97			70-130	Pass	
LCS - % Recovery							
Total Recoverable Hydrocarbons - 2013 NEPM Fractions							
Naphthalene	%	122			70-130	Pass	
LCS - % Recovery							
Polycyclic Aromatic Hydrocarbons							
Acenaphthene	%	89			70-130	Pass	
Acenaphthylene	%	92			70-130	Pass	
Anthracene	%	73			70-130	Pass	
Benz(a)anthracene	%	113			70-130	Pass	
Benzo(a)pyrene	%	88			70-130	Pass	
Benzo(b&j)fluoranthene	%	74			70-130	Pass	
Benzo(g.h.i)perylene	%	121			70-130	Pass	
Benzo(k)fluoranthene	%	74			70-130	Pass	
Chrysene	%	114			70-130	Pass	
Dibenz(a.h)anthracene	%	84			70-130	Pass	
Fluoranthene	%	108			70-130	Pass	
Fluorene	%	98			70-130	Pass	

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Environment Testing

Test			Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Indeno(1.2.3-cd)pyrene			%	94			70-130	Pass	
Naphthalene			%	77			70-130	Pass	
Phenanthrene			%	89			70-130	Pass	
Pyrene			%	102			70-130	Pass	
LCS - % Recovery									
Ammonia (as N)			%	109			70-130	Pass	
Chloride			%	99			70-130	Pass	
Nitrate & Nitrite (as N)			%	113			70-130	Pass	
Nitrite (as N)			%	103			70-130	Pass	
Sulphate (as SO4)			%	108			70-130	Pass	
Total Dissolved Solids Dried at 180 °C ± 2 °C			%	85			70-130	Pass	
Total Kjeldahl Nitrogen (as N)			%	76			70-130	Pass	
Phosphate total (as P)			%	99			70-130	Pass	
LCS - % Recovery									
Alkalinity (speciated)									
Carbonate Alkalinity (as CaCO3)			%	86			70-130	Pass	
Total Alkalinity (as CaCO3)			%	90			70-130	Pass	
LCS - % Recovery									
Heavy Metals									
Arsenic (filtered)			%	96			80-120	Pass	
Cadmium (filtered)			%	94			80-120	Pass	
Chromium (filtered)			%	96			80-120	Pass	
Copper (filtered)			%	96			80-120	Pass	
Lead (filtered)			%	96			80-120	Pass	
Mercury (filtered)			%	99			80-120	Pass	
Nickel (filtered)			%	98			80-120	Pass	
Zinc (filtered)			%	95			80-120	Pass	
LCS - % Recovery									
Alkali Metals									
Calcium			%	98			80-120	Pass	
Magnesium			%	97			80-120	Pass	
Potassium			%	95			80-120	Pass	
Sodium			%	93			80-120	Pass	
LCS - % Recovery									
Per- and Polyfluoroalkyl Substances (PFASs) - Short									
1H.1H.2H.2H-perfluorooctanesulfonic acid(6:2 FTSA)			%	90			50-150	Pass	
Perfluorohexanesulfonic acid (PFHxS)			%	88			50-150	Pass	
Perfluorooctanesulfonic acid (PFOS)			%	102			50-150	Pass	
Perfluorooctanoic acid (PFOA)			%	93			50-150	Pass	
Test	**Lab Sample ID**	**QA Source**	**Units**	**Result 1**			**Acceptance Limits**	**Pass Limits**	**Qualifying Code**
Spike - % Recovery									
Total Recoverable Hydrocarbons				Result 1					
TRH C6-C9	M23-De0045096	NCP	%	72			70-130	Pass	
TRH C10-C14	M23-De0045609	NCP	%	111			70-130	Pass	
TRH C6-C10	M23-De0045096	NCP	%	76			70-130	Pass	
TRH >C10-C16	M23-De0045609	NCP	%	103			70-130	Pass	
Spike - % Recovery									
BTEX				Result 1					
Benzene	M23-De0045096	NCP	%	96			70-130	Pass	
Toluene	M23-De0045096	NCP	%	86			70-130	Pass	
Ethylbenzene	M23-De0045096	NCP	%	85			70-130	Pass	
m&p-Xylenes	M23-De0045096	NCP	%	82			70-130	Pass	
o-Xylene	M23-De0045096	NCP	%	83			70-130	Pass	
Xylenes - Total*	M23-De0045096	NCP	%	82			70-130	Pass	

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Environment Testing

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Spike - % Recovery									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1					
Naphthalene	M23-De0045096	NCP	%	98			70-130	Pass	
Spike - % Recovery									
Polycyclic Aromatic Hydrocarbons				Result 1					
Acenaphthene	M23-De0006367	NCP	%	114			70-130	Pass	
Acenaphthylene	M23-De0014440	NCP	%	96			70-130	Pass	
Anthracene	M23-De0014440	NCP	%	87			70-130	Pass	
Benz(a)anthracene	M23-De0014440	NCP	%	104			70-130	Pass	
Benzo(a)pyrene	M23-De0014440	NCP	%	99			70-130	Pass	
Benzo(b&j)fluoranthene	M23-De0014440	NCP	%	98			70-130	Pass	
Benzo(g.h.i)perylene	M23-De0014440	NCP	%	95			70-130	Pass	
Benzo(k)fluoranthene	M23-De0014440	NCP	%	113			70-130	Pass	
Chrysene	M23-De0014440	NCP	%	113			70-130	Pass	
Dibenz(a.h)anthracene	M23-De0014440	NCP	%	73			70-130	Pass	
Fluoranthene	M23-De0014440	NCP	%	90			70-130	Pass	
Fluorene	M23-De0014440	NCP	%	88			70-130	Pass	
Indeno(1.2.3-cd)pyrene	M23-De0014440	NCP	%	80			70-130	Pass	
Naphthalene	M23-De0014440	NCP	%	102			70-130	Pass	
Phenanthrene	M23-De0014440	NCP	%	76			70-130	Pass	
Pyrene	M23-De0006367	NCP	%	80			70-130	Pass	
Spike - % Recovery									
				Result 1					
Nitrate & Nitrite (as N)	M23-De0049292	NCP	%	116			70-130	Pass	
Nitrite (as N)	M23-De0049292	NCP	%	105			70-130	Pass	
Total Kjeldahl Nitrogen (as N)	M23-De0047035	NCP	%	73			70-130	Pass	
Phosphate total (as P)	M23-De0041093	NCP	%	99			70-130	Pass	
Spike - % Recovery									
Heavy Metals				Result 1					
Arsenic (filtered)	M23-De0044984	NCP	%	95			75-125	Pass	
Cadmium (filtered)	M23-De0044984	NCP	%	90			75-125	Pass	
Chromium (filtered)	M23-De0044984	NCP	%	93			75-125	Pass	
Copper (filtered)	M23-De0044984	NCP	%	91			75-125	Pass	
Lead (filtered)	M23-De0044984	NCP	%	91			75-125	Pass	
Mercury (filtered)	M23-De0044984	NCP	%	82			75-125	Pass	
Nickel (filtered)	M23-De0044984	NCP	%	92			75-125	Pass	
Zinc (filtered)	M23-De0044984	NCP	%	94			75-125	Pass	
Spike - % Recovery									
Alkali Metals				Result 1					
Magnesium	M23-De0048475	NCP	%	107			75-125	Pass	
Potassium	M23-De0044351	NCP	%	117			75-125	Pass	
Sodium	M23-De0048475	NCP	%	117			75-125	Pass	
Spike - % Recovery									
Per- and Polyfluoroalkyl Substances (PFASs) - Short				Result 1					
1H.1H.2H.2H-perfluorooctanesulfonic acid(6:2 FTSA)	M23-De0048453	NCP	%	95			50-150	Pass	
Perfluorohexanesulfonic acid (PFHxS)	M23-De0048453	NCP	%	84			50-150	Pass	
Perfluorooctanesulfonic acid (PFOS)	M23-De0048453	NCP	%	91			50-150	Pass	
Perfluorooctanoic acid (PFOA)	M23-De0048453	NCP	%	88			50-150	Pass	

Test	Lab Sample ID	QA Source	Units	Result 1			Acceptance Limits	Pass Limits	Qualifying Code
Duplicate									
Total Recoverable Hydrocarbons				Result 1	Result 2	RPD			
TRH C6-C9	M23-De0045101	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH C15-C28	M23-De0038424	NCP	mg/L	0.7	0.6	12	30%	Pass	
TRH C29-C36	M23-De0038424	NCP	mg/L	0.3	0.3	6.5	30%	Pass	
TRH C6-C10	M23-De0045101	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
TRH >C10-C16	M23-De0038424	NCP	mg/L	0.10	0.14	33	30%	Fail	Q15
TRH >C16-C34	M23-De0038424	NCP	mg/L	0.9	0.8	11	30%	Pass	
TRH >C34-C40	M23-De0038424	NCP	mg/L	0.1	< 0.1	40	30%	Fail	Q15
Duplicate									
BTEX				Result 1	Result 2	RPD			
Benzene	M23-De0045101	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Toluene	M23-De0045101	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Ethylbenzene	M23-De0045101	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
m&p-Xylenes	M23-De0045101	NCP	mg/L	< 0.002	< 0.002	<1	30%	Pass	
o-Xylene	M23-De0045101	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Xylenes - Total*	M23-De0045101	NCP	mg/L	< 0.003	< 0.003	<1	30%	Pass	
Duplicate									
Total Recoverable Hydrocarbons - 2013 NEPM Fractions				Result 1	Result 2	RPD			
Naphthalene	M23-De0045101	NCP	mg/L	< 0.01	< 0.01	<1	30%	Pass	
Duplicate									
Polycyclic Aromatic Hydrocarbons				Result 1	Result 2	RPD			
Acenaphthene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Acenaphthylene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Anthracene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benz(a)anthracene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(a)pyrene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(b&j)fluoranthene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(g.h.i)perylene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Benzo(k)fluoranthene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Chrysene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Dibenz(a.h)anthracene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluoranthene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Fluorene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Indeno(1.2.3-cd)pyrene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Naphthalene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Phenanthrene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Pyrene	B23-De0056020	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Duplicate									
				Result 1	Result 2	RPD			
Ammonia (as N)	M23-De0048339	NCP	mg/L	0.65	0.65	<1	30%	Pass	
Chloride	M23-De0044251	NCP	mg/L	1900	2000	2.8	30%	Pass	
Nitrate & Nitrite (as N)	M23-De0048339	NCP	mg/L	1.0	1.0	<1	30%	Pass	
Nitrate (as N)	M23-De0048625	NCP	mg/L	0.75	0.76	1.4	30%	Pass	
Nitrite (as N)	M23-De0048339	NCP	mg/L	< 0.02	< 0.02	<1	30%	Pass	
Sulphate (as SO4)	M23-De0044251	NCP	mg/L	350	350	<1	30%	Pass	
Total Dissolved Solids Dried at 180 °C ± 2 °C	M23-De0047773	NCP	mg/L	2700	3100	14	30%	Pass	
Total Kjeldahl Nitrogen (as N)	M23-De0048624	NCP	mg/L	11	11	5.5	30%	Pass	
Phosphate total (as P)	M23-De0047773	NCP	mg/L	0.87	0.90	2.7	30%	Pass	
Duplicate									
Alkalinity (speciated)				Result 1	Result 2	RPD			
Bicarbonate Alkalinity (as CaCO3)	M23-De0044563	NCP	mg/L	510	480	5.5	30%	Pass	
Carbonate Alkalinity (as CaCO3)	M23-De0044563	NCP	mg/L	< 10	< 10	<1	30%	Pass	
Hydroxide Alkalinity (as CaCO3)	M23-De0044563	NCP	mg/L	< 20	< 20	<1	30%	Pass	
Total Alkalinity (as CaCO3)	M23-De0044563	NCP	mg/L	510	480	5.5	30%	Pass	

Duplicate									
Heavy Metals				Result 1	Result 2	RPD			
Arsenic (filtered)	M23-De0044984	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Cadmium (filtered)	M23-De0044984	NCP	mg/L	< 0.0002	< 0.0002	<1	30%	Pass	
Chromium (filtered)	M23-De0044984	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Copper (filtered)	M23-De0044984	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Lead (filtered)	M23-De0044984	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Mercury (filtered)	M23-De0044984	NCP	mg/L	< 0.0001	< 0.0001	<1	30%	Pass	
Nickel (filtered)	M23-De0044984	NCP	mg/L	< 0.001	< 0.001	<1	30%	Pass	
Zinc (filtered)	M23-De0044984	NCP	mg/L	< 0.005	< 0.005	<1	30%	Pass	
Duplicate									
Alkali Metals				Result 1	Result 2	RPD			
Calcium	M23-De0044351	NCP	mg/L	160	160	2.3	30%	Pass	
Magnesium	M23-De0044351	NCP	mg/L	790	810	2.2	30%	Pass	
Potassium	M23-De0044351	NCP	mg/L	55	56	2.5	30%	Pass	
Sodium	M23-De0044351	NCP	mg/L	1700	1800	3.1	30%	Pass	
Duplicate									
Per- and Polyfluoroalkyl Substances (PFASs) - Short				Result 1	Result 2	RPD			
1H.1H.2H.2H-perfluorooctanesulfonic acid(6:2 FTSA)	M23-De0048876	NCP	ug/L	< 0.05	< 0.05	<1	30%	Pass	
Perfluorohexanesulfonic acid (PFHxS)	M23-De0048876	NCP	ug/L	0.07	0.07	3.5	30%	Pass	
Perfluorooctanesulfonic acid (PFOS)	M23-De0048876	NCP	ug/L	0.11	0.10	7.6	30%	Pass	
Perfluorooctanoic acid (PFOA)	M23-De0048876	NCP	ug/L	< 0.01	< 0.01	<1	30%	Pass	

Comments

Sample Integrity

Custody Seals Intact (if used)	N/A
Attempt to Chill was evident	Yes
Sample correctly preserved	Yes
Appropriate sample containers have been used	Yes
Sample containers for volatile analysis received with minimal headspace	Yes
Samples received within HoldingTime	Yes
Some samples have been subcontracted	No

Qualifier Codes/Comments

Code	Description
N01	F2 is determined by arithmetically subtracting the "naphthalene" value from the ">C10-C16" value. The naphthalene value used in this calculation is obtained from volatiles (Purge & Trap analysis).
N02	Where we have reported both volatile (P&T GCMS) and semivolatile (GCMS) naphthalene data, results may not be identical. Provided correct sample handling protocols have been followed, any observed differences in results are likely to be due to procedural differences within each methodology. Results determined by both techniques have passed all QAQC acceptance criteria, and are entirely technically valid.
N04	F1 is determined by arithmetically subtracting the "Total BTEX" value from the "C6-C10" value. The "Total BTEX" value is obtained by summing the concentrations of BTEX analytes. The "C6-C10" value is obtained by quantitating against a standard of mixed aromatic/aliphatic analytes.
N07	Please note:- These two PAH isomers closely co-elute using the most contemporary analytical methods and both the reported concentration (and the TEQ) apply specifically to the total of the two co-eluting PAHs
N11	Isotope dilution is used for calibration of each native compound for which an exact labelled analogue is available (Isotope Dilution Quantitation). The isotopically labelled analogues allow identification and recovery correction of the concentration of the associated native PFAS compounds.
Q15	The RPD reported passes Eurofins Environment Testing's QC - Acceptance Criteria as defined in the Internal Quality Control Review and Glossary page of this report.

