North Somerville

District Water Management Strategy

May 2022

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Executive Summary

Hyd2o was commissioned by City of Kalgoorlie-Boulder (CKB) to prepare this District Water Management Strategy (DWMS) to support the proposed district structure planning process for an area of land within the suburb of Somerville (herein referred to as the site).

The site has a total area of approximately 35 ha located within CKB. The proposed district structure plan aims to facilitate urban development over a number of lots currently under various zonings such as general residential, parks and recreation, and rural under the City's Town Planning Scheme (TPS) No. 1. A District Structure Plan (DSP) has been prepared by Rowe Group to indicate a proposed layout for this development.

The site is bound to the west by Great Eastern Hwy, banks of Gribble Creek regarded as public open space (POS) to the north, Connor St to the east and urban development to the south (Figure 1). It is mainly cleared with sparse vegetation for a combination of rural and parkland uses. Three of the smaller lots have already been developed for general residential/rural living.

From a stormwater management perspective the site has good clearance to groundwater but is limited by low permeability/high runoff clay loam soils. A number of existing surface flow paths traverse the site which need to be considered and maintained given the servicing of large upstream urban catchments. These surface flow paths currently breakout across the site from the main Gribble Creek channel in major storm events.

This document has been prepared to provide recommendations in implementing an integrated flood management approach for the site that addresses these existing constraints.

This document has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008), and has considered previous flood study documentation and recommendations for the area prepared by GHD (2019) and Advisian (2017).

Implementation of the strategy will be undertaken in accordance with Better Urban Water Management through the development and implementation of a Local Water Management Strategy and Urban Water Management Plans for individual stages of development within the site.

District Water Management Strategy Summary

Water Supply	
Water Efficiency	• Promotion of 6 star building standards (water efficient fixtures and fittings). • 'Waterwise' targets in homes and 'waterwise' designs out of home (POS & gardens).
Water Supply	• Construction; Non-potable ideal however scheme usage where/if required. • Lots: Water Corporation IWSS and rainwater tanks (optional). • POS: Seek innovative alternatives to groundwater and scheme water.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Design & Management	• All habitable development levels to have suitable clearance above the 1% AEP flood levels of the local stormwater management system. • Post development stormwater discharge from the site assessed and considered relative to existing conditions and the sites existing opportunities and constraints. • Integrate design with existing flow paths to the benefit of the local area. • Water quality aim to be improved relative to pre development conditions to improve ecological outcomes.
Lot Scale	• Lot connections to minimise imported fil. • Rainwater tanks (optional). • Water-wise landscaping (where appropriate).
Street Scale	• Rain gardens / biofiltration areas. • Swales / piped drainage.
Estate Scale	• Water quality treatment areas for first 15 mm runoff via biolfitration. • Flood management areas sized to attenuate flows in accordance with agency requirements and capacity of downstream infrastructure. • Pre and post development performance monitoring and annual reporting.
Groundwater	
Fill & Subsoil	• Use of imported fill to be minimised, subject to provision of suitable clearance above major event flood levels. • Subsoil unlikely to be required under lots and roads
Acid Sulphate Soils	• No known risk of ASS.
Implementation	
Process	• No structured predevelopment monitoring programme specified. Actual major events to inform planning if/where applicable. • Post-development, the system to be assessed in terms of its performance in relation to design over the defects liability and maintenance period • Future stages of planning consistent with BUWM including preparation of LWMS's and UWMP's.

1. Introduction

Hyd2o was commissioned by City of Kalgoorlie-Boulder (CKB) to prepare this District Water Management Strategy (DWMS) to support the district structure planning process for an area of land in North Somerville (herein referred to as the site). The site has a total area of approximately 35 ha located within the CKB (Figure 1).

The site comprises of the following lots for rezoning:

- Portion R44344 Hannan St
- Lots 209 and 211 Patroni Rd
- Lot 400 and portion Lot 67 Bates Dr
- Lot 500 Galbraith St
- Lots 151, 208, 210 and 2892 O'Connor St

A district structure plan (DSP) has been prepared by Rowe Group, shown in Figure 2, to facilitate urban development near the banks of the Gribble Creek system (GCS).

The proposed rezoning of the site and DSP has considered the opportunities and constraints of the existing environment and uses this information to inform the development of this document.

This document provides an integrated total water cycle management approach to the rezoning application, with an assessment of the pre-development environment, development of water use sustainability initiatives, flood management, water quality, a stormwater management and groundwater management strategy and a plan for implementation.

A completed copy of DWER's DWMS Checklist is included as Appendix A to assist the review of this document.

1.1 Planning Context

The lots contained with the proposed DSP area are zoned for various land uses under the CKB Town Planning Scheme (TPS) No 1 including general residential, parks and recreation, and rural. CKB's Local Planning Scheme (LPS) No.2, shows the majority of these lots zoned for urban development.

The eastern lots within the DSP contain recognised Special Control Areas (SCA) in LPS No. 2 with additional height (airport) and flood control (Gribble Creek) considerations and requirements to be met in planned development.

Better Urban Water Management (Western Australian Planning Commission (WAPC), 2008) provides guidance on the implementation of State Planning Policy 2.9 Water Resources (Government of WA, 2003).

The urban water management planning process for the site is shown in Table 1. Three water management documents are likely to be required to facilitate development of the site, this District Water Management Strategy (DWMS), a Local Water Management

Strategy (LWMS) and an Urban Water Management Plan (UWMP). Note that several urban water management plans may be required for the site depending on the staging of subdivision.

This DWMS supports the proposed development of the area as urban.

Table 1: Urban Water Management Process

Planning Phase	Planning Document	Urban Water Management Documents
District	District Structure Plan, Region Scheme Amendment, Local Planning Strategy	North Somerville District Water Management Strategy **THIS DOCUMENT**
Local	Local Structure Plan, Local Planning Scheme Amendment	Local Water Management Strategy **FUTURE PREPARATION**
Subdivision	Subdivision Application	Urban Water Management Plan **FUTURE PREPARATION**

1.2 Previous Studies and Relevant Documents

This DWMS uses the following key documents to define its principles, criteria, objectives, and implementation responsibilities:

- Flood Risk Assessment for Lot 5 Krygger Close, Somerville, Kalgoorlie-Boulder (GHD, 2021)
- Meldrum Ave and Speculation Rd Culvert Hydraulics (GHD, 2019)
- Gribble Creek Flood Study (Advisian, 2017)
- Decision Process for Stormwater Management in WA (DWER, 2017)
- Better Urban Water Management (WAPC, 2008)
- Guidelines for District Water Management Strategies (Department of Water, 2013)
- Stormwater Management Manual for WA (Department of Water, 2007)

2. Existing Environment

2.1 Existing Landuse

The site has a total area of approximately 35 ha located within the suburb of Somerville in the City of Kalgoorlie-Boulder.

Figure 3 shows an aerial photograph with existing land use and topography.

The site is bound to the west by Great Eastern Hwy, banks of Gribble Creek regarded as public open space (POS) to the north, Connor St to the east and urban development to the south (Figure 1). It is mainly cleared with sparse vegetation for a combination of rural and parkland associated uses. Three of the smaller lots have already been developed for general residential/rural living and are to be retained as such within the overall DSP.

Natural surface elevations across the site vary from 361 mAHD on the southwest boundary to 353 mAHD at its eastern boundary, with a general fall from west to east across the site.

2.2 Climate & Rainfall

The site experiences very hot days during summer months and mild days with cold nights during winter. Summer maximum temperatures commonly exceed 40°C.

The nearest Bureau of Meteorology (BoM) weather station is Kalgoorlie-Boulder Airport (station no 012038) located approximately 8 km south west of the site. This station has a recorded long term annual average rainfall of 266 mm (1939-2021) indicating a dry climate.

Average monthly rainfall totals indicate a relatively flat distribution of rainfall throughout the year and even rainfall distribution between summer and winter months. Rainfall is however irregular and there can be long periods between significant falls of rain. Winter rainfall is much more reliable than summer rainfall. Summer rains result from thunderstorm activity or tropical cyclone remnants that become rain bearing depressions.

The annual average Class A pan evaporation is 2900 mm per annum (Luke et al, 1987).

Design rainfall depths derived by BoM (2016) for various durations (1 minute to 168 hours) and average exceedance probabilities (AEP's, 63% to 1%) are provided in Appendix B.

2.3 Environmental Geology

According to the Kalgoorlie 1:100 000 Geology Series Sheet 3136 (DMIRS, 1988), the site is characterised as colluvial soils, comprising gravel, sand and silt as sheet or talus. A pocket of mafic rock exists to the west of the site while alluvial deposits exist within the Gribble Creek system to the east. A geotechnical plan is contained as Figure 4.

2.3.1 Acid Sulphate Soils

No Acid Sulphate Soil (ASS) risk mapping is available over the Kalgoorlie-Boulder region however, given that ASS is an occurrence associated with coastal areas no risk is expected over the site.

2.4 Environmental

According to the City of Kalgoorlie-Boulder Intramaps (2022) the site does not contain or sit in the proximity of any environmental conservation reserves with the abutting banks of the Gribble Creek System recognised as public open space (POS).

2.5 Surface Water

2.5.1 Predevelopment Site Flow

The site is located within the catchment of the Gribble Creek System (GCS). The GCS runs through City of Kalgoorlie-Boulder and is an episodic watercourse that provides a means of drainage attenuation, conveyance and discharge for the majority of City.

Given the soil landscape it is expected that the majority of rainfall over the site would become overland flow which topographically falls generally east to eventually drain to the GCS.

The majority of this flow is expected to be intercepted by four excavated areas which Landgate Mapviewer historical imagery (accessed online 2022) suggests were initially installed for rural purposes. For the majority of storm events these pits would attenuate flow prior to discharging back as overland flow towards a site outlet that passes underneath O'Connor St and becomes a drain travelling east along Docherty Place. The largest of these attenuation pits, located in the northeast corner of the site, also has a topographic outlet at the north-eastern boundary of the site. Flow from this outlet would enter an open drain placed to direct flow to a culvert running under Meldrum Ave and drain east via a drain along Speculation Rd.

An open drain currently runs through the south of the site which provides a means of drainage conveyance for upstream urban development. The drain runs for approximately 360m within the site and then continues a further 300m externally before crossing beneath O'Connor St and continuing east. In its entirety this drain acts as a tributary to the GCS. Given topography, the drain would only service a small section of the site. Points of discharge for the site on are shown in Figure 5.

Pre-development flows for the 20% and 1% Annual Exceedance Probability (AEP) events were modelled for the DSP area using XP-Storm. The design storms modelled by XP-Storm were based on Australian Rainfall & Runoff (AR&R) (Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, 2019) and the Bureau of Meteorology Computerised Design Intensity Frequency Duration (IFD) Rainfall System. Storm durations modelled included temporal patterns ranging from 30 minutes to 72 hours.

Peak flows from the site itself were modelled as overland flow without attenuation in the pits described above. Runoff parameters for the urban and rural/undeveloped areas of the site were sourced from the flood study report by Advisian (2017) which characterised the drainage properties of such areas within the CKB with clay loam soils.

For modelling the site was separated into two topographic catchments. The northern catchment represents overland flow to the two northern outlets while the southern catchment represents flow intersected by the southern drain. Developed residential lots that front O'Connor St have also been included as part of the northern catchment. Catchment boundaries are shown in Figure 5 with modelled flows shown in Table 2

Table 2: Predevelopment Site Flows

Modelling Parameters/Outputs	Northern Catchment	Southern Catchment
Undeveloped/Rural (ha) (Green Ampt: Average Capillary Suction – 208.8 mm Sat. Hydraulic Conductivity – 2 mm/hr Initial Moisture Deficit – 0.267)	27.33	7.01
Developed Residential (ha) (20% AEP @ 34% RO 1% AEP @ 43% RO)	1.38	-
20% AEP Event		
Peak Flow (m^3/s)	0.17	0.06
Critical Event	1 hr	1 hr
1% AEP Event		
Peak Flow (m^3/s)	1.47	0.57
Critical Event	3 hr	1 hr

2.5.2 Gribble Creek Flooding

Given the proximity of the site to the GCS its floodplain extends into a portion of the DSP area. Studies carried out by Advisian (2017) and GHD (2019) both evaluated the extent to which flooding would occur in the vicinity of the site in order to identify opportunities to improve flood control in the local area.

Both these studies identified that a large extent of flooding occurred over the site as a result of a considerable breakout from the main flood channel that flows across the site's northwest region.

Upgrades implemented by the City following these studies included channel improvement between Hannans St and Meldrum Ave and an increase in culverts at Speculation Rd (Figure 6). Both these measures increase the flow capacity of the main GCS channel to reduce the amount of breakout flow across the site and other areas.

A further GHD (2021) modelling study was carried out to demonstrate the effectiveness of the upgrades with an update to flood mapping. LiDAR survey within the model was also updated to 2021 data. The resulting flood mapping for the critical 1% AEP event is shown in Figure 6.

The study found that the upgrades were effective in reducing breakout flows with a reduction in the extent of flooding over the site apparent when comparing the GHD (2019) and GHD (2021) mapping. The extent of critical 1% AEP flooding over the site prior to the upgrades as depicted by GHD (2019) is also shown in Figure 6.

1% AEP flood maps from both GHD studies are contained in Appendix C.

It should be noted that the GHD (2021) study boundary is limited to the extent of the main channel just south of Speculation Rd and as such the effects of the increased channel flow capacity on downstream areas has not been assessed.

2.5.3 Major Event Site Discharge

As previously discussed, the site is an area of land that provides flow routes for the GCS catchment and as such it is expected that a greater discharge to downstream areas occurs compared to site flows.

The breakout flows from the main GCS across Patroni Rd and into the site are considered to be intentional with a constructed drain placed to direct flow towards the large northeast attenuation basin when flows in the main channel reach a certain flood elevation.

Based on Landgate topography of the GCS however, flows are able to access the site prior to this at the northeast corner and any flows held back at the main Meldrum Avenue culvert crossing would also flow into the site. This is confirmed by GHD (2021) and as such flow into the site is currently considered to be uncontrolled.

Advisian (2017) modelling indicates a 1% AEP critical flow of 30.92 m^3/s just after Hannan St as result of the 1807 ha catchment to this point. This flow with the addition of the catchment between Hannan St and Meldrum Avenue would pass either via the main Meldrum Avenue culvert crossing or detour via the site. Key extracts from the Advisian report are contained in Appendix D.

Flows discharging from the site's two northern outlets as a combination of flood breakout and site flows (Catchment A in Figure 5) have been identified as problematic with the undersized drainage network downstream becoming compromised in major rainfall events resulting in significant flooding of downstream development. Flooding of residential areas can be recognized as a result of the flooding out of O'Connor St, the Speculation Rd drain and the Docherty Pl drain. Issues associated with 1% AEP flooding of the GCS are shown in Figure 6.

In contrast, 1% AEP modelling/mapping of the open drain that runs on the southern boundary of the site shows it is able to discharge the southern and upstream catchment (Catchment B in Figure 5) without any flooding into the site. The discharge also does not appear to cause any flooding issues for downstream development.

Hyd2o modelled predevelopment flows from site via the southern outlet using XP-Storm are shown in Table 3. Mapping of the upstream catchment was based on Advisan (2017) as well as estimated urban runoff parameters. The 1% AEP 24 hour event flow was modelled as this event was reported in GHD (2019) as critical to the main GCS system.

Table 3 also contains modelling of Catchment C which reflects the portion of the site that directly discharges onto O'Connor St as result of facing residential lots. Based on Landgate topography flow is expected to drain towards the Docherty Pl drain during minor events. During the critical 1% AEP 24 hr event, catchment runoff would be expected to contribute (albeit a minor component) to general flooding of the area east of O'Connor St (Figure 6).

Table 3: Predevelopment Discharge Flows – 1% AEP 24 hr

Modelling Parameters/Outputs	Catchment B	Catchment C
Undeveloped/Rural (ha) (Green Ampt: Average Capillary Suction – 208.8 mm Sat. Hydraulic Conductivity – 2 mm/hr Initial Moisture Deficit – 0.267)	8.74 (7.03 site) (1.71 external)	-
Residential (ha) (@ 43% RO)	14.89	0.53
Industrial (ha) (@ 100% RO)	0.94	-
Roads (ha) (@ 100% RO)	5.86	-
1% AEP – 24 hr Event		
Peak Flow (m³/s)	0.98	0.012

2.6 Groundwater

No historical DWER groundwater information is available for the site however, groundwater is expected to be present at considerable depth (DWER, 2022a). A groundwater investigation was conducted in 2020 over an area approximately 5.5km southwest of the site and found that groundwater depth was in excess of 30 m below ground level across three slotted bores (Ramboll, 2020).

Groundwater in the Kalgoorlie region is saline to hypersaline and is currently used only for mining purposes (Kern, 1995). There is no fresh groundwater in the region however limited areas of brackish groundwater may exist in the upper reaches of some catchments.

2.7 Water Quality

Hyd2o is unaware of any groundwater or surface quality monitoring to date undertaken in reference to the site. Similarly no water quality action plans are known to exist relating to Gribble Creek.

No contaminated sites or areas are located in or around the site. Landuse near and upstream would suggest any water quality leaving the site would include typical urban levels of nutrients and other parameters.

No predevelopment groundwater monitoring is expected to be required by DWER due to the depth of groundwater beneath the site. DWER typically do not require predevelopment groundwater monitoring where the groundwater depth exceeds 5m.

2.8 Constraints and Opportunities

Based on the sites existing environment, the following key constraints and opportunities are identified to guide the development of the water management strategy:

- There is good clearance to regional groundwater across the site.
- Underlying soils will limit opportunities for infiltration/retention in stormwater management across the site.
- Existing surface water flows paths are located on site servicing upstream catchments and will need to be accommodated post development.

- Discharge from the site is limited by the size of existing drainage infrastructure directly downstream of the site which ultimately drains to the GCS. The GCS itself has limited capacity with some current drainage sections of the main channel not well defined and with undersized culvert infrastructure.
- Breakout flow from the main GCS channel currently breaks out across the northeast section of the site and creates an extent of flooding. Flow across the site as a combination of local runoff and the breakout flow exceed the capacity of downstream drainage infrastructure and result in potential flooding of existing developed areas during major events.
- Development of the DSP area will provide the opportunity to improve management of stormwater locally and control discharge from site to downstream problem areas.
- Development levels will provide an opportunity to create a more defined GCS main channel.
- It is assumed that the catchment upstream, particularly the residential area serviced by the southern drain, does not currently provide any form of surface water quality treatment before discharge to the GCS. Therefore there is the opportunity to provide improved Water Sensitive Urban Design (WSUD) outcomes by sizing measures to also manage these flows where possible.

3. Design Principles & Criteria

Key design principles and criteria for the site are shown in Table 4 and have been established consistent with the key reference documents previously detailed in Section 1.2, and reflect the site constraints and opportunities identified in Section 2. These principles and criteria are used to formulate the water management strategy for the site to remain within the identified constraints and opportunities of the existing environment.

Table 4: Design Principles & Criteria

Strategy Elements	DWMS Method & Approach
Environmental	
Gribble Creek System	• No conservation reserve within the DSP area or in its proximity with the abutting banks of Gribble Creek recognised as POS • No related environmental approvals or conditions considered to apply in development of the DSP area • No water quality action plans known to exist relating to Gribble Creek
Water Use Sustainability	
Water Efficiency	• Implementation of water efficient fixtures and fittings • Aim for less than 100 kL/person/year water use. • Waterwise POS design, plantings and irrigation systems.
Water Supply	• Minimise overall use of scheme water for non-drinking purposes. • Water Corporation IWSS for lots plus rainwater tanks (non mandated). • Seek possible POS irrigation alternatives via CoK's 'Waterwise Town' initiatives eg. treated effluent.
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Ecological Protection	• Establishment of biofiltration areas for treatment of first 15mm road and lot runoff prior to offsite discharge.
Serviceability	• Piped drainage system sized to convey the 20% AEP event.
Flood Protection	• Establish minimum habitable floor levels at 0.5m above the 1% AEP flood level of the local stormwater management system. • Overland flow paths within road reserves for safe conveyance of flows exceeding pipe drainage system capacity. • 1% average exceedance probability (AEP) events to continue to flow offsite at acceptable rates consistent with downstream infrastructure constraints. • Redirect excess breakout flow from GCS back towards main channel while minimising increased flows effects on downstream areas.
Groundwater	
Fill Requirement & Subsoil Drainage	• No fill or subsoil drainage requirement in regards to groundwater given significant clearance below natural surface.
ASS Risk & Contamination	• No ASS risk expected over the site based on geographical location • No contamination sites near the site with contaminant levels expected to be consistent with urban runoff

4. Water Management Strategy

4.1 Water Supply Management

4.1.1 Fit for Purpose Water Supply

The Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to future homes on the site.

As discussed in Section 2.5 groundwater use in the City of Kalgoorlie is limited by salinity with extraction from present fracture rock aquifers predominantly used for mining purposes (DWER, 2022b). As a result the use of scheme water for non-potable uses such as irrigation must be considered to compensate for any insufficient supplies. Based on the City of Kalgoorlie Boulder's 'Waterwise Town' initiatives other non-potable supplies should first be sought. For example treated effluent water is currently being used to irrigate parks, reserves and gardens across the City.

With respect to construction water requirements groundwater as a supply is also considered likely to be unsuitable given risk of creating saline soils.

4.1.2 Water Efficiency Measures

Water conservation measures will be implemented within the development and will be consistent with Water Corporation's "Waterwise" land development criteria and the City of Kalgoorlie Boulder's 'Waterwise Town' initiatives. Measures include:

- Promotion of use of waterwise practices including water efficient fixtures and fittings (taps, showerheads, toilets and appliances, waterwise landscaping).
- Water efficiency consistent with Building Codes of Australia.
- Aim for less than 100 kL/person/year water use
- Maximising on site retention and reuse of stormwater (rainwater tanks).
- Waterwise plantings of POS areas with efficient watering schedules for parks and reserves using scheme water

Further detail of water conservation measures will be provided at later stages of planning.

4.1.3 Wastewater Management

Wastewater will be deep sewerage (reticulated) with management by CKB.

4.2 Stormwater Management Strategy

It is recognised that development of the DSP area has the potential to provide improved hydrological outcomes for the Gribble Creek system with particular reference to improved flood management. Given the current flow paths through the site there are opportunities to better control discharge both in terms of quantity and quality from upstream areas to downstream areas.

Best practice urban water management approaches used to inform the proposed development were made in consideration of Better Urban Water Management (WAPC), 2008), the Stormwater Management Manual for Western Australia (DoW, 2007), Gribble

Creek Flood Study (Advisian, 2017) and Meldrum Ave and Speculation Rd Culvert Hydraulics (GHD, 2019). The integrated strategy is as follows:

- Flood management of any increased runoff on site via detention in POS areas for up to the 1% AEP event. Finished levels within the DSP area are to account for Gribble Creek flooding.
- Retain surface flows paths, upstream catchments and points of discharge from predevelopment to post development where possible.
- Water quality management of the first 15mm runoff from lots and roads (inclusive of upstream) within biofiltration systems prior to discharge to detention systems. Management of developed upstream areas should considerably reduce nutrient output and improve water quality relative to current conditions, with the aim of improving downstream ecological systems.
- Discharge from site to be done at a rate consistent with the current drainage infrastructure in order to remove the risk of flooding of development areas immediately downstream. This includes the drain along Speculation Rd, the drain along Docherty Pl and the southern drain.
- Construct Patroni Rd as a bund with an extension to Meldrum Ave in order redirect breakout flow back towards the main Meldrum Ave crossing. This bund should mean that the retained northern point of discharge from the site will become the sole upstream contributor to the Speculation Rd drain.
- Provide designated flood storage to replicate current 1% AEP Event flood storage within the site with a controlled inflow through the bund. It is proposed that this storage be consistent with flooding of the site prior to recent upgrades on the main channel (Figure 6). This is to mitigate any potential impacts on areas downstream of the GHD (2021) study boundary given the increased channel flow capacity. The extent of indicative flooding as shown in GHD (2019) and Figure 6 is estimated by Hyd2o to represent an approximate flood volume of 34,500 m^3 attenuated within the site based on GIS analysis of the flood depth mapping.
- Integrate with areas external to the DSP area (owned by the CKB) in order to achieve best water management outcomes. This includes extension of drainage POS to the culvert at Meldrum Ave northwest of the site to provide better opportunity for flow control to the Speculation Rd drain. This also includes modification to the southern drain as necessary to enable better land use integration and water quality outcomes.
- Prioritising protection of existing environmental assets and significant trees in the site via adopting approaches to minimise large scale trucking of fill. This includes integration of the existing large northwest attenuation basin into a nominated flood storage area to preserve trees within as much as possible.

