# Memorandum

**Ref:** D25#1150695

**Date**: 31 October 2025

**Subject:** **Kwinana Freeway Upgrade: Risk of groundwater abstraction to Thomsons Lake**

## 1. The Proposal

Main Roads Western Australia (Main Roads) is proposing to widen and upgrade approximately 20 kilometres of the Kwinana Freeway between Roe Highway and Mortimer Road (the Proposed Action; the Proposal) to improve safety, reduce congestion, enhance user journeys and provide better connection to Perth's southern suburbs. This work will include constructing additional lanes, which will increase the freeway's capacity and will improve road user safety, smooth traffic flow and freight efficiency.

The Proposed Action will include the construction of:

- Additional lanes in each direction
- Freeway ramp upgrades
- Noise walls, Principal Shared Paths.
- Other road infrastructure such as safety barriers, drainage structures and landscaping

The scope of this memo is specific to the potential impacts of groundwater abstraction for the purpose of construction water between Armadale Road and Rowley Road on Thomsons Lake (RAMSAR wetland). The assessment was conducted using the outcomes of groundwater modelling and available monitoring data.

## 2. Risk assessment outcome

The groundwater drawdown predicted by the groundwater model after 1 year of continuous abstraction at 10 L/s is <10 cm at the Ramsar site boundary. In addition, changes to groundwater flow (direction) resulting from the modelled abstraction are localised (to within approximately 300m of the production bore) and the direction of groundwater flow within or adjacent (within approximately 1000 m) to the Ramsar site is not impacted.

The risk assessment indicates the risk to Thomsons Lake is low/negligible. Further details of the modelling and the risk assessment are provided in the following sections.

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## 3. Thomsons Lake

Thomsons Lake Ramsar site encompasses 538 ha (as part of the Forrestdale and Thomsons Lakes Ramsar site). The lake is an interdunal groundwater wetland with limited natural surface water inflow (Maher and Davis 2009) it is shallow (<2 m) and dominated by submerged and floating macrophytes and fringed with rushes and sedges. The site provides an important breeding, migration stop-over and drought refuge for water birds (Maher and Davis 2009).

Thomsons Lake (and Forrestdale Lake – both listed under the same Ramsar site) meets criterion 1 and 3 for Ramsar listing as detailed in Maher and Davis (2009) and summarised below:

- Criterion 1: the best remaining examples of large brackish, seasonal lakes with extensive fringing sedgeland typical of the Swan Coastal Plain.
- Criterion 3: provide important habitat for waterbirds on the Swan Coastal Plain with 85 species of waterbird occurring at the two lakes, including 29 migratory species listed under the EPBC Act.

## 4. Hydrogeological setting

The Proposal is situated on the central Swan Coastal Plain. The hydrogeology and geomorphology of the area is well understood and the underlying aquifers are accessed by multiple users including the Water Corporation as part of the Perth Integrated Water Supply Scheme. The major aquifers from shallowest to deepest are the Superficial aquifer, followed by the Leederville Aquifer and the Yarragadee Aquifer.

In the vicinity of the Proposal area the Superficial Aquifer is comprised of Bassendean Sand with occasional swamp deposits and the Guildford formation (particularly to the east of the Proposal Area). Gnangara Sand and Ascot Formation are two deeper formations within the Superficial Aquifer. The Superficial Aquifer is underlain (in the vicinity of the proposal area) by the Kardinya Shale formation which forms an aquitard between the Superficial and the deeper Leederville Aquifer. The Kardinya Shale is approximately 60-80m thick (**Figure 1**).

The Leederville Aquifer is up to 250m thick and comprised of four formations including the Henley Sandstone and Pinjarra Member. The South Perth Shale underlies the Leederville Aquifer and forms an aquitard (where present) between the Leederville and the underlying Yarragadee Aquifer.

Groundwater in the Superficial Aquifer is relatively shallow (approximately 4 to 8 m below ground surface) and flows from east to west. Many wetlands on the Swan Coastal Plain, including Thomsons Lake are connected to groundwater (in the Superficial Aquifer) with seasonal inflow of groundwater into wetlands, in part, maintaining wetland water regimes. Recharge to the Superficial Aquifer occurs as direct infiltration of rainfall.

Monitoring data from monitoring bores in the vicinity of the Proposal indicate that water levels in the Superficial Aquifer are relatively steady (particularly for the period 2015 to 2025) with no clear increase or decline in water levels (**Figure 2**). This is in part due to changing land use to predominantly urban development counteracting regional declines in rainfall and changes in groundwater management in the area (DWER 2024).