Authorised by:

Savini Suduweli	Analytical Services Manager
Caitlin Breeze	Senior Analyst-Inorganic
Carroll Lee	Senior Analyst-PFAS
Emily Rosenberg	Senior Analyst-Metal
Joseph Edouard	Senior Analyst-Organic
Joseph Edouard	Senior Analyst-Volatile
Mary Makarios	Senior Analyst-Inorganic
Mary Makarios	Senior Analyst-Metal

Glenn Jackson
Managing Director

Final Report – this report replaces any previously issued Report

- Indicates Not Requested

* Indicates NATA accreditation does not cover the performance of this service

Measurement uncertainty of test data is available on request or please click here.

QUALITY CONTROL REPORT

Work Order	: **EM2322584**	Page	: 1 of 12
Client	: **JACOBS GROUP(AUSTRALIA)PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MS ERIN MCINTOSH	Contact	: Peter Ravlic
Address	: PO BOX 312 FLINDERS LANE MELBOURNE VIC AUSTRALIA 8009	Address	: 4 Westall Rd Springvale VIC Australia 3171
Telephone	: +61 07 3026 7100	Telephone	: +6138549 9645
Project	: IW238424	Date Samples Received	: 18-Dec-2023
Order number	: IW238424	Date Analysis Commenced	: 19-Dec-2023
C-O-C number	: ----	Issue Date	: 27-Dec-2023
Sampler	: JACOBS		
Site	: ----		
Quote number	: EN/000		
No. of samples received	: 9		
No. of samples analysed	: 8		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted, unless the sampling was conducted by ALS. This document shall not be reproduced, except in full.

This Quality Control Report contains the following information:

- Laboratory Duplicate (DUP) Report; Relative Percentage Difference (RPD) and Acceptance Limits
- Method Blank (MB) and Laboratory Control Spike (LCS) Report; Recovery and Acceptance Limits
- Matrix Spike (MS) Report; Recovery and Acceptance Limits

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Dilani Fernando	Laboratory Coordinator	Melbourne Inorganics, Springvale, VIC
Nancy Wang	2IC Organic Chemist	Melbourne Organics, Springvale, VIC

General Comments

The analytical procedures used by ALS have been developed from established internationally recognised procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are fully validated and are often at the client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis. Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

Key : Anonymous = Refers to samples which are not specifically part of this work order but formed part of the QC process lot
CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
RPD = Relative Percentage Difference
# = Indicates failed QC
* = The final LOR has been raised due to dilution or other sample specific cause; adjusted LOR is shown in brackets. The duplicate ranges for Acceptable RPD% are applied to the final LOR where applicable.

Laboratory Duplicate (DUP) Report

The quality control term Laboratory Duplicate refers to a randomly selected intralaboratory split. Laboratory duplicates provide information regarding method precision and sample heterogeneity. The permitted ranges for the Relative Percent Deviation (RPD) of Laboratory Duplicates are specified in ALS Method QWI-EN/38 and are dependent on the magnitude of results in comparison to the level of reporting: Result < 10 times LOR: No Limit; Result between 10 and 20 times LOR: 0% - 50%; Result > 20 times LOR: 0% - 20%.

Sub-Matrix: **WATER**

				Laboratory Duplicate (DUP) Report					
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 5505481)									
EM2321820-001	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	2060	1960	4.7	0% - 20%
EM2322418-008	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	35500	35000	1.4	0% - 20%
EM2322480-002	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	967	961	0.6	0% - 20%
EM2322574-012	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	12400	13800	10.4	0% - 20%
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QC Lot: 5508369)									
EM2322484-047	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	320	326	1.9	0% - 20%
EM2322484-058	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	<10	0.0	No Limit
EM2322484-069	Anonymous	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	1720	1640	4.7	0% - 20%
EM2322584-004	BH4	EA015H: Total Dissolved Solids @180°C	----	10	mg/L	2900	2820	3.0	0% - 20%
ED037P: Alkalinity by PC Titrator (QC Lot: 5501823)									
EM2322584-002	DUP_1	ED037-P: Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	0.0	No Limit
		ED037-P: Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	537	537	0.0	0% - 20%
		ED037-P: Total Alkalinity as CaCO3	----	1	mg/L	537	537	0.0	0% - 20%
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QC Lot: 5505244)									
EM2322584-001	BH201	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1 (5)*	mg/L	<5	<5	0.0	No Limit
EM2322514-001	Anonymous	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	47	47	0.0	0% - 20%
ED045G: Chloride by Discrete Analyser (QC Lot: 5505245)									
EM2322514-001	Anonymous	ED045G: Chloride	16887-00-6	1	mg/L	297	303	1.8	0% - 20%
EM2322584-001	BH201	ED045G: Chloride	16887-00-6	1	mg/L	104	103	1.3	0% - 20%

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
ED093F: Dissolved Major Cations (QC Lot: 5508818)									
EM2322584-002	DUP_1	ED093F: Calcium	7440-70-2	1	mg/L	59	59	0.0	0% - 20%
		ED093F: Magnesium	7439-95-4	1	mg/L	41	41	0.0	0% - 20%
		ED093F: Sodium	7440-23-5	1	mg/L	118	118	0.0	0% - 20%
		ED093F: Potassium	7440-09-7	1	mg/L	6	6	0.0	No Limit
EG020F: Dissolved Metals by ICP-MS (QC Lot: 5508817)									
EM2322584-001	BH201	EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
		EG020A-F: Arsenic	7440-38-2	0.001	mg/L	0.041	0.041	0.0	0% - 20%
		EG020A-F: Chromium	7440-47-3	0.001	mg/L	0.003	0.003	0.0	No Limit
		EG020A-F: Copper	7440-50-8	0.001	mg/L	0.013	0.014	0.0	0% - 50%
		EG020A-F: Lead	7439-92-1	0.001	mg/L	0.002	0.002	0.0	No Limit
		EG020A-F: Nickel	7440-02-0	0.001	mg/L	0.022	0.024	9.2	0% - 20%
		EG020A-F: Zinc	7440-66-6	0.005	mg/L	0.018	0.017	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 5508813)									
EM2322091-001	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EM2322285-006	Anonymous	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EG035F: Dissolved Mercury by FIMS (QC Lot: 5508819)									
EM2322584-004	BH4	EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 5501598)									
EM2322091-001	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.11	0.12	0.0	0% - 50%
EM2322285-006	Anonymous	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.05	0.04	0.0	No Limit
EK055G: Ammonia as N by Discrete Analyser (QC Lot: 5501600)									
EM2322584-004	BH4	EK055G: Ammonia as N	7664-41-7	0.01	mg/L	0.39	0.38	3.1	0% - 20%
EK057G: Nitrite as N by Discrete Analyser (QC Lot: 5505246)									
EM2322514-001	Anonymous	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EM2322584-001	BH201	EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	<0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 5501599)									
EM2322091-001	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	18.4	18.5	0.4	0% - 20%
EM2322285-006	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.01	0.01	0.0	No Limit
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QC Lot: 5501601)									
EM2322584-004	BH4	EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	0.02	0.01	0.0	No Limit
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 5501863)									
EM2322266-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	0.1 (0.5)*	mg/L	118	116	2.0	0% - 20%
EM2322584-002	DUP_1	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	33.0	34.0	2.9	0% - 20%
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QC Lot: 5501865)									
EM2322584-009	BH3	EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	0.5	0.5	0.0	No Limit
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 5501864)									

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
				Laboratory Duplicate (DUP) Report					
EK067G: Total Phosphorus as P by Discrete Analyser (QC Lot: 5501864) - continued									
EM2322266-001	Anonymous	EK067G: Total Phosphorus as P	----	0.01 (0.05)*	mg/L	0.55	0.52	5.6	0% - 50%
EM2322584-002	DUP_1	EK067G: Total Phosphorus as P	----	0.01	mg/L	0.30	0.29	0.0	0% - 20%
EK071G: Reactive Phosphorus as P by discrete analyser (QC Lot: 5505247)									
EM2322584-001	BH201	EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	0.19	0.19	0.0	0% - 50%
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QC Lot: 5502239)									
EM2322584-001	BH201	EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	<0.5	0.0	No Limit
		EP075(SIM): Naphthalene	91-20-3	1	µg/L	2.3	2.8	17.7	No Limit
		EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	<1.0	0.0	No Limit
		EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	<1.0	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 5501799)									
EM2322584-004	BH4	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
EM2322447-001	Anonymous	EP080: C6 - C9 Fraction	----	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Petroleum Hydrocarbons (QC Lot: 5502240)									
EM2322584-001	BH201	EP071: C15 - C28 Fraction	----	100	µg/L	6860	5730	18.0	0% - 20%
		EP071: C10 - C14 Fraction	----	50	µg/L	14000	11800	16.7	0% - 20%
		EP071: C29 - C36 Fraction	----	50	µg/L	420	320	25.1	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 5501799)									
EM2322584-004	BH4	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.0	No Limit
EM2322447-001	Anonymous	EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	<20	0.0	No Limit
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QC Lot: 5502240)									
EM2322584-001	BH201	EP071: >C10 - C16 Fraction	----	100	µg/L	20100	17000	16.8	0% - 20%
		EP071: >C16 - C34 Fraction	----	100	µg/L	1420	1120	23.8	0% - 50%
		EP071: >C34 - C40 Fraction	----	100	µg/L	<100	<100	0.0	No Limit
EP080: BTEXN (QC Lot: 5501799)									

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP080: BTEXN (QC Lot: 5501799) - continued									
EM2322584-004	BH4	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.0	No Limit
EM2322447-001	Anonymous	EP080: Benzene	71-43-2	1	µg/L	<1	<1	0.0	No Limit
		EP080: Toluene	108-88-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: Ethylbenzene	100-41-4	2	µg/L	<2	<2	0.0	No Limit
		EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	0.0	No Limit
		EP080: ortho-Xylene	95-47-6	2	µg/L	<2	<2	0.0	No Limit
		EP080: Naphthalene	91-20-3	5	µg/L	<5	<5	0.0	No Limit
EP231A: Perfluoroalkyl Sulfonic Acids (QC Lot: 5503182)									
EM2322091-001	Anonymous	EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	<0.02	0.0	No Limit
EM2322091-004	Anonymous	EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	<0.02	0.0	No Limit
EP231B: Perfluoroalkyl Carboxylic Acids (QC Lot: 5503182)									
EM2322091-001	Anonymous	EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	0.03	0.04	34.1	No Limit
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	0.03	0.03	0.0	No Limit
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	<0.1	0.0	No Limit
EM2322091-004	Anonymous	EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	<0.02	0.0	No Limit
		EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	<0.1	0.0	No Limit
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QC Lot: 5503182)									
EM2322091-001	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	<0.05	0.0	No Limit

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Laboratory Duplicate (DUP) Report					
				LOR	Unit	Original Result	Duplicate Result	RPD (%)	Acceptable RPD (%)
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QC Lot: 5503182) - continued									
EM2322091-001	Anonymous	EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	<0.05	0.0	No Limit
EM2322091-004	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	<0.05	0.0	No Limit
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	<0.05	0.0	No Limit
EP231P: PFAS Sums (QC Lot: 5503182)									
EM2322091-001	Anonymous	EP231X: Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Sum of PFAS (WA DER List)	----	0.01	µg/L	0.06	0.07	15.4	No Limit
EM2322091-004	Anonymous	EP231X: Sum of PFHxS and PFOS	355-46-4/1763-23-1	0.01	µg/L	<0.01	<0.01	0.0	No Limit
		EP231X: Sum of PFAS (WA DER List)	----	0.01	µg/L	<0.01	<0.01	0.0	No Limit

Method Blank (MB) and Laboratory Control Sample (LCS) Report

The quality control term Method / Laboratory Blank refers to an analyte free matrix to which all reagents are added in the same volumes or proportions as used in standard sample preparation. The purpose of this QC parameter is to monitor potential laboratory contamination. The quality control term Laboratory Control Sample (LCS) refers to a certified reference material, or a known interference free matrix spiked with target analytes. The purpose of this QC parameter is to monitor method precision and accuracy independent of sample matrix. Dynamic Recovery Limits are based on statistical evaluation of processed LCS.