The proposed stormwater management system post development is shown in Figure 7.

To implement the above strategy, a total volume of approximately 38,000 m^3 (minimum) will be required on site to replicate predevelopment flood storage provided. This is a combination of approximately 34,500 m^3 provided by the extent of flooding on site as well as approximately 3,500 m^3 provided in the POS drainage extension to the culvert at Meldrum Ave. These values are contingent on the analysis performed and available GIS data at the time of this study, and should be refined at the LWMS stage.

The controlled inflow through the bund to allow for replicated flood storage will require culvert design catering to infrastructure invert levels. Therefore further detail in the design of this system will be determined when design levels become available at the LWMS stage.

Modelling was conducted based on the current DSP to ensure the proposed strategy as feasible with post development catchments selected to reflect likely surface water flow paths based on the concept layout. Modelling results are shown in Appendix E including details of flood management area sizing and peak discharge flows based on XP-Storm outcomes.

Note that modelling was inclusive of breakout flows from the main GCS channel, based on calibration of Advisian (2017) parameters to replicate the 30.92 m^3/s 1% AEP flow for the 1807 ha catchment to Hannan St. While catchments did change post development, breakout inflows to the site remained consistent in the model from pre to post to assess the 38,000 m^3 predevelopment flood storage criteria. Additional flood storage for the site above this amount is a reflection of site landuse change.

The Catchment 1 storage was modelled with a 600mm outlet to become the sole upstream contributor to the Speculation Rd drain post development. This is a considerable reduction to the 3 x 450mm x 1200mm culverts currently at Meldrum Ave directing flows to this drain (GHD, 2021). This reduction is proposed to retain the required regional storage upstream of Meldrum Ave. This initial modelling produced a peak discharge of 1.15 m^3/s to the Speculation Rd drain. Determination of the actual capacity of the Speculation Rd drain and refinement of the culvert size will be required at the LWMS stage.

All XP-Storm modelling output extracts are contained in Appendix F.

The concept stormwater management plan based on modelling shown in Appendix E has been developed to demonstrate that the proposed approach to stormwater management post development is feasible. More detailed modelling will be required as part of the local structure planning process and LWMS to refine these outcomes.

Further details on the adopted stormwater management measures including their staging, distribution, sizing and location will be able to be provided in the LWMS as an LSP is developed.

4.3 Groundwater Management Strategy

4.3.1 Fill and Subsoil Drainage

Given the large separation to groundwater on site the implementation of fill will not be required to provide adequate clearance.

Subsoil drainage is considered to not be required on the basis that infiltration is not part of the proposed stormwater strategy however subsoil pipes will be required for the function of POS biofiltration areas given underlying soils.

Finished lot levels and fill requirements will instead be dominated by flood levels as a detailed design issue to be addressed during the preparation of detailed engineering design drawings and preparation of the LWMS and UWMP and will be ultimately submitted for council approval at that stage.

4.3.2 Acid Sulphate Soils

Acid sulphate soil risk has been previously discussed in Section 2.2.1 as not being considered an issue at the site on the basis of geographical location away from the coast.

Management of acid sulphate soils (ASS) will be addressed by a separate study if required depending on possible disturbance and excavation depths for engineering services. Details regarding the outcomes of any ASS studies required will be included as part of later water management planning document for the site. All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series Identification and Investigation of Acid Sulphate Soils (DoE, 2004).

4.4 Staging

Staging of stormwater works to maintain a functioning stormwater management system for the site and the City's existing drainage system will be required as development proceeds.

Staging of stormwater changes will be implemented to ensure key hydrological performance criteria in relation to the receiving environment and key design objectives are maintained during the transition process.

Staging aspects of the development will be addressed in later stages of water management planning and include the identification of any temporary measures.

5. Implementation Framework

5.1 Considerations and Requirements for Local Planning

A number of additional documents will be required to progress further stages of planning and subdivision/development of the site.

Local Water Management Strategy's (LWMS's) will be required for the site to support the preparation of local structure plans. Subject to approval of a relevant LWMS, an Urban Water Management Plan (UWMP) will then need to be prepared as a condition of subdivision. Depending on the staging of development, several UWMP's may be required.

The preparation of all these future plans and the contained recommendations will be consistent with this DWMS, Better Urban Water Management (WAPC 2008), Stormwater Management Manual Western Australia (DoW, 2007), and other relevant DWER and City of Kalgoorlie guideline documents.

Key additional information to be reported in the LWMS will include:

- Additional site geotechnical reporting.
- Additional survey to confirm key infrastructure details.
- Detailed engineering earthworks and refinement of post development catchments.
- Detailed stormwater modelling to refine volumes, areas and levels and ensure discharge from the site is consistent with downstream infrastructure capacity.
- POS landscape designs showing the integration of stormwater function.

It is considered that the impacts of land use change within the site from a water management perspective can be readily managed via the Better Urban Water Management (WAPC, 2008) process.

Continued engagement and collaboration with the City of Kalgoorlie will be undertaken as part of the planning process to assist developing an approach which will maximise the water management benefits land use change will provide to the area.

5.2 Monitoring

5.2.1 Pre Development

Given the large separation to groundwater on site, no groundwater monitoring is considered to be required.

Given the nature of flows within Gribble Creek, a traditional predevelopment surface water quality monitoring programme is also not considered to be required to support development.

It is however considered that should any flood events occur, that observational data from the site be collected (photographic evidence, debris levels, etc) following and/or during the event to assist in informing future more detailed water management planning. This should also extend to areas upstream and downstream of the site.

Any additional collected data should be assessed and reported on in the site's LWMS/UWMP.

5.2.2 Post Development

Post development, the system will be assessed in terms of its performance in relation to design detailed in this report over the defects liability and maintenance period.

No further post development monitoring is proposed.

5.3 Funding and Ongoing Maintenance Responsibilities

Key implementation actions and responsibilities are detailed in Table 5.

The development and implementation of a Local Structure Plan and accompanying Local Water Management Strategy will be the responsibility of the City of Kalgoorlie.

Ongoing funding and maintenance responsibilities will be appropriately detailed at LWMS and UWMP stages and will include a summary of responsibility for City of Kalgoorlie and DWER.

Table 5: Implementation Responsibilities

Implementation Action	Responsibility	
	City of Kalgoorlie-Boulder	DWER
Preparation of LWMS to support local structure planning	✓	
Review and approval of LWMS	✓	✓
Preparation of a UWMP for individual development stages	✓	
Review and approval of UWMP	✓	✓
Construction of water management system and maintenance post construction until council handover	✓	
Long term water management system operation and maintenance	✓	

6. References

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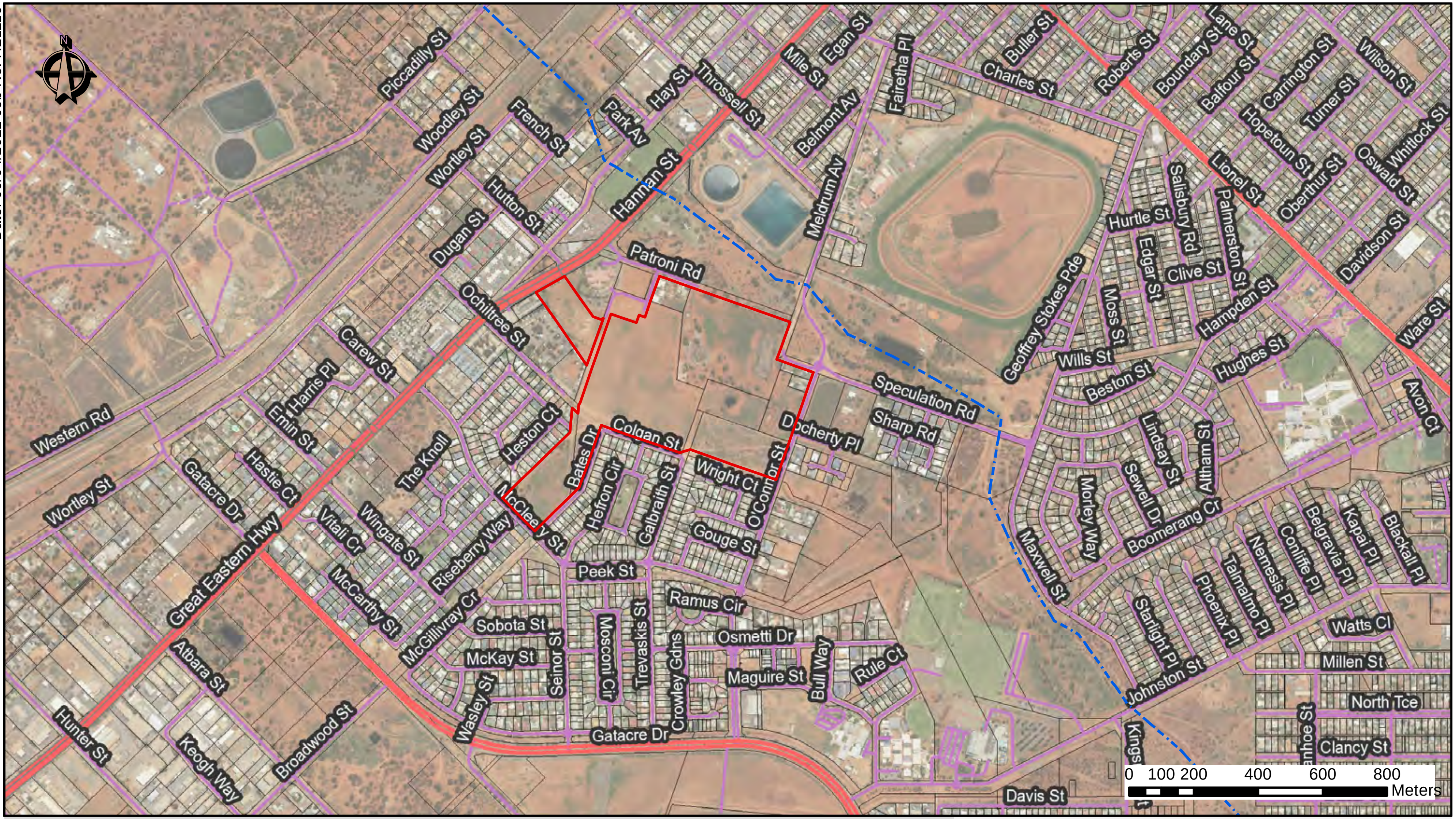
FIGURES

Date: 06/04/2022 Job No. H21110



Site

GribbleCreek

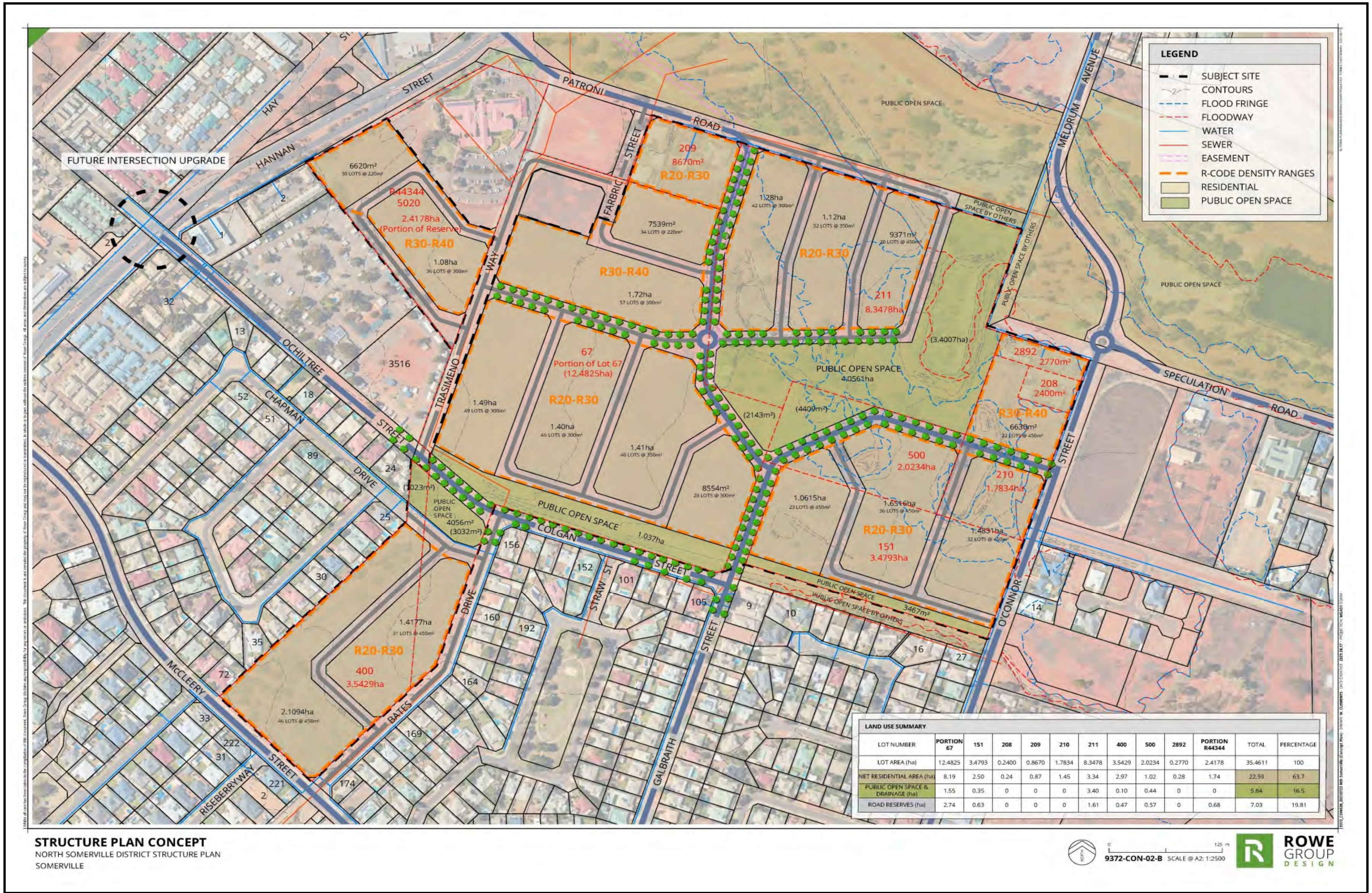
hyd2o

North Somerville District Water Management Strategy

Location Plan

Figure 1

Document Set ID: 3527361
Version: 1, Version Date: 20/05/2022



LAND USE SUMMARY

LOT NUMBER	PORTION 67	151	208	209	210	211	400	500	2892	PORTION R44344	TOTAL	PERCENTAGE
LOT AREA (ha)	12.4825	3.4793	0.2400	0.8670	1.7834	8.3478	3.5429	2.0234	0.2770	2.4178	35.4611	100
NET RESIDENTIAL AREA (ha)	8.19	2.50	0.24	0.87	1.45	3.34	2.97	1.02	0.28	1.74	22.59	63.7
PUBLIC OPEN SPACE & DRAINAGE (ha)	1.55	0.35	0	0	0	3.40	0.10	0.44	0	0	5.84	16.5
ROAD RESERVES (ha)	2.74	0.63	0	0	0	1.61	0.47	0.57	0	0.68	7.03	19.81

Source: Rowe Group (2021)

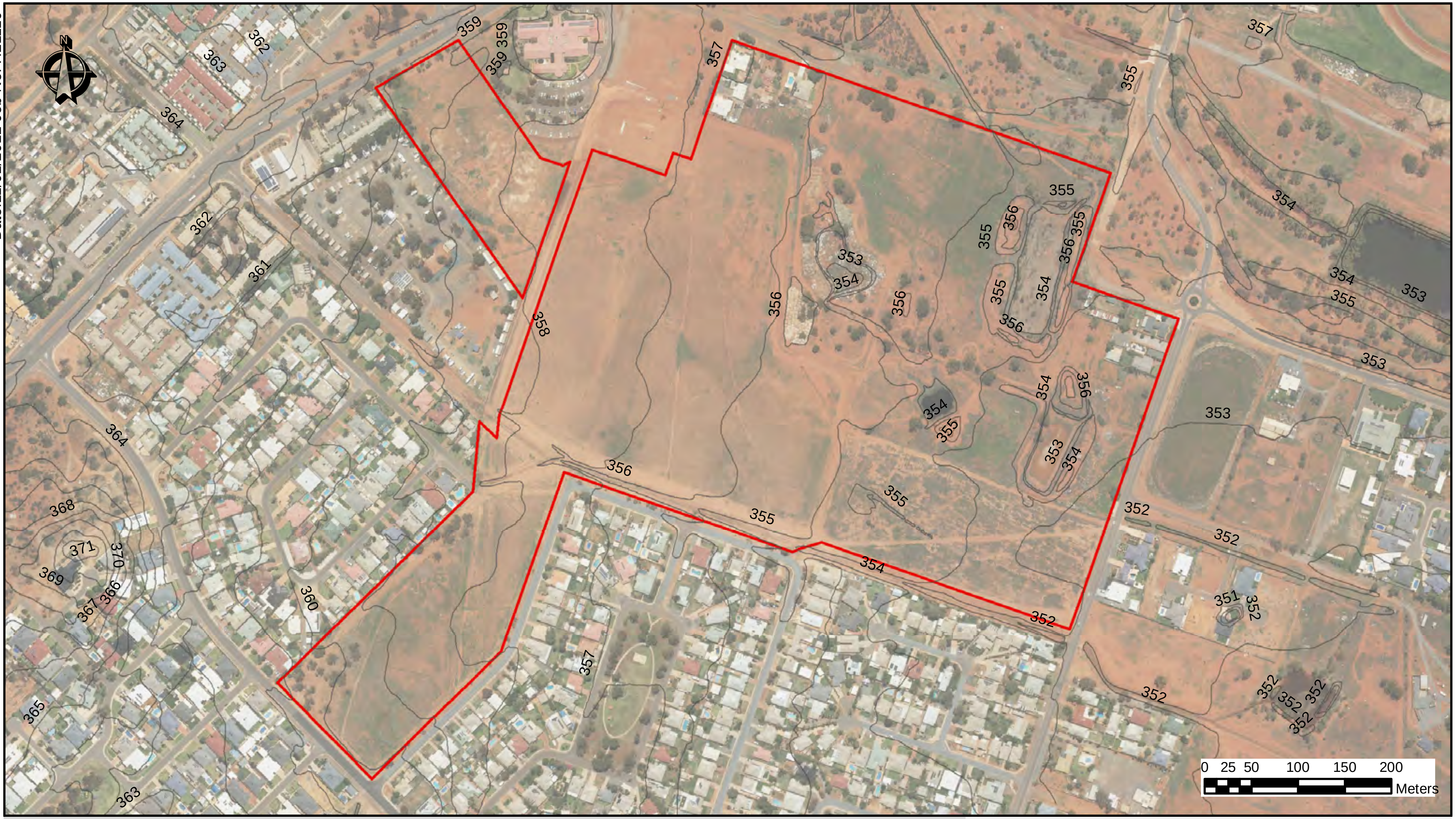
hyd₂o

North Somerville District Water Management Strategy

District Structure Plan Concept

Figure 2

Date:11/02/2022 Job No. H21110



Site

Landgate 1m Topography (mAHD)

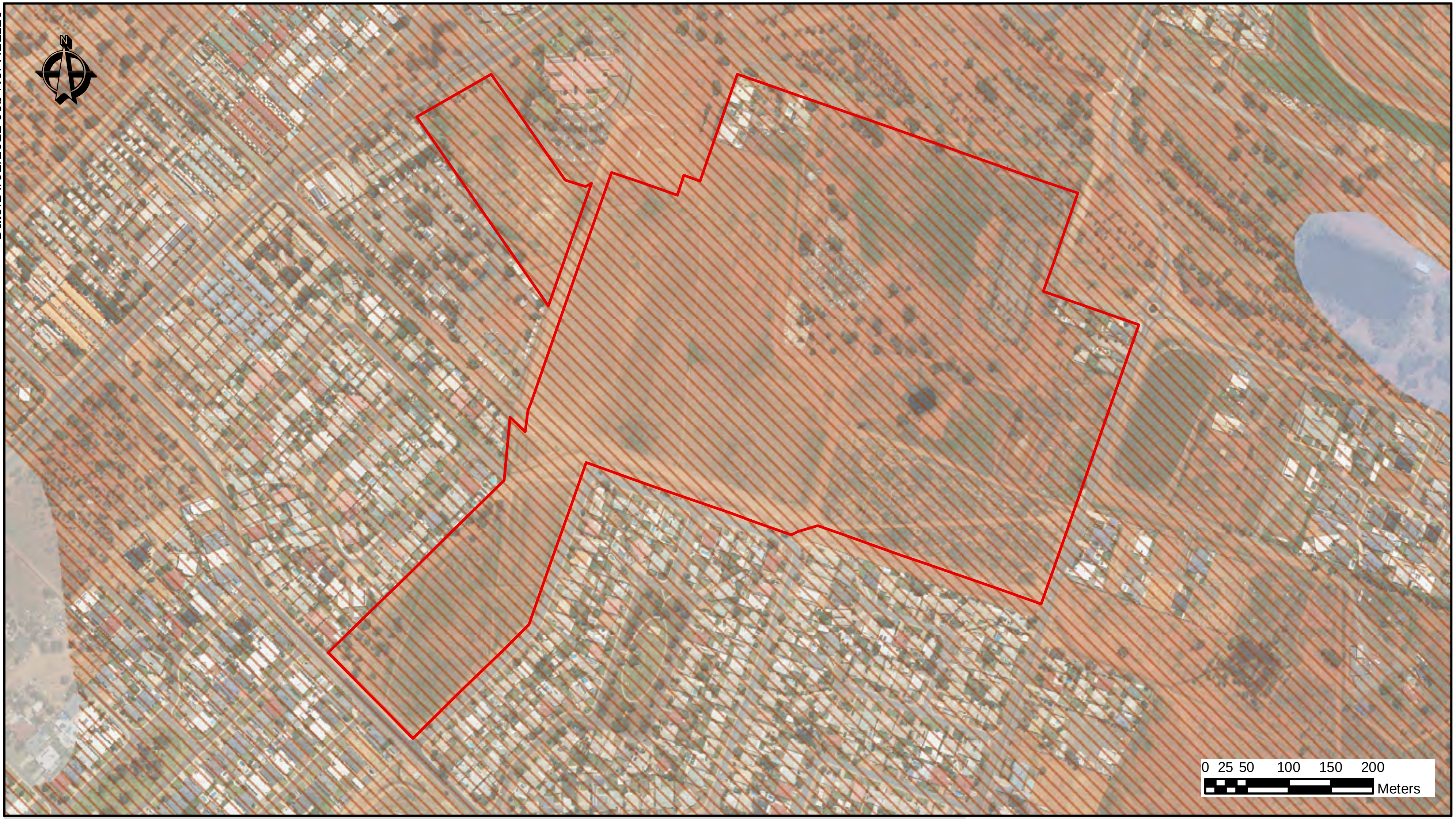
hyd2o

North Somerville District Water Management Strategy

Site Conditions Plan

Figure 3

Date:14/02/2022 Job No. H21110



Site

Geological Survey of WA (DMIRS)