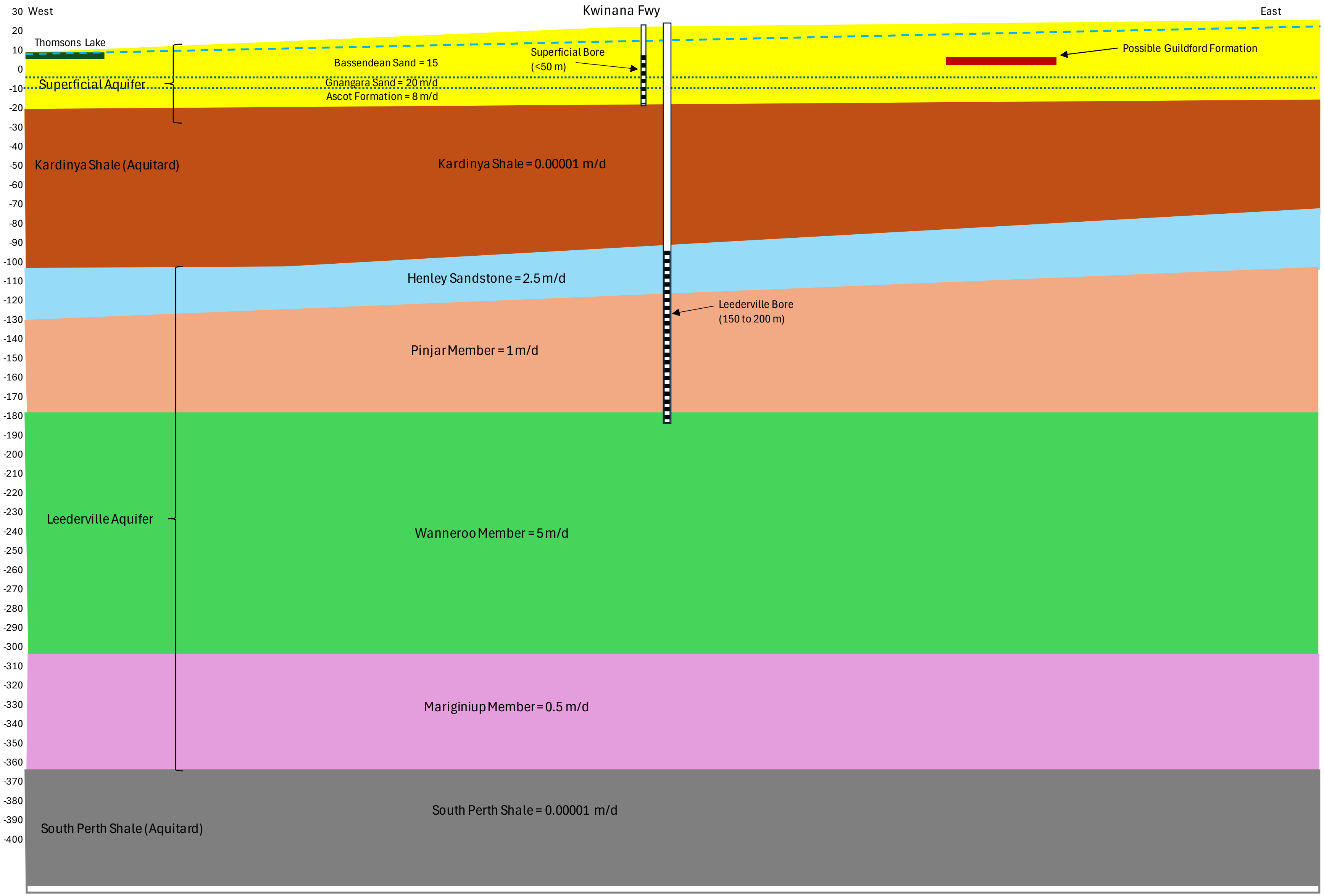


**Figure 1:** Geological cross section (east to west through Proposal Area and Thomsons Lake)


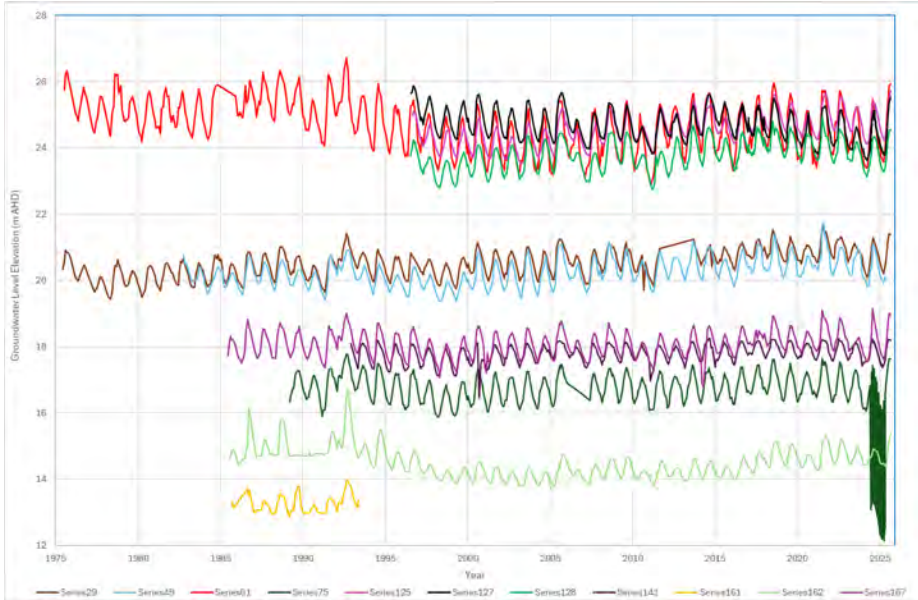


**Figure 2:** Bore locations and hydrographs for monitoring bores representative of local Superficial groundwater levels

The Superficial Aquifer is the most relevant aquifer for the current assessment due to its connectivity to Thomsons Lake and given that it is the most likely target for groundwater abstraction during construction of the Proposal.

The Superficial Aquifer in area of the Proposal is part of the Jandakot groundwater system managed by the Department of Water and Environmental Regulation under Ministerial Statement No. 688. DWER monitoring compliance with water levels at 23 criteria sites and monitor nine vegetation sites and ten wetland sites. Monitoring of surface and groundwater levels in Thomsons Lake is part of this monitoring and compliance program with the aim of ensuring water levels stay within a range necessary to protect environmental values (DWER 2024). The most recent compliance report prepared by DWER (2024) indicates that groundwater levels 'had generally been rising from 2010-11 to 2022-23 but declined by about 0.5 m in 2023-24' which was attributed to very low rainfall in spring 2023 – autumn 2024.

It is also noted that water levels in Thomsons Lake have been artificially supplemented during winter since 2004. The aim of supplementation is to ensure the lake water levels are maintained through late spring and early summer to support migratory and local bird populations (DWER 2024).

## 5. Modelling

Groundwater modelling was completed for an abstraction scenario based on the conceptual hydrogeology detailed in the previous section. The numerical groundwater model was developed using the software Visual MODFLOW, which is a 3D finite difference groundwater flow model used extensively throughout the world.

Appendix C provides a description of the model setup and main input parameters.

For the groundwater abstraction model scenarios, a pumping well was located on the western side of Kwinana Fwy in an area that has the shortest distance to Thomsons Lake. The pumping well was then pumped for two different pumping rate scenarios, 5 L/s over 365 days and 10 L/s over 365 days (Figure 3).

For both of the modelled pumping rate scenarios, the modelled groundwater level drawdown does not reach Thomsons Lake.