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 5505481)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2000 mg/L	105	91.0	110
				<10	2340 mg/L	117	80.8	119
				<10	293 mg/L	105	91.0	110
EA015: Total Dissolved Solids dried at 180 ± 5 °C (QCLot: 5508369)								
EA015H: Total Dissolved Solids @180°C	----	10	mg/L	<10	2000 mg/L	97.7	91.0	110
				<10	2340 mg/L	108	80.8	119
				<10	293 mg/L	98.0	91.0	110
ED037P: Alkalinity by PC Titrator (QCLot: 5501823)								
ED037-P: Total Alkalinity as CaCO3	----	----	mg/L	----	200 mg/L	100.0	85.0	116
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5505244)								
ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	500 mg/L	105	90.0	110
				<1	25 mg/L	104	90.0	110
ED045G: Chloride by Discrete Analyser (QCLot: 5505245)								
ED045G: Chloride	16887-00-6	1	mg/L	<1	1000 mg/L	100	90.0	110
				<1	10 mg/L	91.2	90.0	110
ED093F: Dissolved Major Cations (QCLot: 5508818)								
ED093F: Calcium	7440-70-2	1	mg/L	<1	50 mg/L	96.7	80.0	120
ED093F: Magnesium	7439-95-4	1	mg/L	<1	50 mg/L	92.3	80.0	120
ED093F: Sodium	7440-23-5	1	mg/L	<1	50 mg/L	95.4	80.0	120
ED093F: Potassium	7440-09-7	1	mg/L	<1	50 mg/L	91.8	80.0	120
EG020F: Dissolved Metals by ICP-MS (QCLot: 5508817)								
EG020A-F: Arsenic	7440-38-2	0.001	mg/L	<0.001	0.1 mg/L	99.2	89.0	111
EG020A-F: Cadmium	7440-43-9	0.0001	mg/L	<0.0001	0.1 mg/L	103	83.5	111
EG020A-F: Chromium	7440-47-3	0.001	mg/L	<0.001	0.1 mg/L	93.8	83.2	109
EG020A-F: Copper	7440-50-8	0.001	mg/L	<0.001	0.1 mg/L	97.0	83.1	107
EG020A-F: Lead	7439-92-1	0.001	mg/L	<0.001	0.1 mg/L	94.8	84.6	108
EG020A-F: Nickel	7440-02-0	0.001	mg/L	<0.001	0.1 mg/L	97.5	84.3	110
EG020A-F: Zinc	7440-66-6	0.005	mg/L	<0.005	0.1 mg/L	105	86.3	112
EG035F: Dissolved Mercury by FIMS (QCLot: 5508813)								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	109	71.6	116
EG035F: Dissolved Mercury by FIMS (QCLot: 5508819)								

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
				Result	Concentration	LCS	Low	High
EG035F: Dissolved Mercury by FIMS (QCLot: 5508819) - continued								
EG035F: Mercury	7439-97-6	0.0001	mg/L	<0.0001	0.01 mg/L	94.5	71.6	116
EK055G: Ammonia as N by Discrete Analyser (QCLot: 5501598)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	104	90.0	110
EK055G: Ammonia as N by Discrete Analyser (QCLot: 5501600)								
EK055G: Ammonia as N	7664-41-7	0.01	mg/L	<0.01	1 mg/L	103	90.0	110
EK057G: Nitrite as N by Discrete Analyser (QCLot: 5505246)								
EK057G: Nitrite as N	14797-65-0	0.01	mg/L	<0.01	0.5 mg/L	102	90.0	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 5501599)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	95.9	90.0	110
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 5501601)								
EK059G: Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	0.5 mg/L	94.6	90.0	110
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 5501863)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	5 mg/L	94.9	70.0	117
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 5501865)								
EK061G: Total Kjeldahl Nitrogen as N	----	0.1	mg/L	<0.1	5 mg/L	92.9	70.0	117
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 5501864)								
EK067G: Total Phosphorus as P	----	0.01	mg/L	<0.01	2.21 mg/L	91.5	71.9	114
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 5505247)								
EK071G: Reactive Phosphorus as P	14265-44-2	0.01	mg/L	<0.01	0.5 mg/L	104	90.0	110
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 5502239)								
EP075(SIM): Naphthalene	91-20-3	1	µg/L	<1.0	5 µg/L	92.6	42.8	114
EP075(SIM): Acenaphthylene	208-96-8	1	µg/L	<1.0	5 µg/L	100	48.6	119
EP075(SIM): Acenaphthene	83-32-9	1	µg/L	<1.0	5 µg/L	95.2	47.0	117
EP075(SIM): Fluorene	86-73-7	1	µg/L	<1.0	5 µg/L	102	49.5	119
EP075(SIM): Phenanthrene	85-01-8	1	µg/L	<1.0	5 µg/L	103	49.4	121
EP075(SIM): Anthracene	120-12-7	1	µg/L	<1.0	5 µg/L	104	48.4	122
EP075(SIM): Fluoranthene	206-44-0	1	µg/L	<1.0	5 µg/L	108	50.3	124
EP075(SIM): Pyrene	129-00-0	1	µg/L	<1.0	5 µg/L	110	50.0	126
EP075(SIM): Benz(a)anthracene	56-55-3	1	µg/L	<1.0	5 µg/L	113	49.4	127
EP075(SIM): Chrysene	218-01-9	1	µg/L	<1.0	5 µg/L	108	48.7	126
EP075(SIM): Benzo(b+j)fluoranthene	205-99-2 205-82-3	1	µg/L	<1.0	5 µg/L	103	54.5	134
EP075(SIM): Benzo(k)fluoranthene	207-08-9	1	µg/L	<1.0	5 µg/L	100	56.1	134
EP075(SIM): Benzo(a)pyrene	50-32-8	0.5	µg/L	<0.5	5 µg/L	106	55.6	135

Sub-Matrix: **WATER**

Method: Compound	CAS Number	LOR	Unit	Method Blank (MB) Report Result	Laboratory Control Spike (LCS) Report Spike Concentration	Spike Recovery (%) LCS	Acceptable Limits (%) Low	High
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 5502239) - continued								
EP075(SIM): Indeno(1.2.3.cd)pyrene	193-39-5	1	µg/L	<1.0	5 µg/L	109	54.4	126
EP075(SIM): Dibenz(a.h)anthracene	53-70-3	1	µg/L	<1.0	5 µg/L	111	54.5	126
EP075(SIM): Benzo(g.h.i)perylene	191-24-2	1	µg/L	<1.0	5 µg/L	108	54.4	126
EP080/071: Total Petroleum Hydrocarbons (QCLot: 5501799)								
EP080: C6 - C9 Fraction	----	20	µg/L	<20	360 µg/L	113	66.2	134
EP080/071: Total Petroleum Hydrocarbons (QCLot: 5502240)								
EP071: C10 - C14 Fraction	----	50	µg/L	<50	4840 µg/L	58.0	47.2	122
EP071: C15 - C28 Fraction	----	100	µg/L	<100	15400 µg/L	67.5	52.9	131
EP071: C29 - C36 Fraction	----	50	µg/L	<50	8450 µg/L	67.2	50.4	127
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 5501799)								
EP080: C6 - C10 Fraction	C6_C10	20	µg/L	<20	450 µg/L	109	66.2	132
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 5502240)								
EP071: >C10 - C16 Fraction	----	100	µg/L	<100	6590 µg/L	66.8	49.1	125
EP071: >C16 - C34 Fraction	----	100	µg/L	<100	20400 µg/L	66.8	51.6	128
EP071: >C34 - C40 Fraction	----	100	µg/L	<100	1500 µg/L	63.8	47.2	130
EP080: BTEXN (QCLot: 5501799)								
EP080: Benzene	71-43-2	1	µg/L	<1	20 µg/L	114	68.8	127
EP080: Toluene	108-88-3	2	µg/L	<2	20 µg/L	116	72.9	129
EP080: Ethylbenzene	100-41-4	2	µg/L	<2	20 µg/L	115	71.7	130
EP080: meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	40 µg/L	122	72.3	136
EP080: ortho-Xylene	95-47-6	2	µg/L	<2	20 µg/L	123	75.9	134
EP080: Naphthalene	91-20-3	5	µg/L	<5	5 µg/L	104	68.3	131
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 5503182)								
EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.02	µg/L	<0.02	0.222 µg/L	97.0	72.0	130
EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.01	µg/L	<0.01	0.228 µg/L	86.6	68.0	131
EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.01	µg/L	<0.01	0.232 µg/L	91.5	65.0	140
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 5503182)								
EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	0.1	µg/L	<0.1	1.25 µg/L	91.4	73.0	129
EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.02	µg/L	<0.02	0.25 µg/L	90.6	72.0	129
EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.02	µg/L	<0.02	0.25 µg/L	107	72.0	129
EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.02	µg/L	<0.02	0.25 µg/L	87.6	72.0	130
EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.01	µg/L	<0.01	0.25 µg/L	88.0	71.0	133
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 5503182)								

Sub-Matrix: **WATER**

				Method Blank (MB) Report	Laboratory Control Spike (LCS) Report			
					Spike	Spike Recovery (%)	Acceptable Limits (%)	
Method: Compound	CAS Number	LOR	Unit	Result	Concentration	LCS	Low	High
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 5503182) - continued								
EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.05	µg/L	<0.05	0.234 µg/L	95.6	63.0	143
EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.05	µg/L	<0.05	0.238 µg/L	97.8	64.0	140
EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.05	µg/L	<0.05	0.24 µg/L	101	67.0	138
EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.05	µg/L	<0.05	0.242 µg/L	86.6	70.0	130
EP231P: PFAS Sums (QCLot: 5503182)								
EP231X: Sum of PFHxS and PFOS	355-46-4/17 63-23-1	0.01	µg/L	<0.01	----	----	----	----
EP231X: Sum of PFAS (WA DER List)	----	0.01	µg/L	<0.01	----	----	----	----

Matrix Spike (MS) Report

The quality control term Matrix Spike (MS) refers to an intralaboratory split sample spiked with a representative set of target analytes. The purpose of this QC parameter is to monitor potential matrix effects on analyte recoveries. Static Recovery Limits as per laboratory Data Quality Objectives (DQOs). Ideal recovery ranges stated may be waived in the event of sample matrix interference.

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA (QCLot: 5505244)							
EM2322584-002	DUP_1	ED041G: Sulfate as SO4 - Turbidimetric	14808-79-8	500 mg/L	74.9	70.0	130
ED045G: Chloride by Discrete Analyser (QCLot: 5505245)							
EM2322584-002	DUP_1	ED045G: Chloride	16887-00-6	400 mg/L	110	70.0	142
EG020F: Dissolved Metals by ICP-MS (QCLot: 5508817)							
EM2322584-001	BH201	EG020A-F: Arsenic	7440-38-2	0.2 mg/L	96.1	76.6	124
		EG020A-F: Cadmium	7440-43-9	0.05 mg/L	103	74.6	118
		EG020A-F: Chromium	7440-47-3	0.2 mg/L	91.8	71.0	135
		EG020A-F: Copper	7440-50-8	0.2 mg/L	95.4	76.0	130
		EG020A-F: Lead	7439-92-1	0.2 mg/L	88.4	75.0	133
		EG020A-F: Nickel	7440-02-0	0.2 mg/L	96.5	73.0	131
		EG020A-F: Zinc	7440-66-6	0.2 mg/L	96.8	75.0	131
EG035F: Dissolved Mercury by FIMS (QCLot: 5508813)							
EM2322091-002	Anonymous	EG035F: Mercury	7439-97-6	0.01 mg/L	110	70.0	120
EG035F: Dissolved Mercury by FIMS (QCLot: 5508819)							
EM2322584-008	BH201	EG035F: Mercury	7439-97-6	0.01 mg/L	79.4	70.0	120
EK055G: Ammonia as N by Discrete Analyser (QCLot: 5501598)							
EM2322091-002	Anonymous	EK055G: Ammonia as N	7664-41-7	1 mg/L	# Not Determined	70.0	130
EK055G: Ammonia as N by Discrete Analyser (QCLot: 5501600)							