Abm - metamorphosed high Mg basalt, mafic rock

Czc - Colluvium; gravel, sand and loam as sheetwash and talus

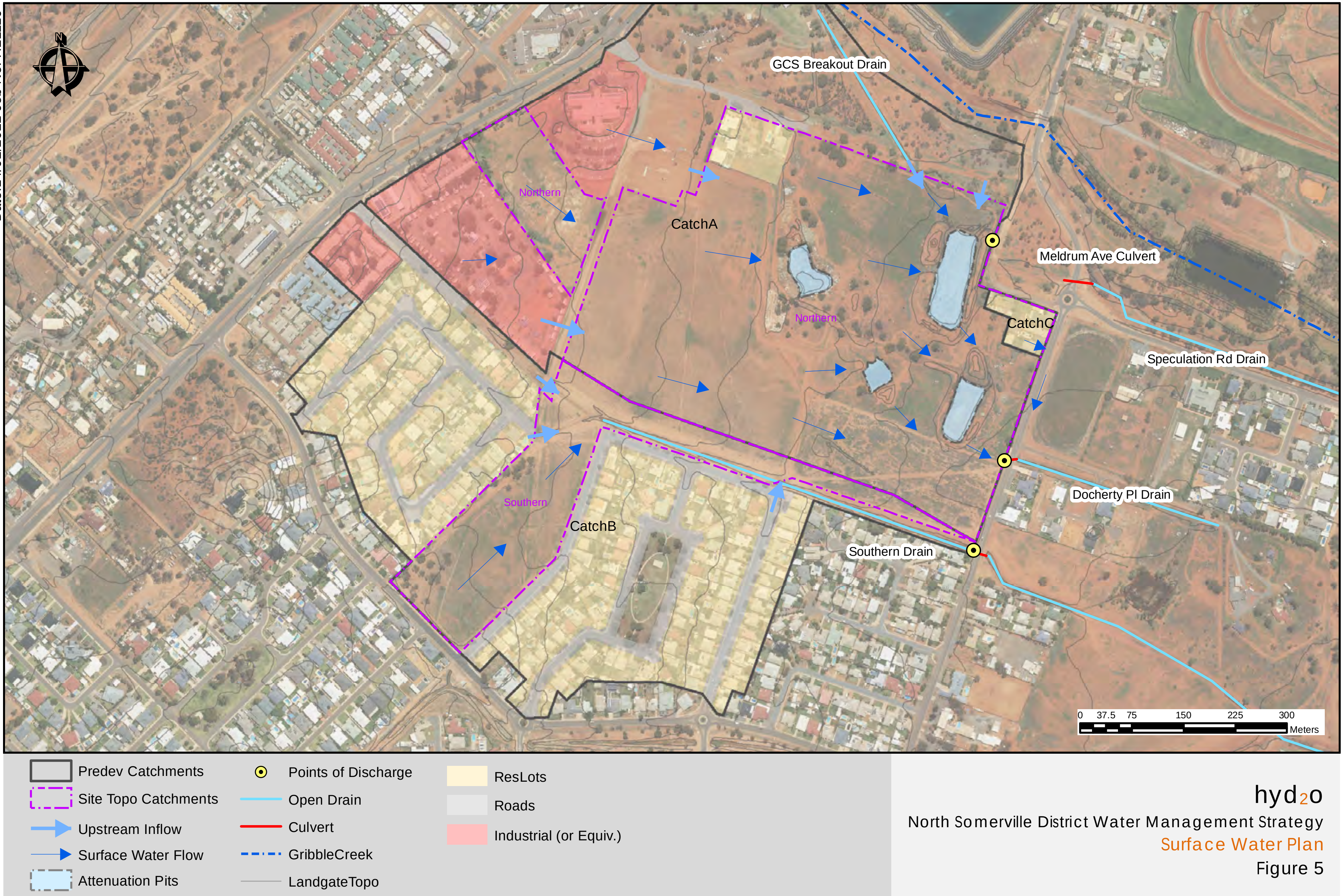
Qa - Alluvium; clay, silt, sand and gravel in channels

hyd2o

North Somerville District Water Management Strategy

Geotechnical Plan

Figure 4

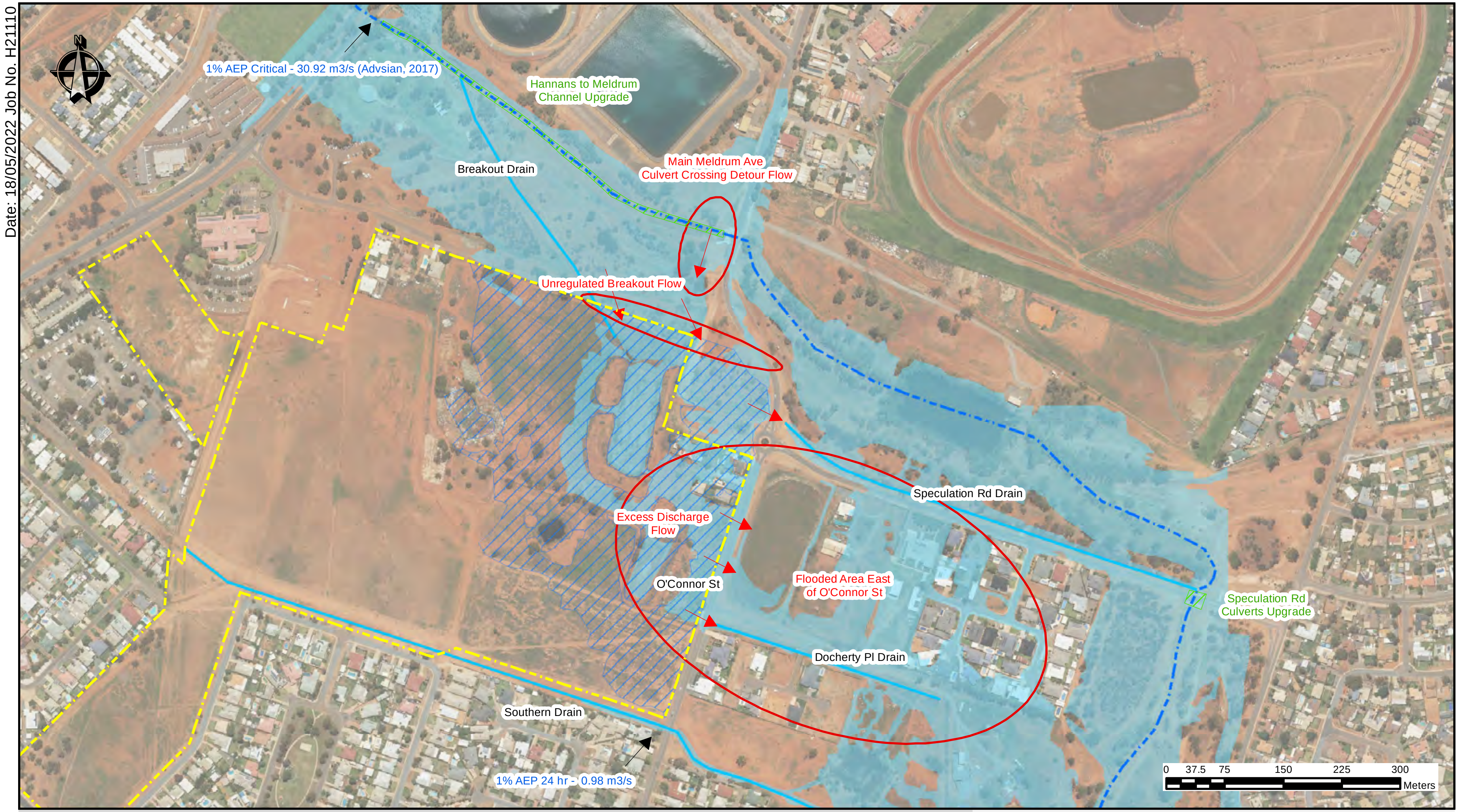


hyd2o

North Somerville District Water Management Strategy

Surface Water Plan

Figure 5



Site

GCS Main Channel Upgrades

1% AEP Critical Flood Extent (GHD, 2021)

1% AEP Critical Site Flood Extent Prior to Upgrades (GHD, 2019)

Open Drains

Flow Path

Areas for Key Consideration

Gribble Creek

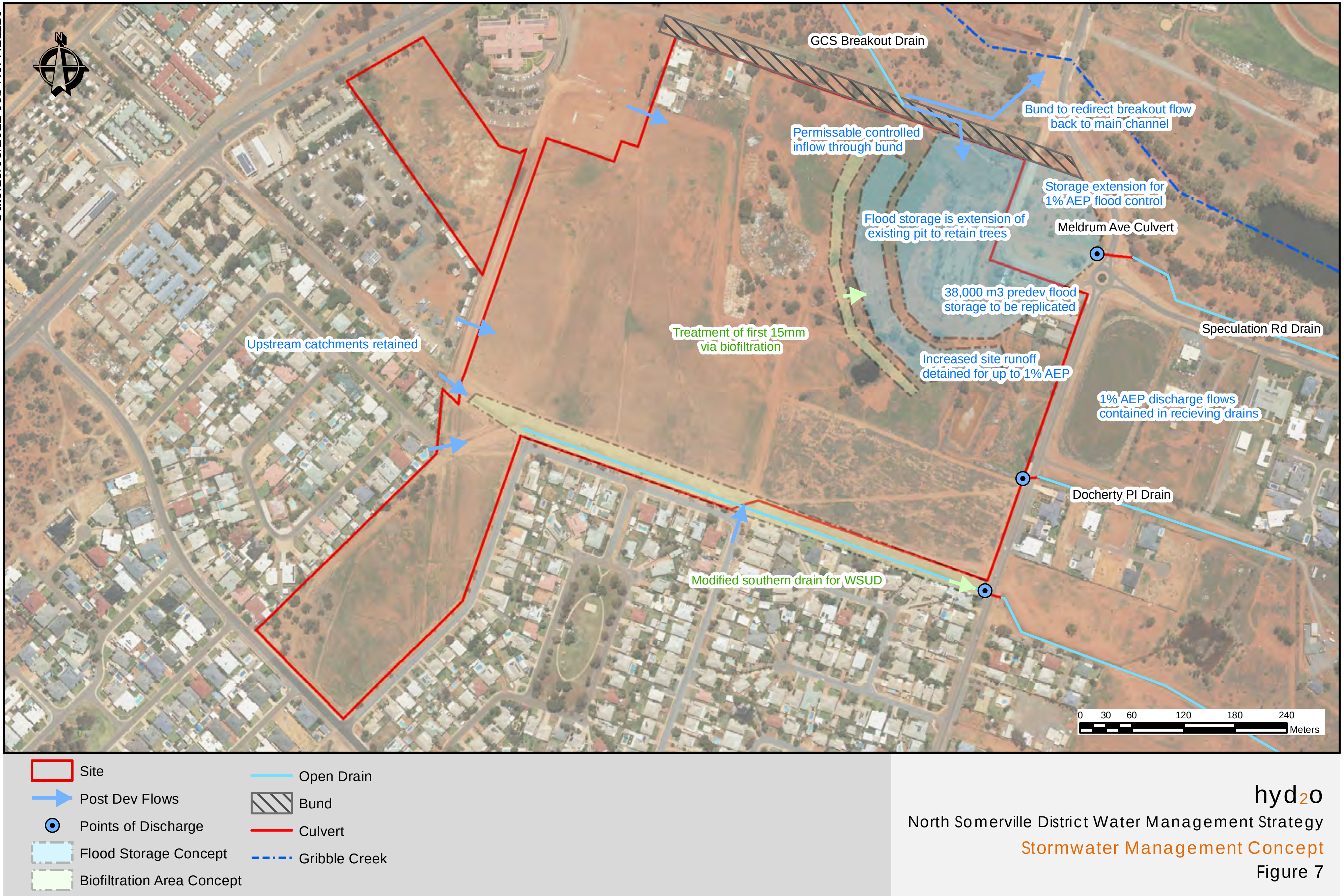
hyd2o

North Somerville District Water Management Strategy

Flood Plan

Figure 6

Document Set ID: 3527361
Version: 1, Version Date: 20/05/2022



hyd2o

North Somerville District Water Management Strategy

Stormwater Management Concept

Figure 7

APPENDIX A
DWER DWMS Checklist

District water management strategy guide

Use the guide below to assist with the completion of the DWMS. Tick the box where items have been met. If the item is not applicable to the DWMS, include N/A with explanation in the notes column. Provide any other relevant comments briefly in the notes column.

District water management strategy item	☑	Notes
Executive summary		
Describe proposed water management objectives and how the objectives will be met.	☑	refer Executive Summary
Planning background and previous studies		
Map the location of the site.	☑	Location or site context plan refer Figure 1
State which planning document the strategy is supporting.	☑	District structure plan if available refer Section 1.1, Table 1
Provide references to the key state and/or local policies, guidelines, strategies and their relevance.	☑	refer Section 1.2, Section 5
Design criteria		
Recognise water management principles, objectives and design criteria.	☑	refer Chapter 3, Table 4
Design objectives from previous water strategies and/or plans.	☑	refer Chapter 3, Table 4
Pre-development environment (identification of assets, risks and constraints)		
Describe site characteristics: provide preliminary desktop assessments and/or field investigations (if required)	☑	Include existing data refer Chapter 2
Describe climate.	☑	Description refer Section 2.2
Describe and map topography, landform and geotechnical conditions.	☑	Aerial photo refer Figure 3 Geotechnical plan refer Figure 4 Acid sulfate soil risk mapping

District water management strategy item	☑	Notes
Describe the existing land use.	☑	Description refer Section 2.1
Identify environmental assets and their significance.	☑	Environmental plan plus supporting data where available refer Section 2.3
Detail the social, cultural and heritage considerations.		n.a.
Describe the hydrology and hydrogeology of the area: • surface water • groundwater • water-dependent ecosystems • water resource issues.	☑	Surface water hydrology plan refer Section 2.4, Figure 5 Groundwater and topographic contours plan (or depth to groundwater) refer Section 2.5 Waterways and wetlands plan refer Section 2.4, Figure 6 Indicative water balance (pre- and post-development water balances can be presented together – see below)
Describe existing drainage infrastructure and other infrastructure likely to affect management of water resources.	☑	Arterial drainage plan (if available) including local drainage refer Section 2.4, Figure 5
Post-development water management		
Identify the proposed broad scale management strategies that will address water resource issues and meet the objectives and design criteria.	☑	refer Section 4.2, Figure 7
Calculate an indicative water balance.	☑	Indicative water balance. May be presented as a diagram including pre- and post-development volumes with explanatory notes
Describe the impacts to water resources and/or impacts to proposed change in land use from water issues.	☑	refer Chapter 4
Surface water – Estimate land requirements for water management. – Identify water quality issues and scope for improvement. – Describe proposed strategy for management of small, minor and major surface flows.	☑	Include any existing data refer Appendix E refer Section 2.7 refer Section 4.2
Describe groundwater levels, use, management and maintenance.	☑	Include data if available refer Section 2.5

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District water management strategy item	☑	Notes
Identify water-dependent ecosystems	☑	refer Section 2.3
Identify contamination issues – high risk acid sulfate soils, contaminated sites or areas with historical high nutrient and/or non-nutrient contaminants.	☑	Include data or plans if available refer Section 2.2 & 2.6,
Water services and efficiency initiatives		
Describe potable water supply – options including details of technical, environmental and regulatory feasibility – regulatory approvals, technical investigations and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained refer Section 4.1
Identify wastewater servicing – options including preferred option, location, treatment process, level of treatment, disposal, buffers and infrastructure – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained refer Section 4.1.3
Identify non-potable (fit-for-purpose) water supply – non-potable water source options. Highlight preferred option with consideration of pre and post development water balance – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	☑	Written evidence if obtained refer Section 4.1.1 & Section 4.1.2

District water management strategy item	☑	Notes
Implementation framework		
Describe commitments and obligations for the next stage of the planning process (e.g. LWMS). Identify issues that need specialised investigation and management for the subsequent LWMS. Make recommendations for implementing the DWMS.	☑	Commitments and obligations may be displayed in table format refer Chapter 5, Table 5

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APPENDIX B

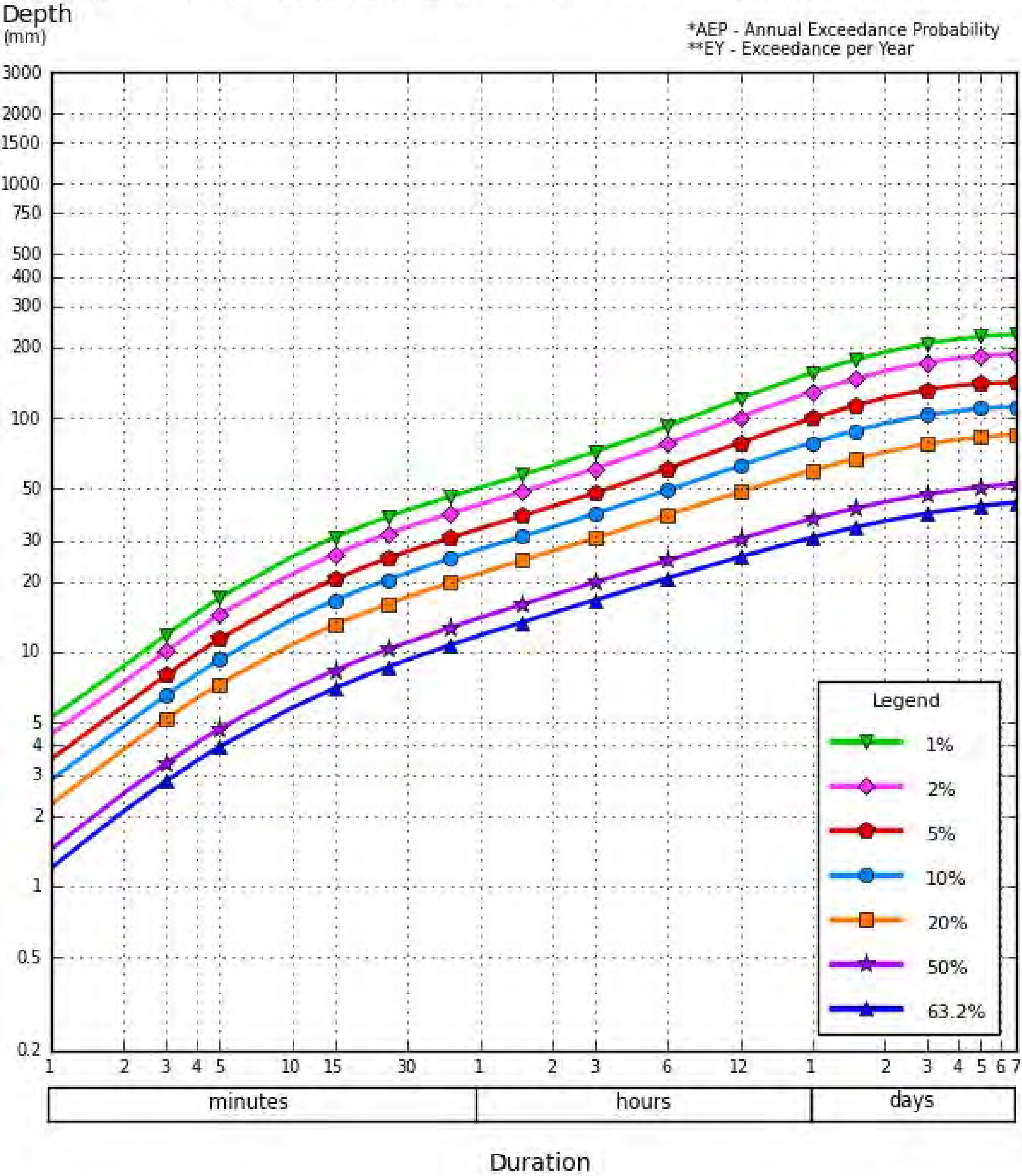
Bureau of Meteorology Rainfall IFD's

Requested coordinate Latitude: -30.7668 Longitude: 121.4599
Nearest grid cell Latitude: 30.7625 (S) Longitude: 121.4625 (E)

IFD Design Rainfall Depth (mm)

Issued: 11 April 2022

Rainfall depth in millimetres for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).



APPENDIX C

GHD (2019) & GHD (2021) 1% AEP Flood Maps

Paper Size A3

0 20 40 80 120 160

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

City of Kalgoorlie-Boulder
Meldrum Ave

Job Number	6138014
Revision	B
Date	15 Apr 2019

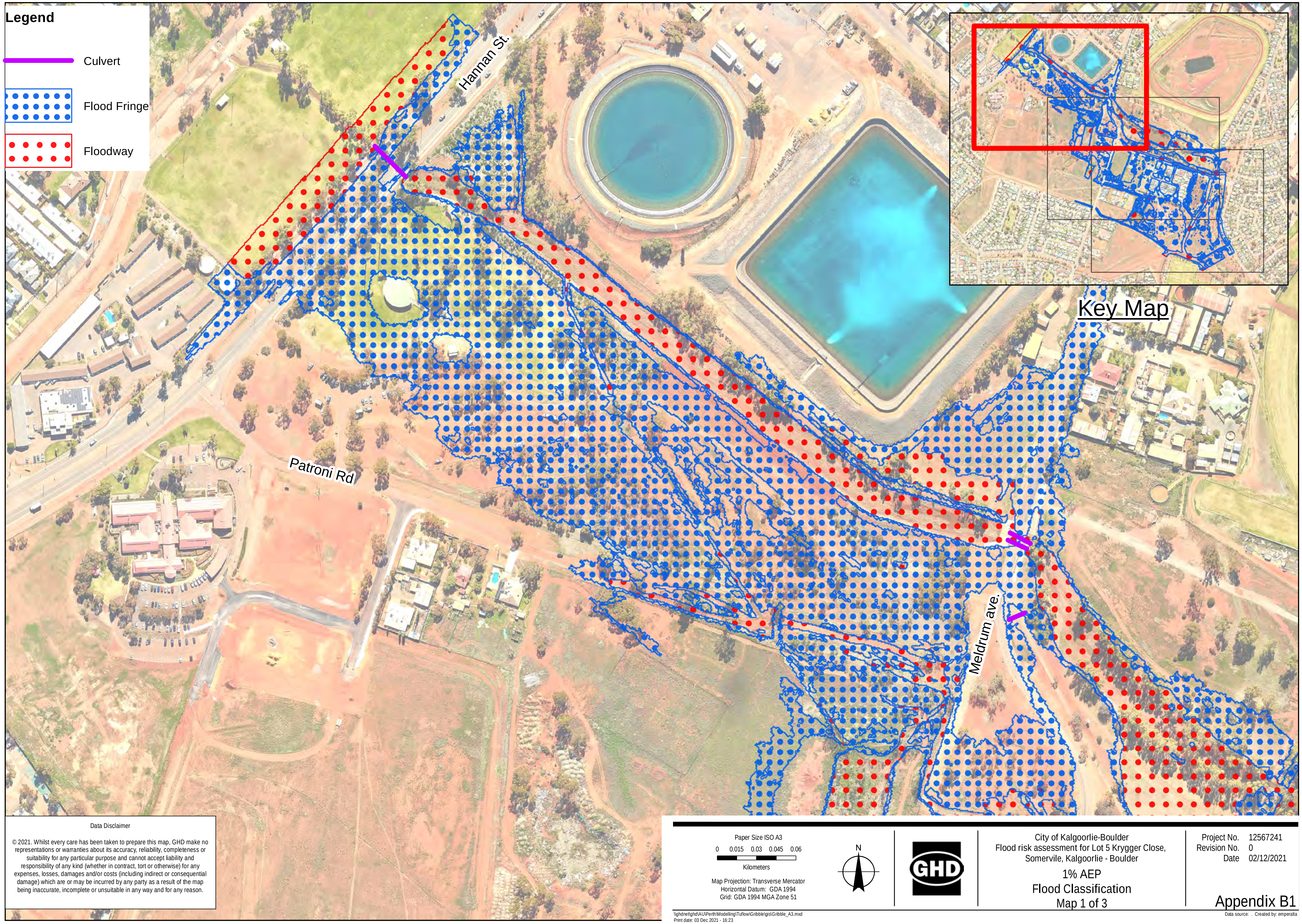
Flood Depths
1% AEP Existing

Figure 3

G:\61\38014\GIS\Maps\Working\6138014-Fig3_A_Existing.mxd

180 Lonsdale Street Melbourne VIC 3000 Australia T 61 3 8687 8000 F 61 3 8687 8111 E melmail@ghd.com W www.ghd.com

Data source: Data Custodian, Data Set Name/Title, Version/Date. Created by:cfinneran



Paper Size ISO A3

0 0.015 0.03 0.045 0.06

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

City of Kalgoorlie-Boulder
Flood risk assessment for Lot 5 Krygger Close, Somervile, Kalgoorlie - Boulder

