

23 November 2020

HYDROGEOLOGICAL ASSESSMENT

**16-18 JOHN STREET & 23-25 CHURCH AVENUE,
MASCOT**

Da Vito Ferro Apartments Pty Ltd
SYD2020-0153AB Rev0

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1 INTRODUCTION

1.1 Scope

CMW Geosciences (CMW) was engaged by Da Vito Ferro Apartments Pty Ltd to address the hydrogeological requirements of Bayside Council in relation to the development application of the abovementioned site, located at 16-18 John Street & 23-25 Church Avenue, Mascot (Figures 1.1 and 1.2).

This report provides a hydrogeological assessment to support the application, including the development of a numerical groundwater model to simulate the effects of the excavation dewatering and the completed tanked basement structure, on the groundwater system.

This Assessment Report has been used to inform development of the Implementation Plan (Ref. SYD2020-0153AC) dated 23 November 2020 and subsequent scope for detailed design.



Figure 1.1 Site Location

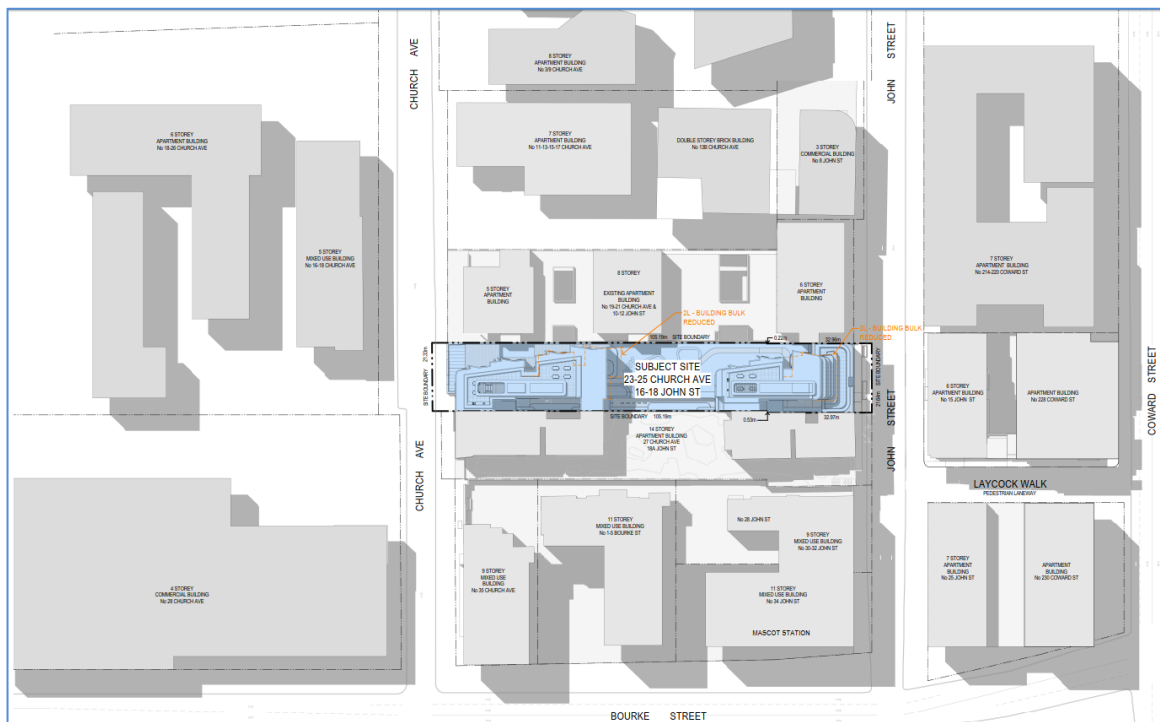


Figure 1.2 Site Neighbourhood

1.2 Background

Previous work undertaken and considered include the following geotechnical studies, investigations and drawings:

- Aargus Pty Ltd (2020a). *Groundwater Well Installation Report 23-25 Church St Mascot, NSW, 2020*. Report prepared for C & V Engineering Services, no. GS8023-4A 17 November 2020.
- Aargus Pty Ltd (2020b). *Geotechnical Investigation Report 23-25 Church St & 16-18 John Street Mascot, NSW, 2020*. Report prepared for C & V Engineering Services, no. GS8023-1A 4 September 2020.
- Northrop (2020). *Carmela & Vito Apartments - Structural Report, 23-25 Church Avenue and 16-18 John Street, Mascot*. 7 September 2020.
- Squillace (2020). *Drawing set for proposed development at 23-25 Church Avenue and 16-18 John Street, Mascot*.

1.3 Proposed Development

The development comprises a multi-level building with a multi-level below ground car park basement. The basement will be a tanked construction intersecting the groundwater table, and in addition perimeter cut-off shoring walls will be installed to approximately 6 m below the basement to intersect the lower-permeability deeper formation.

2 EXISTING ENVIRONMENT

2.1 Climate

Annual rainfall near Mascot is 1,077 mm/year, with a range from 523 to 2,025 based on the record for Sydney Airport (BOM station 66037) from 1929 to 2020. The rainfall pattern is unevenly distributed, with somewhat higher rainfall experienced from the months January to June. The mean monthly maximum temperature ranges from 17.2C (July) to 26.7 (December).

2.2 Hydrogeology

Groundwater in the vicinity occurs within an unconfined sandy aquifer.

The aquifer is hosted within a sand, clayey sand and silty sand profile, grading at depth to bedrock of extremely weathered clayey shale (encountered between approximately -8 to -10 mAHD), and underlying shale (Aargus, 2020a).

Confined groundwater conditions are not expected, and the shale bedrock is expected to behave largely as a lower confining layer for the groundwater system.

2.2.1 Groundwater levels

Groundwater levels reported in Aargus (2020b) based on three monitoring wells at the site (BH03, BH04 and BH05) ranged from RL 3.4 mAHD to 4.8 mAHD. Bore information from the three onsite monitoring bores is provided in Table 2.1.

Bore ID	Drilled depth (mBGL)	Surface level (mAHD)	Screen interval (mAHD)	Groundwater level (mAHD)	Top of weath. shale (mAHD)
BH03	22.9	7.2	5.2 to -6.8	4.8	-8.8
BH04	24.7	7.3	5.3 to -7.4	3.4	-10.2
BH05	25.3	6.86	-10.2 to -16.2	4.5	-8.1

Groundwater time-series hydrographs, provided by Alliance Geotechnical, are presented in Figures 2.1 to 2.4 for three monitoring bores at the site. The hydrographs show significant groundwater level fluctuation in the site area over the time period monitored (August 2019 to November 2020) with the maximum range recorded for BH4 of 1.7 m, but typically in the range of approximately 0.7 m.