Sub-Matrix: **WATER**

Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Matrix Spike (MS) Report: Spike Concentration	SpikeRecovery(%) MS	Acceptable Limits (%) Low	Acceptable Limits (%) High
EK055G: Ammonia as N by Discrete Analyser (QCLot: 5501600) - continued							
EM2322584-008	BH201	EK055G: Ammonia as N	7664-41-7	1 mg/L	77.0	70.0	130
EK057G: Nitrite as N by Discrete Analyser (QCLot: 5505246)							
EM2322584-002	DUP_1	EK057G: Nitrite as N	14797-65-0	0.5 mg/L	108	80.0	114
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 5501599)							
EM2322091-002	Anonymous	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	99.1	70.0	130
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser (QCLot: 5501601)							
EM2322584-008	BH201	EK059G: Nitrite + Nitrate as N	----	0.5 mg/L	97.7	70.0	130
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser (QCLot: 5501863)							
EM2322285-001	Anonymous	EK061G: Total Kjeldahl Nitrogen as N	----	5 mg/L	92.2	70.0	130
EK067G: Total Phosphorus as P by Discrete Analyser (QCLot: 5501864)							
EM2322285-001	Anonymous	EK067G: Total Phosphorus as P	----	1 mg/L	93.4	70.0	130
EK071G: Reactive Phosphorus as P by discrete analyser (QCLot: 5505247)							
EM2322584-002	DUP_1	EK071G: Reactive Phosphorus as P	14265-44-2	0.5 mg/L	94.7	79.0	123
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons (QCLot: 5502239)							
EM2322584-004	BH4	EP075(SIM): Acenaphthene	83-32-9	5 µg/L	84.5	39.3	123
		EP075(SIM): Pyrene	129-00-0	5 µg/L	95.0	44.0	124
EP080/071: Total Petroleum Hydrocarbons (QCLot: 5501799)							
EM2322447-002	Anonymous	EP080: C6 - C9 Fraction	----	280 µg/L	75.4	33.9	126
EP080/071: Total Petroleum Hydrocarbons (QCLot: 5502240)							
EM2322584-008	BH201	EP071: C10 - C14 Fraction	----	4840 µg/L	65.0	48.0	126
		EP071: C15 - C28 Fraction	----	15400 µg/L	59.4	51.7	132
		EP071: C29 - C36 Fraction	----	8450 µg/L	57.1	50.5	127
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 5501799)							
EM2322447-002	Anonymous	EP080: C6 - C10 Fraction	C6_C10	330 µg/L	73.3	34.0	122
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions (QCLot: 5502240)							
EM2322584-008	BH201	EP071: >C10 - C16 Fraction	----	6590 µg/L	73.2	48.0	128
		EP071: >C16 - C34 Fraction	----	20400 µg/L	56.8	50.4	130
		EP071: >C34 - C40 Fraction	----	1500 µg/L	56.7	47.4	131
EP080: BTEXN (QCLot: 5501799)							
EM2322447-002	Anonymous	EP080: Benzene	71-43-2	20 µg/L	88.2	56.3	133
		EP080: Toluene	108-88-3	20 µg/L	86.7	60.4	132
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 5503182)							
EM2322091-002	Anonymous	EP231X: Perfluorobutane sulfonic acid (PFBS)	375-73-5	0.222 µg/L	109	72.0	130
		EP231X: Perfluorohexane sulfonic acid (PFHxS)	355-46-4	0.228 µg/L	97.1	68.0	131

Sub-Matrix: **WATER**

				Matrix Spike (MS) Report			
				Spike	SpikeRecovery(%)	Acceptable Limits (%)	
Laboratory sample ID	Sample ID	Method: Compound	CAS Number	Concentration	MS	Low	High
EP231A: Perfluoroalkyl Sulfonic Acids (QCLot: 5503182) - continued							
EM2322091-002	Anonymous	EP231X: Perfluorooctane sulfonic acid (PFOS)	1763-23-1	0.232 µg/L	96.5	65.0	140
EP231B: Perfluoroalkyl Carboxylic Acids (QCLot: 5503182)							
EM2322091-002	Anonymous	EP231X: Perfluorobutanoic acid (PFBA)	375-22-4	1.25 µg/L	99.6	73.0	129
		EP231X: Perfluoropentanoic acid (PFPeA)	2706-90-3	0.25 µg/L	91.2	72.0	129
		EP231X: Perfluorohexanoic acid (PFHxA)	307-24-4	0.25 µg/L	108	72.0	129
		EP231X: Perfluoroheptanoic acid (PFHpA)	375-85-9	0.25 µg/L	98.2	72.0	130
		EP231X: Perfluorooctanoic acid (PFOA)	335-67-1	0.25 µg/L	91.5	71.0	133
EP231D: (n:2) Fluorotelomer Sulfonic Acids (QCLot: 5503182)							
EM2322091-002	Anonymous	EP231X: 4:2 Fluorotelomer sulfonic acid (4:2 FTS)	757124-72-4	0.234 µg/L	99.7	63.0	143
		EP231X: 6:2 Fluorotelomer sulfonic acid (6:2 FTS)	27619-97-2	0.238 µg/L	102	64.0	140
		EP231X: 8:2 Fluorotelomer sulfonic acid (8:2 FTS)	39108-34-4	0.24 µg/L	98.4	67.0	138
		EP231X: 10:2 Fluorotelomer sulfonic acid (10:2 FTS)	120226-60-0	0.242 µg/L	119	70.0	130

QA/QC Compliance Assessment to assist with Quality Review

Work Order	: **EM2322584**	Page	: 1 of 11
Client	: **JACOBS GROUP(AUSTRALIA)PTY LTD**	Laboratory	: Environmental Division Melbourne
Contact	: MS ERIN MCINTOSH	Telephone	: +6138549 9645
Project	: IW238424	Date Samples Received	: 18-Dec-2023
Site	: ----	Issue Date	: 27-Dec-2023
Sampler	: JACOBS	No. of samples received	: 9
Order number	: IW238424	No. of samples analysed	: 8

This report is automatically generated by the ALS LIMS through interpretation of the ALS Quality Control Report and several Quality Assurance parameters measured by ALS. This automated reporting highlights any non-conformances, facilitates faster and more accurate data validation and is designed to assist internal expert and external Auditor review. Many components of this report contribute to the overall DQO assessment and reporting for guideline compliance.

Brief method summaries and references are also provided to assist in traceability.

Summary of Outliers

Outliers : Quality Control Samples

This report highlights outliers flagged in the Quality Control (QC) Report.

- **NO Method Blank value outliers occur.**
- **NO Duplicate outliers occur.**
- **NO Laboratory Control outliers occur.**
- **Matrix Spike outliers exist - please see following pages for full details.**
- **For all regular sample matrices, NO surrogate recovery outliers occur.**

Outliers : Analysis Holding Time Compliance

- **Analysis Holding Time Outliers exist - please see following pages for full details.**

Outliers : Frequency of Quality Control Samples

- **Quality Control Sample Frequency Outliers exist - please see following pages for full details.**

Outliers : Quality Control Samples

Duplicates, Method Blanks, Laboratory Control Samples and Matrix Spikes

Matrix: **WATER**

Compound Group Name	Laboratory Sample ID	Client Sample ID	Analyte	CAS Number	Data	Limits	Comment
Matrix Spike (MS) Recoveries							
EK055G: Ammonia as N by Discrete Analyser	EM2322091--002	Anonymous	**Ammonia as N**	7664-41-7	Not Determined	----	**MS recovery not determined, background level greater than or equal to 4x spike level.**

Outliers : Analysis Holding Time Compliance

Matrix: **WATER**

Method		Extraction / Preparation			Analysis		
Container / Client Sample ID(s)		*Date extracted*	*Due for extraction*	***Days overdue***	*Date analysed*	*Due for analysis*	***Days overdue***
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural BH201,	DUP_1	----	----	----	20-Dec-2023	16-Dec-2023	**4**
Clear Plastic Bottle - Natural BH4,	BH201	----	----	----	20-Dec-2023	17-Dec-2023	**3**
Clear Plastic Bottle - Natural BH3		----	----	----	20-Dec-2023	18-Dec-2023	**2**
EK071G: Reactive Phosphorus as P by discrete analyser							
Clear Plastic Bottle - Natural BH201,	DUP_1	----	----	----	20-Dec-2023	16-Dec-2023	**4**
Clear Plastic Bottle - Natural BH4,	BH201	----	----	----	20-Dec-2023	17-Dec-2023	**3**
Clear Plastic Bottle - Natural BH3		----	----	----	20-Dec-2023	18-Dec-2023	**2**

Outliers : Frequency of Quality Control Samples

Matrix: **WATER**

Quality Control Sample Type		Count		Rate (%)		Quality Control Specification
Analytical Methods	Method	QC	Regular	Actual	Expected	
Matrix Spikes (MS)						
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	21	4.76	5.00	NEPM 2013 B3 & ALS QC Standard

Analysis Holding Time Compliance

If samples are identified below as having been analysed or extracted outside of recommended holding times, this should be taken into consideration when interpreting results.

This report summarizes extraction / preparation and analysis times and compares each with ALS recommended holding times (referencing USEPA SW 846, APHA, AS and NEPM) based on the sample container provided. Dates reported represent first date of extraction or analysis and preclude subsequent dilutions and reruns. A listing of breaches (if any) is provided herein.

Holding time for leachate methods (e.g. TCLP) vary according to the analytes reported. Assessment compares the leach date with the shortest analyte holding time for the equivalent soil method. These are: organics 14 days, mercury 28 days & other metals 180 days. A recorded breach does not guarantee a breach for all non-volatile parameters.

Holding times for ***VOC in soils*** vary according to analytes of interest. Vinyl Chloride and Styrene holding time is 7 days; others 14 days. A recorded breach does not guarantee a breach for all VOC analytes and should be verified in case the reported breach is a false positive or Vinyl Chloride and Styrene are not key analytes of interest/concern.

Matrix: **WATER** Evaluation: × = Holding time breach ; ✓ = Within holding time.

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method / Container / Client Sample ID(s)		Sample Date	Extraction / Preparation: Date extracted	Due for extraction	Evaluation	Analysis: Date analysed	Due for analysis	Evaluation
EA015: Total Dissolved Solids dried at 180 ± 5 °C								
Clear Plastic Bottle - Natural (EA015H) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	21-Dec-2023	✓
Clear Plastic Bottle - Natural (EA015H) BH4,	BH201	**15-Dec-2023**	----	----	----	**21-Dec-2023**	22-Dec-2023	✓
Clear Plastic Bottle - Natural (EA015H) BH3		**16-Dec-2023**	----	----	----	**21-Dec-2023**	23-Dec-2023	✓
ED037P: Alkalinity by PC Titrator								
Clear Plastic Bottle - Natural (ED037-P) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	28-Dec-2023	✓
Clear Plastic Bottle - Natural (ED037-P) BH4,	BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	29-Dec-2023	✓
Clear Plastic Bottle - Natural (ED037-P) BH3		**16-Dec-2023**	----	----	----	**20-Dec-2023**	30-Dec-2023	✓
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Clear Plastic Bottle - Natural (ED041G) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Natural (ED041G) BH4,	BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Natural (ED041G) BH3		**16-Dec-2023**	----	----	----	**20-Dec-2023**	13-Jan-2024	✓
ED045G: Chloride by Discrete Analyser								
Clear Plastic Bottle - Natural (ED045G) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Natural (ED045G) BH4,	BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Natural (ED045G) BH3		**16-Dec-2023**	----	----	----	**20-Dec-2023**	13-Jan-2024	✓
ED093F: Dissolved Major Cations								
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**22-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) BH4,	BH201	**15-Dec-2023**	----	----	----	**22-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (ED093F) BH3		**16-Dec-2023**	----	----	----	**22-Dec-2023**	13-Jan-2024	✓
EG020F: Dissolved Metals by ICP-MS								
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**22-Dec-2023**	11-Jun-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) BH4,	BH201	**15-Dec-2023**	----	----	----	**22-Dec-2023**	12-Jun-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG020A-F) BH3		**16-Dec-2023**	----	----	----	**22-Dec-2023**	13-Jun-2024	✓

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method **Container** / Client Sample ID(s)	**Sample Date**	Extraction / Preparation **Date extracted**	Due for extraction	Evaluation	Analysis **Date analysed**	Due for analysis	Evaluation
EG035F: Dissolved Mercury by FIMS							
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) BH201, DUP_1	**14-Dec-2023**	----	----	----	**21-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) BH4, BH201	**15-Dec-2023**	----	----	----	**21-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Nitric Acid; Filtered (EG035F) BH3	**16-Dec-2023**	----	----	----	**21-Dec-2023**	13-Jan-2024	✓
EK055G: Ammonia as N by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK055G) BH201, DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) BH4, BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK055G) BH3	**16-Dec-2023**	----	----	----	**20-Dec-2023**	13-Jan-2024	✓
EK057G: Nitrite as N by Discrete Analyser							
Clear Plastic Bottle - Natural (EK057G) BH201, DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	16-Dec-2023	✗
Clear Plastic Bottle - Natural (EK057G) BH4, BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	17-Dec-2023	✗
Clear Plastic Bottle - Natural (EK057G) BH3	**16-Dec-2023**	----	----	----	**20-Dec-2023**	18-Dec-2023	✗
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH201, DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH4, BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK059G) BH3	**16-Dec-2023**	----	----	----	**20-Dec-2023**	13-Jan-2024	✓
EK061G: Total Kjeldahl Nitrogen By Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK061G) BH201, DUP_1	**14-Dec-2023**	**20-Dec-2023**	11-Jan-2024	✓	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) BH4, BH201	**15-Dec-2023**	**20-Dec-2023**	12-Jan-2024	✓	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK061G) BH3	**16-Dec-2023**	**20-Dec-2023**	13-Jan-2024	✓	**20-Dec-2023**	13-Jan-2024	✓
EK067G: Total Phosphorus as P by Discrete Analyser							
Clear Plastic Bottle - Sulfuric Acid (EK067G) BH201, DUP_1	**14-Dec-2023**	**20-Dec-2023**	11-Jan-2024	✓	**20-Dec-2023**	11-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) BH4, BH201	**15-Dec-2023**	**20-Dec-2023**	12-Jan-2024	✓	**20-Dec-2023**	12-Jan-2024	✓
Clear Plastic Bottle - Sulfuric Acid (EK067G) BH3	**16-Dec-2023**	**20-Dec-2023**	13-Jan-2024	✓	**20-Dec-2023**	13-Jan-2024	✓

Work Order : EM2322584

Client : JACOBS GROUP(AUSTRALIA)PTY LTD

Project : IW238424

Matrix: **WATER**

Evaluation: ✗ = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation			Analysis		
			Date extracted	Due for extraction	Evaluation	Date analysed	Due for analysis	Evaluation
EK071G: Reactive Phosphorus as P by discrete analyser								
Clear Plastic Bottle - Natural (EK071G) BH201,	DUP_1	**14-Dec-2023**	----	----	----	**20-Dec-2023**	16-Dec-2023	✗
Clear Plastic Bottle - Natural (EK071G) BH4,	BH201	**15-Dec-2023**	----	----	----	**20-Dec-2023**	17-Dec-2023	✗
Clear Plastic Bottle - Natural (EK071G) BH3		**16-Dec-2023**	----	----	----	**20-Dec-2023**	18-Dec-2023	✗
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP075(SIM)) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	21-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	22-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP075(SIM)) BH3		**16-Dec-2023**	**19-Dec-2023**	23-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
EP080/071: Total Petroleum Hydrocarbons								
Amber Glass Bottle - Unpreserved (EP071) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	21-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP071) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	22-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP071) BH3		**16-Dec-2023**	**19-Dec-2023**	23-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	28-Dec-2023	✓	**20-Dec-2023**	28-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	29-Dec-2023	✓	**20-Dec-2023**	29-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH3		**16-Dec-2023**	**19-Dec-2023**	30-Dec-2023	✓	**20-Dec-2023**	30-Dec-2023	✓
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013 Fractions								
Amber Glass Bottle - Unpreserved (EP071) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	21-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP071) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	22-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber Glass Bottle - Unpreserved (EP071) BH3		**16-Dec-2023**	**19-Dec-2023**	23-Dec-2023	✓	**20-Dec-2023**	28-Jan-2024	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	28-Dec-2023	✓	**20-Dec-2023**	28-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	29-Dec-2023	✓	**20-Dec-2023**	29-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH3		**16-Dec-2023**	**19-Dec-2023**	30-Dec-2023	✓	**20-Dec-2023**	30-Dec-2023	✓

Matrix: **WATER**

Evaluation: × = Holding time breach ; ✓ = Within holding time.