1% AEP
Flood Classification
Map 1 of 3

Project No. 12567241
Revision No. 0
Date 02/12/2021

Appendix B1

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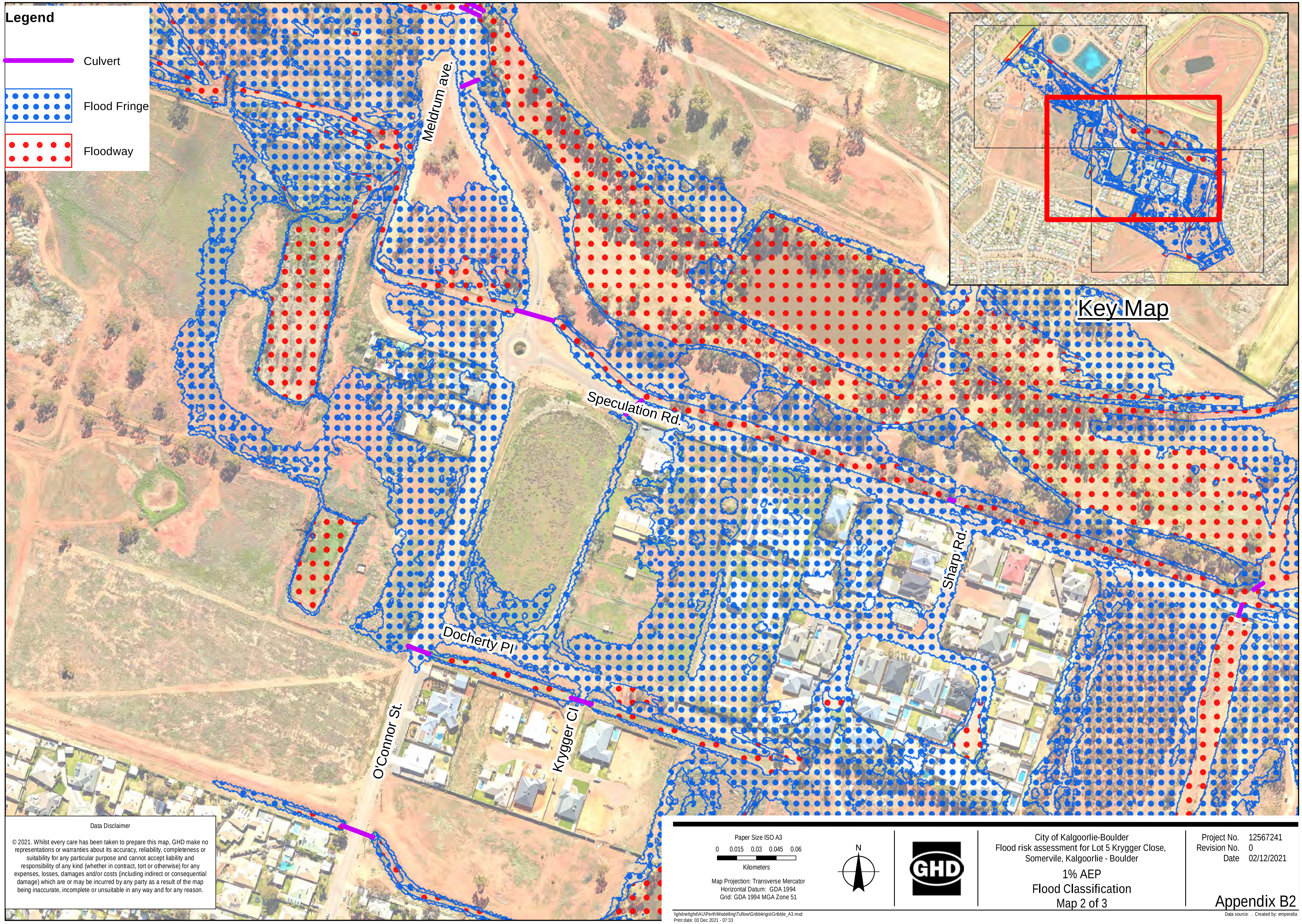

Data Disclaimer

Paper Size ISO A3

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Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

City of Kalgoorlie-Boulder
Flood risk assessment for Lot 5 Krygger Close, Somervile, Kalgoorlie - Boulder

1% AEP
Flood Classification
Map 2 of 3

Project No. 12567241
Revision No. 0
Date 02/12/2021

Appendix B2

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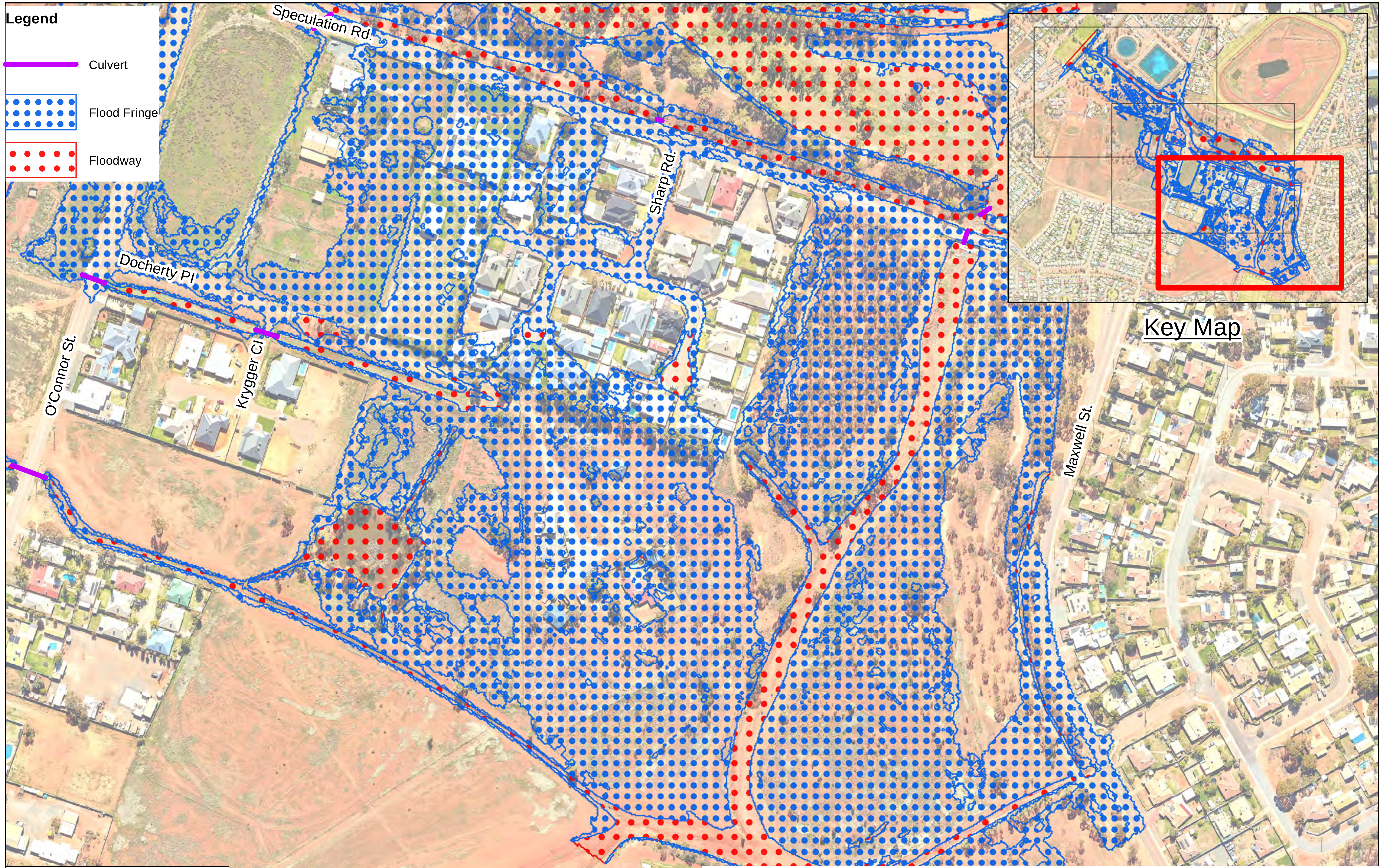

Data Disclaimer

Paper Size ISO A3

0 0.015 0.03 0.045 0.06

Kilometers

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 51

N

GHD

City of Kalgoorlie-Boulder
Flood risk assessment for Lot 5 Krygger Close, Somervile, Kalgoorlie - Boulder

1% AEP
Flood Classification
Map 3 of 3

Project No. 12567241
Revision No. 0
Date 02/12/2021

Appendix B3

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Print date: 03 Dec 2021 - 07:21

Data source: . Created by: emperalta

APPENDIX D

Advisian (2017) Flood Study Extracts

4.3 XP-SWMM Modelling

The XP-SWMM model developed by Cardno in 2010 was amended for this Project to incorporate more recent LiDAR data and land developments. The Gribble Creek 2D hydraulic model domain (the DEM) and 1D catchment areas are shown in Figure 4-1.

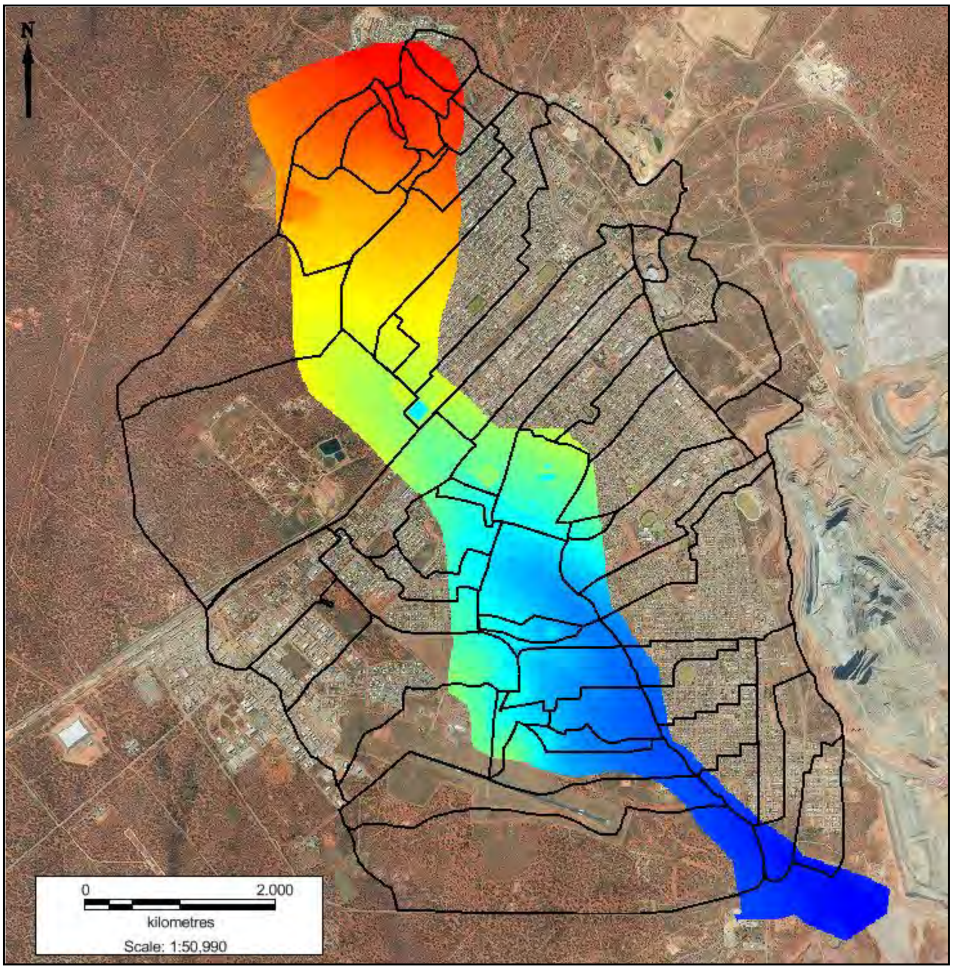

Figure 4-1: Extent of the 2D XP-SWMM model domain is shown by the coloured DEM while the total catchment and sub-catchment areas are shown in black.

XP-SWMM modelling software allows rainfall-runoff modelling and coupled 1D/2D hydraulic modelling to be completed using one software package. The 1D and 2D capabilities are useful for both engineering design and environmental assessments.

The rainfall runoff modelling is conducted in 1D and routed to the 2D model grid. The flows entering the grid are then routed in 2D through the model domain. 1D elements such as culvert waterway crossings are also included in the model and coupled to the 2D grid where required to ensure the hydraulic behaviour at these waterway crossings is captured accurately.

Table 4-3: Manning's "n" values adopted for 1D Rainfall Runoff Modelling

Type	Manning's n
Residential Properties	0.20
Industrial Properties	0.016
Roads	0.016
Piped Drainage Networks	0.014
Undisturbed catchment areas	0.035

4.3.2 2D Model Setup

4.3.2.1 Model Grid

A 5m x 5m grid cell size was selected for the 2D hydraulic model domain to represent the main catchment features in the City of Kalgoorlie-Boulder and to provide accurate representation of natural creek channels, whilst achieving practical simulation times. Average ground elevation values (mAHD) were assigned by XP-SWMM to each cell in the grid using a Digital Elevation Model (DEM) created by LiDAR data.

4.3.2.2 Model DEM

The following two DEM's were used:

1. ***Calibration event:*** The 2010 DEM was updated to include the following developments completed prior to the January 2014 rainfall event:
   - Corner of Meldrum Ave and Speculation Road - area within the Kalgoorlie Boulder Race Course;
   - Dugan St development (No. 259);
   - Decommissioned Ex-Hannans Dam;
   - Drain between Shepherdson St and Reservoir; and
   - Stage 1 Ray Finlayson Sporting Centre (Equestrian Centre).

2. ***Design rainfall event:*** The 2015 DEM was provided later in this project and used for the design rainfall event modelling. The 2015 survey is a higher resolution with points taken at 1m intervals. The 2015 DEM did not penetrate standing water present at the locations shown Figure 4-3 at the time of survey. Standing water was not present at the time of the 2010 survey therefore these levels were used to amend the 2015 survey data to ensure that the dams and basins were accurately represented in the model. Minor amendments to the DEM were made

6 Design Event Modelling

6.1 Model Parameters

A multi-storm analysis was completed using the calibrated XP-SWMM model to determine the critical duration event for all ARI / AEP events. The model was run for the 3hr, 4.5hr, 6hr, 12hr, 24hr and 48hr duration design events, with the Piccadilly Dam set to a spillway level of 359.5 mAHD. The model parameters adopted are for each event presented in Table 6-1.

Table 6-1: Parameters adopted for the design rainfall events

Urban / Developed Areas						
Land use type	Impervious Fraction (%)	AEP Runoff Coefficient				
		20%	10%	5%	2%	1%
Residential	50	0.34	0.36	0.38	0.41	0.43
Industrial	85	0.81	0.85	0.89	0.98	1.00
Roads	100	1.00	1.00	1.00	1.00	1.00
Rural / Undeveloped Areas						
Land use type	Average Capillary Suction (mm)	Saturated Hydraulic Conductivity (mm/hr)	Initial Moisture Deficit			
Rural (Clay Loam)	208.8	2.0	0.267			

6.2 Results

The results from the multi-storm analysis showed that the critical duration for the 20%, 10%, 5%, 2% and 1% AEP events was 24 hours at the downstream boundary of the model as well along other locations upstream within the model domain. The estimated 1% AEP peak flow for the 24 hour duration event was 60.6 m^3/s at the downstream boundary of the model (Figure 6-1). Peak flow estimates for the 20%, 10%, 5%, 2% and 1% AEP events extracted from the model at the downstream boundary are summarised in Table 6-2 and the associated hydrographs shown in Figure 6-2. Flood maps showing the peak depth and extent of flooding as well as peak velocities for 20%, 10%, 5%, 2% and 1% AEP events are provided in Appendix E. Design AEP event profile drawings are presented in Appendix F - 301012-02179-CI-DAL-0008-0012. Peak flood levels and flow rates at key locations along Gribble Creek are summarised Table 6-3.

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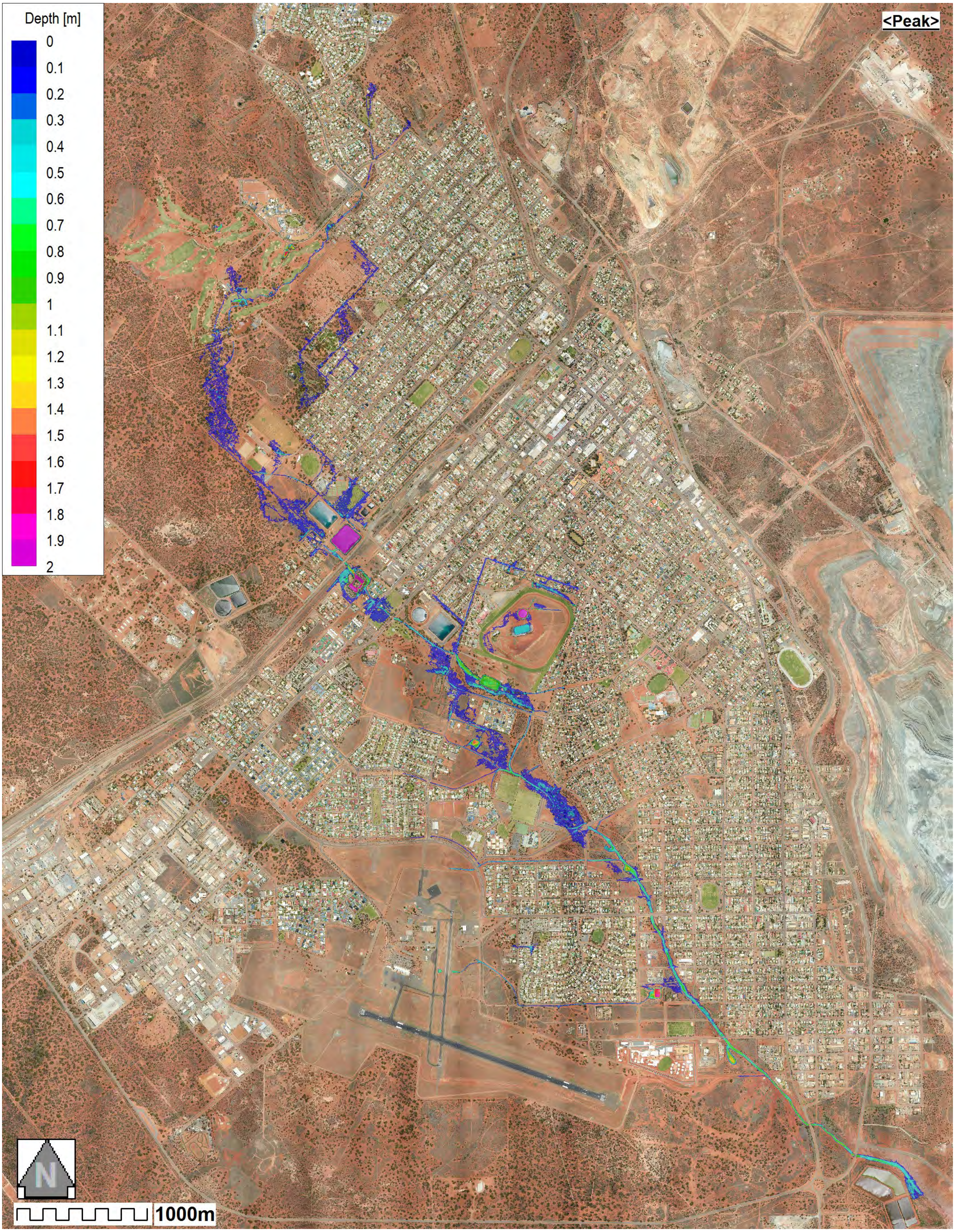


Project
Gribble Creek Flood Study

Consultant
Advisian

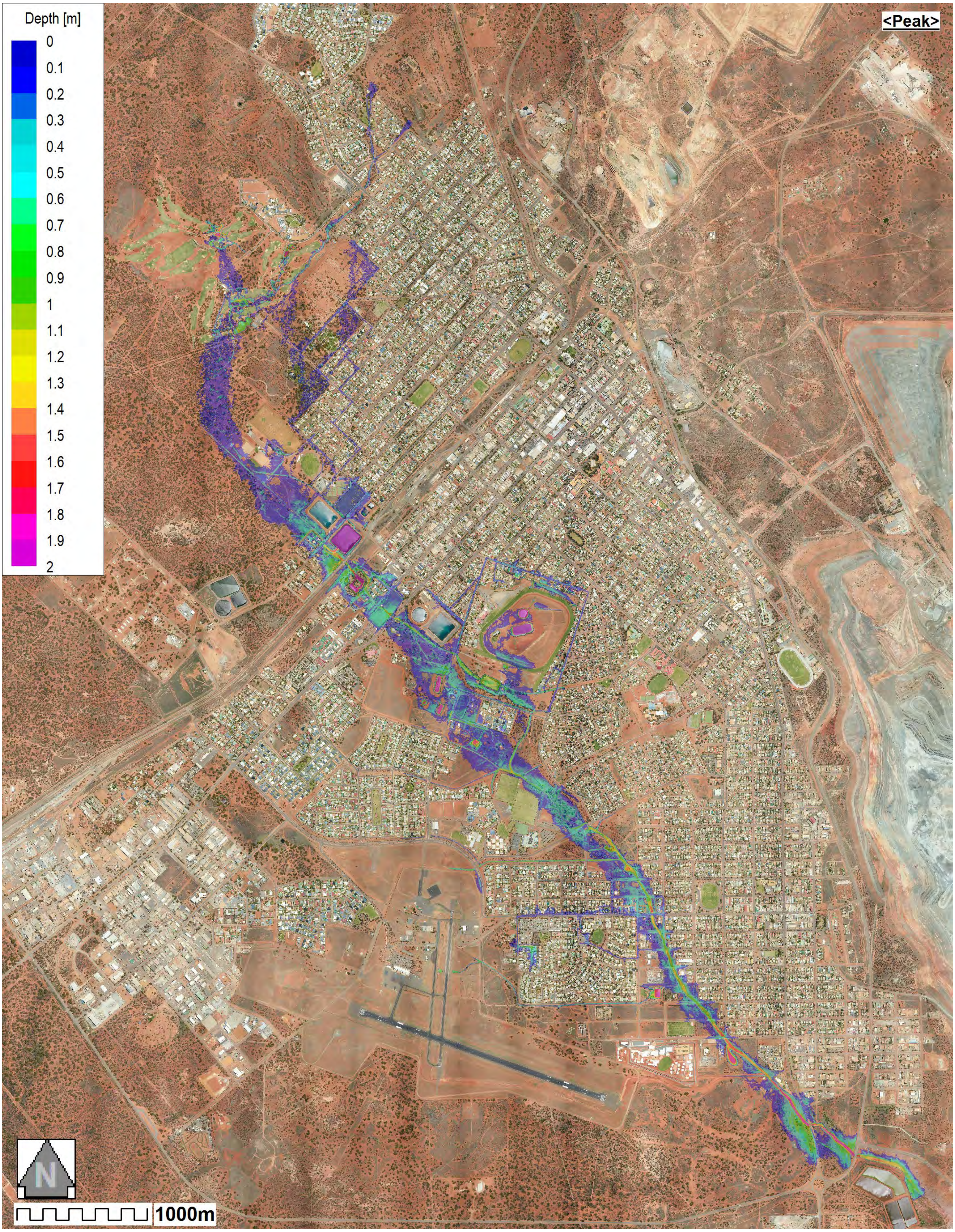
Advisian
WorleyParsons Group

Client
City of Kalgoorlie-Boulder

Title
20% Annual Exceedance Probability (5yr ARI)
Peak Flood Depth

Date
January 2017

Document Set ID: 3527361
Version: 1, Version Date: 20/05/2022

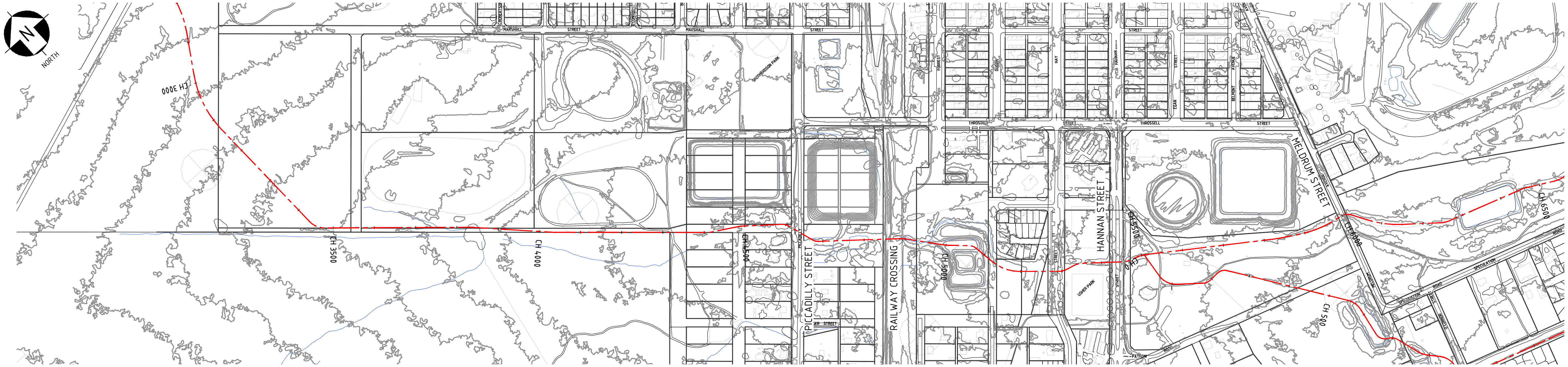


Project	Client	Title	Date
Gribble Creek Flood Study	City of Kalgoorlie-Boulder	1% Annual Exceedance Probability (100yr ARI) Peak Flood Depth	January 2017