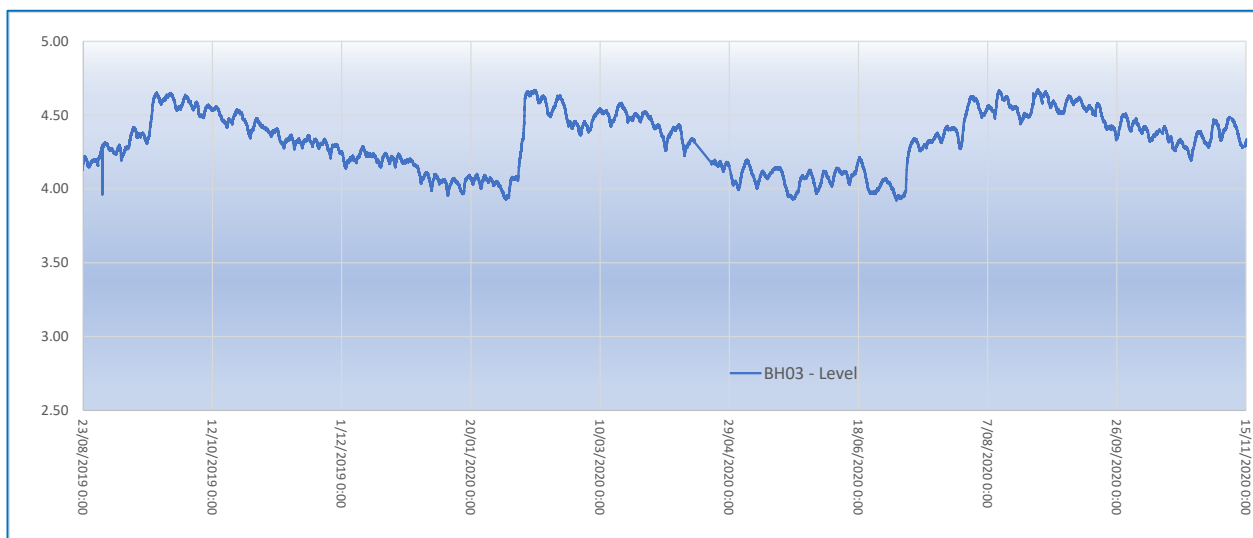


Figure 2.1 Groundwater hydrograph – BH3

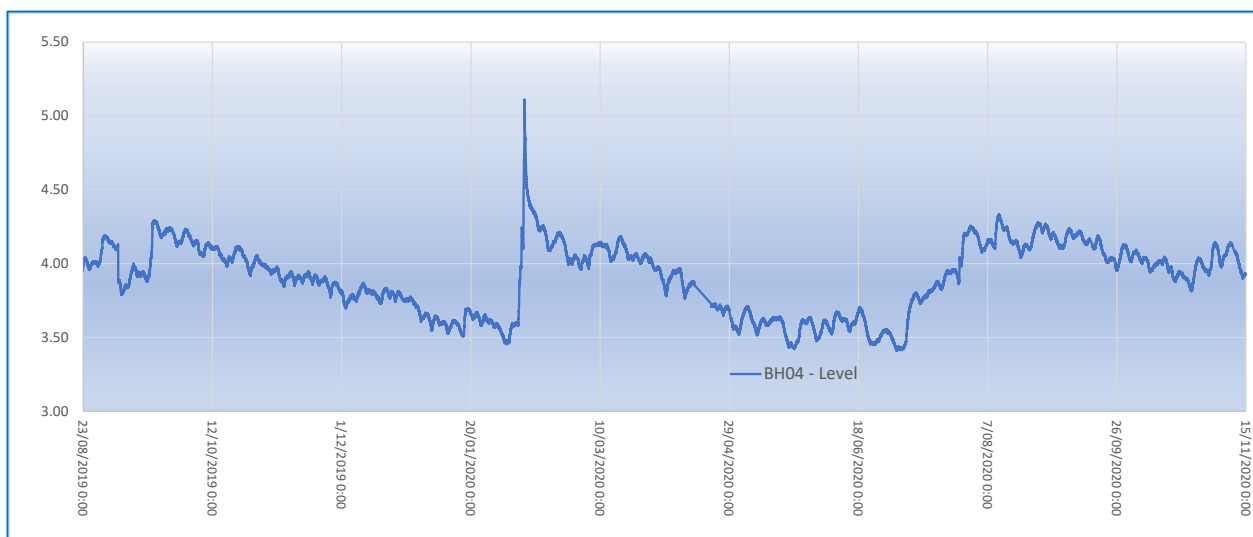


Figure 2.2 Groundwater hydrograph – BH4



Figure 2.3 Groundwater hydrograph – BH5

2.3 Hydraulic Parameters

Aquifer hydraulic tests were undertaken at the three monitoring bores to assess hydraulic conductivity of the formation. The tests conducted were rising-head slug tests, utilising bailers for slug removal, and downhole data loggers for monitoring recovery.

Recovery rates at the shallower wells (BH03 and BH05) were rapid, whereas recovery at the deeper well (BH05) was slow due to generally low permeability. The tests were analysed with Aqtesolv software for the analysis of aquifer tests (Duffield, 2007) using both the Bouwer and Rice (1976) and Hvorslev (1951) solutions. The results are presented in Table 2.2.

Table 2.2: Slug test analyses				
Bore ID	Screened lithology	Hydraulic Conductivity (m/day)		
		Bouwer & Rice	Hvorslev	GeoMean
Upper screened bores				
BH03	Sand, clayey sand, silty sand	0.484	0.485	
BH04	Sand, clayey sand, silty sand	0.198	0.203	
	Geometric mean	0.310	0.314	0.31
Deep screened bore				
BH05	Shale	0.164	0.027	0.066

The results indicate a hydraulic conductivity range from approximately 0.03 to 0.5 m/day, values which span an order of magnitude due to the heterogeneous lithology. Because hydraulic conductivity is a logarithmically distributed parameter, it is appropriate to use the geometric mean as an indicator of central tendency.

Based on the results obtained, an estimate of the bulk hydraulic conductivity at the site is approximately 0.31 m/day for the upper sandy profile, and 0.07 m/day for the weathered shale.

3 GROUNDWATER MODELLING

Numerical modelling was conducted for the purpose of:

- Predicting groundwater dewatering flow rates for the development;
- Predicting the anticipated groundwater drawdown due to the excavation dewatering; and
- Predicting the likely effect the construction will have on future groundwater levels, once tanking is completed.

A layered 3D numerical model was implemented, with model design undertaken using the Groundwater Vistas modelling environment. The numerical modelling code utilised for the simulations was USGS Modflow 2005, an industry standard finite-difference groundwater flow model. Modflow is suitable for both steady-state and transient flow simulations.

3.1 Model setup

3.1.1 Discretisation

A multi-layer model was setup, with 20 m row and column spacing, refined to 5 m spacing in the site area to improve resolution. Ten layers were adopted, with a model base assigned at -30 mRL. The model grid extent is 2,000 metres (X) by 1,500 metres (Y).

Surface topography was not explicitly modelled, and unnecessary as surface processes (such as evapotranspiration) were not incorporated in the model.

3.1.2 Hydraulic Parameters

Horizontal hydraulic conductivity (K_h) adopted was 0.31 m/day for the upper sandy layers, and 0.07 m/day for the weathered shale layers. The basal model layer was assigned a K_h of 0.01 m/day. Vertical hydraulic conductivity (K_v) was assigned an order of magnitude of lower than K_h in all cases.

Porosity and specific yield (S_y) were assigned as follows:

- Upper layers: Porosity = 0.1 S_y = 0.05
- Weathered shale: Porosity = 0.05 S_y = 0.01
- Basal layer: Porosity = 0.01 S_y = 0.001

3.1.3 Boundary Conditions

Regional boundary conditions applied to the model are shown on Figure 3.1.

A constant-head boundary was applied to represent the Alexandra Canal, at a surface water RL of 0 mAHD. No-flow boundary cells were applied to inactive areas of the model beyond the Alexandra Canal boundary.

Rainfall recharge was applied across the model as net recharge and assigned during the calibration process to achieve a watertable RL at the site area consistent with observations.



Figure 3.1 Model extent and boundary conditions

3.1.4 Existing buildings

Tanked basement structures for existing buildings were represented by assigning no-flow cells to model areas representative of the building locations.

The nine buildings detailed in Table 3.1 were investigated, however only four of these (in bold, including Mascot Railway Station) had building footprints that were deeper than the typical watertable elevation.

Table 3.1: Existing buildings		
Site address	Sealing system	Basement RL
1-5 Bourke St, Mascot	Tanked (assumed)	3.15
3-9 Church Ave, Mascot	Tanked (assumed)	4.5
13A Church Ave Mascot	Tanked	1.3
6-8 John St and 13B Church Ave	Drained (assumed)	7.15
19-21 Church Ave + 12 John St Mascot	Tanked (assumed)	5.2
24-28 John St, Mascot	Drained (assumed)	6.0
27 Church Ave + 18A + 20-22 John St	Tanked (assumed)	-1.5 Cut-off wall to RL -7.5

30-32 John St, Mascot	Drained (assumed)	6.0
Mascot Station & Tunnel	Tanked (assumed)	-17

Figure 3.2 shows the nominal basement outlines in the model overlaid with the numerical model grid, and with no-flow cells represented in black. For each site represented, the no-flow cells are applied to a depth representative of each tanked basement incorporated. This was facilitated by specifying specific model layer elevations that correspond with the basement RLs. Figure 3.3 shows a typical cross-section.