Method Container / Client Sample ID(s)		Sample Date	Extraction / Preparation Date extracted	Due for extraction	Evaluation	Analysis Date analysed	Due for analysis	Evaluation
EP080: BTEXN								
Amber VOC Vial - Sulfuric Acid (EP080) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	28-Dec-2023	✓	**20-Dec-2023**	28-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	29-Dec-2023	✓	**20-Dec-2023**	29-Dec-2023	✓
Amber VOC Vial - Sulfuric Acid (EP080) BH3		**16-Dec-2023**	**19-Dec-2023**	30-Dec-2023	✓	**20-Dec-2023**	30-Dec-2023	✓
EP231A: Perfluoroalkyl Sulfonic Acids								
HDPE (no PTFE) (EP231X) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	11-Jun-2024	✓	**20-Dec-2023**	11-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	12-Jun-2024	✓	**20-Dec-2023**	12-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH3		**16-Dec-2023**	**19-Dec-2023**	13-Jun-2024	✓	**20-Dec-2023**	13-Jun-2024	✓
EP231B: Perfluoroalkyl Carboxylic Acids								
HDPE (no PTFE) (EP231X) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	11-Jun-2024	✓	**20-Dec-2023**	11-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	12-Jun-2024	✓	**20-Dec-2023**	12-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH3		**16-Dec-2023**	**19-Dec-2023**	13-Jun-2024	✓	**20-Dec-2023**	13-Jun-2024	✓
EP231D: (n:2) Fluorotelomer Sulfonic Acids								
HDPE (no PTFE) (EP231X) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	11-Jun-2024	✓	**20-Dec-2023**	11-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	12-Jun-2024	✓	**20-Dec-2023**	12-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH3		**16-Dec-2023**	**19-Dec-2023**	13-Jun-2024	✓	**20-Dec-2023**	13-Jun-2024	✓
EP231P: PFAS Sums								
HDPE (no PTFE) (EP231X) BH201,	DUP_1	**14-Dec-2023**	**19-Dec-2023**	11-Jun-2024	✓	**20-Dec-2023**	11-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH4,	BH201	**15-Dec-2023**	**19-Dec-2023**	12-Jun-2024	✓	**20-Dec-2023**	12-Jun-2024	✓
HDPE (no PTFE) (EP231X) BH3		**16-Dec-2023**	**19-Dec-2023**	13-Jun-2024	✓	**20-Dec-2023**	13-Jun-2024	✓

Quality Control Parameter Frequency Compliance

The following report summarises the frequency of laboratory QC samples analysed within the analytical lot(s) in which the submitted sample(s) was(were) processed. Actual rate should be greater than or equal to the expected rate. A listing of breaches is provided in the Summary of Outliers.

Matrix: **WATER**

Evaluation: × = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Laboratory Duplicates (DUP)							
Alkalinity by Auto Titrator	ED037-P	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	3	23	**13.04**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	3	23	**13.04**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	3	23	**13.04**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Per- and Polyfluoroalkyl Substances (PFAS) by LCMSMS	EP231X	2	12	**16.67**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	8	65	**12.31**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	3	21	**14.29**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	5	**20.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	2	13	**15.38**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Laboratory Control Samples (LCS)							
Alkalinity by Auto Titrator	ED037-P	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Ammonia as N by Discrete analyser	EK055G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Per- and Polyfluoroalkyl Substances (PFAS) by LCMSMS	EP231X	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	2	20	**10.00**	**10.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	6	65	**9.23**	**7.50**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Method Blanks (MB)							

Matrix: **WATER**

Evaluation: ✘ = Quality Control frequency not within specification ; ✓ = Quality Control frequency within specification.

Quality Control Sample Type		Count		Rate (%)			Quality Control Specification
Analytical Methods	*Method*	*QC*	*Regular*	***Actual***	***Expected***	*Evaluation*	
Method Blanks (MB) - Continued							
Ammonia as N by Discrete analyser	EK055G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Major Cations - Dissolved	ED093F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Per- and Polyfluoroalkyl Substances (PFAS) by LCMSMS	EP231X	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Dissolved Solids (High Level)	EA015H	4	65	**6.15**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	2	21	**9.52**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Matrix Spikes (MS)							
Ammonia as N by Discrete analyser	EK055G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Chloride by Discrete Analyser	ED045G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Mercury by FIMS	EG035F	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Dissolved Metals by ICP-MS - Suite A	EG020A-F	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	2	23	**8.70**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Nitrite as N by Discrete Analyser	EK057G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Per- and Polyfluoroalkyl Substances (PFAS) by LCMSMS	EP231X	1	12	**8.33**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Reactive Phosphorus as P-By Discrete Analyser	EK071G	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	1	20	**5.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	1	21	**4.76**	**5.00**	✘	NEPM 2013 B3 & ALS QC Standard
Total Phosphorus as P By Discrete Analyser	EK067G	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH - Semivolatile Fraction	EP071	1	5	**20.00**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard
TRH Volatiles/BTEX	EP080	1	13	**7.69**	**5.00**	✓	NEPM 2013 B3 & ALS QC Standard

Brief Method Summaries

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the US EPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request. The following report provides brief descriptions of the analytical procedures employed for results reported in the Certificate of Analysis. Sources from which ALS methods have been developed are provided within the Method Descriptions.

Analytical Methods	Method	Matrix	Method Descriptions
Total Dissolved Solids (High Level)	EA015H	WATER	In house: Referenced to APHA 2540C. A gravimetric procedure that determines the amount of `filterable` residue in an aqueous sample. A well-mixed sample is filtered through a glass fibre filter (1.2um). The filtrate is evaporated to dryness and dried to constant weight at 180+/-5C. This method is compliant with NEPM Schedule B(3)
Alkalinity by Auto Titrator	ED037-P	WATER	In house: Referenced to APHA 2320 B This procedure determines alkalinity by automated measurement (e.g. PC Titrate) on a settled supernatant aliquot of the sample using pH 4.5 for indicating the total alkalinity end-point. This method is compliant with NEPM Schedule B(3)
Sulfate (Turbidimetric) as SO4 2- by Discrete Analyser	ED041G	WATER	In house: Referenced to APHA 4500-SO4. Dissolved sulfate is determined in a 0.45um filtered sample. Sulfate ions are converted to a barium sulfate suspension in an acetic acid medium with barium chloride. Light absorbance of the BaSO4 suspension is measured by a photometer and the SO4-2 concentration is determined by comparison of the reading with a standard curve. This method is compliant with NEPM Schedule B(3)
Chloride by Discrete Analyser	ED045G	WATER	In house: Referenced to APHA 4500 Cl - G.The thiocyanate ion is liberated from mercuric thiocyanate through sequestration of mercury by the chloride ion to form non-ionised mercuric chloride. In the presence of ferric ions the liberated thiocynate forms highly-coloured ferric thiocynate which is measured at 480 nm.
Major Cations - Dissolved	ED093F	WATER	In house: Referenced to APHA 3120 and 3125; USEPA SW 846 - 6010 and 6020; Cations are determined by either ICP-AES or ICP-MS techniques. This method is compliant with NEPM Schedule B(3) Sodium Adsorption Ratio is calculated from Ca, Mg and Na which determined by ALS in house method QWI-EN/ED093F. This method is compliant with NEPM Schedule B(3) Hardness parameters are calculated based on APHA 2340 B. This method is compliant with NEPM Schedule B(3)
Dissolved Metals by ICP-MS - Suite A	EG020A-F	WATER	In house: Referenced to APHA 3125; USEPA SW846 - 6020, ALS QWI-EN/EG020. Samples are 0.45µm filtered prior to analysis. The ICPMS technique utilizes a highly efficient argon plasma to ionize selected elements. Ions are then passed into a high vacuum mass spectrometer, which separates the analytes based on their distinct mass to charge ratios prior to their measurement by a discrete dynode ion detector.
Dissolved Mercury by FIMS	EG035F	WATER	In house: Referenced to APHA 3112 Hg - B (Flow-injection (SnCl2)(Cold Vapour generation) AAS) Samples are 0.45µm filtered prior to analysis. FIM-AAS is an automated flameless atomic absorption technique. A bromate/bromide reagent is used to oxidise any organic mercury compounds in the filtered sample. The ionic mercury is reduced online to atomic mercury vapour by SnCl2 which is then purged into a heated quartz cell. Quantification is by comparing absorbance against a calibration curve. This method is compliant with NEPM Schedule B(3).
Ammonia as N by Discrete analyser	EK055G	WATER	In house: Referenced to APHA 4500-NH3 G Ammonia is determined by direct colorimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Nitrite as N by Discrete Analyser	EK057G	WATER	In house: Referenced to APHA 4500-NO2- B. Nitrite is determined by direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Nitrate as N by Discrete Analyser	EK058G	WATER	In house: Referenced to APHA 4500-NO3- F. Nitrate is reduced to nitrite by way of a chemical reduction followed by quantification by Discrete Analyser. Nitrite is determined seperately by direct colourimetry and result for Nitrate calculated as the difference between the two results. This method is compliant with NEPM Schedule B(3)

Analytical Methods	Method	Matrix	Method Descriptions
Nitrite and Nitrate as N (NOx) by Discrete Analyser	EK059G	WATER	In house: Referenced to APHA 4500-NO3- F. Combined oxidised Nitrogen (NO2+NO3) is determined by Chemical Reduction and direct colourimetry by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Total Kjeldahl Nitrogen as N By Discrete Analyser	EK061G	WATER	In house: Referenced to APHA 4500-Norg D (In house). An aliquot of sample is digested using a high temperature Kjeldahl digestion to convert nitrogenous compounds to ammonia. Ammonia is determined colorimetrically by discrete analyser. This method is compliant with NEPM Schedule B(3)
Total Nitrogen as N (TKN + Nox) By Discrete Analyser	EK062G	WATER	In house: Referenced to APHA 4500-Norg / 4500-NO3-. This method is compliant with NEPM Schedule B(3)
Total Phosphorus as P By Discrete Analyser	EK067G	WATER	In house: Referenced to APHA 4500-P H, Jirka et al, Zhang et al. This procedure involves sulphuric acid digestion of a sample aliquot to break phosphorus down to orthophosphate. The orthophosphate reacts with ammonium molybdate and antimony potassium tartrate to form a complex which is then reduced and its concentration measured at 880nm using discrete analyser. This method is compliant with NEPM Schedule B(3)
Reactive Phosphorus as P-By Discrete Analyser	EK071G	WATER	In house: Referenced to APHA 4500-P F Ammonium molybdate and potassium antimonyl tartrate reacts in acid medium with othophosphate to form a heteropoly acid -phosphomolybdic acid - which is reduced to intensely coloured molybdenum blue by ascorbic acid. Quantification is by Discrete Analyser. This method is compliant with NEPM Schedule B(3)
Ionic Balance by PCT DA and Turbi SO4 DA	* EN055 - PG	WATER	In house: Referenced to APHA 1030F. This method is compliant with NEPM Schedule B(3)
TRH - Semivolatile Fraction	EP071	WATER	In house: Referenced to USEPA SW 846 - 8015 The sample extract is analysed by Capillary GC/FID and quantification is by comparison against an established 5 point calibration curve of n-Alkane standards. This method is compliant with the QC requirements of NEPM Schedule B(3)
PAH/Phenols (GC/MS - SIM)	EP075(SIM)	WATER	In house: Referenced to USEPA SW 846 - 8270 Sample extracts are analysed by Capillary GC/MS in SIM Mode and quantification is by comparison against an established 5 point calibration curve. This method is compliant with NEPM Schedule B(3)
TRH Volatiles/BTEX	EP080	WATER	In house: Referenced to USEPA SW 846 - 8260 Water samples are directly purged prior to analysis by Capillary GC/MS and quantification is by comparison against an established 5 point calibration curve. Alternatively, a sample is equilibrated in a headspace vial and a portion of the headspace determined by GCMS analysis. This method is compliant with the QC requirements of NEPM Schedule B(3)
Per- and Polyfluoroalkyl Substances (PFAS) by LCMSMS	EP231X	WATER	In-house: Analysis of fresh and saline waters by Solid Phase Extraction (SPE) followed by LC-Electrospray-MS-MS, Negative Mode using MRM and internal standard quantitation. Isotopically labelled analogues of target analytes used as internal standards and surrogates are added to the sample container. The entire contents are transferred to a solid phase extraction (SPE) cartridge. The sample container is successively rinsed with aliquots of the elution solvent. The eluted extract is combined with an equal volume of reagent water and a portion is filtered for analysis. Method procedures and data quality objectives conform to US DoD QSM 5.3, table B-15 requirements.