Consultant
Advisian

Advisian
WorleyParsons Group

Document Set ID: 3527361
Version: 1, Version Date: 20/05/2022



PLAN
1:5000

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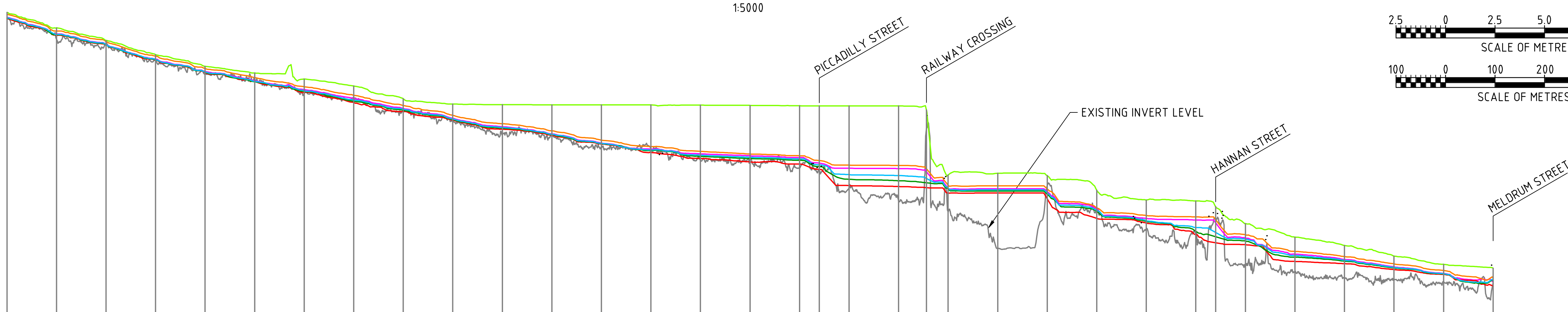
SCALE OF METRES 1:125

100 0 100 200 300 400 500
SCALE OF METRES 1:5000



DATUM RL.356

PMF WATER LEVEL	368.61	367.83	367.20	366.48	365.89	365.55	365.25	364.90	364.26	363.99	363.95	363.95	363.95	363.94	363.93	363.92
DESIGNATED FLOOD LEVEL	368.50	367.67	367.15	366.41	365.78	365.32	364.86	364.43	363.91	363.42	363.00	362.63	362.17	361.85	361.60	361.46
1% AEP (100YR ARI) WATER LEVEL	368.35	367.52	367.00	366.25	365.63	365.17	364.71	364.27	363.76	363.27	362.85	362.48	362.02	361.71	361.47	361.38
2% AEP (50YR ARI) WATER LEVEL	368.33	367.50	366.98	366.23	365.61	365.14	364.66	364.19	363.72	363.23	362.81	362.46	362.00	361.67	361.40	361.30
5% AEP (20YR ARI) WATER LEVEL	368.31	367.48	366.97	366.22	365.60	365.11	364.63	364.13	363.67	363.20	362.77	362.44	361.99	361.63	361.34	361.23
10% AEP (10YR ARI) WATER LEVEL	368.28	367.46	366.97	366.21	365.57	365.12	364.57	364.07	363.61	363.17	362.72	362.42	361.97	361.55	361.24	361.07
EXISTING SURFACE	368.27	367.26	367.01	366.17	365.50	365.09	364.49	364.29	363.69	363.13	362.44	362.35	361.78	361.72	361.13	361.19
CHAINAGE	3000	3100	3200	3300	3400	3500	3600	3700	3800	3900	4000	4100	4200	4300	4400	4500

PMF WATER LEVEL	363.90	363.89	363.89	363.89	363.69	360.41	360.50	360.38	359.64	359.15	359.10	358.81	357.95	357.27	356.85	356.32	355.90	355.71
DESIGNATED FLOOD LEVEL	361.38	361.14	360.91	360.89	360.73	359.89	359.86	359.71	358.75	358.36	358.29	358.15	357.40	356.55	356.29	355.93	355.59	355.21
1% AEP (100YR ARI) WATER LEVEL	361.29	361.00	360.75	360.73	360.58	359.74	359.71	359.57	358.69	358.21	358.14	358.00	357.23	356.41	356.15	355.78	355.44	355.01
2% AEP (50YR ARI) WATER LEVEL	361.22	360.92	360.43	360.38	360.24	359.75	359.66	359.51	358.62	358.11	357.76	357.51	357.17	356.35	356.11	355.75	355.43	355.08
5% AEP (20YR ARI) WATER LEVEL	361.15	360.83	360.19	360.12	360.02	359.70	359.60	359.44	358.57	358.07	357.57	357.29	357.07	356.26	356.06	355.72	355.41	355.06
10% AEP (10YR ARI) WATER LEVEL	360.96	360.69	359.87	359.82	359.77	359.50	359.50	359.21	358.22	357.98	357.40	356.99	356.89	356.04	355.93	355.63	355.39	354.80
EXISTING SURFACE	360.77	360.62	359.73	359.11	362.72	358.55	356.70	359.87	358.52	357.68	357.41	358.22	355.82	355.54	355.21	355.15	355.04	354.95
CHAINAGE	4600	4640	4700	4800	4856	4900	5000	5100	5200	5300	5400	5440	5500	5600	5700	5800	5900	6000

PROFILE
1:5000H 1:125V

LEGEND
- WATER COURSE CENTERLINE
- 10% AEP (10 YR ARI) WATER LEVEL
- 5% AEP (20 YR ARI) WATER LEVEL
- 2% AEP (50 YR ARI) WATER LEVEL
- 1% AEP (100 YR ARI) WATER LEVEL
- PMF YEAR WATER LEVEL
- DESIGNATED FLOOD LEVEL

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LOCATION \\PERWORFIL1\INFAIT04_MOVE\301012-02179 KALGOORLIE GRIBBLE CREEK\9_DRAWINGS\CIVIL\DWG\301012-02179-CI-DAL-0009.DWG

USER NAME: trevor.james

PLOT DATE & TIME: 30/1/2017 12:01:10 PM
SAVE DATE & TIME: 30/1/2017 12:00:37 PM

REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPROVED	CUSTOMER	REF DRAWING No	REFERENCE DRAWING TITLE
0	30-JAN-17	ISSUED FOR USE	TJ		SR	SA				

A1 SHEET SCALE AS SHOWN

OneWay to zero harm

WORLEYPARSONS PROJECT No. 301012-02179

ENGINEERING AND PERMIT STAMPS (As Required)

CUSTOMER

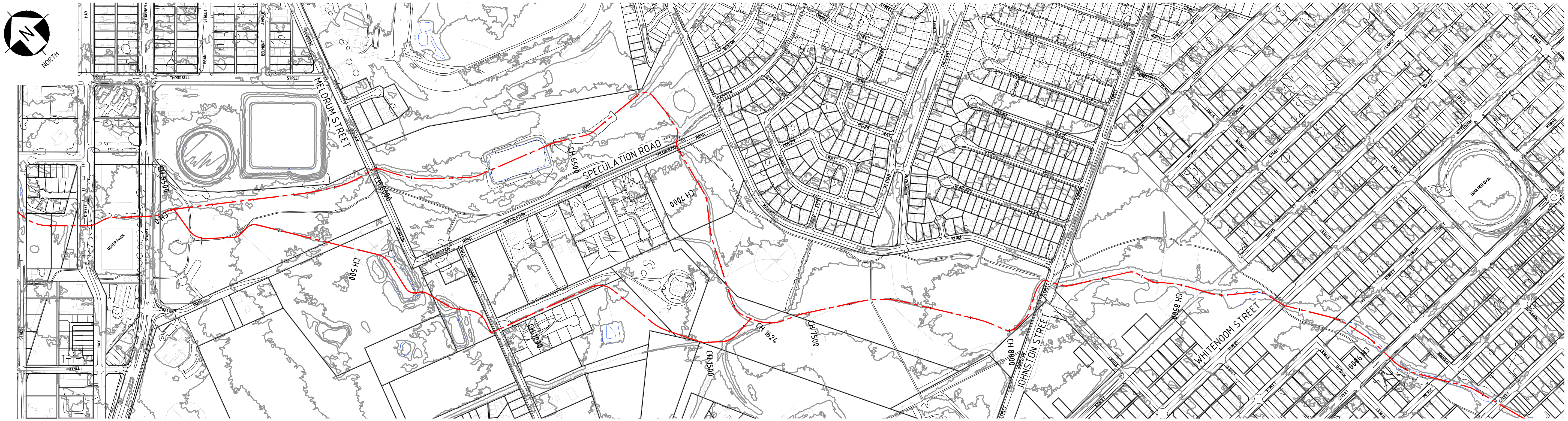
City of KALGOORLIE-BOULDER

WorleyParsons resources & energy
Advisian WorleyParsons Group

GRIBBLE CREEK FLOOD STUDY
KALGOORLIE TOWNSITE
10%, 5%, 2%, 1% AEP AND PMF WATER LEVELS
SURFACE PROFILES - SHEET 2 OF 4

DRG No 301012-02179-CI-DAL-0009 REV 0

WORLEYPARSONS_A1_REV2



PLAN

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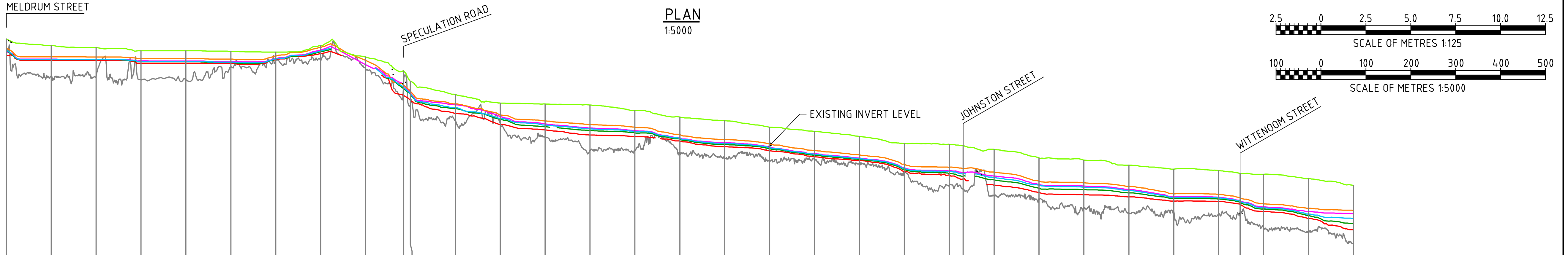

CHAINAGE	PMF WATER LEVEL	DESIGNATED FLOOD LEVEL	1% AEP (100YR ARI) WATER LEVEL	2% AEP (50YR ARI) WATER LEVEL	5% AEP (20YR ARI) WATER LEVEL	10% AEP (10YR ARI) WATER LEVEL	EXISTING SURFACE
6000	355.71	355.21	355.01	355.08	355.06	354.80	354.95
6100	355.34	354.71	354.58	354.56	354.55	354.51	353.64
6200	355.22	354.70	354.57	354.56	354.54	354.51	353.63
6300	355.05	354.61	354.48	354.45	354.43	354.35	353.42
6400	355.05	354.61	354.48	354.45	354.43	354.35	353.43
6500	355.02	354.58	354.45	354.41	354.39	354.33	354.15
6600	354.97	354.75	354.60	354.58	354.58	354.55	354.48
6700	355.34	355.23	355.08	355.02	354.99	354.88	354.54
6800	354.70	354.51	354.27				354.06
6885	353.92	353.13	353.13	353.00	352.93	352.55	353.29
6900	353.33	352.78	352.69	352.64	352.61	352.28	351.97
7000	352.61	352.09	352.04	351.87	351.82	351.56	351.13
7100	352.13	351.46	351.38	351.26	351.23	350.93	350.97
7200	352.08	351.14	350.97	350.90	350.81	350.63	350.21
7300	352.02	350.93	350.74	350.69	350.60	350.35	349.49
7400	351.71	350.78	350.59	350.54	350.47	350.25	349.50
7500	351.35	350.37	350.20	350.17	350.12	350.01	349.33
7600	351.15	350.10	349.92	349.88	349.81	349.69	349.07
7700	350.78	349.84	349.67	349.64	349.57	349.47	348.96
7800	350.54	349.48	349.30	349.28	349.22	349.14	348.97
7900	350.27	349.24	349.06	349.03	348.98	348.93	348.77
8000	349.87	348.71	348.53	348.50	348.44	348.31	348.19
8100	349.83	348.55	348.35	348.30	348.21	348.12	347.55
8131	349.76	348.48	348.25	348.18	348.05	347.90	347.33
8200	349.55	348.28	348.06	347.98	347.84	347.55	346.96
8300	349.07	347.77	347.58	347.54	347.37	347.14	346.77
8400	348.94	347.68	347.50	347.44	347.30	347.02	346.23
8500	348.67	347.49	347.31	347.25	347.12	346.90	346.00
8600	348.44	347.07	346.90	346.87	346.81	346.66	346.08
8700	348.36	347.04	346.87	346.84	346.78	346.64	345.84
8748	348.20	346.84	346.68	346.65	346.59	346.48	346.09
8800	348.16	346.51	346.34	346.29	346.22	346.08	345.19
8900	347.91	346.26	346.08	345.94	345.85	345.70	345.00
9000	347.55	346.15	345.97	345.70	345.42	345.06	344.31

PROFILE

1:5000H 1:125V

LEGEND

- WATER COURSE CENTERLINE
- 10% AEP (10 YR ARI) WATER LEVEL
- 5% AEP (20 YR ARI) WATER LEVEL
- 2% AEP (50 YR ARI) WATER LEVEL
- 1% AEP (100 YR ARI) WATER LEVEL
- PMF YEAR WATER LEVEL
- DESIGNATED FLOOD LEVEL

INFORMATION ONLY
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LOCATION: \\PERWORFIL\INFA\TO_MOVE\301012-02179 KALGOORLIE GRIBBLE CREEK\9_DRAWINGS\CI\DWG\301012-02179-CI-DAL-0010.DWG

USER NAME: trevor.james

PLOT DATE & TIME: 30/1/2017 12:01:03 PM
SAVE DATE & TIME: 30/1/2017 12:00:34 PM

REV	DATE	REVISION DESCRIPTION	DRAWN	DRAFT CHK	DESIGNED	ENG CHK	APPROVED	CUSTOMER	REF DRAWING No	REFERENCE DRAWING TITLE
0	30-JAN-17	ISSUED FOR USE	TJ		SR	SA				

A1 SHEET SCALE AS SHOWN

ENGINEERING AND PERMIT STAMPS (As Required)

OneWay to zero harm

WORLEYPARSONS PROJECT No. 301012-02179

CUSTOMER

City of KALGOORLIE-BOULDER

WorleyParsons resources & energy
Advisian WorleyParsons Group

GRIBBLE CREEK FLOOD STUDY
KALGOORLIE TOWNSITE
10%, 5%, 2%, 1% AEP AND PMF WATER LEVELS
SURFACE PROFILES - SHEET 3 OF 4

DRG No 301012-02179-CI-DAL-0010 REV 0

WORLEYPARSONS_A1_REV2

Advisian
WorleyParsons Group

Chainage	Peak Flow (m^3/s)						Peak Flood Level (mAHD)						Peak Velocity (m/s)					
	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	PMF Event	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	PMF Event	20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	PMF Event
4800	2.23	4.20	10.44	16.33	23.16	458.25	359.61	359.82	360.10	360.37	360.73	363.9	0.42	0.57	0.64	0.66	0.69	2.27
4900	2.75	3.77	12.00	19.45	27.71	448.98	359.45	359.57	359.68	359.72	359.76	363.9	2.46	2.56	2.55	3.09	3.23	2.34
5000	2.62	4.60	12.18	17.64	26.40	458.02	359.34	359.38	359.43	359.46	359.48	360.68	0.96	1.14	1.65	1.72	2.56	5.50
5100	2.06	3.81	9.64	15.51	23.47	452.98	359.11	359.16	359.16	359.19	359.24	360.4	0.29	0.62	0.95	1.14	1.17	2.84
5200	1.74	3.27	8.35	12.84	19.93	457.01	358.24	358.25	358.60	358.70	358.78	360.18	0.91	1.19	1.46	1.56	1.61	2.64
5300	2.79	4.64	12.65	19.08	27.83	451.10	358.02	358.03	358.18	358.22	358.31	359.68	0.84	0.85	1.36	1.35	1.38	2.55
5400	3.82	6.27	12.97	18.81	27.57	494.13	357.63	357.69	357.83	357.93	358.18	359.25	1.64	1.75	2.10	2.10	2.11	2.30
5500	3.91	5.91	14.59	21.66	30.92	494.33	356.65	356.78	357.02	357.05	357.05	359.14	0.81	0.94	1.23	1.31	1.43	2.19
5600	2.67	4.75	11.63	18.27	28.40	492.01	355.91	356.06	356.33	356.37	356.41	358.19	0.47	0.52	0.82	1.01	1.25	2.87
5700	3.07	6.00	15.99	21.86	30.70	507.36	355.80	355.90	355.91	355.93	355.98	358.53	0.65	0.81	1.17	1.25	1.34	2.92
5800	3.34	6.09	13.00	19.51	28.41	515.62	355.57	355.61	355.64	355.65	355.65	358.2	0.80	0.88	1.04	1.12	1.21	2.54
5900	3.75	6.23	14.64	19.06	27.86	514.30	355.27	355.28	355.28	355.28	355.29	357.44	0.71	0.72	1.19	1.25	1.27	2.45
6000	0.14	0.41	0.41	2.28	2.72	536.77	355.31	355.35	355.36	355.49	355.49	356.05	1.21	1.28	1.28	1.28	1.28	2.00
6100	2.28	2.74	3.57	4.21	4.86	62.30	354.52	354.53	354.55	354.56	354.58	355.86	0.33	0.73	0.79	0.36	0.39	1.54
6200	2.46	2.90	3.70	4.36	5.00	122.22	354.48	354.49	354.51	354.53	354.55	355.72	0.63	0.66	0.69	0.69	0.71	2.74
6300	2.60	3.18	4.24	4.95	5.52	89.54	354.36	354.39	354.43	354.46	354.48	355.24	0.55	0.64	0.71	0.77	0.92	2.51
6400	2.45	3.00	3.86	4.55	5.20	54.63	354.36	354.39	354.43	354.45	354.48	355.15	0.27	0.27	0.33	0.44	0.30	3.41
6500	2.15	2.53	3.70	4.08	4.78	51.19	354.32	354.34	354.44	354.48	354.51	355.12	0.68	0.63	0.73	0.76	0.79	2.14
6600	3.38	4.08	5.52	6.20	6.90	50.45	354.47	354.47	354.44	354.47	354.44	354.95	0.47	0.51	0.86	0.92	0.86	2.18
6700	3.62	4.87	6.78	7.97	9.53	50.45	354.67	354.67	354.69	354.69	354.71	354.94	0.59	0.73	1.37	1.58	1.46	3.91
6800	2.74	3.67	5.37	7.04	8.58	37.30	354.11	354.15	354.21	354.23	354.27	354.85	0.57	0.61	0.65	0.68	0.73	2.70
6900	2.52	3.60	5.64	7.19	9.54	115.37	352.36	352.41	352.55	352.58	352.78	354.86	1.05	1.05	1.17	1.39	1.72	3.00
7000	4.67	6.90	7.66	7.64	10.96	117.57	351.54	351.72	351.81	351.86	352.02	353.82	1.28	1.71	1.83	1.37	1.31	1.71
7100	3.18	4.83	7.12	9.06	12.21	134.66	350.91	351.07	351.17	351.25	351.35	352.86	1.10	1.23	1.54	1.92	1.96	1.82
7200	4.77	6.16	9.50	11.27	13.75	129.13	350.61	350.69	350.94	351.00	351.03	352.12	0.98	1.14	1.28	1.36	1.34	1.23
100*	2.14	4.26	11.52	16.83	26.16	158.10	354.75	354.78	354.82	354.86	354.92	351.73	0.67	0.84	0.83	0.74	0.82	2.12
200*	1.78	3.41	9.76	15.37	24.64	465.76	354.06	354.11	354.45	354.55	354.63	355.76	0.91	0.77	0.78	0.95	1.17	1.26
300*	1.38	3.23	9.89	15.39	24.35	455.65	354.02	354.06	354.14	354.17	354.22	355.48	0.22	0.28	0.51	0.71	1.03	1.07
400*	3.11	4.97	13.11	19.59	29.20	462.25	353.77	353.81	353.83	353.83	353.96	355.08	0.76	0.79	0.96	1.17	1.24	1.72
500*	0.76	2.89	9.13	14.09	22.72	467.23	352.73	352.78	352.90	352.97	353.29	354.75	0.48	0.52	0.67	0.64	0.80	2.48
600*	1.60	3.87	11.78	17.02	26.13	497.24	352.82	352.97	353.11	353.15	353.17	354.41	0.93	1.00	1.06	1.31	1.45	2.76
700*	1.47	3.08	9.26	15.12	24.32	501.50	352.77	352.80	352.82	352.83	352.85	353.77	0.62	1.36	1.23	1.32	1.07	2.18
800*	0.91	3.35	9.88	15.82	18.91	498.12	352.23	352.25	352.27	352.26	352.25	353.37	0.45	0.74	0.98	1.03	1.16	2.05
900*	0.44	2.09	8.71	14.92	19.39	517.60	351.64	351.70	351.78	351.79	351.80	352.94	0.58	0.90	1.10	1.07	1.29	4.24
1000*	0.40	1.43	7.99	13.78	16.66	514.38	351.38	351.40	351.41	351.41	351.42	353.16	0.35	0.54	1.00	1.05	1.05	2.41
1100*	1.37	3.89	13.34	19.77	24.39	510.19	350.87	350.89	350.91	350.95	350.98	352.54	0.61	0.72	1.10	1.42	1.54	2.28
7400	5.34	8.36	16.13	23.89	29.05	510.04	350.17	350.29	350.43	350.50	350.55	352.18	0.77	0.89	1.26	1.21	1.23	1.52
7500	4.92	7.99	16.72	24.62	30.03	673.20	349.98	350.04	350.12	350.17	350.21	351.74	0.75	0.82	1.06	1.21	1.28	2.36
7600	5.41	8.59	17.56	25.58	30.92	686.78	349.64	349.70	349.81	349.88	349.92	351.53	0.68	0.68	0.68	0.70	0.74	2.43
7700	5.25	8.11	17.87	25.85	31.95	714.55	349.48	349.53	349.60	349.65	349.68	351.38	1.08	1.07	1.07	1.17	1.17	2.02
7800	5.36	8.76	17.97	26.55	32.03	693.44	349.09	349.13	349.21	349.29	349.31	351.04	0.67	0.76	0.86	0.87	0.94	2.28
7900	5.28	8.39	17.80	25.75	31.02	694.74	348.87	348.90	348.97	349.02	349.05	350.85	0.38	0.68	0.68	0.67	0.69	2.14
8000	7.28	9.59	17.80	25.55	30.99	717.97	348.57	348.57	348.62	348.66	348.69	350.25	1.08	1.09	1.27	1.24	1.30	2.10
8100	5.69	8.69	17.39	25.66	31.13	830.32	348.24	348.24	348.29	348.35	348.38	350.21	0.83	1.37	1.53	1.44	1.48	2.71
8200	5.08	7.70	17.34	25.65	31.21	822.66	347.80	347.90	348.05	348.15	348.21	349.78	1.21	1.24	1.23	1.33	1.16	2.35
8300	5.44	9.46	18.97	28.94	33.94	820.93	347.07	347.66	347.83	347.91	347.95	349.76	1.24	1.49	1.81	2.20	2.53	2.53