Deep cut-off walls, such as secant-piled walls, are represented using the Modflow HFB (horizontal flow boundary) package to simulate these features. Apart from the subject site, the only site identified with deep cut-off walls was 27 Church Ave-20-22 John St, with a secant-piled wall to RL -7.5 mAHD. The cut-off wall parameters assumed were 900 mm thick walls with 1×10^{-8} m/sec hydraulic conductivity.

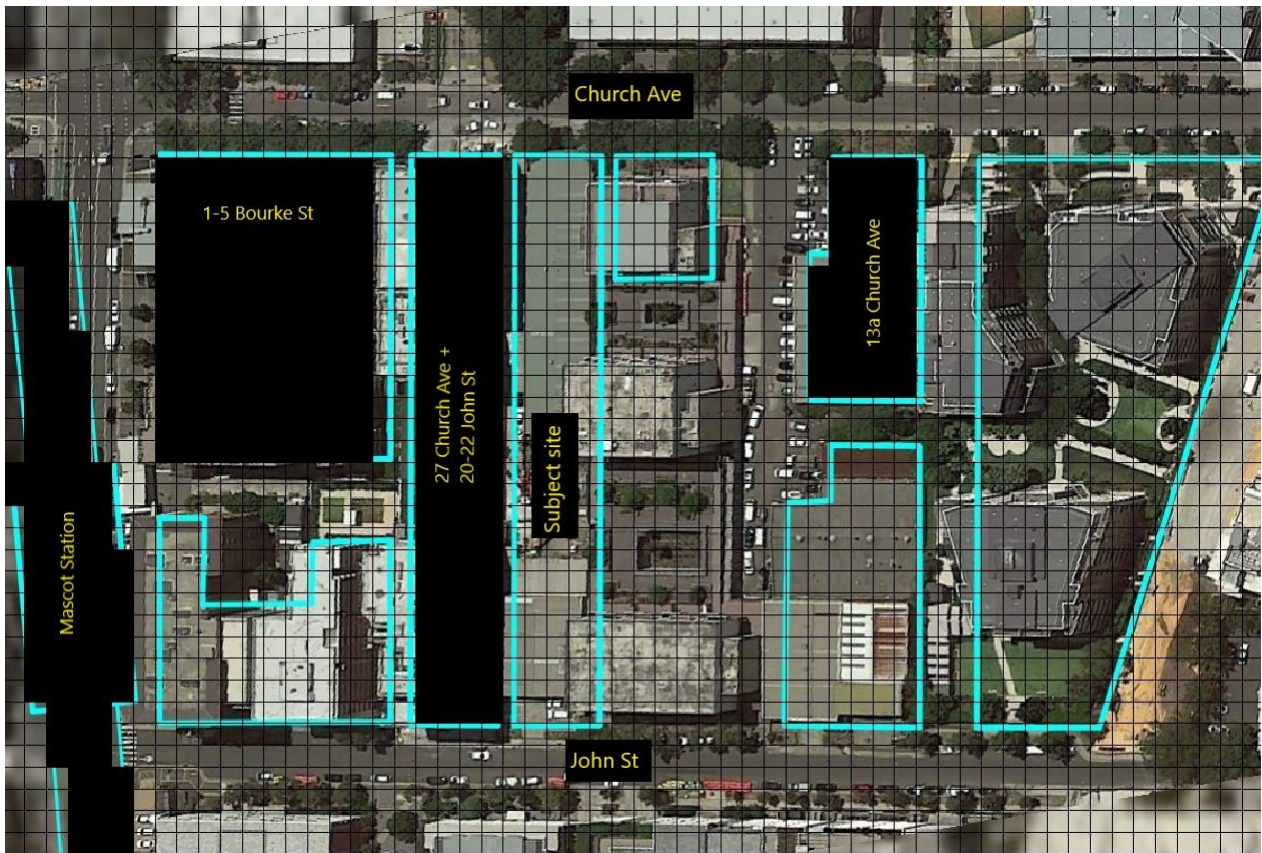


Figure 3.2 Basement outlines

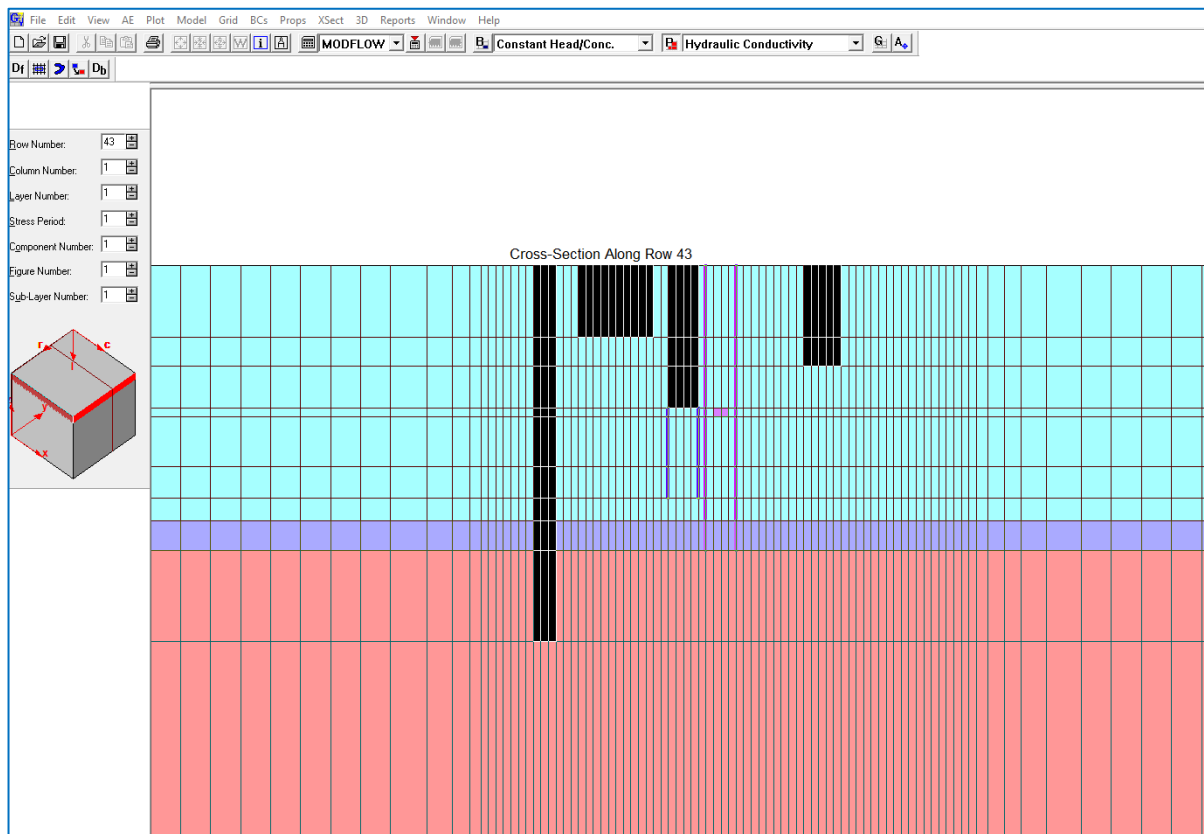


Figure 3.3 Model east-west cross-section (vertically exaggerated)

4 SIMULATIONS

4.1 Baseline simulation

Both steady-state and transient simulations were conducted. An initial steady-state simulation was undertaken to provide a baseline groundwater surface. This baseline groundwater surface provides starting heads for the predictive simulations. Figure 4.1 shows the steady-state simulated groundwater contours. The hydraulic gradient is primarily influenced by the nearby Alexandra Canal, a tributary of the Cooks River, which forms the main nearby hydraulic boundary.

The influence of tanked basements on contours of groundwater head can be observed, noting that the groundwater pressure distribution is a three-dimensional feature, and the contours are integrated to display a two-dimensional surface.