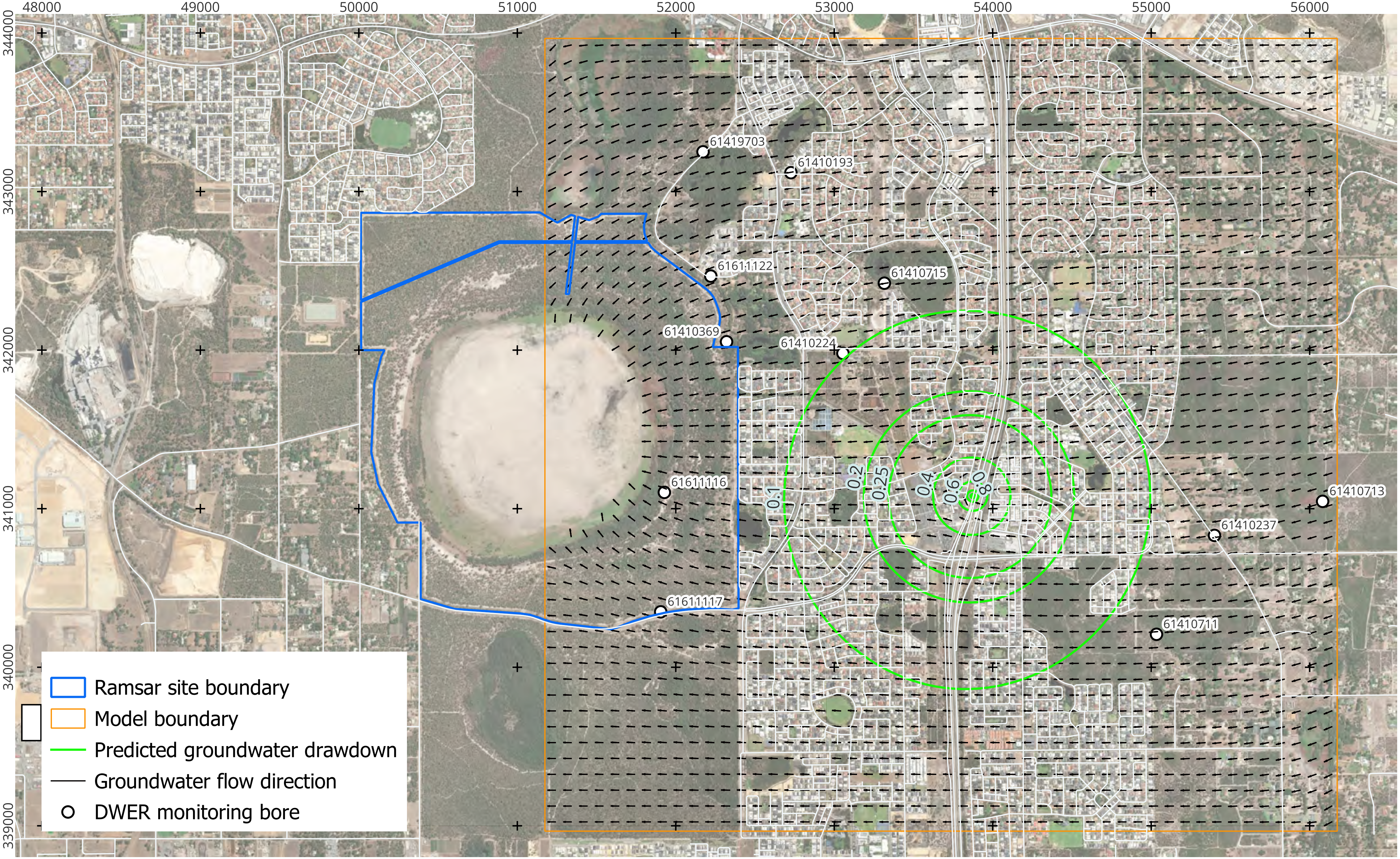


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**Figure 3: Groundwater modelling outputs 365 days abstraction scenario**

Thomsons Lake groundwater risk assessment

N

0 1 2 km

Base map © ESRI and its data suppliers. Landgate (2020)

CRS: GDA2020/MGA zone 50

Project ref: NA

Date: 30/10/25 Author: MB

## 6. Risk Assessment

The assessment uses a methodology based on that developed by Froend and Loomes (2004) to assess the risks to GDEs from groundwater abstraction on the Swan Coastal Plain. The methodology has been adapted from the original Froend and Loomes (2004) approach incorporating outcomes of previous consultation with DWER for completion of ecological water requirements for the Peel Integrated Water Initiative, and described in Braimbridge *et al.* (2018).

The methodology uses a semi quantitative approach to rate the risk of impact to GDEs. The assessment considers the type and conservation value of the ecosystem, the current depth to groundwater and historical change to rate the susceptibility of ecosystems (Figure 4). A risk of impact from a predicted drawdown (obtained from a numerical groundwater model) is also assigned to GDEs. A score is assigned at each step and the overall risk of impact determined based on the total score. The method and steps to complete the assessment are outlined in Appendix A.

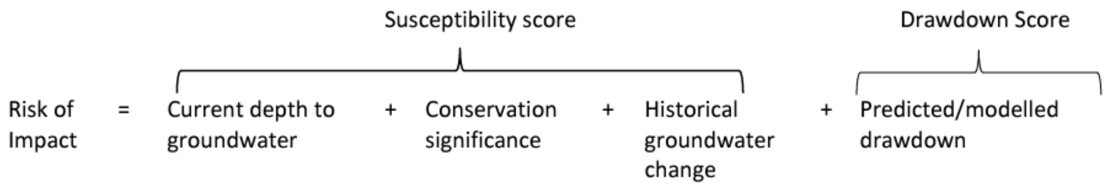



**Figure 4:** Calculation for risk of impact from modelled drawdown

The assessment was completed with Thomsons Lake as the ecosystem being assessed. The current depth to groundwater for Thomsons Lake was based on available monitoring data and set at <3m and for a wetland ecosystem, scored as 4 according to the assessment process.

Given the lakes status as a Ramsar site of international significance the ecological values was considered high and scored 4.

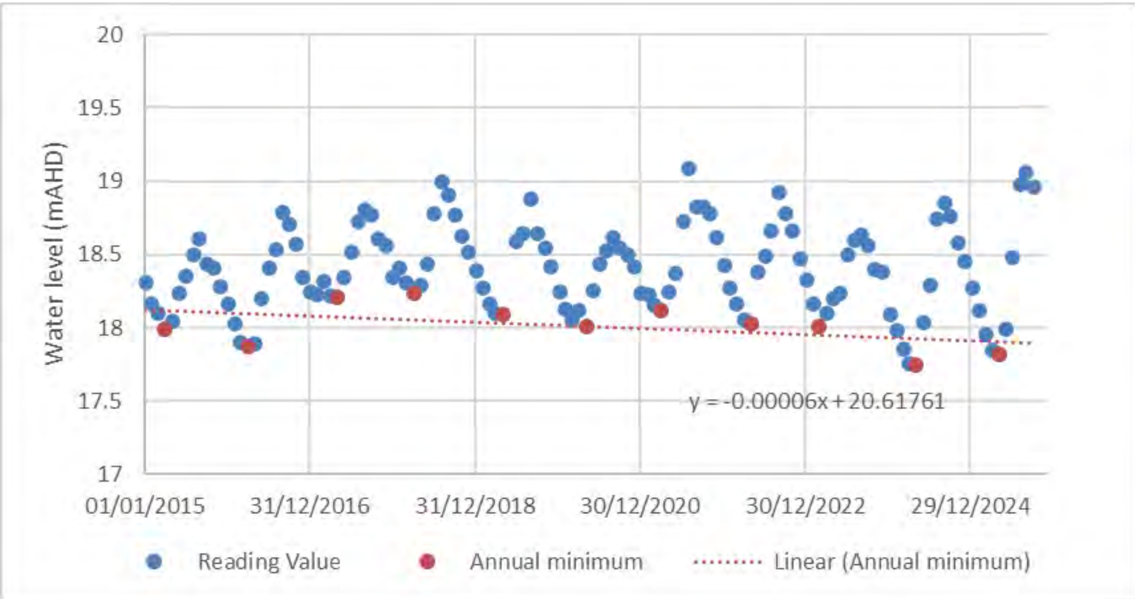
Groundwater monitoring data from two bores monitored by DWER were used to assess the historical change in groundwater. As illustrated in (Figure 5), minimum water levels (Autumn) in bore TM13C (AWRC ref 61611117) have increased over the last 10 years (similar trend also observed in other nearby bores by DWER (2024). Bore TM16C (AWRC ref. 61410371) shows a slight decline in groundwater levels. Full records of water levels in both bores are provided in Appendix B.

