WIM100 Test Pit

Iluka Resources

Phase 2 Dewatering Assessment

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Executive Summary

Iluka are currently preparing to undertake a test pit excavation program that plans to obtain up to 1,500 t of dry equivalent ore for metallurgical testing form the WIM100 East ore body. This test pit is likely to intersect groundwater as the ore body is believed to be below the water table.

This report describes a numerical groundwater model that has been used to estimate the inflows, drawdowns, water management options and risks that the excavation may pose to groundwater receptors. The report and numerical modelling builds on previous work which provided some preliminary estimates of inflows and disposal infrastructure. Subsequently, Iluka have refined their pit design, pit location and have proposed a water management strategy.

The numerical modelling presented here indicates that the maximum groundwater inflow rates to the test pit are likely to range between 0.2 and 11 L/s, requiring the disposal of between 0 m^3 (all inflow water is used for dust suppression) and ~11,000 m^3. These estimates are lower than presented during the original modelling as the depth to water table at the revised pit location is lower and the duration for which the pit is planned to be open is reduced. Further, due to the reduced pit inflows and the use of onsite water disposal within the model, modelling indicates that the drawdown associated with the proposed test is less than previously indicated, reaching a maximum distance of ~550 m for the scenarios considered.

Based on the results of the numerical modelling presented in this study, the proposed water management strategy is more than sufficient to dispose of the likely range of pit inflows, and poses a negligible to low risk to groundwater receptors. However, as there is no local hydrogeological information at the proposed site, these results are based on the range of likely conditions anticipated at the site. As such, it is recommended that prior to full development of the excavation and water disposal infrastructure, hydrogeological information (groundwater level, chemistry and hydraulic conductivity) be collected during initial site development to inform and re-run the presented numerical model. Further, the overall pit stability and potential for heave of the pit floor should be assessed through an appropriate geotechnical investigation.

1. Introduction

1.1 Background

Iluka Resources Limited (Iluka) have undertaken a series of operations in the Murray Basin that have included the mining, processing, transport, storage and shipment of mineral sand products. This includes the mining of mineral sand deposits at the Douglas and Echo mine sites near Balmoral in south west Victoria, as well as at the Kulwin and WRP mine sites near Ouyen. These sites have completed their mining phase and are now largely in the rehabilitation phase of their operational lifespan. Based on this experience, Iluka are assessing a number of new sites for potential mines.

Iluka holds exploration licences for a number of fine-grained mineral sand deposits within the southern Murray Basin that have yet to be developed, including the WIM50, WIM100 and Goschen South deposits. To this end, Iluka is undertaking various baseline assessments on these mineral sands deposits to identify the preferred deposit sequence to progress to a Pre-Feasibility Stage (PFS) for a potential future mine. As part of the assessment of the viability and mining options for these deposits, a test pit is proposed to be dug into the WIM100 East ore body to obtain up to 1,500 t of dry equivalent ore for metallurgical testing. This test pit is likely to intersect groundwater, as the ore body is believed to be below the water table.

Iluka has engaged Jacobs Group (Australia) Pty Ltd (Jacobs) to estimate the groundwater inflows to the test pit and the possible groundwater impacts associated with the test pit. During initial inflow assessments in July 2018 (Jacobs, 2018a), Jacobs developed a conceptual site model based on the regional and local hydrogeology at the proposed test pit. Subsequently, a combination of numerical and analytical modelling was undertaken to estimate the range of likely pit inflow rates, and the types of infrastructure necessary to manage such inflows.

Subsequent to this initial assessment, Iluka have updated the dimensions, location and timelines for the proposed pit excavation. Furthermore, based on the information provided in Jacobs' initial assessment, Iluka have developed a preliminary strategy for managing pit inflows. As such, Jacobs have been further engaged by Iluka to refine pit inflow estimates in consideration of the updated test pit specifications, and review the potential effects of drawdown and mounding associated with the proposed water management strategy.

1.2 Scope

This objective of this study is to undertake numerical modelling to inform the potential inflows, drawdowns and mounding associated with the proposed test pit excavation (to collect bulk ore samples) and water management strategies. Subsequently, these effects are to be considered in the context of regulatory frameworks and guidelines to inform the overall feasibility of onsite water management. The study aims to do this by:

- Building a numerical groundwater model based on the conceptualised local hydrogeology presented in Jacobs 2018a and drilling data provided by Iluka;
- Modelling inflow rates and drawdown to the proposed pit for the range of likely hydrogeological conditions;
- Incorporating water disposal (such as basins and injections wells) into the numerical model to assess the combined effect of dewatering and disposal on groundwater drawdown and mounding;
- Based on the above, assess the risk of dewatering/disposal to groundwater receptors, consider the operational limitations and requirements for the disposal of excess water, and outline the approval requirements and possible regulatory pathways necessary for the disposal of pit inflows.

2. Site location

The proposed test pit is located along Natimuk-Hamilton Road, approximately 30 km south west from the township of Horsham and 8 km to the north of the Tolondo Reservoir.

The site works boundary associated with the proposed test pit is illustrated by the red outline in Figure 2-1, while the deepest section of the pit is centred around the exploration drill core V17716.

Figure 2-1 Location of proposed test pit

3. Regional conceptualisation

This section briefly summarises the hydrogeological setting surrounding the WIM100 deposit to provide context in which the subsequent inflow assessment can be interpreted. Further detail regarding the regional geology and hydrogeology surrounding the WIM50 and WIM100 areas has been provided in the Baseline Groundwater Assessment (Jacobs, 2018b).

3.1 Climate

Monitoring of rainfall occurs locally at Clear Lake (~10 km west of the proposed site) and Telangatuk East (~20 km south of the proposed site), while monitoring of evapotranspiration (ET) occurs at Horsham (~30 km to the north east of the site). A comparison of monthly rainfall and evapotranspiration is illustrated below in Figure 3-1.

The average annual rainfall for the area is 497 mm. Rainfall is lower in summer months, with an average monthly rainfall <30 mm/month between December and March, increasing to >50 mm/month between May and September (Figure 3-1).

The average annual ET for the area is 1,613 mm, with monthly ET ranging from <40 mm/month in June to >200 mm/month between December and February (Figure 3-1).

The monitoring indicates that on average, rainfall only exceeds ET during June and July. Given this, seasonal recharge throughout the area is likely to be limited.

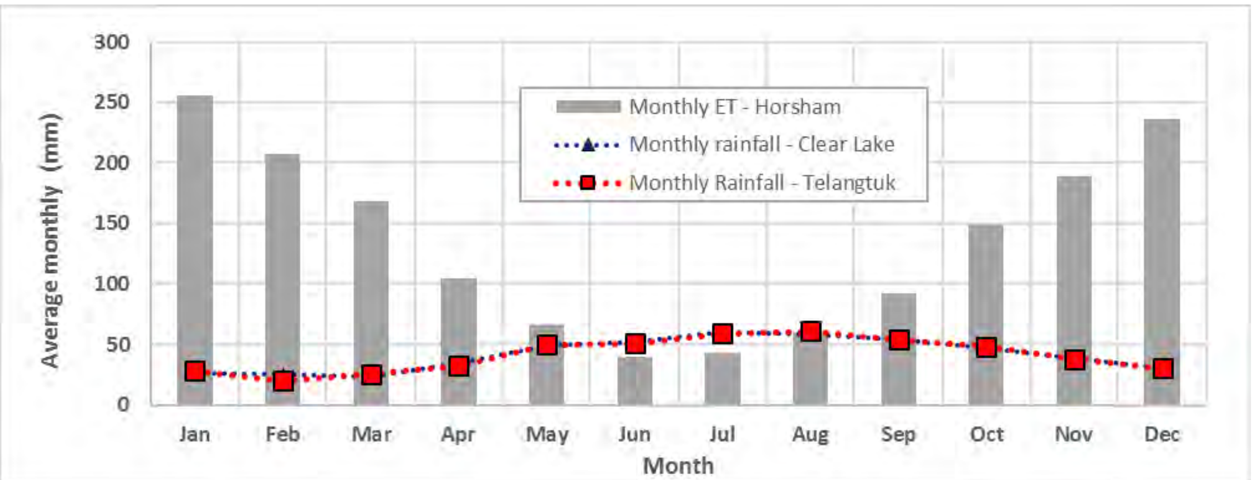


Figure 3-1 Average monthly rainfall and evapotranspiration

3.2 Geology

The WIM 100 East assessment area is located towards the south western edge of the Murray (Geological) Basin. The formation of the basin is the result of basement subsidence following the break-up of Gondwana, and the subsequent periods of marine transgression and regression during the Tertiary period. The basin comprises up to ~600 m of marine, coastal and continental sediments that is underlain by Palaeozoic basement rocks, and surrounded by low mountain ranges of the same age.

The WIM100 Deposit falls within the Mallee-Limestone Province of the Murray Basin, which lies to the west of the Neckarboo Ridge in western Victoria and South Australia. The major geological units in the Mallee-Limestone Province are listed below from oldest to youngest, with their stratigraphic relationship illustrated in Figure 3-2:

- Renmark Group
- Ettrick Formation, Winambool Formation and Geera Clay

- Murray Group Limestone
- Loxton-Parilla Sands
- Shepparton Formation

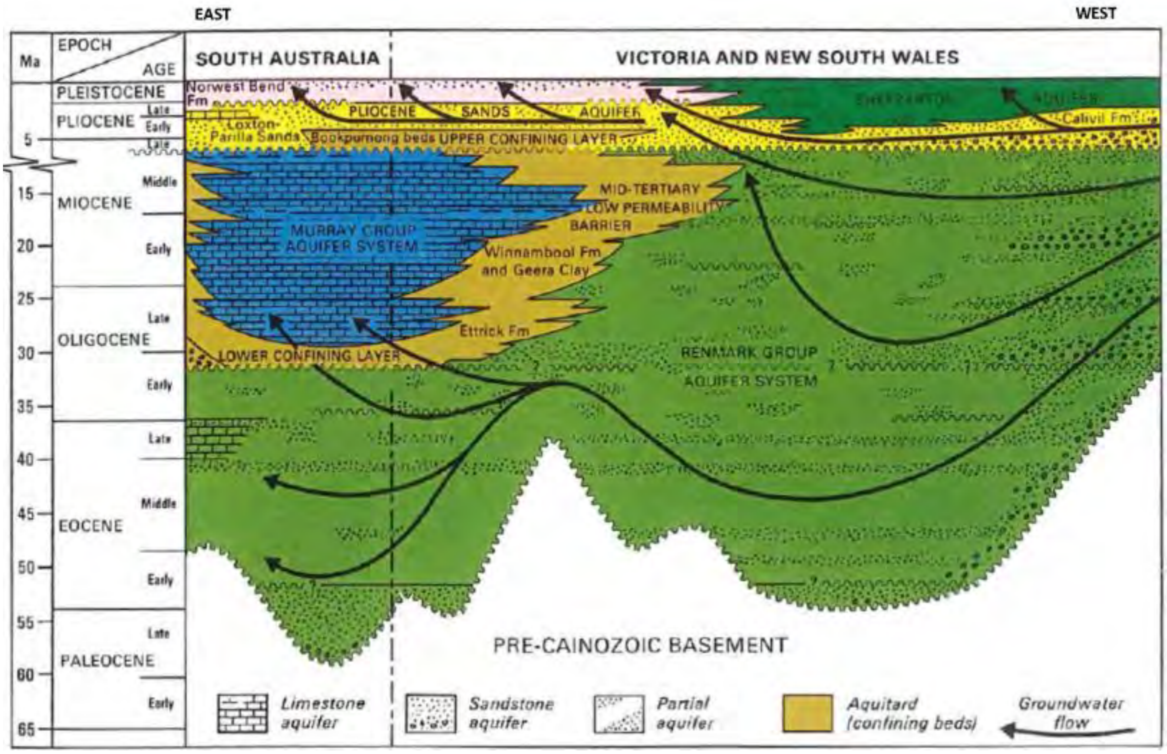


Figure 3-2 Regional stratigraphy of the Murray Basin (after Evans and Kellett, 1989)

The Renmark Group forms the basal unit lying unconformably above the pre-tertiary basement rocks throughout most of the Murray Basin. The unit was formed in a fluvial-lacustrine setting in the early to mid-Tertiary period and is comprised of variable amounts of gravel, quartz sand, silt and clay (Birch, 2003).

The deposition of the Ettrick Formation, Winambool Formation and Geera Clay represent a period of mid-Tertiary marine transgression in which terrestrial deposition was replaced with marine shelf and lagoonal deposition. The result of the transgression was the formation of marl, carbonaceous silts and clays, and some minor sands and gravels.

The Murray Group Limestone was deposited during the final stages of the Mid-Tertiary marine transgression, resulting in the formation of highly fossiliferous limestones and calcareous sandstones that form the Murray Group Limestone. Subsequent marine regression during the Late-Tertiary period saw the formation of shallow marine clays and marls termed the Bookpurnong Formation, that unconformably lie above the Murray Group Limestone.

The Loxton Parilla Sands (LPS) were formed during a period of rapid marine transgression in the Late-Tertiary period. The sands represent beach, dune and back barrier-lagoonal depositional settings and cover a significant portion of the Murray Basin. These are locally represented by poorly sorted, micaceous fine to grit sized sands. The LPS host the heavy mineral (HM) deposits that are the target for mining in this area and is the geological unit of most interest for this assessment.

The Shepparton Formation is comprised of non-marine sands and clays deposited from the Late-Tertiary and Quaternary periods after marine regression. It is poorly consolidated and forms the surface unit through much of the central and eastern portions of the Murray Basin.

3.3 Mineralisation

The WIM100 East orebody site is characterised by “WIM style” mineral sand deposits which form in the low-energy facies of the LPS, including lower-shore and inner-shelf environments. A generalised schematic representation of WIM style deposition is illustrated in Figure 3-3 below. The mechanism for the separation of heavy mineral lenses in this environment are yet to be explained in full, however, the presence of hummocky cross stratification in the WIM150 deposit suggests their development during episodic storm-wave processes, above (but near) storm wave base where depositional rates during storms are high enough to preserve hummocks (Whitehouse, 2009).

Heavy mineralisation at the WIM100 East site is present within the LPS between 130 and 145 mAHD (~15 m in thickness). It typically occurs ~15 m below the ground surface where it becomes saturated (i.e. occurs below the water table). These occur within the lowershore facies of the LPS as they overlie the Winnambool and Ettrick Formations (i.e. the Murray Group Limestone is absent). The sands in this area consist of poorly sorted, micaceous fine to grit sized sands with high clay content, overlying stacked units of very fine to fine lowershore sand, in places separated by a thin coarser lens (the surf zone). Iron oxide induration is intense at the contact between the Shepparton and the LPS, and variable within the LPS.

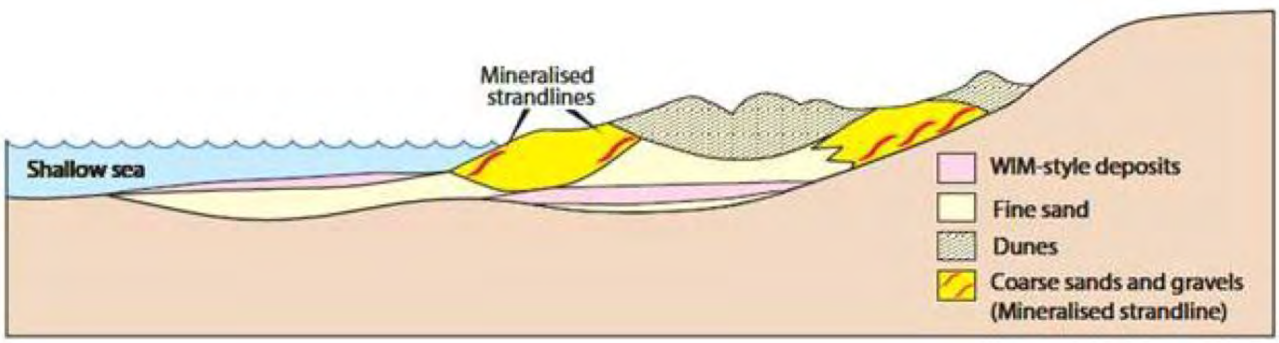


Figure 3-3 Conceptualised WIM style depositional setting

3.4 Regional hydrogeology

Figure 3-4 below presents the conceptualised hydrogeology of the region surrounding the proposed test pit. The figure provides a good approximation of the major hydrogeological units and processes occurring regionally. This includes a regional water table in the LPS at a depth of around 15 m below ground level (mbgl). It also shows that the mineralised zone within the LPS tends to occur at least in part, below the regional water table.

There are two key regional features in Figure 3-4 which should be addressed with respect to local variations at the proposed test pit. Firstly, it should be noted that while drilling and mapping have indicated the presence of the Murray Group Limestone regionally, exploration drilling at the proposed test pit indicates that it is not present locally.

Secondly, the majority of surface water features throughout the region occur in depressions that overlay impermeable clays of the Shepparton Formation. It is conceptualised that the water that pools in such areas slowly infiltrates into the Shepparton Formation and subsequently, into the underlying LPS. Given this, groundwater dependent ecosystems surrounding such features are likely to rely on perched or local groundwater, rather than the underlying regional groundwater which is typically >15 mbgl.

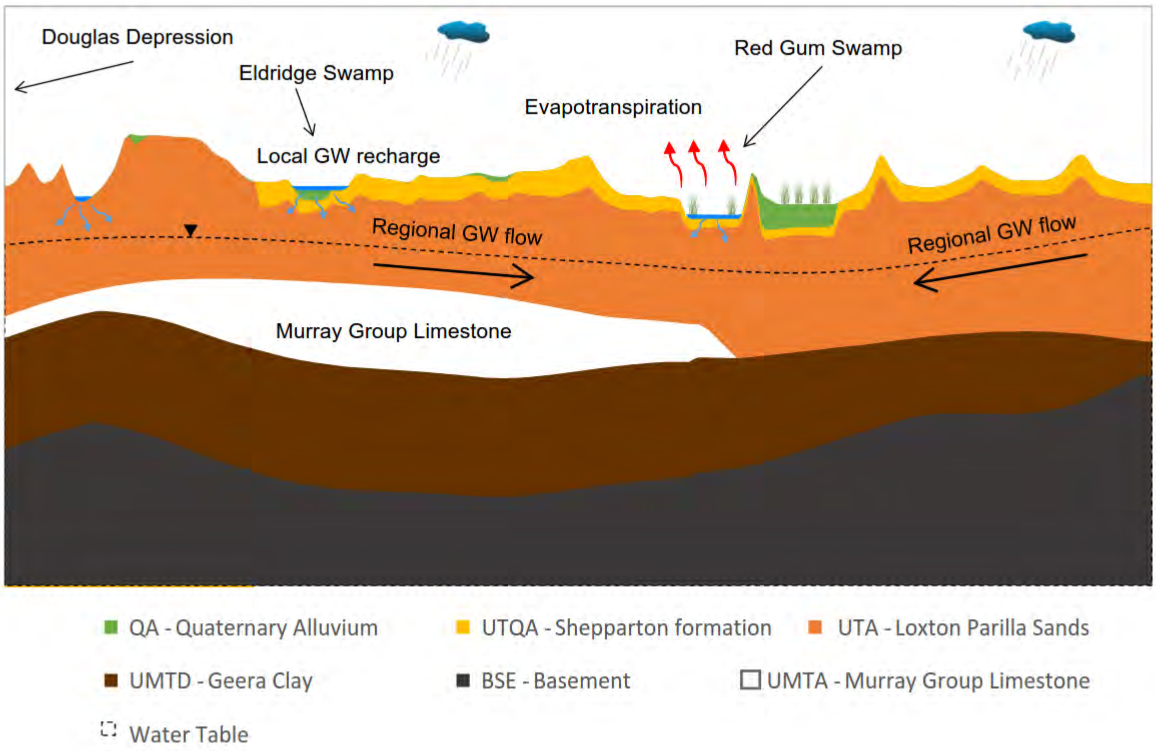


Figure 3-4 Summarised hydrogeological conceptual understanding of the WIM50 and WIM100 region

4. Site hydrogeology

This section considers the expected hydrogeological conditions that may be encountered at the WIM100 test pit, with the aim of informing inputs for the numerical groundwater model and subsequent groundwater risk assessments. The section does this by considering the stratigraphy, groundwater levels, groundwater salinity and groundwater receptors in proximity to the proposed pit. However, local scale information regarding the physical properties of the aquifers at the proposed test pit site is not available and as such, properties for the aquifers at a regional level have been utilised for the analysis in this section.