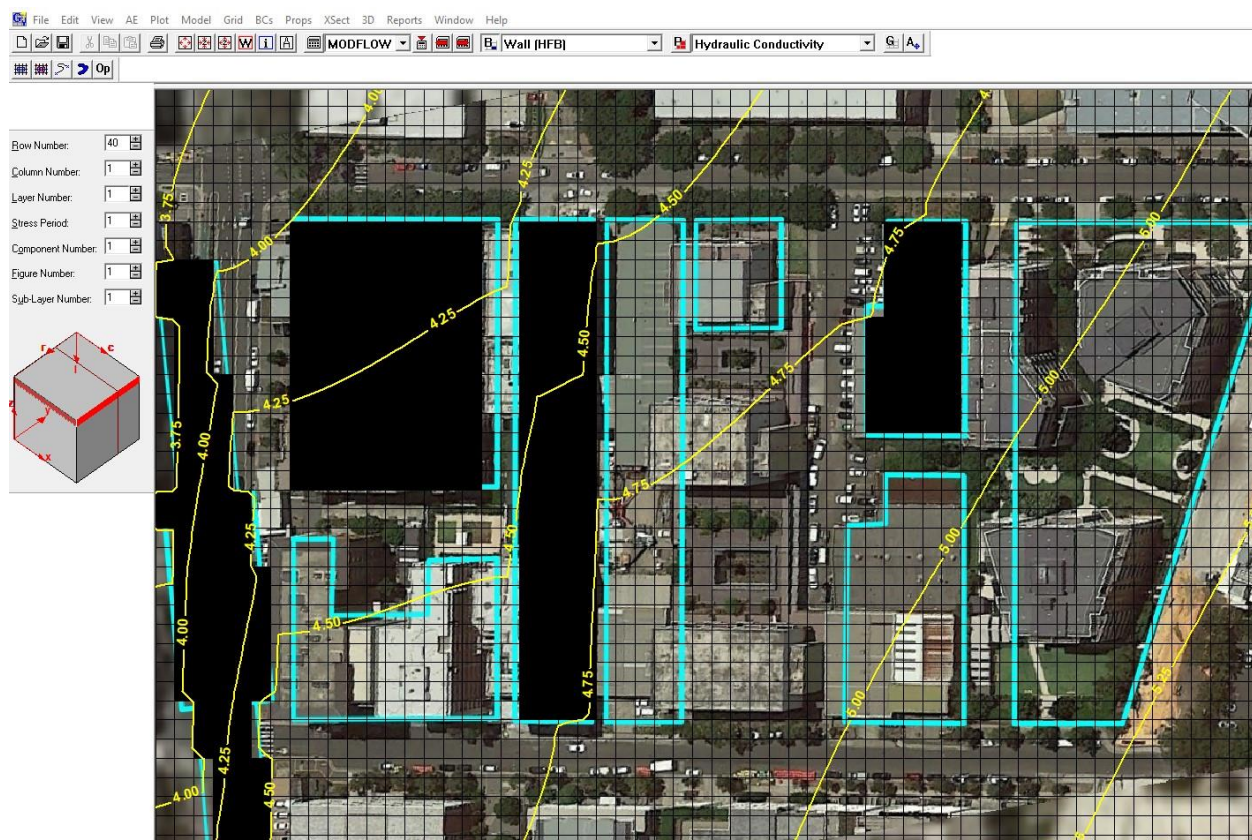


Figure 4.1 Steady-state simulated groundwater contours

4.2 Dewatering simulations

Dewatering of the site was undertaken using transient (time-dependent simulations). Simulations were run to predict groundwater inflows and drawdown over time for two scenarios representing different cut-off wall depths.

The Modflow HFB package was used to simulate the perimeter shoring walls planned for the excavation of the site. These walls are proposed to be Cutter Soil Mixing (CSM) walls, with a hydraulic conductivity of 1×10^{-8} m/sec and a thickness of 900 mm (Northrop advice), installed to a depth of approximately 6 m below the basement. For the first simulation, the walls were incorporated to the base of model Layer 7 at RL -9 mAHD (top of weathered shale). For the second simulation, the walls were incorporated to the base of model Layer 8 at RL -11 mAHD (top of shale).

Dewatering of the subject site was simulated using the Modflow Drains package. To achieve this, drain cells were incorporated inside the cut-off wall boundaries. Because the basement lower elevation is stepped

across the site, between Church Ave and John St, these drain cells were assigned in Layer 4 at -2.1 mAHD (Church Ave section) and Layer 5 at -5.4 mAHD (John St section).

4.2.1 Simulation – cut-off wall to RL -9 mAHD

Figures 4.2 to 4.4 show simulated groundwater drawdown in the vicinity of the development site at 7 days, 30 days and 90 days respectively.

The modelling indicates the following conclusions with respect to excavation dewatering over a period of 90 days - groundwater drawdown of:

- approximately 5 metres is indicated, but restricted to 10 metres from the site boundary.
- approximately 1 metre is indicated, but restricted to 30 metres from the site boundary.
- approximately 0.25 metre at 75 metres from the site boundary.

The model mass balance indicates initial drain inflows of approximately 100 to 150 m³/day decreasing rapidly to below 40 m³/day by around 90 days. It should be noted that the model, unlike the real world, assumes a drained watertable surface at the specified dewatering elevation ‘instantaneously’ at the commencement of the model simulation. In reality, excavation progress (and therefore dewatering inflow proceeds on a more modest basis, and the high early-time flow rates are not encountered, and the extent of drawdown also progresses more modestly.

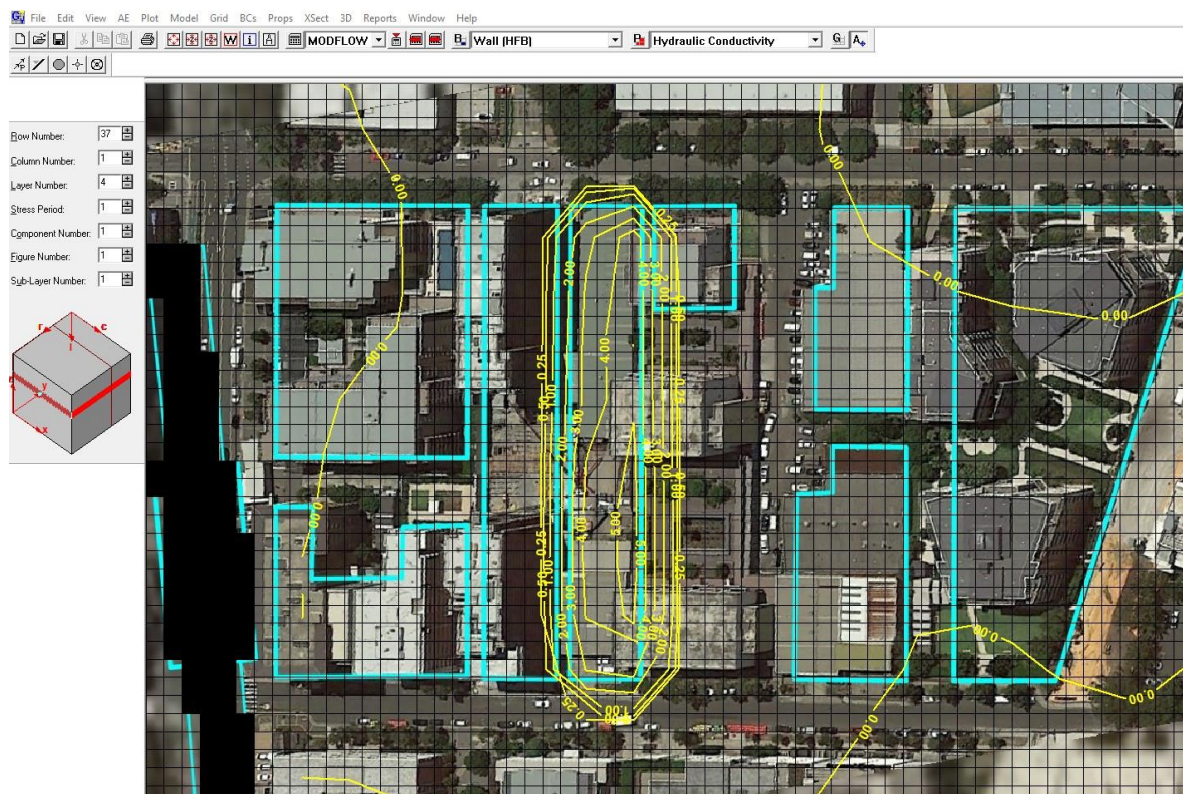


Figure 4.2 Groundwater drawdown – 7 days (cut-off wall to RL -9 mAHD)

