APPENDIX 4

LOCAL WATER MANAGEMENT STRATEGY

(HYD2O)

From: Sasha Martens
To: "Nicole Barnao"
Cc: Emma van der Linden
Subject: Lot 594 Wanneroo Rd, Hocking LWMS
Date: Friday, 30 August 2019 12:33:31 PM

Regards
Sasha

Sasha Martens
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Sent: Friday, 30 August 2019 10:27 AM
To: sasha@hyd2o.com.au
Subject: Lot 594 Wanneroo Rd, Hocking LWMS

Hi Sasha,

Thanks for the referral of the about Local Water Management Strategy (LWMS). Due to the scale of the proposed development and the lack of significant water issues, the Department of Water and Environmental Regulation defers the assessment and approval of the document to the City of Wanneroo.

Kind regards,

Bree Lyons
A/ Senior Natural Resource Management Officer
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Lot 594 Wanneroo Rd, Hocking

Local Water Management Strategy

August 2019

Client: David Barnao & Co Pty Ltd

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Executive Summary

Hyd2o was commissioned by David Barnao & Co Pty Ltd to prepare this Local Water Management Strategy (LWMS) to support the proposed subdivision development of Lot 594 Wanneroo Road, Hocking.

The site is located approximately 20 km north of Perth City Centre within the City of Wanneroo. The site has an approximate area of 6.7 ha and is bound by existing development to the north, Kirkstall Drive and existing development to the south, Wanneroo Road to the west and St Elizabeth's Catholic Primary School to the east.

The proposed development consists of business/commercial development along Wanneroo Rd and series of 51 traditional and 38 laneway residential lots within the internal area of the site. A large Public Open Space (POS)/conservation area comprising almost 16% of the total site will be created to retain an existing area of Marri/Jarrah and Banksia Woodland. The western half of the site is generally parkland cleared with small pockets of trees and areas of low-height vegetation.

Topography of the site slopes from approximately 57 mAHD at the north eastern corner to 53 mAHD in two low lying areas in the north-west and south-east of the site. The Department of Water and Environmental Regulation's (DWER) Perth Groundwater Map indicates the historical maximum groundwater level at the site to be between 36 and 37 mAHD, indicating a depth to groundwater of more than 15 m even in low lying areas.

The site is considered a "Low Risk Classification" for development based on the City's Local Planning Policy 4.4 (City of Wanneroo, 2019).

Given the depth to groundwater and highly permeable sandy soils in the area, the proposed stormwater management system will retain and infiltrate all stormwater on site post development.

This LWMS has been prepared in accordance with the principles, objectives, and key criteria of Better Urban Water Management (Western Australian Planning Commission, 2008). Implementation of the strategy will be undertaken in accordance with Better Urban Water Management through the development and implementation of Urban Water Management Plans for individual stages of development within the site.

Local Water Management Strategy Summary

Strategy Elements	LWMS Method & Approach
Water Use Sustainability	
Water Efficiency	• Use of water efficient fixtures and fittings. • Use of native plantings in POS / stormwater management areas. • Maximise infiltration of stormwater at source.
Water Supply	• Water Corporation IWSS for lots with rainwater tanks optional. • Any irrigation of landscaped stormwater infiltration areas to be via groundwater and existing licences. • No long term irrigation of Conservation/Public Open Space
Wastewater	• Water Corporation reticulated sewerage
Stormwater	
Ecological Protection (15 mm Event)	▪ Implement both structural and non-structural controls. • Use of soakwells at lot scale (where lot size permits) to retain 15mm on site. • Commercial lots to retain all stormwater on site upto1% AEP event. ▪ Total storage volume of 150 m^3 and area of 505 m^2 required for biofiltration systems to manage flood events for remainder of site (ex commercial) up to a 15 mm event, representing approximately 0.7 % of total site area. ▪ Local scale street scale measures to be detailed and designed at UWMP stage in consultation the City of Wanneroo and project civil engineers. Opportunities to be considered include use of side boundary lots for raingardens and use of bottomless manholes.
Serviceability (0.2 Exceedances per Year Event)	▪ Road drainage system designed so roads will be passable in the 0.2 EY event. ▪ Total storage volume of 240 m^3 and area of 875 m^2 required to manage flood events up to the 0.2 EY event, representing approximately1.3 % of total site area.
Flood Protection (1% Annual Exceedance Probability Event)	• Provide flood paths for overland flows which exceed the capacity of piped drainage. • Total storage volume of 755 m^3 and area of 1530 m^2 required to manage flood events up to the 1% AEP event, representing approximately 2.3 % of total site area. • Establish minimum habitable floor levels at 0.5m above the 1% AEP event flood level of stormwater storage areas. • Establish minimum habitable floor levels at 0.3 m above the 1% AEP event flood level in local drainage network.
Groundwater	
Fill & Subsoil Drainage	• Finished lot levels will be in excess of 15 m above the DWER historical maximum groundwater table, therefore no subsoil drainage is required for the proposed development. • Earthworks will comprise a cut and fill operation and within some imported fill likely to be required to meet gradients requirements, level lots, and interface with existing site boundaries.
ASS & Contamination	• No known risk of ASS or Contamination

1 Introduction

Hyd2o was commissioned by David Barnao & Co Pty Ltd to prepare this Local Water Management Strategy (LWMS) to support the proposed subdivision development of Lot 594 Wanneroo Road Hocking (herein referred to as the site).

The site is located approximately 20 km north of Perth City Centre within the City of Wanneroo. The site has an approximate area of 6.7 ha and is bound by existing development to the north, Kirkstall Drive and existing development to the south, Wanneroo Road to the west and St Elizabeth's Catholic Primary School to the east.

This LWMS provides a total water cycle management approach to development and has been prepared consistent with the overarching City of Wanneroo Stormwater Drainage Design Guidelines (2019c) and Better Urban Water Management (Western Australian Planning Commission, 2008).

This document provides the outcomes of site specific investigations related to groundwater and surface water and provides a clear vision in terms of adopting best management practises to achieve water sensitive design.

LWMS Checklists to assist in the review of this document are contained as Appendix A.

1.1 Planning Background

The site is currently zoned 'Urban' under the Metropolitan Region Scheme and zoned as 'Urban Development' under the City of Wanneroo District Planning Scheme No. 2.

The site is located within the cadastral boundary of the St Elizabeth's Catholic Primary school, and proposes residential, commercial land uses and POS/conservation areas.

The urban water management planning process for the site is shown in Table 1. This LWMS supports the proposed local structure plan for the site.

Table 1: Integrated Planning and Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Document and Status
Local	Local Structure Plan Lots 594 Wanneroo Rd Hocking	Lots 594 Wanneroo Rd Hocking Local Water Management Strategy **THIS DOCUMENT**
Subdivision	Subdivision Application	Urban Water Management Plan (for individual subdivision applications) **FUTURE PREPARATION**

1.2 Key Documents and Previous Studies

This LWMS uses the following key documents to define its principles, criteria, and objectives:

- Local Planning Policy 4.4: Urban Water Management (City of Wanneroo, 2019b).
- Local Planning Policy 4.3: Public Open Space (City of Wanneroo, 2016).
- Stormwater Drainage Design Guidelines WD5 (City of Wanneroo, 2019c)
- Decision Process for Stormwater Management in WA (Department of Water, 2017)
- Better Urban Water Management (WAPC, 2008)
- Stormwater Management Manual for WA (Department of Water, 2007)

2 Proposed Development

The structure plan for the site is shown in Figure 2. Consideration of the predevelopment environment of the site and existing constraints has guided the development of this plan.

The proposed development consists of business/commercial development along Wanneroo Road (3 lots) and series of 51 traditional residential lots and 38 laneway residential lots within the internal area of the site. The average lots size is approximately 300 m^2.

The site will create a large 1.1 ha POS/conservation area comprising over 16% of the total site to retain an existing area of Marri/Jarrah and Banskia Woodland and trees identified as significant trees for Black Cockatoos.

The site will create two areas for stormwater management, one in the north-western corner of the site adjacent to Wanneroo Road and one on the south eastern area adjacent to the proposed conservation area. These areas represent the existing natural low lying areas of the site.

Details of the preliminary sizing of the stormwater management areas are presented in Section 6. Both stormwater management areas have been designed and sized for this LWMS assuming the areas are established as biofiltration areas with a landscaped flood storage area. This approach is considered conservative from the view of determining land take requirements for stormwater management.

Given the location of the north-western storage site adjacent to Wanneroo Rd and an existing sump to the north, it is possible this site may be ultimately designed and constructed as a fenced sump. Guidance will be sought from the City of Wanneroo on a preferable design outcome for this location at UWMP stage.

3 Pre-Development Environment

3.1 Site Conditions

A site conditions plan is included as Figure 3.

The western half of the 6.7 ha site is generally parkland cleared with small pockets of trees and areas of low-height vegetation, with the eastern area containing areas of Marri/Jarrah and Banksia Woodland. Several significant trees have been identified in this area as having potential for Black Cockatoo breeding by PGV Environmental. The site also contains an existing limestone retaining wall (approx. height 1.5m) along its northern boundary for existing residential lots to the north.

DWER 1m Lidar topographic contours are shown on Figure 3. Topography of the site slopes from approximately 57 mAHD at the north eastern corner to approximately 53 mAHD in two low lying areas in the north-west and south-east of the site.

3.2 Geotechnical

Environmental geology mapping on the Perth Metropolitan Region Sheet 2034 II and part 2034 III and 2134 III (Gozzard, 1986) is shown in Figure 4. The site is characterised as:

- S7 – SAND – Pale and olive yellow, medium to course grained, sub angular to sub rounded quartz, trace of feldspar, moderated sorted, of residual origin.

This classification extends over a very wide area around the site indicating relative homogeneous underlying soil conditions in the area.

The equivalent unit on geological maps is Sand derived from Tamala Limestone (Qts). This unit is classified as having good permeability and considerable depth to groundwater (Gozzard,1986).

Hyd2o undertook permeability testing on the site on 10 July 2019 in low lying area likely to be used for drainage purposes (refer Section 3.2.1). Two deeper bores were also hand augered at these locations to approximately 2m below natural surface to determine subsurface conditions.

Locations are shown on Figure 4. At both sites the observed soil profile below the initial topsoil layer, was uniform as yellow medium grained sand to the augered depth. This profile was consistent with expectations based on Gozzard (1986).

3.2.1 Field Saturated Hydraulic Conductivity Testing

Hyd2o undertook onsite permeability testing on 10 July 2019 at two locations to determine the saturated hydraulic conductivity of the soils in areas to be used for stormwater infiltration. This testing was undertaken to derive parameters to be used in stormwater modelling in Section 6.

Test locations are shown in Figure 4. All tests were carried out using a borehole permeameter at an approximate depth of 0.7 m and repeated three times at each location to ensure consistency in results. To estimate the field saturated hydraulic conductivity, each hole was saturated with clean water prior to testing.

The average rates per test location are summarised in Table 2. Details of calculations are included in Appendix B. Average saturated hydraulic conductivity rates of 29.8 m/day and 32.1 m/day were observed at the two sites.

Based on these results, a hydraulic conductivity of 15 m/day was adopted for modelling in this report. This is based on applying a 1.0 soil moderation factor and a 50% reduction to account for clogging, consistent with City of Wanneroo guidelines (CoW, 2019c).

These results indicate the site as suitable for infiltration of stormwater.

Table 2: Saturated Hydraulic Conductivity Field Testing Results

Permeability Test Site	Soil Type	K_s m/day
HW1 : North west corner of site near Wanneroo Rd	Yellow Medium Sand	29.8
HW2 : Low point within Banksia Woodland area	Yellow Medium Sand	32.1

3.2.2 Acid Sulphate Soils

Acid Sulphate Soil (ASS) mapping in the vicinity of the site is shown in Figure 4. Published acid sulphate risk mapping indicates the site has no known risk of ASS.

3.3 Contaminated Sites

A search of the Department of Water and Environmental Regulation's Contaminated Sites database indicates no known contaminated areas within the site.

3.4 Aboriginal Heritage Sites

A search of the Aboriginal Heritage Inquiry System indicates no Registered Aboriginal Heritage Sites are located within the site.

3.5 Surface Water and Wetlands

There are no defined waterways, watercourses, or drains within the site, and no external catchments drain into the site.

All surface water runoff infiltrates through the sandy subsurface profile. Even in major events any diffuse overland flow which may occur in localised areas would be infiltrated on site.

According to Department of Environment and Conservation's (DEC's) Geomorphic Wetlands of the Swan Coastal Plain dataset, there are no wetlands located within the site.

3.6 Groundwater

DWER's Perth Groundwater Map (PGM) indicates the historical maximum groundwater level at the site to be between 36 and 37 mAHD, indicating a depth to groundwater of more than 15 m at the site even in low lying areas, with groundwater flow to the west.

The PGM also provides groundwater contours based on May 2003 recorded groundwater levels for the site ranging from 35.5 to 36.5 mAHD. These contours are considered to represent a summer minimum groundwater condition.

Given the relatively minor difference between historical maximum and minimum values, an analysis of four nearby long term DWER bores in proximity of the site was conducted to provide further verification of site groundwater levels. Key statistics for each bore is shown in Table 3 in relation to PGM data. Bore locations and long term hydrographs shown in Appendix C.