4.1 Acid sulfate soil and rock

As part of a parallel exploration drilling program, three exploration cores were taken from the WIM100 East optimised ore body during March 2018, approximately 1 to 2 km to the south of the proposed test pit. A total of twelve samples were collected for acid sulfate soil and rock (ASS/ASR) testing and assessed as part of the preliminary dewatering assessment (Jacobs, 2018a). The results presented and discussed in the report provided no indication that acid sulfate soils or acid sulfate rock occur at the proposed test pit location, and in fact, suggest that some of the material has the capacity to neutralise any acidic material if it were to be encountered.

4.2 Hydrostratigraphy

The hydrostratigraphy at the proposed test pit is based on a transect of reverse-circulation air-core exploration drill holes, the locations of which are shown in Figure 2-1. These cores include V17717, V17716 and V17715. Full lithological logs for these cores have been detailed in Appendix A and summarised in Figure 4-1 below.

The drill logs and Figure 4-1 illustrate that the upper stratigraphy at the proposed test pit is characterised by yellow-grey-brown sandy clays of the Shepparton Formation, which exhibit a clay content of >70%. The thickness of the Shepparton Formation is estimated to be 7 m to the west of the test pit (V17717), 7 m at the test pit itself (V17716) and 8 m to the pit's east (at V17715).

The Shepparton Formation at the proposed test pit is underlain by grey-brown-orange sands and clayey sands of the LPS with an average clay content of <20%. The sands thicken slightly from 21 m in thickness at V17715 to 23 m at V17717.

The LPS is underlain by dark grey-brown sandy clays of the Geera Clay. The unit contains a clay fraction of around 70%, is over 30 m in thickness and extends well below the proposed base of the test pit.

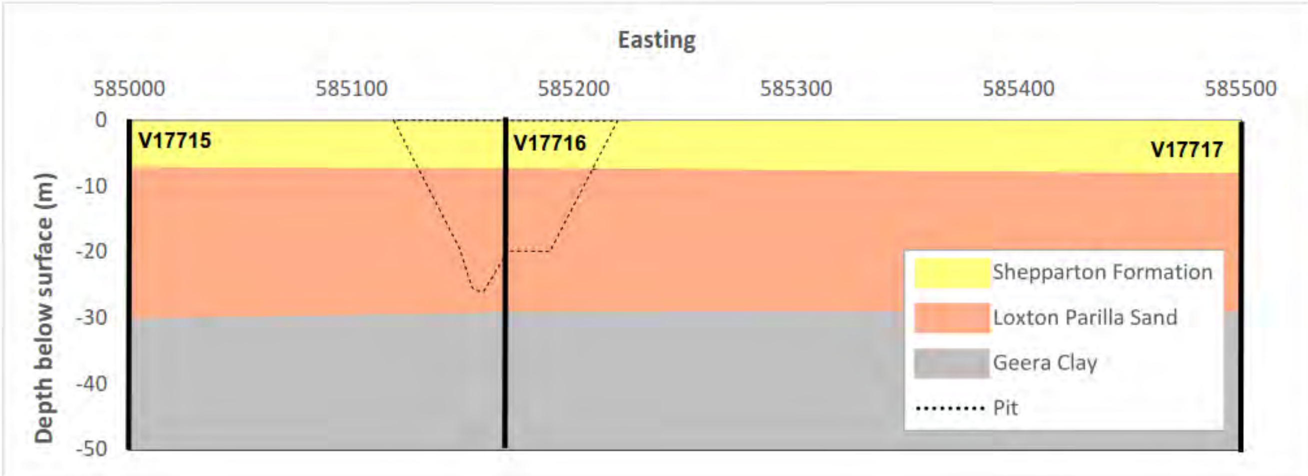


Figure 4-1 Hydrostratigraphy at proposed test pit, VE = 10, cross section is E-W and oblique to NW-SE trending test pit

4.3 Aquifer properties

Hydraulic testing of the Shepparton Formation, LPS or Geera Clay has yet to be undertaken at the proposed test pit. In lieu of on-site testing, aquifer properties have been estimated based on previously reported test work and modelling that has occurred regionally.

Accordingly, as the major aquifer unit throughout the region, only the LPS has been characterised by multiple studies. Within the southern Murray Basin, the hydraulic conductivity of the LPS is reported to range between 0.03 and 5.3 m/day (Rockwater, 1987), with an overall hydraulic conductivity of around 1 to 2 m/day (Smart, 1991). These values are also similar to the value of 0.37 m/day given by infiltration test work in the Parilla Sand as reported by Judkins (2001) and values of between 1 and 2 m/day for similar materials obtained by Wimmera Industrial Minerals at their WIM150 deposit. Previous modelling at the nearby Iluka Douglas Mine yielded hydraulic conductivities ranging between 0.05 to 17 m/day with a specific storage of 1 x 10^{-5} and a porosity of 0.03 to 0.2 (CDM Smith, 2014).

Within the same modelling study, all units other than the LPS were assigned a horizontal hydraulic conductivity of 0.01 m/day, a specific storage of 1 x 10^{-5}, and a porosity of 0.05 (CDM Smith, 2014). Further to this, while the Murray Group Limestone is present regionally, drilling has indicated its absence at the proposed test pit location (see local hydrogeology). The assessment by CDM Smith (2014) has been extensively reviewed (VCAT 107, 2017) and accepted, and provides a starting point for this assessment.

4.4 Groundwater levels and flow

As part of initial investigations and modelling (Jacobs, 2018a), groundwater levels and flow directions at the proposed test pit were estimated a number of different ways. This included previous depth to water table mapping by DEWLP (2014), the depth to “wet” material extracted from Iluka exploration drill cores in 2014 and 2018, empirically recorded groundwater levels in nearby monitoring wells and interpolated groundwater levels based on monitoring data collected by Iluka contractors in 2017.

A review of this information found that the interpolated groundwater levels based on monitoring in 2017 was most likely to characterise the groundwater levels encountered at the site, and was consistent with exploration drill holes near the proposed pit (Figure 4-2). Accordingly, the prevailing groundwater flow direction across the proposed pit is interpreted to be north to north-west, declining from >150 m Australian Height Datum (AHD) near Red-Gum Swamp ~4 km to the south of the proposed pit, to <135 mAHD near Cooks Lane ~5 km north of the proposed pit.

Available and inferred hydraulic head data suggest the LPS aquifer is unconfined at the test-pit.

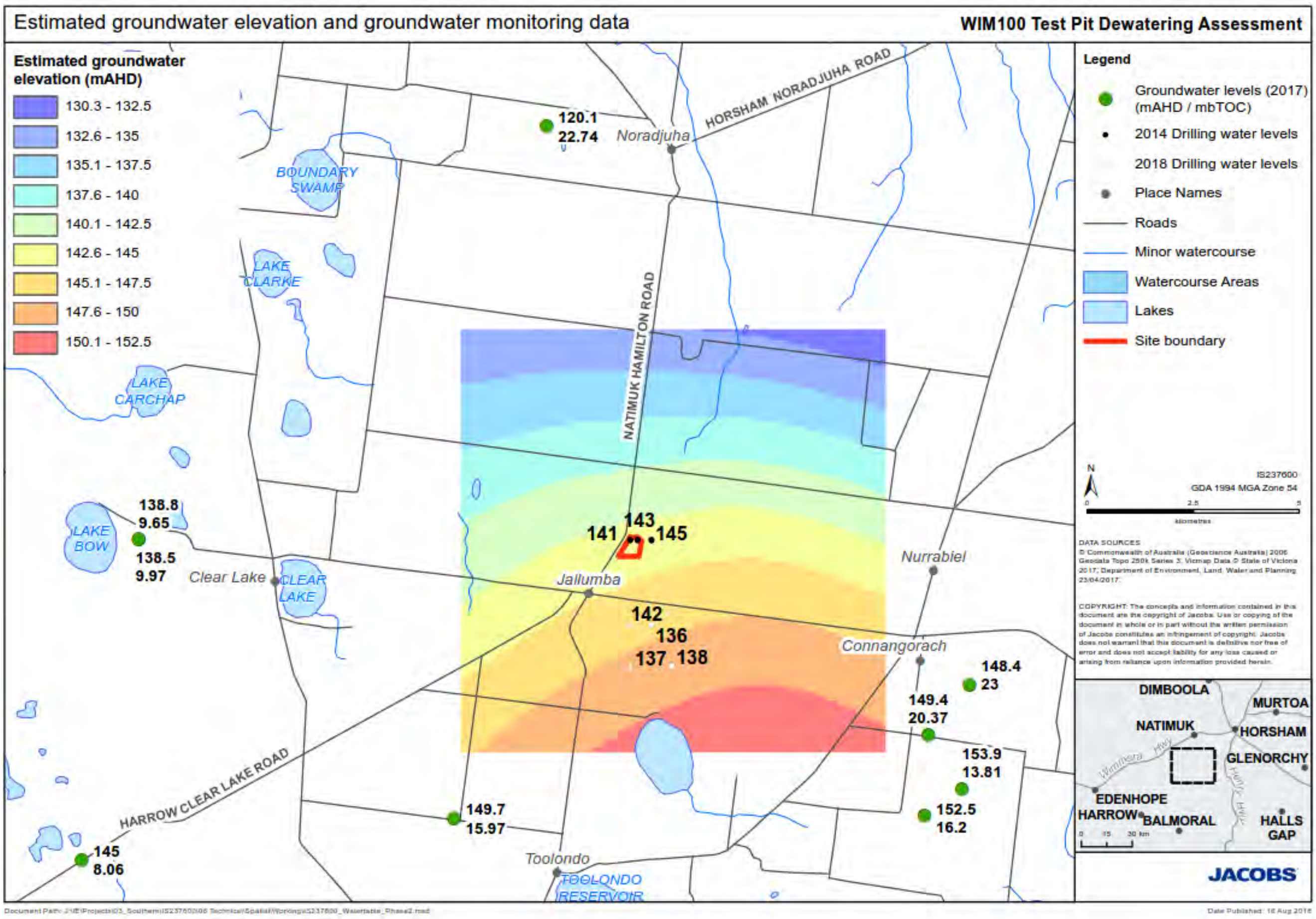


Figure 4-2 Groundwater levels and flow at proposed test pit

4.5 Groundwater salinity

Regional groundwater salinity mapping of the area (DELWP, 2014) indicates a groundwater salinity ranging between 3,500 mg/L and 13,000 mg/L total dissolved solids (TDS). However, during exploration drilling, groundwater was decanted from saturated aquifer material and analysed for TDS. The recovered groundwater had a TDS ranging between 2,300 and 3,400 mg/L (Figure 4-3).

Given that regional salinity mapping is based on information collected at a regional level, it tends to be indicative in nature. Further, the current hydrogeological conceptualisation of the region is that the recharge of relatively fresh water may occur via surface water features such as red-gum swamp (section 3.4). Given this, the locally obtained groundwater salinity information is more likely to reflect groundwater at the proposed test pit (i.e. exhibit a salinity closer to 2,300-3,400 mg/L). As such, groundwater at the site is more likely to require management under segments B and C of the Groundwater's of Victoria SEPP (EPA, 1997), and would need to be protected against the beneficial uses listed in Table 4-1.

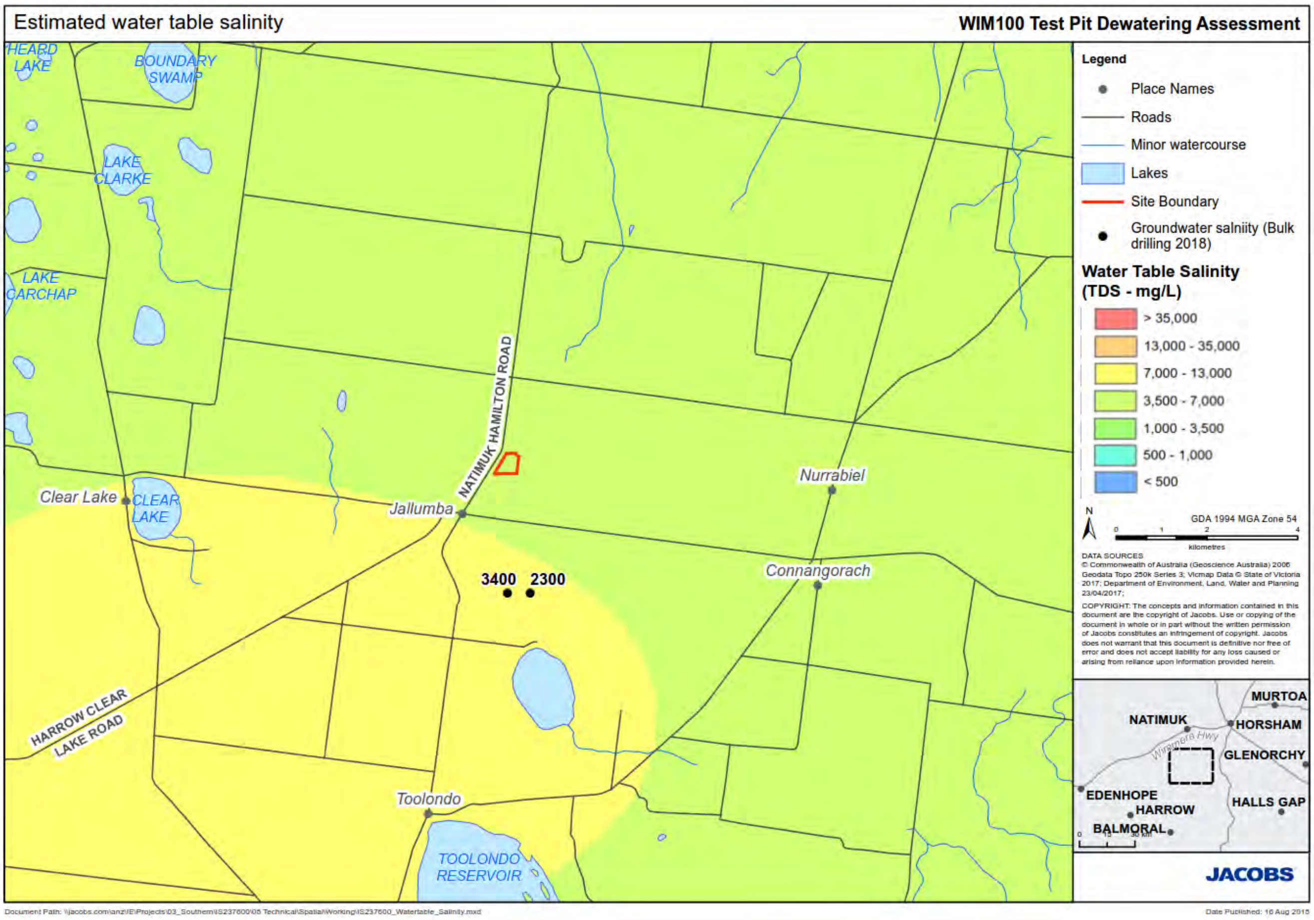


Figure 4-3 Regional salinity (DELWP, 20104) and groundwater salinity from bulk drilling

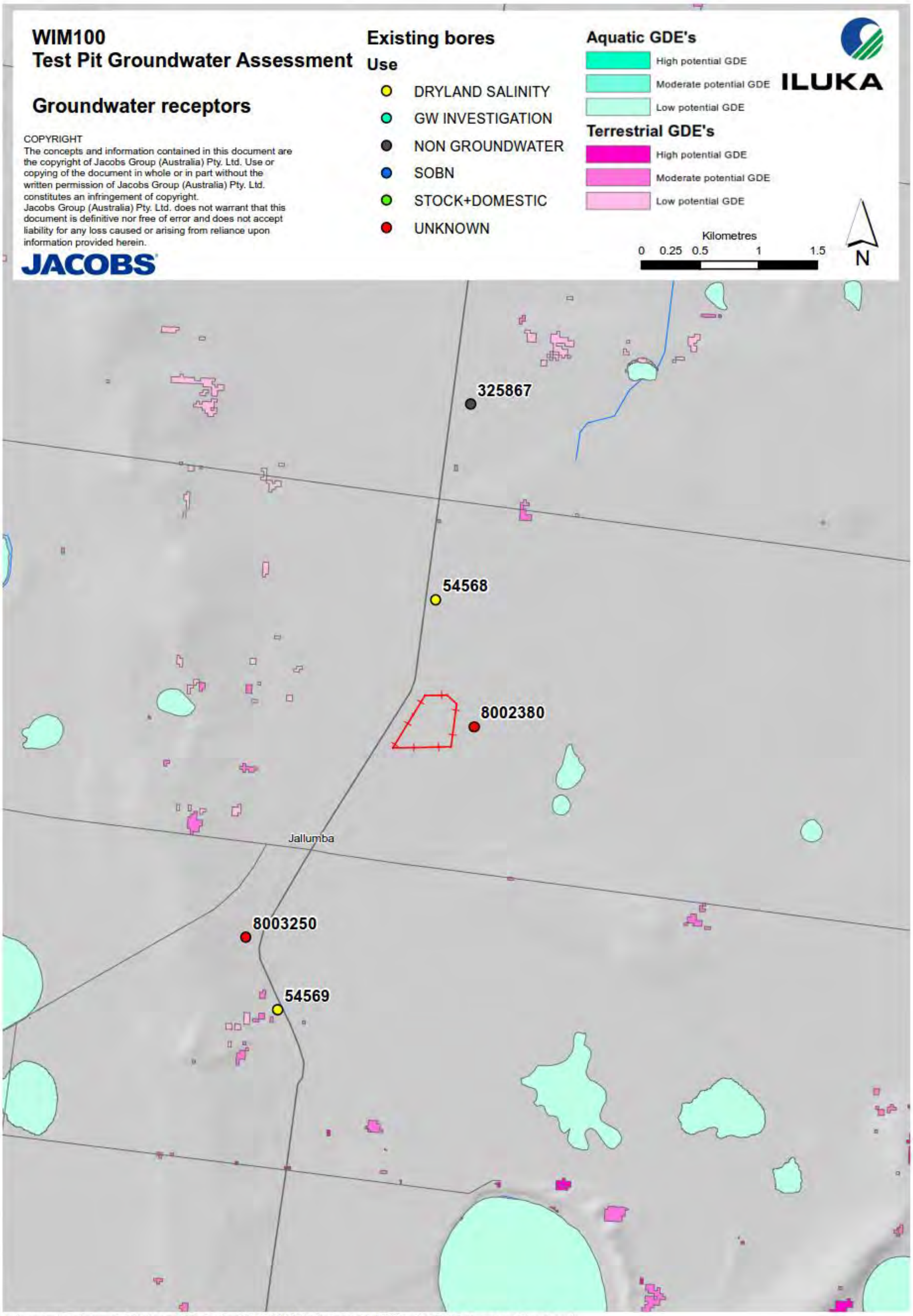
Table 4-1 Beneficial uses of groundwater (EPA, 1997)

	Beneficial Uses	Segments (mg/L TDS)				
		A1	A2	B	C	D
		0-500	501-1,000	1,001-3,500	3,501-13,000	> 13,000
1	Maintenance of ecosystems	✓	✓	✓	✓	✓
2	Potable water supply					
	desirable	✓				
	acceptable		✓			
3	Potable mineral water supply	✓	✓	✓		
4	Agriculture, parks and gardens	✓	✓	✓		
5	Stock watering	✓	✓	✓	✓	
6	Industrial water use	✓	✓	✓	✓	✓
7	Primary contact recreation (eg. Bathing, swimming)	✓	✓	✓	✓	
8	Buildings and structures	✓	✓	✓	✓	✓

4.6 Groundwater receptors

As outlined in during initial assessments by Jacobs (2018a), a review of the Visualising Victoria Groundwater bore database yields four potential groundwater users within 5 km of the proposed test pit. These have been reviewed in light of the test pit relocation which brings the pit slightly closer to the bores than previously. The nearest bores include bore 54568, 54569, 8003250 and 8002380 (Figure 4-4). Several attempts have been made to locate these bores in an effort to help inform this assessment. Three separate attempts to locate bores 54568 and 54569 failed to yield any evidence of their existence. Attempts to locate bore 8003250 were made via both aerial photography and from the property boundary, neither of which yielded evidence of its existence. Finally, headworks associated with bore 8002380 were identified, however, the bore was found to have collapsed near the surface and the bore was found to be non-operational (Appendix B). Given this, for the purposes of this assessment we have determined that no active groundwater users are currently operational within a 5 km radius of the proposed test pit.