To determine the historical decline in groundwater levels the minimum water level was determined for each year from 2015-2025. A line of best fit (linear trend line) was added to both hydrographs (based on annual minimum water levels) and the rate of declined determined from the slope of the equation for the line of best fit. Minimum water levels in bore TM13C have increased slightly over the ten years since 2015. For bore TM16C the minimum water levels have decreased slightly (the slope for the line of best fit was -0.00006). To take a conservative approach to the assessment the historical trend in groundwater levels was assessed using data from bore TM16C (rate of decline is 0.00006m/year) and scored a 1.

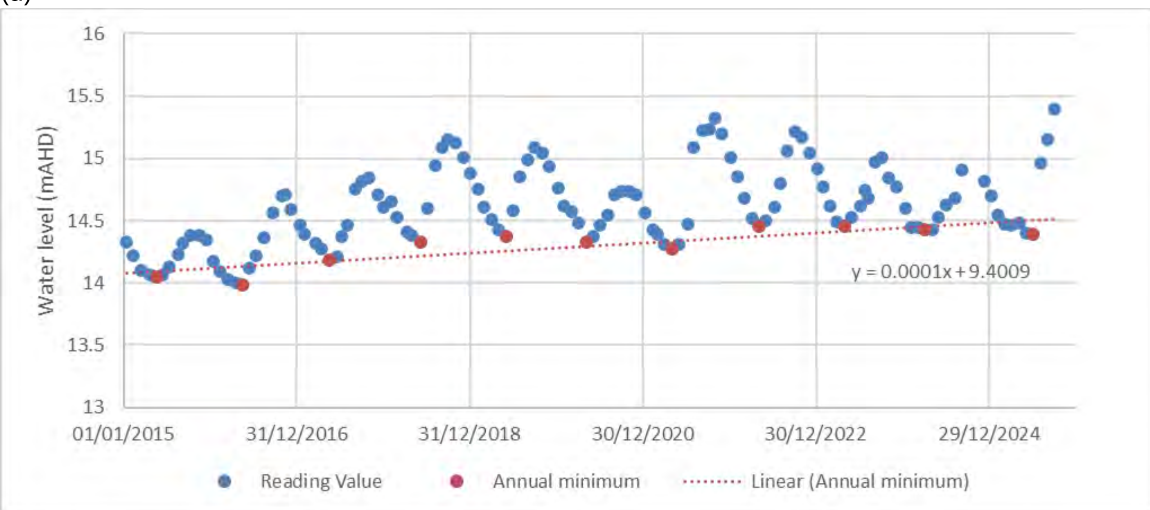
The combined susceptibility score for Thomsons Lake was calculated as 9. Indicating the site is potentially susceptible to impact from drawdown.

The modelling outputs indicate that at its closest point the 0.10 m drawdown contour (the lowest drawdown output from the model) is approximately 300 m from Thomsons Lake Ramsar site boundary. Drawdown of between 0-0.09m results in a drawdown score of 0.

This results in an overall risk of impact score of 9 in the low risk/acceptable category.




(a)




(b)

**Figure 5:** Hydrographs for monitoring bores (a) TM16C (AWRC ref. 61410371) and (b) TM13C (AWRC ref 61611117) used to determine historical groundwater change (2015 – 2025).

## 7. Conclusions

The modelling undertaken predicted groundwater drawdown and changes in groundwater flow direction associated with a potential abstraction of 10l/s for a continuous 365 days. This was considered a worst case scenario which is expected to exceed groundwater requirements during construction which is more realistically likely to be periodic in nature and allow for greater aquifer recovery between pumping. The model outputs are therefore considered likely to exceed actual drawdown making the assessment completed conservative in nature.

The modelling of groundwater drawdown associated with groundwater abstraction during construction indicates that the 10 cm drawdown contour will not intersect the Thomsons Lake Ramsar site boundary and the risk of any impact (to Thomsons Lake) associated with groundwater abstraction for the project is low. This is supported by the outcome of the risk assessment which took into account the depth to groundwater, ecological values, historical change in groundwater and the modelled drawdown.

Changes to groundwater flow direction are predicted to be restricted to within approximately 300 m of the production bore location, and would not influence groundwater flow within approximately 1000 m of the Ramsar site boundary.

It is also noted that the water levels in Thomsons Lake are artificially supplemented by the Water Corporation and DBCA to maintain water levels and associated bird habitat during late spring and summer.

## 8. References

Antao M (2015). Peel Coastal groundwater allocation plan: groundwater- dependent ecosystems, Department of Water, Perth, Western Australia.

Braimbridge M, Barron O and Hodgson G (2018). Assessment of ecological water requirements for the Peel Integrated Water Initiative. CSIRO, Australia.

DWER (2024). Environmental management of groundwater from the Jandakot Mound groundwater resources, Annual compliance assessment report July 2023-June 2024. Department of Water and Environmental Regulation, Western Australia.

Froend R and Loomes R (2004). Interim EWR Approach. Edith Cowan University Joondalup: Centre for Ecosystem Management.

Froend R, Loomes R, Horwitz P, Bertuch M, Storey A and Bamford M (2004). Study of Ecological Water Requirements on the Gnangara and Jandakot Mounds under Section 46 of the Environmental Protection Act - Task 2: Determination of Ecological Water Requirements. Prepared for: The Water and Rivers Commission by Centre for Ecosystem Management, ECU.

Maher K and Davis J (2009). Ecological Character Description for Forrestdale and Thomsons Lakes Ramsar Site, A report to the Department of Environment and Conservation. Murdoch University, Western Australia.

# APPENDIX A

### *Step 1: Identify potential GDEs and current depth to groundwater*

Ecosystems were identified as potentially groundwater dependent where the current maximum depth to groundwater was less than 10 m. Previous studies on the Swan Coastal Plain have identified 10 m as an approximate maximum depth where groundwater dependence of vegetation is likely (e.g., Antao 2015, Froend *et al*. 2004). Groundwater may still provide a water source to deep rooted vegetation, however dependence on groundwater is considered low or opportunistic beyond 10 m.

Potential GDEs were scored based on the ecosystem type and current depth to groundwater (DTGW) categories (Table 1) using the maximum depth to groundwater value for each feature. Ecosystems with a shallower depth to groundwater score higher because they are considered to have a greater dependency on groundwater and therefore a higher susceptibility to impact from groundwater drawdown. Consistent with the application of the scoring method elsewhere, wetlands were scored higher, indicating a higher susceptibility or sensitivity to drawdown than groundwater dependent vegetation at the same depth to groundwater.