The results indicate the historical maximum contour values for the two closest bores to the site (WM2 2 and WM42) are the same as the maximum historical groundwater levels at these locations, giving high confidence in the PGM maximum contours in the area. Analysis of May 2003 data indicates the May 2003 contours as less reliable in this immediate area.

On this basis the PGM Maximum Groundwater Level (MGL) contours are considered suitable for use in the stormwater design of the site as detailed in Section 6.

Table 3: Nearby DWER Bore AAMGLs and MGLs

Bore	Period of Record	May 2003 Recorded GW Level (mAHD)	May 2003 Contours via PGM (mAHD)	Diff (m)	Max Historical GW Level (mAHD)	Max Contours via PGM (mAHD)	Diff (m)
WM22	1975-2019	36.6	36.3	-0.3	38.0	38.0	0.0
WM42	1995-2019	26.9	27.6	+0.7	28.1	28.1	0.0
JB4	1977-2019	42.3	42.7	+0.4	43.7	45.8	+2.1
GN8	1963-2019	38.0	38.0	0.0	39.3	38.7	-0.6

4 Design Criteria

Key design criteria for the site are shown in Table 4 and have been established consistent with criteria specified in the key reference documents previously detailed in Section 1.3

These design criteria are used in Sections 5, 6 and 7 together with the identified constraints and opportunities of the predevelopment environment (Section 3) to establish the water management strategy for the site.

Table 4: Key Urban Water Management Design Objectives

Design Objectives	Reference/Source
Water Conservation and Supply	
Increase Water Use Efficiency and Reduce Potable Water Demand.	City of Wanneroo (2019b)
Reflect best practice in water conservation, harvesting, reuse and irrigation in public open space areas.	City of Wanneroo (2016)
Where possible use locally indicative species and local building styles to preserve local heritage and landscape character.	City of Wanneroo (2016)
Water Quality Management : Small Events	
Retain and/or detain and treat (if required) stormwater runoff from constructed impervious surfaces generated by the first 15 mm of rainfall at-source as much as practical.	Department of Water (2017)
Flood Management : Major Events	
Maintain the 1% annual exceedance probability (AEP) pre-development flood regime (flood level, peak flow rates and storage volumes).	Department of Water (2017) City of Wanneroo (2019c)
In addition to small events, commercial lots will be require to manage minor (0.2 EY) and major event (1% AEP) runoff on site.	City of Wanneroo (2019c)
Minimum habitable floor levels shall be a minimum of 0.5 m above the 1% AEP storm event in stormwater storage areas.	Department of Water (2017) City of Wanneroo (2019c)
Minimum habitable floor levels shall be a minimum of 0.3 m above the 1% AEP storm event flood level in local drainage networks.	Department of Water (2017) City of Wanneroo (2019c)
Disease Vector and Nuisance Insect management	
To reduce health risks from mosquitos, retention and detention treatments should be designed to ensure that immobile stormwater is fully infiltrated in a time period not exceeding 36 hours for the 0.2 EY Event and 84 for the 1% AEP Event (time measured from the end of the event).	City of Wanneroo (2019c)

5 Water Use Sustainability Initiatives

5.1 Water Efficiency Measures

Development of the site will lead to an increased demand of potable water for residential use and irrigation of gardens and POS/drainage areas. Water conservation measures will be implemented to reduce scheme water consumption within the development will be consistent with Water Corporation's "Waterwise" land development criteria including:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets, rainwater tanks, waterwise landscaping).
- Use of native plants in POS and drainage landscaped area.
- Maximising on site retention of stormwater.

5.2 Water Supply

Potable water supply to future homes in the site will be via the Water Corporation Integrated Water Supply System (IWSS). Rainwater tanks have been identified as a non-potable source to be integrated as part of the domestic water supply scheme to assist in reducing stormwater generation and minimise scheme water importation.

The site is located within the Wanneroo groundwater management area (GMA). Table 5 summarises the current quotas and allocation according to the Department of Water's online Water Register (2019c), indicating both the Superficial (Lake Gnangara Subarea) and Leederville (Wanneroo Confined Sub Area) aquifers as being fully allocated.

The subdivision application area contains one POS/Conservation area (Figure 2) and two identified drainage areas. The POS area comprises Marri/Jarrah and Banskia Wooland and is not envisaged to require irrigation. The south-eastern drainage area (and possibly north western one) will be landscaped and will consist of an integrated and landscaped biofiltration and infiltration storage area for up to the 1% AEP event.

An indicative landscape concept plan for the POS/Conservation area is contained as Appendix D. Details of calculations for stormwater volumes used to inform landscape planning are contained in Section 6. Further refinement and provision of landscape design plans will occur at UWMP stage prior to POS construction as engineering and landscape detailed design is progressed. Detailed landscape plans and detailed engineering for POS will be provided to the CoW for approval during the detailed planning phase of POS.

It should be noted that while the aquifers in the area are fully allocated, the adjacent school has an allocation of 6750 kL/yr, which given DWER's standard allocation rates indicates an allocation for irrigation of approximately 1 ha. It is considered likely this allocation was also to cover for a future expansion of the school across the site, as the current irrigation areas appears to be only approximately 0.4 ha.

Should any irrigation for the site be required, negotiations with the school will be conducted with a view to the transfer of allocation. Any groundwater licence will be ultimately transferred to the City of Wanneroo upon handover of POS areas.

Table 5: Groundwater Resource and Licenced Allocation

Groundwater Area	Subarea	Aquifer	Allocation Limit	Water Availability
Wanneroo	Lake Gnangara	Superficial	7.5 GL	Fully allocated
	Wanneroo Confined	Leederville	1.25 GL	Fully allocated

5.3 Wastewater Management

Wastewater will be deep sewerage (reticulated) with management by the Water Corporation.

6 Stormwater Management Strategy

Stormwater management is proposed to be undertaken consistent with DWER water sensitive design practices, via a combination of lot and street scale infiltration, biofiltration areas, and overflow depression storage areas to capture and infiltrate all major event runoff on–site. No off-site discharge is proposed.

With respect to local scale street scale measures, these will be detailed and designed at UWMP stage in consultation the City of Wanneroo and project civil engineers. Opportunities to be considered for street scale infiltration will include use of side boundary lots for raingardens and use of bottomless manholes. These measures will ultimately reduce the volumes required to be provided within drainage areas detailed in Section 6.2.

6.1 Water Quality Management

This LWMS proposes a treatment train approach to water quality management, including:

- **Non-Structural Controls**
  Planning : Lot product, POS and storage locations and configuration
  Landscape : Native plantings, WSUD integration
  Maintenance : Storage areas, street sweeping, manhole education
  Monitoring : Post development program and review
- **Structural Controls**
  Soakwells at lot scale to minimise runoff
  Bioretention storages as 15mm event treatment areas

These measures represent known best management practice as detailed in the Stormwater Management Manual for Western Australia (DoW, 2007). Table 9 details a summary from DoW (2007) of expected pollutant removal efficiencies for various WSUD measures in relation to water quality design criteria. While DoW (2007) does not provide expected pollutant removal efficiencies for all BMP's, application of a treatment train approach with a combination of the measures detailed will therefore achieve the design objectives for water quality as detailed in Better Urban Water Management (WAPC, 2008).

Bioretention areas will be sized to retain treat and infiltrate 15mm in accordance with DWER requirements (DoW, 2017). Biofiltration areas and volumes are detailed in Table 7. All biofiltration systems will be designed consistent with the Adoption Guidelines for Stormwater Biofiltration Systems (CRC for Water Sensitive Cities, 2015).

Table 6: BMP Water Quality Performance via DoW (2017)

Parameter	Criteria via WAPC (2008) (removal as compared to a development with no WSUD)	Nutrient Output Reduction	
		Bioretention Systems	Detention/ Retention Storages
Total Suspended Solids	80%	60-80%	65-99%
Total Phosphorus	60%	30-50%	40-80%
Total Nitrogen	45%	25-40%	50-70%
Gross Pollutants	70%	-	>90%

6.2 Flood Management

Stormwater modelling of proposed stormwater management areas was undertaken using the PONDS shallow water table infiltration model. PONDS is a program specifically designed for modelling groundwater/surface water interactions for the design of stormwater infiltration areas based on the finite difference computer program MODFLOW.

The design storms modelled by PONDS were calculated based on the methodology in Australian Rainfall and Runoff (ARR) and the Bureau of Meteorology Computerised Design IFD Rainfall System (CDIRS). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 1 hour to 72 hours.

Recent updates to Australian Rainfall and Runoff (Ball et al, 2016) have resulted in changes in terminology to describe design rainfalls. Generally, Exceedance per Year (EY) terminology is recommended to be used for very frequent design rainfalls, Annual Exceedance Probability (AEP, %) used for frequent and infrequent design rainfalls, and AEP (1 in x) used for rare design rainfalls. These replace previous ARI terminology as follows:

- 1 Year Average Rainfall Interval (ARI) – replaced with 1 EY
- 5 Year ARI – replaced with 0.2 EY
- 100 Year ARI – replaced with 1% AEP

The following key parameters were used for modelling purposes for this LWMS :

- Two catchments based on existing topography and POS areas (Figure 6).
- Groundwater level of 37 mAHD (maximum) and nominal storage invert of 51.5 mAHD.
- 1:0 side slopes for biofiltration areas to a maximum depth of 0.3 m.
- Minimum side slopes of 1 in 6 for minor/major event flood storage, assuming both drainage areas are landscaped.
- Maximum storage depths of 0.9 m (0.2EY) and 1.2 m (1% AEP).
- A saturated hydraulic conductivity of 15 m/day for flood management areas (Section 3.2.1), and 2.5 m/d for biofiltration areas (5 m/d design specification, 50% clogging).

Various runoff coefficients applied to different land uses for each of the events modelled are shown in Table 7. These have been determined using Hyd2o's CUURV runoff rate calculator with detailed calculations included as Appendix E. These rates assume all residential lots will be have soakwells sized to retain a 15 mm event on site, and the commercial lots will be required to manage all events up to the 1% AEP within their site.

Modelling results for the POS storages are provided in Table 7 and Figure 7, with hydrographs shown in Appendix F. A summary of stormwater management areas required for the 15mm, 0.2EY, and 1% AEP events relative to the total site area is provided in Table 8.

The final storage area configuration (side slopes, treatments etc), location, and elevations will be documented in the UWMP and will be dependent on final earthworks, drainage, and road design levels for the development. Minor refinements to catchment areas shown in this report may occur as detailed design proceeds, and stormwater modelling will be updated accordingly if required during the UWMP process.

All building floor levels will comply with requirements for a 0.3 m clearance above the 100 year flood level within the street drainage system and 0.5 m above the flood level within stormwater storage areas.

Table 7: Stormwater Modelling

Site Characteristics	Catchment A	Catchment B
Traditional Lots (ha) (15mm : 0% RO, 0.2EY : 31% RO, 1%AEP : 45% RO)	0.87	0.56
Laneway Lots (ha) (15mm : 0% RO, 0.2EY : 31% RO, 1%AEP : 45% RO)	0.14	0.86
Commercial (ha) (15mm : 0% RO, 0.2EY : 0% RO, 1%AEP : 0% RO)	0.00	0.00
Drainage (ha) (15mm : 4% RO, 0.2EY : 17% RO, 1%AEP : 56% RO)	0.08	0.09
POS (ha) (15mm : 1% RO, 0.2EY : 5% RO, 1%AEP : 17% RO)	0.00	1.10
Road Reserve (ha) (15mm : 59% RO, 0.2EY : 71% RO, 1%AEP : 85% RO)	0.69	0.99
Total Contributing Area (ha)	1.78	3.60
Effective Impervious Area (ha) (15 mm)	0.41	0.60
Effective Impervious Area (ha) (0.2EY)	0.82	1.21
Effective Impervious Area (ha) (1% AEP)	1.09	1.72
Storage Design Parameters		
K (m/day) Field Tested Rate	29.8	32.1
K (m/day) Adopted for Design (with 50% clogging allowance)	2.5 (biofilter) 15 (flood storage)	2.5 (biofilter) 15 (flood storage)
Estimated Groundwater Level (mAHD)	37	37
Side Slopes (v:h) : Biofiltration Flood Storage	1:0 1:6	1:0 1:6
Biofiltration : 15 mm Event		
Nominal Invert (mAHD)	51.5	51.5
Base Area (m^2)	205	300
TWL (m AHD)	51.8	51.8
TWL Surface Area (m^2)	205	300
Flood Rise (m)	0.30	0.30
Total Volume (m^3)	60	90
Separate Flood Storage : 0.2EY Event		
Base Area (m^2)	49 (7m x7m)	144 (12m x12m)
Flood Rise (m)	0.41	0.27
Volume (m^3)	40	50
TWL Surface Area (m^2)	140	230
Critical Storm (hr)	1	1
Separate Flood Storage : 1% AEP Event		
Flood Rise (m)	1.12	1.06
Volume (m^3)	230	375
TWL Surface Area (m^2)	415	610
Critical Storm (hr)	1	1

Note : Runoff rates for various land uses estimated based on Hyd2o CUURV runoff rate calculator

Table 8: Stormwater Area Summary

Event	Catchment A Area (m^2)	Catchment B Area (m^2)	Total Area (m^2)	% of Total Site Area
15 mm	205	300	505	0.7%
0.2 EY (Total area inclusive of 15mm)	345	530	875	1.3%
1% AEP (Total area inclusive of 15mm and 0.2 EY Area)	620	910	1530	2.3%

7 Groundwater Management Strategy

Wood & Grieve Engineers (2019) civil engineering services report, indicates earthworks for the site will comprise a cut and fill operation and with some imported fill likely to be required to meet gradients requirements, level lots, and interface with existing site boundaries.