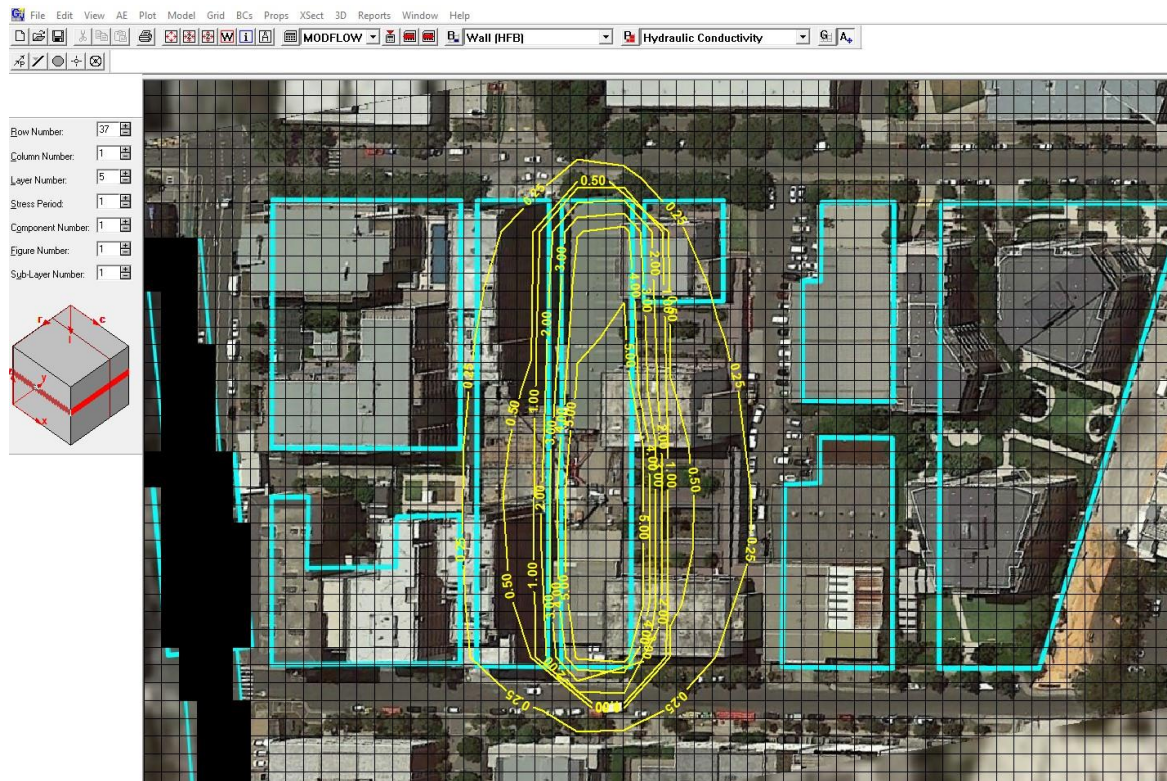


Figure 4.3 Groundwater drawdown – 30 days (cut-off wall to RL -9 mAHD)

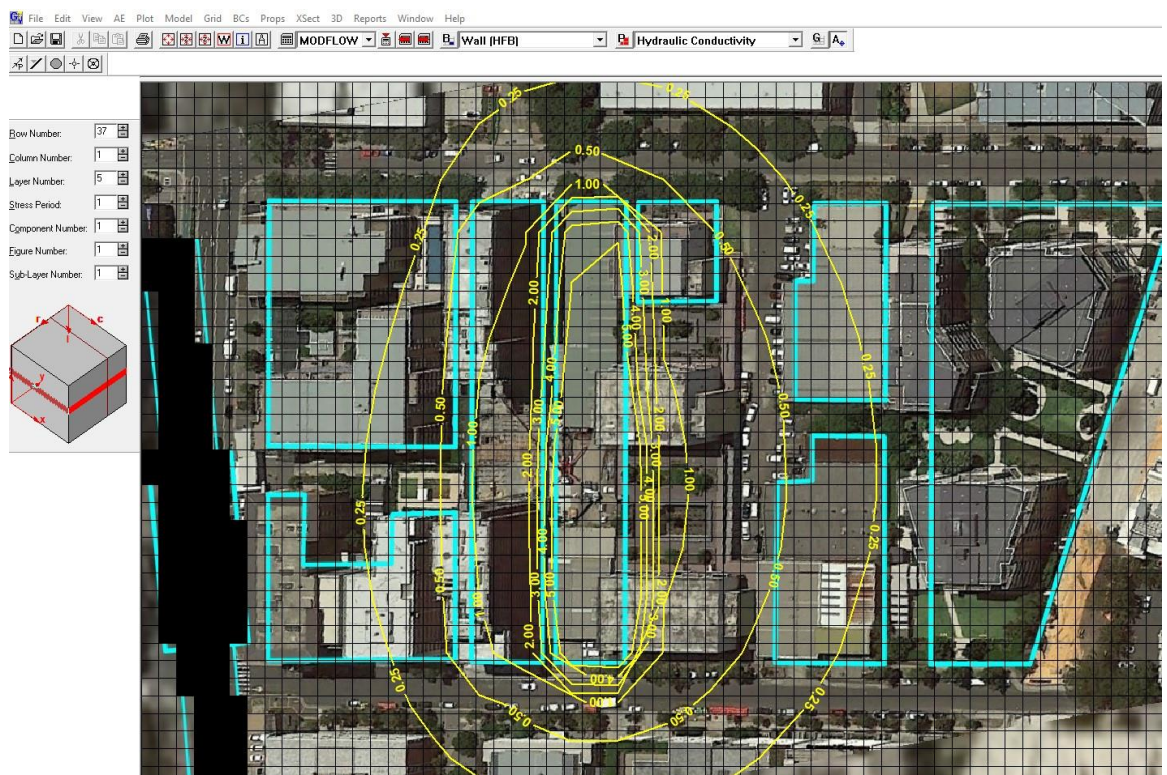


Figure 4.4 Groundwater drawdown – 90 days (cut-off wall to RL -9 mAHD)

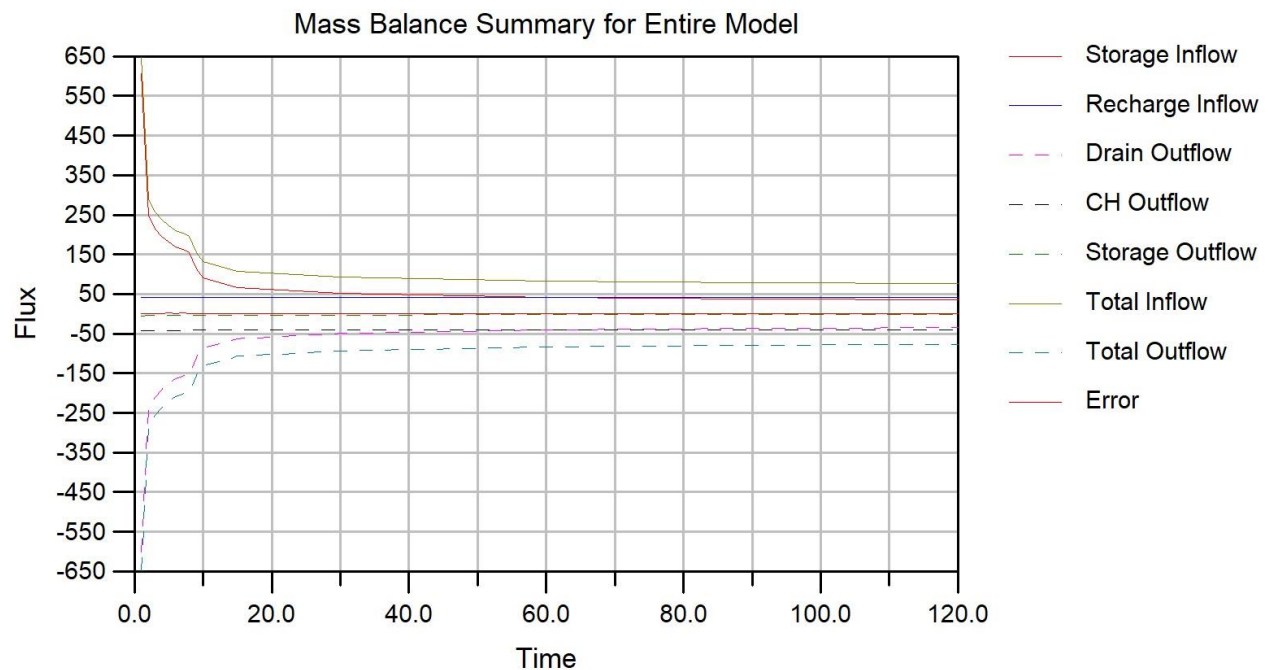


Figure 4.5 Model transient mass balance (cut-off wall to RL -9 mAHD)

4.2.2 Simulation – cut-off wall to RL -11 mAHD

Figures 4.6 to 4.8 show simulated groundwater drawdown in the vicinity of the development site at 7 days, 30 days and 90 days respectively.