**Table 1: Current depth to groundwater (DTGW) categories and scoring (adapted from Froend and Loomes 2004)**

| Score | DTGW Category | Current DTGW Description |
|---|---|---|
| 0 | >10 m | Watertable estimated to be >10.5 m |
| 1 | 6 – 10 m | Watertable estimated to be 6 – 10.5 m DTGW |
| 2 | 3 – 6 m | Watertable estimated to be 3 - 6 m DTGW |
| 3 | 0 – 3 m (vegetation) | Watertable estimated to be 0 -3 m DTGW, vegetation site |
| 4 | <3 m (wetland) | Watertable estimated to be < 3 m DTGW, wetland site |

### *Step 2: Assess ecological value/conservation significance of GDEs*

The ecological value of potential GDE features were scored as low, moderate (locally significant) or high (regionally, nationally or internationally significant), based on the categories in Table 2.

This scoring system acknowledges that the consequence and risk of impact of groundwater drawdown is greater for high value ecological features, however, not that these features are necessarily more susceptible to impacts.

**Table 2: Ecological value score**

| Score | Category | GDE values |
|---|---|---|
| 1 | Low | Assessed as having no recognised values and moderately to severely impacted from surrounding land uses, where values are:<br>- Multiple use wetland<br>- Remnant vegetation consisting of a vegetation complex with greater than 30% pre-clearing extent remaining intact and located on private land |
| 2 | Locally significant (moderate) | Assessed as having some recognised values and low to moderately impacted from surrounding land uses, where values are:<br>- Resource enhancement wetland<br>- Remnant vegetation consisting of a vegetation complex with less than 30% pre-clearing extent remaining intact |
| 4 | Regionally, Nationally or internationally significant (high) | Formally assessed international, national or regional environmental values with evidence of low to moderate impacts from surrounding land use, where values include:<br>- Ramsar wetland<br>- Directory of important wetlands in Australia<br>- Conservation category wetlands<br>- Native vegetation supporting threatened and priority species or ecological communities |

### *Step 3: Assess historical groundwater level change*

Declines in groundwater over the previous 10 years may indicate an ecosystem is already under water stress and potentially more susceptible to risk of impact from additional declines in groundwater.

The calculated historical change in groundwater was scored based on Table 3.

**Table 3: Historical change (10 years previous) in groundwater score**

| Rate of decline m/yr | | DTGW Category and Score | | | |
|---|---|---|---|---|---|
| Lower Threshold (≥) | Upper threshold (<) | 6-10 m | 3-6 m | 0-3 m Vegetation | 0-3 m Wetland |
| | **-1†** | 0 | 0 | 0 | 0 |
| **0** | **0.025** | 1 | 1 | 1 | 1 |
| **0.025** | **0.05** | 1 | 1 | 2 | 2 |
| **0.05** | **0.075** | 1 | 1 | 2 | 3 |
| **0.075** | **0.1** | 1 | 2 | 2 | 4 |
| **0.1** | **0.125** | 1 | 2 | 3 | 5 |
| **0.125** | **0.15** | 2 | 3 | 3 | 5 |
| **0.15** | **0.175** | 2 | 3 | 3 | 5 |
| **0.175** | **0.2** | 3 | 3 | 4 | 5 |
| **0.2** | **0.225** | 3 | 4 | 5 | 5 |
| **0.225** | **0.25** | 4 | 4 | 5 | 5 |
| **0.25** | **0.275** | 4 | 5 | 5 | 5 |
| **0.275** | **3** | 5 | 5 | 5 | 5 |

The selected monitoring bores are operated by DWER and provide superficial groundwater trends representative for the site.

### *Step 4: Rate GDE susceptibility to change in DGWL (Susceptibility score)*

The susceptibility of identified GDEs was calculated by adding the scores from Step 1: depth to groundwater, Step 2: environmental value/conservation significance and Step 3: historical change in groundwater (Figure 4).

### *Step 5: Risk of modelled drawdown (Drawdown score)*

The potential impact of construction activities on GDEs was assessed using drawdown predicted for proposed abstraction scenario provided by FSG (2025)

Scoring for drawdown is based on the risk of impact resulting from change in depth to groundwater level described in Froend and Loomes (2004). The scoring applied in this assessment as outlined in Table 4, incorporates modifications arising from previous consultation with DWER, as described in Braimbridge *et al.* (2018).

The scoring outlined in Table 4 rates the risk of impact (from low 1to severe 5) associated with groundwater level drawdown for GDEs in each depth to groundwater category (determined in step 1).

**Table 4: Risk of modelled groundwater drawdown score**

| Modelled drawdown | | DTGW Category and Score | | | |
|---|---|---|---|---|---|
| Lower | Upper | 6–10 m | 3–6 m | 0–3 m Vegetation | 0–3 m Wetland |
| **0** | **0.09** | 0 | 0 | 0 | 0 |
| **0.10** | **0.24** | 1 | 1 | 1 | 1 |
| **0.25** | **0.49** | 1 | 1 | 2 | 3 |
| **0.5** | **0.74** | 1 | 1 | 2 | 4 |
| **0.75** | **0.99** | 1 | 2 | 3 | 5 |
| **1** | **1.24** | 2 | 3 | 3 | 5 |
| **1.25** | **1.49** | 3 | 3 | 4 | 5 |
| **1.5** | **1.74** | 3 | 4 | 4 | 5 |
| **1.75** | **1.99** | 3 | 4 | 5 | 5 |
| **2** | **2.24** | 4 | 4 | 5 | 5 |
| **2.25** | **2.5** | 4 | 5 | 5 | 5 |
| **2.5** | **2.74** | 4 | 5 | 5 | 5 |
| **2.75** | **3** | 5 | 5 | 5 | 5 |