Preparation Methods	Method	Matrix	Method Descriptions
TKN/TP Digestion	EK061/EK067	WATER	In house: Referenced to APHA 4500 Norg - D; APHA 4500 P - H. This method is compliant with NEPM Schedule B(3)

Preparation Methods	*Method*	*Matrix*	*Method Descriptions*
Separatory Funnel Extraction of Liquids	ORG14	WATER	In house: Referenced to USEPA SW 846 - 3510 100 mL to 1L of sample is transferred to a separatory funnel and serially extracted three times using DCM for each extract. The resultant extracts are combined, dehydrated and concentrated for analysis. This method is compliant with NEPM Schedule B(3) . ALS default excludes sediment which may be resident in the container.
Volatiles Water Preparation	ORG16-W	WATER	A 5 mL aliquot or 5 mL of a diluted sample is added to a 40 mL VOC vial for purging.
Solid Phase Extraction (SPE) for PFAS in water	ORG72	WATER	In-house: Isotopically labelled analogues of target analytes used as internal standards and surrogates are added to the sample container. The entire contents are transferred to a solid phase extraction (SPE) cartridge. The sample container is successively rinsed with aliquots of the elution solvent. The eluted extract is combined with an equal volume of reagent water and a portion is filtered for analysis. Method procedures conform to US DoD QSM 5.3, table B-15 requirements.

A.10 Analytical Results Summary Table

Jacobs

							Monitoring Zone				
							Location Code				
							Field ID	BH3	BH4	BH201a	BH201b
							Location Type				
							Date	16 Dec 2023	15 Dec 2023	14 Dec 2023	15 Dec 2023
							Depth				
							Lab Report Number	EM2322584	EM2322584	EM2322584	EM2322584
							Sample Type	Normal	Normal	Normal	Normal
	Unit	EQL	ANZECC 2000 Stock Watering	ANZECC 1992 Industrial Water Use	AS2159-2009 Piling – Design and Installation (Buildings & Structures)	ANZECC PFAS FW 95%	ANZG (2018) Freshwater 95% toxicant DGVs				
NA											
Phosphorus total (as P)	MG/L	0.01						0.10	0.81	0.30	0.42
Metals											
Arsenic (filtered)	µg/L	1	500					10	10	41	4
Cadmium (filtered)	µg/L	0.1	10				0.2[#5]	<0.1	<0.1	<0.1	<0.1
Chromium (III+VI) (filtered)	µg/L	1	1,000					<1	6	3	<1
Copper (filtered)	µg/L	1	1,000[#1]				1.4[#5]	2	13	13	1
Lead (filtered)	µg/L	1	100				3.4[#6]	<1	18	2	<1
Magnesium	µg/L	500						-	-	-	-
Magnesium (filtered)	µg/L	500						20,000	145,000	42,000	44,000
Mercury (filtered)	µg/L	0.1	2				0.6[#7]	<0.1	<0.1	<0.1	<0.1
Nickel (filtered)	µg/L	1	1,000				11[#7]	5	14	22	19
Zinc (filtered)	µg/L	5	20,000				8[#8]	8	35	18	<5
Inorganics											
Soluble Carbonate as CaCO3*	mg/L	1						<1	<1	<1	<1
Alkalinity (Hydroxide) as CaCO3	mg/L	1						<1	<1	<1	<1
Alkalinity (total) as CaCO3	mg/L	1						172	371	517	477
Bicarbonate Alkalinity as CaCO3	mg/L	1						172	371	517	477
Calcium	mg/L	0.5		420				-	-	-	-
Calcium (filtered)	mg/L	0.5		420				31	226	60	61
Chloride	mg/L	1		19,000	6,000			53	1,380	104	70
Nitrogen (Organic)	mg/L	0.2						-	-	-	-
Potassium	mg/L	0.5						-	-	-	-
Potassium (filtered)	mg/L	0.5						2	12	6	7
Sodium	mg/L	0.5	230[#2]					-	-	-	-
Sodium (filtered)	mg/L	0.5	230[#2]					37	526	119	85
Sulfate as SO4 - Turbidimetric (filtered)	mg/L	1						2	51	<5[#10]	3
Sulfate as SO4 2-	mg/L	5		2,700	1,000			-	-	-	-
Total Dissolved Solids	mg/L	10		35,000				257	2,900	1,060	650
Nutrients											
Ammonia as N	mg/L	0.01					0.9[#9]	0.04	0.39	0.06	0.06
Nitrate (as N)	mg/L	0.01	90[#3]					0.01	0.02	0.01	0.02
Nitrite (as N)	mg/L	0.01						<0.01	<0.01	<0.01	<0.01
Nitrate & Nitrite (as N)	mg/L	0.01						0.01	0.02	0.01	0.02
Kjeldahl Nitrogen Total	mg/L	0.1						0.5	1.9	31.6	2.6
Nitrogen (Total)	mg/L	0.1						0.5	1.9	31.6	2.6
Phosphorus reactive (as P)	mg/L	0.01						<0.01	<0.01	0.19	<0.01
TRH - NEPM 2013 Fractions											
TRH >C6 - C10	mg/L	0.02						<0.02	<0.02	0.02	<0.02
TRH >C10 - C16	mg/L	0.05						<0.1	<0.1	20.1	12.7
TRH >C16 - C34	mg/L	0.1						<0.1	<0.1	1.42	0.79
TRH >C34 - C40	mg/L	0.1						<0.1	<0.1	<0.1	<0.1
TRH >C10 - C40 (Sum of total)	mg/L	0.1						<0.1	<0.1	21.5	13.5
TRH >C6 - C10 less BTEX (F1)	mg/L	0.02						<0.02	<0.02	<0.02	<0.02
TRH >C10 - C16 less Naphthalene (F2)	mg/L	0.05						<0.1	<0.1	20.1	12.7
BTEXN											
Benzene	µg/L	1					950[#6]	<1	<1	<1	<1
Toluene	µg/L	1						<2	<2	2	<2
Ethylbenzene	µg/L	1						<2	<2	<2	<2
Xylene (m & p)	µg/L	2						<2	<2	<2	<2
Xylene (o)	µg/L	1					350[#7]	<2	<2	<2	<2
Xylene Total	µg/L	2						<2	<2	<2	<2
Naphthalene	µg/L	1					16[#7]	<1.0	<1.0	2.3	<1.0
Total BTEX	µg/L	1						<1	<1	2	<1

	Unit	EQL	ANZECC 2000 Stock Watering	ANZECC 1992 Industrial Water Use	AS2159-2009 Piling – Design and Installation (Buildings & Structures)	ANZECC PFAS FW 95%	ANZG (2018) Freshwater 95% toxicant DGVs				
Monitoring Zone											
Location Code											
Field ID								BH3	BH4	BH201a	BH201b
Location Type											
Date								16 Dec 2023	15 Dec 2023	14 Dec 2023	15 Dec 2023
Depth											
Lab Report Number								EM2322584	EM2322584	EM2322584	EM2322584
Sample Type								Normal	Normal	Normal	Normal
Polycyclic aromatic hydrocarbons (PAHs)											
Naphthalene (value used in F2 calc)	mg/L	0.005						<0.005	<0.005	<0.005	<0.005
Acenaphthene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Acenaphthylene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Anthracene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Benz(a)anthracene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Benzo(k)fluoranthene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Benzo(b+j)fluoranthene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Benzo(g,h,i)perylene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Benzo(a) pyrene	µg/L	0.5						<0.5	<0.5	<0.5	<0.5
Benzo(a)pyrene TEQ calc (zero)	µg/L	0.5						<0.5	<0.5	<0.5	<0.5
Chrysene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Dibenz(a,h)anthracene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Fluoranthene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Fluorene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Indeno(1,2,3-c,d)pyrene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Phenanthrene	µg/L	1						<1.0	<1.0	<1.0	<1.0
Pyrene	µg/L	1						<1.0	<1.0	<1.0	<1.0
PAHs (Sum of total)	µg/L	0.5						<0.5	<0.5	2.3	<0.5
Per- and Poly-fluoroalkyl Substances (PFAS)											
Perfluorobutanesulfonic acid (PFBS)	µg/L	0.02						<0.02	<0.02	<0.02	<0.02
Perfluorohexanesulfonic acid (PFHxS)	µg/L	0.01						<0.01	<0.01	<0.01	<0.01
Perfluorooctanesulfonic acid (PFOS)	µg/L	0.01				0.13[#4]		<0.01	<0.01	<0.01	<0.01
Perfluorobutanoic acid (PFBA)	µg/L	0.1						<0.1	<0.1	<0.1	<0.1
Perfluoro-n-pentanoic acid (PFPeA)	µg/L	0.02						<0.02	<0.02	<0.02	<0.02
Perfluorohexanoic acid (PFHxA)	µg/L	0.02						<0.02	<0.02	<0.02	<0.02
Perfluoroheptanoic acid (PFHpA)	µg/L	0.02						<0.02	<0.02	<0.02	<0.02
Perfluorooctanoic acid (PFOA)	µg/L	0.01				220[#4]		<0.01	<0.01	<0.01	<0.01
Sum (PFHxS + PFOS)	µg/L	0.01						<0.01	<0.01	<0.01	<0.01
(n:2) Fluorotelomer Sulfonic Acids											
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.05						<0.05	<0.05	<0.05	<0.05
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.05						<0.05	<0.05	<0.05	<0.05
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.05						<0.05	<0.05	<0.05	<0.05
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	µg/L	0.05						<0.05	<0.05	<0.05	<0.05

Comments
#1 Trigget value for cattle adopted
#2 Moderately tolerant crop value adopted. Specific values available for other tolerance levels.
#3 Converted from 400 mg/L nitrate
#4 Australian and New Zealand Environment and Conservation Council (ANZECC), Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Technical Draft Default Guideline Values (ANZECC, 2016)
#5 Very high reliability
#6 Moderate reliability
#7 Low reliability
#8 High reliability
#9 High reliability. Ammonia as total ammonia, measured as [NH3-N] at pH 8. DGV may not protect key test species from chronic toxicity (this refers to experimental chronic values or geometric mean for species).
#10 Reported Analyte LOR is higher than Requested Analyte LOR