Finished lot levels will be in excess of 15 m above the DWER historical maximum groundwater table, and no subsoil drainage is required for the proposed development. Earthworks levels are therefore not considered a critical factor in defining the sites structure plan, and detailed earthworks plans for the site will be developed during subdivision stage and submitted as part of the UWMP for the site.

Water quality aspects of groundwater management will be achieved via street scale bottomless manholes (given depth to groundwater) and biofiltration areas in future POS areas to treat stormwater runoff prior to infiltration at source.

There are no groundwater dependent ecosystems nearby to the site, therefore the site has a very low hydrological risk of impacting any groundwater dependent ecosystems, and the use of bioretention areas in POS and bottomless manholes will provide sufficient treatment for stormwater.

Final finished lot levels are a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the UWMP and will be ultimately submitted for council approval at that stage.

7.1 Acid Sulphate Soils

As previously detailed in Section 3.2, published acid sulphate risk mapping indicates the site has no known risk of ASS. It is therefore not anticipated that an ASS Management Plan would be necessary for subdivisional development.

Further examination of ASS risks will be evaluated during the sites geotechnical investigation. Should ASS be identified, management will be addressed as a separate study to the LWMS/UWMP process, however details regarding the outcomes will be included as part of the Urban Water Management Plan (UWMP).

All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series documentation (Department of Environmental Regulation, 2015a & b).

8 Urban Water Management Plans

Consistent with processes defined in WAPC (2008), an Urban Water Management Plan (UWMP's) will be developed and submitted to support a subdivision application for the site.

The UWMP will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of the City of Wanneroo and DWER.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design including the size, location and design of public open space areas, integrating major and minor flood management capability.
- Management of groundwater levels including proposed cut/fill level, and any subsoil drainage inverts (if/where required).
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, expected performance and agreed ongoing management arrangements.
- Management of subdivisional works
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).

More detail on stormwater storage integration will be provided during the development of the UWMP, including refinement of stormwater modelling, preparation of landscape plans (species selection and treatments), and detailed engineering design drawings.

Preparation of the UWMP will be the responsibility of the developer.

9 Monitoring

9.1 Pre Development Monitoring

As outlined in DoW (2012), groundwater monitoring should be undertaken where groundwater has a close interaction with the surface. Due to historical maximum groundwater levels exceeding 15 m below surface, no predevelopment monitoring is required or proposed within the site.

9.2 Post Development Monitoring

Due to the substantial depth to groundwater at the site, a post development groundwater monitoring program is not proposed. The proposed post development monitoring program for stormwater is detailed in Table 9.

The monitoring program is proposed to operate over a two year post development period to assess the overall performance of the stormwater storage areas. This period of post development monitoring is considered appropriate given the scale of the development to assess the functioning of the surface water management system.

A standardised proforma will be used to assess performance against design intent. The proforma will consider processes such as vegetation health, scour, erosion, deposition, water levels, and retention periods in bioretention and flood storage areas.

Assessment of monitoring outcomes and system performance will be undertaken as part of the annual review and reporting process. Should the system not be functioning in accordance with design a contingency action plan will be implemented, including:

- Assessing if an isolated, development area or regional occurrence.
- Determining if due to the development or other external factors.
    a) Identify and remove any point sources causing problems.
    b) Review operational and maintenance practices.
    c) Consider alterations to POS areas and the stormwater system.
    d) Consider initiation of community based projects.
- If necessary, inform residents of any required works and their purpose.

The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area or to alter the scope of the program itself. Any modification to the program would be identified through review of the collected data and would require the agreement of all parties (DWER, City of Wanneroo, and the developer).

Table 9: Post Development Monitoring Program

Monitoring	Parameter	Location	Method	Frequency/Timing
Local stormwater	Flow rate Performance assessment via proforma	Stormwater storage, inlets, and outlets	Visual assessment	Monthly when flowing, typically June to October (5 times per year) for 2 years

10 Implementation

Table 10 details the roles, responsibilities and funding to implement the LWMS.

Should the UWMP require any deviations to the strategy detailed in this LWMS, this will require the agreement of all parties (DWER, City of Wanneroo, and developer).

Details of construction and maintenance responsibilities will be appropriately detailed at UWMP stage.

Operation and maintenance of the stormwater management system will initially be the developer's responsibility, ultimately reverting to the City following handover. Details of maintenance responsibilities will be further outlined at UWMP stage.

The schedule for maintenance works will be consistent with typical requirements of the City of Wanneroo for stormwater management.

Table 10: Implementation Roles and Responsibilities

	Responsibility & Funding	
Implementation Action	**Developer**	**City of Wanneroo**
Preparation of UWMP	☑	
Review & Approval of UWMP		☑
Post Development Monitoring Program	☑	
Construction of Stormwater System	☑	
Operation & Maintenance		
a) Prior to Handover	☑	
b) Following Handover		☑

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FIGURES

Date: 1/08/2019 Job No. H19033

Site

0 200 400 600 800
Meters

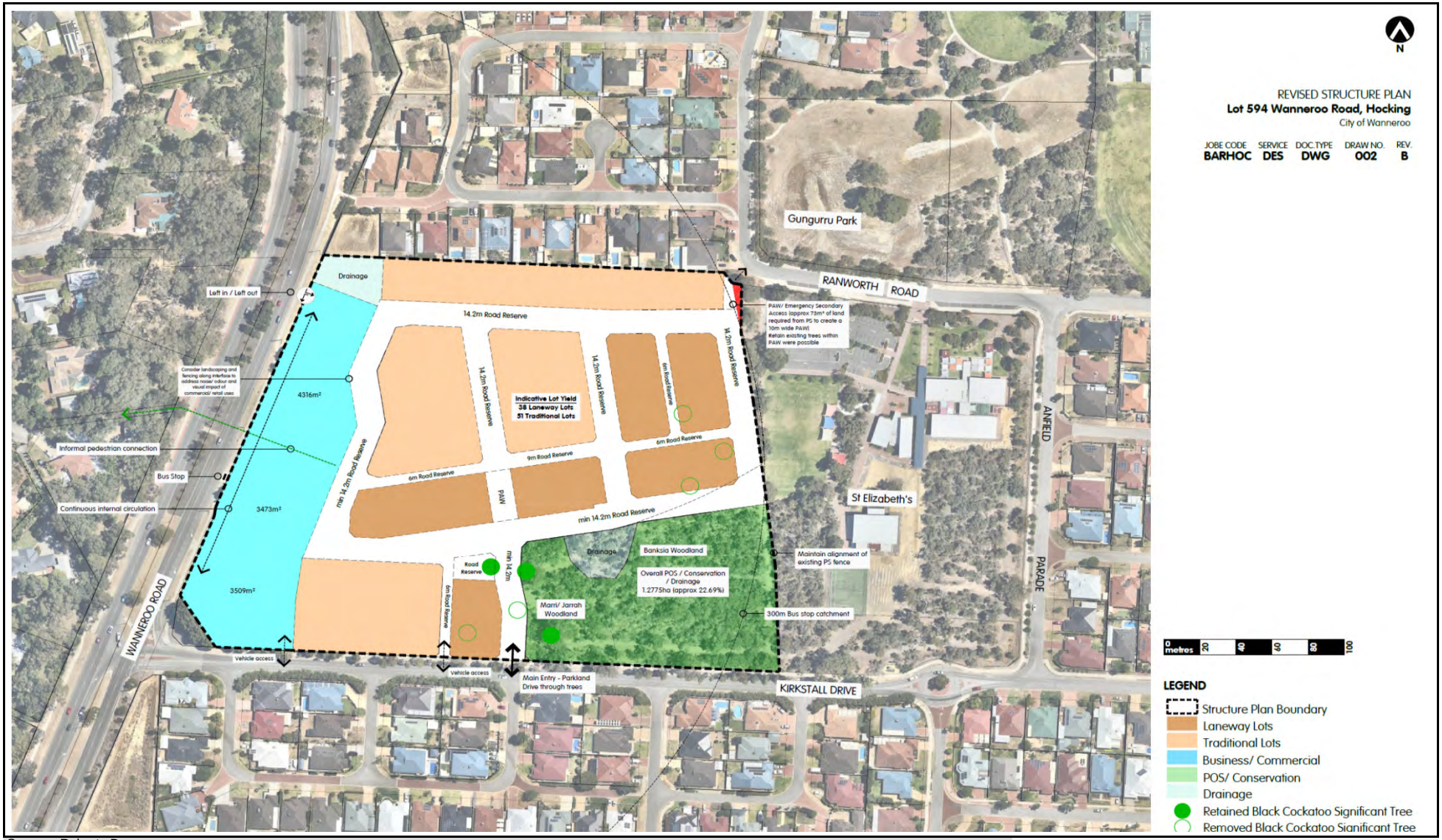
hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Location Plan

Figure 1

Date: 30/07/2019 Job No H19033



Source : Roberts Day

hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Indicative Structure Plan

Figure 2

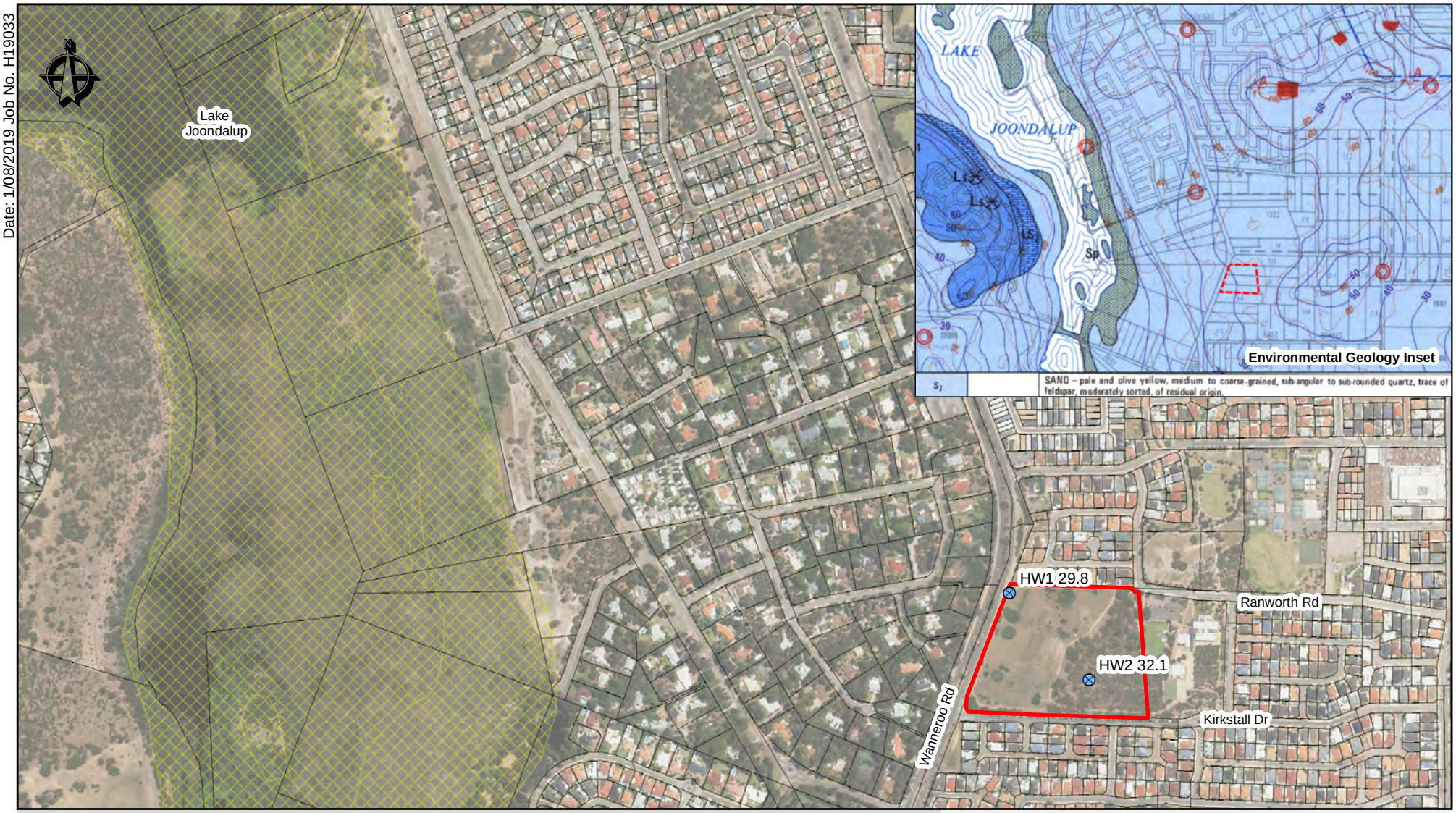
hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Site Condition Plan

Figure 3

Date: 1/08/2019 Job No. H19033



Site

High to Moderate Risk of ASS

Permeabilty Test Location & Result (m/day)