APPENDIX E

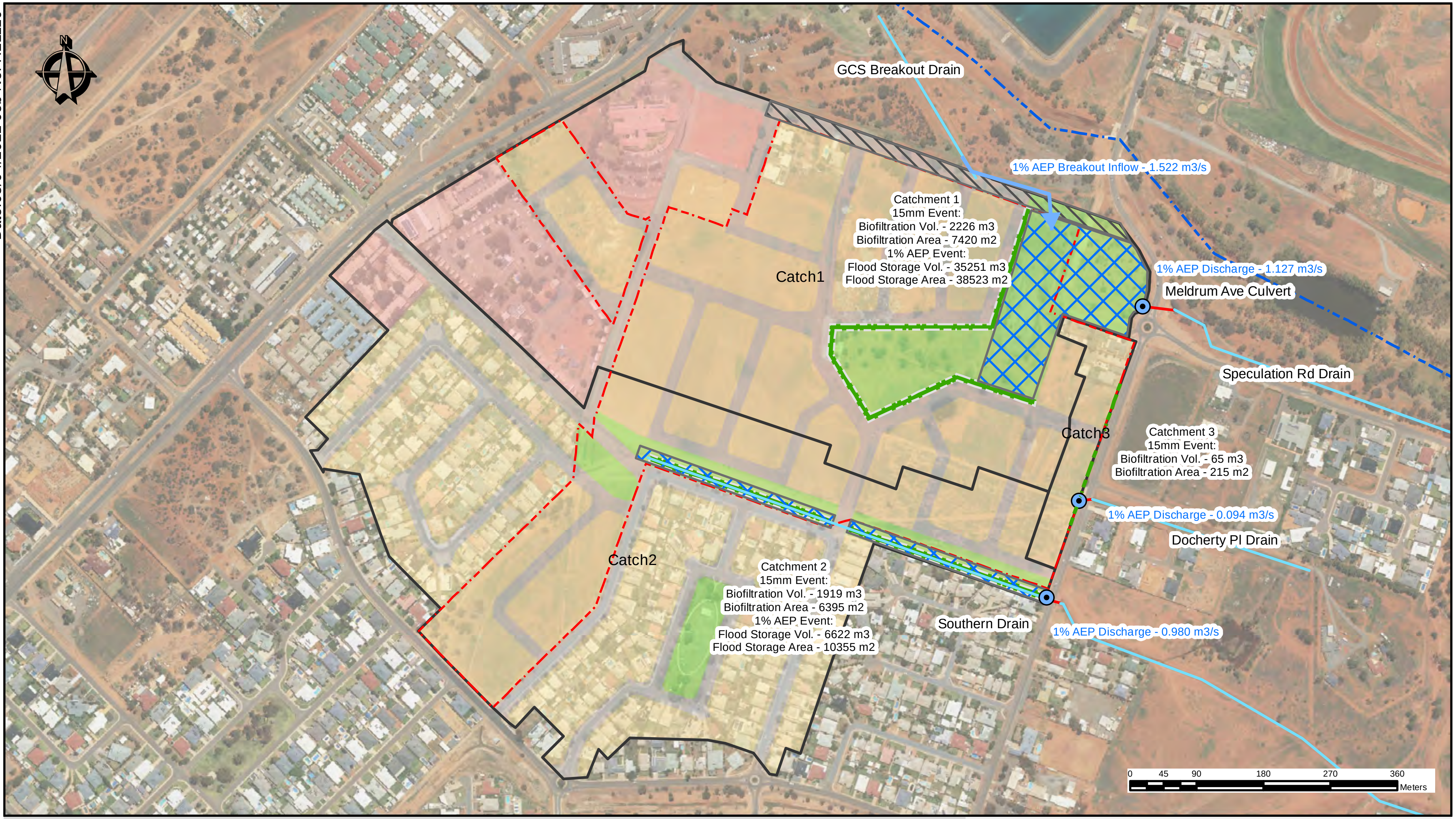
Stormwater Modelling of Concept DSP

Hyd2o – 08/04/2022

North Somerville Concept DSP Stormwater Management Summary

Catchment	1	2	3
Residential Lots (ha) (15mm @ 22% RO, 20% AEP @ 34% RO, 1% AEP @ 43% RO)	14.64	21.75	1.54
Roads (ha) (15mm @ 87% RO, 20% AEP & 1% AEP @ 100% RO)	7.30	8.42	0.10
Industrial (ha) (15mm @ 74% RO, 20% AEP @ 81% RO, 1% AEP @ 100% RO)	7.12	0.92	-
POS/Drainage (ha) (Green Ampt: Average Capillary Suction – 208.8 mm Sat. Hydraulic Conductivity – 2 mm/hr Initial Moisture Deficit – 0.267)	5.64	3.18	-
Total Area (ha)	34.7	34.27	1.64
Biofiltration Area			
Depth (m)	0.3	0.3	0.3
Side Slopes (v:h)	1:0	1:0	1:0
15mm Event			
Equiv. Imp. Area (ha)	14.84	12.79	0.43
Volume (m³)	2226	1919	65
TWL Area (m²)	7420	6395	215
Flood Storage Area			
Depth (m)	1.2	0.9 (on top bio)	Discharge to O'Connor St
Side Slopes (v:h)	1:6	1:6	
1% AEP Event			
Flood Rise (m)	1.18	0.86	
Volume (m³)	35251 (33025 exc. bio)	6622	
TWL Area (m²)	38523 (31103 exc. bio)	10355	
Beakout Inflow (m³/s)	1.551	-	-
Peak Discharge (m³/s)	1.143	0.980	0.094
Critical Storm (hr)	24	3	1

Date:08/04/2022 Job No. H21110



Site
Post Dev Catchments
Post Dev Discharge Points
Bund
FloodStorage
Biofiltration Areas
Rain garden
Bund Inflow
Open Cut Drain
Culvert
GribbleCreek
Lots
POS
Roads
Industrial (or Equiv)

hyd2o

North Somerville District Water Management Strategy

Stormwater Modelling of DSP

Appendix E

CURRV

Calculator for Urban Runoff Rates & Volumes

08-04-22

hyd2o HYDROLOGY

Project: North Somerville: City of Kalgoorlie-Boulder

	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	Residential	1.00	Yes	1.5	12.0	2.0	0.0	0.50	50%	40	10	50	
2	Road Reserves	1.00	Yes	1.5	12.0	2.0	0.0	0.50	100%	0	100	0	
3	Industrial	1.00	Yes	1.5	12.0	2.0	0.0	0.50	100%	45	40	15	
4								0.50					
5								0.50					
6								1.00					
7								1.00					
8								1.00					
9								1.00					
10								1.00					

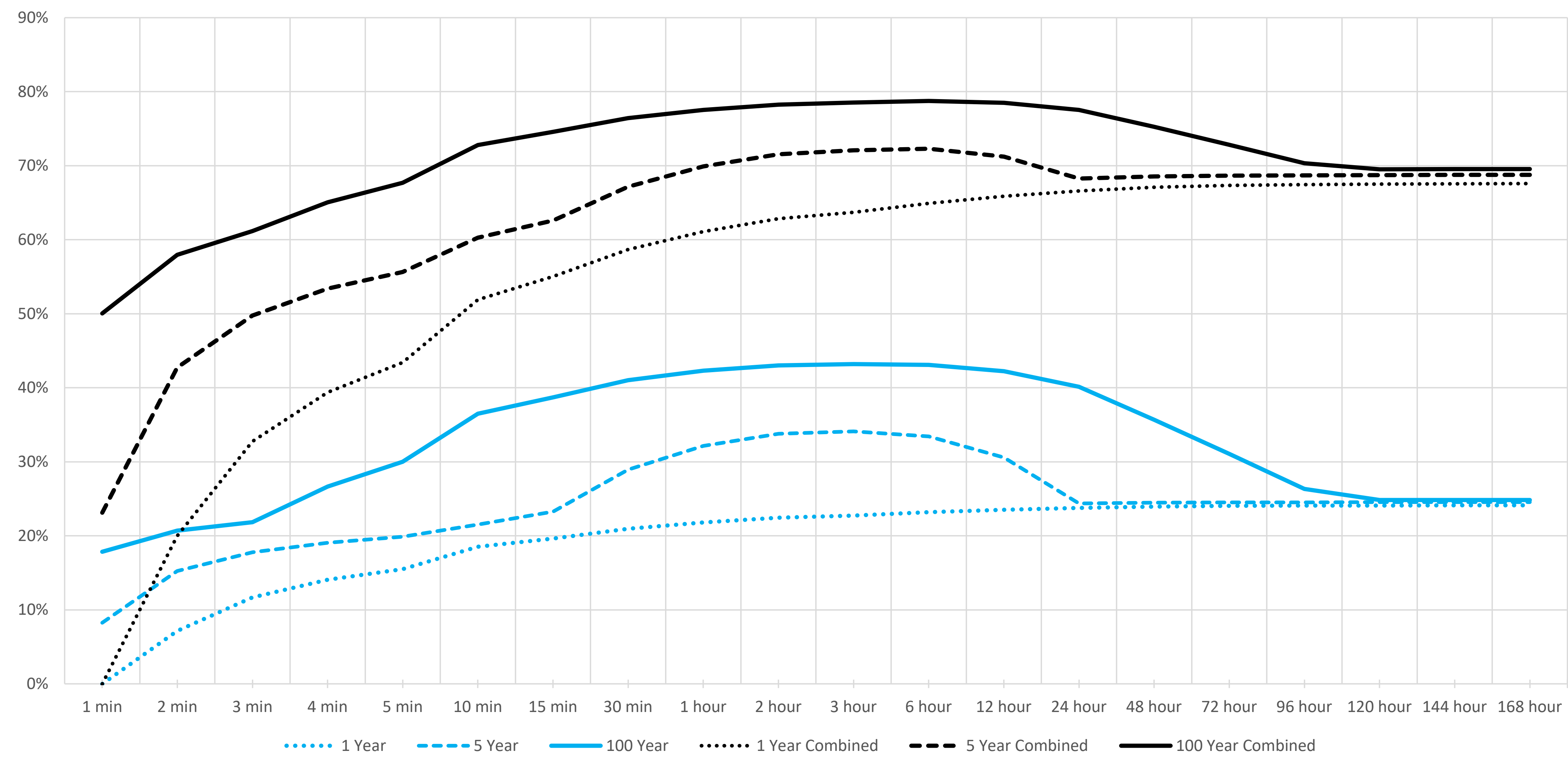
EIA : Effective Impervious Area, TIA : Total Impervious Area

Land Use Graph Selector	1

(11 - combined total)

Residential

Estimated Runoff Rates for Various Land Use and ARI



Rainfall IFD Data

Annual Exceedence Probability

	Duration	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
1	1 min	1.2	1.4	2.2	2.9	3.5	4.5	5.3
2	2 min	2.1	2.5	3.9	4.8	5.9	7.4	8.7
3	3 min	2.8	3.4	5.2	6.6	8.0	10.1	11.9
4	4 min	3.4	4.1	6.3	8.0	9.8	12.4	14.6
5	5 min	4.0	4.7	7.3	9.3	11.4	14.5	17.1
6	10 min	5.8	6.9	10.8	13.8	17.0	21.6	25.6
7	15 min	7.0	8.4	13.1	16.7	20.5	26.2	31.0
8	30 min	9.3	11.0	17.2	21.8	26.9	34.2	40.4
9	1 hour	11.8	14.0	21.7	27.5	33.7	42.7	50.4
10	2 hour	14.7	17.5	27.0	34.2	41.9	56.4	62.6
11	3 hour	16.7	19.9	30.7	39.0	47.8	60.8	71.7
12	6 hour	20.7	24.6	38.5	49.2	60.8	77.8	92.4
13	12 hour	25.5	30.5	48.3	62.5	78.3	101.0	121.0
14	24 hour	30.9	37.1	59.9	78.5	99.8	130.0	156.0
15	48 hour	36.2	43.8	71.6	94.9	122.0	159.0	191.0
16	72 hour	39.2	47.2	77.5	103.0	132.0	173.0	208.0
17	96 hour	40.9	49.2	80.8	107.0	138.0	180.0	217.0
18	120 hour	42.1	50.7	82.8	110.0	140.0	184.0	223.0
19	144 hour	42.9	51.7	84.0	111.0	141.0	186.0	226.0
20	168 hour	43.5	52.3	84.7	111.0	142.0	187.0	227.0

Estimated Runoff Rates

Annual Exceedence Probability

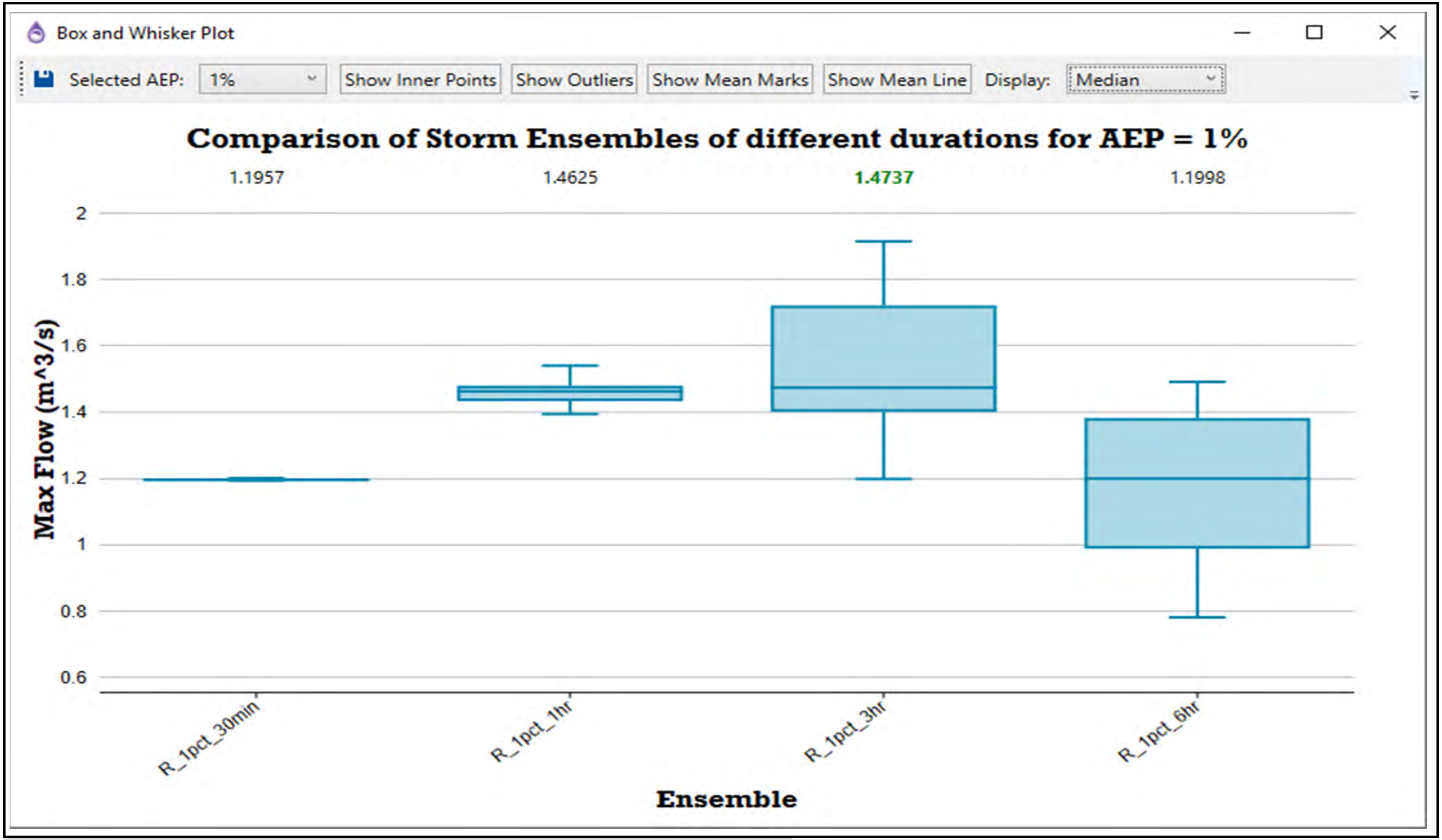
Maximum of All Events	63.2% 1.00	50% 1.44	20% 4.48	10% 10	5% 20	2% 50	1% 100
Residential	24%	26%	34%	38%	40%	42%	43%
Road Reserves	97%	97%	98%	99%	99%	99%	99%
Industrial	82%	83%	87%	90%	92%	94%	95%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**68%**	68%	**72%**	**75%**	76%	78%	**79%**

Event Selector	9	1 hour					
Residential	22%	22%	32%	36%	39%	41%	42%
Road Reserves	87%	89%	93%	95%	96%	96%	97%
Industrial	74%	76%	84%	88%	90%	92%	93%
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%
0	0%	0%	0%	0%	0%	0%	0%
0	0%	0%	0%	0%	0%	0%	0%
combined total	**61%**	63%	**70%**	**73%**	75%	77%	**78%**

Document Set ID: 3527361
Version: 1, Version Date: 20/05/2022

APPENDIX F
XP-Storm Modelling Outputs

Date : 11/04/2022 Job No: H21110

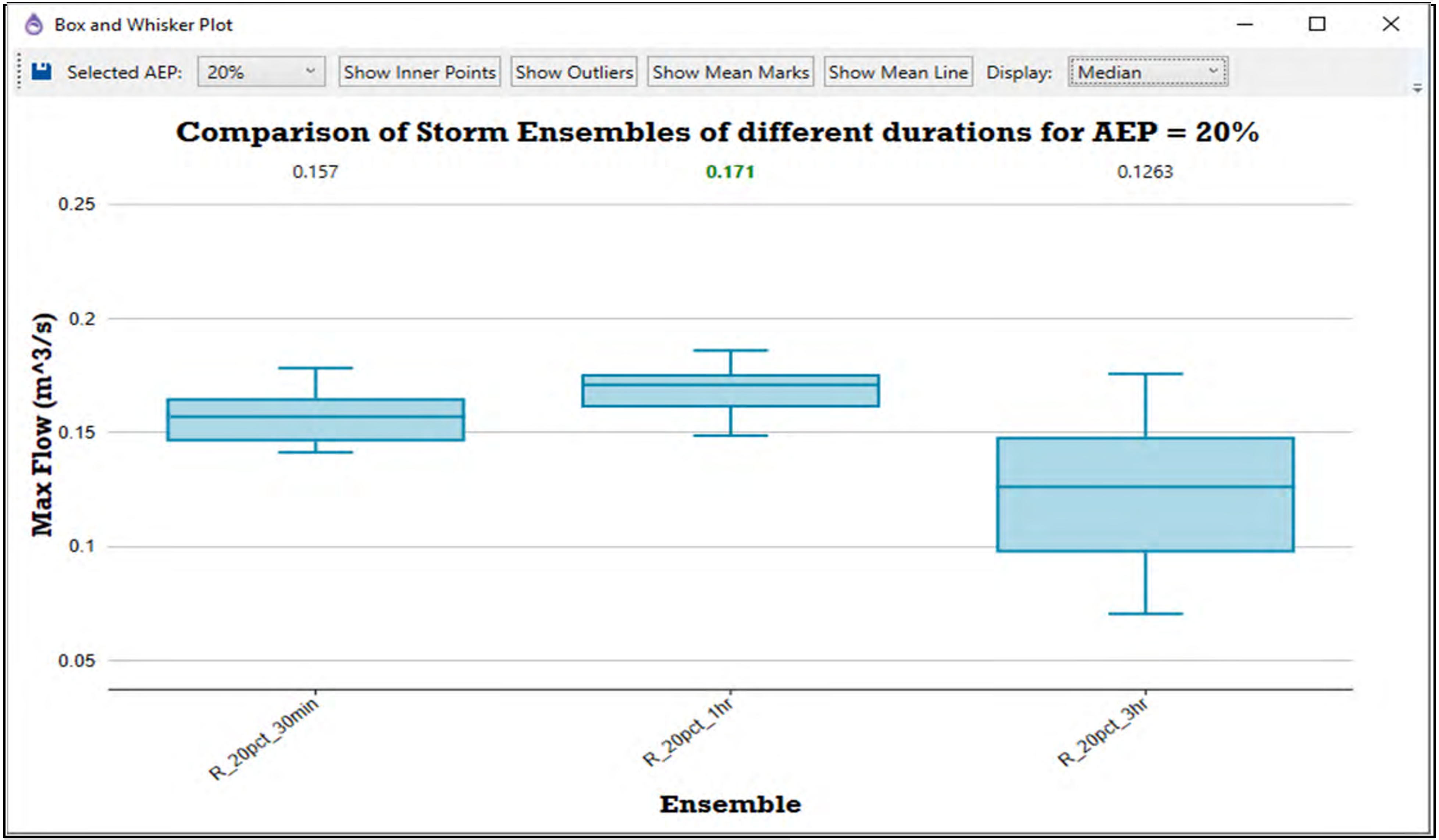


hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 1% AEP Flow Rate Estimation: Northern

Appendix F1

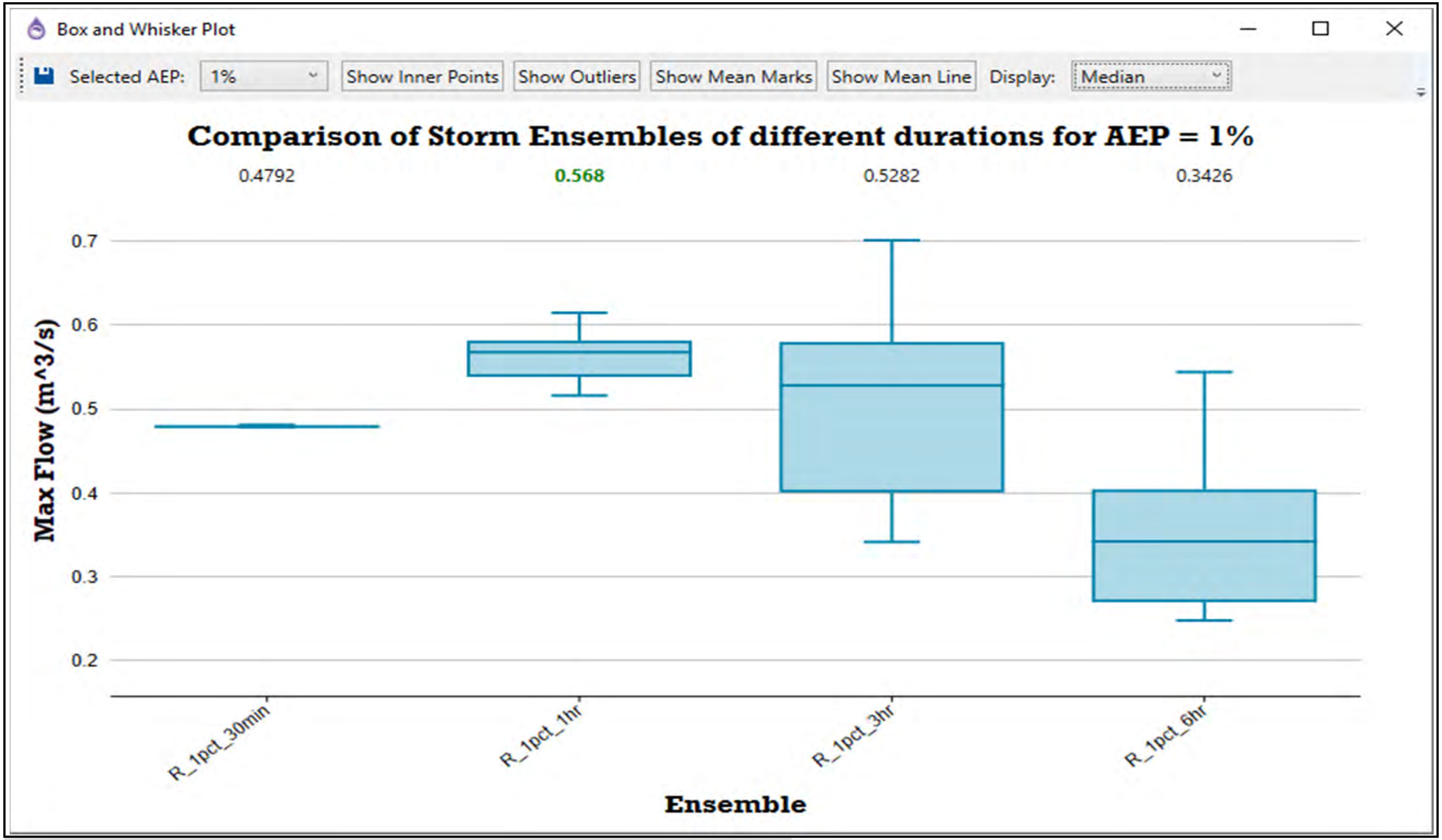


hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 20% AEP Flow Rate Estimation: Northern