A review of the potential groundwater dependant ecosystems (GDE) in the area surrounding the proposed test pit was undertaken using the GDE atlas in light of the test pit relocation (BOM, 2016). This indicates that the nearest potential Terrestrial GDE are woodland plain ecosystems with a low potential to be groundwater dependant, located both 1.3 km west of the proposed pit (Figure 4-4). The review also identified two wetlands with a low potential to be groundwater dependant near to the pit, including an unnamed potential wetland ~2.3 km west of the proposed pit and an unnamed potential wetland ~1.1 km to the east of the proposed pit (Figure 4-4). In addition, Nurrabiel Reserve (Swamp) was highlighted as a wetland with a low potential to be groundwater dependant and is ~6 km north of the proposed pit. While the mapping suggests that these ecosystems have a potential to be groundwater dependant, the regional water table is expected to be > 15 mbgl. Given this, the wetlands identified are almost certainly not reliant on the regional groundwater, and thus are not expected to be affected by the test pit.



Refer to Jacobs document: J:\IE\Projects\03_Southern\IS237600\08 Technical\Spatial\Working\IS237600_Receptors_Phase2.mxd

Figure 4-4 Potential groundwater receptors surrounding proposed test pit

5. Test pit design and water management

5.1 Water management

This section provides a review of the potential methods available by which water from inflows to the proposed test pit may be disposed. A summary of the regulatory frameworks relevant to each of the viable disposal methods is considered, and subsequently, an outline of the proposed water management strategy for the test pit is delineated.

5.1.1 Indicative water quality

As outlined in Section 4, there are no groundwater monitoring bores screened within the LPS or Shepparton Formation aquifers in close proximity to the proposed test pit. Hence, in order to obtain more localised groundwater samples and a subsequent indication on the quality of water likely to be produced during dewatering, water samples were obtained from two exploration boreholes (V18024 and V18025) located approximately 2 km from the proposed test pit.

The laboratory analysis of these groundwater samples is presented in Appendix C. The certificates of analysis are provided in Appendix D.

Sampling of groundwater from open boreholes is subject to contribution of inflows from multiple depths, and should ordinarily be conducted in monitoring wells constructed to the standards set out by Minimum Construction Requirements for Water Bores in Australia (National Uniform Drillers Licensing Committee [NUDLC], 2011). On this basis, the groundwater results presented in Appendix C provide for a qualitative assessment of the beneficial use of the LPS and disposal options available.

Further, it is possible that samples are relatively fresh in comparison to regional groundwater as a result of recharge from nearby surface water feature, such as Red-Gum Swamp (Section 3.3). If this is the case, groundwater salinity at the proposed test pit may be greater than indicated by these samples and should be viewed accordingly.

5.1.2 Consideration of disposal options

A number of potential options for disposal of pit inflow water exist, including:

1. Disposal into a watercourse or roadside drain;
2. Transfer into a farm dam on neighbouring agricultural land;
3. Irrigation on neighbouring agricultural land;
4. Irrigation on land within the test pit site;
5. Dust suppression on overburden, subsoil and topsoil stockpiles within the test pit site;
6. Dust suppression across all areas of the test pit site;
7. Disposal via an infiltration/evaporation basin located on the test pit site;
8. Disposal via groundwater re-injection wells located on the test pit site;
9. Disposal to sewer; and,
10. Combination of the disposal methods outlined above.

In order to determine whether a disposal option is permissible or precluded, groundwater samples presented in Appendix C have been compared against water quality/chemistry indicators and objectives published for all of the above disposal options, these include:

- State Environment Protection Policy (SEPP) (Waters of Victoria) – Water quality objectives for surface waters in lowlands of the Wimmera Catchment (EPA Victoria, 2003) – **Disposal Option 1**.
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Water quality objectives for Livestock Drinking and Irrigation uses (National Water Quality Management Strategy [NWQMS], 2000) – **Disposal Options 2 to 6**.
- SEPP (Groundwater of Victoria) – Water quality objectives for Segment B and C – **Disposal Options 7 to 8**.
- City West Water (CWW) Approved Acceptance Criteria for discharge to the sewerage system (CWW, 2018) – **Disposal Option 9**.

A comparison of average groundwater quality and chemistry, to the statutory indicators and objectives, is tabulated in Appendix C.

Disposal of produced water to a local watercourse or roadside drain (**Disposal Option 1**), is precluded under the water quality objectives for surface waters in lowlands of the Wimmera Catchment (EPA Victoria, 2003). The groundwater likely to be produced during test pit dewatering exceeds water quality objectives for salinity, pH, aluminium, arsenic, boron, and chromium.

The disposal of water produced during dewatering is precluded for the use of irrigating crops (**Disposal Option 2 to 6**), under the water quality objectives for Irrigation Use (NWQMS, 2000), due to the exceedance of iron, molybdenum and sodium concentrations in mean average groundwater. In contrast, water is not precluded for Livestock Drinking Use (NWQMS, 2000) and permissible for all stock with the exception of poultry and dairy cattle.

Jacobs understands that Iluka have engaged with the landowner at the proposed test pit and that the construction of a new farm dam is not suitable for the owner’s ongoing farming operations. However, this may be a suitable option for other similar types of development in the future. If so, an application would need to be submitted to Grampians Wimmera Murray Water (GWM Water):

- Domestic and stock dam registration form (https://www.gwmwater.org.au/component/edocman/726-download-the-domestic-and-stock-dam-registration-form/download)

In the absence of groundwater quality data, groundwater reinjection via infiltration basins and/or injection wells (**Disposal Options 7 to 8**), needs to be compliant with the objectives set out in SEPP (Groundwater of Victoria), and specifically Segments B and C based on the regional observations of TDS (detailed in Section 4.4). As no significant alteration to groundwater will likely occur following dewatering of the proposed test pit (groundwater will not be used for mineral processing purposes prior to disposal), well construction for groundwater disposal via reinjection is managed by GWM Water via:

- Application for a licence to construct, decommission or alter a bore (https://gwmwater.org.au/component/edocman/639-application-for-a-licence-to-construct-decommission-or-alter-a-bore/download)

Jacobs have contacted GMW Water and preliminary conversations indicate that unlike some other water authorities (such as Southern Rural Water) there is no formal application or licence is required for the disposal of water via bores. As such, consent for the disposal of pit inflows via an injection bore will require approval in writing from GMW Water.

In Jacobs’ experience, large-scale disposal of groundwater to sewerage systems (**Disposal Option 9**) is of a low preference to water corporations administrating trade waste services. Despite this anecdotal preference for disposal, a review of GMW waters trade waste criteria (GMWW, 2018) indicates a maximum daily salt load of 200 kg/day entering sewer. Based on this, the criteria for trade waste is likely to be exceeded under all but the lowest pit inflow rates (Jacobs, 2018a), assuming a mean average TDS in groundwater of 2,450 mg/L.

5.1.3 Water management strategy

Based on the above, and numerical and analytical modelling results from initial inflow assessments (Jacobs, 2018a), Iluka have developed a preliminary water management strategy. The strategy allows for the use and disposal of pit inflows in three ways. This includes the use of approximately 30,000 L/day (0.35 L/sec) for suppression of dust at the test pit during excavation, a disposal basin of up to 65 m x 100 m x 5 m, and up to 3 wells for injection of inflows.

An outline of the site, the potential extent of the disposal basin, the location of the injection wells and water transfer systems have been illustrated in Figure 5-1 below. This strategy has been used as a basis for numerical groundwater modelling in the following section (Section 6), in order to assess (1) its capacity to manage the anticipated inflows, and (2) highlight any risks to risks to groundwater receptors that may arise from the combined inflows and disposal.

Figure 5-1 Outline of proposed test pit site including basin, injection wells and water transfer systems

5.2 Test pit dimensions

Schematic representations at the proposed test pit have been illustrated in Figure 5-2 to Figure 5-5. The shows that the proposed pit is characterised by a 210 m long x 15 m wide ramp that descends 21 m from the ground surface to a 30 m x 30 m surface at the top of the proposed ore body. Given that the anticipated depth to water table is ~17 mbgl at the site, the majority of this excavation is anticipated to be dry.

A further excavation 15 m x 30 m to a depth 5 m below the top of the ore with a 1:1 batter slope (a pit base 5 m x 20 m) is proposed to collect ore material for metallurgical analysis. It is anticipated that all of this material will be below the water table and is saturated prior to dewatering activities.

It is noted that subsequent to the execution of numerical modelling described in the following section, the proposed dimensions of the test pit have been further refined by Iuka. The revised pit dimensions include steeper wall slopes (50°) between the ground surface and 143.3 mAHD, and shallower slopes (42°) between 143.3 and the pit base at 134.3 mAHD. While this will result in a slightly larger pit footprint (i.e. a length and width of ~77.4 m opposed to the 71 m illustrated below), the changes are not expected to significantly affect the model results given the range of possible paramaters that have been tested. We expect that the range of possible outcomes presented in the modelling can encompass the effects of this change. As such, the dimensions illustrated in Figure 5-2 to Figure 5-5 remain the basis of the numerical model for assessing inflows into the proposed pit. Incorporation further changes to pit dimensions will be considered along with on-site information that is planned to be collected during the initial stages of site development.

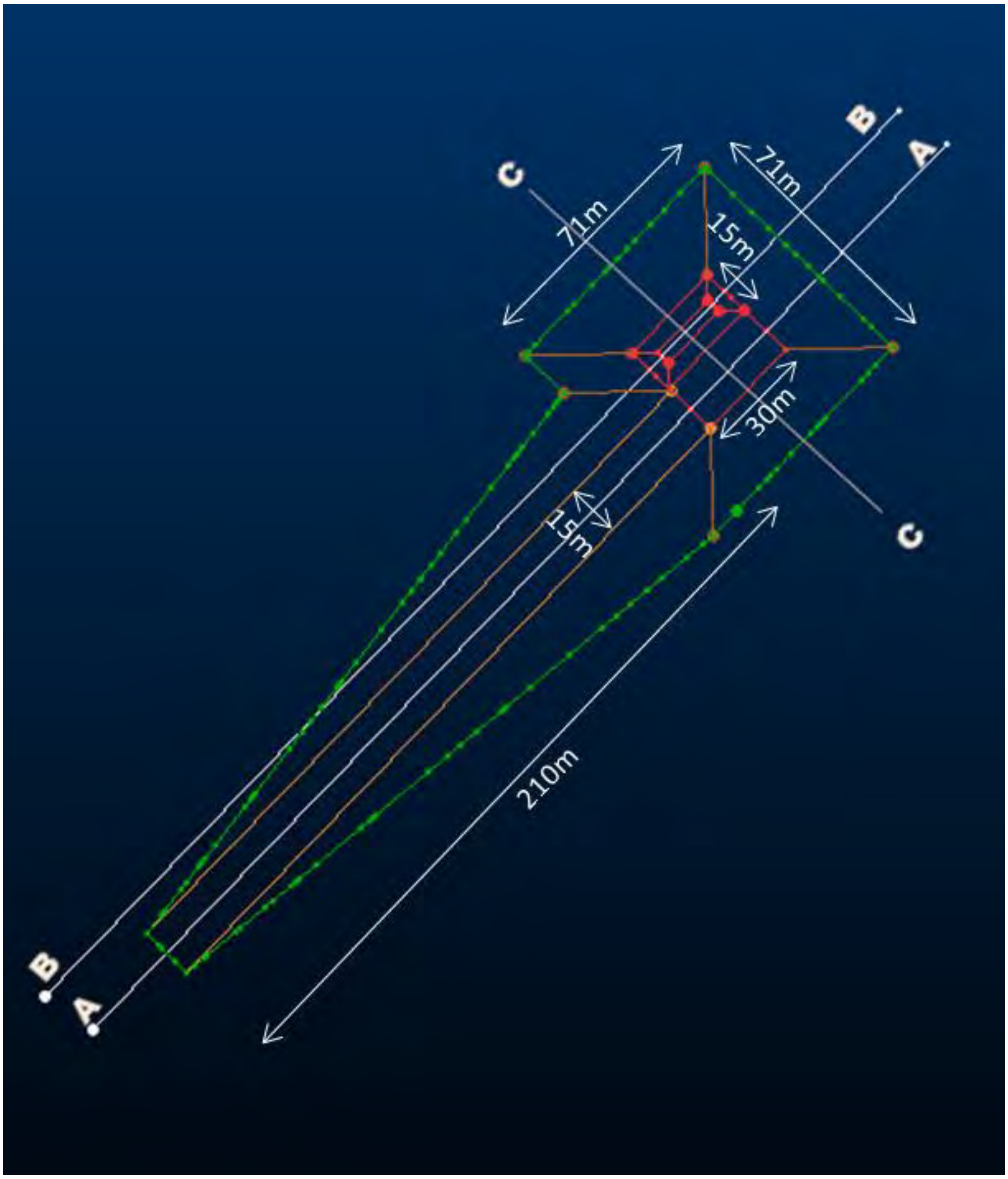


Figure 5-2 Top down schematic of proposed test pit

Figure 5-3 Cross section A-A at test pit (vertical exaggeration = 5.0)

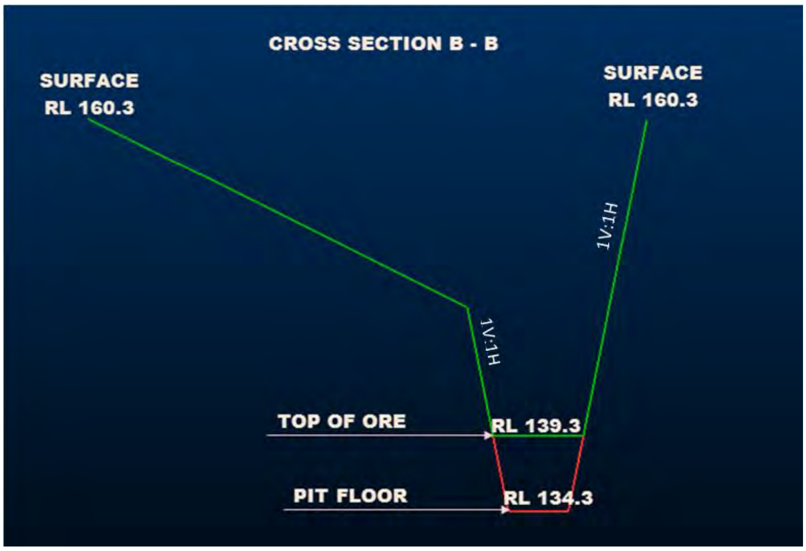


Figure 5-4 Cross section B-B at test pit (vertical exaggeration = 5.0)

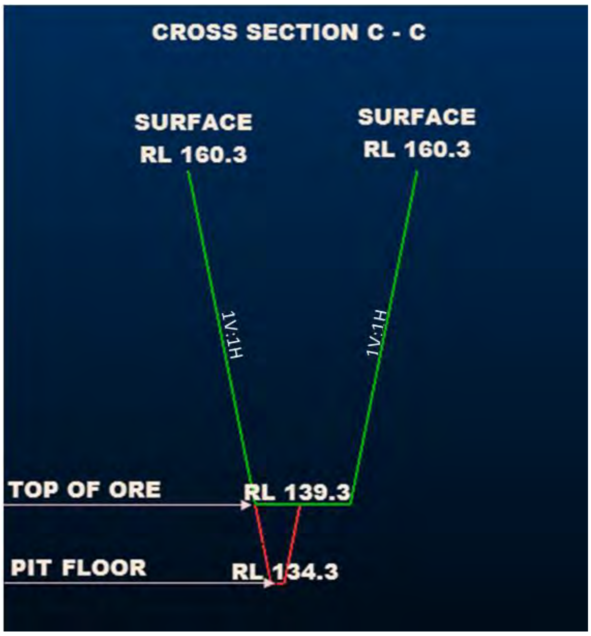


Figure 5-5 Cross section C-C at test pit (vertical exaggeration = 5.0)

6. Numerical modelling

6.1 Objectives

The groundwater model of the WIM100 Test Pit has been developed to:

1. Estimate a likely range of inflows into the test pit,
2. Assess the potential for bore injection and a shallow basin to dispose of excess water produced during test pit excavation and operations,
3. Assess potential drawdown and mounding impacts that may arise during test pit excavation and operation

6.2 Confidence Level Classification

The models developed for this investigation are based on the best available understanding of the site hydrogeology as defined from the available hydrogeological data at the site and its surroundings. The available data is limited and there are a number of gaps in our current knowledge of the site. While a basic calibration has been undertaken, the calibration targets (groundwater heads in steady state) have been interpolated from measured groundwater heads several kilometres from the site. In this case there is considerable uncertainty associated with the calibration data and hence this introduces uncertainty in the calibration process. There is no observed groundwater response at the site with which the modelled outputs can be compared. In line with the Australian Groundwater Modelling Guidelines (Barnett et al, 2012) the model is accordingly ranked as being of *"low confidence"* or Class 1. As the nearest active monitoring bore is located approximately 7.5 km from the proposed pit, and hydraulic conductivities and pre-development groundwater heads included in the model are based on regional values, improved confidence levels could be attained in the future if additional data are obtained closer to the proposed pit. Subsequently, the model can be calibrated by comparing estimates with observed groundwater behaviour.

6.3 Design

The model has been developed in Feflow version 7.0 finite element modelling code. Feflow is an industry standard finite element modelling code and its ability to simulate groundwater behaviour in the vicinity of mineral sand mines is well established. The model domain (10 km by 10 km square) and mesh are presented in Figure 6-1. The elevation of the ground surface across the model domain is presented in Figure 6-2. The nodes are refined progressively within 1 km and 200 m of the pit to allow the model to better capture details of groundwater levels closer to the pit, disposal basin and injection wells.

The simulated pit is based on the schematics presented in Figure 5-1 to Figure 5-5. This yields a pit base of 5 m by 20 m with an invert elevation of 134.3 mAHD. The pit walls are assumed to have a 1:1 batter slope that extends to an elevation of 139.3 mAHD to a 30 m by 30 m bench. The remaining excavation grades linearly to ground surface where the pit footprint is 71 m by 71 m, except at the access ramp which is 210 m long, oriented to the southwest and extending from the bench to the surface.

The model includes three layers consisting of the outcropping Shepparton Formation, the intermediate LPS and the underlying Geera Clay. The base of each layer was calculated by assuming an average formation thickness applied sequentially from the ground surface down. As there is little variation in unit thickness across the site, the model layers have been based on the interpreted lithology at drill core V17716 which is located in the centre of the proposed test pit.

It should be noted that the Shepparton Formation lies above the water table elevation and is therefore unsaturated across the model domain. It is included in the model because of its significance in controlling infiltration rates in the disposal basin. In order for the model to adequately simulate water infiltration and percolation through the unsaturated zone, it has been designed to simulate unsaturated zone processes using the Van Genuchten (1980) approach. The model starts with unsaturated conditions in the Shepparton

Formation. As water is pumped to the disposal basin, the local saturation of the Shepparton Formation increases and the model simulates accumulation of water in the basin. The unsaturated zone parameters used within the model include porosity (θ), the residual water content (θr), the saturated water content (θs) the pore size distribution fitting parameter (n) and the air suction parameter (α). The Feflow default values for these parameters were adopted for the unsaturated zone layers (layers 1-3) and are listed in Table 6-1 below. While these were adopted for model runs, the sensitivity and effect of each parameter on the nature of basin filling and inflows was also assessed (see section 6.6.2). The values adopted for sensitivity analysis were calculated using the Van Genuchten equation for soil types of the Shepparton Formation and LPS according to Australia Soil Texture (Marshall, 1974) and are listed in Table 6-2. It should be noted that for the saturated and residual water content, the values incorporated in Feflow are the fluid volume:pore volume ratio and not strictly equal to the definitions described by Van Genuchten (1980).