0 100 200 300 400 Meters

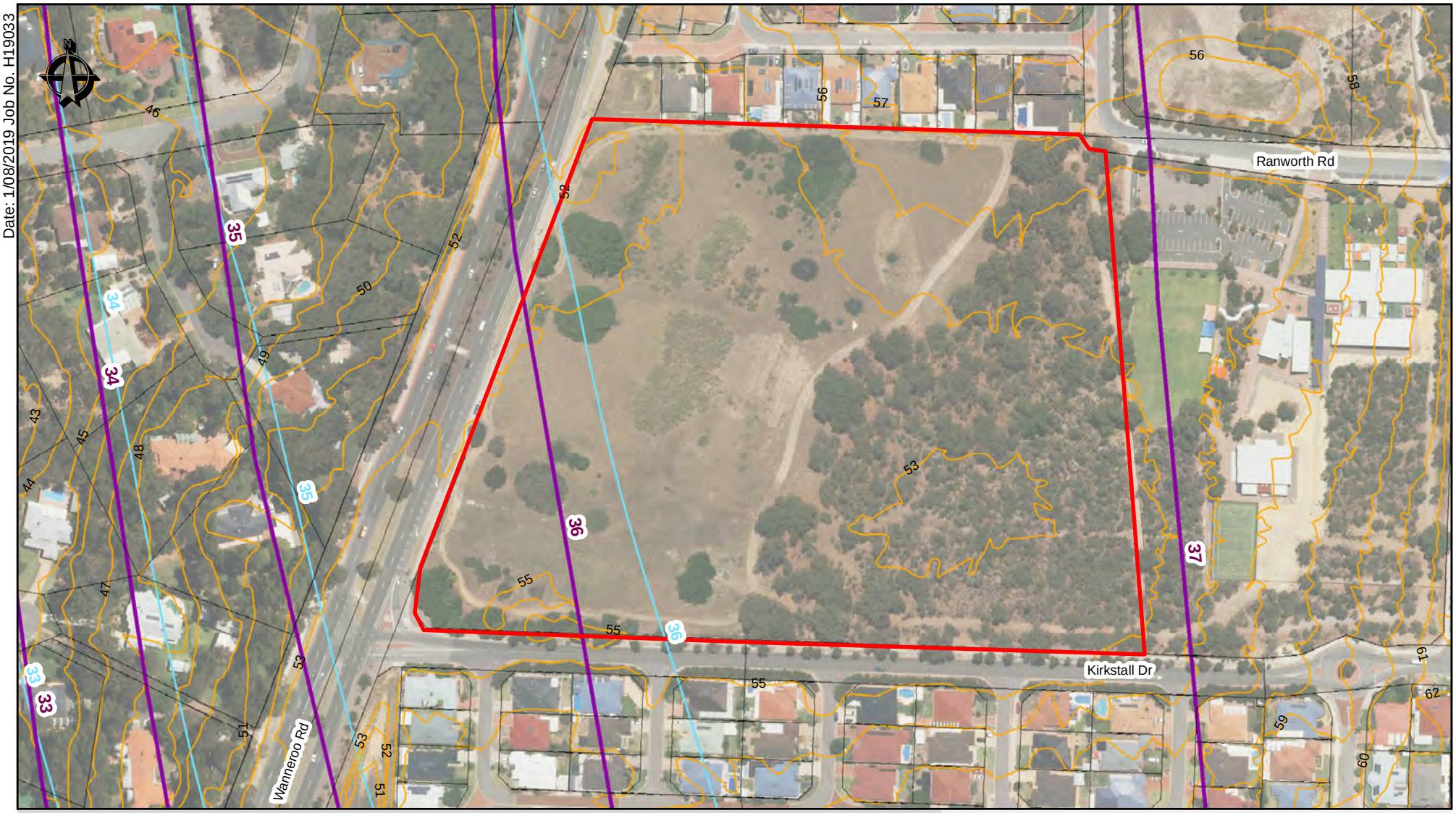
hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Geotechnical Plan

Figure 4

Date: 1/08/2019 Job No. H19033



hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Groundwater Plan

Figure 5

Date: 1/08/2019 Job No. H19033

Site
Topography (mAHD)

0 25 50 75 100 Meters

Commercial
Drainage
Laneway Lots
POS/Conservation
Road Reserve
Traditional Lots

hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Stormwater Catchment Plan

Figure 6

hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

Stormwater Management Plan

Figure 7

APPENDIX A
LWMS Checklist

Better Urban Water Management LWMS Checklist

Local Water Management Strategy Item	Deliverable	✓	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Design elements and requirements for BMP's and critical control points	☑	Executive Summary & Section 4
Introduction			
Total water cycle management - principles and objectives Planning background Previous studies		☑	Introduction, Sections 1.1 & 1.2
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site context plan Structure plan	☑	Section 1, 2, & 3. Figure 1, Figure 2, Figure 3
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape plan	☑	Stormwater Areas and Volumes to inform POS credits in Section 6 & Figure 6. Water availability identified in Section 5.2. Landscape Plan in Appendix D
Design criteria			
Agreed design objective and source of objective		☑	Section 4
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 3 & Figures 3-5
Site conditions- existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	☑	Section 3.1, Figure 3
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 3.2, Figure 4. Appendix B
Environmental- areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Sections 3.3-3.5
Surface water- topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface water plan	☑	Section 3.5
Groundwater - topography, pre development groundwater levels and water quality, test bore locations	Groundwater plan plus details of groundwater monitoring and testing	☑	Section 3.6, Figure 5, Appendix C
Water use sustainability initiatives			
Water efficiency measures- private and public open spaces including method of enforcement		☑	Section 5.1
Water supply (fit- for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		☑	Section 5.2
Wastewater management		☑	Section 5.3
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points, 100 year flow paths and 100 year detentions storage areas	100yr event plan Long section of critical points	☑	Section 6 & 6.2, Figure 6, Appendix F
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event plan	☑	Section 6 & 6.2, Figure 6, Appendix F
Protect ecology - detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1 yr event plan Typical cross sections	☑	Section 6 & 6.1, Figures 6 and 7

Local Water Management Strategy Item	Deliverable	✓	Comments
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoil areas/exclusion zones	Groundwater/subsoil plan	☑	Section 7
Actions to address acid sulphate soils or contamination		☑	Section 7.1
The next stage - subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design		☑	Section 8
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9
Implementation			
Developer commitments		☑	Section 10
Roles, responsibilities, funding for implementation		☑	Section 10
Review		☑	Section 10

APPENDIX B
Hyd2o Permeability Testing

Borehole Permeameter : Field Result Analysis

Project/Site	Lot 594 Wanneroo Rd Hocking : Site HW1 (near Wanneroo Rd)
Soil Profile	Yellow Medium Sand (Moist) @ 0.6-0.7m Test Depth
Location	387463 mE
	6484346 mN

TEST 1

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**3.5**	
5	**23.2**	19.7
10	**31.1**	7.9
15	**45.2**	14.1
20	**49.3**	4.1
25	**72.1**	22.8
28 (EOT)		

	13.7
q (cm^3/s)	24.1

TEST 2

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**4.2**	
5	**17.2**	13.0
10	**28.1**	10.9
15	**39.8**	11.7
20	**46.0**	6.2
25	**56.5**	10.5
30	**66.8**	10.3
35	**72.0**	5.2
37 (EOT)		

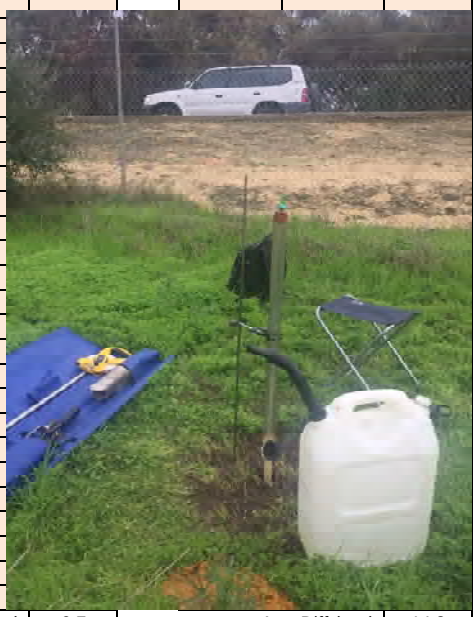
Avg Diff (cm)	9.7
q (cm^3/s)	17.0

TEST 3

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**4.4**	
5	**25.2**	20.8
10	**38.8**	13.6
15	**44.5**	5.7
20	**59.5**	15.0
25 (EOT)	**76.0**	16.5

Avg Diff (cm)	14.3
q (cm^3/s)	25.2



METHOD 1 : Elrick and Reynolds (1992)

Ks (cm/s)	0.0377	Ks (cm/s)	0.0266	Ks (cm/s)	0.0393
Ks (m/day)	32.54	Ks (m/day)	22.97	Ks (m/day)	33.96
Average (m/day)	**29.82**				

METHOD 2 : Talsma and Hallam Method (recommended for low Ks only <2.9)

q (cm3/min)	1448.8		1022.8	cm3/min	1512.2	cm3/min
r (cm)	4		4.0	cm	4.0	cm
H (cm)	10.0		10.0	cm	10.0	cm
$0.5\sinh^{-1}(H/2r)$	0.52		0.52		0.52	
-sqrt((r/H)^2+0.25)	-0.64		-0.64		-0.64	
r/H	0.40		0.40		0.40	
Sum	0.28		0.28		0.28	
Sum*4.4*q	1807.17		1275.78		1886.20	
$2*pi*H^2$	628.32		628.32		628.32	
Ksat (cm/min)	2.9		2.0		3.0	
Ksat (m/day)	41.42		29.24		43.23	
Average (m/day)	**37.96**					

Borehole Permeameter : Field Result Analysis

Project/Site	Lot 594 Wanneroo Rd Hocking : Site HW2 (Banksia Woodland)
Soil Profile	Yellow Medium Sand (Moist) @ 0.6-0.7m Test Depth
Location	387608 mE
	6484187 mN

TEST 1

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**3.5**	
5	**19.0**	15.5
10	**32.0**	13.0
15	**42.9**	10.9
20	**56.5**	13.6
25	**69.2**	12.7
28 (EOT)		

Avg Diff (cm) 13.1
q (cm^3/s) 23.1

TEST 2

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**4.4**	
5	**22.2**	17.8
10	**33.5**	11.3
15	**48.2**	14.7
20	**57.2**	9.0
25	**71.3**	14.1
28 (EOT)		

Avg Diff (cm) 13.4
q (cm^3/s) 23.5

TEST 3

r	4.0	cm
H	10.0	cm
time step	5	secs
H/r	2.50	
C	1.06	

Time (sec)	Level (cm)	Diff (cm)
0	**5.7**	
5	**23.0**	17.3
10	**29.2**	6.2
15	**48.0**	18.8
20	**65.8**	17.8
25 (EOT)	**76.0**	10.2

Avg Diff (cm) 14.1
q (cm^3/s) 24.7

METHOD 1 : Elrick and Reynolds (1992)

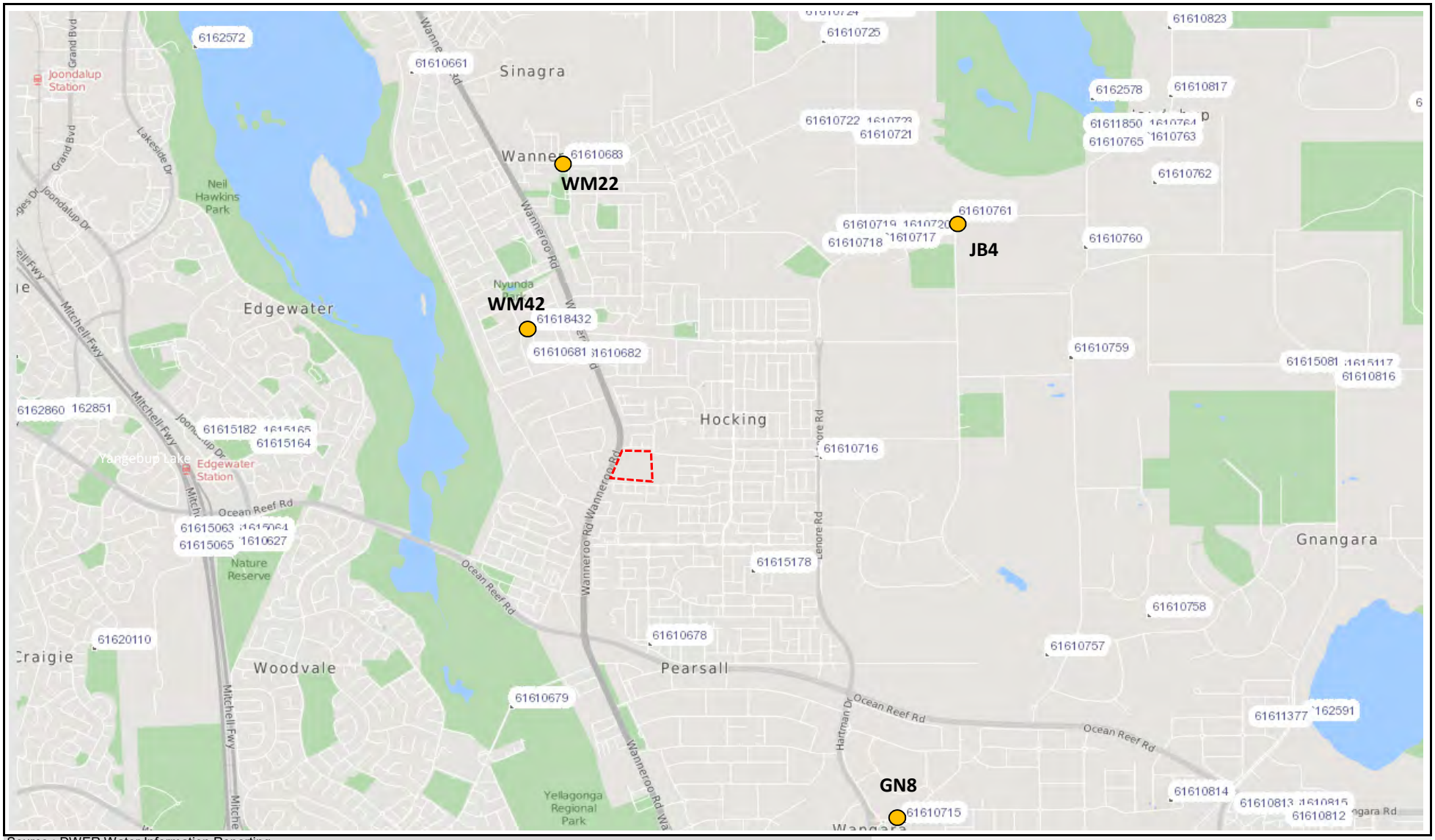
	TEST 1	TEST 2	TEST 3
Ks (cm/s)	0.0361	0.0367	0.0386
Ks (m/day)	31.16	31.73	33.34
Average (m/day)	**32.08**		