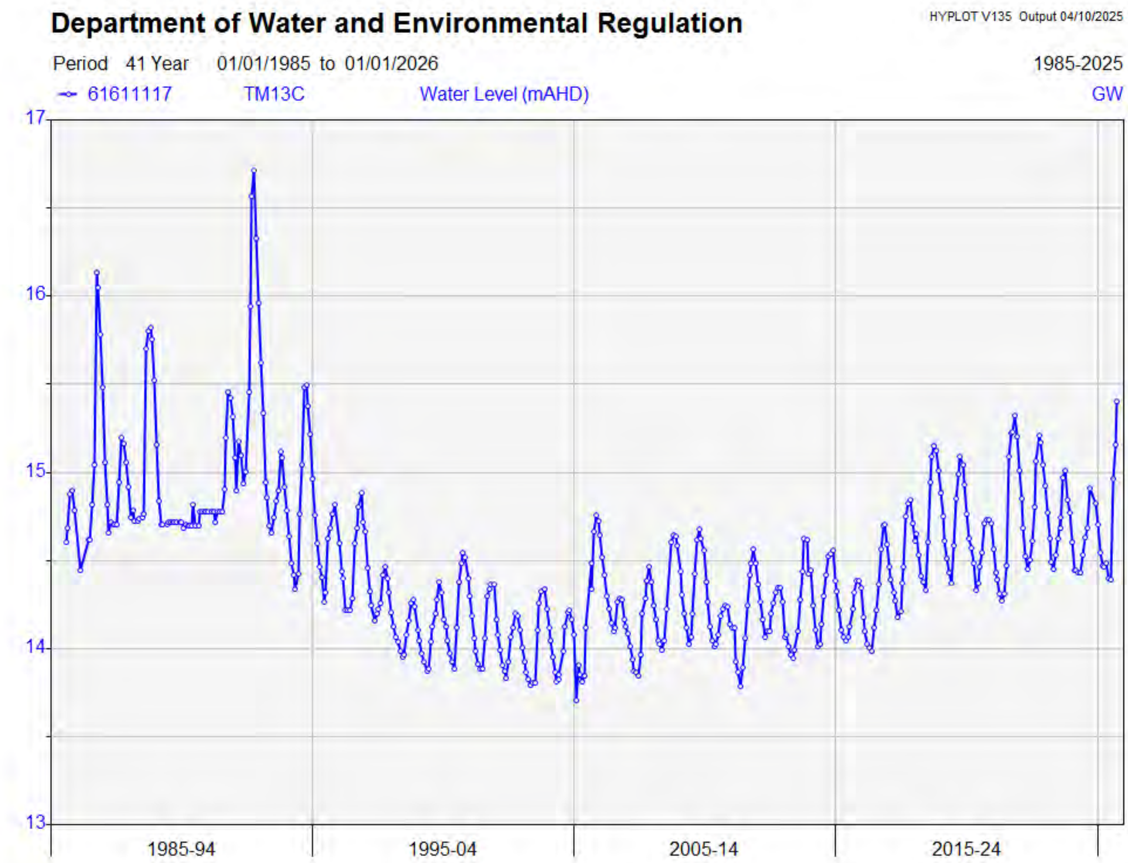
### *Step 6: Overall risk of impact*

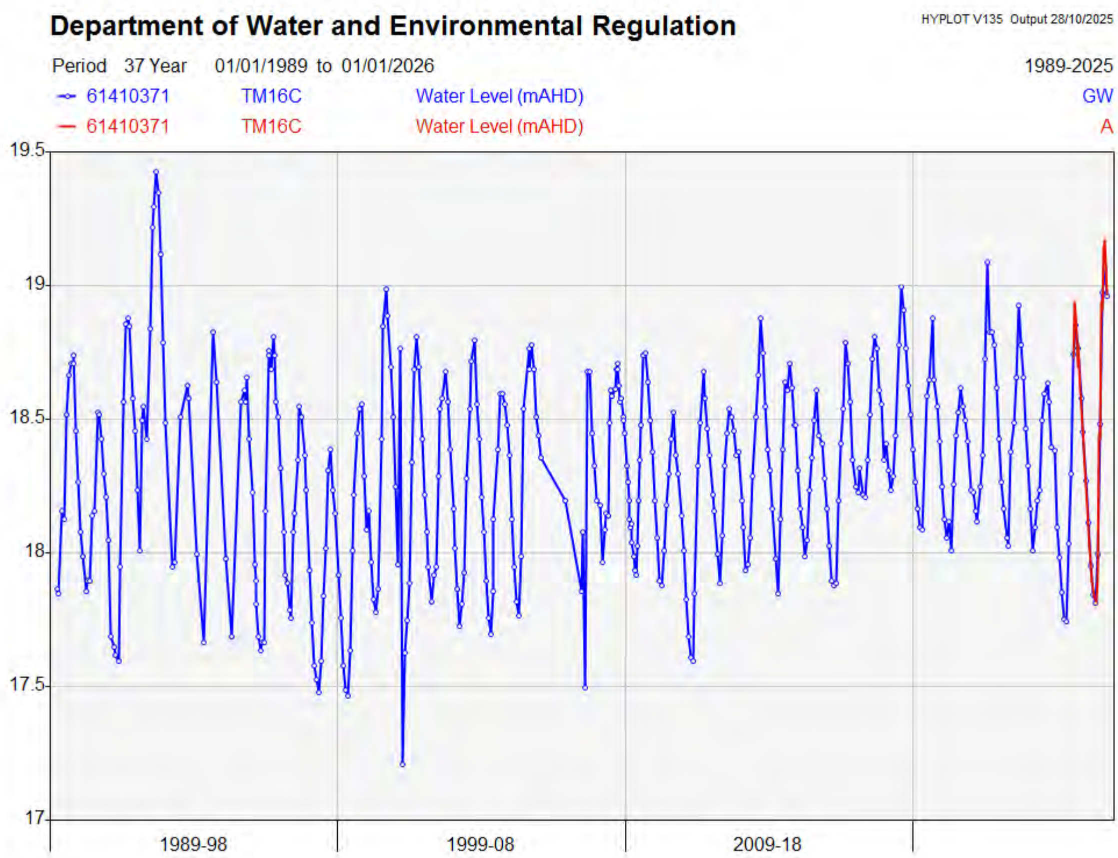
The susceptibility score is combined with the drawdown score to obtain an overall risk of impact. Based on the sum of susceptibility and drawdown, the risk to GDEs from a decline in groundwater level is then classed as either ‘acceptable’, ‘manageable’ or ‘unacceptable’ (Table 5).

**Table 5: Sum of susceptibility and drawdown risk**

| Risk of Impact | Risk category | Score |
|---|---|---|
| Low | Acceptable | <10 |
| Moderate | Manageable | 10 - 13 |
| High | Unacceptable | >13 |

# APPENDIX B: HYDROGRAPHS FOR MONITORING BORES TM13C AND TM16C



# APPENDIX C: GROUNDWATER MODEL DESCRIPTION

## 1.0 Model Setup

The numerical groundwater model was developed using the software Visual MODFLOW, which is a 3D finite difference groundwater flow model used extensively throughout the world.
The model setup and main input parameters are outlined below.

### 1.1 EXTENT AND GRID SIZING

Figure A shows the extent of the model, which is 5km long and 5 km wide, which was selected so that Thomsons Lake was included along the western model boundary and that the model boundaries were set at distances judged to be far enough outside the anticipated influence of groundwater drawdown caused by pumping from the modelled pumping bore.
The grid sizing within the model is 10 m by 10 m across the whole model domain. The model consists of a total of 500 rows and 500 columns.
The model has been setup using the Perth Coastal Grid (PGC) 2020coordinate system with no model rotation.