Table 6-1 Van Genuchten (1980) parameters used for unsaturated zone

Van Genuchten Parameters				
θs	θr	θ	a	n
1	0.003	0.05-0.15	4	1.964

Table 6-2 : Van Genuchten (1980) parameters used for unsaturated zone sensitivity analysis

Sensitivity analysis					
Model Layer	Van Genuchten Parameters				
	θs	θr	θ	a	n
1	0.95	0.054	0.507	0.99	1.11
2	0.95	0.054	0.507	0.99	1.11
3	0.95	0.042	0.436	20.72	1.31

The disposal basin is included as an additional model layer at the top of the model. It has a thickness of 2.5 m within the area of the basin and minimal thickness (0.01 m) elsewhere. This model layer is assumed to represent the void in the basin and it has been assigned a porosity of 1.0 and a hydraulic conductivity of 1000 m/day. In this way the water that accumulates in the basin will lead to an appropriate rise and fall in water level as the basin storage is filled and released respectively. The water table is hosted in the LPS which acts as an unconfined aquifer and the water in the disposal basin is formed in the model as a perched system in the Shepparton Formation.

The model mesh allows for the inclusion of three injection wells that can be used to dispose of excess water that exceeds the capacity of the water disposal basin.

Constant head boundary conditions have been assigned to all four edges of the model domain with heads assigned on the basis of the interpolated groundwater elevations in Figure 4-2; heads are shown at in Figure 6-3. These boundary conditions allow water to enter or exit the model domain depending on the predicted hydraulic gradients at the model edges. Boundary effects were not visible in model outputs, even under the maximum drawdown scenario (Figure 6-14), and hence are considered negligible.

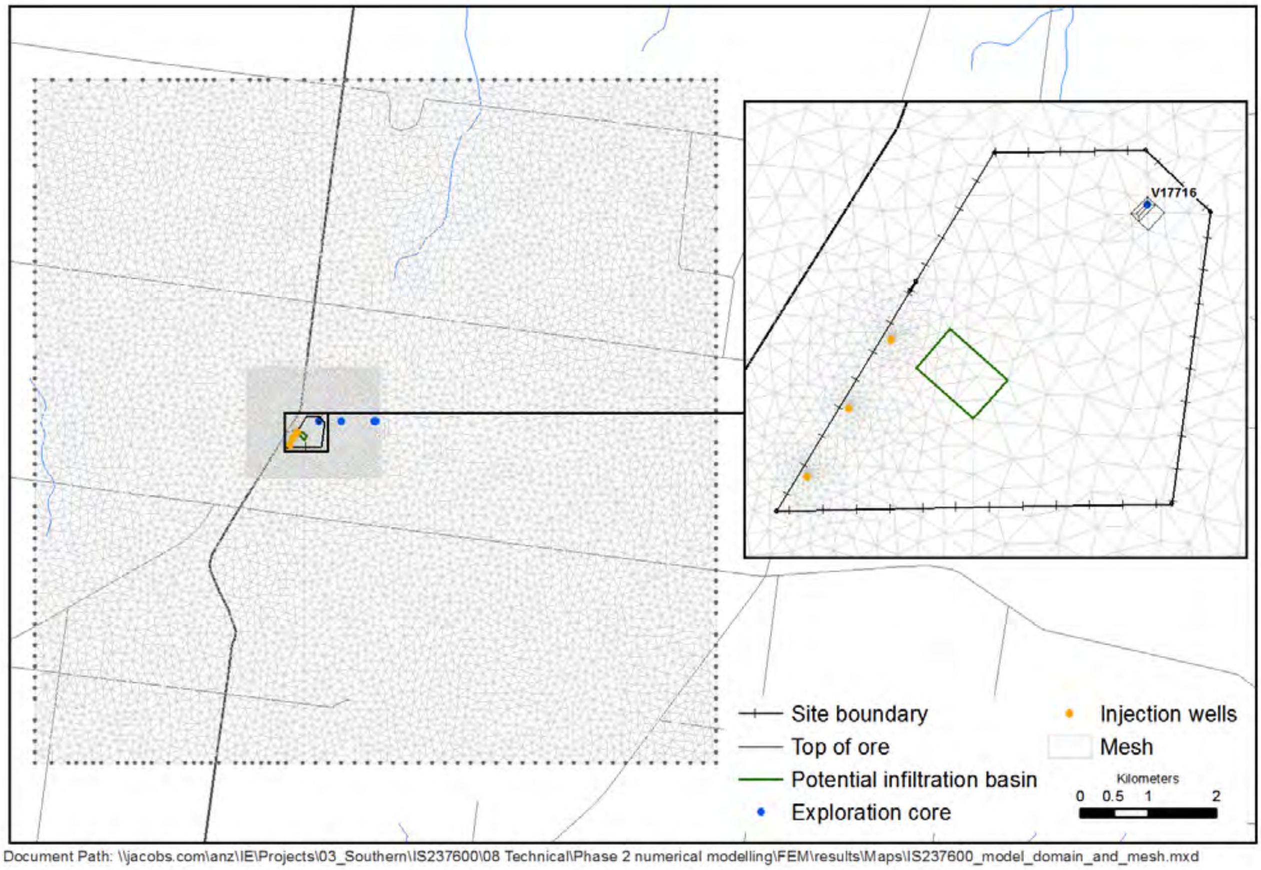


Figure 6-1 : Model domain and mesh.

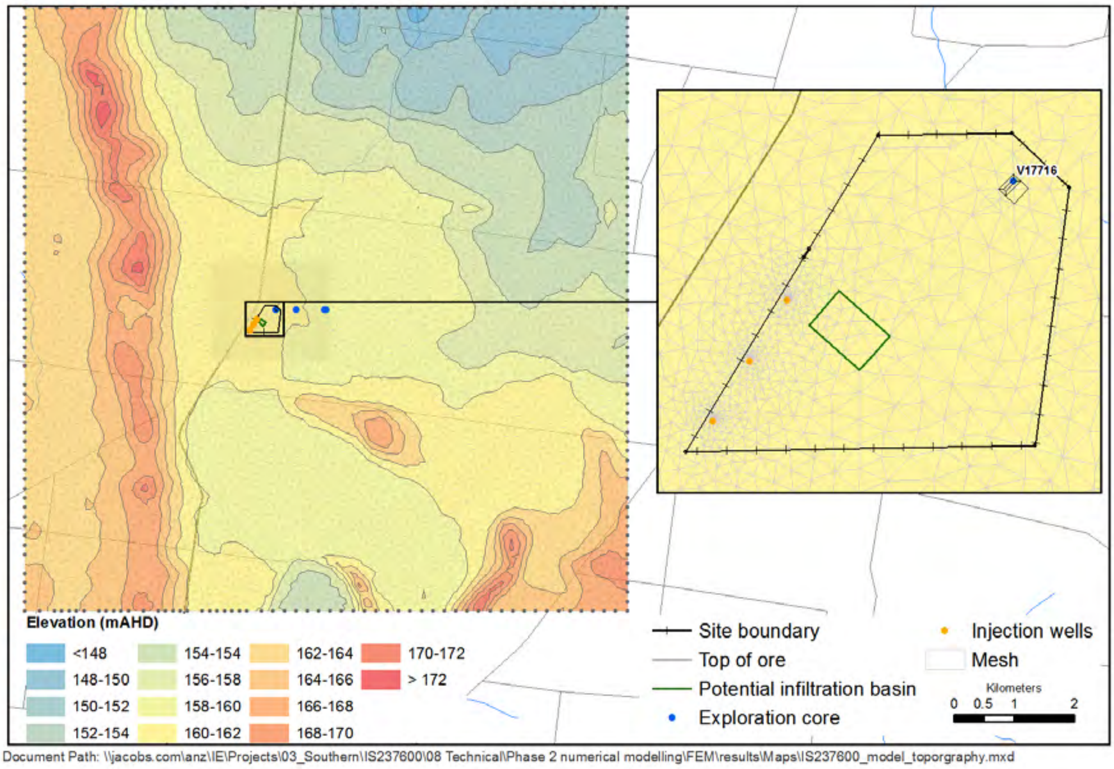


Figure 6-2 : Ground elevation contours (mAHD)

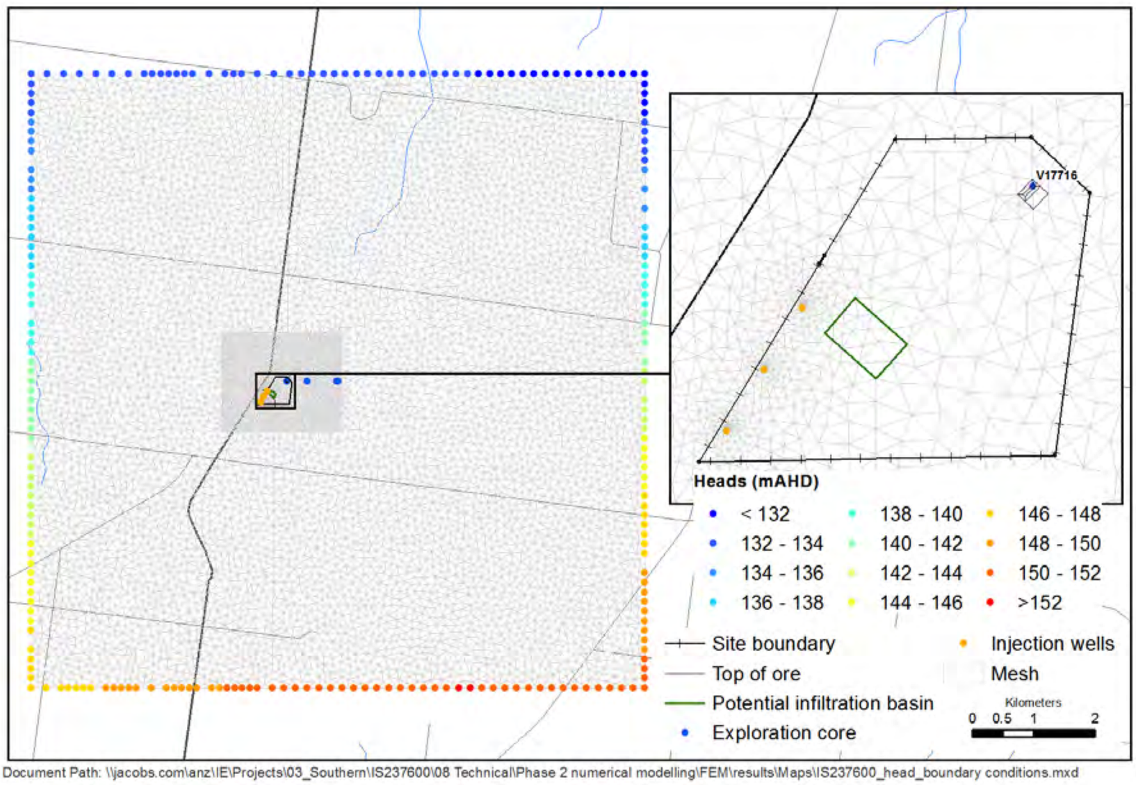


Figure 6-3 : Constant head boundary conditions

6.4 Calibration

In the absence of local groundwater observations, groundwater elevations measured in monitoring wells located approximately 8 - 15 km from the site were used in steady state calibration.

The points used to calibrate the model are presented in Figure 6-4. Model predicted steady state heads were compared with observed heads. Recharge to the model was varied at the start of each model run until steady state conditions achieved a reasonable correlation with groundwater levels at the calibration points. This indicated low recharge rates for the model domain (<10 mm/year or <2% of the mean annual rainfall) and is consistent with the absence of seasonal recharge (evidenced by the dominance of evapotranspiration over rainfall and the absence of seasonal water table fluctuations – see Jacobs 2018a).

At the present time, the model has been constructed with best estimate parameters that are based on the current conceptual understanding of nearby sites. However, site specific hydraulic testing has not been undertaken. Table 6-3 presents the best estimate of the physical hydrogeological parameters of the site. Given the uncertainty in the hydraulic conductivity, the LPS has been modelled with hydraulic conductivity values of 0.1, 1 and 5 m/day respectively as a sensitivity analysis. Recharge rates were varied for different assumed hydraulic conductivities in the LPS in order to achieve reasonable calibration for each model used in sensitivity analysis. The scatter plot of simulated groundwater heads plotted against measured heads for a hydraulic conductivity of 1 m/day (best estimate case) is presented in Figure 6-5.

In order to demonstrate that no boundary conditions have affected the estimates presented within the context of the modelling, a model water balance was undertaken. This was conducted by comparing the flux of water across the edge of the model domain both with and without the simulated test pit. The results indicate a flux into the domain of 631 m^3/day and a flux out of the model domain of 2,233 m^3/day, both with and without the pit for scenario 2, indicating that egdge effects are not apparent.

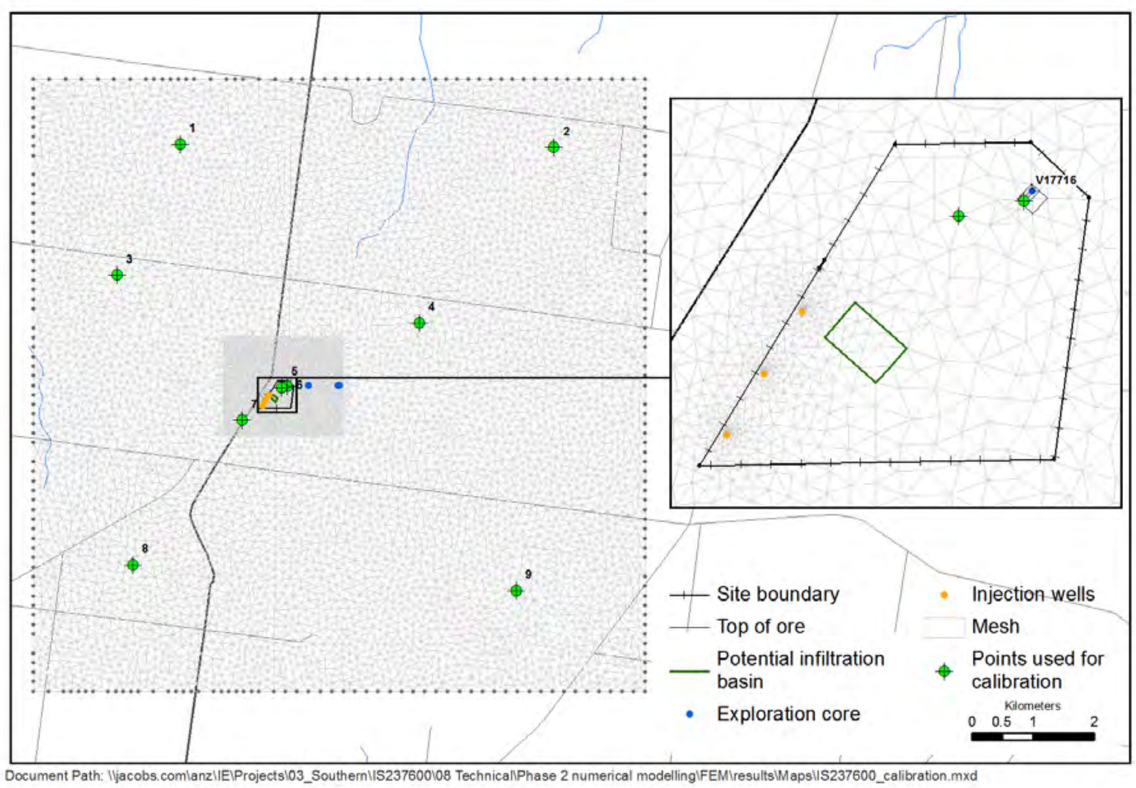


Figure 6-4 : Points used to calibrate the model.

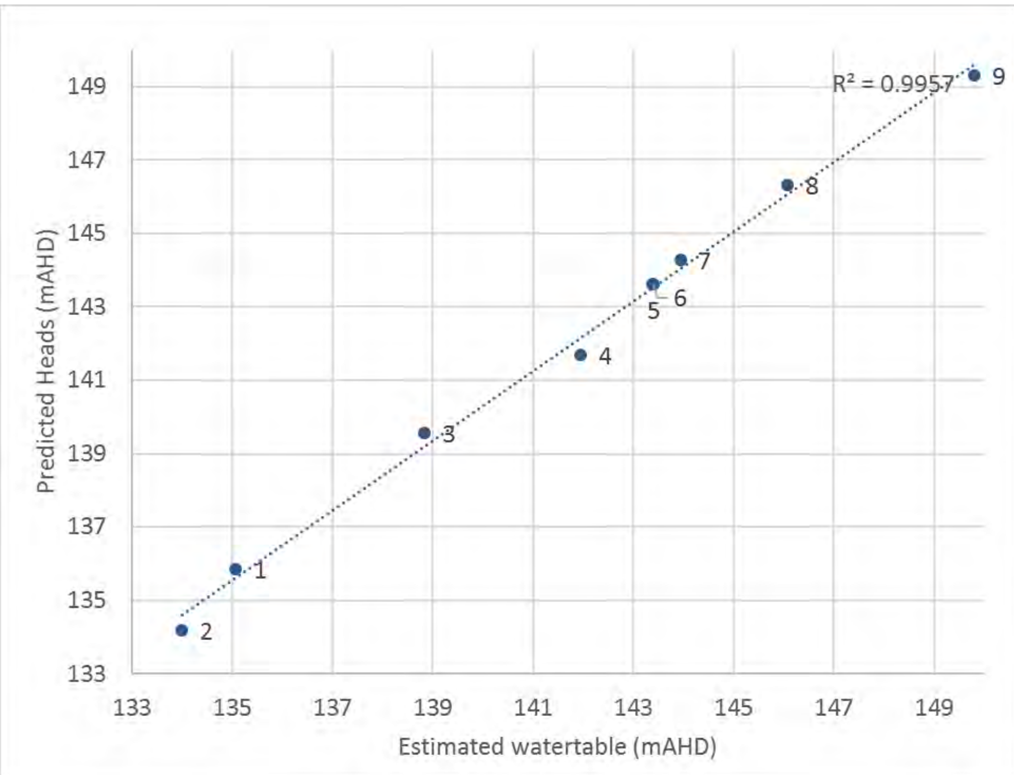


Figure 6-5 : Estimated and predicted groundwater elevations

Table 6-3 : Hydrogeological parameters

Unit	Kh (m/day)	Kv (m/day)	S	Porosity
Shepparton Formation	0.01	0.01	0.00001	0.05
LPS	1	0.1	0.00001	0.15
Geera Clay	0.01	0.001	0.00001	0.05

6.5 Scenarios

Predictive scenarios were modelled to assess future groundwater behaviour during test pit excavation and operation. Time-varying Hydraulic Head Boundary Conditions were assigned across the area of the proposed pit with progressive decline in the assigned heads used to match the assumed rate of excavation below the water table. In this manner, the predictive scenarios simulate inflow of groundwater to the pit with the use of in-pit drains, sumps and pumps to capture and remove water from the pit floor.

Each predictive scenario was run twice. The first model run included the test pit excavation and operation only. Predicted groundwater inflows to the pit were extracted from the model and a second model run was undertaken that included simulation of both the test pit excavation and the disposal of excess water in the disposal basin. The excess water rate is estimated as the water pumped from the test pit, less 0.35 L/sec as assumed to be used for dust suppression. The excess water is then converted to a recharge rate applied to the surface of the disposal basin. Heads in the disposal basin are reported by the model and indicate the evolution of water levels in the basin during disposal operations. The model estimates the seepage fluxes through the basin floor and through the unsaturated zone below the basin before it enters groundwater at the water table. It is expected that water disposal into injections wells will be undertaken if the disposal basin fills to capacity.

For scenarios in which the basin was found to fill to capacity, a further model run was implemented which included disposal of water into an injection well at a rate equal to the predicted rate of overflow of the basin. The capture and magnitude of overflow from the disposal basin was simulated and estimated through the use of

Hydraulic Head Boundary Conditions were assigned to the basin in order to prevent overfilling. Heads were set at the maximum operating or “trigger” level, assumed to be 0.5 m below ground level (i.e. a freeboard of 0.5 m was maintained within the 2.5 m deep basin and assigned as the trigger levels illustrated in Figure 6-7). The boundary condition is constrained to prevent recharge and as such is only active if the computed head exceeds the maximum operating level. Under these conditions the boundary condition withdraws water at a rate required to maintain the nominated maximum water level in the basin. To honour the site water balance, it is necessary to dispose of the predicted overflow volumes (the volume of water extracted from the hydraulic head boundary condition assigned to the Basin) into injection wells.

The maximum test pit depth is assumed to be 26 mbgl or 134 mAHD and the undisturbed groundwater level at the site is approximately 17 mbgl or at an elevation of 143 mAHD. The base of the pit is therefore assumed to be about 9 m below the water table.