METHOD 2 : Talsma and Hallam Method (recommended for low Ks only <2.9)

	TEST 1	TEST 2	TEST 3
q (cm3/min)	1387.6	1412.9 cm3/min	1484.7 cm3/min
r (cm)	4	4.0 cm	4.0 cm
H (cm)	10.0	10.0 cm	10.0 cm
$0.5\sinh^{-1}(H/2r)$	0.52	0.52	0.52
-sqrt((r/H)^2+0.25)	-0.64	-0.64	-0.64
r/H	0.40	0.40	0.40
Sum	0.28	0.28	0.28
Sum*4.4*q	1730.78	1762.39	1851.96
$2*pi*H^2$	628.32	628.32	628.32
Ksat (cm/min)	2.8	2.8	2.9
Ksat (m/day)	39.67	40.39	42.44
Average (m/day)	**40.83**		

APPENDIX C
Nearby DWER Groundwater Bore Hydrographs

Date: 31/07/2019 Job No H19033



Source : DWER Water Information Reporting

Site

Nearby DWER Monitoring Bores with Long Term Record

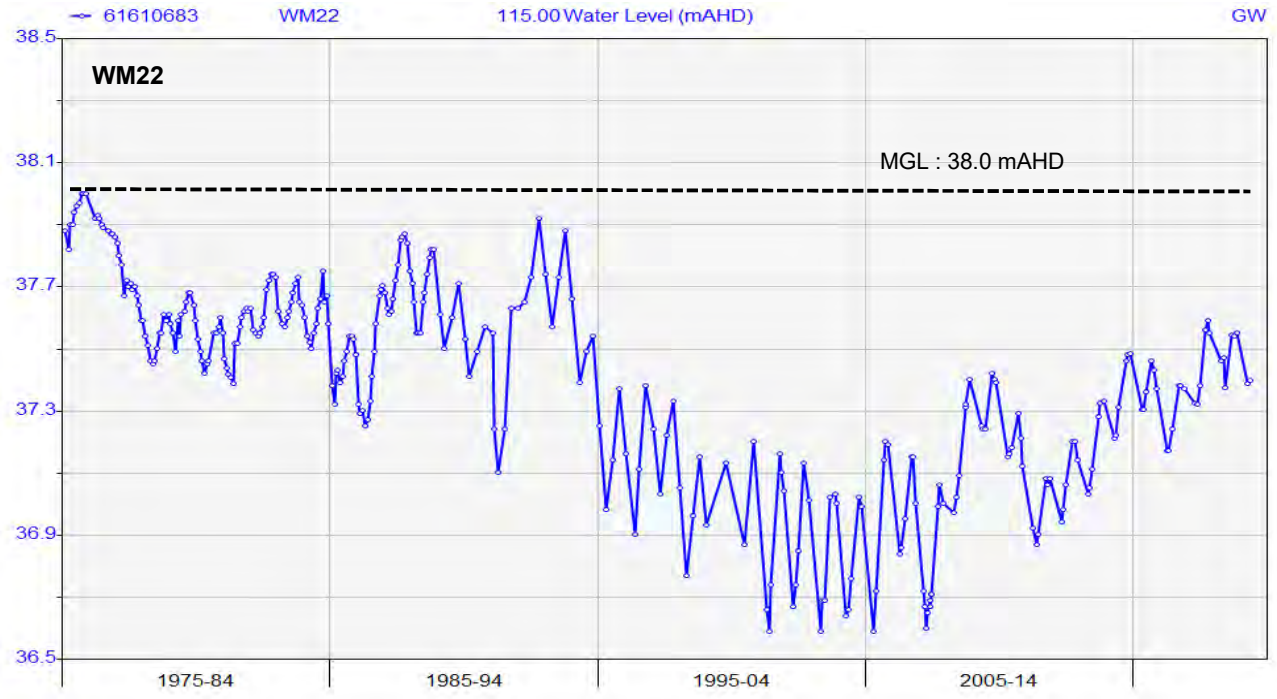
hyd$_2$o

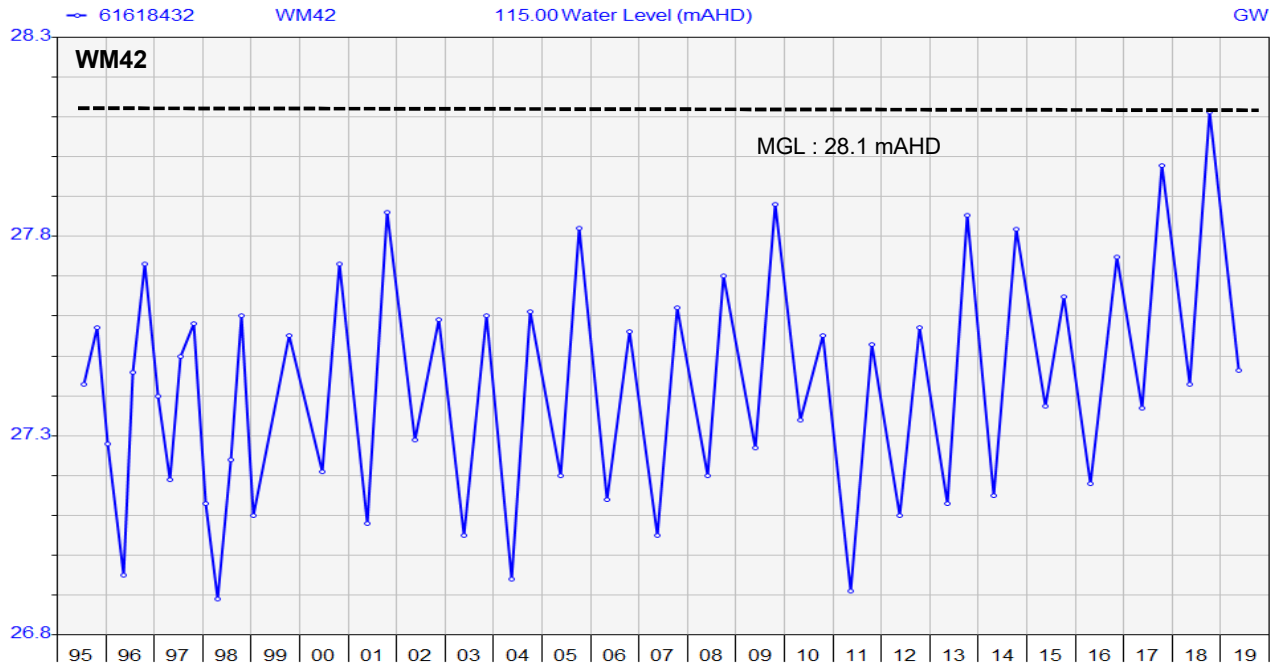
Lot 594 Wanneroo Rd Hocking LWMS

DWER Nearby Groundwater Bore Locations

Appendix C1

Date: 1/8/2019 Job No. H19033





Source : DWER Water Information Reporting

---- Maximum Groundwater Level (MGL)

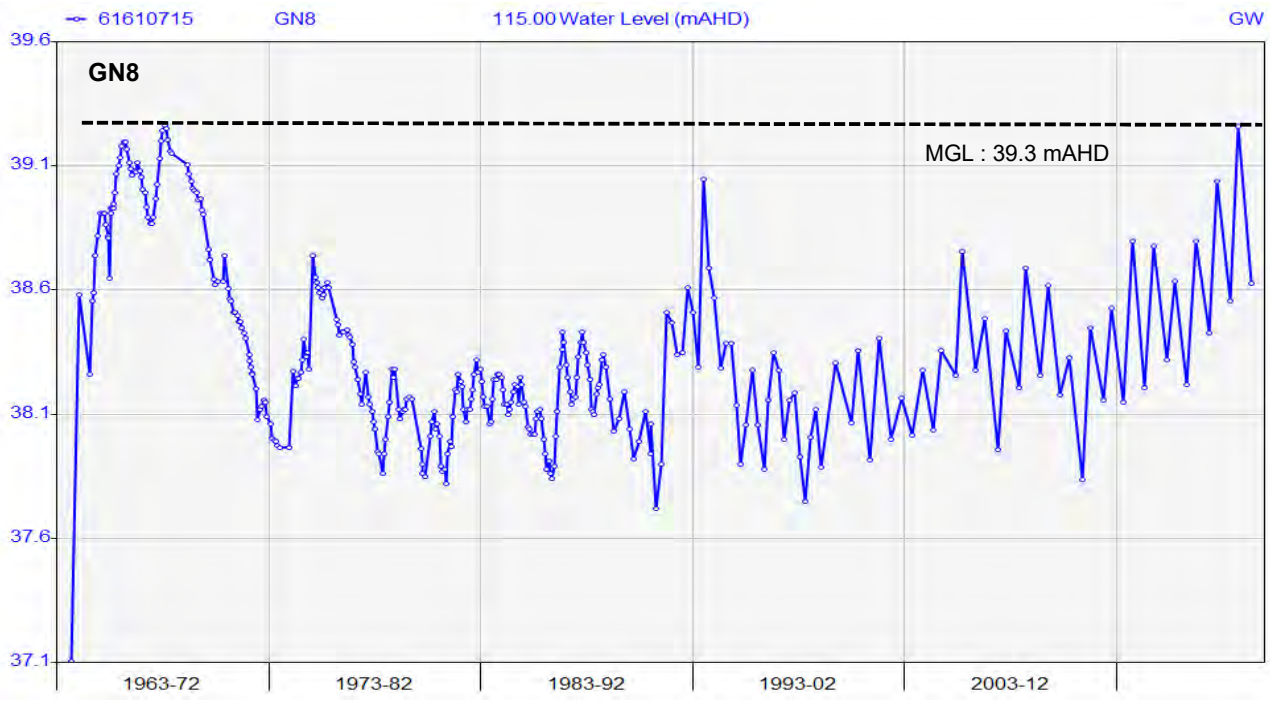
hyd2o

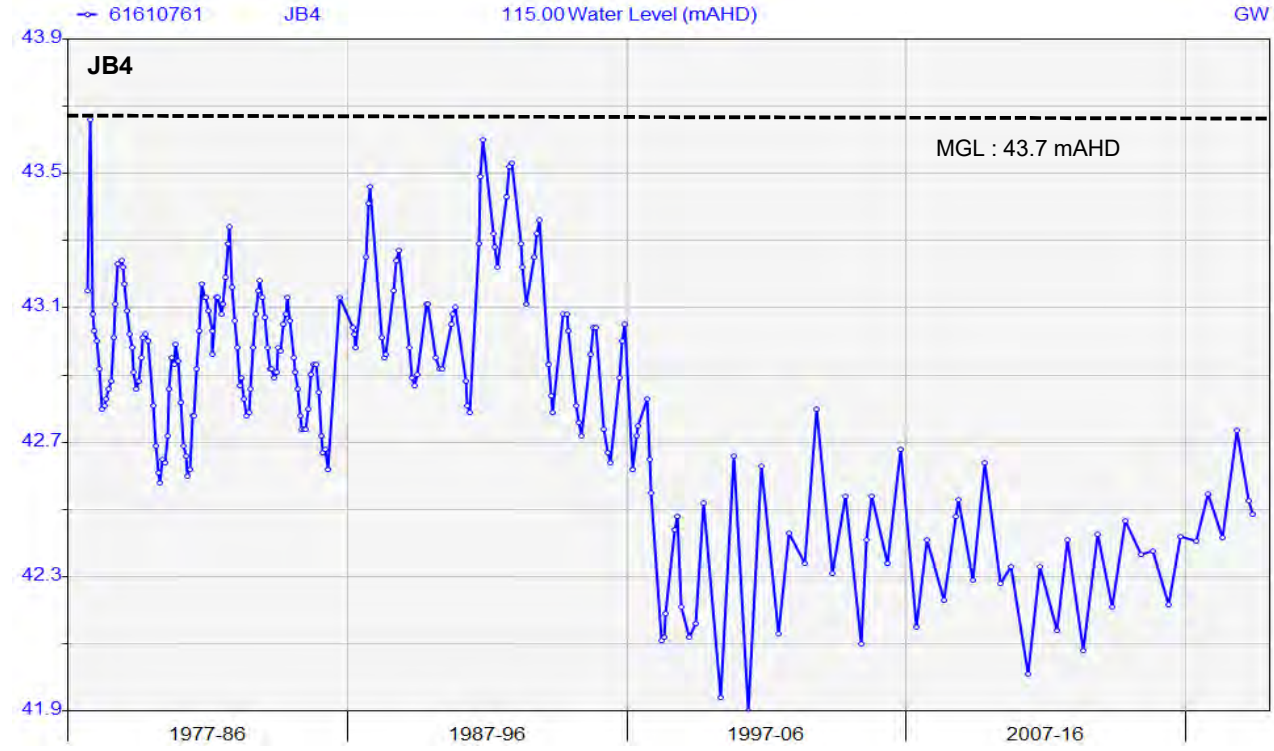
Lot 594 Wanneroo Rd Hocking LWMS

DWER Bore Hydrographs

Appendix C2

Date: 1/8/2019 Job No. H19033





Source : DWER Water Information Reporting

---- Maximum Groundwater Level (MGL)

hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

DWER Bore Hydrographs

Appendix C3

APPENDIX D
Landscape Concept Plans

INDICATIVE POS CONCEPT PLAN

LOT 594 WANNEROO ROAD, HOCKING

our ref: BAR HOC_DES_ILL_002 A POS CONCEPT PLAN

APPENDIX E
CURRV Runoff Rate Calculator

CURRV

Calculator for Urban Runoff Rates & Volumes

02-08-19

Project: Lot 594 Wanneroo Rd Hocking : Catch A

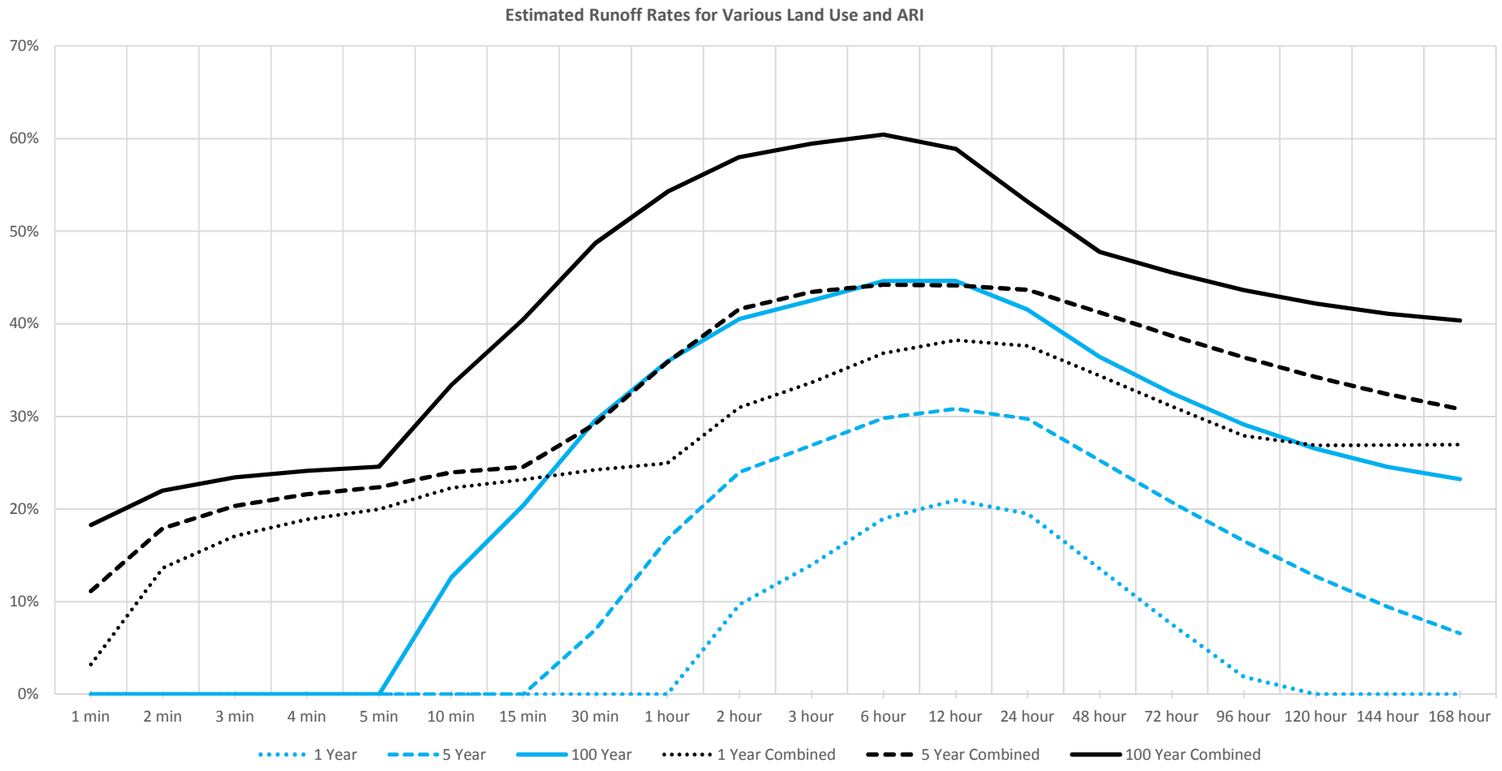
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Traditional Lots	0.87	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	soakwells
2	Laneway Lots	0.14	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	soakwells
3	POS	0.00	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	no POS in catchment A
4	Drainage	0.08	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	5	95	to include direct rainfall on storage area
5	Road Reserve	0.69	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	assume similar EIA/TIA to rural residential
6			No	1.5	20.0	4.0		1.00					
7			No	1.5	20.0	4.0		1.00					
8			No	1.5	20.0	4.0		1.00					
9			No	1.5	20.0	4.0		1.00					
10			No	0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector: **1**

(11 - combined total)

Traditional Lots



Rainfall IFD Data

Annual Exceedence Probability

	Duration	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
1	1 min	1.70	2.09	2.53	2.92	3.37	4.01	4.52
2	2 min	2.99	3.65	4.35	4.98	5.71	6.77	7.65
3	3 min	4.00	4.89	5.86	6.72	7.73	9.19	10.40
4	4 min	4.84	5.92	7.13	8.20	9.45	11.20	12.70
5	5 min	5.55	6.80	8.21	9.46	10.90	13.00	14.70
6	10 min	8.08	9.94	12.10	14.00	16.10	19.20	21.70
7	15 min	9.78	12.00	14.60	16.90	19.50	23.20	26.10
8	30 min	13.10	16.10	19.40	22.40	25.80	30.60	34.50
9	1 hour	17.00	20.80	25.00	28.80	33.20	39.60	44.90
10	2 hour	21.80	26.50	31.80	36.70	42.60	51.40	58.80
11	3 hour	25.10	30.50	36.50	42.30	49.40	60.10	69.20
12	6 hour	31.80	38.60	46.40	54.10	63.60	78.20	91.00
13	12 hour	40.10	48.70	58.60	68.30	80.40	99.10	116.00
14	24 hour	50.30	61.20	73.20	84.40	97.90	119.00	138.00
15	48 hour	62.80	76.50	90.10	102.00	115.00	136.00	154.00
16	72 hour	71.90	87.40	102.00	113.00	126.00	147.00	163.00
17	96 hour	79.40	96.60	112.00	124.00	137.00	158.00	173.00
18	120 hour	86.30	105.00	121.00	134.00	148.00	170.00	186.00
19	144 hour	92.80	113.00	130.00	144.00	161.00	183.00	201.00
20	168 hour	99.20	120.00	139.00	155.00	174.00	199.00	219.00

Estimated Runoff Rates

Annual Exceedence Probability

Maximum of All Events	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
Traditional Lots	21%	26%	31%	34%	38%	42%	45%
Laneway Lots	21%	26%	31%	34%	38%	42%	45%
POS	1%	1%	5%	8%	11%	15%	17%
Drainage	5%	5%	17%	28%	38%	49%	56%
Road Reserve	69%	69%	71%	75%	78%	82%	85%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**38%**	42%	**44%**	**49%**	53%	58%	**60%**

Event Selector	7	15 min					
Traditional Lots	0%	0%	0%	1%	8%	15%	20%
Laneway Lots	0%	0%	0%	1%	8%	15%	20%
POS	1%	1%	1%	1%	1%	4%	7%
Drainage	4%	4%	4%	5%	5%	14%	23%
Road Reserve	59%	61%	63%	64%	65%	68%	72%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**23%**	24%	**25%**	**25%**	30%	36%	**40%**

CURRV

Calculator for Urban Runoff Rates & Volumes

02-08-19

Project: Lot 594 Wanneroo Rd Hocking : Catch B

	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Traditional Lots	0.56	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	soakwells
2	Laneway Lots	0.86	Yes	1.5	20.0	4.0	15.0	1.00	60%	65	22	13	soakwells
3	POS	1.10	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	conservation area
4	Drainage	0.09	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	5	95	to include direct rainfall on storage area
5	Road Reserve	0.99	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	assume similar EIA/TIA to rural residential
6			No	1.5	20.0	4.0		1.00					
7			No	1.5	20.0	4.0		1.00					
8			No	1.5	20.0	4.0		1.00					
9			No	1.5	20.0	4.0		1.00					
10			No	0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Rainfall IFD Data

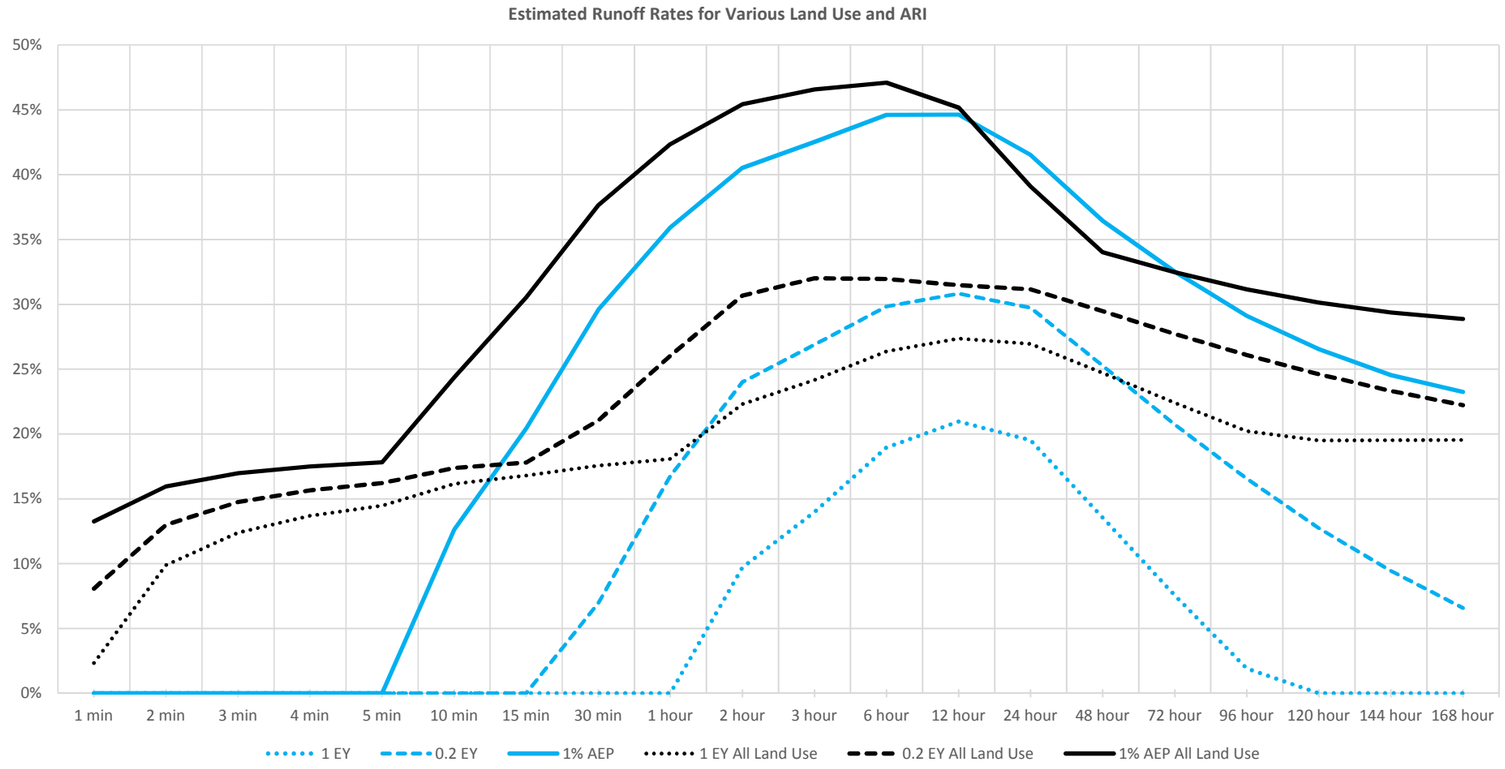
Annual Exceedence Probability

	Duration	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
1	1 min	1.70	2.09	2.53	2.92	3.37	4.01	4.52
2	2 min	2.99	3.65	4.35	4.98	5.71	6.77	7.65
3	3 min	4.00	4.89	5.86	6.72	7.73	9.19	10.40
4	4 min	4.84	5.92	7.13	8.20	9.45	11.20	12.70
5	5 min	5.55	6.80	8.21	9.46	10.90	13.00	14.70
6	10 min	8.08	9.94	12.10	14.00	16.10	19.20	21.70
7	15 min	9.78	12.00	14.60	16.90	19.50	23.20	26.10
8	30 min	13.10	16.10	19.40	22.40	25.80	30.60	34.50
9	1 hour	17.00	20.80	25.00	28.80	33.20	39.60	44.90
10	2 hour	21.80	26.50	31.80	36.70	42.60	51.40	58.80
11	3 hour	25.10	30.50	36.50	42.30	49.40	60.10	69.20
12	6 hour	31.80	38.60	46.40	54.10	63.60	78.20	91.00
13	12 hour	40.10	48.70	58.60	68.30	80.40	99.10	116.00
14	24 hour	50.30	61.20	73.20	84.40	97.90	119.00	138.00
15	48 hour	62.80	76.50	90.10	102.00	115.00	136.00	154.00
16	72 hour	71.90	87.40	102.00	113.00	126.00	147.00	163.00
17	96 hour	79.40	96.60	112.00	124.00	137.00	158.00	173.00
18	120 hour	86.30	105.00	121.00	134.00	148.00	170.00	186.00
19	144 hour	92.80	113.00	130.00	144.00	161.00	183.00	201.00
20	168 hour	99.20	120.00	139.00	155.00	174.00	199.00	219.00