Appendix F2

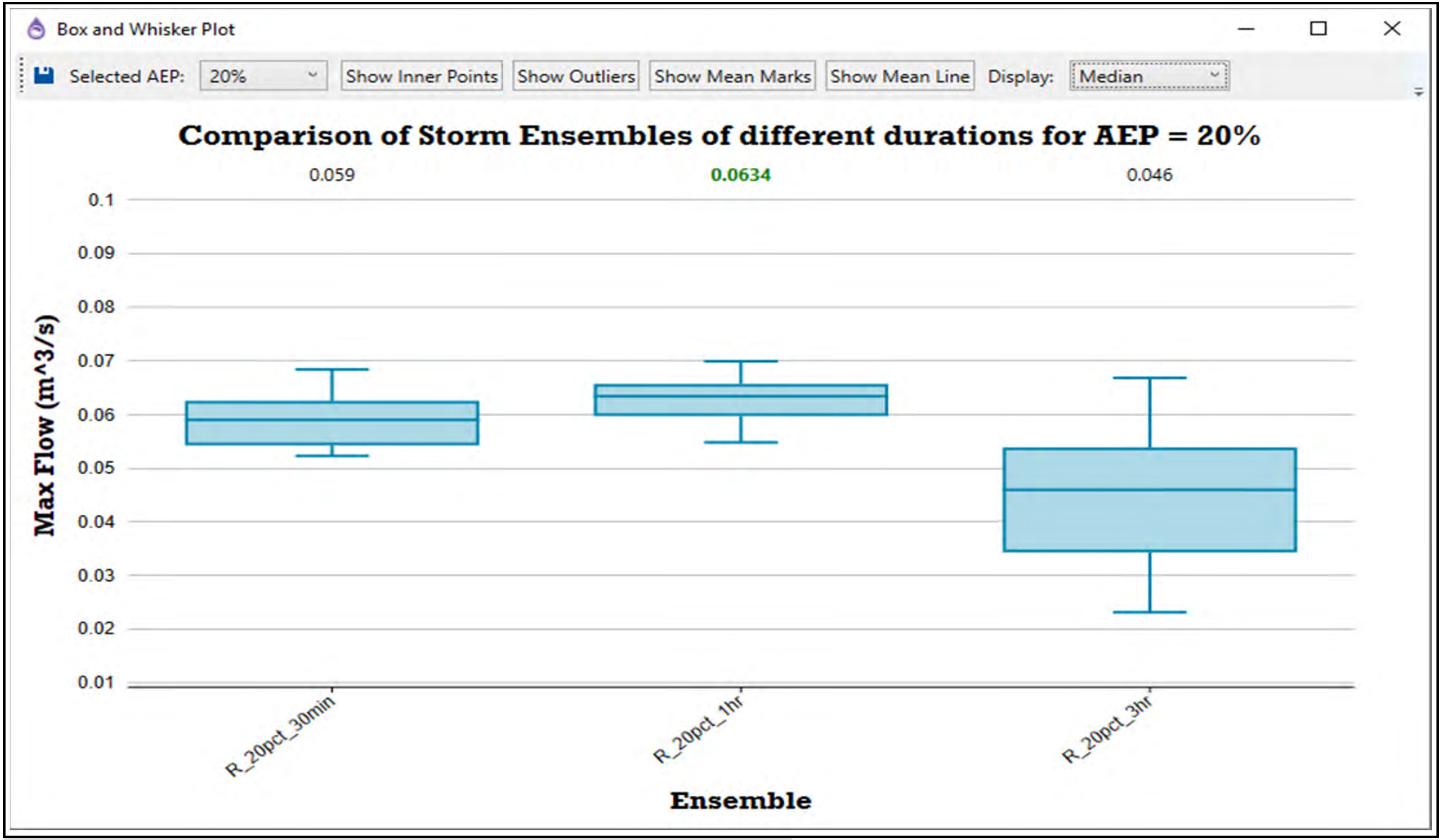


hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 1% AEP Flow Rate Estimation: Southern

Appendix F3

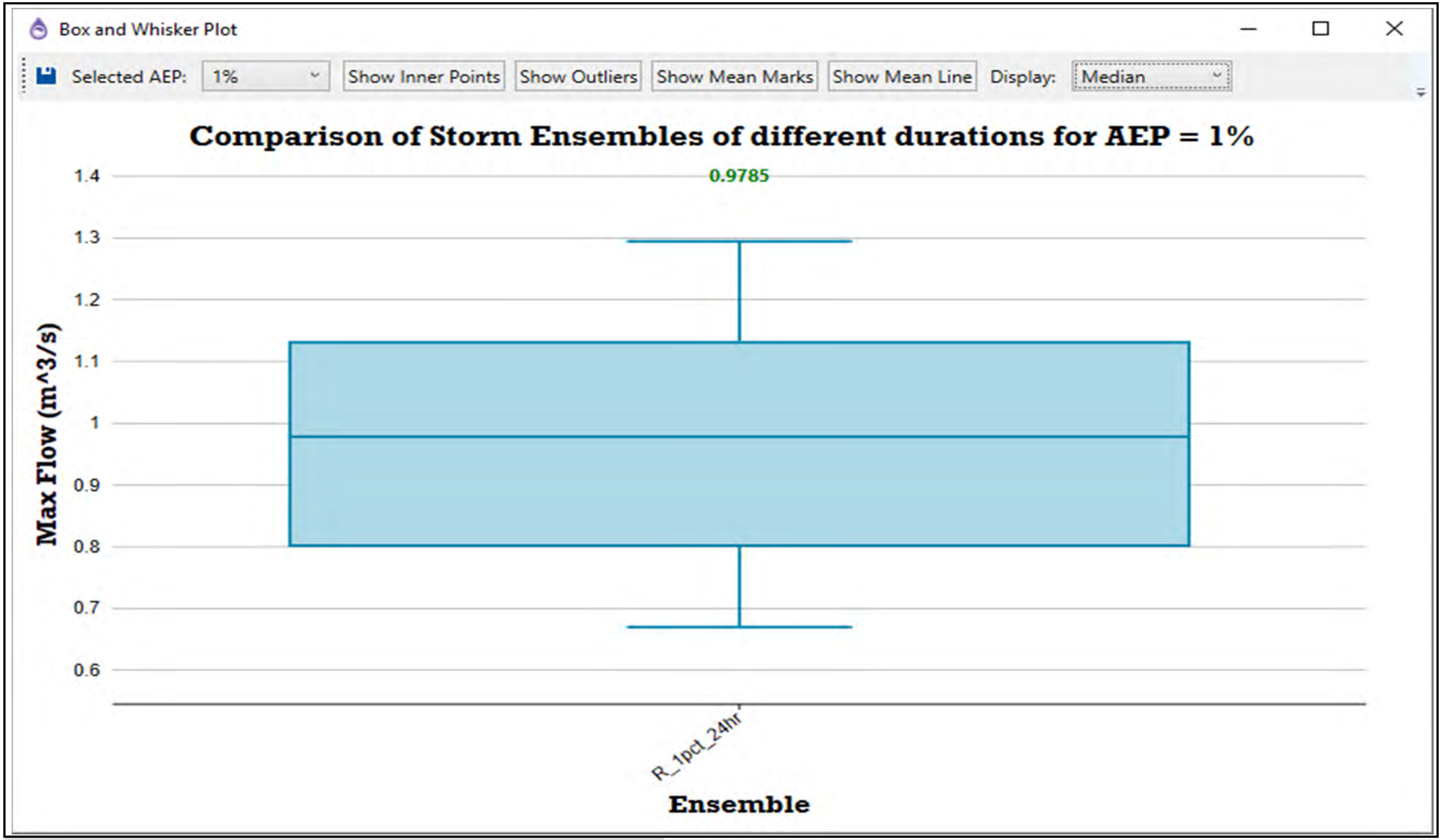


hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 20% AEP Flow Rate Estimation: Southern

Appendix F4

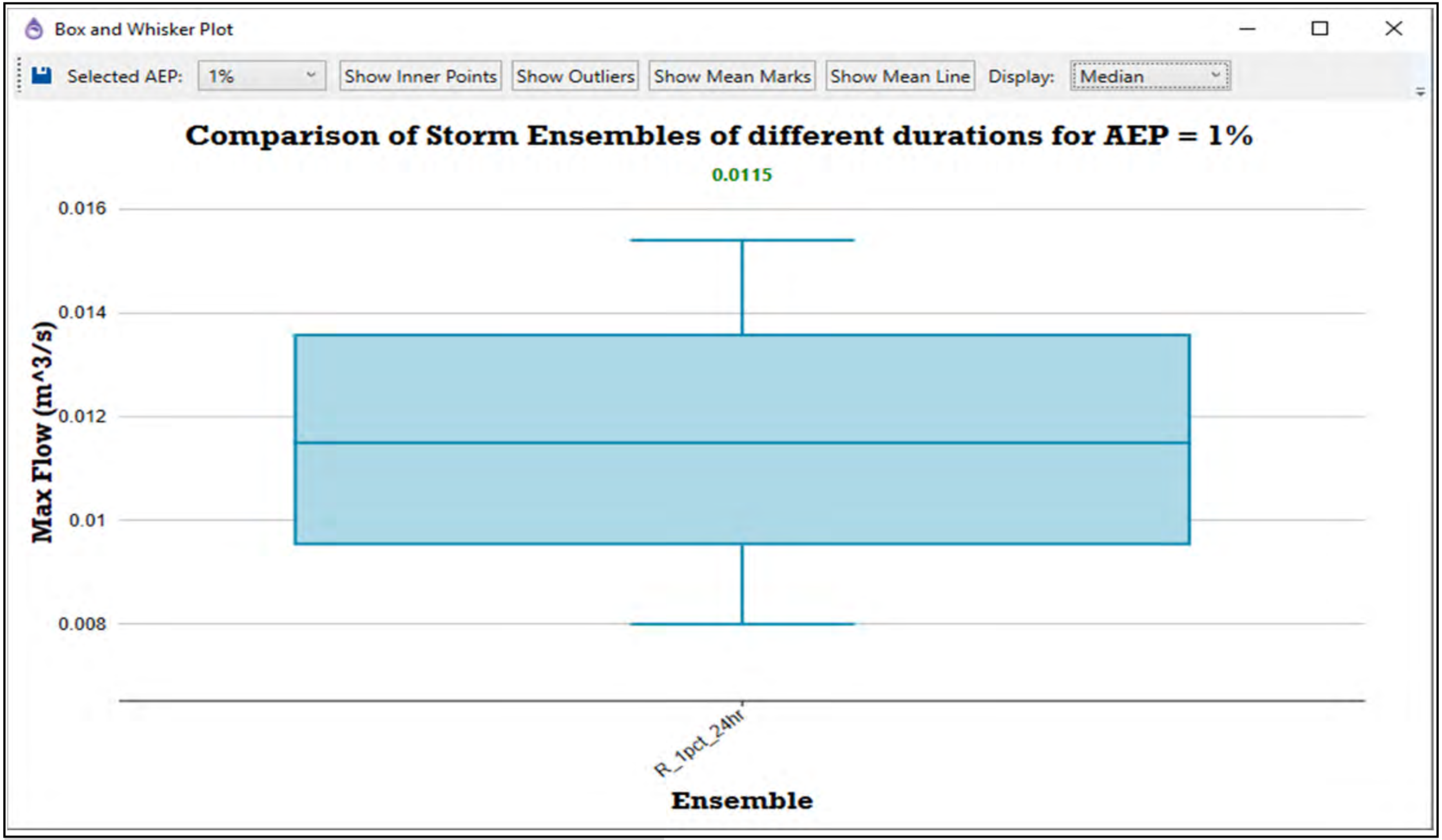


hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 1% AEP 24 Hr Discharge Rate: Catchment B