The following scenarios have been run:

Scenario 1 – Best Estimate. This model includes the most likely hydrogeological parameters for all hydrogeological units as listed in Table 6-3. It also assumes the current best estimate of the pre-disturbed water table elevation at the site (143 mAHD).

Scenario 2 – Upper Bound. This model includes the upper bound estimate of hydraulic conductivity in the LPS of 5 m/day. This scenario produces higher pit inflow rates than the best estimate scenario and hence requires greater water disposal capacity.

Scenario 3 – Lower Bound. This model includes the lower bound estimate of hydraulic conductivity in the LPS of 0.1 m/day. Pit inflows and water disposal rates are lower for this scenario compared to Scenario 1.

Scenario 4 – Upper Bound with Injection. Scenario 2 was repeated with disposal of excess water to the disposal basin and with a continuous injection of ~3.5 L/sec into a single injection well. Scenario 2 did not result in an overflow of the disposal basin and hence injection of excess water was not included. Scenario 4 was run to help illustrate the potential capacity of injection wells and any potential impact that disposal may have on inflows.

Scenario 5 – Higher Water table. Scenario 2 was repeated assuming the water table is at 145 mAHD. Given the lack of available data on water table elevations at the site, it was considered judicious to run an additional scenario that assumes a higher pre-disturbed water table elevation.

6.6 Results

6.6.1 Predicted Inflows

The inflows to the test pit are controlled by the assumed hydraulic conductivity of the LPS in which the pit is to be excavated. This can be seen in Figure 6-6 showing the predicted inflow rates for Scenarios 1, 2, 3 and 5. The predicted inflow rates for Scenario 4 have not been illustrated as they were the same as those shown for Scenario 2. This indicates that the addition of water disposal into the basin and into injection wells did not have a measurable impact on the predicted inflow rates.

The inflow rates for all scenarios are predicted to increase steadily during pit excavation below the water table (from day 10 to day 15). The maximum predicted inflow rate occurs at day 15 and varies from 11 L/s for Scenario 5 to 0.2 L/s for Scenario 3. After the pit is fully constructed, the inflow rates are predicted to gradually decline.

The influence of increased water table elevation can be seen in the increased pit inflow predictions for Scenario 5 compared to those for Scenario 2. This illustrates that for a hydraulic conductivity of 5 m/day, a water table 2 m higher than that the best estimate is likely to result in an inflow rate increase of ~1.5 L/s.

The total volume of water requiring disposal ranged between 0 m^3 for Scenario 3 (all water used for dust suppression) and ~11,000 m^3 for Scenario 5.

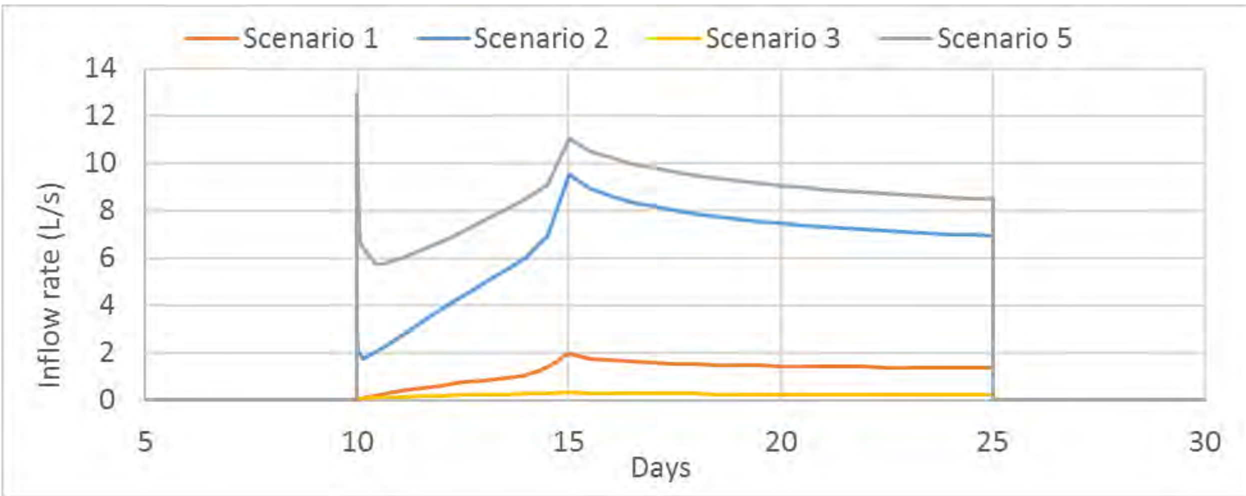


Figure 6-6: Predicted pit inflow rates for all scenarios

6.6.2 Disposal Basin Capacity

During preliminary modelling (Jacobs, 2018a), the holding capacity of a storage basin was considered for a range of potential pit inflow volumes. It was considered judicious during these early estimates, to allow for minimal leakage and evaporation from the basin. Further, the assessment considered a greater duration of dewatering, a shallower depth to water table and an allowance for the pit to infill. This led to basin holding capacity estimates of up to ~33,000 m^3. In contrast, the basin considered here in the revised model has a capacity of ~12,350 m^3. The approximate dimensions of the basin are 95 m in length, 65 m in width and 2.5 m in depth with an allowance for 0.5 m of freeboard.

The disposal basin is a shallow basin (the basin floor is assumed to be 2.5 m below the ground surface) that sits within the Shepparton Formation and is a considerable distance above the water table. Disposal of water to the basin was modelled at a rate equal to the pit inflow rate minus 30 m^3/day (~ 0.35 L/s), which has been assumed to be required for dust suppression at the test pit. Water pumped into the disposal basin is modelled to seep into the ground below the basin.

Water levels in the basin will vary depending on the amount of water it receives. At lower disposal rates, the seepage through the basin floor will equal the disposal rate and thus, the basin is not predicted to fill. As the disposal rate increases it will exceed the rate at which water seeps into the basin floor and water will start to fill the basin. Should the water disposal rate continue to exceed seepage rates, the water levels will rise and may eventually reach the maximum operating level. Water that seeps through the floor of the basin will percolate through the unsaturated zone before entering the water table some distance below the basin.

The hydrographs presented in Figure 6-7 illustrate the capacity of the disposal basin to store the load of excess water from Scenarios 1, 2, and 5.

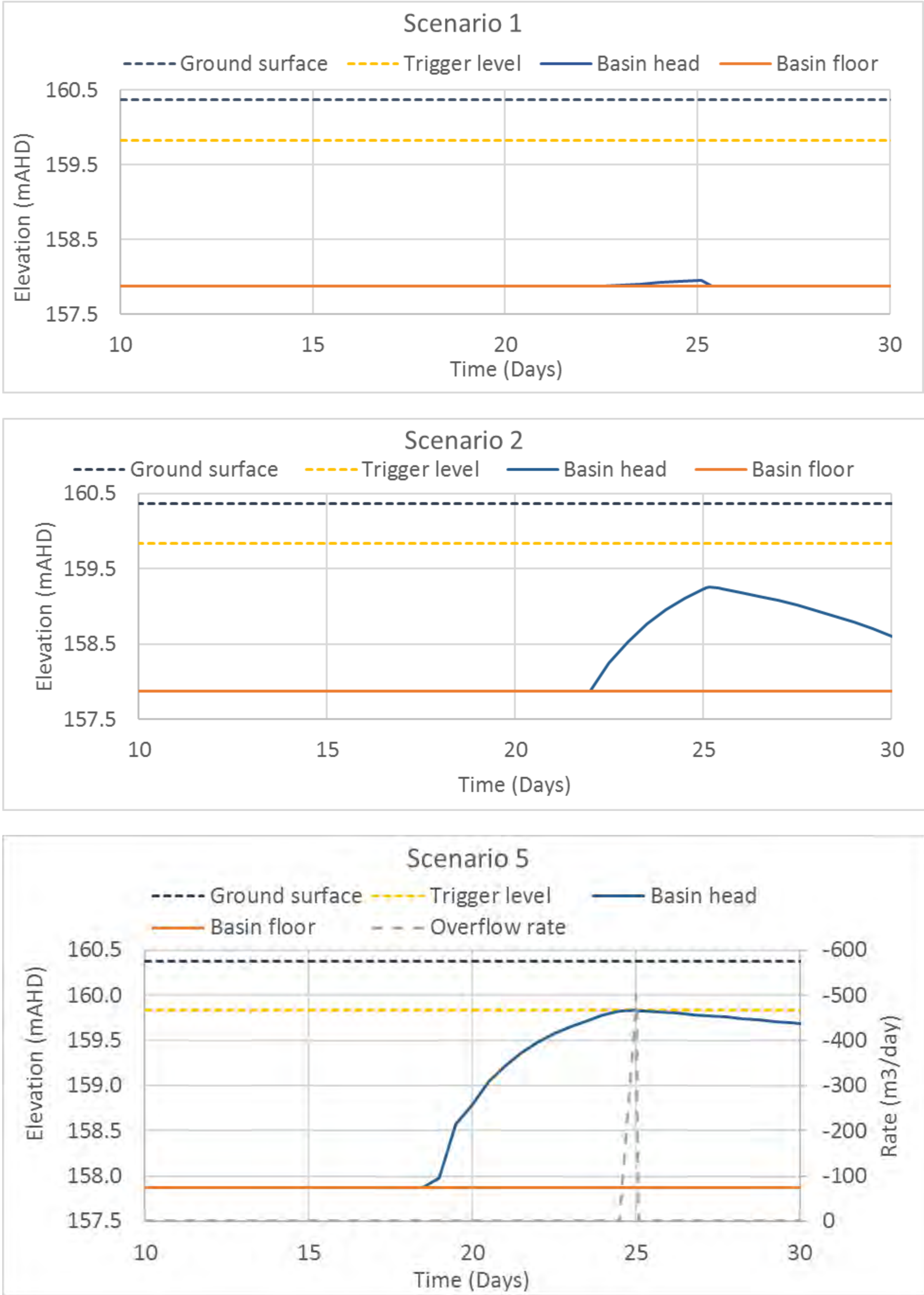


Figure 6-7: Predicted water levels in the disposal basin

For Scenario 1, the disposal rates are relatively small and do not lead to a significant filling of water in the basin (i.e. disposal rates are commensurate with seepage rates). For Scenario 2, the basin is predicted to fill to an elevation of about 159.5 mAHD which is about 1 m below the maximum operating level. For Scenario 3, the disposal basin is not required as all the produced water is required for dust suppression. Scenario 4 has a relatively small disposal load for the basin as much of the excess water is assumed to be disposed in an injection well. In Scenario 5, the predicted water level in the basin reaches the maximum operating level in the final day of operation.

In summary, the results suggest that the shallow disposal basin is expected to be capable of disposing the excess water generated by the excavation and operation of the test pit, and disposal via an injection well is only anticipated to be necessary if the groundwater level in the LPS or its hydraulic conductivity exceed the likely range of conditions anticipated at the site, or if the seepage rate from the basin is significantly less than anticipated.

In addition to the above predicted basin water levels, the effect of the unsaturated zone on water seepage through the basin, and the resulting rate of basin filling was assessed by considering a range of potential values for the unsaturated zone model parameters. Figure 6-8 below illustrates the effect of porosity, residual water content (θr), saturated water content (θs) and the soil water suction parameter (α) on basin filling with respect inflows from scenario 2. It shows that seepage losses are greatest (i.e. the basin does not fill) when porosity increases. Conversely, when the water suction parameter for the basin is reduced, the basin fills more rapidly (although it does not reach the trigger level for inflows given by scenario 5). This is expected as the total inflow volume given by scenario 2 is <12,000 m^3 and the holding volume of the basin is >12,000 m^3.

This shows that for the potential range in unsaturated zone parameters, the water level in the basin may approach the trigger level (although not exceed the level as suggested by sensitivity in the local groundwater level – scenario 5), but may also exhibit minimal pooling of water if seepage from the basin is elevated.

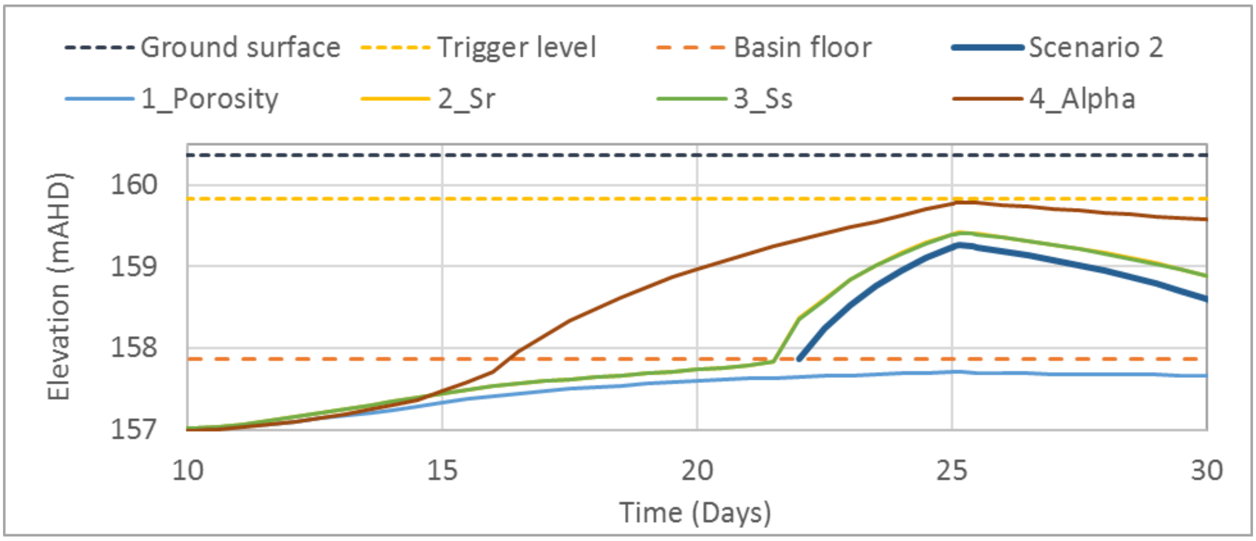


Figure 6-8: Predicted water levels in the disposal basin due to UZ variability

6.6.3 Injection well capacity

Scenario 4 has been run in order to assess the injection well capacity in the event that additional disposal capacity may be required. Results described above suggest that it is unlikely that injection wells will be required to assist with water disposal. However, it is recommended that an injection well be available as a disposal contingency and as such, it is important to assess the capacity of an injection well screened in the LPS at the site. Scenario 4 includes constant injection at 300 m^3/day (~3.5 L/sec) for the duration of test pit excavation and operation below the water table. The predicted water level in the injection well is shown in Figure 6-9. It can be seen that the heads are predicted to rise rapidly to levels just above the base of the Shepparton Formation.

It should be noted that if the hydraulic conductivity of the LPS at the injection well is lower that assumed here, the head in bore will increase to a greater level than estimated below and may exceed the bores operation capacity. If this were the case, and the conductivity of the LPS at the pit was significantly greater than at the injection well, additional wells may be required to manage excess pit inflows.

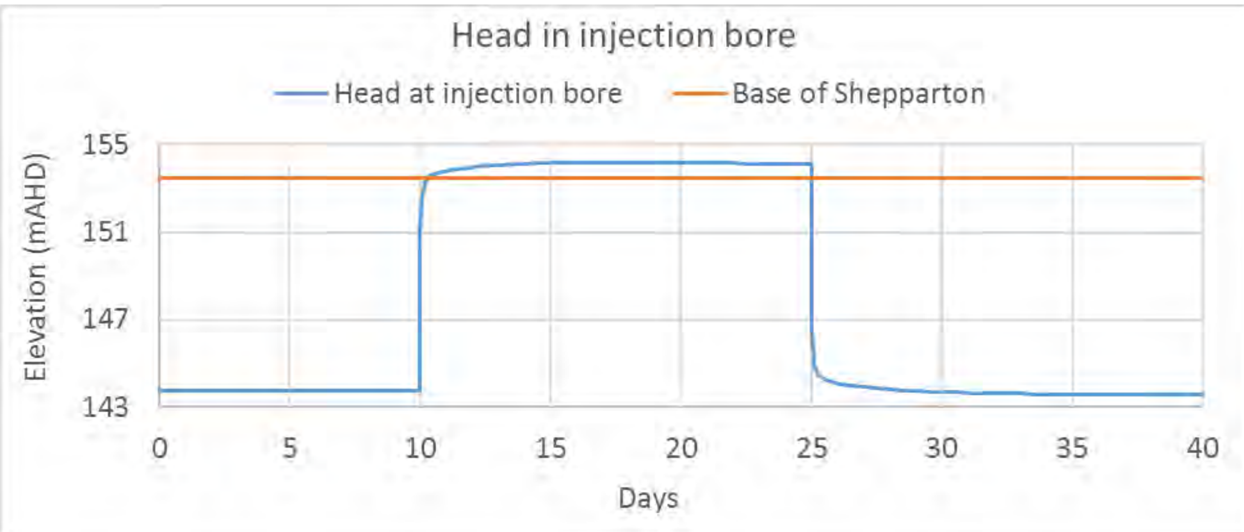


Figure 6-9: Predicted heads in injection bore Scenario 4.

6.6.4 Predicted drawdown and mounding

The predicted drawdown and mounding impacts at the time of maximum pit inflow (day 15 when the test pit excavation reaches full depth) are shown in Figure 6-10 to Figure 6-14 for the five scenarios considered in this report. The figures illustrate that drawdown is expected to be the dominant change in groundwater heads. This is because (1) water disposal rates are less than pit dewatering rates due to volumes required for dust suppression, and (2) because disposal into the shallow basin occurs above the water table and the unsaturated zone storage tends to be dominant compared to deep recharge rates over the duration of the project.

The effects of water disposal can only be seen in Figure 6-11, Figure 6-13 and Figure 6-14. As noted above, the disposal into a shallow basin has a muted mounding response because much of the disposed water is lost to storage in the unsaturated zone. On the other hand, Scenario 4 assumes disposal of 3.5 L/sec directly into the saturated aquifer in the LPS, which elicits a more rapid response.