Land Use Graph Selector: **1**

(11 - combined total for all land use)

Traditional Lots



Estimated Runoff Rates

Annual Exceedence Probability

Maximum of All Events	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
Traditional Lots	21%	26%	31%	34%	38%	42%	45%
Laneway Lots	21%	26%	31%	34%	38%	42%	45%
POS	1%	1%	5%	8%	11%	15%	17%
Drainage	5%	5%	17%	28%	38%	49%	56%
Road Reserve	69%	69%	71%	75%	78%	82%	85%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**27%**	30%	**32%**	**36%**	40%	45%	**47%**

Event Selector	7	15 min					
Traditional Lots	0%	0%	0%	1%	8%	15%	20%
Laneway Lots	0%	0%	0%	1%	8%	15%	20%
POS	1%	1%	1%	1%	1%	4%	7%
Drainage	4%	4%	4%	5%	5%	14%	23%
Road Reserve	59%	61%	63%	64%	65%	68%	72%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**17%**	17%	**18%**	**18%**	21%	26%	**31%**

CURRV

Calculator for Urban Runoff Rates & Volumes

02-08-19

Project: Lot 594 Wanneroo Rd Hocking : Full Site Runoff

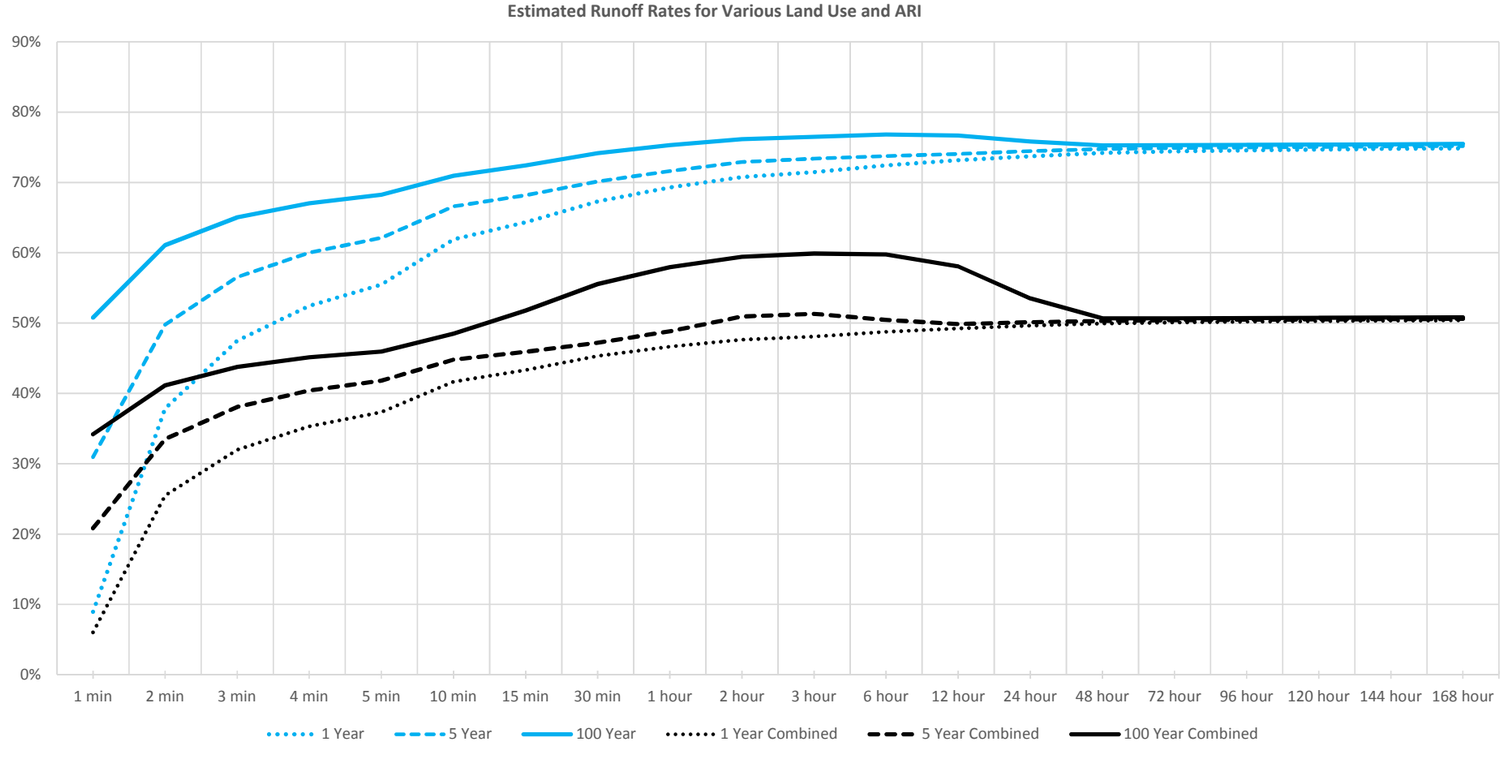
	Land Use Description	Area (ha)	Use in Calc	Imperv Initial Loss mm	Perv Initial Loss mm	Perv Continue Loss mm/hr	On Site Soak (mm)	Empty (days)	AR&R EIA/TIA System Connect Ratio	Roof %	Ext Imp %	Ext Perv %	Comment
1	Traditional Lots	1.65	Yes	1.5	20.0	4.0	0.0	1.00	60%	65	22	13	
2	Laneway Lots	1.00	Yes	1.5	20.0	4.0	0.0	1.00	60%	65	22	13	
3	POS	1.10	Yes	1.5	20.0	4.0	0.0	1.00	30%	0	5	95	
4	Drainage	0.17	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	5	95	
5	Road Reserve	1.68	Yes	1.5	20.0	4.0	0.0	1.00	100%	0	70	30	
6	Commercial	1.13	Yes	1.5	20.0	4.0	0.0	1.00	80%	60	35	5	
7			No	1.5	20.0	4.0		1.00					
8			No	1.5	20.0	4.0		1.00					
9			No	1.5	20.0	4.0		1.00					
10			No	0.0	20.0	4.0		1.00					

EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	6

(11 - combined total)

Commercial



Rainfall IFD Data

Annual Exceedence Probability

	Duration	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
1	1 min	1.70	2.09	2.53	2.92	3.37	4.01	4.52
2	2 min	2.99	3.65	4.35	4.98	5.71	6.77	7.65
3	3 min	4.00	4.89	5.86	6.72	7.73	9.19	10.40
4	4 min	4.84	5.92	7.13	8.20	9.45	11.20	12.70
5	5 min	5.55	6.80	8.21	9.46	10.90	13.00	14.70
6	10 min	8.08	9.94	12.10	14.00	16.10	19.20	21.70
7	15 min	9.78	12.00	14.60	16.90	19.50	23.20	26.10
8	30 min	13.10	16.10	19.40	22.40	25.80	30.60	34.50
9	1 hour	17.00	20.80	25.00	28.80	33.20	39.60	44.90
10	2 hour	21.80	26.50	31.80	36.70	42.60	51.40	58.80
11	3 hour	25.10	30.50	36.50	42.30	49.40	60.10	69.20
12	6 hour	31.80	38.60	46.40	54.10	63.60	78.20	91.00
13	12 hour	40.10	48.70	58.60	68.30	80.40	99.10	116.00
14	24 hour	50.30	61.20	73.20	84.40	97.90	119.00	138.00
15	48 hour	62.80	76.50	90.10	102.00	115.00	136.00	154.00
16	72 hour	71.90	87.40	102.00	113.00	126.00	147.00	163.00
17	96 hour	79.40	96.60	112.00	124.00	137.00	158.00	173.00
18	120 hour	86.30	105.00	121.00	134.00	148.00	170.00	186.00
19	144 hour	92.80	113.00	130.00	144.00	161.00	183.00	201.00
20	168 hour	99.20	120.00	139.00	155.00	174.00	199.00	219.00

Estimated Runoff Rates

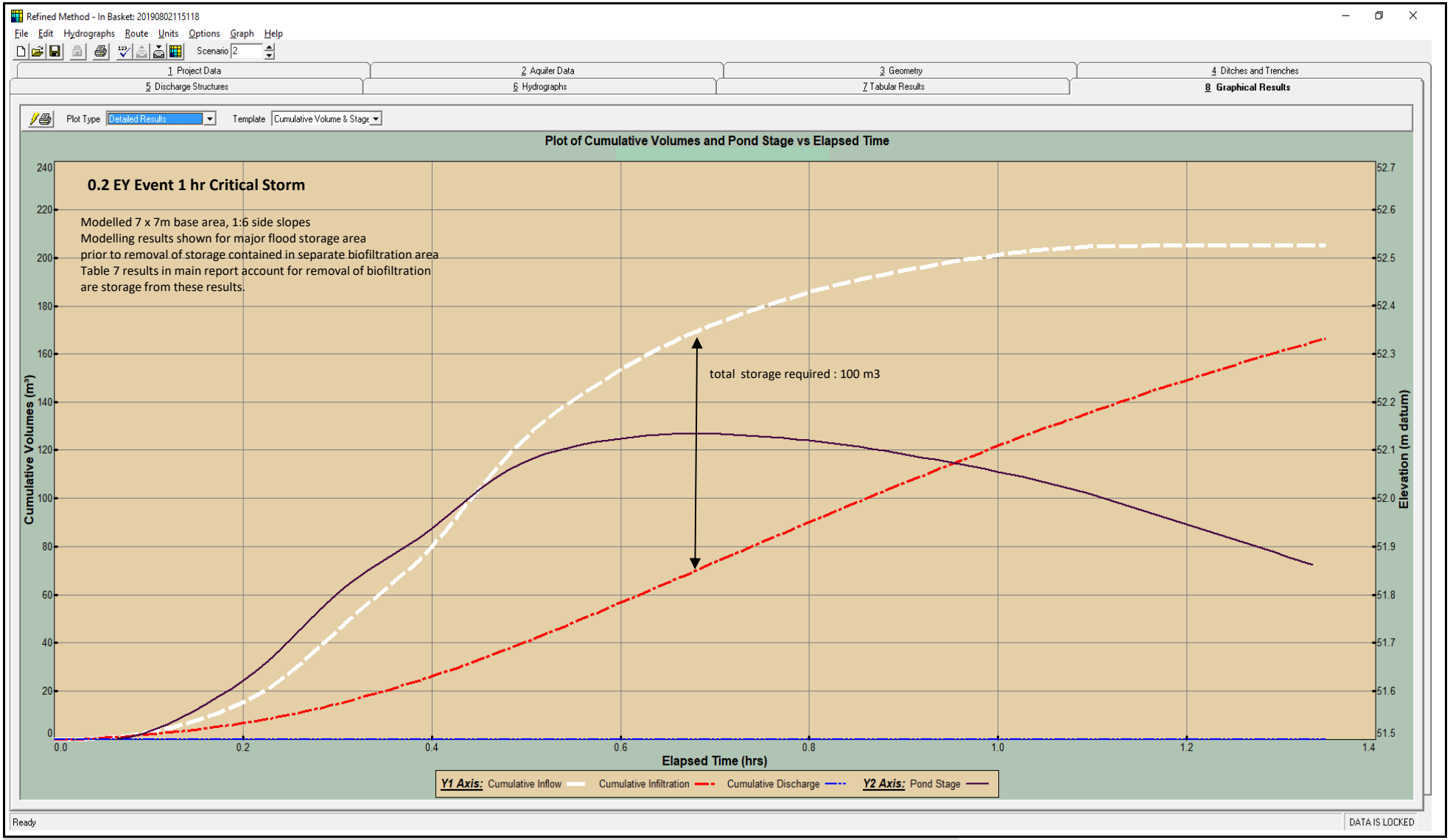
Annual Exceedence Probability

Maximum of All Events	1 EY	0.5 EY	0.2 EY	10% AEP	5% AEP	2 % AEP	1 % AEP
Traditional Lots	51%	52%	52%	52%	53%	55%	55%
Laneway Lots	51%	52%	52%	52%	53%	55%	55%
POS	1%	1%	5%	8%	11%	15%	17%
Drainage	5%	5%	17%	28%	38%	49%	56%
Road Reserve	69%	69%	71%	75%	78%	82%	85%
Commercial	75%	75%	75%	75%	75%	76%	77%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**50%**	51%	**51%**	**54%**	56%	58%	**60%**