The modelling indicates the following conclusions with respect to excavation dewatering over a period of 90 days - groundwater drawdown of:

- approximately 5 metres is indicated, but restricted to 10 metres from the site boundary.
- approximately 1 metre is indicated, but restricted to 20 metres from the site boundary.
- approximately 0.25 metre at 60 metres from the site boundary.

The model mass balance under this scenario indicates slightly reduced drain inflows compared to the -9 RL cut-off scenario, decreasing rapidly to below 30 m³/day by around 90 days.

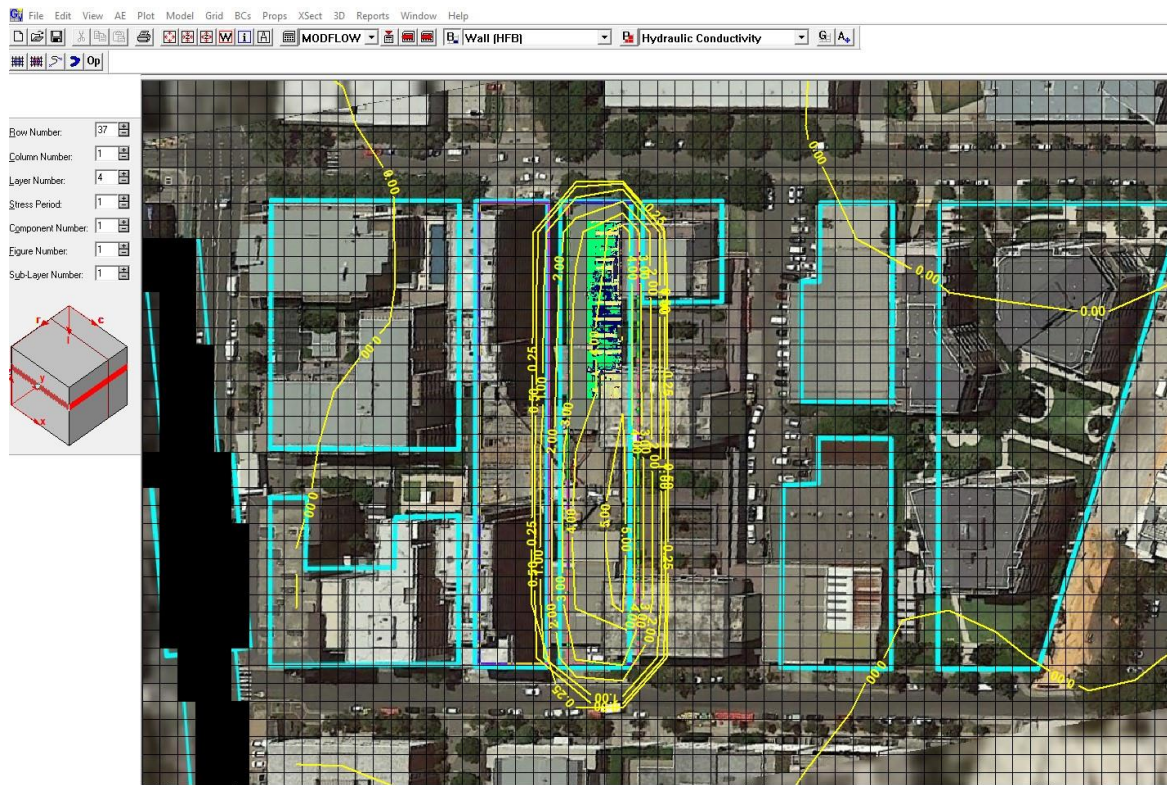


Figure 4.6 Groundwater drawdown – 7 days (cut-off wall to RL -11 mAHD)

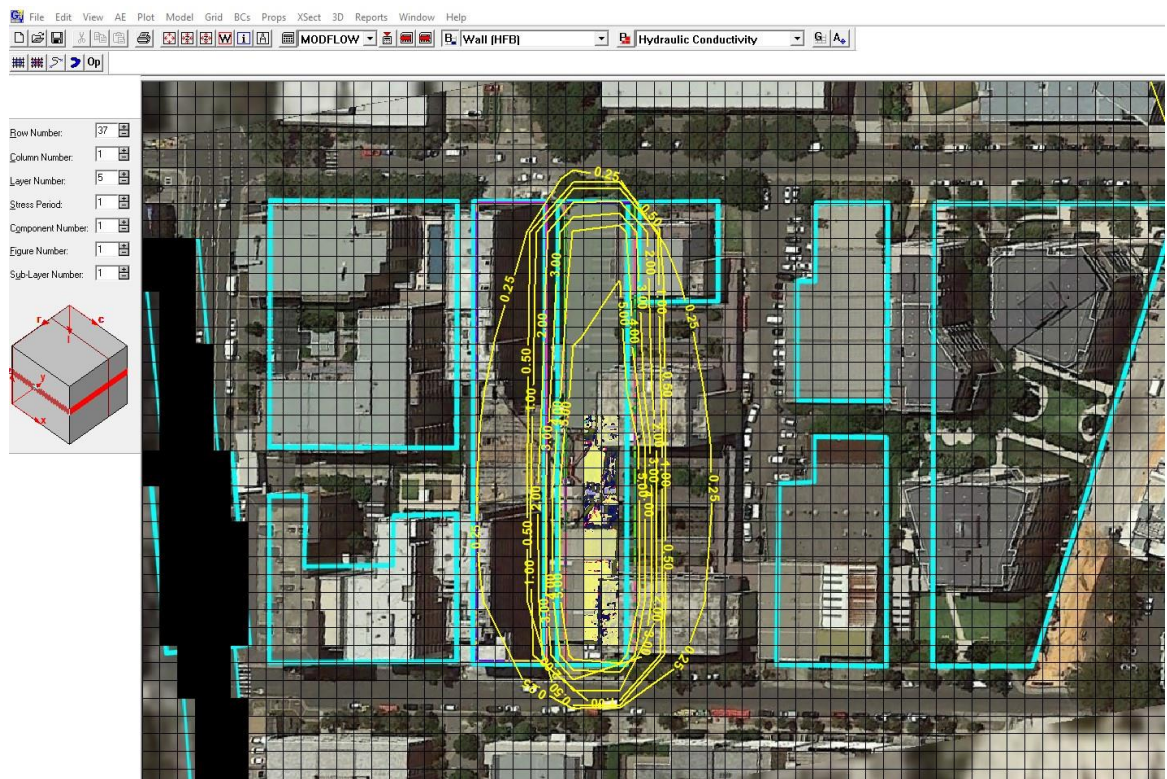


Figure 4.7 Groundwater drawdown – 30 days (cut-off wall to RL -11 mAHD)