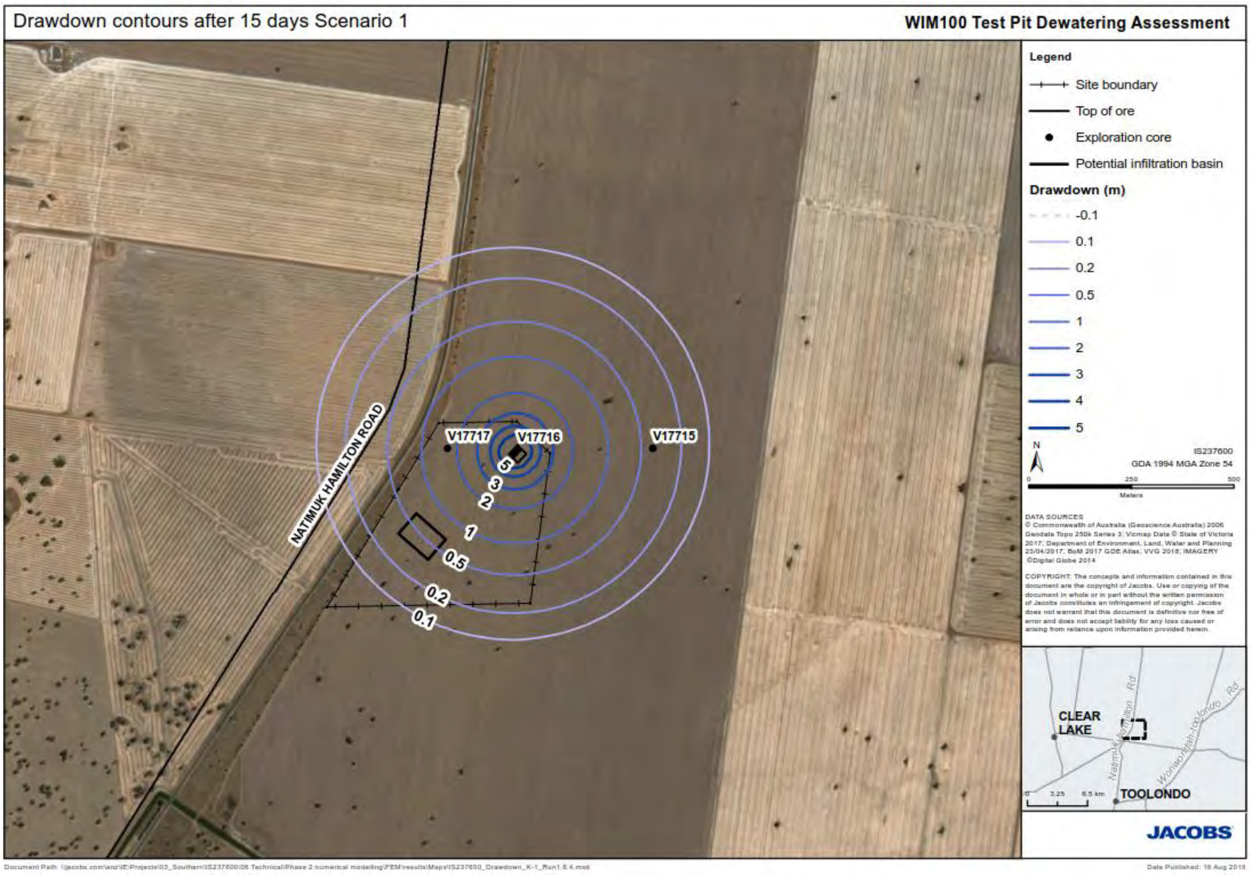


Figure 6-10: Predicted drawdown and mounding for Scenario 1 at Day 15

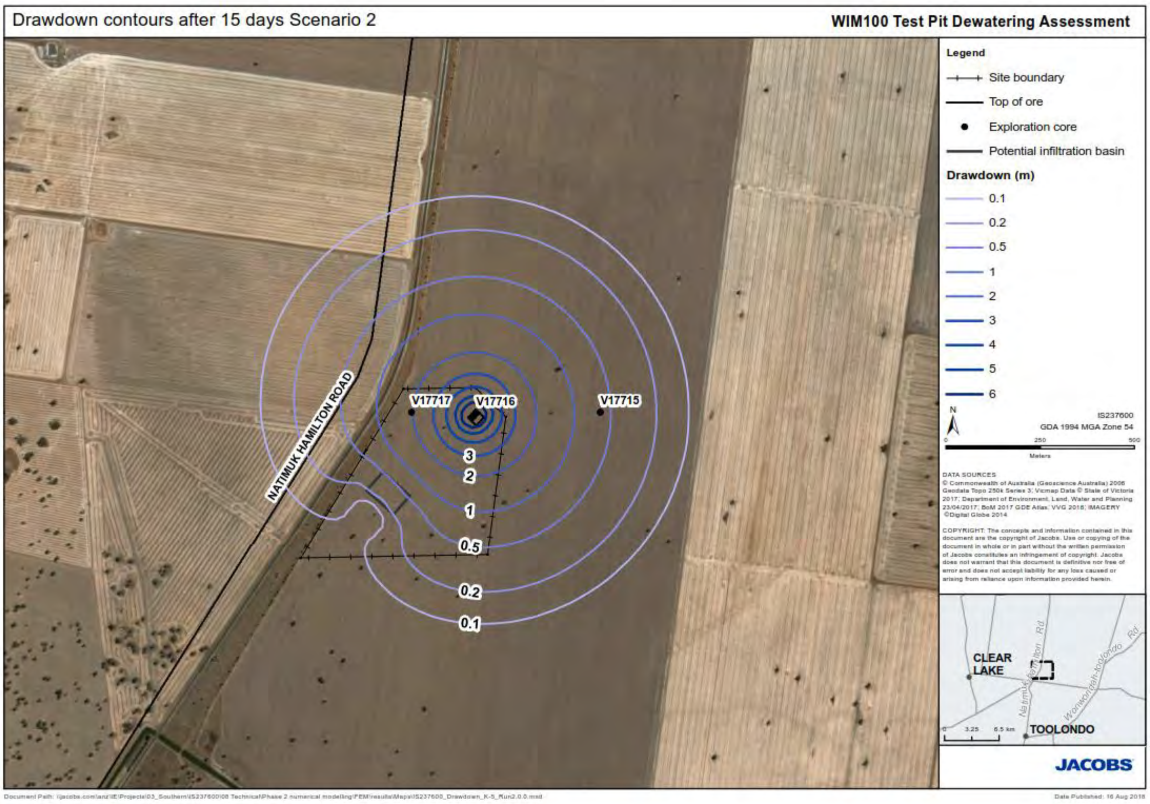


Figure 6-11: Predicted drawdown and mounding for Scenario 2 at Day 15

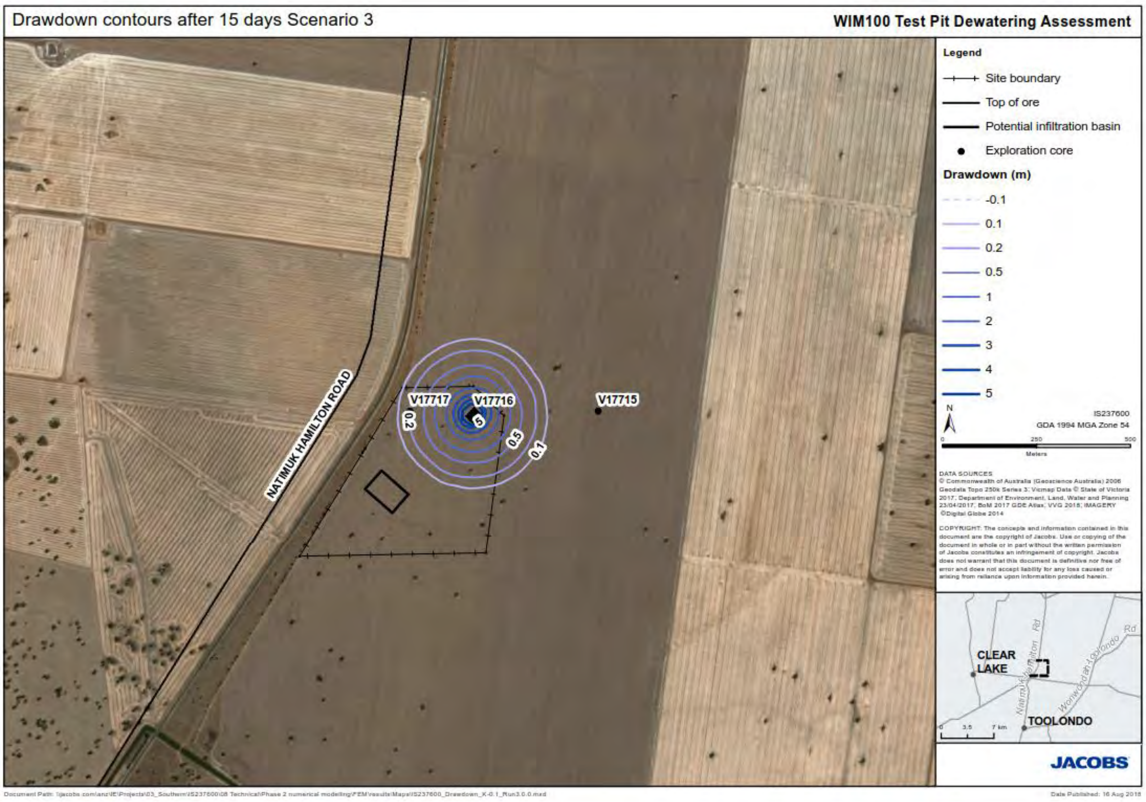


Figure 6-12: Predicted drawdown and mounding for Scenario 3 at Day 15

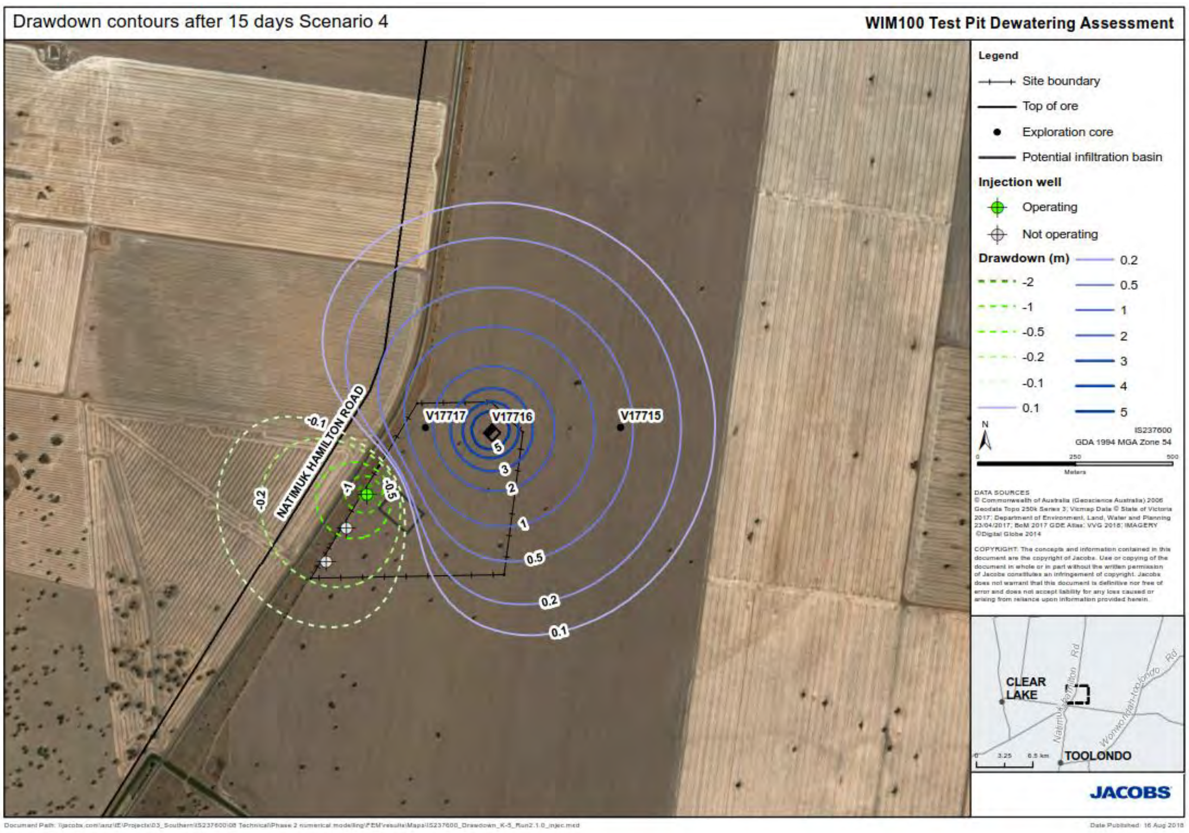


Figure 6-13: Predicted drawdown and mounding for Scenario 4 at Day 15

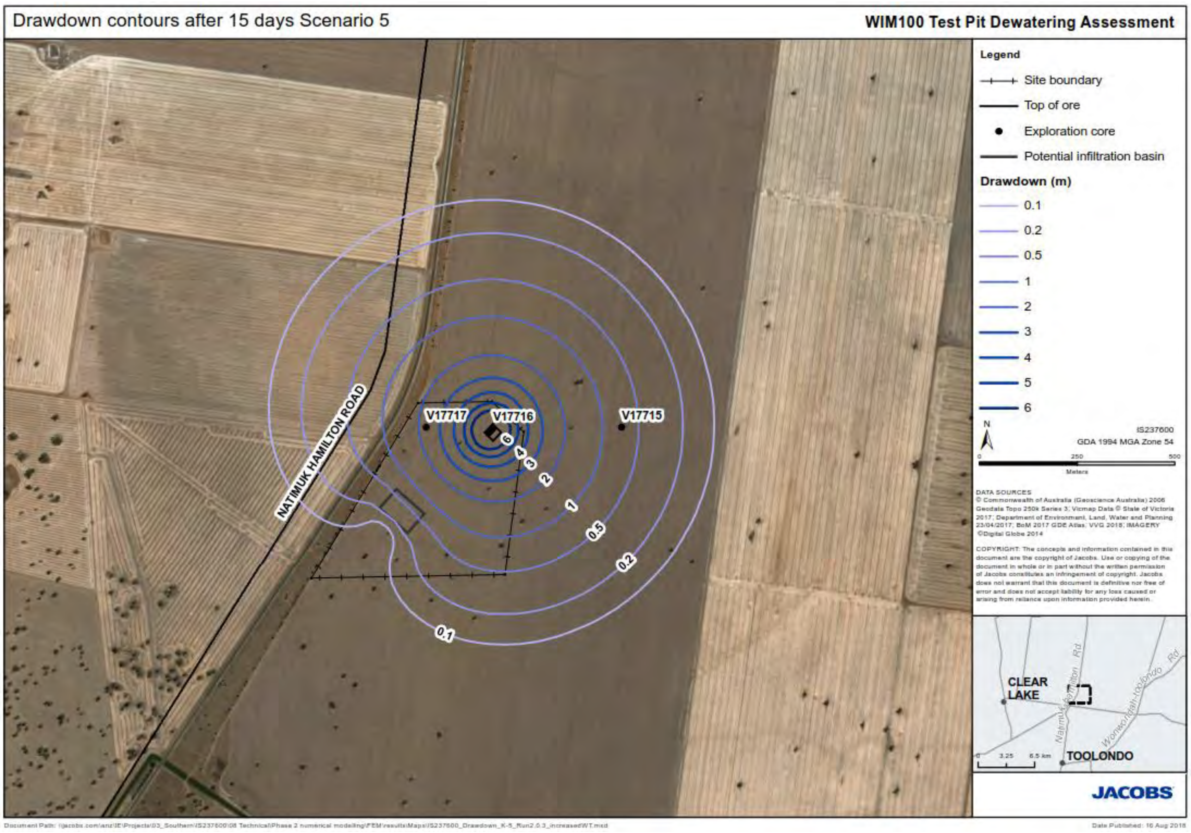


Figure 6-14: Predicted drawdown and mounding for Scenario 5 at Day 15

6.6.5 Pore pressure distribution and pit stability

The model has been used to plot pore pressures in the region of the test pit and disposal basin. A number of cross sections are shown in Figure 6-15 Figure 6-16 Figure 6-17 for Scenario 1, 2 and 4 respectively. The figures illustrate the drawdown and mounding impacts that will occur during the project.

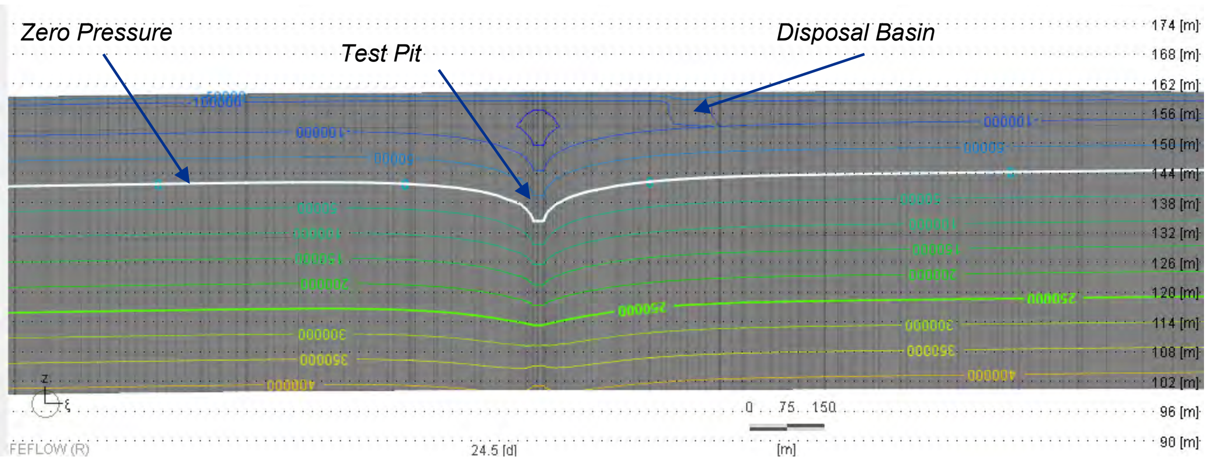


Figure 6-15: Pore pressure (pascals) contours for Scenario 1

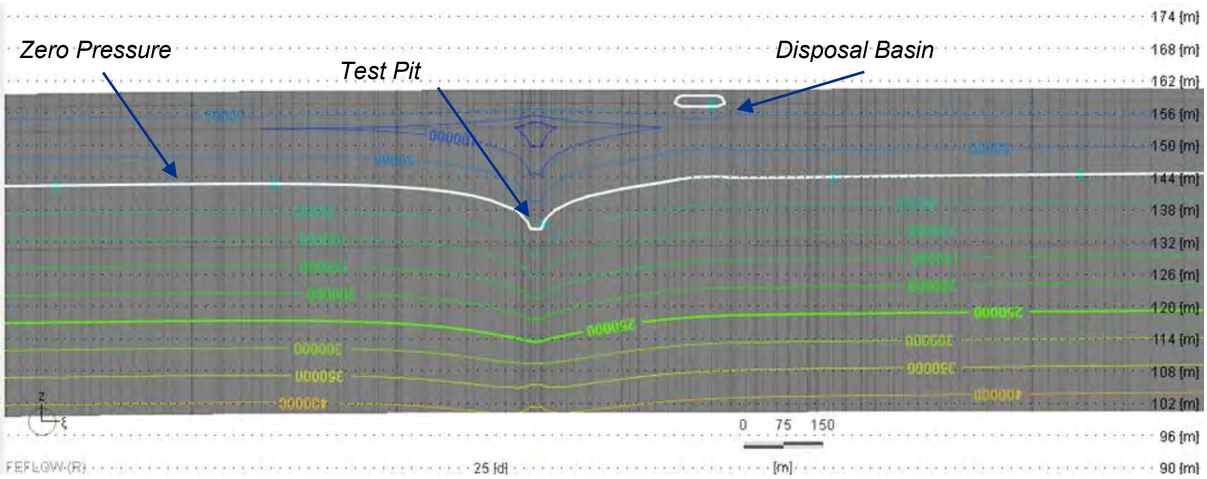


Figure 6-16: Pore pressure (pascals) contours for Scenario 2

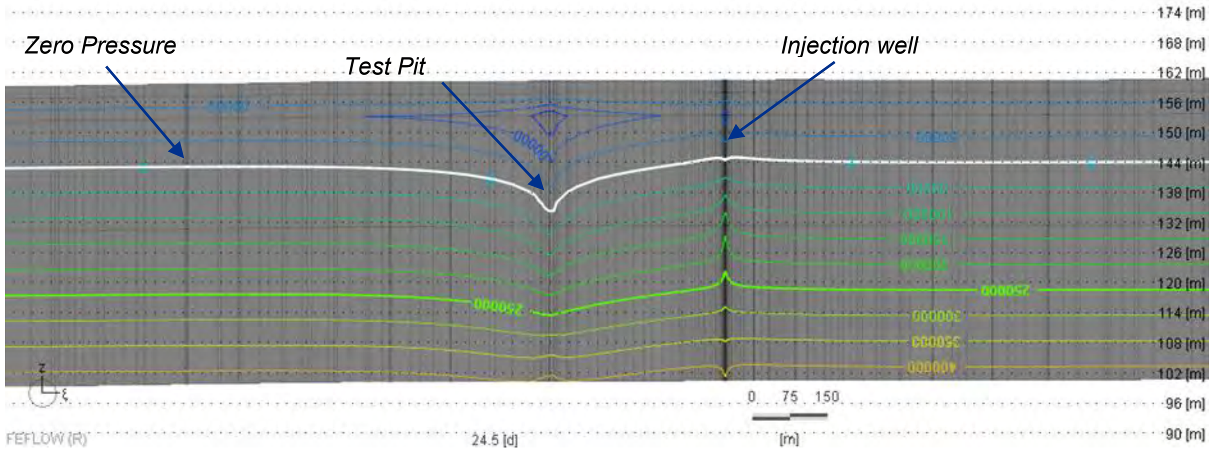


Figure 6-17: Pore pressure (pascals) contours for Scenario 4

The figures illustrate that that the pore pressure directly below the pit floor is expected to reduce from ~10 kpa to less than 5 kpa. The reduction in pore pressure propagates downward to elevations of ~108 m AHD (~50 meters below the ground surface). Vertical pressure gradients through the model thickness are relatively uniform indicating that there are no elevated gradients near the base of the pit. It is however noted that the model has a relatively coarse layer structure that is not ideal for simulating vertical pressure gradients in the underlying Geera Clay aquitard (Feflow predicts pressures at the top and bottom of each unit and hence cannot represent the curvature in pressure gradients within a model layer).