**Figure C: Model Extent**

## 1.2 MODEL LAYERS

Figure B shows schematic long-sections in the model along the alignment in a west-east direction. The model is divided into 3 layers to represent the hydrogeological units of the Superficial Aquifer.

The surface elevation is based on the publicly available 1m LIDAR surface elevation, while the remaining layers are flat (i.e. constant elevation). The bottom of the model represents the contact with the Kardinya Shale, which is here considered an impermeable aquitard.

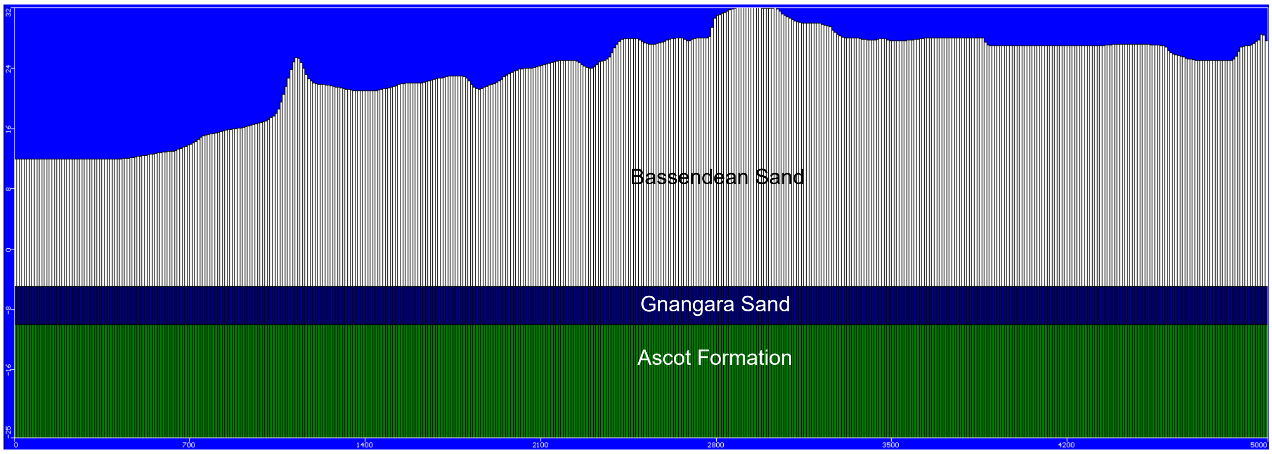



**Figure D: Groundwater Model Long-Section with Model Grid and Layers**

## 1.3 BOUNDARY CONDITIONS

Boundary conditions are assigned at the edges of the model to assess how water will flow into and out of the model. It is preferable that natural boundaries are used where they exist, otherwise boundaries should be set far enough away that they do not influence what is occurring within the model.

Figure C shows boundary conditions applied to the model.

No Flow Boundary


**Figure E: Boundary Conditions**

### 1.3.1 Lake

A Lake function was applied to Thomsons Lake. The lake level was set based on wetland water level measurements (set at RL 12 m AHD). The lake function can both give and receive a finite amount of water. The amount of water that it can receive/give depends on the applied conductance of the cells, which are determined based on an assumed permeability of the base of the wetland.

### 1.3.2 General Head

General Head boundaries were applied to the remaining model boundaries to simulate groundwater flow through these sections. Assigning a General head means that cell and receive or give an infinite amount of water. The amount of water that it can receive/give depends on the applied conductance of the cells, which are determined based on the hydraulic conductivity of the hydrogeological units. The advantage of a General Head is that the groundwater level drawdown can extend to the model boundary with the groundwater level drawdown able to be modelled beyond the model boundary.

### 1.3.3 Recharge

A spatially and temporally uniform recharge value was applied across the whole model. Since the model is run for 365 days, the annual recharge rate was applied to the model and set at 150 mm/yr, which is based on the DWER PRAMS model input parameters (around 20% of the annual rainfall).

### 1.3.4 Transient Model (Non-Steady-State) – Groundwater Abstraction

For the groundwater abstraction model runs a well function was added to the proposed location of the pumping well. The wells were assumed to be drilled to the base of the Superficial Aquifer and screened across the whole aquifer, and then a pumping rate was applied over a set period/duration. The pumping well was located on the western side of Kwinana Fwy in an area that has the shortest distance to Thomson Lake.

### 1.4 MODEL ASSUMPTIONS

The following is a list of assumptions used in the development of the model:

- Each hydrogeological unit is homogenous.
- The recharge was uniform across the model.

### 1.5 ADOPTED HYDRAULIC PROPERTIES

Figure D presents a long-sectional view through the model column where the pumping well is placed with the adopted hydraulic input parameters (obtained from publicly available literature and based on our experience in the area).
The specific yield was set to 0.2 with a Storage coefficient of 1 x $10^{-4}$ m/s.

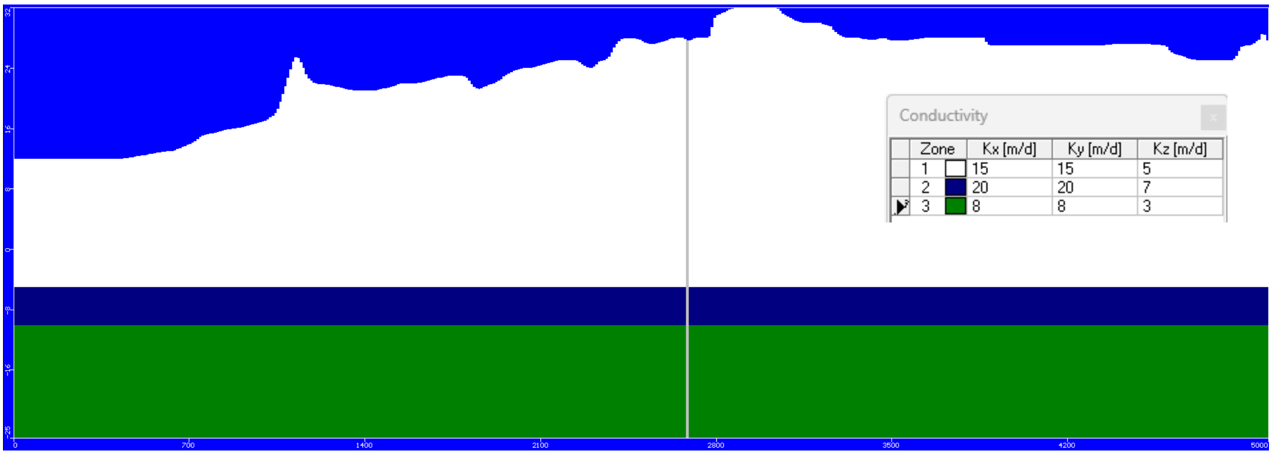



**Figure F: Applied Hydraulic Properties**

## 2 Model Results

Figure E shows a long-sectional view of the modelled groundwater levels for the Stead-State model, which was used as head input into the transient (pumping) model. The model was calibrated by changing the elevation of the general head boundaries so that the current estimated minimum groundwater level along Kwinana Fwy was achieved. The reason for calibrating to the dry season groundwater levels is that it would result in the lowest hydraulic gradient between Thomsons Lake and Kwinana Fwy (conservative approach).