Appendix F5



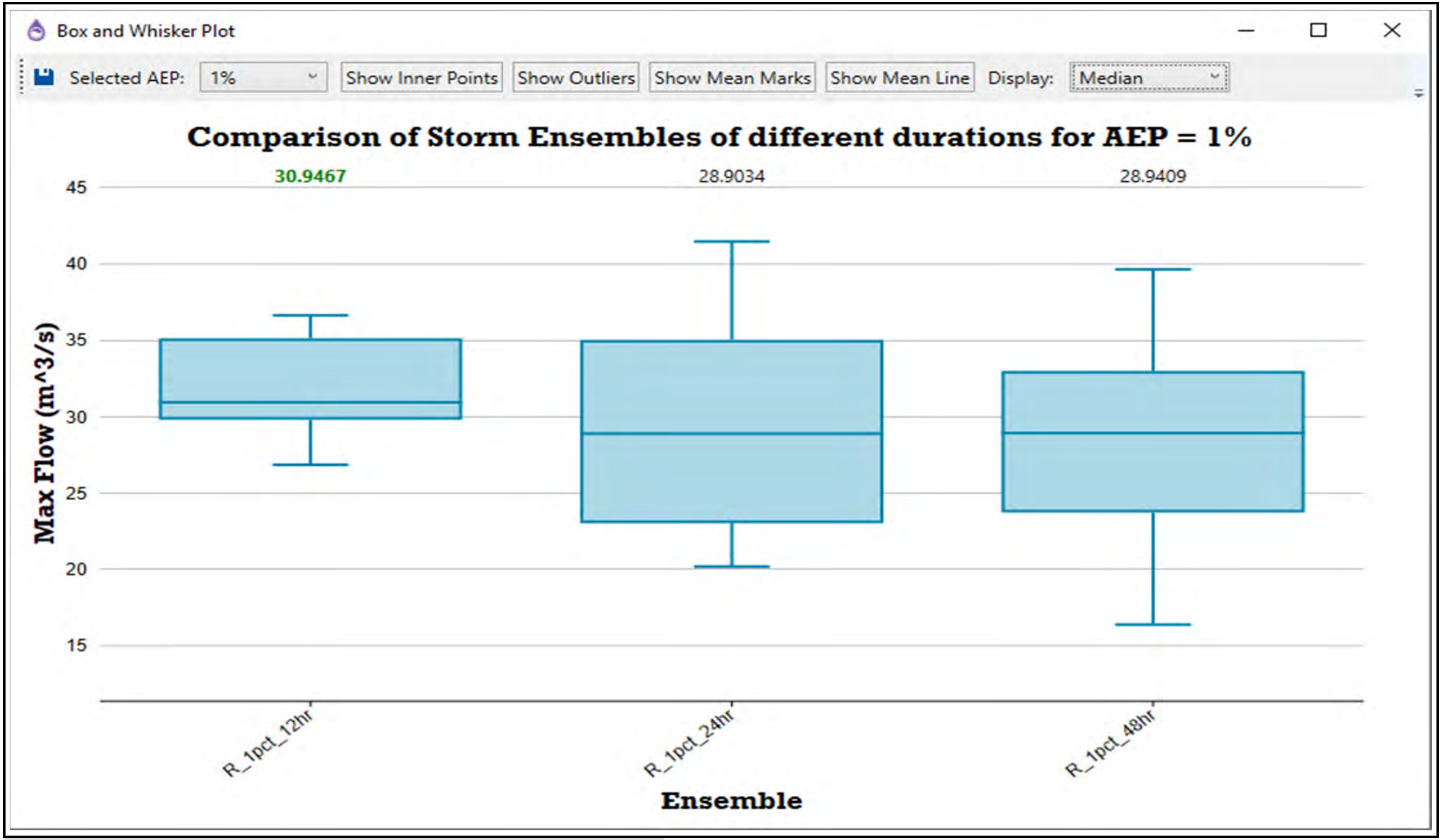
hyd2o

North Somerville Distrcit Water Management Strategy

Predevelopment 1% AEP 24 Hr Discharge Rate: Catchment C

Appendix F6

Date : 11/04/2022 Job No: H21110

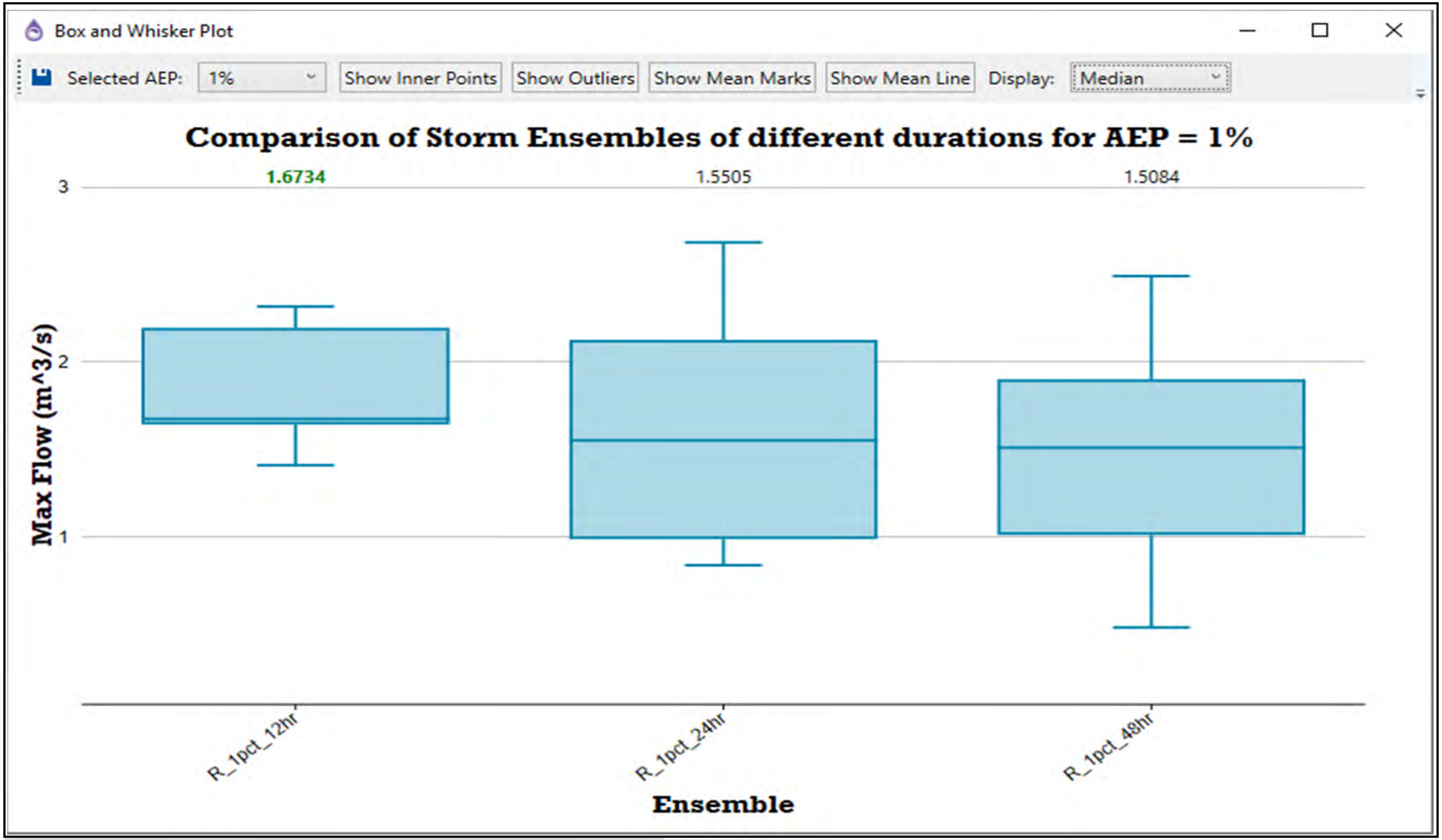


hyd2o

North Somerville Distrcit Water Management Strategy

1% AEP Stormwater Mangement Criteria: Hannans St Flow

Appendix F7

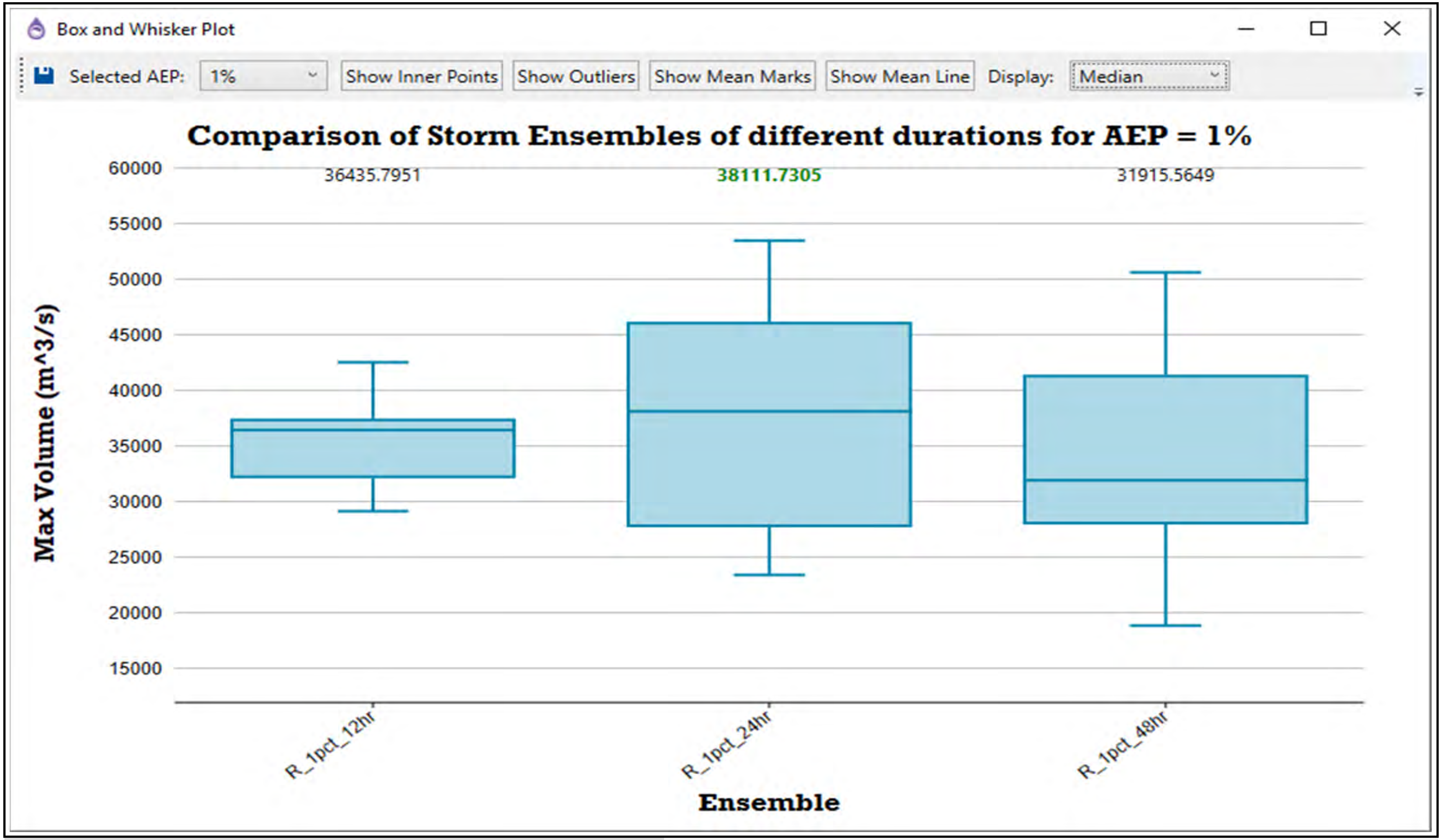


hyd2o

North Somerville Distrcit Water Management Strategy

1% AEP Stormwater Mangement Criteria: Breakout Inflow

Appendix F8



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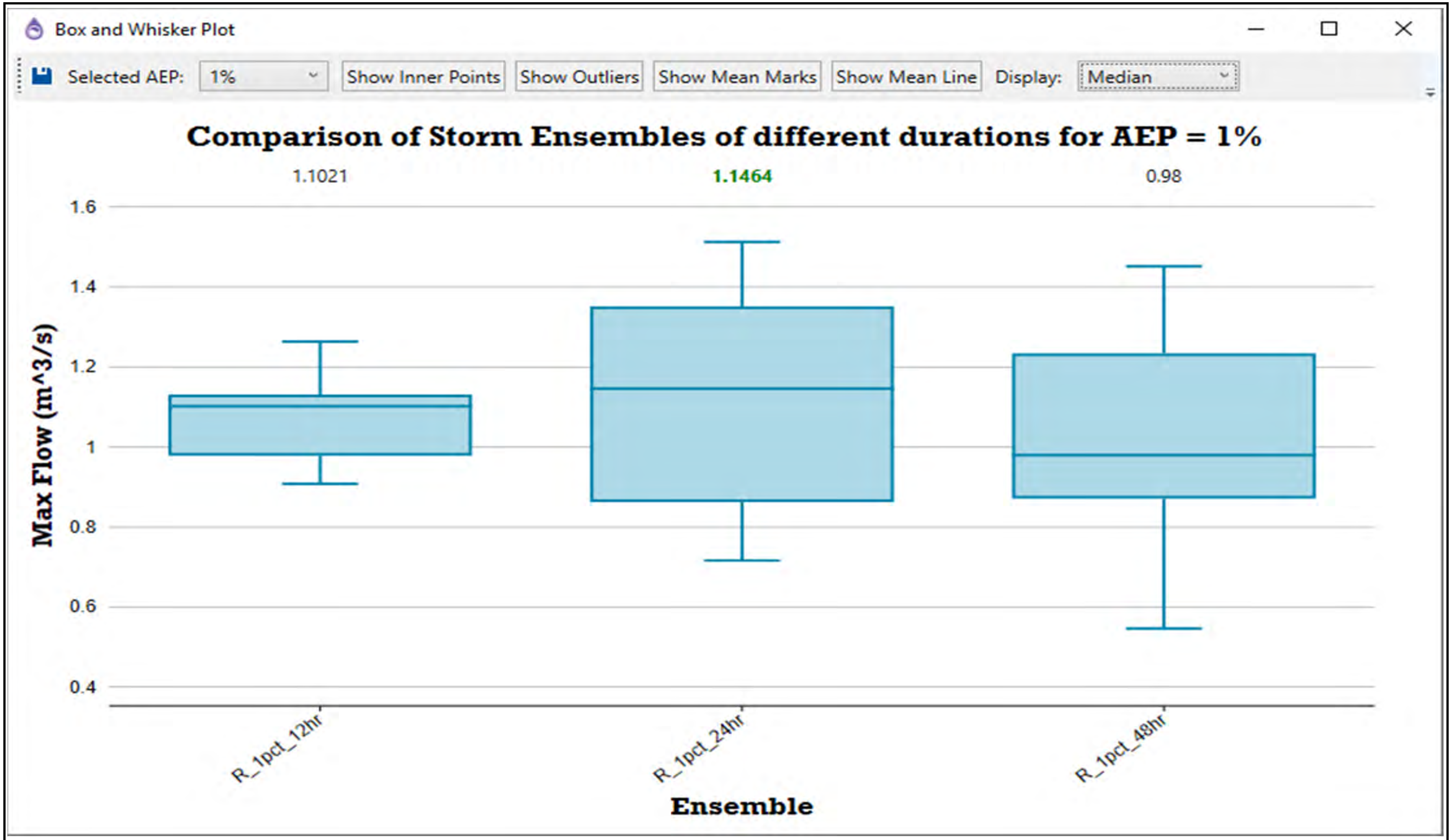
North Somerville Distrcit Water Management Strategy

1% AEP Stormwater Mangement Criteria: Replicate Flood Storage

Appendix F9



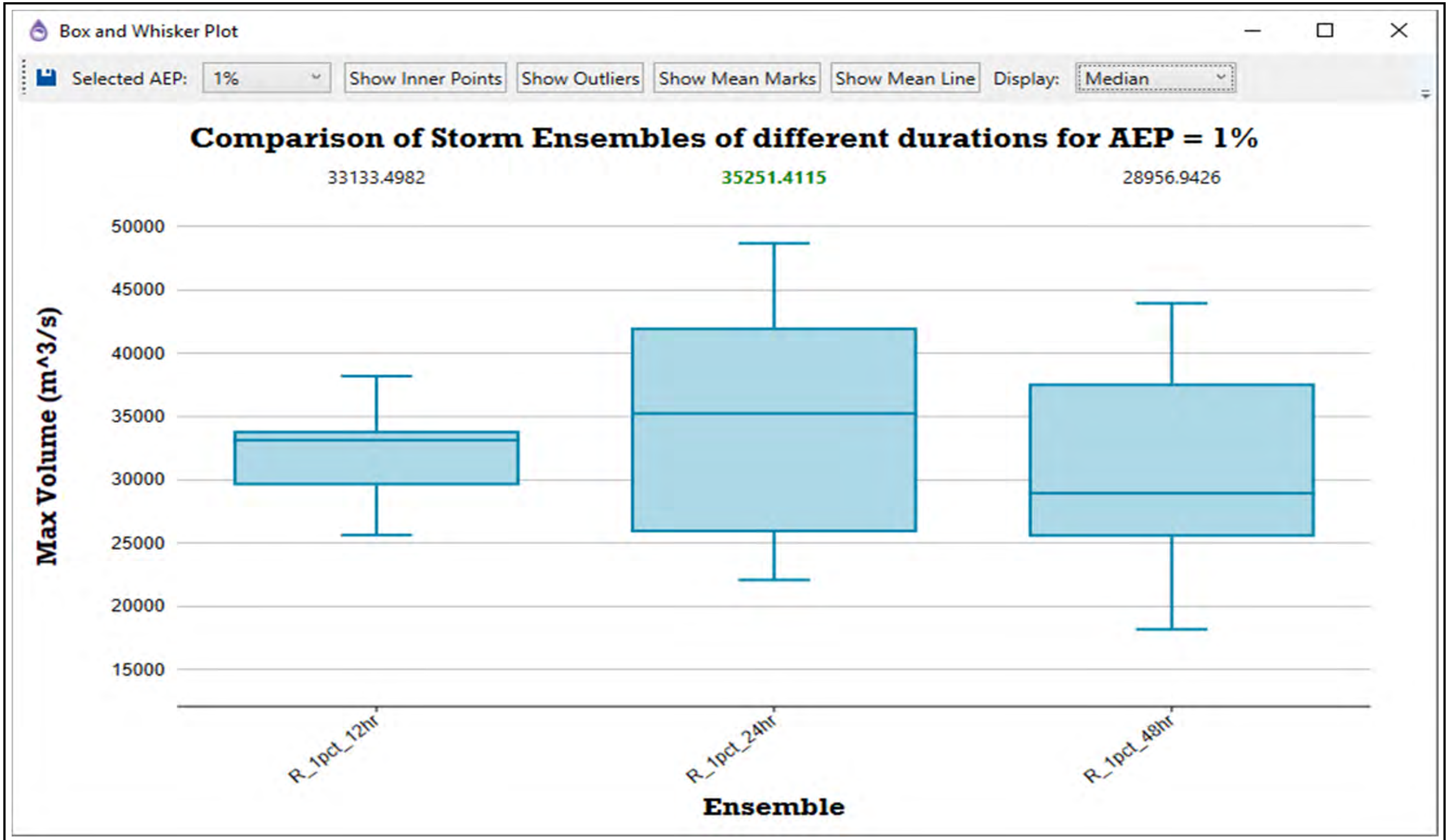
hyd2o

North Somerville Distrcit Water Management Strategy

1% AEP Stormwater Mangement Criteria: Spec Rd Drain Discharge

Appendix F10

Date : 11/04/2022 Job No: H21110

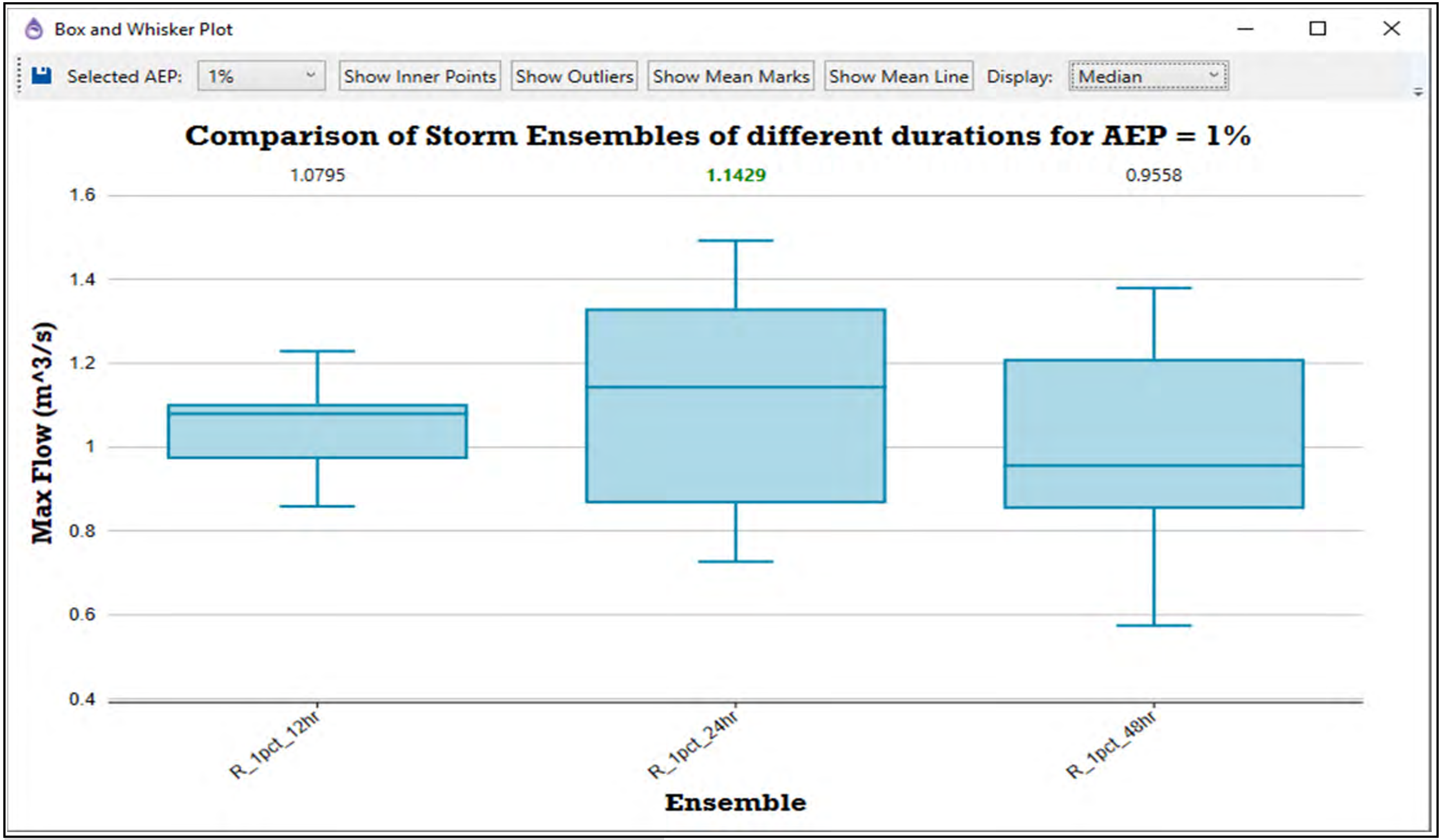


hyd2o

North Somerville Distrcit Water Management Strategy

1% AEP Post Development Flood Storage: Catchment 1

Appendix F11



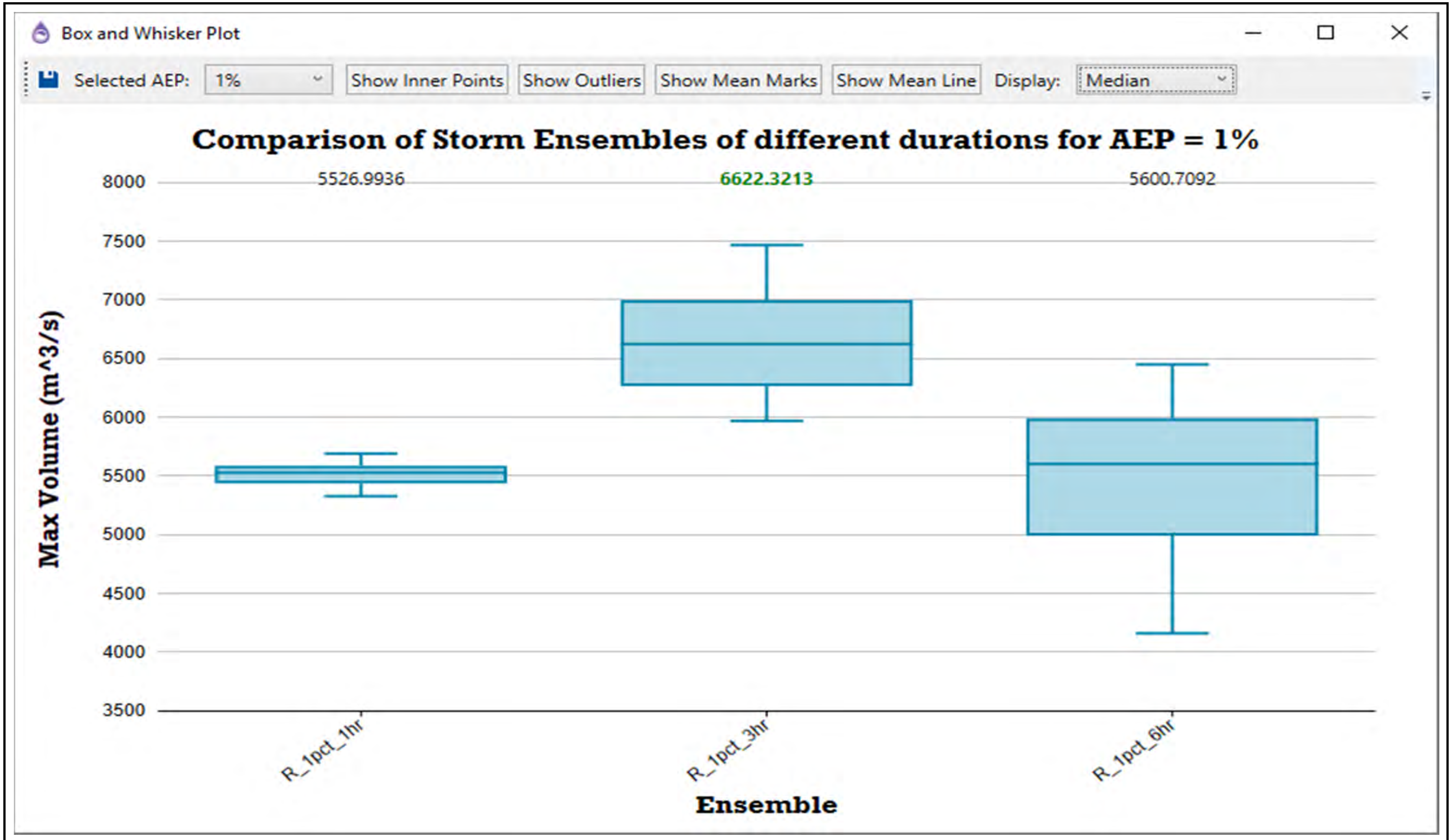
hyd2o

North Somerville Distrcit Water Management Strategy

1% AEP Post Development Discharge: Catchment 1

Appendix F12

Date : 11/04/2022 Job No: H21110



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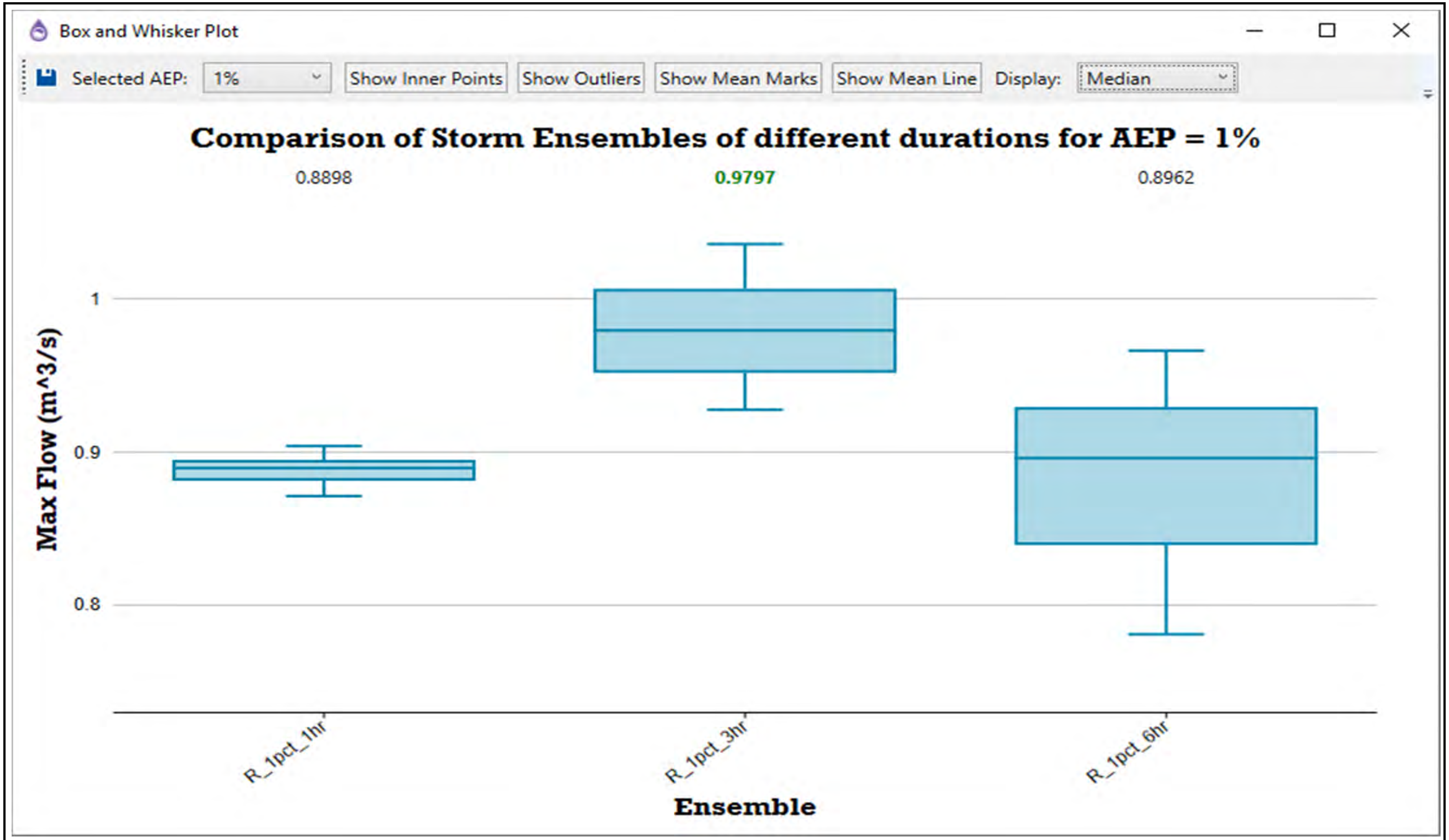
North Somerville Distrcit Water Management Strategy

1% AEP Post Development Flood Storage: Catchment 2

Appendix F13



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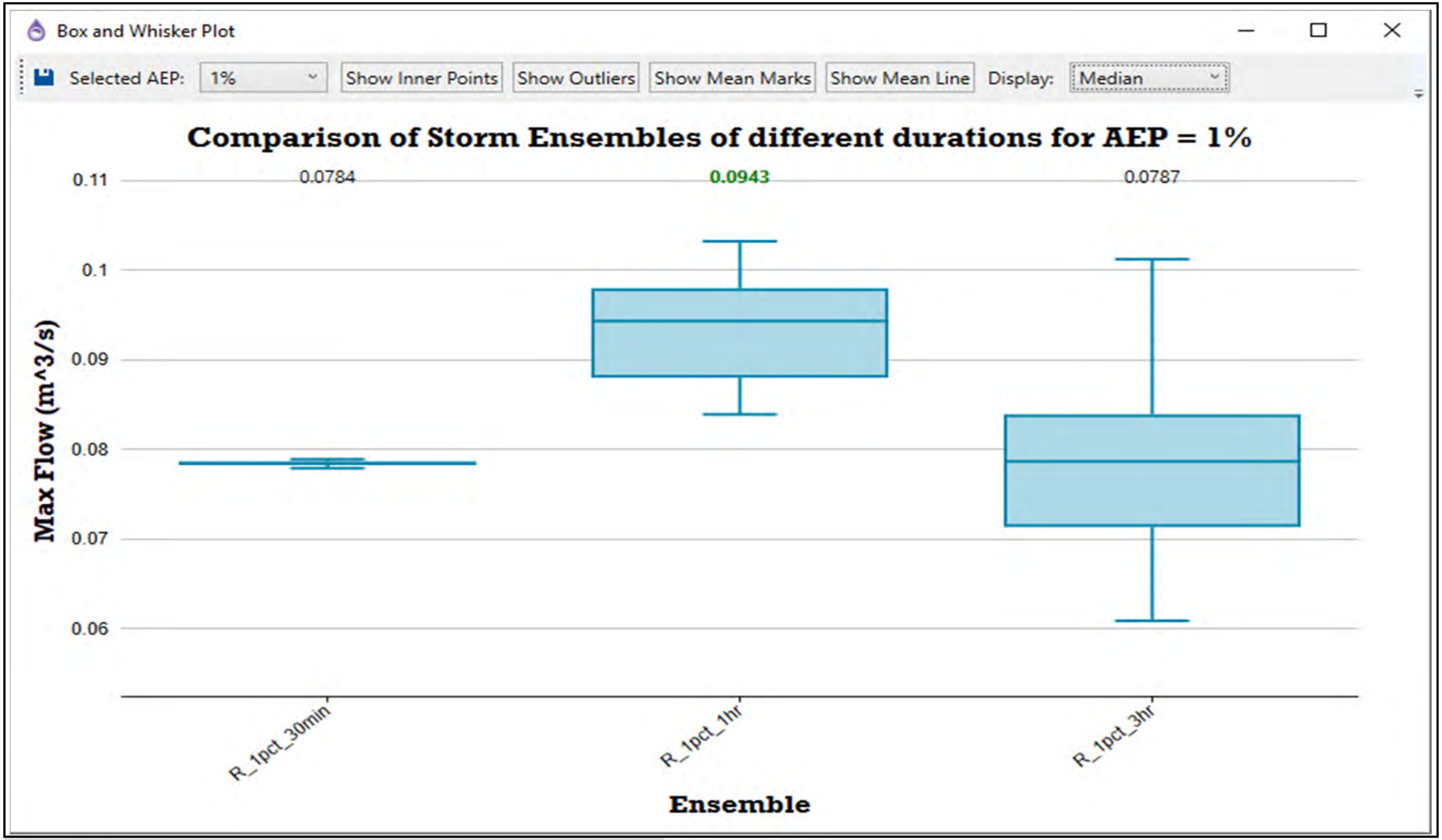
North Somerville Distrcit Water Management Strategy

1% AEP Post Development Discharge: Catchment 2

Appendix F14



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North Somerville Distrcit Water Management Strategy

1% AEP Post Development Discharge: Catchment 3

Appendix F15