Although not demonstrated in Figure 6-15 to Figure 6-17, the , the presence of low permeability Geera Clay formation, located about 3 m below the base of the test pit, may give rise to pit stability issues. In particular, the fact that dewatering is unlikely to fully depressurise the Geera Clay, there is a potential for high pressures immediately below the floor of the pit that may give rise to unacceptable uplift pressures on the pit floor. The potential for heave of the pit floor should be assessed through an appropriate geotechnical investigation.

7. Risks to groundwater receptors

7.1 Risk assessment framework

The overall risk that drawdown presents to GDE and groundwater users is defined by the likelihood of an outcome occurring and the consequence of that outcome. The risk matrix is presented for both GDE and groundwater users in Table 7-1 below. In the two cases the likelihood and consequence varies for users and GDE and is explained further below.

Table 7-1 Risk assessment matrix for groundwater receptors

	Consequence		
Likelihood	Low	Medium	High
High	Medium	High	High
Medium	Low	Medium	High
Low	Low	Low	Medium

7.1.1 GDE

The risk that drawdown presents to GDE relies on the likelihood of an impact occurring and the consequence of the impact. For this assessment, we have adopted the risk assessment matrix from previous work done for the Victorian government. This is relevant in this region and has been accepted by potential regulators (Jacobs (2015). This classifies consequence as a function of the depth to water table and the value of the asset as summarised in Table 7-2 below. The subsequent likelihood of a given drawdown resulting in a consequence is summarised in Table 7-3.

Table 7-2 GDE consequence matrix

Sensitivity (depth to water table)	Value		
	Low (potential GDE, not high value)	Medium (confirmed GDE, not high value)	High (High value GDE in ministerial guidelines)
High (<2 m)	Medium	High	High
Medium (2-6 m)	Low	Medium	High
Low (> 6 m)	Low	Low	Medium

Table 7-3 GDE likelihood of consequence matrix

Likelihood	Drawdown at GDE
High	>2 m
Medium	0.1 – 2 m
Low	<0.1 m

7.1.2 Groundwater users

As with GDE the risk that groundwater extraction poses to nearby users is a function of the likelihood of an impact occurring, and the consequence of the impact occurring.

The value of groundwater to a user is considered to be high if it is bore licenced for take and use, medium it it's a stock and domestic bore and low if it is a bore of another type (Table 7-4). The sensitivity if the bore is considered to vary according to the available drawdown in the bore.

The likelihood of extraction having an impact on a bore is ranked as either high, medium or low according to the percentage reduction in available drawdown estimated for a bore (Table 7-5).

Table 7-4 **Groundwater user's consequence matrix**

Sensitivity (available drawdown)	Value		
	Low (other bore type)	**Medium** (stock and domestic bore)	**High** (bore with a take and use licence)
High (1-10 m head)	Medium	High	High
Medium (>10 to 20 m head)	Low	Medium	High
Low (> 20 m head)	Low	Low	Medium

Table 7-5 **Groundwater user's likelihood matrix**

Likelihood	% Reduction in available drawdown
High	>20
Medium	11-20
Low	0 - 11

7.2 Risk assessment

The risk of drawdown impacting upon groundwater users or GDE has been assessed based on the modelling results for Scenario 5. As the modelling results indicate that drawdowns will be greatest for this scenario, it represents a conservative approach to assessing the potential risks to groundwater receptors. Accordingly, Figure 7-1 illustrates the modelled drawdown for Scenario 5 with the GDE and groundwater users identified in Section 4.6.

As outlined in Section 4.6, the bores identified within 1.5 km of the test pit are have either collapsed, been decommissioned or are not groundwater bores. Accordingly, Figure 7-1 below shows that there are no groundwater users within the radius of drawdown given by any of the numerical model scenarios. Similarly, there are no potential GDE identified within the zone of drawdown given by any of the numerical model scenarios.

Thus, the modelling considered here indicates that pit inflows and disposal according to the planned water management strategy poses a low or negligible risk to groundwater receptors (Table 7-6).

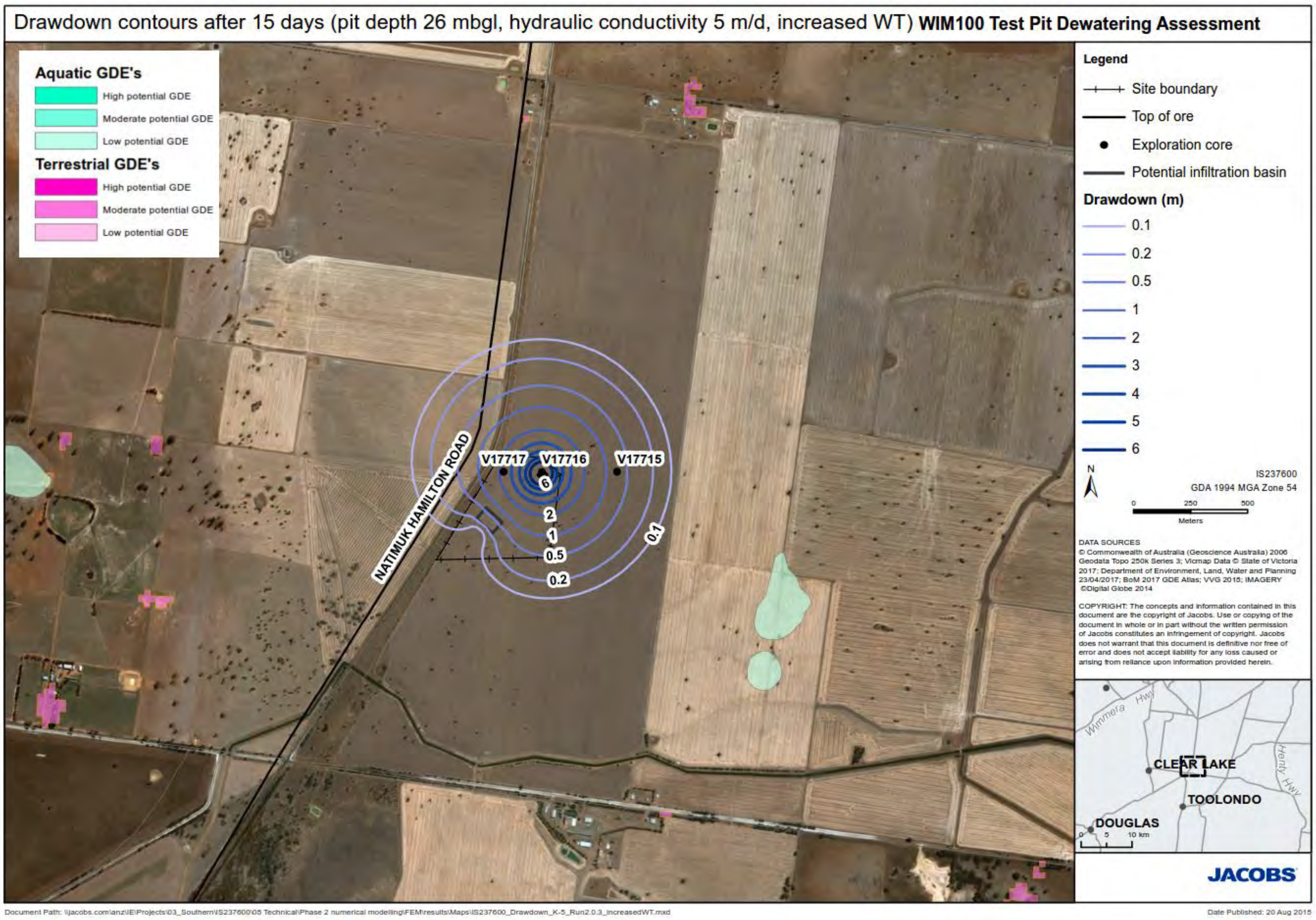


Figure 7-1 Drawdown associated with Scenario 5, groundwater users and GDE

Table 7-6 Summary of risks to groundwater receptors

Receptor	Description	Likelihood	Consequence	Risk
Unnamed aquatic GDE	~1.1 km east	Low	Low	Low
Unnamed aquatic GDE	~2.3 km west	Low	Low	Low
Unnamed terrestrial GDE	~1.7 km west	Low	Low	Low
Bore 54568	Decommissioned	Nil	Nil	Nil
Bore 54569	Decommissioned	Nil	Nil	Nil
Bore 8003250	Decommissioned	Nil	Nil	Nil
Bore 8002380	Collapsed	Nil	Nil	Nil
Bore 325867	Non groundwater	Nil	Nil	Nil

8. Summary and recommendations

8.1 Summary

The report describes a numerical groundwater model that has been used to estimate inflow rates to a proposed test pit. The model presented is informed by preliminary modelling (Jacobs, 2018a) and refined according to subsequent changes to the location and dimensions of the pit. Further, the report reviews the potential effects of drawdown and mounding associated with a proposed water management strategy.

The best available water quality information indicates that disposal of water via irrigation, an on-site farm dam or to trade waste is unsuitable and thus, disposal of pit inflow water via a basin and injection wells were considered within the model.

The modelling found that inflow rates and drawdowns were less than indicated during initial modelling as a result of three key factors:

1. The revised pit location is further west where the water table is estimated to be ~ 2 m lower than during initial modelling, leading to reduced inflow rates and volumes.

2. The duration of works program was reduced in comparison to the initial model, leading to a reduced duration and volume of inflows.

3. The incorporation of onsite disposal within the model indicates some seepage from the disposal basin and/or injection well, leading to reduced drawdown.

Accordingly, the range of maximum inflow rates given by the modelled scenarios ranges between 0.2 and 11 L/s. For the same scenarios, the total volumes requiring disposal are estimated to range between 0 (all water used for dust suppression) and ~11,000 m^3.

Results indicate that the holding capacity of the disposal basin was sufficient to accommodate the disposal of pit inflows for all scenarios except Scenario 5, which considered a water table 2 meters greater than currently estimated. Under this scenario, an injection well was required to dispose of inflows only on the final day of pit excavation. Conversely, if the geological material in the basin floor is highly porous, increased seepage from the basin floor may limit the pooling of water to negligible levels.

The risk of drawdown impacting upon groundwater receptors was conservatively assessed by considering the maximum drawdowns associated with the highest modelled pit inflows. Accordingly, the results indicate that pit inflows and disposal according to the planned water management strategy poses no risk to groundwater receptors.

In summary, according to the modelling results above, the water management strategy proposed within this report is sufficient to manage pit inflows in accordance with the test pit design and excavation program for a reasonable range of hydrogeological conditions. This includes a depth to water table 2 m greater than estimated and an upper estimate of the aquifer hydraulic conductivity (5 m/day).

8.2 Recommendations

While the above modelling results indicate that the proposed water management strategy is likely to be sufficient for water disposal, and currently poses no risk to groundwater users, it is based on information collected at a regional level. It is Jacobs understanding that during the initial development of the site, and prior to excavation of the pit below the water table, the installation and testing of up to 3 bores will be undertaken by on-site Iluka hydrogeologists. Given this, it is recommended that:

- Groundwater samples be collected and analysed from these bores during the initial stages of site set up to confirm the suitability of the disposal options. Analysis for the following parameters is recommended:

- General water quality parameters (pH, EC, TDS, ORP, DO, Temperature)
- Speciated alkalinity and major ions (Na, K, Ca, Mg, Cl, F, Br, SO4)
- Nutrients (P, PO4, NO2, NO3, NH4)
- Metals (Al (speciated), Sb, As, Ba, Be, B, Cd, Cr, Co, Cu, Fe (speciated), Pb, Mn, Mo, Ni, Se, Ag, Sr, Tl, Th, Sn, Ti, U, V, Zn, Hg)
- Radionuclides (Ra226, Ra228, U238, U)

- Groundwater level and hydraulic conductivity information be collected and incorporated into the numerical model prior to the completion of the disposal basin or injection wells. This will allow for refinement of inflow rates, disposal rates, and subsequent refinement of the necessary dimensions of disposal basins or injection wells.
- The overall pit stability and potential for heave of the pit floor should be assessed through an appropriate geotechnical investigation

9. References

Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A (2012) Australian groundwater modelling guidelines. Waterlines Report #82. National Water Commission, Canberra.

Birch W.D. (2003) Geology of Victoria. Geological Society of Australia, Special Publication 23.

BOM (2016) Bureau of Meteorology Bioregional Assessment Programme – 2016. National Groundwater Dependent Ecosystems (GDE) Atlas. Bioregional Assessment Derived Dataset. Viewed 11 January 2018.

CDM Smith (2014) Douglas Mine Site Hydrogeological Modelling - Hold Point 2 Calibration Report. 28 April, 2014.

City West Water (2018) Approved Acceptance Criteria for discharge to the sewerage system. Accessed from https://www.citywestwater.com.au/business/trade_waste/industrial_commercial_businesses.aspx. City West Water, Sunshine Victoria.

DELWP (2014) Department of Environment Land Water and Planning. Victorian Department of State Development, Business and Innovation. Victoria – Water table mapping 2014.

EPA (1997) State Environmental Protection Policy – Groundwaters of Victoria. Section 16(1) No. S 160 Wednesday 17 December 1997.

EPA Victoria (2003) State Environment Protection Policy (Water of Victoria). Publication 905. EPA Victoria, June 2003.

Evans, W. R. and Kellett, J. R. (1989). The hydrogeology of the Murray Basin, southeastern Australia, BMR Journal of Australian Geology and Geophysics, 11: 147-166.

GMWW (2018) Trade waste criteria. https://www.gwmwater.org.au/connecting-services/wastewater-sewerage-and-trade-waste/about-trade-waste

Jacobs (2018a) WIM100 Test Pit: Dewatering Assessment. Final Draft. March 5 2018.

Jacobs (2018b) WIM 100 East: Preliminary Baseline Groundwater Assessment. Final, May 7th, 2018.

Jacobs, 2015. Groundwater Interference Tool Development. May 2015. Project number: IS066100 / IS091900

Marshall TJ (1947) Mechanical composition of soil in relation to field descriptions of texture. Council for Scientific and Industrial Research, Bulletin No. 224, Melbourne.

NUDLC (2011) Minimum Construction Requirements for Water Bores in Australia. Third edition, February 2012.

NWQMS (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Prepared on behalf of the Australian and New Zealand Environment and Conservation Council (ANZECC) & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Van Genuchten (1980) A closed-form equation for pre-dicting the hydraulic conductivity of unsaturated soils. Soil Sci. Soc. Am. J. 44:892-898.

Appendix A. Lithological logs at test pit

V17715				
Depth from	Depth to	Colour	Lithology	Clay%
0	1	Dark grey-yellow	Claystone	95
1	2	Dark grey-yellow	Claystone	95
2	3	Grey-yellow	Sandy clay	90
3	4	Grey-yellow	Sandy clay	90
4	5	Grey-yellow	Claystone	95
5	6	Red-brown	Claystone	95
6	7	Grey-brown	Sandy clay	90
7	8	Grey	Sandy clay	80
8	9	Grey-brown	Clayey sand	45
9	10	Grey-brown	Silty sand	25
10	11	Light grey-brown	Sand	15
11	12	Light yellow	Sand	13
12	13	Orange-brown	Sand	15
13	14	Orange-brown	Sand	18
14	15	Light brown	Sand	14
15	16	Light grey	Sand	10
16	17	Light orange-brown	Sand	20
17	18	Light brown	Sand	14
18	19	Light brown	Sand	11
19	20	Light grey	Sand	12
20	21	Light grey-brown	Sand	18
21	22	Light brown	Sand	15
22	23	Light brown	Sand	20
23	24	Light grey-brown	Sand	13
24	25	Light brown	Sand	15
25	26	Light grey-brown	Silty sand	26
26	27	Light brown	Sand	18
27	28	Light yellow-brown	Sand	28
28	29	Orange-brown	Clayey sand	45
29	30	Brown	Sandy clay	70
30	31	Brown	Sandy clay	70
31	32	Brown	Sandy clay	80
32	33	Brown	Sandy clay	80
33	34	Brown	Sandy clay	70
34	35	Brown	Sandy clay	70
35	36	Brown	Sandy clay	80
36	39	Grey-brown	Silty sand	36
39	42	Dark brown	Sand	25
42	45	Dark grey-yellow	Sandy clay	65
45	48	Black	Clayey sand	50
48	51	Black	Sandy clay	65
51	54	Dark grey-yellow	Claystone	85
54	57	Dark grey-yellow	Claystone	90
57	60	Light grey-yellow	Sandy clay	65
60	63	Light grey-yellow	Sandy clay	70
63	66	Light grey-yellow	Sandy clay	85
66	69	Light grey-yellow	Andesite	80

69	72	Light grey-yellow	diorite	15
72	75	Light grey-yellow	diorite	18
75	78	Light grey-yellow	diorite	10
78	81	Light grey-yellow	diorite	10
81	84	Light grey-yellow	diorite	10
		V17716		
Depth from	**Depth to**	**Colour**	**Lithology**	**Clay%**
0	1	Grey	Claystone	95
1	2	Grey-brown	Sandy clay	90
2	3	Grey-brown	Claystone	95
3	4	Grey-brown	Claystone	95
4	5	Grey-brown	Sandy clay	95
5	6	Red-brown	Sandy clay	80
6	7	Grey-brown	Sandy clay	75
7	8	Light brown	Sand	16
8	9	White	Sand	16
9	10	White	Sand	11
10	11	Light brown	Sand	13
11	12	Light orange	Sand	16
12	13	Light orange-brown	Sand	9
13	14	Light orange-brown	Sand	14
14	15	Light orange-brown	Sand	22
15	16	Orange-brown	Sand	10
16	17	Light orange-brown	Sand	12
17	18	Orange-brown	Sand	14
18	19	Light brown	Sand	12
19	20	Light brown	Sand	16
20	21	Grey-brown	Silty sand	18
21	22	Light brown	Sand	22
22	23	Light brown	Sand	15
23	24	Light brown	Sand	18
24	25	Light yellow-brown	Sand	15
25	26	Orange-brown	Clayey sand	30
26	27	Light orange-brown	Sand	16
27	28	Orange-brown	Silty sand	25
28	29	Grey-brown	Clayey sand	40
29	30	Dark grey-brown	Sandy clay	70
30	31	Dark grey-brown	Sandy clay	65
31	32	Dark grey-brown	Sandy clay	65
32	33	Dark grey-brown	Sandy clay	70
33	34	Dark grey-brown	Sandy clay	80
34	35	Dark grey-brown	Sandy clay	80
35	36	Dark grey-brown	Sandy clay	75
36	39	Dark grey	Sandy clay	60
39	42	Dark brown	Clayey sand	30
42	45	Dark grey	Sandy clay	60
45	48	Grey-brown	Clayey sand	50
48	51	Dark grey	Sandy clay	65
51	54	Dark grey	Sandy clay	90
54	57	Dark grey	Claystone	90
57	60	Dark grey	Claystone	90

Depth from	Depth to	Colour	Lithology	Clay%
60	63	Grey-green	Saprolite - sap	75
63	65.8	Grey-green	Saprolite - sap	50
		V17717		
Depth from	**Depth to**	**Colour**	**Lithology**	**Clay%**
0	1	Dark grey-brown	Sandy clay	90
1	2	Light grey	Sandy clay	70
2	3	Grey-brown	Sandy clay	85
3	4	Grey-brown	Sandy clay	85
4	5	Brown	Sandy clay	85
5	6	Brown	Sandy clay	85
6	7	Red-brown	Sandy clay	70
7	8	Orange-brown	Sand	15
8	9	White	Sand	12
9	10	Orange	Sand	12
10	11	Light yellow-brown	Sand	13
11	12	Light grey-brown	Sand	16
12	13	Light brown	Sand	11
13	14	Light yellow-brown	Sand	20
14	15	Light orange-brown	Sand	21
15	16	Orange	Sand	25
16	17	Light brown	Clayey sand	35
17	18	Light brown	Silty sand	22
18	19	Light brown	Sand	22
19	20	Light grey	Sand	22
20	21	Light grey-brown	Sand	15
21	22	Grey-brown	Sand	12
22	23	Light brown	Sand	13
23	24	Light brown	Silty sand	18
24	25	Grey-brown	Silty-clay-sand	28
25	26	Grey-brown	Silty sand	40
26	27	Light brown	Silty-clay-sand	34
27	28	Brown	Sand	20
28	29	Red-brown	Sand	35
29	30	Brown	Silty sand	25
30	31	Dark brown	Claystone	75
31	32	Dark grey	Claystone	80
32	33	Dark grey	Claystone	80
33	34	Dark grey-brown	Sandy clay	50
34	35	Dark grey-brown	Sandy clay	60
35	36	Dark grey	Silty-clay	85
36	39	Dark grey-brown	Silty-clay	80
39	42	Dark grey-brown	Sand	15
42	45	Black	Sand	15
45	48	Black	Clayey sand	40
48	51	Dark grey-yellow	Sandy clay	70
51	54	Black	Silty-clay	80
54	57	Black	Silty-clay	80
57	60	Black	Claystone	95
60	63	Black	Claystone	90
63	66	Grey-green	Saprolite - sap	90
66	69	Grey-green	Saprolite - sap	80