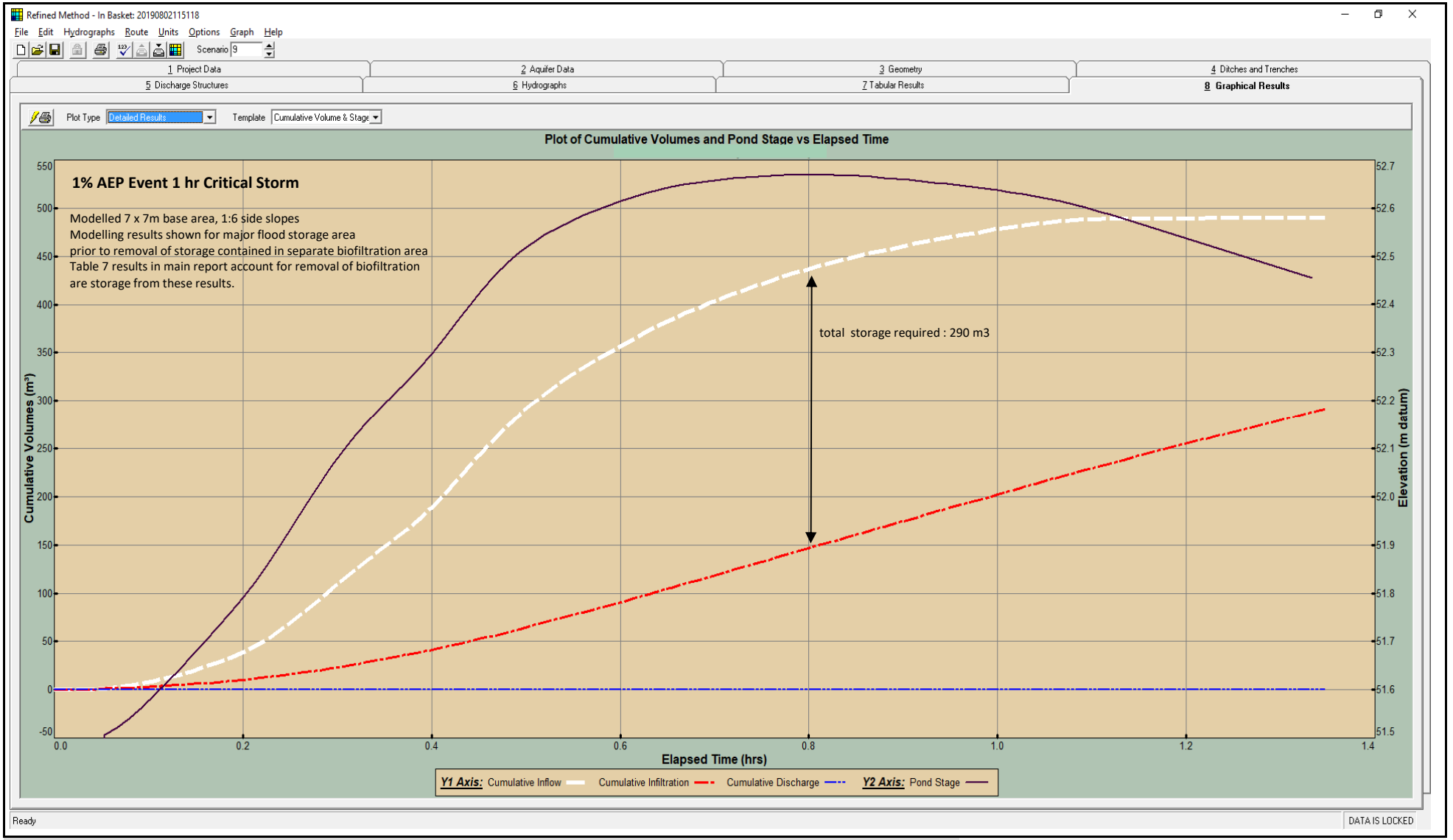
Event Selector	12	6 hour					
Traditional Lots	50%	50%	51%	52%	53%	55%	55%
Laneway Lots	50%	50%	51%	52%	53%	55%	55%
POS	1%	1%	3%	7%	10%	14%	16%
Drainage	5%	5%	10%	23%	34%	46%	54%
Road Reserve	67%	67%	69%	74%	78%	82%	84%
Commercial	72%	73%	74%	75%	75%	76%	77%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**49%**	49%	**50%**	**53%**	56%	58%	**60%**

APPENDIX F
PONDS Stormwater Modelling Outputs

Date : 2/08/2019 Job No: H19033



Date : 2/08/2019 Job No: H19033



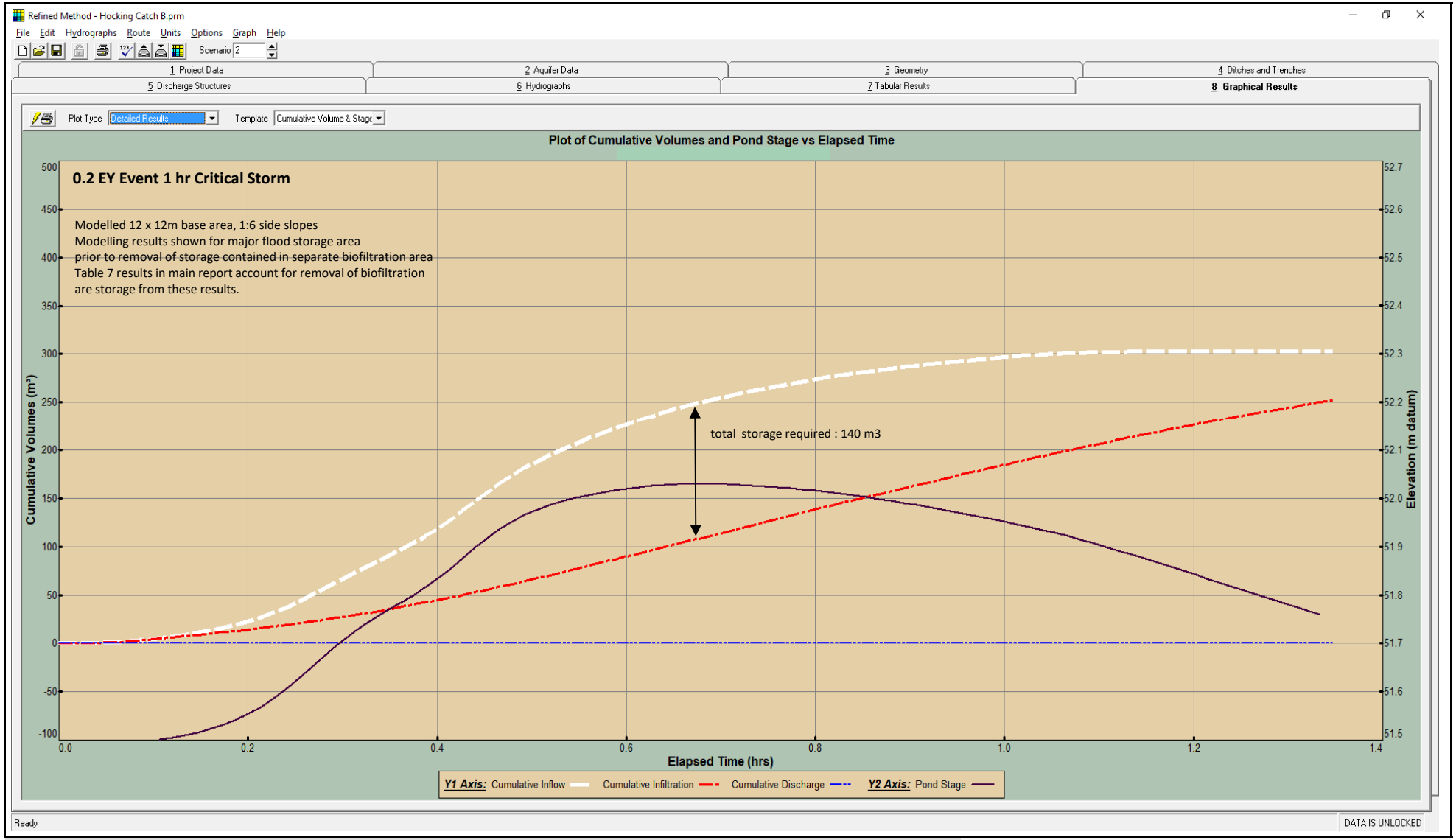
hyd$_2$o

Lot 594 Wanneroo Rd Hocking LWMS

1% AEP Event PONDS Modelling : Catchment A

Appendix F2

Date : 2/08/2019 Job No: H19033



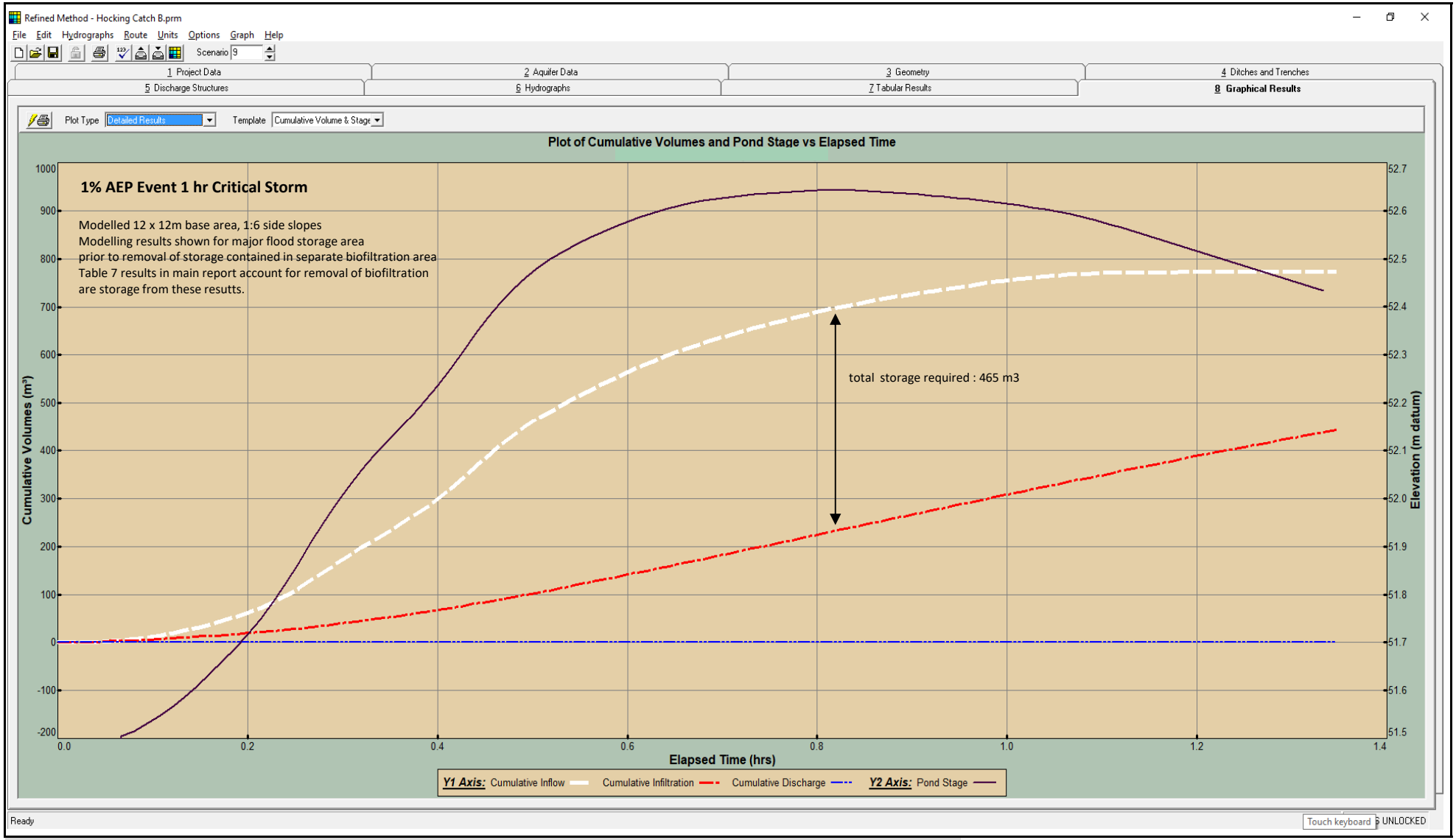
hyd$_2$o

Lot 594 Wanneroo Rd Hocking LWMS

0.2 EY Event PONDS Modelling : Catchment B

Appendix F3

Date : 2/08/2019 Job No: H19033



hyd2o

Lot 594 Wanneroo Rd Hocking LWMS

1% AEP Event PONDS Modelling : Catchment B

Appendix F4

abn 93 697 380 883
suite 6b 103 rokeby rd subiaco wa 6008
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