		Field ID	BH201	DUP_1		BH201	TRIP_1	
		Date	14 Dec 2023	14 Dec 2023		14 Dec 2023	14 Dec 2023	
		Lab Report Number	EM2322584	EM2322584		EM2322584	1055286	
		Sample Type	Normal	Field_D		Normal	Interlab_D	
		Matrix Type	Water	Water	RPD	Water	Water	RPD
	Unit	EQL						
NA								
Phosphorus total (as P)	MG/L	0.01	0.30	0.30	0	0.30	0.11	93
Metals								
Arsenic (filtered)	µg/L	1	41	40	2	41	39	5
Cadmium (filtered)	µg/L	0.1	<0.1	<0.1	0	<0.1	<0.2	0
Chromium (III+VI) (filtered)	µg/L	1	3	3	0	3	3	0
Copper (filtered)	µg/L	1	13	11	17	13	12	8
Lead (filtered)	µg/L	1	2	3	40	2	2	0
Magnesium	µg/L	500	-	-	-	-	40,000	-
Magnesium (filtered)	µg/L	500	42,000	41,000	2	42,000	-	-
Mercury (filtered)	µg/L	0.1	<0.1	<0.1	0	<0.1	0.1	0
Nickel (filtered)	µg/L	1	22	23	4	22	20	10
Zinc (filtered)	µg/L	5	18	16	12	18	10	57
Inorganics								
Soluble Carbonate as CaCO3*	mg/L	1	<1	<1	0	<1	<10	0
Alkalinity (Hydroxide) as CaCO3	mg/L	1	<1	<1	0	<1	<20	0
Alkalinity (total) as CaCO3	mg/L	1	517	537	4	517	450	14
Bicarbonate Alkalinity as CaCO3	mg/L	1	517	537	4	517	450	14
Calcium	mg/L	0.5	-	-	-	-	54	-
Calcium (filtered)	mg/L	0.5	60	59	2	60	-	-
Chloride	mg/L	1	104	127	20	104	120	14
Nitrogen (Organic)	mg/L	0.2	-	-	-	-	33.94	-
Potassium	mg/L	0.5	-	-	-	-	4.8	-
Potassium (filtered)	mg/L	0.5	6	6	0	6	-	-
Sodium	mg/L	0.5	-	-	-	-	120	-
Sodium (filtered)	mg/L	0.5	119	118	1	119	-	-
Sulfate as SO4 - Turbidimetric (filtered)	mg/L	1	<5[#1]	<5[#1]	0	<5[#1]	-	-
Sulfate as SO4 2-	mg/L	5	-	-	-	-	<5	-
Total Dissolved Solids	mg/L	10	1,060	1,100	4	1,060	1,800	52
Nutrients								
Ammonia as N	mg/L	0.01	0.06	0.05	18	0.06	0.06	0
Nitrate (as N)	mg/L	0.01	0.01	0.02	67	0.01	0.02	67
Nitrite (as N)	mg/L	0.01	<0.01	<0.01	0	<0.01	<0.02	0
Nitrate & Nitrite (as N)	mg/L	0.01	0.01	0.02	67	0.01	<0.05	0
Kjeldahl Nitrogen Total	mg/L	0.1	31.6	33.0	4	31.6	34	7
Nitrogen (Total)	mg/L	0.1	31.6	33.0	4	31.6	34	7
Phosphorus reactive (as P)	mg/L	0.01	0.19	0.23	19	0.19	-	-
TRH - NEPM 2013 Fractions								
TRH >C6 - C10	mg/L	0.02	0.02	<0.02	0	0.02	<0.02	0
TRH >C10 - C16	mg/L	0.05	20.1	17.8	12	20.1	27	29
TRH >C16 - C34	mg/L	0.1	1.42	1.52	7	1.42	5	112
TRH >C34 - C40	mg/L	0.1	<0.1	<0.1	0	<0.1	<0.1	0
TRH >C10 - C40 (Sum of total)	mg/L	0.1	21.5	19.3	11	21.5	32	39
TRH >C6 - C10 less BTEX (F1)	mg/L	0.02	<0.02	<0.02	0	<0.02	<0.02	0
TRH >C10 - C16 less Naphthalene (F2)	mg/L	0.05	20.1	17.8	12	20.1	27	29
BTEXN								
Benzene	µg/L	1	<1	<1	0	<1	<1	0
Toluene	µg/L	1	2	2	0	2	2	0
Ethylbenzene	µg/L	1	<2	<2	0	<2	<1	0
Xylene (m & p)	µg/L	2	<2	<2	0	<2	<2	0
Xylene (o)	µg/L	1	<2	<2	0	<2	<1	0
Xylene Total	µg/L	2	<2	<2	0	<2	<3	0
Naphthalene	µg/L	1	2.3	3.2	33	2.3	4	54
Total BTEX	µg/L	1	2	2	0	2	-	-
Polycyclic aromatic hydrocarbons (PAHs)								
Naphthalene (value used in F2 calc)	mg/L	0.005	<0.005	<0.005	0	<0.005	<0.01	0
Acenaphthene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Acenaphthylene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Anthracene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Benz(a)anthracene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Benzo(k)fluoranthene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Benzo(b+j)fluoranthene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Benzo(g,h,i)perylene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Benzo(a) pyrene	µg/L	0.5	<0.5	<0.5	0	<0.5	<1	0
Benzo(a)pyrene TEQ calc (zero)	µg/L	0.5	<0.5	<0.5	0	<0.5	-	-
Chrysene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Dibenz(a,h)anthracene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Fluoranthene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Fluorene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Indeno(1,2,3-c,d)pyrene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Phenanthrene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
Pyrene	µg/L	1	<1.0	<1.0	0	<1.0	<1	0
PAHs (Sum of total)	µg/L	0.5	2.3	3.2	33	2.3	4	54
Per- and Poly-fluoroalkyl Substances (PFAS)								
Perfluorobutanesulfonic acid (PFBS)	µg/L	0.02	<0.02	<0.02	0	<0.02	-	-
Perfluorohexanesulfonic acid (PFHxS)	µg/L	0.01	<0.01	<0.01	0	<0.01	<0.01	0
Perfluorooctanesulfonic acid (PFOS)	µg/L	0.01	<0.01	<0.01	0	<0.01	<0.01	0
Perfluorobutanoic acid (PFBA)	µg/L	0.1	<0.1	<0.1	0	<0.1	-	-
Perfluoro-n-pentanoic acid (PFPeA)	µg/L	0.02	<0.02	<0.02	0	<0.02	-	-
Perfluorohexanoic acid (PFHxA)	µg/L	0.02	<0.02	<0.02	0	<0.02	-	-
Perfluoroheptanoic acid (PFHpA)	µg/L	0.02	<0.02	<0.02	0	<0.02	-	-
Perfluorooctanoic acid (PFOA)	µg/L	0.01	<0.01	<0.01	0	<0.01	<0.01	0
Sum (PFHxS + PFOS)	µg/L	0.01	<0.01	<0.01	0	<0.01	<0.01	0
(n:2) Fluorotelomer Sulfonic Acids								
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.05	<0.05	<0.05	0	<0.05	-	-
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.05	<0.05	<0.05	0	<0.05	<0.05	0
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.05	<0.05	<0.05	0	<0.05	-	-
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	µg/L	0.05	<0.05	<0.05	0	<0.05	-	-

A.11 QAQC Assessment

Quality Assurance and Quality Control Assessment

A review of the quality of data has been based on the following:

- Review of the findings of sample analyses against field observations and measurements;
- Review of data quality based on the verification of field Quality Assurance / Quality Control (QA/QC) procedures, evidence of proper transference of samples and sample analysis and extraction within recommended holding times (RHTs);
- Analysis of duplicate samples at the primary laboratory (blind duplicate);
- Analysis of duplicate samples by an independent secondary laboratory (split duplicate);
- Analysis of trip spike results;
- Analysis of rinsate and field blank results; and Internal laboratory QA/QC analyses including analysis of reagent blanks, spike recoveries and duplicates.

These requirements are defined in NEPM 1999 (2013 amendment) and relevant Australian Standards.

The sample and QAQC results were reported in laboratory reports from the primary lab (ALS) and from the secondary laboratory (Eurofins). The data quality assessment described herein is based upon the results reported in these laboratory certificates and associated QC reports in **Appendix VI and VII.**

Data Quality Indicators (DQIs)

Data Quality Indicators (DQIs) are developed to provide goals for the quality of data required to sufficiently meet the site-specific objectives of Environmental Site Assessments. Precision, sensitivity, accuracy, representativeness, comparability and completeness (PSARCC parameters) are all indicators of data quality. The below points describe each PSARCC parameter in relation to assessment of data quality:

- Precision – measure of the variation in results from a laboratory method. Achieved through assessment of laboratory and field duplicate results;
- Sensitivity – the ability of an analytical method or technology to reliably identify a compound in the sample medium at an appropriate level of interest. Achieved through ensuring that laboratory detection limits are below the adopted criteria;
- Accuracy – measure of the closeness of the analytical result obtained by a method to the 'true' value. Assessed through laboratory QA/QC samples such as matrix spikes, laboratory control samples, method blanks and surrogate spikes;
- Representativeness – expresses the degree to which sample data accurately and precisely represents a characteristic of a population, parameter variations at a sample point of an environmental condition. Achieved through assessment of trip spike, trip blank and rinsate sample results along with standard procedures for sample collection, transport and extraction and holding times;
- Comparability – is a qualitative parameter expressing the confidence with which one data set can be compared with another. Achieved through undertaking fieldwork using standard operating procedures and consistent field personnel; and,
- Completeness – defined as the percentage of measurements made which are judged to be valid measurements. Achieved through assessment of the percentage of data that passed the QA/QC assessment with a goal of 95%.

The DQIs used to assess the PSARCC parameters for this investigation are detailed in **Table 0-1** below.

Table 0-1. Summary of Data Quality Indicators

Data Quality Indicator	Description
Precision	
Field Duplicate RPDs	AS4482.1-2005 states that for every twenty samples taken, one set of blind samples should be taken. The PFAS NEMP states that as PFAS investigations often require quantification of analytes at concentrations close to the limit of reporting (LOR), duplicates should be collected at a higher frequency than AS4482.1-2005 – a frequency of one set of blind samples per ten primary samples is recommended. Precision is assessed by calculation of relative percent difference (RPD) through methods outlined in AS4882.1-2005. AS4482.1-2005 also states that the relevant percent differences (RPDs) of duplicates are typically 30-50%, however, variation can be expected to be higher for organic analyses than inorganic analyses and for low concentrations of analytes (i.e., approaching the LOR). Jacobs has developed the following DQIs for field duplicates that are generally consistent with AS4482.1-2005: Less than 10 times LOR: no limit Between 10-20 times LOR: <50% RPD Greater than 20 times LOR: <30% RPD
Laboratory Duplicate RPDs	The frequency of analysis of laboratory duplicates is guided by the NEPM and/or NATA accreditation requirements but in general, the frequency of laboratory prepared duplicates should be 1 for every 20 samples tested, as per field duplicates. Acceptance limits for RPDs from laboratory duplicates are specified by the laboratory but in general, RPDs for laboratory duplicates should be consistent with field duplicates.
Sensitivity	
Laboratory detection limits	Laboratory achieved LORs to be appropriate for comparison to screening criteria, as detailed in analytical tables attached to the main report, see Appendix VII attached.
Accuracy	
Laboratory Control Samples (LCS)	A laboratory control sample is a sample of known concentration analysed by the laboratory as a quality control check. The amount of analyte recovered is compared to the known value as a measure of accuracy. Recovery limits are specified by the laboratory, generally recovery limits of 70% to 130% are acceptable for inorganics. For organics, recovery limits vary depending upon the analyte and method.
Laboratory Matrix Spikes (MS)	A laboratory matrix spike is where a sample is spiked with a known concentration of the target analyte and the recovery of the spiked is checked against an un-spiked sample. Matrix spikes in conjunction with LCS allow assessment of whether matrix interferences exist. Recovery limits for the spike are specified by the laboratory, generally recovery limits of 70% to 130% are acceptable for inorganics. For organics, recovery limits vary depending upon the analyte and method.
Laboratory Surrogate Spikes	Laboratory surrogate spikes are similar to matrix spikes however the spike consists of an analog of the target analyte, e.g., phenol with 2H-labelled hydrogen rather than natural abundance hydrogen (primary 1H). Surrogate spikes are generally only used for select organic analytes. Acceptable limits are determined by the laboratory based on the recoveries obtained for samples of similar matrix type analysed under the same analytical conditions.

Laboratory Method Blanks	Laboratory method blanks are samples containing no analyte prepared and tested by the laboratory and therefore concentrations reported for method blanks should be below the LOR. In conjunction with results from trip blanks and rinsate samples, method blanks are used to assess if contamination during sample collection and analysis could affect results.
Representativeness	
Trip Blanks	Trip blanks are prepared by the laboratory and stored with samples during the collection process. Trip blanks are used to assess whether volatile contaminants are able to cross-contaminate the field samples during storage and transport. Reported concentrations for trip blanks should be below the LOR.
Rinsate	A rinsate is a sample collected from decontaminated equipment using laboratory supplied rinsate water and collection bottles. The rinsate should be collected from re-useable equipment that was used at multiple sampling locations and decontaminated in between samples. One rinsate sample should be collected per set of equipment per day. The DQI for the rinsate is below the LOR.
Equipment Blanks	An equipment blank is created in the field using laboratory supplied DI water, collected in laboratory supplied bottles. The field blank is exposed to a piece of sampling equipment that is exposed to the collected samples. One equipment blank sample should be collected from disposable equipment to ensure that this has no impact on the data quality. The DQI for the equipment blank is below the LOR.
Standard Procedures	All fieldwork including decontamination procedures to be undertaken in general accordance with Jacobs Standard Operating Procedures (SOPs) which have been developed with reference to the following: ▪ Sample handling, storage and transport to be in accordance with the requirements of NEPM 1999 (2013 amendment) and PFAS NEMP (HEPA, 2020) for PFAS sampling. ▪ QA/QC to be conducted in accordance with NEPM 1999 (2013 amendment) and PFAS NEMP (HEPA, 2020). In addition, samples should be transported to the laboratory under a full chain of custody (CoC) procedure. The laboratory should return a copy of the signed CoC acknowledging the receipt date and time and identity of samples included in the shipment. Samples should be extracted and analysed within appropriate holding times and a Laboratory Certificate of Analysis supplied which details the methods used.
Comparability	
Standard Procedures	Samples to be collected in general accordance with Jacobs' SOPs and the sampling and analysis quality plan for the Site. All field team members to be appropriately trained in these documents. Logs and field data to be recorded for each sample location noting any observed variations between conditions and signs of potential contamination. Primary samples to be stored, handled and transported under the same conditions and analysed by the same laboratory using consistent methods as secondary samples. DQIs to indicate acceptable precision and accuracy.
Completeness	
	Data from all critical samples to be considered valid. Overall dataset to be considered valid (>95% acceptable after data validation procedures).

Assessment of Data Quality

The QA assessment for data collected during this Investigation, including laboratory data, is provided in **Table 0-2** below. Included in **Table 0-2** are the Data Quality Indicators (DQIs) used to measure the Precision, Accuracy, Representativeness, Completeness, Comparability and Sensitivity (PARCCS) parameters for the DSI field and analytical program.

Although there were some minor non-conformances, the majority of the PARCCS indicators were within the specified DQIs and therefore, overall, the data is considered to be of sufficient quality to meet the objectives of the assessment.