69	72	Grey-green	Saprolite - sap	80
72	75	Grey-green	Saprolite - sap	80
75	78	Grey-green	Grey-brown	80
78	81	Grey-green	Grey-brown	80
81	84	Green-brown	Basalt	20
84	87	Green	Basalt	10
87	88	Green	Basalt	10

Appendix B. Photographs

JACOBS

Appendix C. Groundwater Chemistry and Comparison to Relevant Standards

Analyte	Units	CWW Trade Waste Criteria (2018)	ANZECC Irrigation (2000)	ANZECC Livestock Drinking (2000)	SEPP (WoV Wimmera)	V18025	V18024	Mean Average
TDS	mg/L	200 kg/d		2000 - 4000 Suitable for all but poultry or dairy cattle		2400	2500	2450
Conductivity	uS/cm		2900 - 5200 Suitable for salt tolerant crops		<1500	4400	5000	4700
pH	pH units	6 - 10			6.5 - 8.0	8.3	8.4	8.35
Total Alkalinity (as CaCO3)	mg/L					340	280	310
Bicarbonate (as CaCO3)	mg/L					340	280	310
Carbonate (as CaCO3)	mg/L					0	0	0
Hydroxide (as CaCO3)	mg/L					0	0	0
Sulphate (as SO4)	mg/L	<100		<2000		270	290	280
Ammonia (as N)	mg/L					0.1	0.03	0.065
Nitrate (as N)	mg/L				<0.7	<0.01	0.02	0.0125
Nitrite (as N)	mg/L					<0.001	<0.001	0.0005
Total N	mg/L		<5	<30	<0.5	<0.01	0.02	0.01
Orthophosphate	mg/L					0.007	<0.004	0.00375
Chloride	mg/L		<700 only tolerant crops			1100	1300	1200
Fluoride	mg/L	<30	<1	<1		0.45	0.88	0.665
Calcium	mg/L			<1000		89	82	85.5
Magnesium	mg/L					75	76	75.5
Sodium	mg/L		<460 only tolerant crops			670	800	735
Potassium	mg/L					21	21	21
Total Aluminium	mg/L		<5	<5	<0.05	0.61	0.65	0.63

Analyte	Units	CWW Trade Waste Criteria (2018)	ANZECC Irrigation (2000)	ANZECC Livestock Drinking (2000)	SEPP (WoV Wimmera)	V18025	V18024	Mean Average
Total Antimony	mg/L					<0.001	<0.001	0.0005
Total Arsenic	mg/L	<1	<0.1	<0.5	<0.013	0.044	0.012	0.028
Total Barium	mg/L	<150				0.033	0.027	0.03
Total Beryllium	mg/L	<30	<0.1			<0.001	<0.001	0.0005
Total Boron	mg/L	<24	<0.5	<5	<0.37	0.46	0.47	0.465
Total Cadmium	mg/L	<2	<0.02	<0.01	<0.0002	<0.0002	<0.0002	0.0001
Total Chromium	mg/L	<10	<0.1	<1	<0.001	0.001	0.003	0.002
Total Cobalt	mg/L	<10	<0.05	<1		<0.001	0.002	0.00125
Total Copper	mg/L	<10	<0.2	<0.5	<0.0014	<0.001	<0.001	0.0005
Total Iron	mg/L	<100	<0.2			0.89	2.4	1.645
Total Lead	mg/L	<10	<2	<0.1	<0.0034	<0.001	<0.001	0.0005
Total Manganese	mg/L	<10	<0.2		<1.9	0.025	0.027	0.026
Total Molybdenum	mg/L	<10	<0.01	<0.15		0.006	0.011	0.0085
Total Nickel	mg/L	<10	<0.2	<1	<0.011	<0.001	<0.001	0.0005
Total Selenium	mg/L	<10	<0.02	<0.02	<0.005	<0.001	<0.001	0.0005
Total Silver	mg/L	<5			<0.00006	<0.001	<0.001	0.0005
Total Strontium	mg/L					1.2	1.1	1.15
Total Thallium	mg/L	<20				<0.001	<0.001	0.0005
Total Thorium	mg/L					<0.002	<0.002	0.001
Total Tin	mg/L	<10				<0.001	<0.001	0.0005
Total Titanium	mg/L					0.018	0.029	0.0235
Total Uranium	mg/L	<30	<0.01	<0.2		0.002	0.005	0.0035
Total Vanadium	mg/L		<0.1			0.034	0.015	0.0245
Total Zinc	mg/L	<10	<2	<20	<0.008	0.002	0.003	0.0025
Total Mercury	mg/L	<1	<0.002	<0.002	<0.00005	<0.0001	<0.0001	0.00005

Appendix D. Certificates of Analysis - Groundwater

EML (CHEM) PTY LTD
A.C.N. 006 948 321 A.B.N. 86 006 948 321
P.O. Box 466, Canterbury, VIC 3126
417-425 Canterbury Road, Surrey Hills VIC 3127
Telephone (03) 9836 1999 - Facsimile (03) 9830 0961
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FINAL REPORT

Report No: N074388
Job No: 1803/354

Date: 29 March 2018

Ventia Utility Services Pty Ltd
8 Woodward Crt
HAMILTON VIC 3300
Attention: Mr Paul Cleaver

Dear Sir/Madam,

Re: Analysis of 2050_Iluka Toolondo Groundwater Monitoring

METHOD LIST

Method	Method Description (in-house method based on)	Method	Method Description (in-house method based on)
1001G	21st Ed. 2005 A.P.H.A. Method 2540 A, C	ALK	22nd Ed. 2012 A.P.H.A. Method 2320 A, B
CATIONS	22nd Ed. 2012 A.P.H.A. Method 3010 A, 3030, 3111, 3114	CHLORIDE	22nd Ed. 2012 A.P.H.A. Method 4500-Cl- A, D
COND-M	22nd Ed. 2012 A.P.H.A. Method 2510 A, B	ECO-METALS	Determined by external laboratory, ALS Water Resources Group, NATA Accreditation No. 992. See below for report number.
FLUORIDE	22nd Ed. 2012 A.P.H.A. Method 4500-F A, C; Orion ionplus Fluoride Electrode Instruction Manual, Thermo Electron Corporation; J. Thomas, JR et al (1977) - Fl. Content of Clay Minerals & Argillaceous Earth Materials, Clays & Clay Minerals, Vol 25, p278-284	MISC	Miscellaneous Test. NATA Accreditation does not cover the performance of this service.
NH3-LL-DA	22nd Ed. 2012 A.P.H.A. Method 4500-NH3 A, B; Aquakem, Ammonia method AMMDIC, Apr 2004; US EPA, Determination of Ammonia Nitrogen By Semi-Automated Colorimetry, Method 350.1 Rev 2.0 Aug 1993	ORTP-LL-DA	22nd Ed. 2012 A.P.H.A. Method 4500-P A, B, F; Aquakem, Phosphate in waters, Apr 2004; USEPA Method 365.1 Rev 2.0 Aug 1993
PH	22nd Ed. 2012 A.P.H.A. Method 4500-H+ A, B	SO4	15th Ed. 1980 A.P.H.A. Method 426 C; USEPA Method 9038 Rev 0 Sep 1986
TON-HR-DA	Total Oxidised Nitrogen, Nitrate, Nitrite as per 22nd Ed. 2012 A.P.H.A. Method 4500-N A, Method 4500-NO2 B, Method 4500-NO3 H; Aquakem, Total Oxidised Nitrogen, Apr 2004		

ECO-METALS	Report Number	18-14506

Comments:

Some results in this report are indicative results only, please see holding time report for further details

Yours faithfully
EML (CHEM) PTY LTD

K Charlson BAppSc
(Managing Director)

Important Notes

1. This is a final report and it supersedes any previous interim reports pertaining to this work that you may have received
2. The results in this report pertain to samples as submitted to the laboratory

Sample Description			V18024 (Decant)
Sample Collection Method			Received
Sample Taken Date/Time			19/03/2018 01:30pm
Lab. Received Date/Time			20/03/2018 09:00am
EML Lab. No.			EML-4656
Analyte	Unit	Method	
Total Dissolved Solids @ 180C	mg/L	1001G	2500
Conductivity at 25C	uS/cm	COND-M	5000
pH		PH	8.4
Total Alkalinity as CaCO3	mg/L	ALK	280
Bicarbonate Alkalinity as CaCO3	mg/L	ALK	280
Carbonate Alkalinity as CaCO3	mg/L	ALK	0
Hydroxide Alkalinity as CaCO3	mg/L	ALK	0
Sulphate as SO4	mg/L	SO4	290
Ammonia Nitrogen as N	mg/L	NH3-LL-DA	0.03
Nitrate Nitrogen as N	mg/L	TON-HR-DA	0.02
Nitrite Nitrogen as N	mg/L	TON-HR-DA	<0.001
Orthophosphate as P	mg/L	ORTP-LL-DA	<0.004
Chloride as Cl	mg/L	CHLORIDE	1300
Fluoride as F	mg/L	FLUORIDE	0.88
Calcium as Ca	mg/L	CATIONS	82
Magnesium as Mg	mg/L	CATIONS	76
Sodium as Na	mg/L	CATIONS	800
Potassium as K	mg/L	CATIONS	21
Total Cations	meq/L	MISC	46
Total Anions	meq/L	MISC	49
Total Aluminium as Al	mg/L	ECO-METALS	0.65
Total Antimony as Sb	mg/L	ECO-METALS	<0.001
Total Arsenic as As	mg/L	ECO-METALS	0.012
Total Barium as Ba	mg/L	ECO-METALS	0.027
Total Beryllium as Be	mg/L	ECO-METALS	<0.001
Total Boron as B	mg/L	ECO-METALS	0.47
Total Cadmium as Cd	mg/L	ECO-METALS	<0.0002
Total Chromium as Cr	mg/L	ECO-METALS	0.003
Total Cobalt as Co	mg/L	ECO-METALS	0.002
Total Copper as Cu	mg/L	ECO-METALS	<0.001
Total Iron as Fe	mg/L	ECO-METALS	2.4
Total Lead as Pb	mg/L	ECO-METALS	<0.001
Total Manganese as Mn	mg/L	ECO-METALS	0.027
Total Molybdenum as Mo	mg/L	ECO-METALS	0.011
Total Nickel as Ni	mg/L	ECO-METALS	<0.001
Total Selenium as Se	mg/L	ECO-METALS	<0.001
Total Silver as Ag	mg/L	ECO-METALS	<0.001
Total Strontium as Sr	mg/L	ECO-METALS	1.1
Total Thallium as Tl	mg/L	ECO-METALS	<0.001
Total Thorium as Th	mg/L	ECO-METALS	<0.002
Total Tin as Sn	mg/L	ECO-METALS	<0.001
Total Titanium as Ti	mg/L	ECO-METALS	0.029
Total Uranium as U	mg/L	ECO-METALS	0.005
Total Vanadium as V	mg/L	ECO-METALS	0.015
Total Zinc as Zn	mg/L	ECO-METALS	0.003
Total Mercury as Hg	mg/L	ECO-METALS	<0.0001

Notes:

- *Blank space indicates test not performed*
- *Calculated results are based on raw data*
- *LOR: Limit of Reporting, calculated from undiluted sample*
- ** = NATA Accreditation does not cover the performance of this service*

Sample History and Holding Time Report

EML Lab. No.	Analyte	Taken On	Lab. Received On	Analysed On	Result	Unit	Limit	
EML-4656	pH	19/03/18 1:30pm	20/03/18 9:00am	20/03/18 04:47pm	8.4		0.25 h	^

^ *The result is an indicative result only as the sample/test holding time requirement specified in the test method was not met*

Holding Time Reference:
22nd Ed. 2012 A.P.H.A. - Standard Methods for the Examination of Water and Wastewater, Table 1060.I Regulatory

EML Lab. No.	Sample Collection Method	Description
EML-4656	Received	Samples not collected by EML (CHEM) and are analysed as received

EML (CHEM) PTY LTD
A.C.N. 006 948 321 A.B.N. 86 006 948 321
P.O. Box 466, Canterbury, VIC 3126
417-425 Canterbury Road, Surrey Hills VIC 3127
Telephone (03) 9836 1999 - Facsimile (03) 9830 0961
Email: emlchem@emlchem.com.au

FINAL REPORT

Report No: N074389
Job No: 1803/396

Date: 29 March 2018

Ventia Utility Services Pty Ltd
8 Woodward Crt
HAMILTON VIC 3300
Attention: Mr Paul Cleaver

Dear Sir/Madam,

Re: Analysis of 2050_Iluka Toolondo Groundwater Monitoring

METHOD LIST

Method	Method Description (in-house method based on)	Method	Method Description (in-house method based on)
1001G	21st Ed. 2005 A.P.H.A. Method 2540 A, C	ALK	22nd Ed. 2012 A.P.H.A. Method 2320 A, B
CATIONS	22nd Ed. 2012 A.P.H.A. Method 3010 A, 3030, 3111, 3114	CHLORIDE	22nd Ed. 2012 A.P.H.A. Method 4500-Cl- A, D
COND-M	22nd Ed. 2012 A.P.H.A. Method 2510 A, B	CUST-DATA	Data supplied by Customer. NATA Accreditation does not cover the performance of this service.
ECO-METALS	Determined by external laboratory, ALS Water Resources Group, NATA Accreditation No. 992. See below for report number.	FLUORIDE	22nd Ed. 2012 A.P.H.A. Method 4500-F A, C; Orion ionplus Fluoride Electrode Instruction Manual, Thermo Electron Corporation; J. Thomas, JR et al (1977) - Fl. Content of Clay Minerals & Argillaceous Earth Materials, Clays & Clay Minerals, Vol 25, p278-284
MISC	Miscellaneous Test. NATA Accreditation does not cover the performance of this service.	NH3-LL-DA	22nd Ed. 2012 A.P.H.A. Method 4500-NH3 A, B; Aquakem, Ammonia method AMMDIC, Apr 2004; US EPA, Determination of Ammonia Nitrogen By Semi-Automated Colorimetry, Method 350.1 Rev 2.0 Aug 1993
ORTP-LL-DA	22nd Ed. 2012 A.P.H.A. Method 4500-P A, B, F; Aquakem, Phosphate in waters, Apr 2004; USEPA Method 365.1 Rev 2.0 Aug 1993	PH-LIS	22nd Ed. 2012 A.P.H.A. Method 4500-H+ A, B
SO4	15th Ed. 1980 A.P.H.A. Method 426 C; USEPA Method 9038 Rev 0 Sep 1986	TON-HR-DA	Total Oxidised Nitrogen, Nitrate, Nitrite as per 22nd Ed. 2012 A.P.H.A. Method 4500-N A, Method 4500-NO2 B, Method 4500-NO3 H; Aquakem, Total Oxidised Nitrogen, Apr 2004

ECO-METALS	Report Number	18-14720

Comments:

Some results in this report are indicative results only, please see holding time report for further details

Yours faithfully
EML (CHEM) PTY LTD

K Charlson BAppSc
(Managing Director)

Important Notes

1. This is a final report and it supersedes any previous interim reports pertaining to this work that you may have received
2. The results in this report pertain to samples as submitted to the laboratory

Sample Description			V18025 (Decant)
Sample Collection Method			Received
Sample Taken Date/Time			20/03/2018 12:02pm
Lab. Received Date/Time			21/03/2018 09:00am
EML Lab. No.			EML-4789
Analyte	Unit	Method	
Total Dissolved Solids @ 180C	mg/L	1001G	2400
Conductivity at 25C	uS/cm	COND-M	4400
pH (low Ionic strength)		PH-LIS	8.3
Total Alkalinity as CaCO3	mg/L	ALK	340
Bicarbonate Alkalinity as CaCO3	mg/L	ALK	340
Carbonate Alkalinity as CaCO3	mg/L	ALK	0
Hydroxide Alkalinity as CaCO3	mg/L	ALK	0
Sulphate as SO4	mg/L	SO4	270
Ammonia Nitrogen as N	mg/L	NH3-LL-DA	0.10
Nitrate Nitrogen as N	mg/L	TON-HR-DA	<0.01
Nitrite Nitrogen as N	mg/L	TON-HR-DA	<0.001
Orthophosphate as P	mg/L	ORTP-LL-DA	0.007
Chloride as Cl	mg/L	CHLORIDE	1100
Fluoride as F	mg/L	FLUORIDE	0.45
Calcium as Ca	mg/L	CATIONS	89
Magnesium as Mg	mg/L	CATIONS	75
Sodium as Na	mg/L	CATIONS	670
Potassium as K	mg/L	CATIONS	21
Total Cations	meq/L	MISC	40
Total Anions	meq/L	MISC	44
Total Aluminium as Al	mg/L	ECO-METALS	0.61
Total Antimony as Sb	mg/L	ECO-METALS	<0.001
Total Arsenic as As	mg/L	ECO-METALS	0.044
Total Barium as Ba	mg/L	ECO-METALS	0.033
Total Beryllium as Be	mg/L	ECO-METALS	<0.001
Total Boron as B	mg/L	ECO-METALS	0.46
Total Cadmium as Cd	mg/L	ECO-METALS	<0.0002
Total Chromium as Cr	mg/L	ECO-METALS	0.001
Total Cobalt as Co	mg/L	ECO-METALS	<0.001
Total Copper as Cu	mg/L	ECO-METALS	<0.001
Total Iron as Fe	mg/L	ECO-METALS	0.89
Total Lead as Pb	mg/L	ECO-METALS	<0.001
Total Manganese as Mn	mg/L	ECO-METALS	0.025
Total Molybdenum as Mo	mg/L	ECO-METALS	0.006
Total Nickel as Ni	mg/L	ECO-METALS	<0.001
Total Selenium as Se	mg/L	ECO-METALS	<0.001
Total Silver as Ag	mg/L	ECO-METALS	<0.001
Total Strontium as Sr	mg/L	ECO-METALS	1.2
Total Thallium as Tl	mg/L	ECO-METALS	<0.001
Total Thorium as Th	mg/L	ECO-METALS	<0.002
Total Tin as Sn	mg/L	ECO-METALS	<0.001
Total Titanium as Ti	mg/L	ECO-METALS	0.018
Total Uranium as U	mg/L	ECO-METALS	0.002
Total Vanadium as V	mg/L	ECO-METALS	0.034
Total Zinc as Zn	mg/L	ECO-METALS	0.002
Total Mercury as Hg	mg/L	ECO-METALS	<0.0001
Water Depth - Supplied	m	CUST-DATA	22.0

Notes:

- *Blank space indicates test not performed*
- *Calculated results are based on raw data*
- *LOR: Limit of Reporting, calculated from undiluted sample*
- ** = NATA Accreditation does not cover the performance of this service*

Sample History and Holding Time Report

EML Lab. No.	Analyte	Taken On	Lab. Received On	Analysed On	Result	Unit	Limit	
EML-4789	pH (low Ionic strength)	20/03/18 12:02pm	21/03/18 9:00am	21/03/18 01:21pm	8.3		0.25 h	^

^ *The result is an indicative result only as the sample/test holding time requirement specified in the test method was not met*

Holding Time Reference:
22nd Ed. 2012 A.P.H.A. - Standard Methods for the Examination of Water and Wastewater, Table 1060.I Regulatory

EML Lab. No.	Sample Collection Method	Description
EML-4789	Received	Samples not collected by EML (CHEM) and are analysed as received