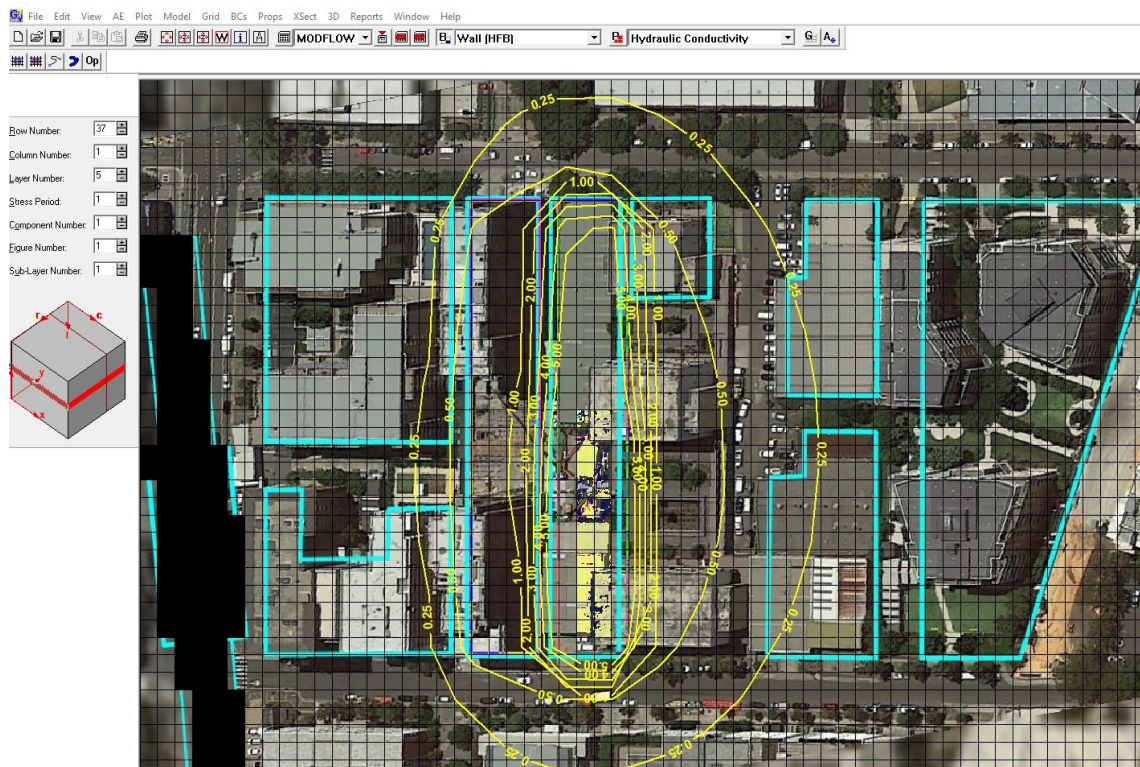


Figure 4.8 Groundwater drawdown – 90 days (cut-off wall to RL -11 mAHD)

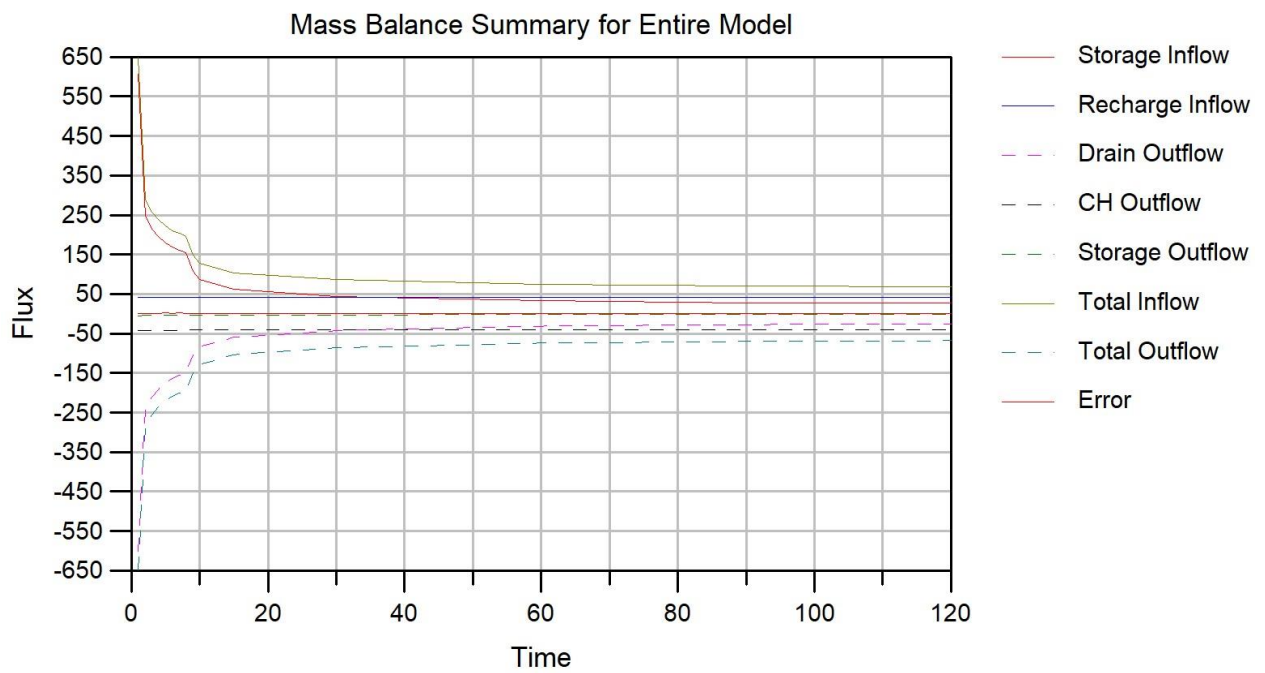


Figure 4.9 Model transient mass balance (cut-off wall to RL -11 mAHD)

4.3 Simulation of completed basement structure

To simulate the effect that the completed basement structure will have on groundwater in the vicinity of the development, a steady-state simulation was undertaken. For this simulation, the drain cells were deleted, and the basement structure represented in the model using no-flow cells. The CSM cut-off walls, represented by in the model as HFB wall boundaries, was retained as these sub-surface structures will remain in place after completion.

Accordingly, the model represents a completed, tanked structure with no groundwater throughflow, and no drainage.

Figure 4.10 shows the post-construction steady-state head distribution, which is substantially unchanged from preconstruction conditions. Figure 4.11 shows the drawdown contours, indicating slight groundwater mounding of a maximum 0.1 metres within 30 metres of the site boundary, in the up-hydraulic gradient direction. No groundwater drawdown is indicated by the modelling.

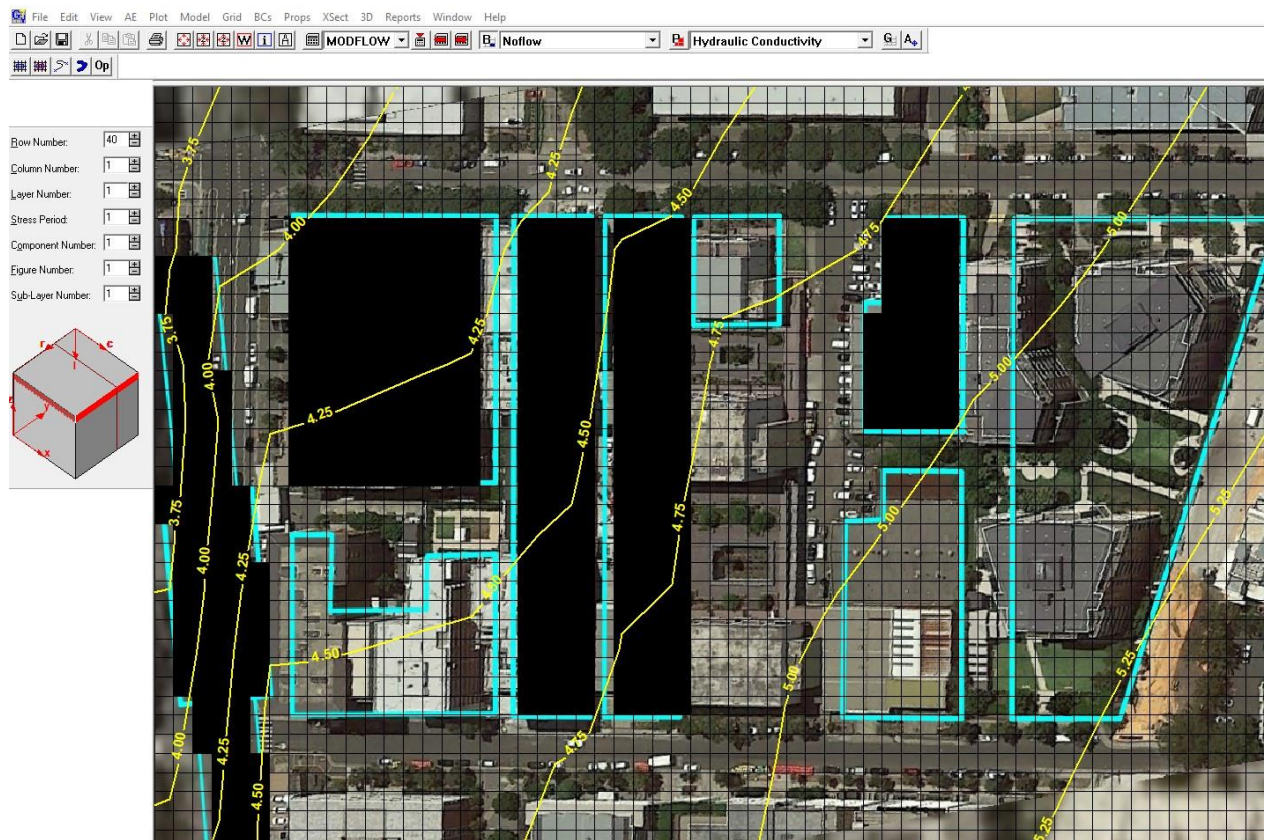


Figure 4.10 Post-construction groundwater head contours (steady-state)