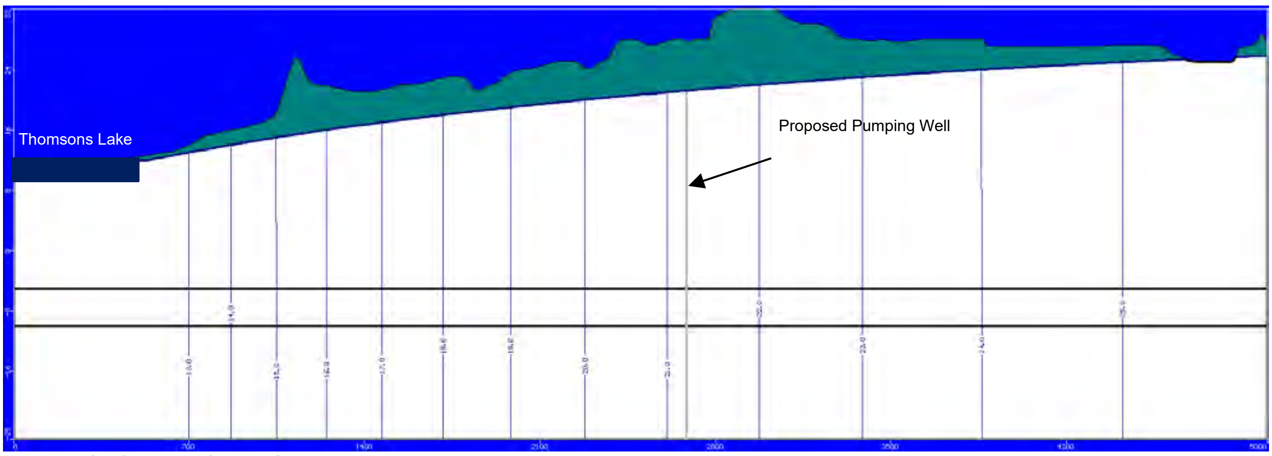



**Figure G: Steady-State Groundwater Levels**

Figures F and G show the same long-sectional view of the modelled groundwater level drawdown for the transient model after pumping from the model pumping well at 5 L/s for 365 days and 10 L/s for 365 days. In both cases, the modelled groundwater levels are not changed at Thomsons Lake.

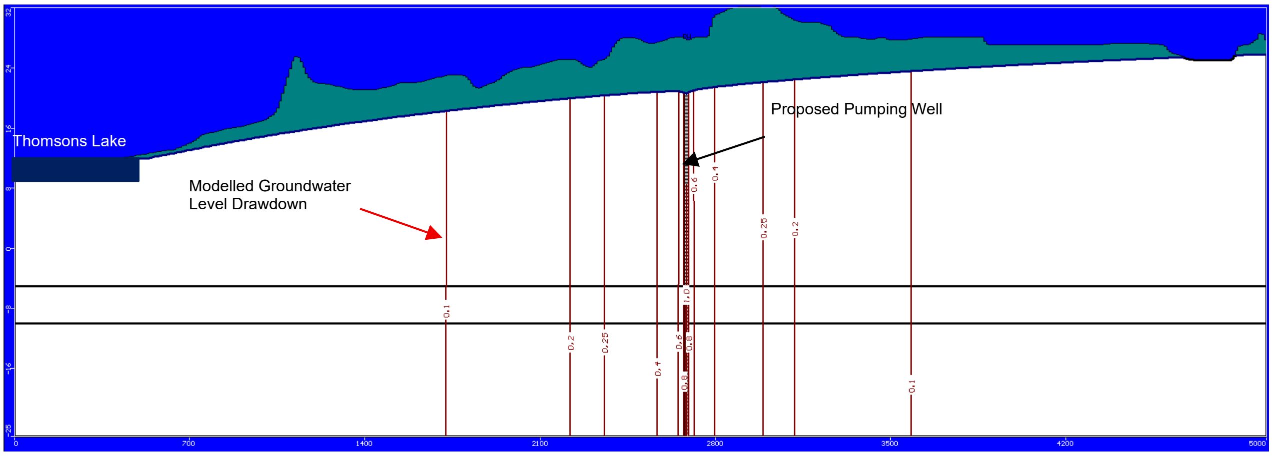



**Figure H: Transient Groundwater Levels after 365 days of pumping 5 L/s from Pumping Well.**

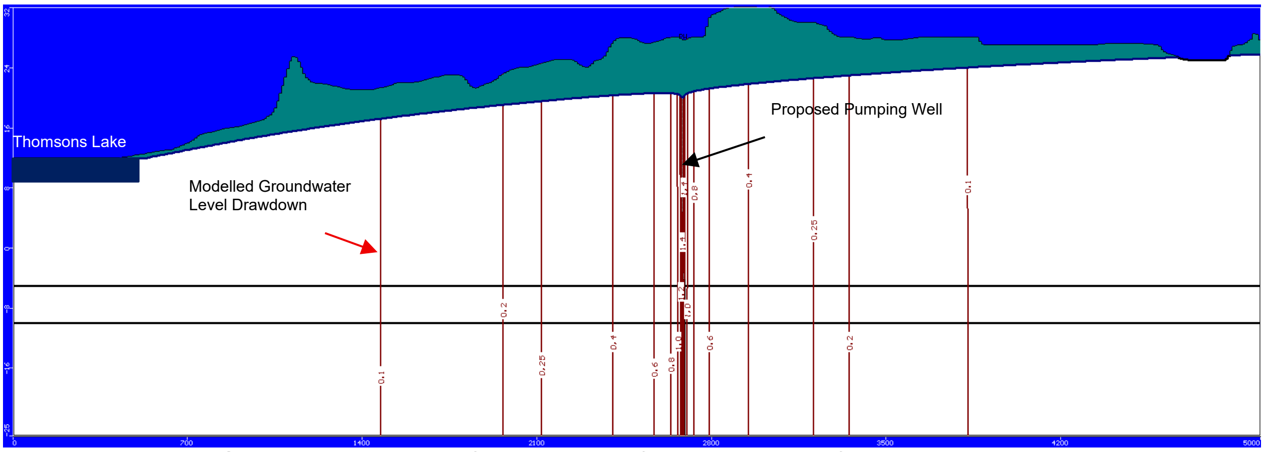



**Figure I: Transient Groundwater Levels after 365 days of pumping 10 L/s from Pumping Well.**