Table 0-2: Assessment of Investigation Data Against DQIs

Data Quality Indicator	Target	Summary of results	Compliance (Yes/No)
Compliance			
Field Duplicate RPDs	1 duplicate pair per 20 samples for groundwater and surface water	One (1) duplicate pair and four (4) primary samples were collected as part of the routine groundwater monitoring program.	Yes
	RPD limits: < 10 times LOR: no limit 10-20 times LOR: <50% RPD > 20 times LOR: <30% RPD	The complete list of RPDs is provided at the conclusion of this appendix. In summary: 1 of 81 blind duplicate RPDs did not meet acceptance limits (99% completeness) 5 of 63 split duplicate RPDs did not meet acceptance limits (92% completeness) Overall, 6 of 144 duplicate RPDs did not meet acceptance limits (96% completeness) For blind and split duplicates, the RPDs outside acceptance limits were phosphorus, TDS, and TRHs. For the remaining outliers, the intralab duplicates were within acceptance limits, therefore no material impact is expected in this investigation. As both laboratories meet specified DQIs, for the purposes of this assessment, the data obtained, both in terms of frequency of duplicates and RPD values, are considered sufficient.	Yes
Laboratory Duplicate RPDs	Laboratory specified frequency and limits	ALS - RPDs for all of the laboratory duplicates were within the acceptable ranges. Duplicates were performed as per NEPM frequency. Due to the relative number of outliers and conforming RPD vales, no material impact on the investigations findings is expected. The criteria are reproduced below: Global RPD Duplicates Acceptance Criteria is 30%; however, the following acceptance guidelines are equally applicable: Results <10 times the LOR: No Limit Results between 10-20 times the LOR: RPD must lie between 0-50% Results >20 times the LOR: RPD must lie between 0-30% Eurofins – duplicates were performed as per NEPM frequency. RPDs for biochemical oxygen demand and chemical oxygen demand (990082) and hexavalent chromium (993171) were outside the NEPM acceptance criteria but passed Eurofins Environment Testing QC acceptance criteria. Refer to laboratory certificates of analysis in Appendix VI of this report.	Yes
Sensitivity			

Laboratory detection limits	LOR < screening criteria	LOR were below the adopted screening criteria. The LORs reported are considered suitable and therefore is not considered a non-compliance. Ultra-trace analysis required to achieve these LORs less than the adopted criteria.	Yes
Accuracy			
Laboratory Control Sample / Spike recovery	Recovery of 70 to 130 % (inorganics) or laboratory specified limits	ALS - LCS were performed as per NEPM frequency. All results were within laboratory acceptance limits. Eurofins - LCS were performed as per NEPM frequency. All results were within laboratory acceptance limits. Refer to laboratory certificates of analysis in **Appendix VI.**	Yes
Laboratory Matrix Spike recovery	Laboratory specified limits	ALS - Matrix spikes were performed as per NEPM frequency. Overall, most results were within laboratory acceptance limits. Eurofins - Matrix spikes were performed as per NEPM frequency. Most results were within laboratory acceptance limits. Refer to laboratory certificates of analysis in **Appendix VI.**	No
Laboratory Method Blanks	Below LOR	ALS - Method blanks were performed as per NEPM frequency. All reported results were <LOR. Eurofins - Method blanks were performed as per NEPM frequency. All reported results were <LOR. Refer to laboratory certificates of analysis in **Appendix VI.**	Yes
Laboratory Surrogate Spikes	Laboratory specified limits	ALS - Surrogates were performed as per NEPM frequency. No surrogate spike recovery non-compliances were reported for all analytes. Eurofins – Surrogate spike recovery not applicable to the scheduled analysis. Refer to laboratory certificates of analysis in **Appendix VI.**	Yes
Representativeness			
Trip Blank	1 trip blank per matrix per dispatch Results below LOR	No trip blanks were analysed as part of the field investigation. Not considered to impact the outcomes of the groundwater monitoring investigation as samples have not been analysed for volatiles.	-
Rinsate	1 rinsate per equipment per day Results below LOR	No rinsate samples were analyzed as part of the field investigation. Unique disposable equipment was used for each sampling location, therefore cross contamination is not considered to impact the outcomes of this investigation.	-
SOPs	Sample handling, storage and transport conducted by qualified persons using approved SOPs developed in accordance with the NEPM	Sample collection, handling and storage was completed by suitably qualified field scientists or engineers following Jacobs SOPs and the SAQP developed for this investigation. Samples were transported from the Site to the laboratory under documented chain of custody via couriers engaged by the laboratory.	Yes

	QA program completed in accordance with the NEPM and other suitable guidance	Refer to this appendix for QA program completed.	Yes
	Use of NATA accredited laboratories and provision of certificates of analysis	The laboratories are NATA accredited for the analyses performed. Lab documentation reports that they are not NATA-accredited for total nitrogen analysis, however as this is a summation, therefore is not considered a non-conformance. Certificates of analysis are provided in Appendix VI.	Yes
Comparability			
SOPs	Sample handling, storage and transport conducted by qualified persons using approved SOPs developed in accordance with the NEPM	See above under representativeness.	Yes
	Field data to be recorded	Field records are provided in **Appendix III** to the main report, including field observations, selected photographs, calibration certificates, bore logs, well construction details, gauging data and purge parameters.	Yes
	Collection and analysis of primary and duplicates using consistent methods	See above under precision.	Yes
DQIs	DQIs set to assess precision and accuracy	See above for precision and accuracy.	Yes
Completeness			
	Data from all critical samples considered valid	See discussion above.	Yes
	Dataset considered valid	See discussion above.	Yes

Appendix B. NSW Aquifer Interference Policy

Table B-1 outlines whether the activity require detailed assessment under the Aquifer Interference Policy (AIP).

Table B-1. Does the activity require detailed assessment under the AIP?

	Considerations	Response
Question 1	Is the activity defined as an aquifer interference activity?	If NO, then no assessment is required under the AIP. If YES, continue to Question 2.
Question 2	Is the activity a defined minimal impact aquifer interference activity according to section 3.3 of the AIP?	If YES, then no further assessment against this policy is required. Volumetric licensing still required for any water taken, unless exempt. If NO, then continue on for a full assessment of the activity.
Response	Question 1 Response: YES. The activity is defined as an aquifer interference activity as there will be removal of water from a water source during construction of the Wanganella Regulator and during operation of both regulators there will be movement of water from one water source to another water source (from a river/lake to an aquifer). The groundwater elevation is well below the base of Hartwood Regulator structure and hence, groundwater dewatering will not be required during its construction. Question 2 Response: For construction YES. Of relevance to the Wanganella Regulator, caverns, tunnels, cuttings, trenches and pipelines (intersecting the water table) are considered as having a minimal impact on water dependent assets, if a water access licence is not required. A groundwater access licence is not required for taking less than or equal to 3ML of groundwater per year in any water source (3 ML or less exemption) (NSW DCCEEW, 2024). This includes temporary dewatering to ensure safe and efficient excavation (NSW DCCEEW, 2024). The NSW Aquifer Interference Policy (AIP) (DPI, 2012) outlines minimal impact considerations for watertable and groundwater pressure drawdown for high priority groundwater dependent ecosystems (GDEs) (as identified in the WSP), high priority culturally significant sites (as identified in the WSP) and existing groundwater supply bores. This is addressed is Table B-5. For operation of the proposal, NO as this is not defined as minimal impact aquifer interference activity.	

A full assessment is not required for construction. However, the operation of the proposal is not defined as a minimal impact aquifer interference activity and hence the following responses have been prepared.

Table B-2. Accounting for, or preventing the take of water

	AIP requirement	Proponent response
1	Described the water source(s) the activity will take water from?	Water sources are described in Section 3 and include Lower Murray Shallow Alluvium (GS27a) / Lower Murrumbidgee Shallow Alluvium (GS28a). The surface water source is Billabong Creek. Billabong Creek is currently and predicted to remain always losing to groundwater during operation. Temporary construction dewatering at Wanganella will remove water from the shallow alluvium, however, a groundwater access licence is not required for taking less than or equal to 3ML of groundwater per year in any water source. Groundwater dewatering is not expected to be required during construction of the Hartwood Regulator.

	AIP requirement	Proponent response
		Hence the responses below relate to operation of the proposal, inclusive of both regulators.
2	Predicted the total amount of water that will be taken from each connected groundwater or surface water source on an annual basis as a result of the activity?	The predicted discharge from the weir pool to groundwater for the existing and tested scenario (operation) are outlined in Section 4.2.1.5 and 4.2.2.5. Negligible increase of leakage from the Hartwood weir pool to groundwater (of less than 0.1% of the estimated current seepage, amounting to around 4 m^3/day). Minor to insignificant change in leakage from the Wanganella weir pool to groundwater as the overall leakage to groundwater and disconnected system remains.
3	Predicted the total amount of water that will be taken from each connected groundwater or surface water source after the closure of the activity?	The predicted discharge from the weir pool to groundwater for the existing and tested scenario (operation) are outlined in Section 4.2.1.5 and 4.2.2.5.
4	Made these predictions in accordance with Section 3.2.3 of the AIP? (refer to Table B-3, below)	See Table B-3
5	Described how and in what proportions this take will be assigned to the affected aquifers and connected surface water sources?	Affected aquifers: Lower Murray Shallow Alluvium (GS27a) and Lower Murrumbidgee Shallow Alluvium (GS28a). Assume equal proportion. Surface water source: Billabong Creek.
6	Described how any licence exemptions might apply?	3ML or less exemption for short term construction dewatering.
7	Described the characteristics of the water requirements?	N/A – no groundwater required for operation
8	Determined if there are sufficient water entitlements and water allocations that are able to be obtained for the activity?	N/A – no groundwater entitlement required for operation
9	Considered the rules of the relevant water sharing plan and if it can meet these rules?	N/A
10	Determined how it will obtain the required water?	N/A – no groundwater required for operation.
11	Considered the effect that activation of existing entitlement may have on future available water determinations?	Billabong Creek is predicted to remain always losing to groundwater and a negligible increase of leakage from the Hartwood weir pool. Minor to insignificant change in leakage from the Wanganella weir pool to groundwater is predicted. No impact to future available water determinations expected.
12	Considered actions required both during and post-closure to minimize the risk of inflows to a mine void as a result of flooding?	N/A – no mine void.

	AIP requirement	Proponent response
13	Developed a strategy to account for any water taken beyond the life of the operation of the project?	N/A
	Will uncertainty in the predicted inflows have a significant impact on the environment or other authorised water users? If YES, items 14-16 must be addressed.	No, the predicted inflows do not significantly impact on the environment or other authorised water users.

Table B-3. Has the proponent provided details on:

	AIP requirement	Proponent response
	For State Significant Development or mining or coal seam gas production, is the estimate based on a complex modelling platform that is: • Calibrated against suitable baseline data, and in the case of a reliable water source, over at least two years? • Consistent with the Australian Modelling Guidelines? • Independently reviewed, robust and reliable, and deemed fit-for-purpose?	The development is not State Significant Development or mining or coal seam gas production. The model is a Class 1 model as defined by the Groundwater Modelling Guidelines (Barnett et al. 2012). This status recognises that the proposed changes to the hydraulic regime associated with the proposed regulators is minor and that they likely present a low risk to aquifers and GDE. Further, based on the available groundwater observations and aquifer detail, a more detailed model is unlikely to provide greater certainty than a class one model for the study area. Available timeseries data was used, however, 2 years of recent groundwater level data was not available. The model has not been independently reviewed.

Table B-4. Has the proponent provided details on:

	AIP requirement	Proponent response
1	Establishment of baseline groundwater conditions?	Existing conditions outlined in Chapter 3 and Appendix A.
2	A strategy for complying with any water access rules?	Dewatering volumes will be monitored. Proposed monitoring during operation outlined in Chapter 6.
3	Potential water level, quality or pressure drawdown impacts on nearby basic landholder rights water users?	Impact assessment in Chapter 4.
4	Potential water level, quality or pressure drawdown impacts on nearby licensed water users in connected groundwater and surface water sources?	Impact assessment in Chapter 4.
5	Potential water level, quality or pressure drawdown impacts on groundwater dependent ecosystems?	Impact assessment in Chapter 4.

	AIP requirement	Proponent response
6	Potential for increased saline or contaminated water inflows to aquifers and highly connected river systems?	The risk of saline groundwater discharging to Billabong Creek is considered nil as the creek is predicted to remain always losing to groundwater.
7	Potential to cause or enhance hydraulic connection between aquifers?	N/A
8	Potential for river bank instability, or high wall instability or failure to occur?	Assessed as part of the geomorphic EIS chapter.
9	Details of the method for disposing of extracted activities (for coal seam gas activities)?	N/A

Relevant water sources and water sharing plans are identified in Section 3.1.1. Different 'Minimal Impact Considerations' from DPI (2012) are applicable to different groundwater system types. In the context of the AIP, the 'alluvial aquifer (highly productive)' category applies. Table B-5 presents the Level 1 Minimal Impact Considerations that apply and the assessment. Under the NSW Aquifer Interference Assessment Policy, the impacts fall within the Level 1 category and the assessment is considered "Level 1 – Acceptable".

Table B-5. Minimal Impact Consideration for Alluvial Aquifer (highly productive)

	Level 1 Minimal Impact Consideration	Assessment
	Water table Less than or equal to a 10% cumulative variation in the water table, allowing for typical climatic post-water sharing plan variations, 40 m from any: high priority groundwater dependent ecosystem or high priority culturally significant site listed in the schedule of the relevant water sharing plan. OR A maximum of a 2 m water table decline cumulatively at any water supply work.	Groundwater drawdown in the vicinity of the construction area at Wanganella will be limited to a maximum of approximately 0.5 m with a peak possible radius of influence of 250 m and a likely maximum discernible radius of effect of less than 50 m. The predicted drawdown and mounding during operation (generally around 0.02 -0.01 m) are presented in section 4.2.1.4 and 4.2.2.4 The predicted watertable decline is less than 2 m and as the Regulators are considered water supply work, the impacts are within the Level 1 impacts category.
	Water pressure A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the base of the water source to a maximum of a 2 m decline, at any water supply work. OR, for the Lower Murrumbidgee Deep Groundwater Source: A cumulative pressure head decline of not more than 40% of the post-water sharing plan pressure head above the top of the relevant	N/A – Groundwater impacts are limited to the Lower Murray Shallow Alluvium (GS27a) and Lower Murrumbidgee Shallow Alluvium (GS28a) which are the watertable aquifers.

	Level 1 Minimal Impact Consideration	Assessment
	aquifer to a maximum of a 3 m decline, at any water supply work	
	Water quality Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity. No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. No mining activity to be below the natural ground surface within 200 m laterally from the top of high bank or 100 m vertically beneath (or the three dimensional extent of the alluvial water source - whichever is the lesser distance) of a highly connected surface water source that is defined as a reliable water supply. Not more than 10% cumulatively of the three dimensional extent of the alluvial material in this water source to be excavated by mining activities beyond 200 m laterally from the top of high bank and 100 m vertically beneath a highly connected surface water source that is defined as a reliable water supply.	Creek is predicted to remain always losing to groundwater and hence, will not lower the beneficial use category of the groundwater source beyond 40 m from the activity. The proposal is therefore, within the Level 1 impacts category.