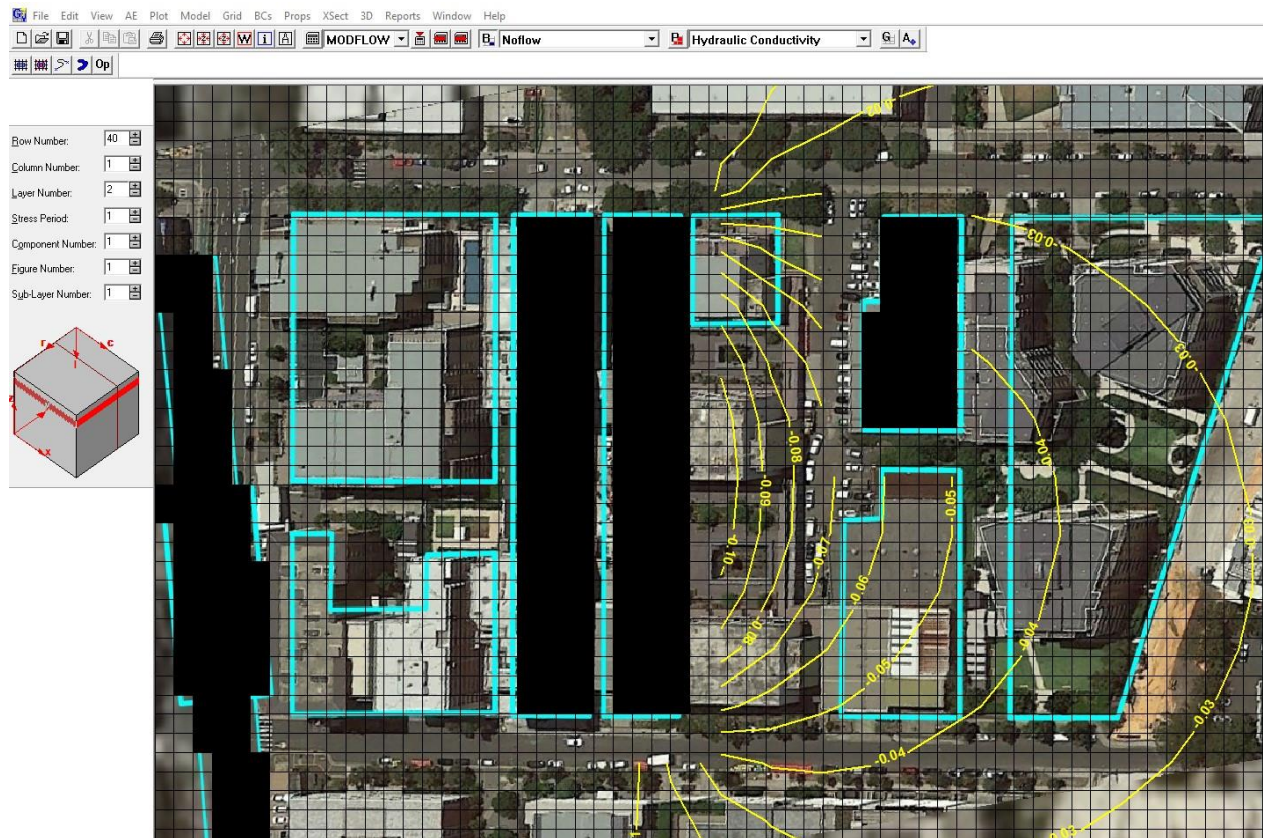


Figure 4.11 Post-construction groundwater drawdown (mounding) (steady-state)

4.4 Uncertainty

All groundwater models are subject to uncertainty.

In particular, uncertainty arises due to parameter uncertainty, and conceptual uncertainty. In addition, the approach undertaken for this project was deterministic, and uncertainty analysis has not been performed. Based on the information available at the time of reporting, including geological and hydrogeological information, the model parameters adopted are considered reasonable, but do not necessarily represent a unique solution. Other interpretations are possible. Accordingly, the modelling results and predictions made in this report should be considered as indicative, and subject to interpretation.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Drawdown due to dewatering

Based on the scenarios considered and the model transient simulations, the following conclusions are made with respect to groundwater drawdown due to excavation dewatering:

- Assuming a cut-off wall to RL -9 mAHD, over a period of 90 days groundwater drawdown of:
 - approximately 5 metres is indicated, but restricted to 10 metres from the site boundary.
 - approximately 1 metre is indicated, but restricted to 30 metres from the site boundary.
 - approximately 0.25 metre at 75 metres from the site boundary.
- Assuming a cut-off wall to RL -11 mAHD, over a period of 90 days groundwater drawdown of:
 - approximately 5 metres is indicated, but restricted to 10 metres from the site boundary.
 - approximately 1 metre is indicated, but restricted to 20 metres from the site boundary.
 - approximately 0.25 metre at 60 metres from the site boundary.

5.2 Impact due to completed development

Based on the model predictions, the following conclusions are made with respect to the completed, tanked basement structure:

- The predicted steady-state head distribution is substantially unchanged from preconstruction conditions.
- Groundwater drawdown contours indicate slight groundwater mounding of a maximum 0.1 metres within 30 metres of the site boundary, in the up-hydraulic gradient direction.
- No groundwater drawdown is indicated by the modelling to result from the completed basement and cut-off wall structure.

The model predictions indicate that the groundwater level impact resulting from the completed basement is less than the range of ambient groundwater level fluctuations observed.

5.3 Site dewatering

Based on the model transient simulations, the following conclusions are made with respect to dewatering inflows due to excavation dewatering:

- Assuming a cut-off wall to RL -9 mAHD, the model mass balance indicates initial drain inflows of approximately 100 to 150 m³/day but decreasing rapidly to below 40 m³/day at around 90 days.
- Assuming a cut-off wall to RL -11 mAHD, the model mass balance indicates slightly reduced drain inflows compared to the -9 RL cut-off scenario, decreasing rapidly to below 30 m³/day at around 90 days.

It is considered that in practice the initial inflow rates may be lower, under the assumption that the actual excavation will proceed on a gradual basis, in contrast to the model assumption of full drainage to the basement levels at the start of the simulation.

From a practical standpoint, dewatering is assumed to comprise arrays of wells, spearpoints or sumps, within the excavation area, and inside the completed cut-off walls. It is noted that the modelling is based on a parameter set that is underpinned by limited testing. Accordingly, the dewatering system design should incorporate flexibility to increase or otherwise manage dewatering rates, should such be necessary, if higher inflows are incurred, for example due to unforeseen geological heterogeneity.

Dewatering from wells located outside the cut-off walls should not be conducted.

6 REFERENCES

Aargus Pty Ltd (2020a). *Groundwater Well Installation Report 23-25 Church St Mascot, NSW, 2020.* Report prepared for C &V Engineering Services, no. GS8023-4A 17 November 2020.

Aargus Pty Ltd (2020b). *Geotechnical Investigation Report 23-25 Church St & 16-18 John Street Mascot, NSW, 2020.* Report prepared for C &V Engineering Services, no. GS8023-1A 4 September 2020.

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